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M4Or1B-03: [Invited] Cryogenics power electronics for electrified aircraft propulsion

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Hybrid power generation and distributed propulsion power have been identified as candidate transformative aircraft configurations for future commercial transport vehicles with reduced fuel burn and harmful emissions. High power converters will be a key enabler for future electrified aircraft propulsion as envisioned by NASA and Boeing [1]. At the system level in aircraft applications, superconducting technologies such as motors/generators along with their supportive power systems will grow in importance. Integrating the associated power electronics into the superconductive motor/generator systems can avoid extra thermal insulation and temperature regulation system, and reduce system complexity and improve the power density.
Cryogenic power electronics offer several game-changing benefits, including 1) improved performance of power semiconductor devices, such as silicon metal oxide field effect transistors (Si- MOSFET) and gallium nitride high electron mobility transistors (GaN HEMT), offering significantly decreased specific on-state resistance and increased switching speed; 2) faster switching frequency operation at cryogenic temperature, greatly reducing the need for passive (e.g. EMI filtering); thereby reducing otherwise bulky filter weight and size; 3) less cooling requirement at extremely low ambient temperatures, and 4) light and/or efficient busbar/connector designs due to the low resistivity of conductors at cryogenic temperature.
This presentation will provide several key perspectives for the cryogenic power electronics design from the component up to the converter level, with emphasis on future electrified aircraft propulsion applications. First, the characteristics of critical components, including power semiconductors and magnetics, at cryogenic temperature are introduced. Second, special considerations, trade, and design studies of cryogenic power converters and filter are discussed. Then, three examples of cryogenically cooled power electronics, including a 40 kW Si-based inverter, a 1 MW SiC-based inverter, and a 1 MVA GaN-based solid-state circuit breaker, will be illustrated. The cooling design, safety considerations, and the protection scheme will be highlighted.

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