Coordinated control strategy for the short-term frequency response of a DFIG-ES system based on wind speed zone classification and fuzzy logic control

In a power system with a high penetration rate of wind power generation, the rotor speed of a doubly fed induction generator (DFIG) is decoupled from the system frequency; thus, DFIG has no short-term frequency response capability, and the system frequency stability is significantly affected compared to that in a power grid with more conventional synchronous generators. For this reason, a novel fuzzy theory-based coordinated control strategy is presented for improving the short-term frequency response capability of a DFIG-energy storage (ES) system. Firstly, to make the short-term frequency response capability of the DFIG-ES system adaptive for various wind speed conditions, based on the analysis of the DFIG operation characteristics under different wind speeds, four wind speed zones are classified, and accordingly different operation strategies are designed for each wind speed zone. Afterwards, two kinds of fuzzy logic controllers (FLCs) are designed and deployed in the DFIG-ES control system. Specifically, according to the fuzzy logic rules, frequency deviation and DFIG operation state are treated as input parameters, and correspondingly the power support from the combined system and the participation coefficient of the DFIG for short-term frequency support are determined. Moreover, the realization of the presented control strategy is detailedly described. Finally, case studies have been conducted to demonstrate the performance of the proposed control strategy via the comparison between different control strategies, and the simulation results illustrate that the coordinated control strategy can effectively improve the short-term frequency response capability of the DFIG-ES system under various wind speeds.