SPACE MICRO

Miniaturized, radiation hard DACS module for propulsion electronics

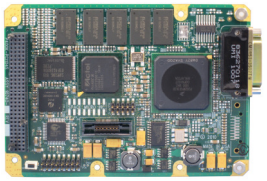
David J. Strobel, J. Romero, H. Cerna, M. Petty, D. R. Czajkowski

New Facility and Capabilities

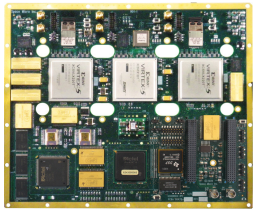
- 20,000 sq. ft
- Improved Clean Room
  - Class 10,000
- Additional Environmental Equipment
  - Thermal vacuum
  - Random vibration
  - Sine vibration
  - Shock
  - Thermal cycling
- SECRET facility
  - COMSEC handling

Radiation Hardened Products

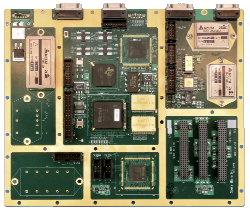
Digital Boards



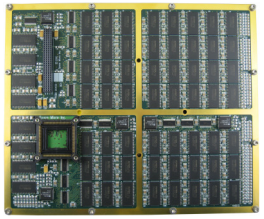
Proton400k-L™Dual-Core Computer



Proton300k™ Reconfigurable SBC

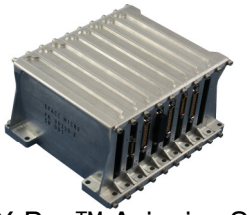


Proton200k™ Custom DSP SBC



Solid State Buffer

Systems/Instruments



ProtonX-Box™ Avionics Suite

------Examples of Configured Slices --------

Proton200k™

FPGA/SpaceWire

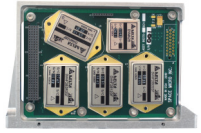
Digital I/O

Analog I/O

GPS (Receiver not shown)

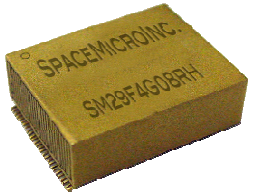
Valve/Relay Driver

Power Switch

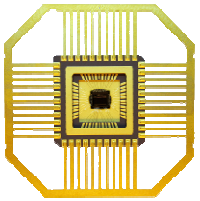


Power Supply

Components

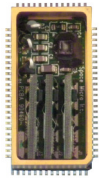


8 Gb RH NAND Flash



H-Core™ Pat. "Watchdog" IC

2.5 Gbps ECC IC

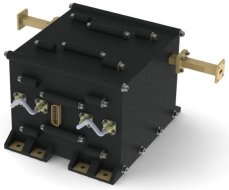


Divert Attitude Controller (DACS)

RF Microwave

uSTDN ™ Transponder

uSGLS™ Transponder



Ka-Band Transmitter

uXLPA™ Linearized SSPA

Abstract & Motivation

Space Micro Inc. will present the results of their Phase II SBIR Contract from the U.S. Missile Defense Agency (MDA), for development of a miniaturized radiation hard propulsion electronics module for missile interceptor or space applications. This electronics is part of the missile Divert and Attitude Control System (DACS). MDA interceptor applications include the SM-3 Block IIB program.

Space Micro has developed a COTS-based miniature DACS electronics module with complete screening and testing. Our plan is to productize this technology and provide propulsion system designers such as Aerojet, ATK, and Pratt-Whitney with DACS electronics that offers a functional drive capability that is equal to or better than current products on the market, but in a smaller package size and at a much lower price point than traditional rad hard parts.

We will report on radiation test results of COTS Power MOSFET semiconductors and motor driver ICs. In addition, thermal and shock modeling analysis using COSMOS will be presented. Test results will also be provided.

The approach to meeting MDA needs is to highly leverage commercial-off-the-shelf COTS technologies including both advanced microelectronics devices in die form, and innovative packaging technology. DACS modules have been delivered future flight testing.

Divert Attitude Control System (DACS)

From SBIR Topic MDA06-044

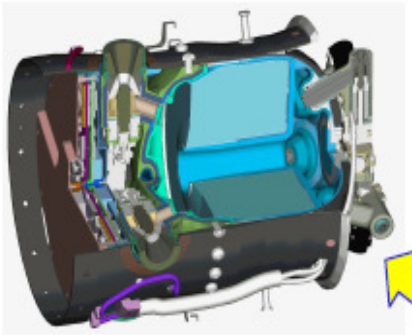
"MDA is seeking reliable and high performance radiation hardened electronics for controlling DACS...the radiation environments for interceptors and space systems differ due to the mission requirements."

HAENS = High Altitude Exoatmospheric Nuclear Standard

Meeting HAENS 2 for MDA Interceptors

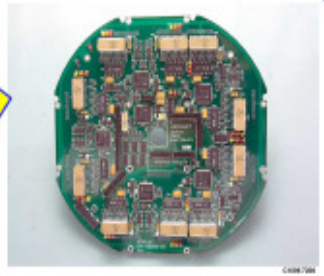
Rad Hard Miniaturized Electronics Supports SM-3

MKV and Future TDACS Applications



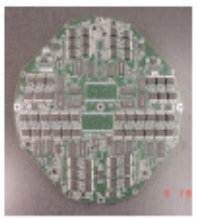
SM-3 Blk 1B TDACS

Current 2nd Generation Digital Avionics



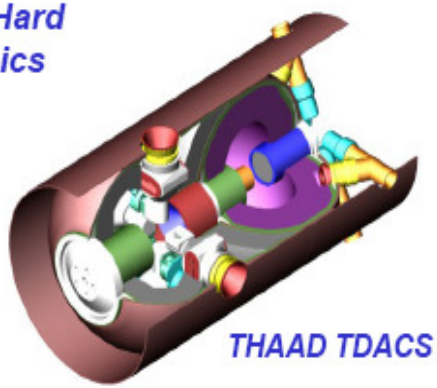
1st Generation Avionics

SM-3 10-Channel Fast Response Controller Board

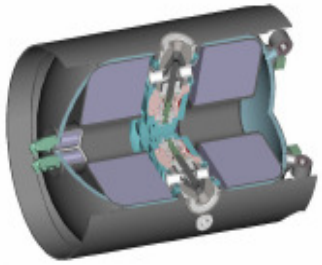


SM-3 10-Channel Actuator Driver Board

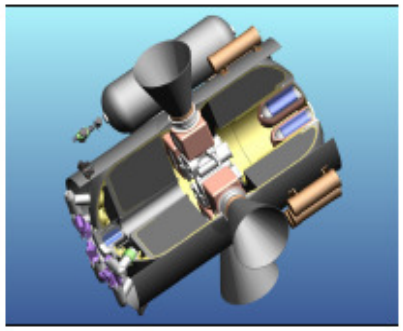
3rd Generation Rad Hard Miniaturized Avionics



THAAD TDACS

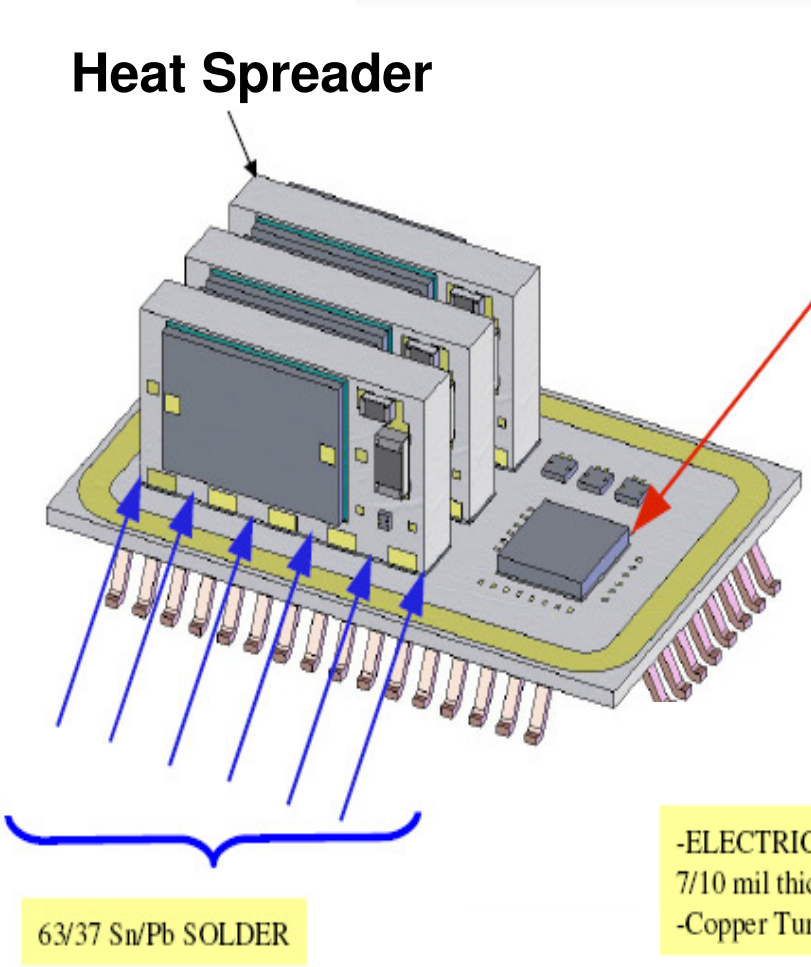


MKV TDACS



SM-3 Blk 2, KEI, and JCR TDACS

MCM Solution for MDE

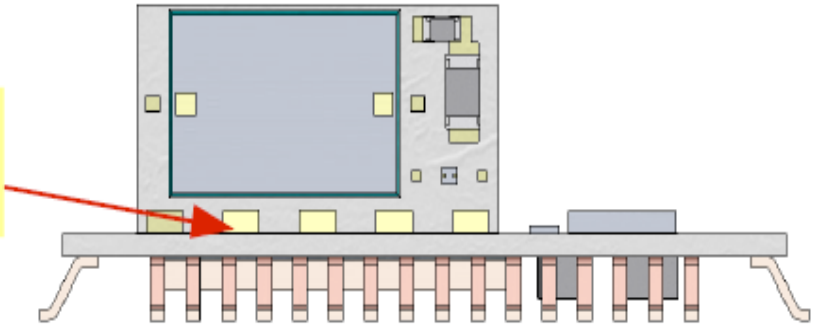


MCM (20 mm x 13 mm) for:

- **MOSFET**
- **MOSFET Driver**

-Module is estimated to sit on a 50°c to 60°c PCB board environment
-Trace widths will support pulsed current levels.
-Key feature is to minimize inductance effects

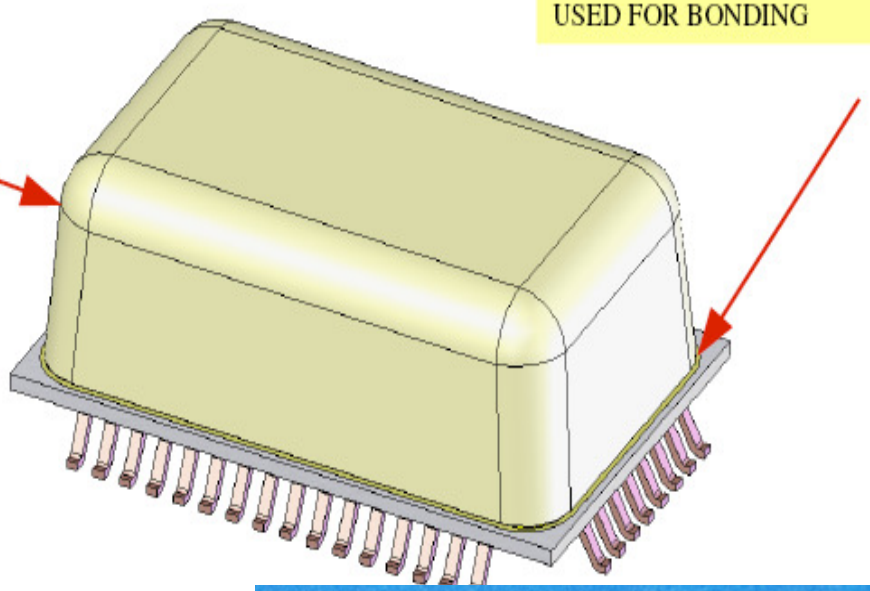
-ELECTRICAL TRACES
7/10 mil thick
-Copper Tungsten



MCM Housing & Mechanical Mockup

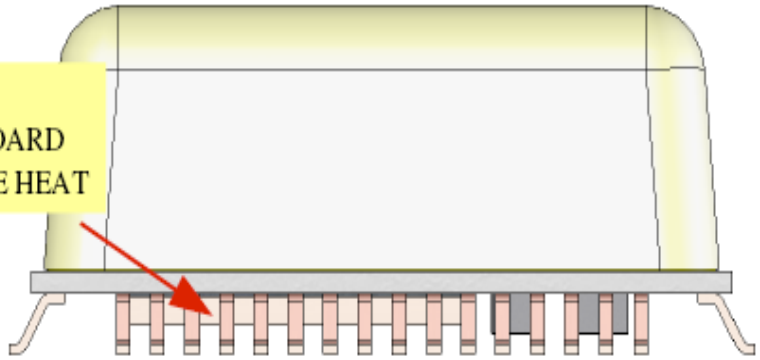
HERMETIC SEAL (not a requirement)
DEPENDS ON TYPE OF PROCESS
USED FOR BONDING

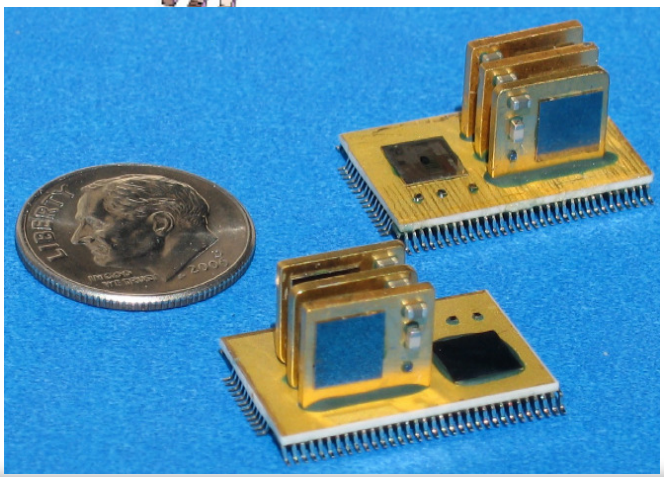
KOVAR lid (nickel-cobalt alloy)



Can also add radiation shield to package

COPPER SLUG:
*HELPS STIFFEN BOARD
*REDUCE PACKAGE HEAT



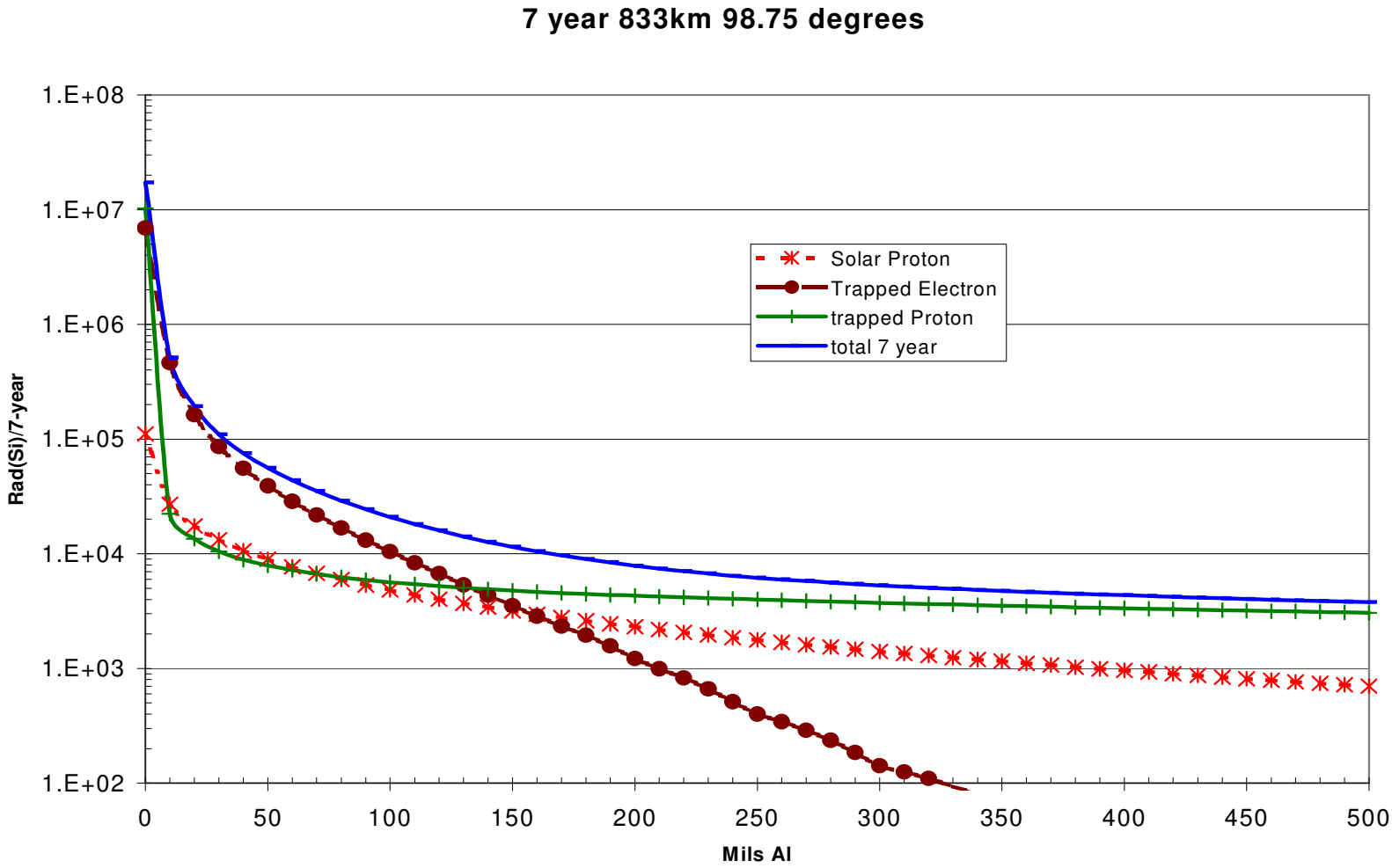


Radiation Mitigation techniques

- Total Ionizing dose (TID)
  - Parts selection
  - Shielding (Spectrum dependent)
- SEU/SEFI Mitigation, including NSEE
  - EDAC (Reed Solomon)
  - Parity
  - TTMR*
  - Hardened Core™ (aka H-Core)*
- Dose Rate (prompt dose)
  - Shielding/modeling
  - C&R with NED? (Nu-Trek sample in house)
  - Testing/part selection

**Patented Space Micro technologies*

Representative LEO Orbit



300 krad(Si) requirement requires
~ 2mm Al of shielding to reduce TID to 45 krad(Si)

Dose Rate Reduction with Shielding

- Reduction through 2 mm Al 4pi Shielding

Black body Temperature (keV)	Reduction factor (Incident/Transmitted)	Meet Dose Rate Survive	Meet Dose Rate Latchup
3	900	Yes	Yes
5	100	Yes	Yes
10	20	Need more shielding	

Expect to exceed Dose Rate requirement with Shielding:

- If entire package can be 4pi shielded
- Margins may be < 50; thus RLAT
- Amount of shielding required is dependent on environment

Radiation Hardness Assurance Testing Requirements for Semiconductors

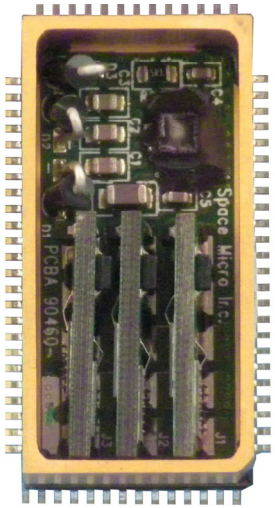
ENVIRONMENT	Ground	Shipboard	Aircraft	Missile	Spacecraft
Total Dose	L (50)	L (50)	L (50)	L (50)	L (50)
Dose Rate Upset	L (50)	L (50)	L (50)	L (50)	L (50)
Dose Rate Survivability, Operate-Through, and Latchup	L (50)	L (50)	L (50)	L (50)	L (50)
Heavy Ion Single Event Upset and Latchup					O
Proton Single Event Upset and Latchup				O	O
Neutron Single Event Upset and Latchup			O	O	O
Neutron Displacement Damage				O (T)	O (T)
Proton Displacement Damage					O (T)

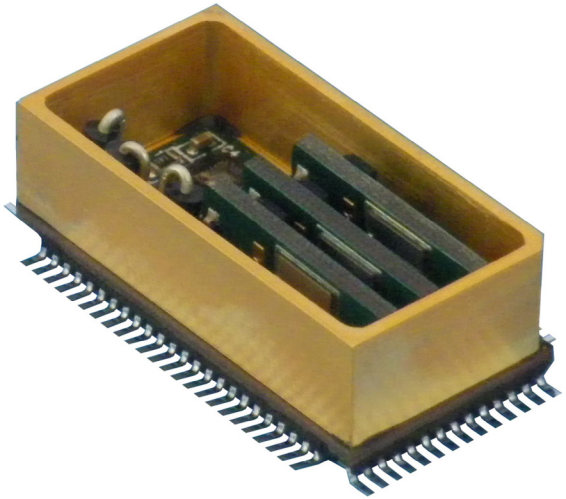
L = Lot testing is required.
O = One time testing is allowed, if process/design/vendor does not change
50 = One time testing may be approved by PMPCB waiver, if radiation test results show 50x margin and design/process/vendor does not change.
T = Neutron testing need not be performed on process-proven technologies (i.e. CMOS).

Package Features

- Hexfet die (dark blue) mounted with solder or AuSn on both sides of AlN heatspreader (light blue)
- Gate circuitry is also contained on heatspreader
- Heatspreader absorbs thermal power spikes
- Wrap Around Metallization of Board Allows Connections to Package Substrate (Green)
- Power Control Die (IR2130-Maroon) flip-chipped or wirebonded to Package Substrate
- Copper Leads added to Substrate to Provide High Reliability and Low Electrical Resistivity
- Plastic Encapsulation of Components for Mechanical Protection and Resistance to Shock

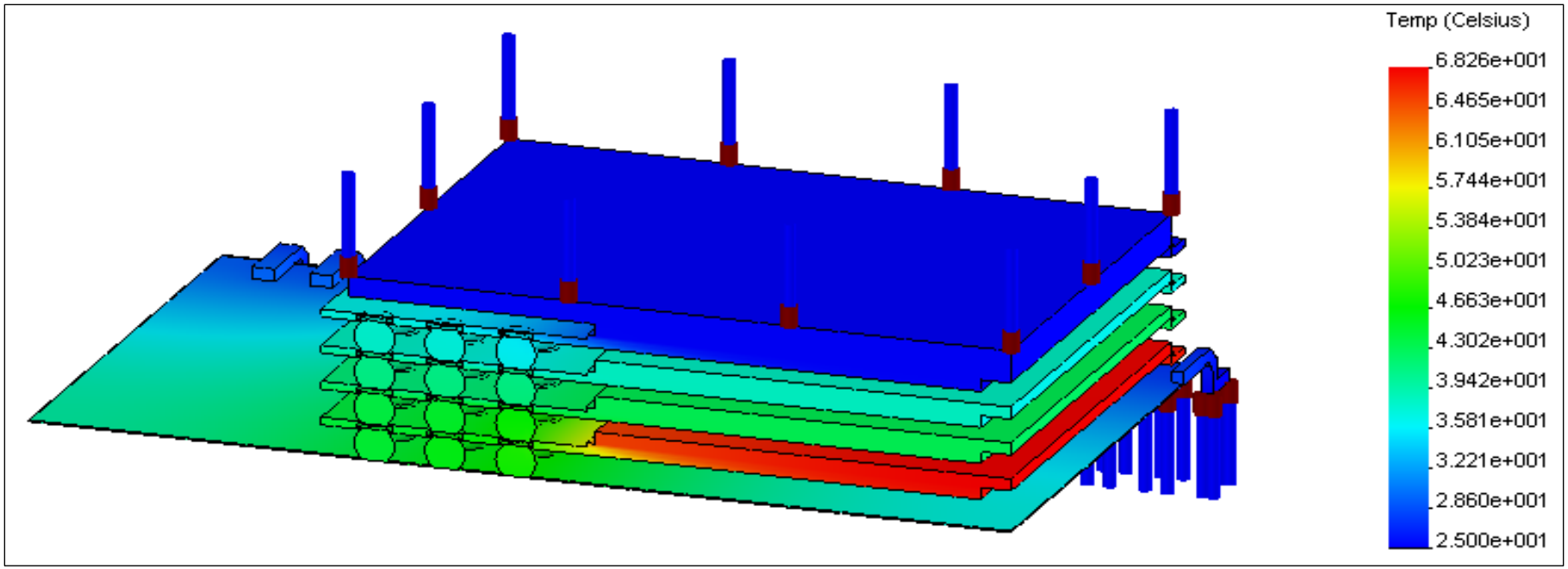
Package Design-Phase I





- Approximate Package Size
  - Footprint = 0.56” x 0.83”= .47 in^2
  - Height = 0.27”
- Low Cost- Only standard processes and materials used

3-D Packaging Thermal Analysis



Tessera technology stacking – Thermal Analysis

Use of COSMOS software tool

Family of Rad hard DACS Products

Interceptors & Space Versions

- TID flexibility
  - 100/300 krad models
- Dose rate hardening -optional in family
- Variable shielding levels
- Reliability vs dormancy

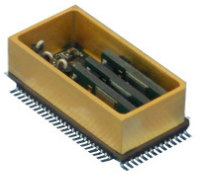
Application Specific Performance

- Output currents
- Mechanical
- Heat removal
- Weight requirements
- Parts quality drives cost
- Mil-PRF-38534?

DACS Data Sheet

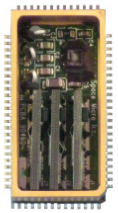
Radiation Hardened Divert Attitude Control System

Space Micro Inc's SM-DACS-1000 Divert Attitude Control System (DACS) was developed for interceptor and space systems that require reliable, miniaturized, high performance electronics that are radiation hardened to meet HAENS 2 requirements. This product is used in high power switching typically encountered in thruster and ignition functioning.



Features for Space

- Miniaturized with 3D stacking technology
- Radiation Hardened to MDA HAENS 2
- No Latch-up
- Ruggedized for missile & space applications
- Surface Mount packaging
- Conductive cooling
- Custom versions available



DACS Module

Applications

- Missiles/Space valve & thruster driver
- Missiles/Space high current driver
- Missiles/Space high side driver
- Missiles/Space high side driver

SM-DACS-1000

Part Numbering

```
SM-DACS-1000-X
             B   Class B, MIL-STD-883
             E   EM Engineering Grade
          |  |__ Base Part Number
          |_____ DACS Application
Space Micro supplier
```

Space Micro Inc

10237 Flanders Court
San Diego, CA 92121
Phone: 858-332-0700
Fax: 858-332-0709
www.spacemicro.com

SPACE MICRO

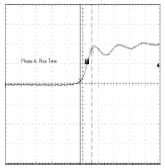
Radiation Hardened Divert Attitude Control System

Specifications

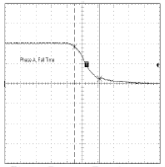
Dimensions:	1.40" x 0.74" x 0.45"H	
Weight:	20 grams	
Temperature:	Operating:	-40°C to +125°C
	Storage:	-55°C to +150°C
Inputs:	Vcc = +15.0V; 3.3V Logic	
	Actuator Supply Voltage = 88V-140V	
Outputs:	3-Phase or 3-Half Bridge, 10.0A	
Screening:	-EM	(Engineering Model)
	-B	(Class B)
Reliability:	MTBF	> 10 years
Environmental:		
Vibration capability	0.04 G^2/Hz from 100 to 2000 Hz	
Mechanical Shock capability	MIL-STD-883, Method 2002 Condition B 1,500 g's, 0.5 ms duration	

Waveforms

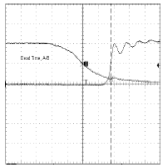
Rise Time:



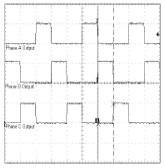
Fall Time:



Dead Time Phase A to Phase B:



3 Phase Output Graph:



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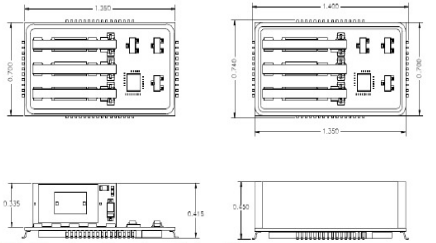
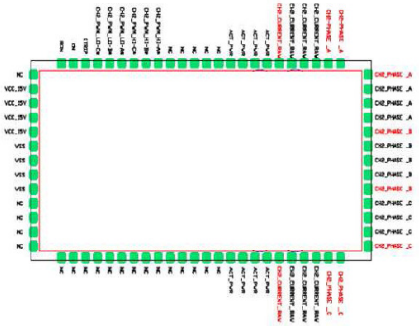
Radiation Hardened Divert Attitude Control System

Mechanical Layout:



DACS Module package dimension and pinout diagram:



Cont
act Space Micro for complete systems characteristics, specific configurations, and availability.

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SPACE MICRO

Current status and availability

- Developed under MDA SBIR Phase II and Phase II transition
- Fabricated 3 lots of MCM units
- Fully electrically characterized over temperature
- Radiation tested both a chip and entire MCM level
- Integrated into subsystem at major propulsion prime
- Designed into MDA SM3 Block IIB program
- Initial product released and selling
- Other versions (higher voltage, current pulses) with NRE

Closing thought

Thank you for your support!

SPACE MICRO