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Editorial

Integration of AC/DC Microgrids into Power Grids

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Abstract: The Special Issue on “Integration of AC/DC Microgrids into Power Grids” is published. A total of six qualified papers are published in this Special Issue. The topics of the papers are the Optimal Power Flow (OPF), control, protection, and the operation of hybrid AC/DC microgrids. Nine researchers participated in this Special Issue. We hope that this Special Issue is helpful for sustainable energy applications.

Keywords: AC/DC Microgrids; Distributed Generations (DGs); Microgrid Control Systems; Power Systems Operation; Power Systems Optimization; Power Systems Planning; Power Systems Protection

1. Introduction

AC/DC microgrids are a small part of low voltage distribution networks that are placed far from power substations and also are also interconnected through the Point of Common Coupling (PCC) to power grids [1–3]. These systems are the important keys to use flexible, techno-economic, and environmentally-friendly generation units for the reliable operation and cost-effective planning of smart electricity grids [4,5]. Although AC/DC microgrids with the integration of renewable energy resources and other energy systems, such as power-to-gas, combined heat and power, combined cooling heat and power, power-to-heat, power-to-vehicle, and pump and compressed air storage, have several advantages, there are some technical aspects that must be addressed. This Special Issue aims to study the configuration, impacts, and prospects of AC/DC microgrids that enable enhanced solutions for intelligent and optimized electricity systems, energy storage systems, and demand-side management in power grids with an increasing share of distributed energy resources. This includes AC/DC microgrids modeling, simulation, control, operation, protection and dynamics along with considering power quality improvement, load forecasting, energy conversion, supervisory and monitoring, diagnostics and prognostics systems.

2. Integration of AC/DC Microgrids into Power Systems

T. V. Nguyen, et al. [6], in their paper entitled “Power Flow Control Strategy and Reliable DC-Link Voltage Restoration for DC Microgrid under Grid Fault Conditions”, proposes an effective Power Flow Control Strategy (PFCS) based on the centralized control method and a reliable DC-link Voltage (DCV) restoration algorithm for a DC microgrid, which consists of a utility grid connection system, a wind power generation system, a battery-based energy storage system, and DC loads, under grid fault conditions. The power flow in a DC microgrid can be autonomously and reliably controlled under both the grid-connected and islanded conditions using the relationship of supply demand power and battery status. By implementing the Constant Current-Constant Voltage (CC-CV) method for the battery-charging operation with the consideration of the battery power limit, the overheating or damage caused by undesirable over-charging/over-discharging is avoided, which expands the battery life, significantly. This paper also develops an effective load shedding algorithm considering the State-of-Charge (SoC) and the maximum capability of the battery to maintain the system power

balance, even in the critical cases. In order to deal with the system power imbalance caused by the delay of grid fault detection, the DCV restoration algorithm is proposed in this paper. In the proposed DCV restoration algorithm, a Local Emergency Control Mode (LECM) is introduced to restore the DCV quickly to a nominal value. The LECM, which is achieved by local controllers either with the battery-based energy storage system or the wind power generation system, operates regardless of the control signals from the central controller under critical conditions for the purpose of ensuring the system power balance. To validate the effectiveness of the PFCS and the proposed DCV restoration algorithm, both simulations based on the PSIM software and experiments based on the prototype laboratory DC microgrid testbed are carried out.

F. Mohammadi, et al. [7], in their paper entitled “A Bidirectional Power Charging Control Strategy for Plug-in Hybrid Electric Vehicles”, proposes a precise bidirectional charging control strategy of Plug-in Hybrid Electric Vehicles (PHEVs) in power grids to simultaneously regulate the voltage and frequency, reduce the peak load, and improve the power quality considering the SoC and available active power in power grids. Different events that may occur during a 24-h scenario in the studied Distributed Generation (DG)-based system consisting of different microgrids, diesel generator and wind farm, PHEVs with several charging profiles, and different loads, are considered. The simulation and analysis are performed in MATLAB/SIMULINK software. The simulation results show the robustness of the proposed control strategy.

F. Mohammadi, et al. [8], in their paper entitled “A New Topology of a Fast Proactive Hybrid DC Circuit Breaker for MT-HVDC Grids”, proposes a new topology of a fast proactive Hybrid DC Breaker (HDCCB) to isolate the DC faults in Multi-Terminal VSC-HVDC (MT-HVDC) grids in case of fault current interruption, along with lowering the conduction losses and lowering the interruption time. All modes of operation of the proposed topology are studied. The simulation results verify that compared to the conventional DC circuit breaker, the proposed topology has a lower interruption time, lower on-state switching losses, and a higher breaking current capability. Due to the fact that MT-HVDC systems can share the power among the converter stations independently and in both directions, and considering the fast bidirectional fault current interruption, as well as reclosing and rebreaking capabilities, the proposed HDCCB can improve the overall performance of MT-HVDC systems and increase the reliability of the DC grids.

M. A. Hassan, et al. [9], in their paper entitled “Optimal Power Control of Inverter-Based Distributed Generations in Grid-Connected Microgrid”, proposes an efficient PI power controller to regulate the predefined injected real and reactive powers to the grid. The control problem is optimally designed based on minimizing the error between the calculated and the injected powers to get the optimal controller parameters. Particle Swarm Optimization (PSO) is employed to design the controller parameters and LC filter components. Different microgrid structures are implemented and examined in MATLAB. Firstly, the optimal proposed controller is designed to control the injected real and reactive powers of one inverter-based DG. Secondly, the optimal proposed controller is designed for two different rated inverter-based DG units to share their injected powers to the grid. Several disturbances, such as step-up/down changes of real and reactive injected powers, three-phase faults, and losing DG units are applied to investigate the effectiveness of the proposed controller and to ensure the system stability after getting disturbed. Additionally, to validate the usefulness of the proposed controller, the considered microgrid is implemented on a Real-Time Digital Simulator (RTDS). To confirm the effectiveness of the proposed optimal control scheme, it is compared with the existing work through extensive simulation and experiments under various disturbances. The results confirm the superiority of the proposed control strategy in providing a fast, accurate and decoupled power control with a lower AC current distortion.

T. V. Nguyen, et al. [10], in their paper entitled “An Improved Power Management Strategy for MAS-Based Distributed Control of DC Microgrid under Communication Network Problems”, proposes an improved Power Management Strategy (PMS) using the Multi-Agent System (MAS)-based distributed control of the DC microgrid. In this study, the DC microgrid consists of a grid agent,

a battery agent, a wind power generation system agent, and a load agent. To ensure the system power balance under various conditions, each agent investigates the information obtained from both the local measurement and the neighboring agents via the communication lines. Then, the decision for local control mode and communication data is optimally made for the system power balance. By using this control scheme, the control mode of agents could be determined locally without any intervention of the central controller, which effectively avoids the single point of failure as in the centralized control. Moreover, all the agents can operate in a deliberative and cooperative manner to ensure globally the optimal operation by the means of the communication network. In addition, to deal with the impact of communication problems in the case of the grid fault, a DCV restoration algorithm is introduced to restore the DCV stably to its nominal value. Furthermore, to recognize the grid recovery reliably in other agents even under communication failure, the grid recovery identification algorithm is introduced. For this purpose, a special current pattern is generated on the DC-link by the grid agent once the grid is recovered. By detecting this current pattern on the DC-link, the remaining agents can reliably identify the grid recovery even without the communication. To validate the feasibility of the MAS-based distributed control as well as the proposed schemes under the communication problems, the simulations based on the PSIM software and the experiments based on laboratory prototype DC microgrid testbed are carried out.

F. Mohammadi, et al. [11], in their paper entitled “Optimal Placement of TCSC for Congestion Management and Power Loss Reduction Using Multi-Objective Genetic Algorithm”, proposes a multi-objective algorithm to optimally allocate Thyristor-Controlled Series Compensators (TCSCs) and their susceptance values, considering power loss reduction, congestion management, and the determination of the power lines compensation rates in power grids. This paper focuses on (1) considering the structure of TCSCs and the AC characteristics of power systems, formulating a nonlinear problem, and solving it using a heuristic algorithm, and (2) determining the optimal allocation and rating of TCSCs through an optimization procedure. The Jacobian sensitivity approach and AC load flow are used for line congestion evaluations. The Multi-Objective Genetic Algorithm (MOGA) is used as an optimization method to determine the optimal locations and susceptance values of TCSCs. The proposed method is deployed on the IEEE 30-bus test system, and the results are investigated to illustrate the applicability and effectiveness of the proposed method. In addition, the obtained results are compared with those from different algorithms, such as the multi-objective PSO algorithm, Differential Evolution (DE) algorithm, and the Mixed-Integer Non-Linear Program (MINLP) technique. The obtained results show the superiorities of the proposed method, in terms of fast convergence and high accuracy, over the other heuristic methods.

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