SUPERconductive Synchronous Machine DRIVEs for High-Power Applications (SUPERDRIVE)

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The SUPERDRIVE project addressed challenges related to design, modeling, and control of MW rating-power electrical machine drives for applications such as naval electric propulsion, aircraft on-board electrical generation, and flywheel energy storage systems. These MW power machine drives require high-efficiency and high compactness to deal with limited space availability and smart utilization of the energy source. Further, fault tolerance is often required to increase reliability. Machine designs that avoid the use of rare-earth permanent magnets are desired and call for the use of direct current (DC) fed high-temperature superconductive (HTS) field winding.

Design specifications have been identified in terms of mechanical output power set at 4 MW and at a speed of 15,000 rpm. DC supply with 1500 V nominal voltage was considered based on to-date current and voltage ratings of power electronic components. The project specifically addressed fault conditions resulting in auxiliary circuits that are used in multi-level (M/L) converters to keep balanced the voltages of the input capacitors. A multi-phase (M/PH) machine drive arrangements was pursued to achieve the required fault tolerance. The proposed machine drive arrangement has dual three-phase stator winding fed through two twin three-phase M/L and M/PH power converters and machine rotor with HTS field winding fed by a M/L Dual-Active-Bridge converter.

Contributions of the SUPERDRIVE project are in the areas of machine electromagnetic design, power electronics and control including fault management. The project outcomes are a starting point for advancing design solutions in HTS excited electrical machines, adoption of wide bandgap technologies for power electronic components, improved PWM techniques for M/L and M/PH power converters, and brushless supply arrangements for machine rotor with HTS winding.

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