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Editorial

Optimal Control of Smart Distributed Power and Energy Systems

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The increase in intermittent renewable energy resources and distributed generation has led to the need for developing new controllers and management techniques for smart grids. In fact, on one hand, renewable energy sources can cause voltage and frequency fluctuations that negatively affect the power system, and on the other hand, they increase the need for modulation from large fossil fuel generation plants, thus affecting the operational life of their components. Therefore, the presence of generators, storage demand response programs and electric vehicle charging stations has led to the need for changing the structure of the electrical grid into a more flexible one. Due to uncertainties associated with the availability of renewable sources, distributed green power production systems can create some problems for the distribution grid, such as power quality losses in the power network, voltage imbalances and undesired peaks. Typically, traditional controllable generators are used to compensate these fluctuations, causing efficiency losses (increasing operational and maintenance costs), resulting in a decrease in regulation margins for the distribution grid.

Thus, new methodological and technological approaches are more and more necessary to optimally manage renewable resources and to integrate them into the new energy systems. These energy systems are equipped by smart instrumentation that can lead to a cooperative and distributed way of controlling the whole system, creating a transition from a centralized structure to a decentralized one (both in terms of sources and controls).

The main aim of the special issue was to collect papers in the field of modelling, control and optimization of power distribution grids (both in stand-alone and grid connected operations), paying specific attention to the methods and real infrastructure applications.

The specific topics of the special issue included:

- New models for distribution power grids.
- Optimal control and planning of distribution grids (both in grid connected and islanded mode).
- Optimization methods related to distributed optimization, stochastic optimization, and model predictive control.

The special issue includes four papers related to operational management and real-time frequency/voltage control of power systems.

In [1], an application-oriented reactive power management concept is proposed, which allows distribution system operators to enable a certain amount of reactive power flexibility at the grid interfaces while supporting voltage imitations in the grid. To evaluate its feasibility, the proposed concept is applied to real medium voltage grids in the south of Germany and is investigated comprehensively in different case studies. The results prove the feasibility and reliability of the proposed concept, which allows the operator to control the reactive power exchange at grid interfaces without causing undesired local voltage problems.

The [2] power-voltage droop controller and the inner voltage regulator for islanded microgrids are redesigned based on a total sliding-mode control technique. As for the power-voltage droop control loop, a droop control relation error between the active power and the point-of-common-coupling voltage amplitude is defined. Then, the scheme is adopted to reach the new droop control relation, where the active power sharing and voltage amplitude recovery can be achieved simultaneously. The power allocation error can be improved by more than 81.2% and 50% than the conventional and proportional-integral-based droop control.

The authors of [3] propose a frequency regulation of a power grid model including loads, traditional generators and several electric vehicles. Two novel control strategies for the optimal control of the batteries of electric vehicles during the frequency regulation service are studied. On the one hand, the control strategies ensure the re-balancing of the power and stabilizing of the frequency of the main grid. On the other hand, the approaches can satisfy different types of needs of vehicles during the charging process.

Finally, [4] a model predictive control for voltage and frequency regulation in interconnected local distribution systems is presented. In the proposed model, each local system represents a collection of intelligent buildings and microgrids with a large capacity in active and reactive power regulation. The related model formalization includes a linear approximation of the power flow equations, based on stochastic variables related to the electrical load and to the production from renewable sources.

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