Hybrid Energy Storage Integrated Wind Energy Fed DC Microgrid Power Distribution Control and Performance Assessment

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Direct current microgrid has emerged as a new trend and a smart solution for seamlessly integrating renewable energy sources (RES) and energy storage systems (ESS) to foster a sustainable energy ecosystem. This article presents a novel power distribution control scheme (PDCS) designed for a small-scale wind-energy fed low-voltage direct current (LVDC) microgrid. The intermittent nature and stochastic volatility of wind energy as well as the unpredictable variations in load demand necessitate the integration of both high-power and high-energy density storage systems in a microgrid. In this context, an actively configured battery and supercapacitor (SC) based hybrid energy storage system (HESS) is linked to the 48 V LVDC bus. The central idea of hybridization is to mitigate the instantaneous surge current demand and alleviate the charge/discharge stress of the battery during transients enhancing the cycle life of the battery. This makes the integrated wind system more dependable and reliable. The proposed PDCS improves the power-sharing among battery and SC to resolve the demand-generation disparity and maintains state-of-charge () within operational boundaries in addition to faster regulation of DC bus voltage rated at 48 V. The developed autonomous LVDC system with the suggested PDCS is experimentally validated with different case studies. The comparative experimental result analysis substantiates the efficacy of the PDCS along with a seamless transition between various modes. Additionally, the novel scheme addresses the charge/discharge control of SC enabling faster SOC recovery.

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