Innovators at NASA’s Glenn Research Center have developed a suite of small spacecraft electric propulsion (SSEP) technologies critical to enabling new, ambitious missions into deep space. Advanced SSEP technologies are based on the use of exceptionally fuel-efficient electrostatic Hall effect thrusters with optimized magnetic shielding, achieving massive reductions in propellant mass relative to traditional chemical propulsion systems. NASA’s low-power, high-throughput SSEP technology dramatically increases the capabilities of small spacecraft while maximizing reliability and reducing launch costs.

The Power Processing Unit (PPU) is available for licensing on its own, or as a component of NASA’s SSEP technology suite, which is available to U.S. companies through a no-cost, non-exclusive license agreement and companion Space Act Agreement. Click the LEW-TOPS-162: Small Spacecraft Electric Propulsion (SSEP) Technologies link in the Additional Information section for details.

BENEFITS

- Provides electrical schematics and test data for key subsystems for a low-power small spacecraft PPU
- Minimizes electrical stress: a lightweight discharge power transformer with copper foil primary and Litz wire secondary windings that minimizes leakage inductance and AC losses and, consequently, electrical stress on power semiconductors
- Reduces input and output ripple: a phase-staggered clock synchronization circuit used by the discharge modules inherently reduces input and output electrical ripple, which accordingly reduces the size of the input and output filters
- Decreases part count: novel circuitry forces load sharing between parallel discharge modules without additional sensors, while the power supply generates high voltage with a reduced number of components
THE TECHNOLOGY

Key subsystems of a scalable PPU for low-power Hall effect electric propulsion have been developed and demonstrated at NASA GRC. The PPU conditions and supplies power to the thruster and propellant flow control (PFC) components. It operates from an input voltage of 24 to 34 VDC to be compatible with typical small spacecraft with 28 V unregulated power systems. The PPU provides fault protection to protect the PPU, thruster, PFC components, and spacecraft. It is scalable to accommodate various power and operational requirements of low-power Hall effect thrusters. An important subsystem of a PPU is the discharge supply, which processes up to 95% of the power in the PPU and must process high voltage to accelerate thrust generating plasma. Each discharge power module in this PPU design is capable of processing up to 500 W of power and output up to 400 VDC. A full-bridge topology operating at switching frequency 50 kHz is used with a lightweight foil transformer. Two or more modules can operate in parallel to scale up the discharge power as required. Output voltage and current regulation controls allow for any of the common thruster start-up modes (hard, soft or glow).

APPLICATIONS

The technology has several potential applications:

- **Aerospace**: a scalable PPU for small spacecraft using Hall effect thrusters
- **Commercial space**: small satellite constellations, station keeping, orbit raising, spacecraft servicing, missions beyond Low Earth Orbit/Geosynchronous Equatorial Orbit

PUBLICATIONS

Patent Pending

LEW-TOPS-162: Small Spacecraft Electric Propulsion (SSEP) Technology Suite

Development of a High-Propellant Throughout Small Spacecraft Electric Propulsion System to Enable Lower Cost NASA Science Missions, Benavides, Gabriel F., et al, August 19, 2019

https://ntrs.nasa.gov/citations/20190030739