Design of a Three-phase Rotating Magnetic Field Power Processing Unit for Inductive Plasmoid Propulsion*

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This work encompasses the design of a three-phase rotating magnetic field power processing unit (RMF PPU) and corresponding switched variable resonant capacitor banks (SVRCs) which drive the antenna currents during the operation of an RMF Thruster. RMF thrusters use an azimuthally rotating magnetic field to generate currents in the propellant plasma and produce thrust via a Lorentz force interaction between the plasma slug and a steady axial bias field. The majority of previous works on RMF propulsion have all employed antenna arrangements consisting of two Helmholtz pairs that form a two-phase RMF. However, the advantage of a three-phase RMF system is to negate the detrimental effects of spatial harmonics in the rotating field [1].

The proposed PPU configuration is a series-loaded resonant sine inverter, which generates kiloampere level currents while only exposing the driving switches to several hundred volts. The primary circuit schematic consists of three half-bridge IGBT units fed by a backing DC capacitor bank and three SVRCs connected in series to the RMF antennae. The resonant capacitor banks are varied to form an LC oscillator at the desired RMF frequency, which then resonates with the voltage square wave from each half-bridge unit. The SVRCs are designed to accommodate rapid changes of RMF frequency for future optimization studies, and they achieve coarse frequency adjustment in a package smaller than conventional vacuum variable capacitors by using high performance relays to switch in and out multiple parallel capacitor stages.

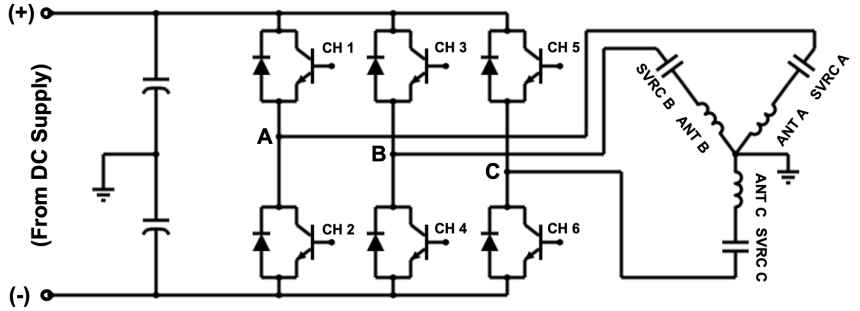

Figure 1 – Primary circuit schematic of the three-phase RMF PPU.

The expected performance of the three-phase RMF system is peak power of 16 kW per phase at a duty cycle of 10%, a frequency range of 0-300 kHz, and peak antenna currents of 4 kA. The RMF system presented in this work represents the second iteration of an RMF PPU, and the new configuration will allow for longer pulse times, higher RMF frequencies, and lower voltage exposure to the switching circuitry. Presently, the three-phase RMF PPU is under construction, and the switched variable resonant capacitor banks are in the engineering design phase, with initial performance testing taking place in early 2021.

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References

[1] W. N. Hugrass, Aust. J. Phys. **39(4),** 513-528 (1986).