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Wed-Mo-Po3.12-12 [107] [Invited]: Superconducting Synchronous Motors for Electric Ship Propulsion

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Synchronous electric machines with superconducting field windings have been around for a long time but have not gone beyond prototypes and very limited demonstrations. However, magnetic resonance imaging (MRI) systems use superconducting magnets that are made in significant volumes each year and run with high reliability. Leveraging significant technology advances in cryogenic systems engineering and electric machine design, it is possible to design commercially-viable superconducting electric machines with volumetric and gravimetric power densities that far exceed other types of AC machines. In addition, superconducting machines, with proper design, can offer efficiency benefits that can increase their value in ship propulsion applications beyond just saving space and weight.
This paper provides a brief review of the technology advances that move superconducting machines toward commercialization and then delves into a notional design of a superconducting synchronous motor rated for 36.5MW of shaft power at 120rpm that would be compatible with a 5kV DC bus. The interaction of the motor with its power electronic drive is also discussed, showing how the design of the motor and the design of the converter are coupled. The motor is based on low temperature superconducting field coils and an armature core with reduced steel. The 7T magnetic fields produced by the field coils result in an air gap magnetic field greater than 2T. The reduced use of magnetic materials yields a 100x reduction in the radial forces of attraction between the armature and field compared to a conventional machine, easing structural issues substantially. Some comparisons are made to homopolar superconducting machines.

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