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C2Or1A-03: Considerations for System level Design Optimization for Power Systems with Multiple Superconducting Devices

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Superconducting power devices offer a high ampacity and power dense solution for power systems of terrestrial electrical power grid, electric aircrafts and electric ships. High Temperature Superconducting (HTS) technology allows to conveniently vary the power loadings by varying the operating temperatures. The deeply coupled electrical, thermal, and magnetic field relationships of superconducting devices offer additional design options, but also create new constraints for superconducting power devices, compared to conventional devices. Optimizing just one operating parameter of a superconducting power device such as current, voltage, magnetic field, temperature, or pressure might inadvertently ignore the system level opportunities and constraints. Besides, in aircrafts and ships with multiple superconducting devices with integrated power and cryogenic systems, it is particularly important to consider operating temperatures of individual devices in the system that make sense at system level. This is especially true when gaseous cryogens are use the cooling media as they allow for larger operating temperature and pressure ranges compared to liquid cryogens. The larger operating ranges also creates additional complexities in understanding and developing the permissible temperature or pressure gradients for the system.

This paper discusses how the operating parameters of superconducting devices such as current, voltage, temperature, and pressure can influence power ratings, cryogenic system efficiency, and capital and operating costs of the overall system. The use of thermal network models developed in our previous to establish the design and operating for achieving system level efficiency when multiple superconducting devices are cooled within a single cryogenic helium gas circulation loop.

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