



Product Overview

July 2020

The CU Aerospace / VACCO Propulsion Unit for CubeSats (PUC) is a complete high-performance and compact small-satellite propulsion solution. The all-welded titanium PUC comes fully integrated with all necessary propulsion subsystems, including controller, power processing unit, micro-cavity discharge thruster, propellant valves, heaters, sensors, and software. PUC is software-configurable to operate over a wide range of power, thrust, and impulse levels. System set-points, system status, and firing telemetry are all accessible and configurable through an RS422 serial interface.

The baseline 0.25U system fits within a compact 350 cm³ volume (0.25U + “hockey puck”), providing outstanding performance for minimal CubeSat volume and mass fraction. The PUC’s 89 mm x 89 mm cross-section intentionally falls well under the CubeSat 100 mm x 100 mm specification, so as to not interfere with other CubeSat subsystems such as solar panels and magnetic torquers. For increased performance, or to meet customer specific mission requirements, the tank width may be customized. The tank may additionally be expanded from 0.25U to any desired length, providing significant potential for increased propellant capacity, i.e. delta-V capability, compared with the baseline 0.25U design.

The PUC achieves its high total impulse, low-volume capability by employing CU Aerospace Micro-Cavity Discharge (MCD) propellant heating technology, high-density and self-pressurizing liquid propellants, and an optimized low-mass-flow nozzle. PUC MCD thrusters demonstrate negligible component wear during 0.25U life cycle testing, providing constant lifetime operations. The robust MCD components permit extensive warm firing beyond the 0.25U operational life, allowing for pre-flight testing and/or increases to the PUC’s propellant tankage without impacting MCD performance or reliability.



Performance Specifications (0.25U System)

Parameter	Warm Fire Only	Cold Fire Only	Unit	Notes
Thrust	4.5	5.5	mN	Nominal
Total impulse	184	124	N-s	
Delta-V capability (4 kg CubeSat)	48	32	m/s	
Delta-V capability (3 kg CubeSat)	64	43	m/s	
Specific impulse	70	47	sec	Nominal
Maximum continuous thrust time	20	54	min	
Minimum impulse bit	---	1.0	mN-s	

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System Features

Operation:

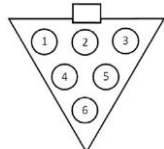
- Two operational modes:
 - Warm gas mode for high specific impulse, large total impulse maneuvers.
 - Cold gas mode for minimum or small total impulse maneuvers.
- Highly configurable controller for on-orbit update of system parameters, including:
 - Thrust duration
 - Plenum pressure (thrust)
 - MCD power level (specific impulse)
 - Temperature set-points
 - Fault set-points
- System status packets for health monitoring
- Regular telemetry packets during operation
- Dedicated propellant heater for continuous operation below +5°C ambient temperature.
- Propellant temperature sensor for closed-loop propellant temperature regulation.
- Propellant vaporizer ensuring 100% vapor delivered from liquid storage.

- Pressure sensor (0.01 to 1.2 atm) for closed-loop propellant mass flow control and thrust throttling.
- Voltage and current sensors for closed-loop MCD power regulation, monitoring, troubleshooting, and over-current protection.
- Life span: 2 years from propellant load.

Mechanical:

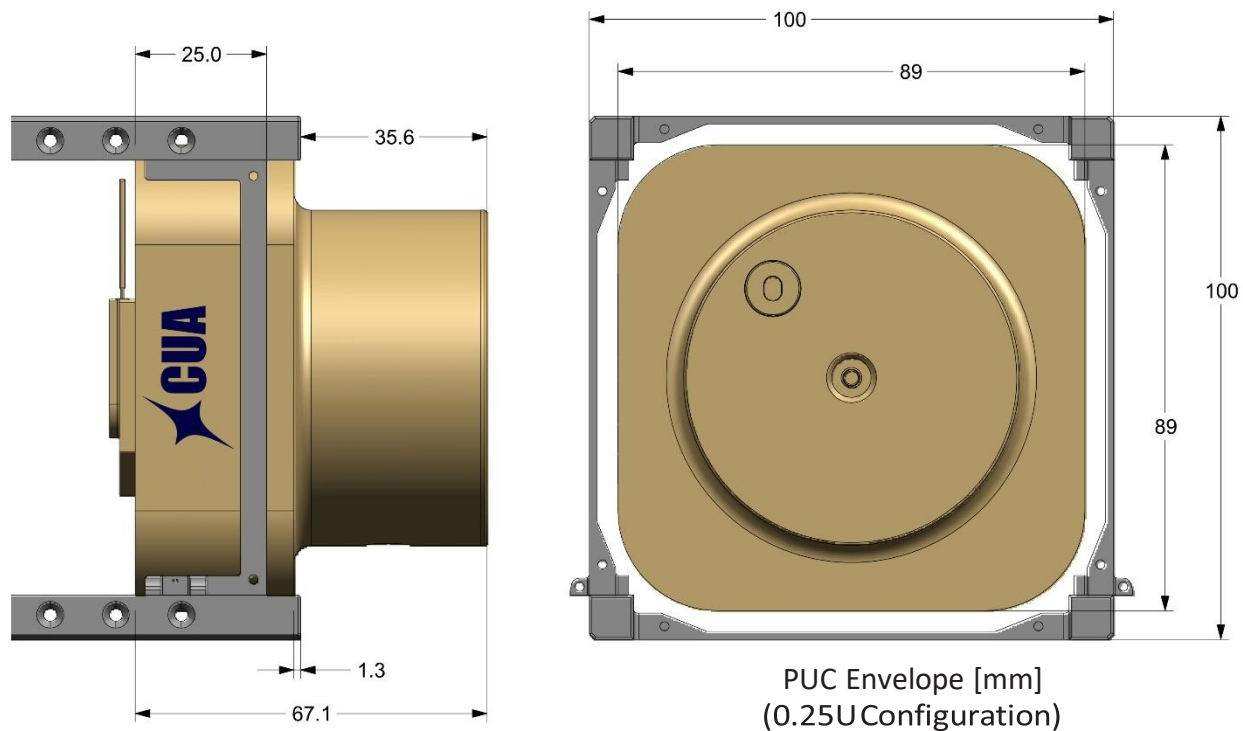
- Low mass, high strength all-welded Ti-6Al-4V propellant tank.
- Reliable, frictionless VACCO valve technology:
 - Valves tested to 75,000+ cold gas firings.
 - System one-failure-tolerant against leakage.
- Volume optimized:
 - All mechanical and electrical subsystems highly integrated into tank structure.
 - Baseline unit only 0.25U.
 - Custom tank sizes available.
- Propellant fill port and firmware update header located in “hockey puck” for ease of accessibility following integration into CubeSat structure.
- Mounting: 4x 2-56 UNC-2B threaded holes

Electrical Specifications

Parameter	Minimum	Nominal	Maximum	Unit	Notes	
Operating voltage	9	11.1	12.6	V	Unregulated	
Max transient voltage			14	V		
Max in-rush current			14.5	A	> 7 amps for less than 50 μs	
DC isolation resistance	0.99	1	1.01	MΩ		
Power						
Warm Fire	12	15	18	W	User programmable	
Cold Fire	5.9	8	9.8	W	Input voltage dependent	
Standby		0.01	0.05	W		
Communication standard	RS422 (115.2 kbps)					
Electrical Wiring (Flying Leads)						
26 AWG PTFE (24" min.)	Blue	Green	Orange	Yellow	Red (x2)	Black (x2)
Purpose	RS422_Y	RS422_Z	RS422_A	RS422_B	9-12.6 V	GND
Firmware Update Header						
Pin #	1	2	3			
Purpose	3.3V	TDO	TDI			
Pin #	4	5	6			
Purpose	TMS	TCK	GND			

Mechanical Specifications (0.25U System)

Parameter	Minimum	Nominal	Maximum	Unit	Notes
Dimensions	89 mm x 89 mm x 67 mm (0.25U + “hockey puck”)				
Wet mass		718		g	nominal
Dry mass		450		g	nominal
Temperature ranges					
Operating	-13		+50	°C	
Storage w/o propellant	+5		+50	°C	recommended preflight storage
Storage w/ propellant	+5		+30	°C	recommended preflight storage
Survivability	-34		+71	°C	flight
Pressure ranges (propellant tank)					
Operating pressure	20	48	122	psia	
Proof pressure	317			psia	
Burst pressure	528			psia	
Vibe acceptance level	14			G _{RMS}	
Leak rates					
Isolation valve (NC)		5	19	g/yr	1 g/yr = 0.04 scch
Proportional valve (NC)		5	19	g/yr	1 g/yr = 0.04 scch
Mass flow regulation (throttle capability)					
Cold fire	20	100	200	%	of nominal
Warm fire	80	100	120	%	of nominal

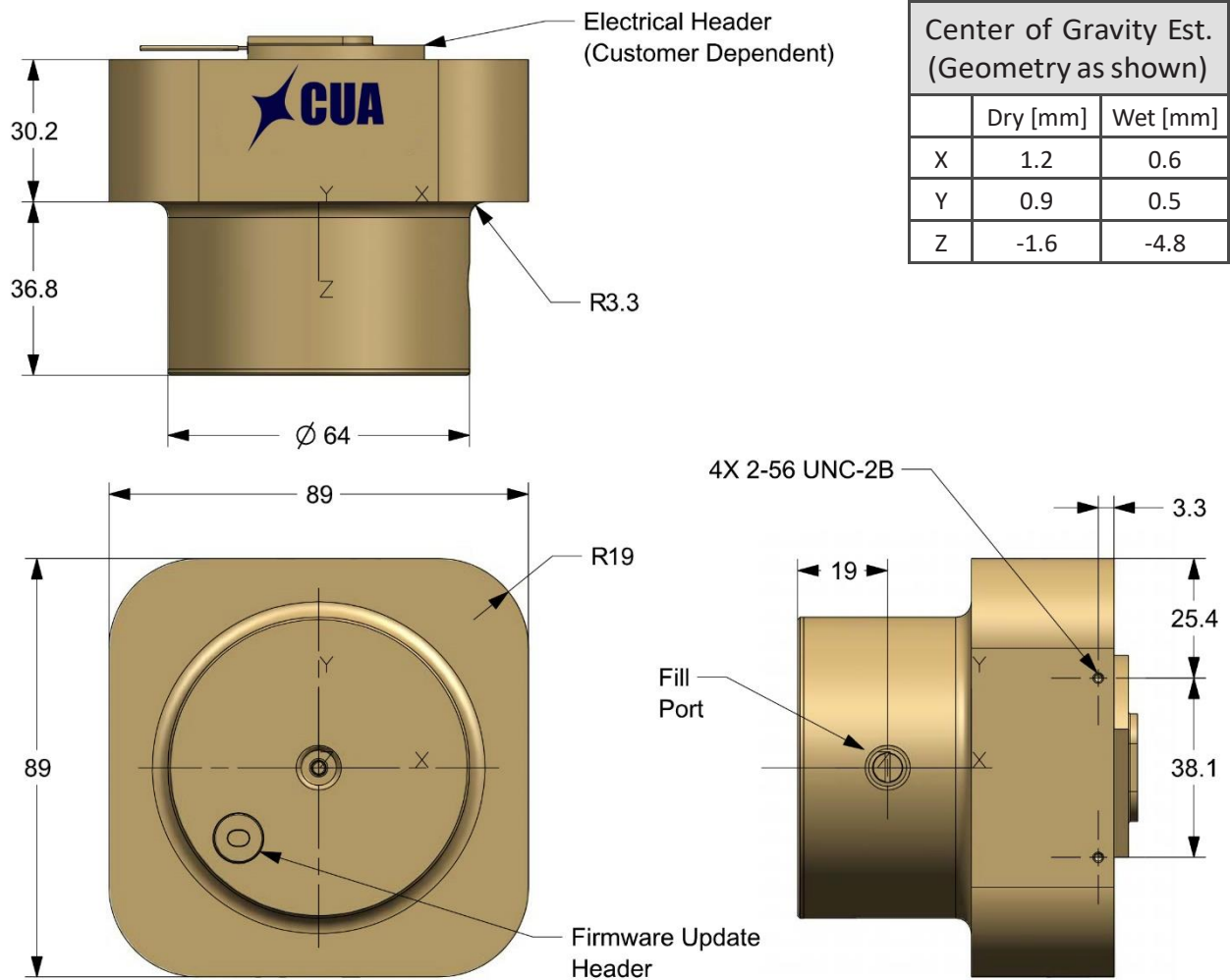


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Propellant Specifications

Parameter	Value	Unit	Notes
Propellant	SO ₂		High Purity Liquid Sulfur Dioxide
Propellant mass (0.25U System)	268	g	Nominal
Critical temperature	156.9	°C	
Freezing point	-75.6	°C	
Vapor pressure	48	psia	At 20°C

Sulfur dioxide (SO₂) characteristics:

- High mass density
- Self-pressurizing
- Non-flammable
- Chemically stable
- High critical temperature
- Low freezing point
- Low vapor pressure
- Commonly used refrigerant prior to the development of freons

PUC is engineered and manufactured through a partnership between CU Aerospace and VACCO Industries.

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