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Aggregation of Electric Vehicles for Emergency Frequency Regulation of Two-Area Interconnected Grid

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Abstract : Frequency control has become more of concern for reliable operation of interconnected power systems due to the integration of low inertia renewable energy sources to the grid and their volatility. Also, in case of a sudden fault, the system has less time to recover before widespread blackouts. Electric Vehicles (EV)s have the potential to cooperate in the Emergency Frequency Regulation (EFR) by a nonlinear control of the power system in case of large disturbances. The time is not adequate to communicate with each individual EV on emergency cases, and thus, an aggregate model is necessary for a quick response to prevent from much frequency deviation and the occurrence of any blackout. In this work, an aggregate of EVs is modelled as a big virtual battery in each area considering various aspects of uncertainty such as the number of connected EVs and their initial State of Charge (SOC) as stochastic variables. A control law was proposed and applied to the aggregate model using Lyapunov energy function to maximize the rate of reduction of total kinetic energy in a two-area network after the occurrence of a fault. The control methods are primarily based on the charging/ discharging control of available EVs as shunt capacity in the distribution system. Three different cases were studied considering the locational aspect of the model with the virtual EV either in the center of the two areas or in the corners. The simulation results showed that EVs could help the generator lose its kinetic energy in a short time after a contingency. Earlier estimation of possible contributions of EVs can help the supervisory control level to transmit a prompt control signal to the subsystems such as the aggregator agents and the grid. Thus, the percentage of EVs contribution for EFR will be characterized in the future as the goal of this study.

Keywords : emergency frequency regulation, electric vehicle, EV, aggregation, Lyapunov energy function
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