Optimised design of a novel energy extraction system for superconducting magnets in future particle accelerators

Abstract

For future accelerators, an alternative approach is studied for energy extraction systems with energy recovery capability. A converter system which controls the voltage across the magnet chain during the energy extraction process and which transfers the energy to a storage unit is proposed. Due to a large number of degrees of freedom, an optimization procedure based on an electrical and a thermal model of the 3-level flying capacitor converter is developed aiming to maximize both system efficiency and power density.

3-level flying capacitor topology and operation

Design space and optimal point with IGBT

Design space and optimal point with SiC MOSFET

Comparison with simulation (IGBT)

Comparison with simulation (MOSFET)

Conclusion

A new active energy extraction system as part of the quench protection of a superconducting magnet chain is presented. The design space for developing such a system is broad and, therefore, an optimization procedure is employed. The design of the 3-level flying capacitor converter is optimized and evaluated for different switching frequencies, module numbers, semiconductor devices, and dimensions, windings and core materials. Finally, two optimal designs are identified and their operation is presented. The total losses and volume of the complete system will be estimated with the introduction of the model of the storage medium.