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Sat-Mo-Po.09-05: Efficient Power Conversion System for SMES-Powered Pulsed Loads

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Pulsed power applications, such as pulsed-field magnets, electromagnetic launchers, and fusion experiments, require high-performance, efficient, and compact energy storage systems. These applications demand large amounts of energy in short bursts, often at high rates, which traditional energy storage technologies cannot support effectively or are highly inefficient. Superconducting Magnetic Energy Storage (SMES) systems are particularly well-suited to pulsed power needs due to their exceptional characteristics, including high cycling efficiency (the ability to charge and discharge repeatedly without significant degradation), fast charge and discharge times, and high power and energy densities. These attributes make SMES systems ideal for powering pulsed loads, such as those used in pulsed-field magnets across various scientific and industrial setups.

To effectively transfer energy from an SMES system to the pulsed magnet load, a high-performance Power Conversion System (PCS) is essential. The PCS must manage the conversion and regulation of energy between the SMES storage and the load, ensuring that energy is delivered rapidly and efficiently. Recent innovations in materials, such as high-temperature superconducting (HTS) materials—particularly second-generation high-temperature superconducting (2GHTS) tapes and wires—and wide band Gap semiconductor devices, hold great promise for enhancing the efficiency and performance of SMES-based pulsed power systems. These advancements allow for higher power densities, faster switching speeds, and reduced energy losses, making them ideal for incorporation into the PCS.

This paper examines the use of an SMES system along with its associated PCS in pulsed power extraction. The system design includes key components such as the SMES, DC link capacitor, IGBT/IGCT-based converter system, and resistive pulsed magnet/load. A comprehensive analysis of different PCS configurations and their respective performance is discussed. The paper compares system efficiency, response time, and overall effectiveness of various designs studied. The insights and results support the continued development of high-performance, efficient SMES systems for pulsed power applications, showcasing their potential to advance future energy storage and delivery technologies.

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