Contribution ID: **9** Type: **Poster Presentation of 1h45m**

Conceptual Design and Evaluation of a HTS Magnet for a SMES Used in Improving Transient Performance of a Grid-Connected PV System

Monday, August 28, 2017 1:15 PM (1h 45m)

Superconducting magnetic energy storage (SMES) enables to offer many technical advantages, such as high energy efficiency, quick response and great controllability, and the SMES applications in distributed renewable energy sources are critical for power systems. This paper suggests a SMES to enhance the transient performance of a 100 kW grid-connected photovoltaic (PV) generation system, and conducts the conceptual design and performance evaluation. Considering the PV fluctuation and transient compensation during a fault, the stored energy of the SMES is designed as 80 kJ, and the Yttrium Barium Copper Oxide (YBCO) tapes made by the Superpower Company are adopted. The high-temperature superconducting (HTS) magnet uses the single-solenoid structure, and its detailed parameters including critical current, tape length, parallel/perpendicular magnetic field are optimized by the genetic algorithm. In order to achieve a comprehensive performance evaluation, not only the effects of the SMES on the PV generation system, but also the magnetic field, mechanical stress and operation loss of the SMES are assessed in the simulations. From the results, using the SMES can effectively improve the fault ride-through (FRT) capability and smooth the power fluctuation of the PV generation system. During the transient process of the power exchange, the maximum stress of the SMES magnet is within the tolerable allowance, and the mechanical strength of the YBCO tapes can be well ensured. Moreover, the operation loss of the SMES magnet is controlled to an acceptable level, and the joule heat caused by the charging and discharging of the SMES is limitable. The demonstrated design and evaluation will lay a good foundation for the prototype manufacture and experimental testing in the future.

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Session Classification: Mon-Af-Po1.06

Track Classification: E5 - Energy Storage - SMES