



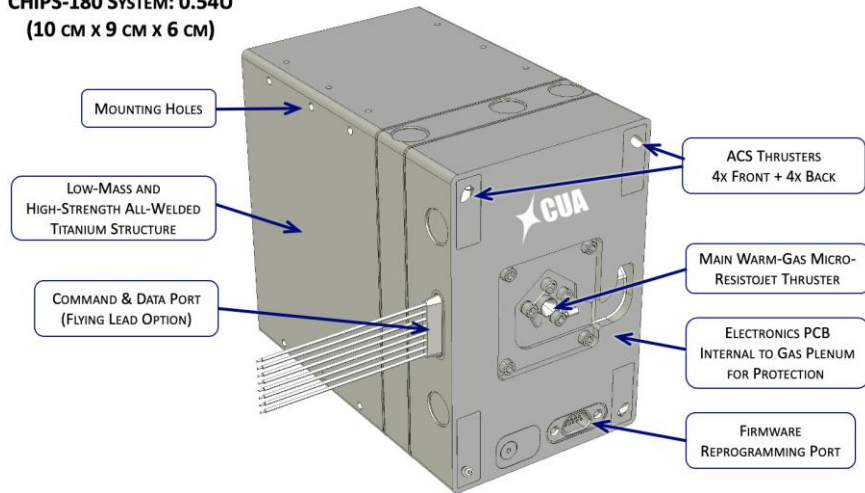
Cubesat High Impulse Propulsion System (CHIPS)

System Overview

August 2022

The CU Aerospace (CUA) Cubesat High Impulse Propulsion System (CHIPS) offers a miniaturized and well-integrated small-satellite propulsion solution, including both a main thruster and three-axis attitude control system (ACS). CHIPS achieves a high total-impulse-to-volume ratio by leveraging CUA's high-efficiency resistojet (superheater) technology with proven valving cycled to >120 million actuations and self-pressurizing, non-toxic, and inert propellants. Waste heat from the electronics and resistojet is efficiently and regeneratively recovered to evaporate propellant, resulting in low system temperature rise (~1°C) over 10-minute operating cycles.

**CHIPS-180 SYSTEM: 0.54U
(10 CM x 9 CM x 6 CM)**



The illustrated CHIPS-180 is an ultra-compact 0.54U fully-throttleable system (10 cm x 9 cm x 6 cm package size) having 180 N-s of total impulse with self-pressurizing R236fa propellant. System set-points, system status, and firing telemetry are all accessible and configurable through a customizable interface port. CHIPS technology can be customized in size to meet customer-specific mission requirements. CHIPS can also be packaged as a cold-gas-only system requiring reduced power, but with a total impulse penalty of approximately 25-30%. The CHIPS package can incorporate up to 8 ACS thrusters for 6 degree-of-freedom (6DOF) operation.

Performance Specifications

Parameter	CHIPS-180	CHIPS-500	CHIPS-1000	Units
Thruster System Package Volume	540 (6 x 9 x 10)	1,300 (13 x 10 x 10)	2,500 (12.5 x 20 x 10)	cm ³
Propellant Mass	329	920	1810	g
System Wet Mass	1,079	1,985	3,425	g
Power Draw (when thrusting)	20	25	25	W
Mass Flow Rate	30	45	45	mg/s
Thrust	16 [11]	25 [18]	25 [18]	mN
Specific Impulse	56 [36]	58 [40]	58 [40]	s
Total Impulse	176 [112]	505 [350]	1,000 [700]	N-s
Volumetric Impulse	326 [207]	387 [270]	400 [280]	N-s/liter
Maximum Continuous Thrust Time	10	10	10	min
Minimum Impulse Bit	< 0.1	< 0.1	< 0.1	mN-s

Note: values in square brackets [xx] represent performance when run in cold gas mode.

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System Features

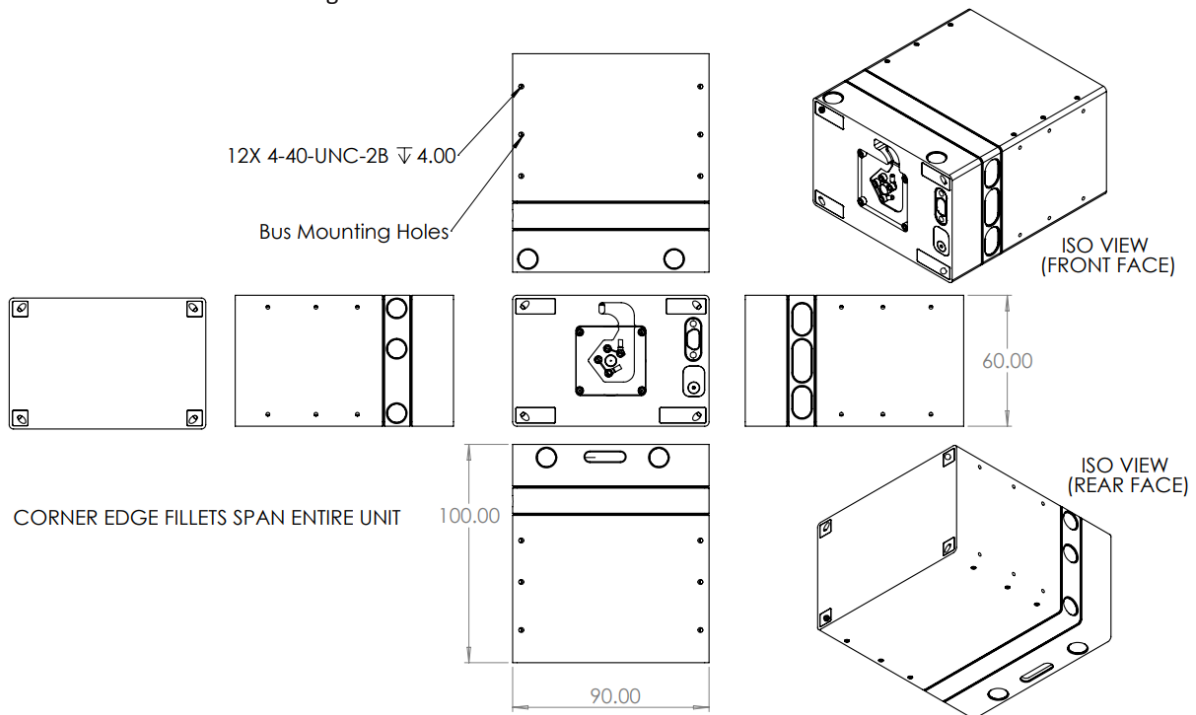
Operation:

- Two operational modes:
 - Warm gas mode for higher specific impulse, large total impulse maneuvers.
 - Cold gas mode for minimum or small total impulse maneuvers.
- Overall control authority: roll, pitch, yaw, $\pm X/Y/Z$
 - 6 Degree of Freedom (6DOF) achievable with 8 ACS thrusters
- Highly configurable controller for on-orbit update of system parameters, including:
 - Thrust duration
 - Plenum pressure (thrust)
 - Superheater power level (specific impulse)
 - Temperature set-points
 - Fault set-points
- Telemetry and system status packets for health monitoring
- Dedicated propellant heaters for continuous operation below 0°C ambient temperature
- Propellant temperature sensor for closed-loop propellant temperature regulation
- Propellant vaporizer ensuring 100% vapor delivered from liquid storage
- Pressure sensor for closed-loop propellant mass flow control and thrust throttling

- Voltage and current sensors for closed-loop power regulation, monitoring, troubleshooting, and over-current protection.
- Life span: 3+ years from propellant load.

Mechanical:

- Low mass, high strength all-welded Ti-6Al-4V (Grade 5) propellant tank
- Reliable valve technology:
 - Valves tested to >120,000,000+ cold gas firings retaining low leak rate $\leq 1 \times 10^{-4}$ scc/sec for GHe
 - System is two-fault-tolerant against leakage
- Volume optimized:
 - All mechanical and electrical subsystems highly integrated into tank structure
 - Miniaturized system only 0.54U
 - Custom tank sizes available
 - Self-contained electronics control board enclosed in gas plenum
- High-density, self-pressurizing R236fa baseline (R134a alternate) propellant
 - Green, non-toxic, non-flammable and inert
 - Chemically stable, high critical temperature, low freezing point, and low vapor pressure



PRELIMINARY DESIGN FOR 0.54U CHIPS WITH 1 PRIMARY & 8 ACS THRUSTERS

Dimensions are for illustrative purposes only. CHIPS is highly adaptable to a wide range of customer-specific geometries. Inquire to see how CUA can adapt CHIPS to meet your mission requirements.

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