Development of a MW-Scale High-Voltage Multiphase Dual-Rotor Generator and Rectifier for a PMAD in an NEP System

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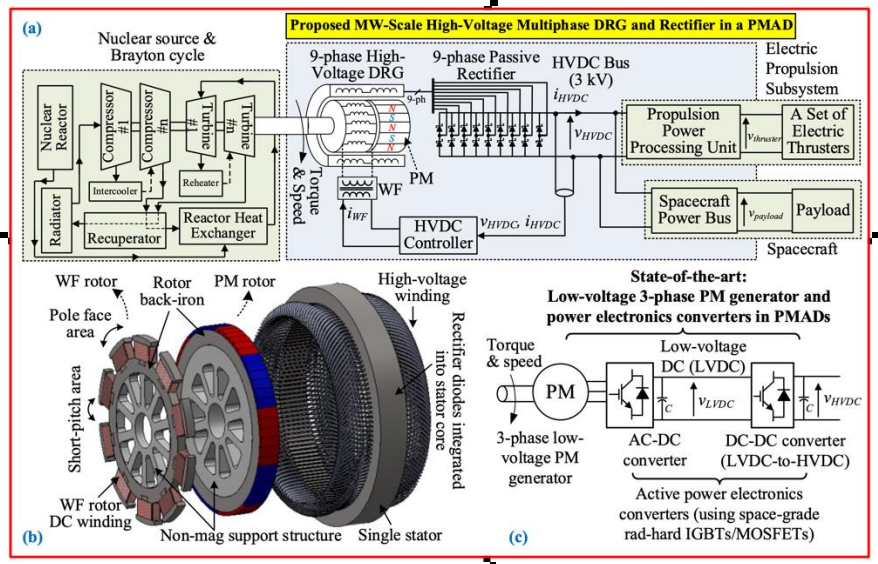
1. Research Objectives

- Innovation: This project proposes design and proof-of-concept validation via scalable prototyping of a MW-scale high-voltage multiphase (3-, 5-, 7-, and 9-phase) dual-rotor generator (DRG) (rated at 3 MW, 955 Nm, 30,000 RPM) and a passive rectifier interfaced to a high-voltage DC (HVDC) bus (rated at 3 kV) for a power management and distribution (PMAD) in a nuclear electric propulsion (NEP) system suitable for large spacecrafts, Fig. 1(a)-(b).
- Advancing state-of-the-art (SOA): Compared to SOA low-voltage PMADs, Fig. 1(c), this project introduces a high-voltage power electronics-less PMAD pushing the limits for: (i) HVDC bus (rated at 3 kV) (ii) Reliability, specific power and specific mass.
- The starting TRL is 2: Due to: (i) Unexamined concept of dual-rotor DRG combining two excitations, a permanent magnet (PM) and a wound field (WF). (ii) In-space high-voltage (3 kV) design



2. Approach

DRG design: (i) The PI will develop an optimized DRG accommodating different winding phases, and defining a split ratio between the PM and WF rotors based off an NEP for Mars opposition-class mission.

(ii) We will consider the design aspects for, and the design of, a DRG integrated with passive rectifier for operations at a high torque (955 Nm) and high speed (30,000 RPM) interfaced to HVDC bus (3 kV). Note, DRG's both rotors are mounted on the same shaft, rotate at the same speed, and share the same stator.

Scalable prototyping: We will build and test (i) a 10 kW DRG with the same PM-to-WF split ratio, magnetic performance, voltage, and speed as 3 MW design to ensure scalability, and (ii) a form-wound DRG high-voltage rectangular coil including insulation at 10 kV.

3. Potential Impact

Benefits to future space science and exploration: One of the major obstacles in high-power PMADs in MW-scale NEP systems is the availability and reliability of high-voltage space-grade rad-hard power electronics devices.

In the proposed PMAD active power electronics are replaced by a passive rectifier that uses diodes that are commercially available at high voltages. This improves PMAD reliability, power-density, specific mass, and facilitates higher voltage implementations. Thus, paving the way for muti-MW NEPs, and their commercialization for large spacecrafts such as for Mars missions.

Facilitating high-voltage DC bus: The legacy DC bus in spacecrafts is limited to 200 V. This project pushes this to 3 kV. This will have a meaningful impact in field as this has not been previously investigated.