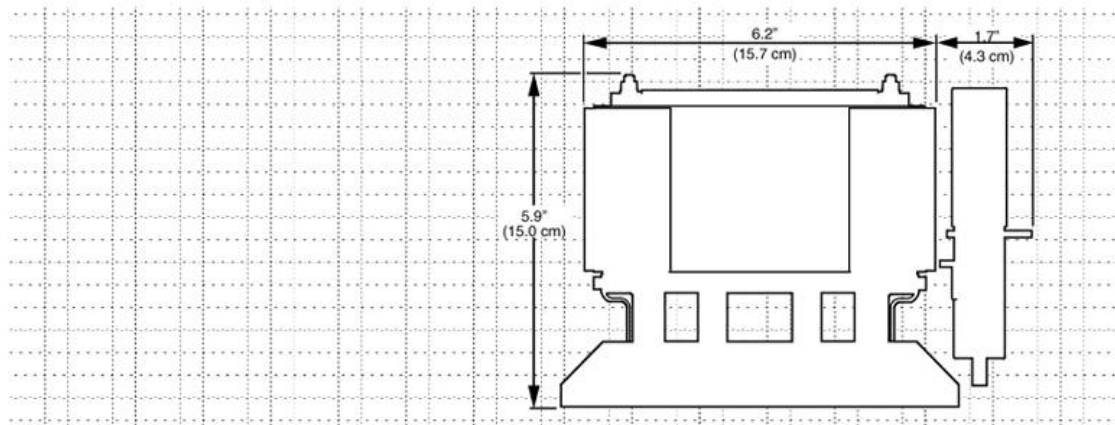
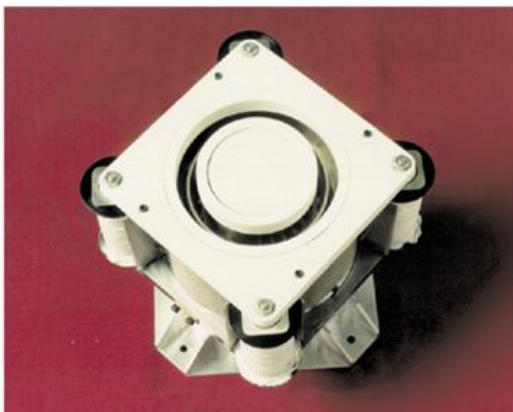


BPT-2000 Hall Effect Thruster



Design Characteristics

- Propellant Xenon
- Mass (Thruster & Cathode) <5.2 kg
- Envelope Dimensions 15 x 17 x 22 cm
- Nominal Input Power 2200 Watt
- Operational Power Range 1200 – 2700 Watt
- Nominal Voltage 350 Volt
- Operational Voltage Range 250 – 400 Volt

Status

- Flight Prototype Unit Fabricated and Tested

Performance at 2.2 kW

- Thrust 123 mN
- Specific Impulse* 1765 sec
- Efficiency* 48%
- Life (Continuous)** >6000 hr
- Total Impulse >2.6 x 10⁶ N-sec
- Nominal Flowrate 7.1 mg/sec
- On/Off Cycles 6000 cycles

* Corrected for facility pressure effects

** Based on accel life tests and analysis

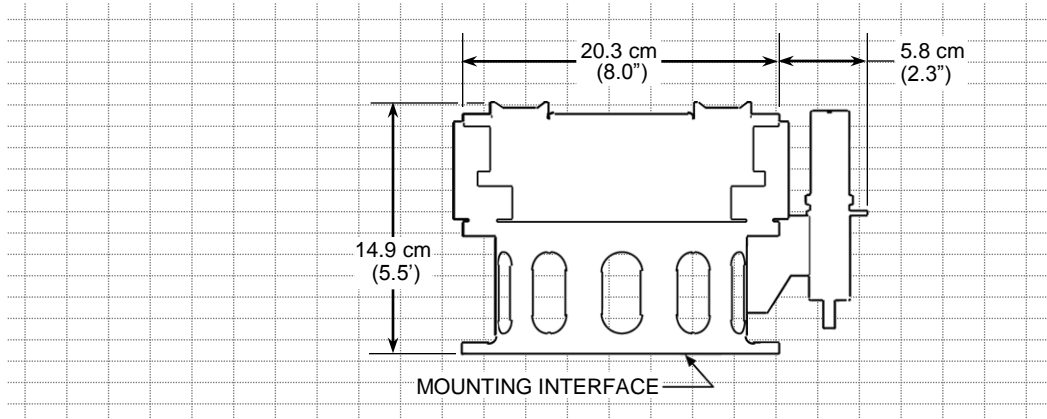
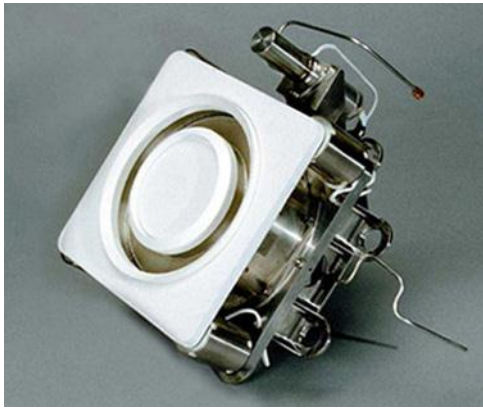
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DUAL MODE BPT-4000 HALL THRUSTER



Design Characteristics

- Propellant Xenon
- Mass (Thruster & Cathode) <12.3 kg
- Envelope 14 x 25 x 28 cm
- Input Power 1000 to 4500 Watt
- Input Voltage 200 or 400 Volt

Status (as of Feb. 2006)

- Qualification Complete
- >6,700 hours Demonstrated, Additional Life Testing Planned
- >6,300 Cycles Demonstrated, Additional Life Testing Planned

Performance

	2.0 kW	3.0 kW	4.5 kW
■ Thrust (300 Volts).	132 mN	195 mN	290 mN
■ Thrust(400 Volts)	117 mN	170 mN	254 mN
■ Specific Impulse (300 V)	1676 sec	1700 sec	1790 sec
■ Specific Impulse (400 V)	1858 sec	1920 sec	2020 sec
■ Life Capability	>10,000 hr		
■ Total Impulse	>5.5 x 10 ⁶ N-sec		
■ On/Off Cycles	6,700 Cycles		

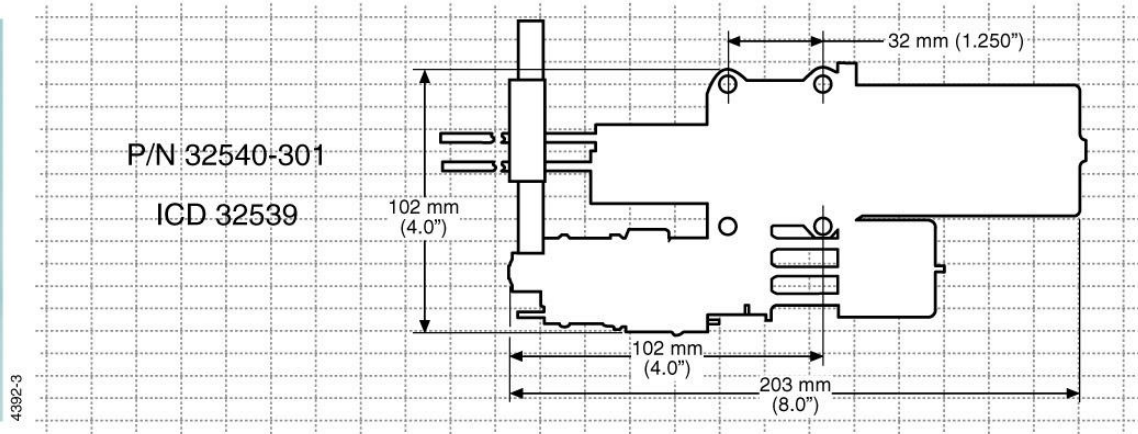
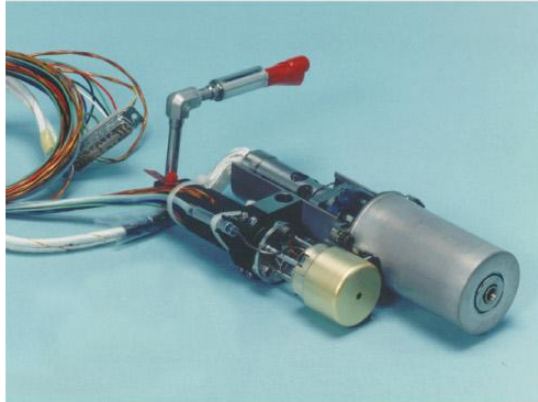
Reference

- AIAA-2005-3682

Date: 6/19/06

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MR-501B ELECTROTHERMAL HYDRAZINE THRUSTER (EHT)



Design Characteristics

- PropellantHydrazine
- Catalyst S405
- Thrust/Steady State 0.369–0.182 N (0.083–0.041 lbf)
- Feed Pressure 24.1 – 6.9 bar (350 – 100 psia)
- Flow Rate
 0.1225–0.045 g/sec (0.00027–0.0001 lbm/sec)
- ValveDual Seat
- Valve Power 8.25 Watts Max @ 28 Vdc & 21°C
- Valve Heater Power 8.00 Watts Max @ 28 Vdc & 21°C
- Cat. Bed Heater Pwr4.00 Watts Max @ 28 Vdc & 21°C
- Augmentation Heater Pwr 493 – 467 Watts
- Augmentation Heater Voltage 24.4 Vdc
- Mass 0.889 kg (1.96 lbm)

Performance

- Mission Specific Impulse at 24.4 Vdc*
 303–294 sec (lbf-sec/lbm)
- Total Impulse 326,928 N-sec (73,500 lbf-sec)
- Demonstrated Total Off-Pulses** 500,000
- Minimum Off-Pulse Bit at Max Feed Pressure
 0.0022 N-sec (0.0005 lbf-sec)
- Steady State Firing 1.7 hrs – Single Firing
 389 hrs – Cumulative

Status

- Flight Proven

Reference

- AIAA-1983-1255

* Performance dependent on feed pressure blowdown

** Designed primarily for steady state operation but has demonstrated off-pulse capability

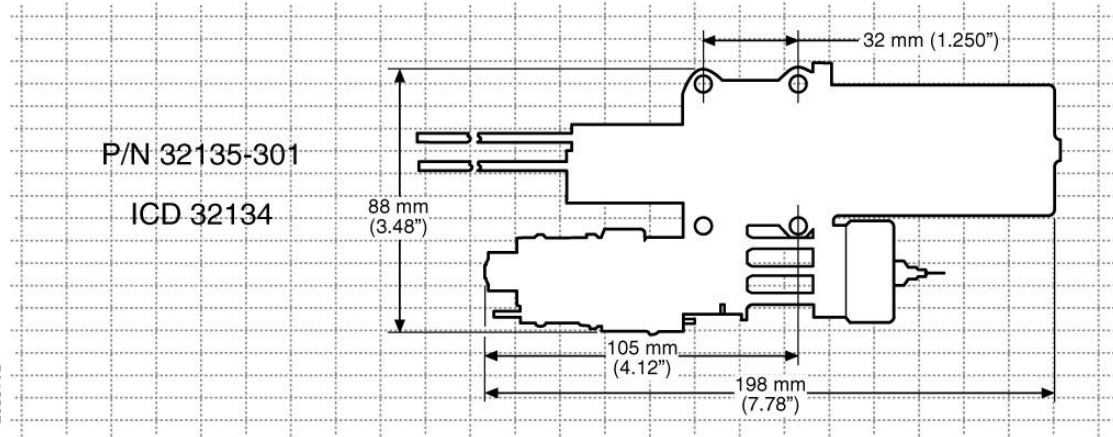
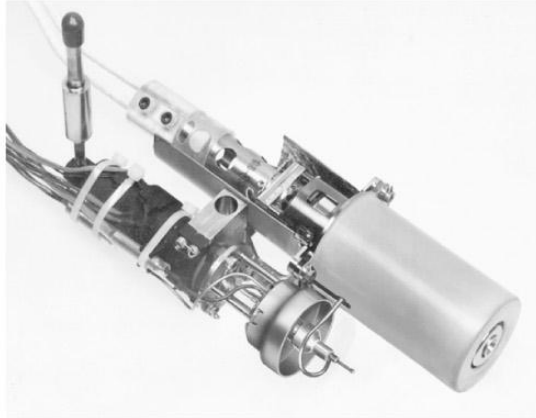
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MR-502A IMPROVED ELECTROTHERMAL HYDRAZINE THRUSTER (IMPEHT)



Design Characteristics

- Propellant Hydrazine
- Catalyst S405
- Thrust/Steady State 0.80 – 0.36 N (0.18 – 0.08 lbf)
- Feed Pressure 26.5 – 6.2 bar (385 – 90 psia)
- Flow Rate 0.28 – 0.12 g/sec (0.0061 – 0.00026 lbm/sec)
- Valve Dual Seat
- Valve Power 8.25 Watts Max @ 28 Vdc & 21°C
- Valve Heater Power 1.54 Watts Max @ 28 Vdc & 21°C
- Cat. Bed Heater Pwr 3.93 Watts Max @ 28 Vdc & 21°C
- Augmentation Heater Pwr 885 – 610 Watts
- Augmentation Htr Voltage 29.5 – 24.5 Vdc Letdown
- Mass 0.87 kg (1.92 lbm)

Performance

- Mission Specific Impulse*
 - Steady-State Blowdown 303 – 294 sec (lbf-sec/lbm)
- Total Impulse 524,864 N-sec (118,000 lbf-sec)
- Total Pulses MR-502A not designed for pulsing
- Steady State Firing 2.0 hrs – Single Firing
 - 370 hrs – Cumulative

Status

- Flight Proven

Reference

- AIAA-1987-0996

*Performance dependent on feed pressure blowdown

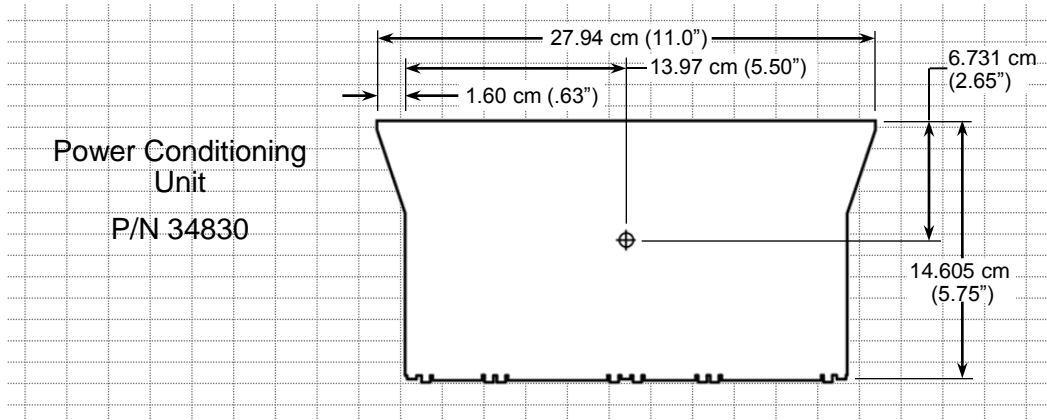
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MR-502 & MR-502A IMPEHT POWER CONDITIONING UNIT



Design Characteristics

- Mass 2 kg
- Envelope 27.94 x 9.42 x 14.61 cm
- Input Voltage 15-29.9 vdc
- Inrush Current 32 Amp Max
- Efficiency >97%

Interface

- Enable/Disable Command Latch Relay Drive
- On/Off Command 0V – Off, 14V – On

Demonstrated Performance

- Limits inrush current to the 30 Amps during augmentation heater warm-up
- Two identical independent channels that can be operated either redundantly or simultaneously
- When used simultaneously, the IMPEHT pair should be started one after the other

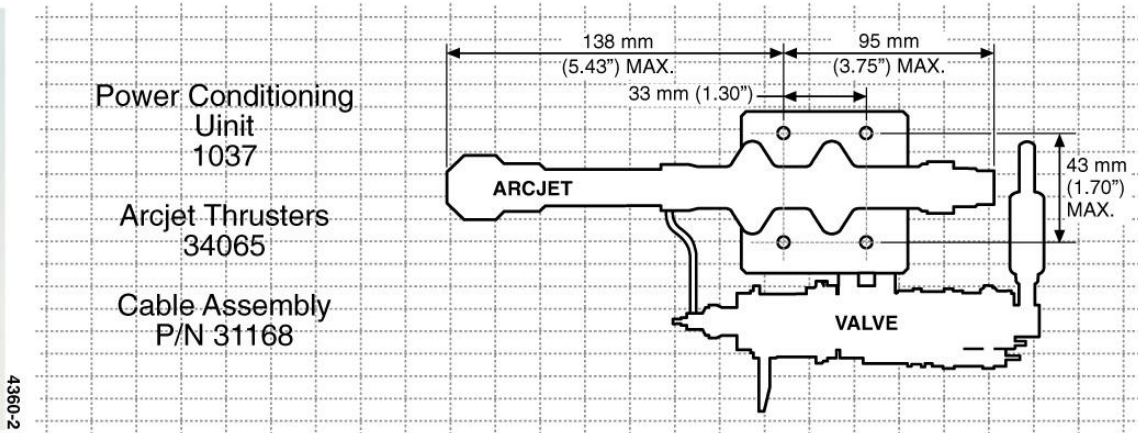
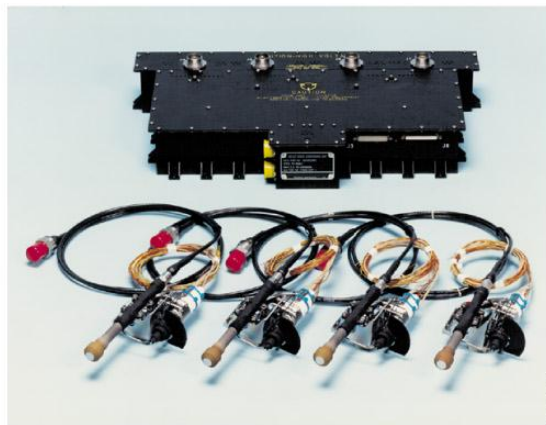
Status

- Flight Proven

Date: 2/22/05

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MR-510 ARCJET THRUSTER & CABLE ASSEMBLY



Design Characteristics

- Propellant Hydrazine
- Feed Pressure (Nominal) 18.6–13.8 bar (270–200 psia)
- Thrust/Steady State 258–222 mN (58-50 mlbf)
- Mass
 - Arcjet Thruster
 - +3175 mm/125" cable 1.58 kg (3.49 lbf)
- Envelopes
 - Arcjet 237 x 125 x 91 mm (9.3 x 4.9 x 3.6 in.)
- Valve Dual Seat
- Valve Power 8.2 Watts Max @ 28 Vdc & 21°C
- Power Cable - PCU Arcjet <4650 mm/183"

Demonstrated Performance

at 2000 Watts input power to the arcjet

- Thrust 258 – 222 mN (58 – 50 mlbf)
- Specific Impulse >585 – 615 sec
- Total Impulse 1,450,000 N-sec. (326,000 lbf-sec)
- Firing Time
 - Total (1 hr On, 1/2 hr Off) >1730 Cycles
 - Longest Single Burn During Qualifications 20 hrs
- Starts >1960
- Telemetry Signals Available
 - Gas Generator Temperature
 - Valve Temperature
 - Arc Voltage and Current through Power Conditioning Unit Telemetry

Status

- Flight Proven

Reference

- AIAA-2001-3901
- AIAA-1999-2272
- IEPC-1997-082

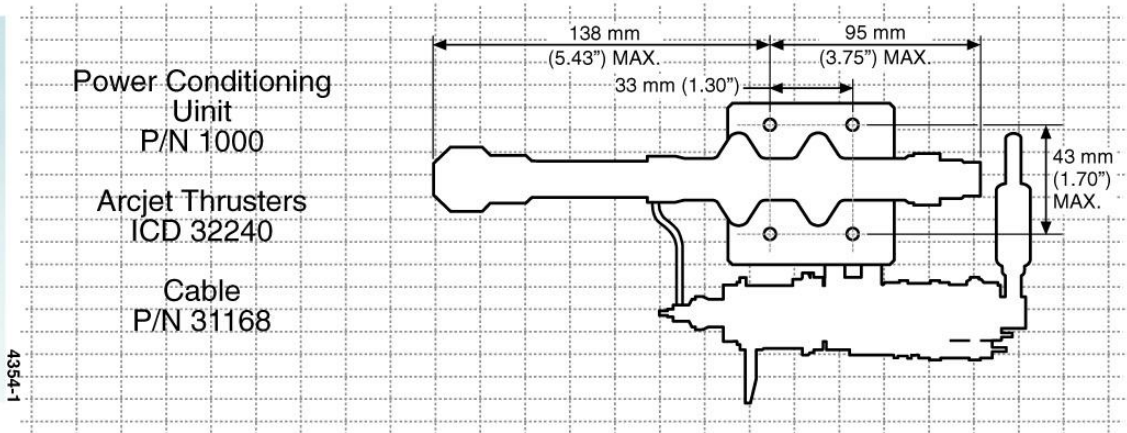
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MR-509 LOW POWER ARCJET SYSTEM



Power Conditioning Unit
P/N 1000

Arcjet Thrusters
ICD 32240

Cable
P/N 31168

4354-1

Design Characteristics

- Propellant Hydrazine
- Feed Pressure (Nominal) 17.6–14.1 bar (255–205 psia)
- Thrust/Steady State 254–213 mN (57-47 mlbf)
- Mass
 - Arcjet Thruster
 - +2000 mm/79" cable 1.38 kg (3.04 lbm)
 - Power Conditioning Unit (PCU) 4.13 kg (9.1 lbm)
- Envelopes
 - Arcjet 237 x 125 x 91 mm (9.3 x 4.9 x 3.6 in.)
 - PCU 236 x 185 x 83 mm (9.3 x 7.3 x 3.3 in.)
- Valve Dual Seat
- Valve Power 8.25 Watts Max @ 28 Vdc & 21°C
- PCU Input Power (per Arcjet) 1800 Watts
- Input Voltage 65–96 Vdc
- PCU Efficiency, Avg >91%
- Power Cable - PCU Arcjet <2000 mm/79"

Demonstrated Performance

at 1670 Watts input power to the arcjet

- Thrust 254–213 mN (57–47 mlbf)
- Specific Impulse (Blowdown Mission Avg.) >502 sec
- Total Impulse 866,500 N-sec. (194,500 lbf-sec)
- Demonstrated Firing Time
 - Total (1 hr On, 1/2 hr Off) >1050 Cycles
 - Longest Single Burn During Qualifications 65 hrs
- Starts >1170
- Telemetry Signals Available
 - Arcjet Current
 - Arcjet Voltage
 - PCU Status Flags
 - Gas Generator Temperature
 - Valve Temperature
 - PCU Temperature

Status

- Flight Proven

Reference

- IEPC-1997-081

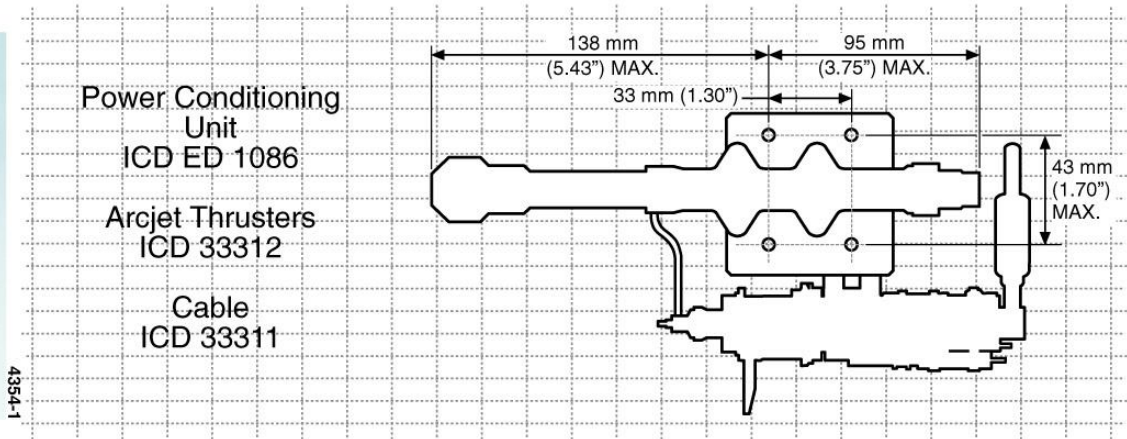
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MR-512 LOW POWER BUS ARCJET SYSTEM



4354-1

Design Characteristics

- Propellant Hydrazine
- Feed Pressure (Nominal) 17.6–13.8 bar (255–200 psia)
- Thrust/Steady State 254–213 mN (57-47 mlbf)
- Mass
 - Arcjet Thruster
 - +2000 mm/79" cable 1.38 kg (3.04 lbm)
 - Power Processing Unit (PPU) 6.2 kg (13.7 lbm)
- Envelopes
 - Arcjet 237 x 125 x 91 mm (9.3 x 4.9 x 3.6 in.)
 - PPU 310 x 220 x 95 mm (12.2 x 8.7 x 3.7 in.)
- Valve Dual Seat
- Valve Power 8.25 Watts Max @ 28 Vdc & 20°C
- PCU Input Power (per Arcjet) 1780 Watts
- Input Voltage 33–51.5 Vdc
- PPU Efficiency, Avg >91%
- Power Cable - PCU Arcjet <2000 mm/79"

Demonstrated Performance

at 1670 Watts input power to the arcjet

- Thrust 254 – 213 mN (57 - 47 mlbf)
- Specific Impulse (Blowdown Mission Avg.) >502 sec
- Total Impulse 866,500 N-sec (194,500 lbf-sec)
- Firing Time
 - Total (1 hr On, 1/2 hr Off) >1050 Cycles
 - Single Burn 65 hrs
- Starts >1170
- Telemetry Signals Available
 - Arcjet Current
 - Arcjet Voltage
 - PCU Status Flags
 - Gas Generator Temperature
 - Valve Temperature
 - PCU Temperature

Status

- Flight Proven

Reference

- AIAA-1998-3631

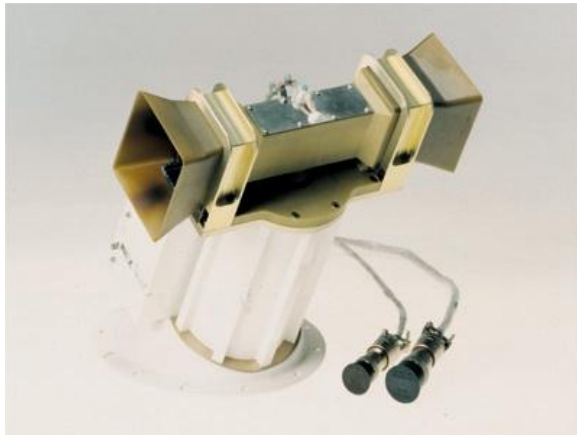
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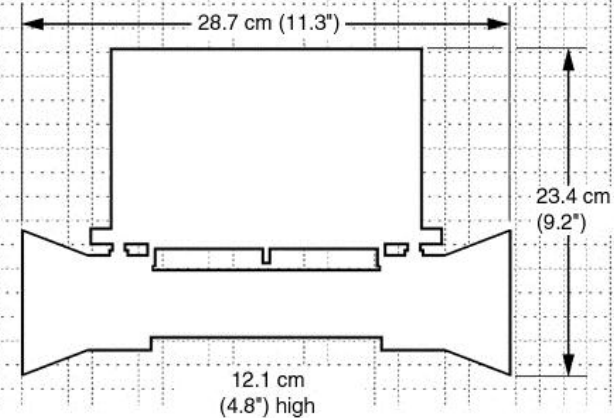
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PRS-101 Pulsed Plasma Thruster System



P/N 1071-1
EO-1 Configuration



Design Characteristics

- Propellant Teflon® (Solid Bar)
- Max Thrust Level1 1.24 mN @ 100 Watts
- Power Level
. Up to 100 Watts @ 28 vdc Unregulated
- Compact Solid State Propulsion System
- Ultra Low Minimum Impulse Bit for Precision Control
- Enables All-thruster ACS (No Momentum Wheels)
- Mass (w/o propellant) 4.74 kg
- Includes Integral Power Processing Electronics
- Power Efficiency >80%

Performance

- Specific Impulse Up to 1350 sec
- Thrust to Power Ratio 12.4 μ N/Watt
- Demonstrated Capability. 3,000 N-sec/thruster
- Predicted Capability (backed by selective testing)
. 15,600 N-sec/system (thruster pair)

Status

- Flight Proven

Reference

- AIAA-2003-5016 ■ AIAA-2001-3637
- AIAA-2002-3973 ■ AIAA-1999-3376

Rev. Date: 4/14/06

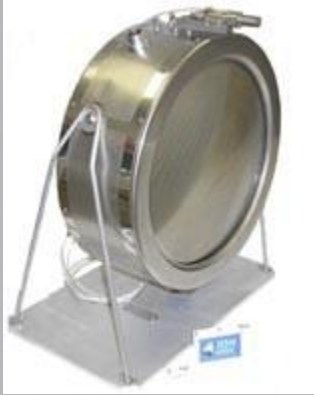
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Gridded Ion Engine Technology

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NEXT 6.9 kWe Ion Thruster and Propellant Management System (with NASA GRC)

NEXIS 20 kWe Ion Thruster (with JPL)

HiPEP 25 kWe Ion Thruster (with NASA GRC)

Low Power Ion Thruster 0.5 kWe Ion Propulsion System (with NASA GRC)

NSTAR-class 2.5 kWe Ion Thruster

Power Processing

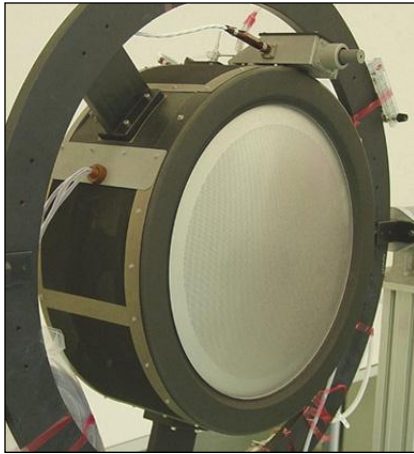
Digital Controllers

Xenon Propellant Management Systems



NEXT 6.9 kW Ion Propulsion System

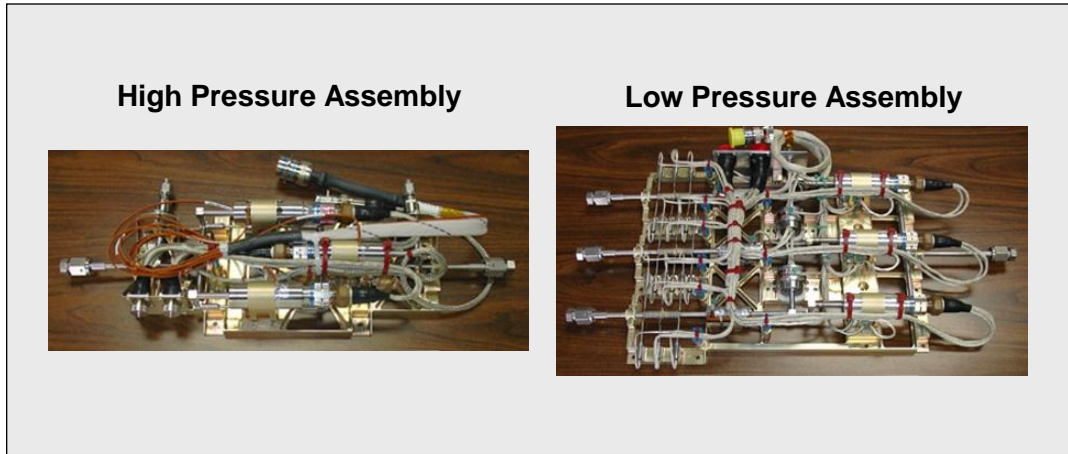
Thruster, Propellant Management System, Digital Control Interface Unit



Thruster Assembly

Design Characteristics

- Propellant Xenon
- Thruster Mass..... <13.3 kg
- Thruster Envelope Dimensions 58 dia. x 44 cm
Active optics area..... 36 cm dia.
- Thruster Input Power 600 to 6900 Watt
- Propellant Management System Mass
High Pressure Assembly < 2.2 kg
Low Pressure Assembly.....< 4.1 kg
- PMS Volume< 11,775 c.c.
PMS does not require plenum tanks
- DCIU interface with Power Processing.....RS-485



Propellant Management System

Performance

- Thrust 235 mN
- Specific Impulse..... >4100 sec
- Efficiency @ full power >70%
- Propellant Throughput..... >270 kg
- On/Off Cycles>3650 cycles
- End of Life Xenon Residuals < 1% BOL

Status

- Thruster at Prototype Model Design
- Propellant Mgmt System at Engineering Model Design
- Digital Control Interface at laboratory design level

Reference

- AIAA-2005-3885
- AIAA-2004-4111

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Space Electronics Heritage

AEROJET

**TELSTAR 4 / SERIES 7000
1.8 kW POWER CONDITIONER**



• QUALIFIED 1992

**A2100
4.4 kW POWER CONDITIONER**



• QUALIFIED 1996

**DRTS
1.8 kW POWER CONDITIONER**



• QUALIFIED 1998

**ATTD
30 kW POWER CONDITIONER**



• QUALIFIED 1993

A2100 POWER RELAY BOX



• QUALIFIED 1997

**NRL EPDM
1.5 kW POWER CONDITIONER**

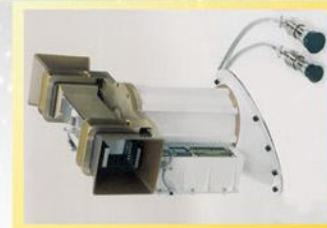


• QUALIFIED 1997

**EHT/IMPEHT
CONTROLLER**



**EO-1
HIGH VOLTAGE
POWER CONDITIONER**



**HALL THRUSTER
PROPULSION SYSTEM
4.5 kW POWER PROCESSING UNIT**



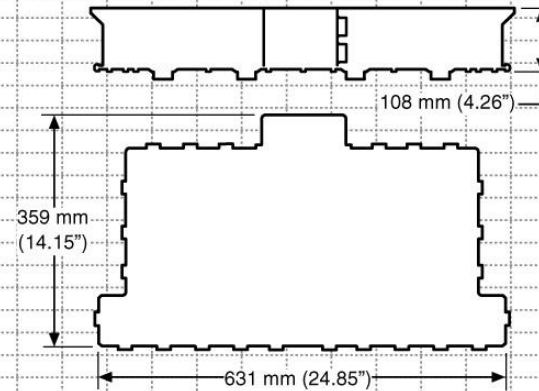
• IN QUALIFICATION

MR-510 ARCJET POWER CONDITIONING UNIT (PCU)



4360-2

Power Conditioning
Unit
P/N 1037



Design Characteristics

- PCU – has three internal power converters, any two of which can operate simultaneously.
- Output can be switched between four different Arcjets
- Includes “Bubble Protection Mode” to mitigate gas induced shutdowns
- Mass 15.8 kg (34.8 lbm)
- Envelope 632 x 361 x 109 mm (24.9 x 14.2 x 4.3 in.)
- Input Voltage 69 ± 1 Vdc
- Efficiency, Avg $>90.7\%$
- Heat Rejection (two Arcjets operating @ 2000 Watts)
. <410 Watts @ 23°C
- Output per Channel (up to two Channels)
. 1500, 1670, 1830 or 2000 Watts
- Input Power, when operating two Arcjets @ 2000 Watts
. 4340 Watts

Demonstrated Performance

- Telemetry Signals Available
 - Arcjet Current
 - Arcjet Voltage
 - PCU Status Flags
 - PCU Temperature

Status

- Flight Proven

Reference

- AIAA-1998-3630

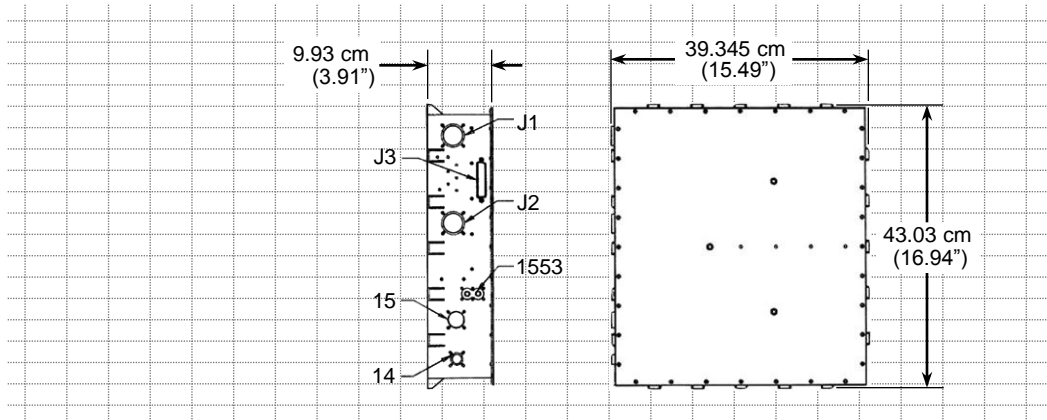
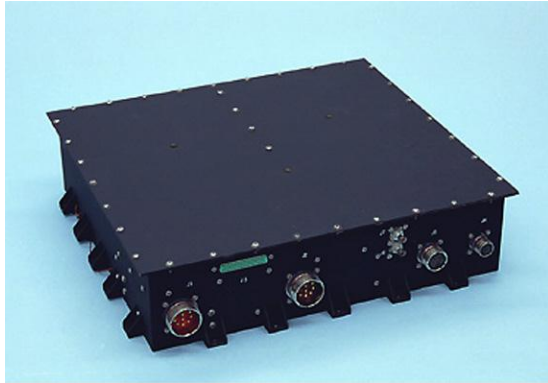
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4.5 kW HALL THRUSTER POWER PROCESSOR UNIT



Design Characteristics

- Mass 12.5 kg
- Envelope 43 x 40 x 11 cm
- Input Voltage 70 +/- 2 VDC
- Efficiency (Avg) >92%
- MIL-STD-1553 Command & Telemetry Interface:
 - 30 Telemetry Channels
- Commandable Power Settings:
 - Discharge Power 2.0 - 4.5 kW
 - Discharge Voltage 150 - 400 V

Demonstrated Performance

- Closed Loop Control of Xenon Flow Controller and Discharge Current
- Holding Valve Drivers
- S-Level, Radiation Hardened Components
- Optimized for Manufacturability
 - Only Four Circuit Cards

Status

- Qualified

Reference

- AIAA-2005-3682

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