Deep Space Avionics

PROPULSION REMOTE TERMINAL UNIT (PRTU)

Fault-Tolerant, Lightweight SmallSat Thruster Driver Unit for LEO and Deep Space Applications

Figure 1: PRTU high-thruster count render

The Propulsion Remote Terminal Unit (PRTU) is a complete interface bridge between a low-level onboard computer/controller and a wide set of HPGP- or Hydrazine-type thrusters.

The PRTU handles electrical actuators, sensors and thruster ConOps, offloading most of the thruster operation complexity from the user. Users control the unit through a single power and communication interface using high-level commands.

The unit is modular such that driven thruster count and type can be increased by duplicating generic modules by plug&play. This way, the PRTU remains the best solution for a wide variety of thruster configurations, mission profiles and spacecrafts.

The needs for high reliability, low mass and long lifetime of deep space missions are met by the PRTU; designed to operate for a TID up to 30 kRad under a proton-heavy environment. It is built to be single-failure-tolerant leading to increased resilience against single events and other type of failures.

All of this makes the PRTU the ideal candidate for deep space, high delta-v but also weight-, size- and reliability- sensitive LEO missions.

MAIN FEATURES

- Single interface towards valve drivers, reactor and valve heaters, reactor thermocouples valve thermistors as well as upstream latch valve and pressure transducer.
- Configurable closed-loop reactor temperature control and automatic thrust sequencing.
- Modular design for optimal, mission-specific performance.
- Best-in-class thruster count to weight ratio optimized for high delta-v missions.
- High reliability and single failure tolerant architecture.
- Extensive internal and external housekeeping (bus, valve, heater, aux voltages, currents, temperatures).

BUDGETS

- Mass: < 0.5 kg (baseline config.).
- Volume (w x h x d): 20 x 120 x 135 mm (baseline config.).
- Power: < 1 W quiescent (baseline config.)

INTERFACES

- Power input: 22 V to 34 V unregulated.
- TM/TC: single or redundant CAN or RS485/422.
- Thruster: single electrical interface per thruster for ease of wiring.
- Thruster types: compatibility is ensured with **1N, 5N and 22N ECAPS HPGP** thruster products.

ENVIRONMENT

- Operational temperature range: -30 °C to +60 °C.
- Non-operational temperature range: -40 °C to +70 °C.
- Radiation: qualified up to 30 kRad total ionizing dose and for high energy protons.
- Lifetime: > 5 years.

READINESS

- Technology readiness: TRL 6 with expected TRL 7 by Q1 2023.

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Performance and Specifications (per module)

- **Flow control valves (FCV):** 4 redundant pairs.
  - Resistance: 60 Ohm$_{min}$
  - Pull and hold voltage: 28 V unreg. and 10 V regulated
- **Thermocouple circuits (Tc):** 4 redundant pairs.
  - Recommended type: K-type
- **Reactor heaters (HTR):** 4 redundant pairs.
  - Power: 25 W$_{max}$ each
  - Voltage: 28 V unregulated
- **Valve heater (htr):** 4 iterations.
  - Power: 5 W$_{max}$ each
  - Voltage: 28 V unregulated
- **Valve thermistor (Th):** 4 iterations.
  - Recommended type: 1k @ 25degC PTC
- **Latch valve (LV):** single iteration.
  - Type: mono- or bipolar with readback
  - Voltage: 28V unregulated
- **Pressure transducer (Pt):** single per module.
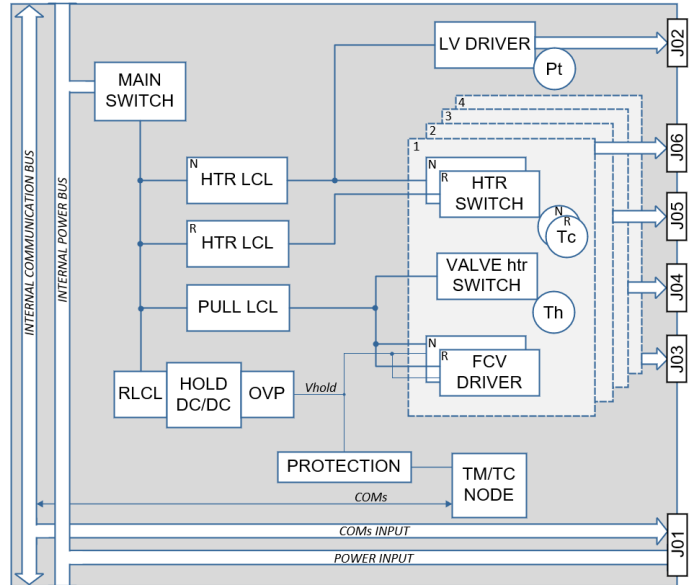 - Recommended type: current-excited resistive bridge

Figure 2: PRTU simplified block diagram

Scalability and example thruster configurations

|	RCS	Delta-v + RCS	High-reliability RCS
Thruster configuration	4x 1N ECAPS HPGP	4x 1N + 2x 5N ECAPS HPGP	12x 1N ECAPS HPGP
PRTU configuration	**Baseline**	**Baseline + 1 extension**	**Baseline + 2 extension**
Latch valves (LV)	1	1/2 used	2/3 used
Pressure transducers (Pt)	1	1/2 used	2/3 used
Flow Control Valves (FCV)	4 (series redundant)	6/8 used (series redundant)	12 (series redundant)
Reactor heaters (HTR)	4 (parallel redundant)	6/8 used (parallel redundant)	12 (parallel redundant)
Thermocouples (Tc)	4 (parallel redundant)	6/8 used (parallel redundant)	12 (parallel redundant)
Valve heaters (htr)	4	6/8 used	12
Valve thermistors (Th)	4	6/8 used	12
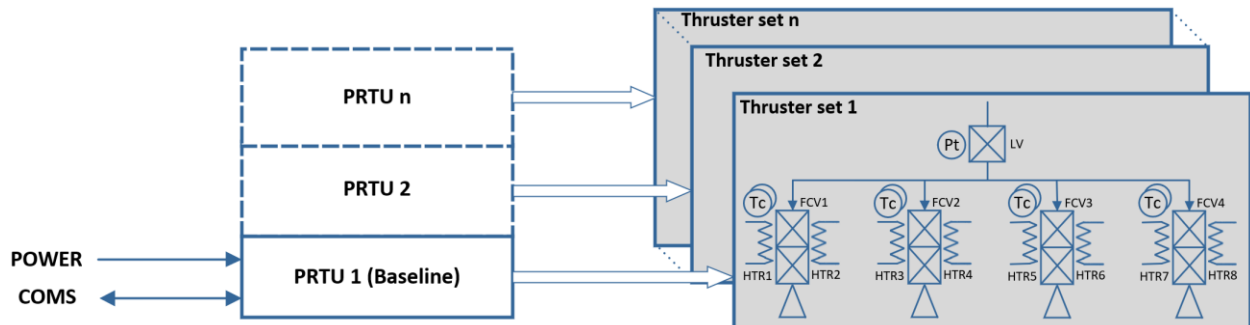
Figure 3: PRTU typical high-thruster-count configuration