Guest Editorial Special Issue on Fault Tolerant Operation and Stability Enhancement of Power Electronics Dominated Grids

THE climate emergency necessitates faster and wide-scale decarbonization of power grids and daily economic activities. As a result, it has triggered large-scale deployments of inertia-less power electronics renewable power generators with intermittent output powers as replacements for existing fossil fuel-based power plants which can dispatch their output powers and possess massive inertia. Power grid decarbonization in this manner presents significant operational and security challenges and exacerbates the risks of instability due to several factors such as low inertia, lack of spinning reserve to quickly nullify active power mismatch between demand and supply, and insufficient fault current for the correct operation of protection systems. Also, the inability to source or sink large active powers in weak ac grids that may result from decommissioning of a large number of existing generators is among the major concerns. Additionally, the transition toward power electronics dominated power systems that consist of numerous grid-following and grid-forming converters and HVdc systems is another major technical challenge that grid operators may face as many of the fundamentals that will dictate steady-state and transient behaviors in the future grid may differ, including methods for assessing grid stability. Modern power converters are versatile and can address many potential challenges that may emerge, nonetheless, their complex dynamics spread over a range of frequencies and must be understood. The highlighted challenges call for new control, protection, technologies, and solutions to be developed to enable the following: safe and reliable operation of power grids during the decarbonization period, in which coexistence of grid-forming and grid-following converters and conventional power plants must be managed carefully, and after the transition to zero-carbon energy systems; increased integration of renewable power generations at all voltage levels; holistic strategies for ac and dc fault handling in both onshore and offshore ac or dc grids; and ways for improving stability and extending active power sourcing and sinking limits in weak ac grids. This Special Issue aimed to foster and document the latest research that addresses the abovementioned emerging challenges. In response to the call for papers, the total number of manuscripts received was 63, and 42 papers were accepted for publication. The submitted manuscripts came from 19 different countries, covering all ten IEEE regions, i.e., China, Brazil, Finland, India, Hong Kong, France, Denmark, Iran, the U.K., the USA, France, Australia, Germany, South Africa, Spain, Canada, Mexico, Belgium, and Taiwan. From the accepted papers, 25 papers address issues directly relevant to this special topic. Broadly, the papers can be categorized as follows: converter topologies, faults and protection, control and stability, and review.

Short discussions of accepted papers are included in the following sections.

A. Converter Topologies

A. A. Aboushady, K. H. Ahmed, and I. Abdelsalam, "Modified Dual Active Bridge DC/DC Converter With Improved Efficiency and Interoperability in Hybrid LCC/VSC HVDC Transmission Grids," in IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS [doi: 10.1109/JESTPE.2020.3031257].

This article proposes a current fed dual active bridge dc/dc converter for dc voltage matching in hybrid dc grid, particularly, to be connected between the line commutated current source converter and the self-commutated voltage source converter.

R. Li and L. Xu, "A Unidirectional Hybrid HVDC Transmission System Based on Diode Rectifier and Full-Bridge MMC," in IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS [doi: 10.1109/JESTPE.2020.3015342].

This article proposes a hybrid converter for unidirectional power flow applications, where a diode rectifier (DR) is series-connected to a fractionally rated full-bridge modular multilevel converter (FB-MMC). The FB-MMC regulates the dc power through manipulation of its dc voltage. The majority of the power flow is forced through the DR due to its cost and efficiency superiority compared to the FB-MMC.

A. R. Sadat and H. S. Krishnamoorthy, "Fault-Tolerant ISOSP Solid-State Transformer for MVDC Distribution," in IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS [doi: 10.1109/JESTPE.2020.3032832].

This article introduces a fault-tolerant solid-state transformer (SST) structure that combines the benefits of

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higher power density and robustness for MVdc distribution systems.

D. Vozikis, G. P. Adam, P. Rault, O. Despouys, and D. Holliday, "Enhanced Modular Multilevel Converter for HVdc Applications: Assessments of Dynamic and Transient Responses to AC and DC Faults," in IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS [doi: 10.1109/JESTPE.2020.2983262].

This article assesses dynamic and ac and dc fault responses of the enhanced modular multilevel converter (EMMC). Moreover, it presents a new variant of the EMMC that allows controlled operation with reduced dc voltage during a pole-to-ground dc fault, without exposing the healthy dc cable and interfacing transformer to additional dc voltage stresses.

B. Faults and Protection

V. A. Lacerda, R. M. Monaro, D. Campos-Gaona, R. Peña-Alzola, and D. V. Coury, "An Approximated Analytical Model for Pole-to-Ground Faults in Symmetrical Monopole MMC-HVDC Systems," in IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS [doi: 10.1109/JESTPE.2020.3028937].

This article presents a simplified approximate analytical model for pole-to-ground dc fault in the half-bridge modular multilevel converter (MMC), and it derives closed-form expressions for the MMC fault currents.

J. Martínez-Turégano, R. Vidal-Albalate, S. Añó-Villalba, S. Bernal-Perez, and R. Blasco-Gimenez, "Protection Strategies for the Connection of Diode Rectifier-Based Wind Power Plants to HVDC Interconnectors," in IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS [doi: 10.1109/JESTPE.2020.3028780].

This article presents a comparative study of five different protection strategies of dc connected wind farms, in which the offshore station uses a diode rectifier arranged as a symmetrical or asymmetrical monopole or bi-pole, with solid or resistive grounding. The study examines two separate scenarios for onshore stations, the half-bridge and full-bridge MMCs.

S. Tang *et al.*, "Centralized Locating Strategy of Fault Current Limiters in MMC-Based Multi-Terminal HVDC Grid," in IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS [doi: 10.1109/JESTPE.2020.3027385].

This article proposes a centralized locating strategy of a fault current limiter (FCL) in HVdc grids. It shows that the centralized approach reduces the number of the FCLs needed to limit the faults in multi-terminal HVdc grids compared with the conventional approach that uses distributed FCLs, while the performance of the two approaches being compared remains similar.

Y. Tao, B. Li, T. Dragičević, T. Liu, and F. Blaabjerg, "HVDC Grid Fault Current Limiting Method Through Topology Optimization Based on Genetic Algorithm," in IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS [doi: 10.1109/JESTPE.2020.3026026].

This article proposes dc grid topology optimization to limit a pole-to-ground (P2G) fault current in symmetrical monopole HVdc systems. Also, it proposes a simplified index for a fast estimate of fault current level in each dc topology. A genetic algorithm is proposed to optimize the dc grid topology to limit the P2G fault current level.

X. Diao, F. Liu, Y. Song, M. X. Y. Zhuang, W. Zhu, and X. Zha, "A New Efficient Bidirectional T-Source Circuit Breaker for Flexible DC Distribution Networks," in IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS [doi: 10.1109/JESTPE.2020.3028206].

This article proposes a new efficient bidirectional T-source dc circuit breaker, in which the number of semiconductor devices in the main conduction path that contributes to the losses during normal operation is reduced by more than 40% compared to the existing bidirectional T-source dc circuit breakers.

Y. Ma, D. Oslebo, A. Maqsood, and K. Corzine, "DC Fault Detection and Pulsed Load Monitoring Using Wavelet Transform-Fed LSTM Autoencoders," in IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS [doi: 10.1109/JESTPE.2020.3019382].

This article proposes a novel machine learning-based algorithm, with long-short-term memory recurrent neural network-based auto-encoder networks to detect dc faults and monitor load conditions of pulse loads in naval applications.

S. Paladhi and A. K. Pradhan, "Adaptive Distance Protection for Lines Connecting Converter-Interfaced Renewable Plants," in IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS [doi: 10.1109/JESTPE.2020.3000276].

In recent years, converter control is found to vary fault characteristics of the renewable plants, thereby affects the performance of the distance relay that protects the lines connected to such plants. Therefore, a distance protection method using local data is proposed for transmission lines that connect renewable plants.

V. Psaras, D. Vozikis, G. Adam, and G. Burt, "DC Fault Management Strategy for Continuous Operation of HVDC Grids Based on Customized Hybrid MMC," in IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS [doi: 10.1109/JESTPE.2020.3048085].

This article investigates an enhanced dc fault performance of the customized hybrid MMC, in which a limited number of full-bridge cells is added into each arm of the conventional MMC in an effort to extend the fault clearance time to the level compatible with relatively slow and cheaper mechanical dc circuit breakers.

S. Zhang, G. Zou, C. Xu, and W. Sun, "A Reclosing Scheme of Hybrid DC Circuit Breaker for MMC-HVDC Systems," in IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS [doi: 10.1109/JESTPE.2020.3025598].

To avoid the exertion of excessive stresses on hybrid dc circuit breakers of conventional schemes in which permanent dc faults are cleared in two attempts, which resemble two consecutive faults, a highly selective reclosing scheme is proposed in this article. Its core principle is an identification method of instantaneous and permanent faults with aid of, traveling wave injection into the faulted dc line.

J. H. Park, J. S. Lee, M. Y. Kim, and K. B. Leea, "Diagnosis and Tolerant Control Methods for an Open-Switch Fault in a Vienna Rectifier," in IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS [doi: 10.1109/JESTPE.2021.3084803].

This article proposes a method for diagnosis of an open-circuit switch fault in a Vienna rectifier, and also presents a fault-tolerant control method that maintains the voltage balance of neutral-point and suppresses ac side current distortions and dc voltage ripples during open-circuit switch fault. The proposed fault diagnosis detects an open-circuit switch fault using only input currents information without the need for the hardware. While the proposed fault-tolerant control method introduces a voltage offset to restore the input currents when the Vienna rectifier operates under an open-circuit switch fault.

C. Control and Stability

M. Abdollahi, J. I. Candela, J. Rocabert, and M. A. Elsaharty, "Active Power Limiter for Static Synchronous Generators in Renewable Applications," in IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS [doi: 10.1109/JESTPE.2020.3019992].

This article proposes an active power limiter for grid-forming virtual synchronous generators that can be operated in both islanded and grid following modes, and emulate inertia and output admittance.

H. Alenius *et al.*, "Hardware-in-the-Loop Methods for Stability Analysis of Multiple Parallel Inverters in Three-Phase AC Systems," in IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS [doi: 10.1109/JESTPE.2020.3014665].

This article presents a method for online stability assessment of grid-connected paralleled inverters using power hardware-in-the-loop measurements based on an OPAL-RT real-time simulator. It is based on simultaneous online measurements of the inverter's current control loop gains and the grid impedance, and aggregation of terminal admittance measurements of the inverters.

M. Raeispour, H. Atrianfar, H. R. Baghaee, and G. B. Gharehpetian, "Robust Hierarchical Control of VSC-Based Off-Grid AC Microgrids to Enhancing Stability and FRT Capability Considering Time-Varying Delays," in IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS [doi: 10.1109/JESTPE.2020.3017713].

This article proposes a robust hierarchical control scheme for off-grid voltage-sourced converter (VSC)-based ac microgrids, with a focus on inner current, outer voltage, virtual impedance, and droop control loops. The inner current loop is designed using adaptive back-stepping integral non-singular fast terminal sliding mode control to regulate and track the current reference in the presence of unknown bounded uncertainties and external disturbances. The outer loop is designed using mixed H2/H∞ control with the aid of the state feedback control law to achieve stable and robust operation against perturbations.

J. Luo, S. Bu, and J. Zhu, "A Novel PMU-Based Adaptive Coordination Strategy to Mitigate Modal Resonance Between Full Converter-Based Wind Generation and Grids," in IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS [doi: 10.1109/JESTPE.2020.3024759].

Generally, mitigation of resonance between the type 4 wind generators and ac grids requires an offline modal interaction study that needs a full system model. Therefore, this article proposes an online approach that facilitates the modal interaction study without the need for a full system model.

Y. Cai, Y. He, H. Zhou, and J. Liu, "Active Damping Disturbance Rejection Control Strategy of LCL Grid-Connected Inverter Based on Inverter-Side Current Feedback," in IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS [doi: 10.1109/JESTPE.2020.3017678].

In the medium- and high-power grid-connected photovoltaic systems, the controller bandwidth is constrained by the low switching frequency. This restricts the resonant frequency of the traditional proportional multi-resonant controller and compromises suppression of significant low-frequency harmonics in the grid current, and performance under severe operating conditions. Thus, a novel first-order active-disturbance-rejection active-damping control strategy, based on the inverter-side current feedback for *LCL* grid-connected inverter, is proposed in this article.

Z. Zhang, D. Chen, K. Givaki, and L. Xu, "A Less-Intrusive Approach to Stabilize VSC Transmission Against Highly Variable Grid Strength," in IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS [doi: 10.1109/JESTPE.2020.3030362].

A less-intrusive solution to stabilize a voltage source converter over an unknown grid strength is presented in this article. The existence of an equilibrium point is investigated as a prerequisite for stabilization. By partially imposing grid-forming control, a simple auxiliary outer loop is proposed to exhaust the physical limit of power delivery in steady state and provide support to fault-ride-through operations over a wide range of grid strength.

P. Chen and X. Chen, "Error Estimation Method of Reduced-order Small-signal Model for Multi-terminal DC Distribution Network," in IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS [doi: 10.1109/JESTPE.2020.2998528].

To ensure the accuracy of the control designs and studies that utilize reduced-order small-signal model dynamic of multi-terminal dc distribution network, an efficient error estimation method for the eigenvalues that represent dominant modes is proposed in this article, using the matrix perturbation theory and the Newton algorithm. To further improve the estimation efficiency and provide a basic judgment of error trend with respect to the change of parameters, an error-bound estimation method and a sensitivity expression of reduction error are developed, respectively.

Y. Chen, L. Xu, A. Egea-Álvarez, B. Marshall, M. Rahman, and O. D. Adeuyi, "MMC Impedance Modelling and Interaction of Converters in Close Proximity," in IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS [doi: 10.1109/JESTPE.2020.3031489].

This article presents a small-signal impedance model of modular multilevel converters using a harmonic state-space method and assesses the stability of a multi-converter system. To simplify and understand the coupling characteristics of different frequencies of the MMCs, the presented model is developed in the positive-negative-zero sequence-frame, with zero-sequence quantities neglected.

M. N. Musarrat and A. Fekih, "A Fault Tolerant Control Framework for DFIG-Based Wind Energy Conversion Systems in a Hybrid Wind/photovoltaic (PV) Microgrid," in IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS [doi: 10.1109/JESTPE.2020.3034604].

This article proposes a fault-tolerant control framework for a doubly fed induction generator (DFIG)-based wind energy conversion system in a hybrid wind/PV microgrid structure. It implements a fractional-order sliding mode control for the DFIG converters to mitigate grid faults and ensure robustness against mismatch uncertainties.

P. A. Gbadega and A. K. Saha, "Load Frequency Control of a Two-Area Power System With a Stand-Alone Micro-Grid Based on Adaptive Model Predictive Control," in IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS [doi: 10.1109/JESTPE.2020.3012659].

This article proposes an adaptive model predictive control technique for load frequency control of a two-area interconnected power system, with a stand-alone microgrid. A generalized state–space model of a typical stand-alone microgrid having controllable and uncontrollable generating power sources is derived to predict the future output and control inputs for the micro-grid frequency control.

X. Li *et al.*, "A Reduced RLC Impedance Model for Dynamic Stability Analysis of PI Controller Based DC Voltage Control of Generic Source-Load Two-Terminal DC Systems," in IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS [doi: 10.1109/JESTPE.2020.3016059].

For the dynamic stability assessment of a PI-based dc voltage controller of a generic source-load two-terminal dc system, a simpler *RLC* parallel impedance model is proposed. By ignoring the fast inner current control, the output impedance model of the dc voltage control system can be represented as a parallel *RLC* circuit, which gives an intuitive insight into the physical sense of parameters of the dc voltage PI controller. Subsequently, a dynamic impedance ratio is introduced to represent the impact of dc voltage droop control and line impedance on the dc voltage control system.

K. Ji *et al.*, "Generalized Impedance Analysis and New Sight at Damping Controls for Wind Farm Connected MMC-HVdc," in IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS [doi: 10.1109/JESTPE.2020.3017896].

The small-signal stability of wind farm-connected MMC-HVdc systems is widely studied by impedance analyses. However, calculating system poles is difficult due to complex internal dynamics. Thus, most of the existing works on impedance analysis methods usually assume that one of the subsystems is stable. To address the above shortcomings, this article divides the wind farm-connected MMC-HVdc into three subsystems and proposed a third-order minor loop-gain matrix to investigate the unified stability of both ac and dc systems.

Y. Khayat, S. Golestan, J. M. Guerrero, J. C. Vasquez, and H. Bevrani, "DC-Link Voltage Control Aided for the Inertial Support During Severe Faults in Weak Grids," in IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS [doi: 10.1109/JESTPE.2020.3033657].

Maintaining a grid-connected converter in synchronism with a weak grid during deep voltage sags is a challenge, particularly, with converter-interfaced renewable energy generation. To address this challenge, a simple and effective solution based on the virtual inertia concept is proposed in this article. The proposed method adds a correction term to the dc-link voltage controller, which adjusts the active and reactive current set orders; hence, enables the converter to remain synchronized to the grid during severe faults.

T. Li, Y. Li, X. Chen, S. Li, and W. Zhang, "Research on AC Microgrid With Current-Limiting Ability Using Power State Equation and Improved Lyapunov-Function Method," in IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS [doi: 10.1109/JESTPE.2020.3013230].

Recent blackouts in Australia and the U.K. have raised serious concerns about renewable-energy-dominated power systems. Hence, this article identifies and studies a suitable control method for an ac microgrid with strong current-limiting ability, in which the outer controller uses a power state equation based on PI control to accurately track the reference power. To reduce the asymmetry and amplitude fault currents, the outer-loop controller only considers the positive-sequence voltage and adds twice the rated current limiter. Moreover, the inner controller adopts an improved Lyapunov function method with anti-parametric disturbance ability to track the reference inductance current.

D. Zhou, R. Li, L. Xu, and Y. Wang, "Energy Based Virtual Damping Control of FB-MMCs for HVDC Grid," in IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS [doi: 10.1109/JESTPE.2020.3040815].

Blocking of the full-bridge modular multilevel converter (FB-MMC) can only suppress its dc terminal current while the fault currents may still circulate along the meshed dc network. To address this issue, an energy-based virtual damping control is proposed, where the dc terminal current of the FB-MMC is regulated to follow the dc voltage in the event of a dc fault. Thus, the converter is controlled as a virtual damping resistor to actively absorb the residual energy in the dc network and quickly suppress the potential circulating dc fault currents.

J. Zhu *et al.*, "Coordinated Flexible Damping Mechanism With Inertia Emulation Capability for MMC-MTDC Transmission Systems," in IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS [doi: 10.1109/JESTPE.2020.3025690].

The rapid growth in penetration levels of power electronics-interfaced renewable power generation into grids have caused system inertia to reduce, resulting in degradation of inherent system capacity in terms of frequency stability and oscillation damping. To address this challenge, this article proposes a

control scheme that realizes a coordinated flexible damping mechanism with inertia emulation capability for modular multilevel converter-based multi-terminal dc (MMC-MTdc) transmission systems. The proposed control scheme allows the MMC-MTdc system to autonomously provide an emulated inertial response with a flexible damping effect to ac systems in a similar fashion to a synchronous generator, without the need for communication.

J. F. Morris, K. H. Ahmed, and A. Egea-Alvarez, "Analysis of Controller Bandwidth Interactions for Vector-Controlled VSC Connected to Very Weak AC Grids," in IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS [doi: 10.1109/JESTPE.2020.3031203].

In this article, a small signal model is derived to quantify the maximum active power transfer in a very weak grid, covering a wide range of controller bandwidths. Investigation of the vector controlled voltage-source converter C controller bandwidth interactions between inner and outer control loops includes the phase-locked loop dynamics, and it has established the existence of a stability bubble for safe operating regions.

S. Pang, B. Nahid-Mobarakeh, S. Pierfederici, Y. Huangfu, G. Luo, and F. Gao, "Large-Signal Stable Nonlinear Control of DC/DC Power Converter With Online Estimation of Uncertainties," in IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS [doi: 10.1109/JESTPE.2020.3010895].

This article proposes a controller and an observer, which are designed simultaneously based on the Hamiltonian framework and Lyapunov criterion. The system design does not separate the dynamics of the controller and the observer. The uncertainties in the model and parameters are considered as equivalent voltage and current sources.

H. Jafari, M. Moghaddami, T. O. Olowu, A. Sarwat, and M. Mahmoudi, "Virtual Inertia-Based Multi-Power Level Controller for Inductive Electric Vehicle Charging Systems," in IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS [doi: 10.1109/JESTPE.2020.3032898].

A method of modulating the power level of a grid-supplied inductive electric vehicle (EV) charger to provide frequency stabilization to the utility grid is presented. The proposed controller can allow inductive EV charging systems to effectively respond to grid frequency fluctuations by online regulating the charging level and adding high virtual inertia.

K. S. Xiahou, Y. Liu, L. L. Zhang, M. S. Li, and Q. H. Wu, "Robust Current Sensorless Control of VSC-Based MTDC Transmissions for Integrating Wind Farms," in IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS [doi: 10.1109/JESTPE.2020.3004868].

This article presents an observer-based robust current sensor-less control scheme for voltage source converter-based multi-terminal dc transmission system integrated with wind farms. Perturbation observer-based point of common coupling voltage controller and dc-link voltage controller are designed for both wind farm and grid side stations.

X. Lu, W. Xiang, W. Lin, and J. Wen, "Analysis of Wide-Band Oscillation of Hybrid MMC Interfacing Weak AC Power System," in IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS [doi: 10.1109/JESTPE.2020.3024740].

The wide-band oscillation of the hybrid MMC induced by excessive power infeed into a weak ac power system is analyzed in this article, with the aid of a closed-loop state-space-based time-domain small-signal model. Unlike the two-level converter or half-bridge MMC, the root locus analysis and participation factor analysis reveal that the oscillation frequency and involved control loops are highly dependent on the operation conditions.

H. Yang, M. Eggers, H. Just, P. Teske, and S. Dieckerhoff, "Linear Time-Periodic Theory Based Harmonic Resonance Analysis of Converter Dominated Power System," in IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS [doi: 10.1109/JESTPE.2020.3041945].

This article investigates harmonic resonance of converter-dominated power systems under asymmetric operating conditions. Complex domain harmonic transfer matrix (HTM) models for the grid-following voltage source converters and the asymmetric network are derived to accurately capture the harmonic frequency coupling effect. Then, the classical resonance mode analysis is generalized by describing the system in terms of a time-periodic impedance matrix, obtained from the reformulation of the HTMs to identify the resonance frequencies.

J. Zhu *et al.*, "Coherence Analysis of System Characteristics and Control Parameters for Hybrid HVDC Transmission Systems Based on Small-Signal Modeling," in IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS [doi: 10.1109/JESTPE.2020.3014434].

A hybrid HVdc system that comprises of a line commutated converter at the sending end (rectifier) and a voltage source converter at the receiving end (inverter) has drawn significant attention in recent years due to its high reliability and economic benefits. This article presents a novel coherence analysis procedure for system stability assessment of a hybrid HVdc system, using a small-signal model. The proposed procedure captures the coherence relationships between the system characteristics and control parameters. It reveals that the circuit and control parameters can affect the oscillatory modes and even cause instability.

A. Kaymanesh and A. Chandra, "Electric Spring Using MPUC5 Inverter for Mitigating Harmonics and Voltage Fluctuations," in IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS [doi: 10.1109/JESTPE.2020.3028586].

This article introduces a novel configuration of electric spring based on the modified five-level packed u-cell (MPUC5) inverter for mitigating harmonics and voltage fluctuations at various points of a grid, with unstable generated power from distributed renewable energy sources. Operation principles, design procedure, and topologies of the MPUC5-based electric spring (MPUC5-ES) are presented. Moreover, a simple and efficient controller for regulating dc bus voltages is proposed.

D. Review

J. V. M. Farias, A. F. Cupertino, H. A. Pereira, S. I. Seleme, and R. Teodorescu, "On Converter Fault Tolerance in MMC-HVDC Systems: A Comprehensive Survey," in IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS [doi: 10.1109/JESTPE.2020.3032393].

Modular multilevel converters (MMCs) have been studied extensively in recent literature. High component counts of the MMCs raise reliability concerns due to increased sources of failures. Consequently, several fault-tolerant schemes have been proposed in literature. This article presents a comprehensive survey on the fault-tolerant strategies of the MMC-HVdc systems, based on the available technical literature.

B. Luscan *et al.*, "A Vision of HVDC Key Role Toward Fault-Tolerant and Stable AC/DC Grids," in IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS [doi: 10.1109/JESTPE.2020.3037016].

Efficient and robust ac/dc transmission systems require a vision of HVdc roles and functionalities in different situations. In addition to HVdc converter core control functions and dc grid protection strategies, a coordinated dc grid control layer is beneficial to supervise control modes toward overall ac/dc transmission system security and stability. This article offers a vision of what a robust ac/dc network can be based on control and protection strategies that can be implemented via HVdc converter capabilities.

I. Alhurayyis, A. Elkhateb, and D. John Morrow, "Isolated and Non-Isolated DC-to-DC Converters for Medium Voltage DC Networks: A Review," in IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS [doi: 10.1109/JESTPE.2020.3028057].

This work presents, for the first time, a review of the dc/dc power converter families in MVdc grids including the leading families of isolated and non-isolated converters, as well as other subfamilies, comparing the specifications and characteristics.

The editorial team hopes that this Special Issue will inspire and excite extensive research on all aspects of developing decarbonized power electronic dominated grids that rely on converter-interfaced renewable power generations, which include: novel control and stability, emerging fault handling and protection methods for multi-infeed and multi-terminal MVdc and HVdc grids, fault-tolerant operation of critical infrastructures, and new dedicated converters. We hope that the continuation of extensive research on the challenges and topics addressed in the Special Issue will lead to innovations that bridge the technology gap for safe transition to a fully decarbonized power grid.

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APPENDIX: RELATED ARTICLES

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