Energies, vol.15, no.5, pp.1736-1-1736-21, .

Performance evaluation of a BESS unit for black start and seamless islanding operation

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Abstract-

The main purpose of this paper is to evaluate the overall performance of a battery energy storage system (BESS) during (I) grid-connected, (II) black start, and (III) islanded operating modes. To do so, firstly, a novel three-mode controller is proposed and developed. The proportional–integral–derivative (PID) controller is implemented, including the following three components: (1) inertia emulation, (2) frequency-active power and voltage-reactive power droops, and (3) secondary frequency and voltage controllers. Secondly, to effectively evaluate the proposed controller performance under various grid operating conditions during both black start and seamless transition to islanded operation, a set of comprehensive dynamic simulations using Matlab/Simulink is carried out. To this end, the sensitivity analyses on numerous grid operating parameters, such as pre-disturbance grid power, total installed BESS capacity, battery state of charge, unbalanced three-phase load flows, implemented power-frequency controller parameters, and distribution network types with various shares of dynamic and static loads, are performed. Thirdly, to practically improve the seamless transition performance enabling the demand response participation, a fast-controlled thermostatic load scheme is implemented. Simulation results show that the BESS unit using the proposed three-mode controller has great potential to successfully control the frequency and voltage within allowable limits during both islanding and black start modes over a wide range of grid operating conditions.

Index Terms- battery energy storage system; black start; islanding; power distribution; three-mode controller

Citation:

Izadkhast, S.; Cossent, R.; Frías, P.; García-González, P.; Rodriguez, A. "Performance evaluation of a BESS unit for black start and seamless islanding operation", Energies, vol.15, no.5, pp.1736-1-1736-21, .