Power Actuation and Switching Module (PASM)
Power Switch Slice (PSS)
Power Control Slice (PCS)

Presenter: Ian Ruiz (Ian.Ruiz@jpl.nasa.gov)
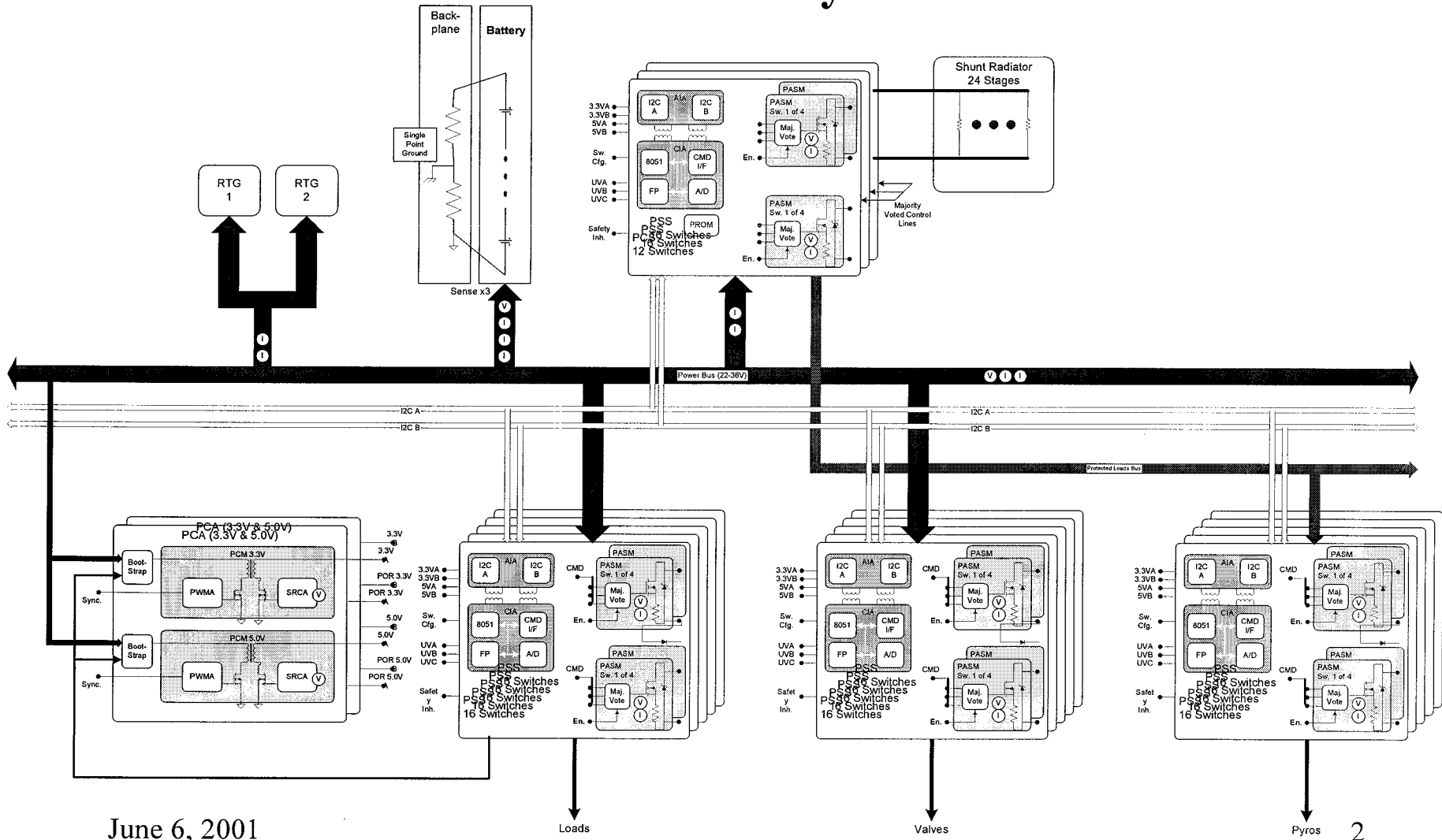Frank Deligiannis (Fotios.Deligiannis@jpl.nasa.gov)

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Power Subsystem

Power Subsystem Key Functions/Driving Requirements

- Power Source
  - Two RTGs
  - BOM Power (484W @ 28V)
  - EOM Power (414W @ 28V)
- Energy Storage
  - Battery Impedance (Drives power bus ripple)
  - Single Fault Tolerance (Cell Failure)
- Power Control
  - Single Fault Tolerance (Majority Voted)
  - Power Bus Voltage Control (22V to 36V, 160mV resolution)
 - Battery Charge Current Control (0 to 12A, 256 levels)

JPL

Power Subsystem Key Functions/Driving Requirements

- Power Distribution
  - Load Fault Protection
  - Current Limit @ 5A
  - Current Trip @ 3.5A (±0.5A) after 20ms
- Valve Drive Electronics
  - Open/close time
  - Provides reverse voltage to reduce turn-off time
  - Provides switch protection for turn-off of inductive loads
- Pyro Drive Electronics
  - Drives NASA Standard Initiators
  - Active current limit protection
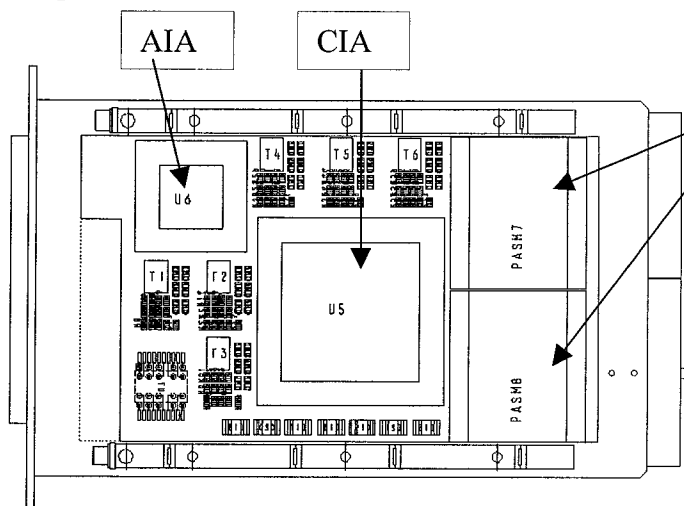 - Safety

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Power Switch Slice & Power Control Slice
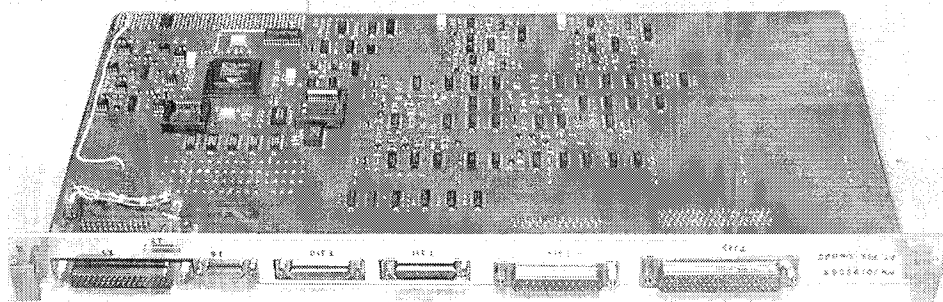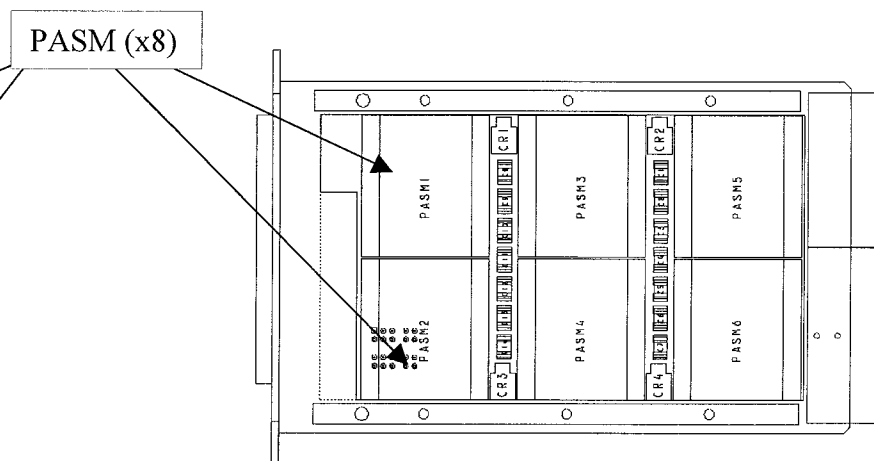
PSS Breadboard (Command Interface Side)
Compact PCI 9U Format
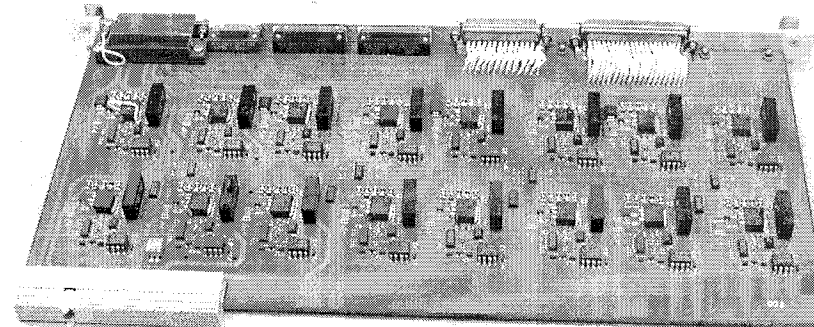
PSS Breadboard (Switch Side)
Compact PCI 9U Format

AIA   CIA   PASM (x8)

PSS floorplan (CIA Side)
Compact PCI 3U Format

PSS floorplan (PASM Side)
Compact PCI 3U Format

CIA-AIA Chip-set

- Mentor 8051 IP Core
- 8 KB of on-chip ROM
  - Program Space
- On-chip RAM
  - Data Space
  - Switch Queue
- Multi-Frequency Operation (M8051 Core)
  - 16.5 MHz
  - 8.25 MHz
  - 0 MHz (Low-Power Mode)
- Two I2C Ports
- External Access to External Data Memory Bus
  - External Boot ROM (Optional)
  - Add Additional RAM or other Memory Mapped I/O
- Analog Portions
  - Power X-Strapping
 - 8-bit ADC
  - Current/Voltage Monitoring

Command Interface ASIC (CIA)
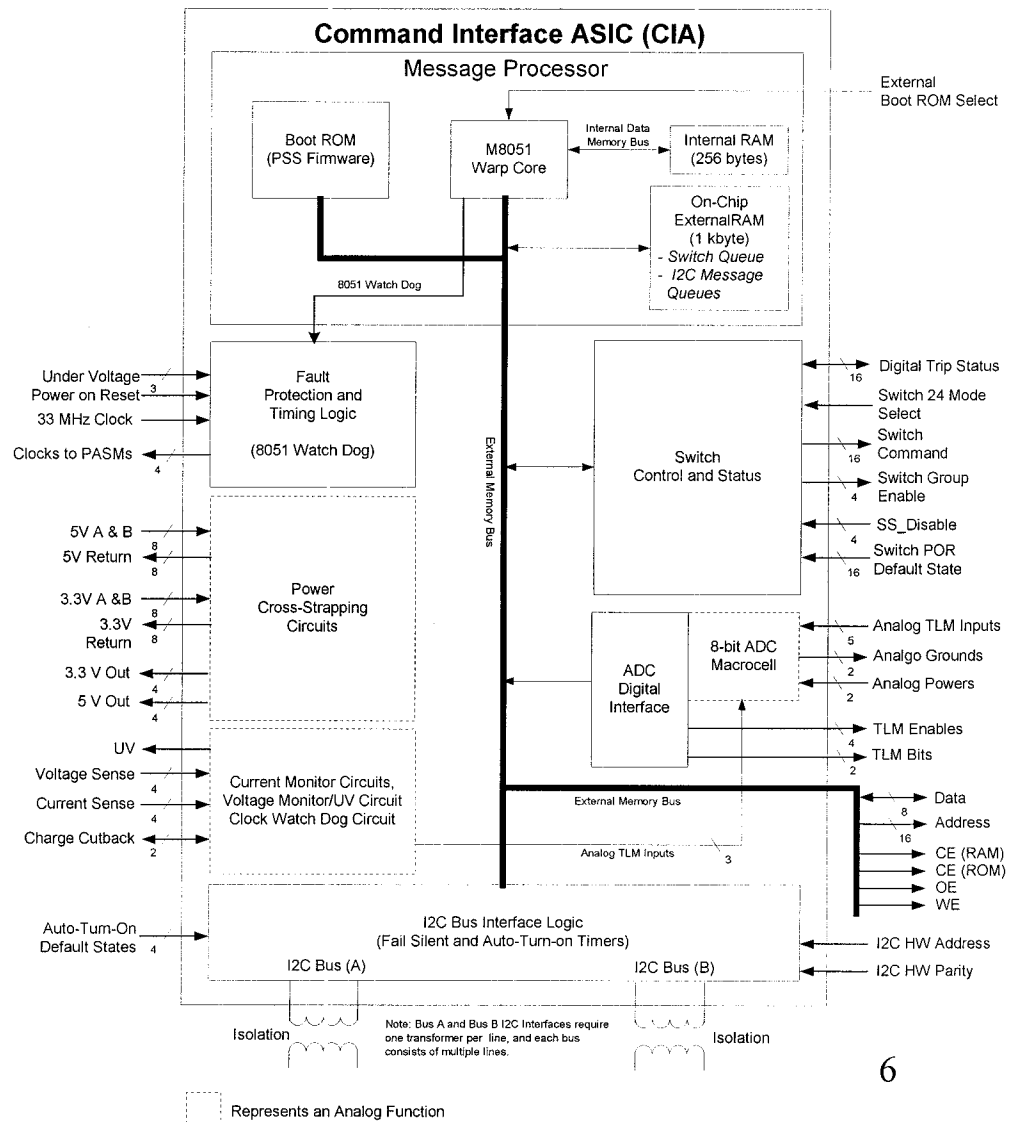
CIA-AIA Chip-set

- Ground Isolation between I2C Link Layer in CIA and I2C bus
  - Transformer Coupled (5 required per bus)
  - Direct Connection (Optional)
  - One AIA per I2C bus
- Power Provided by bus PCM.
- On-Chip Free-Running Oscillator
  - 16.5 MHz.
- Phillips I2C Bus Custom Additions:
  - Slew Rate Control
  - 30 mA Sink Capablility (Industry Standard 3 mA)
- Fault-Tolerant Addition
  - Fail-Silent Mechanism
- Compliant with DIO/MSIO X2000 ASIC Chip-Set (Command and Data Handling I2C bus Master)

Analog Interface ASIC (AIA)

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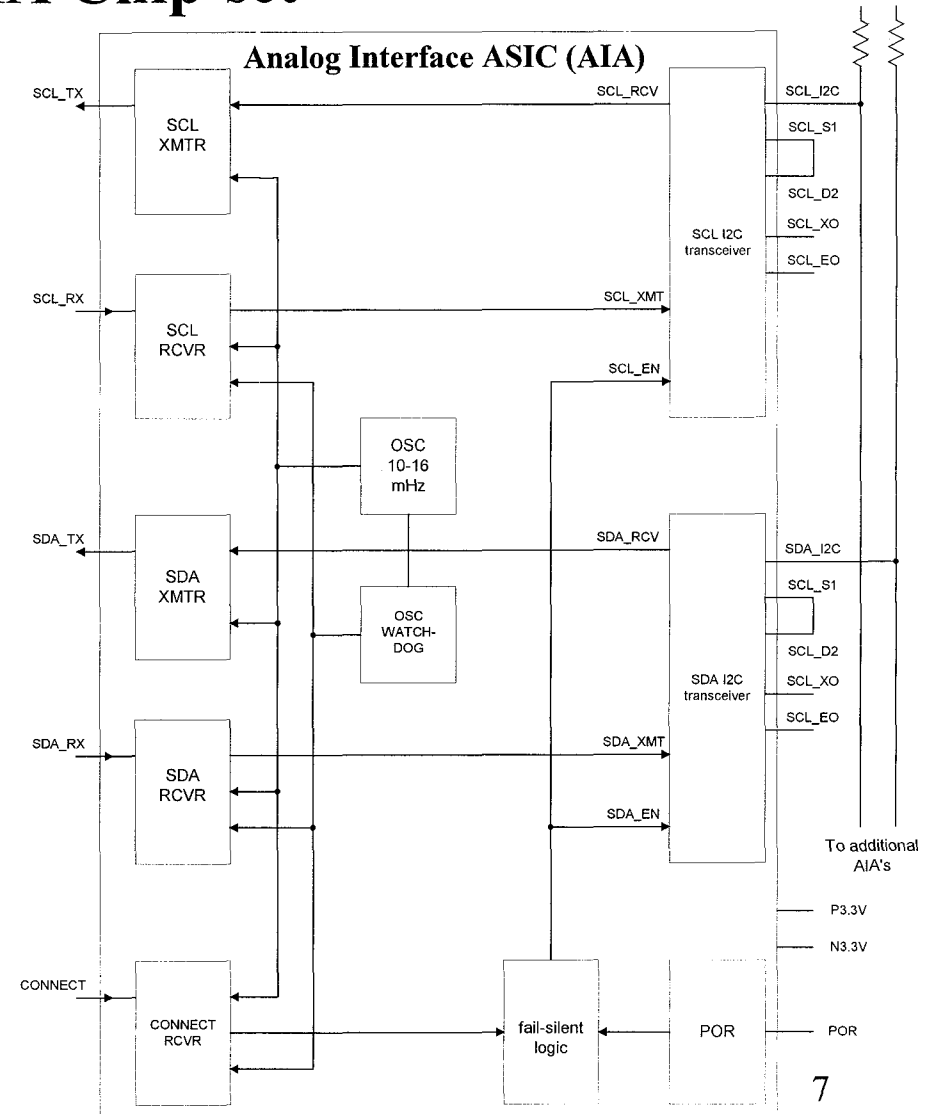
Power Actuation and Switching Module (PASM)
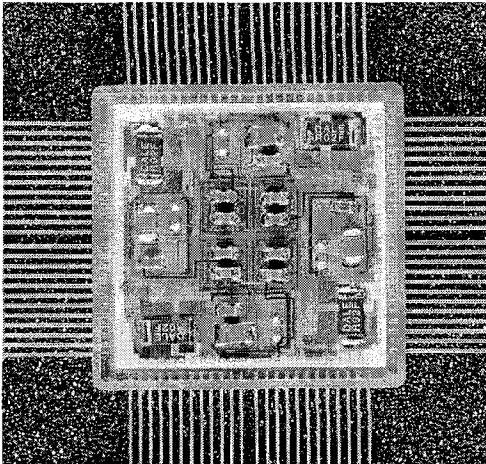
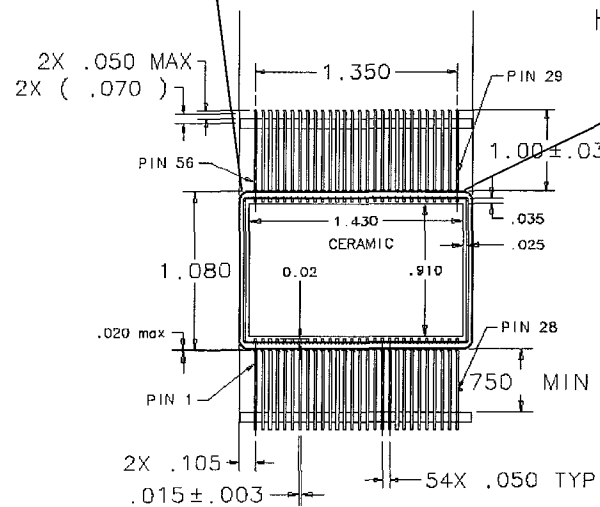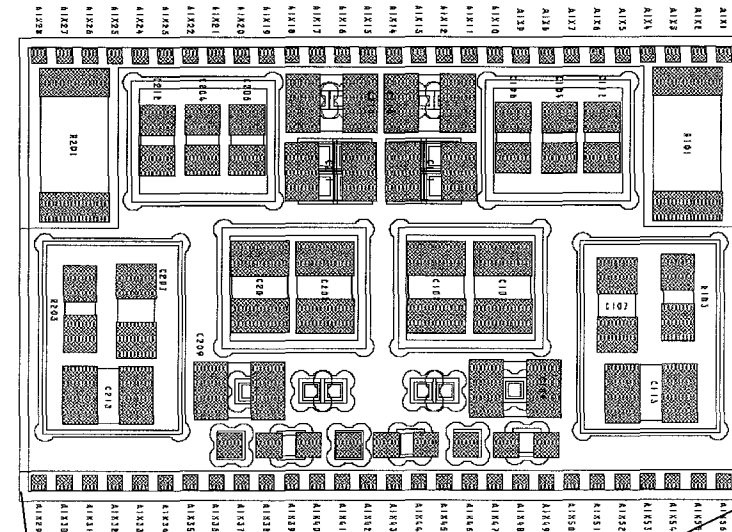DS1 PASM (4 switches per package)
1.5inch x 1.5inch

Advanced Packaging

    High Density Interconnect (HDI)
    module in hermetic can
    Size: 1.560" x 1.080" x 0.226"

    Weight: 23 grams

X2000 PASM Layout
and Package (2 switches
per packaging)

PASM Key Capabilities/Requirements

•2 Independently Controlled Switches
- Used for High Side or Low Side switching
- Can be connected in series or parallel
- Max DC Voltage Rating = 40V
- Max DC Current Rating = 3.0A

•di/dt Limiting at Switch Turn On & Turn Off (active control loop)
- Nominal limit = 7.5A/ms
- User selectable di/dt inhibit (2 options)
  - Jumper between HS I/O pins (same jumper inhibits current limiting)
  - LS di/dt Inhibit Command (does not effect current limiting)

•Current Limiting (Min Limit = 5.0A)
- User selectable limit of 2.0A Min via jumper between I/O pins
  - The same jumper lowers the Overload trip point
- User selectable current limit Inhibit via jumper between I/O pins
  - The same jumper inhibits di/dt limiting at turn On/Off

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PASM Key Capabilities/Requirements (Cont.)

- **Latching Overload Shut Down (Trip Current = 3.5A ±0.5A)**
  - User selectable trip current of 1.1A Min via jumper between I/O pins
    - The same jumper lowers the Current Limit point
  - Min Trip Delay = 21ms (Operation from an External 4MHz Clock)
  - Command Resetable (send Off Command followed by On Command)
  - Overload Fault Telemetry Output
- **Bootstrap Enable (Open Drain Transistor)**
  - Used in certain applications for system Start Up (i.e., PCA)
  - Transistor powers up in the Off mode (Bootstrap Enabled)
  - Transistor latches On after switch turns On for the 1st time (BootStrap Inhibited)

PASM Key Capabilities/Requirements (Cont.)

- **Analog Telemetry Output (0V to 2.56V output range)**

  - Output Signal selected via Analog Mux

    - Switch Output Voltage or Switch Current

  - Analog Telemetry output is high impedance when disabled

  - Single Telemetry Enable command enables both switches

  - Single Telemetry Select command controls both switches

- **Majority Voted, Switch On/Off Commands (2 of 3)**

  - Inputs may be connected together for a single On/Off Command control

- **Powered from Dual (Primary & Back Up) 5V Power Supplies**

  - Both 5V inputs are current limited, then OR'ed together

- **Charge Pump**

  - Supplies floating power to High Side ASIC from the 5V LS input

  - Operates at 4MHz Nominal (from an internal or external clock)

PASM Key Capabilities/Requirements (Cont.)

- **Switch Enable Command**
  - Enabling the switch turns on the Charge Pump & puts switch in Standby Mode
  - Disabling the switch turns off the Charge Pump & saves power
  - Switches must be Enabled before they can be turned On
- **Protection From Switching Inductive Loads (e.g., Valves)**
  - Max Rated Inductive Load = 700mH
  - Max Rated Inductive Energy = 3.15 joules (700mH at 3A)
  - High Side Switch Output clamped at -20V nominal
  - Low Side Switch Input clamped at +60V nominal
- **High Pulse Drive Capability (required to drive multiple pyros in parallel)**
  - Max Rated Pulse Current = 40A
  - Max Rated Pulse Width = 20ms (will trip off after 20ms)
 - Current Limiting must be Inhibited

# PASM Key Capabilities/Requirements (Cont.)

- **Repetitive Pulse Operation**
  - Max On/Off Frequency = 20Hz
    - For Resistive & Inductive Loads
    - Max Duty Cycle = 20%
    - Max Rated Current = 3A
    - di/dt Inhibited

- **Advanced Packaging**
  - High Density Interconnect (HDI) module in hermetic can
  - Size: 1.560" x 1.080" x 0.226"
  - Weight: 23 grams

- **Environment**
  - Operating Temperature Range: -55°C to +100°C (PASM mounting surface)

PASM BLOCK DIAGRAM
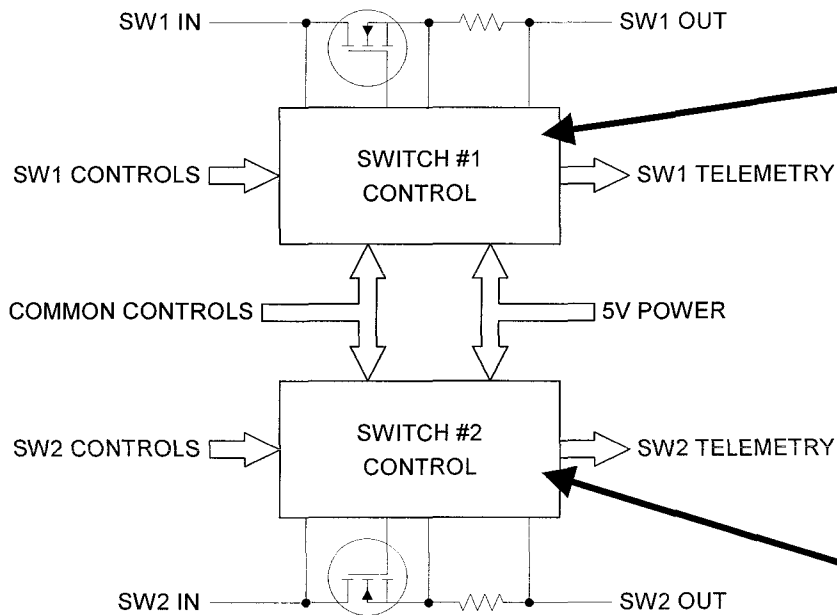
SWITCH BLOCK DIAGRAM
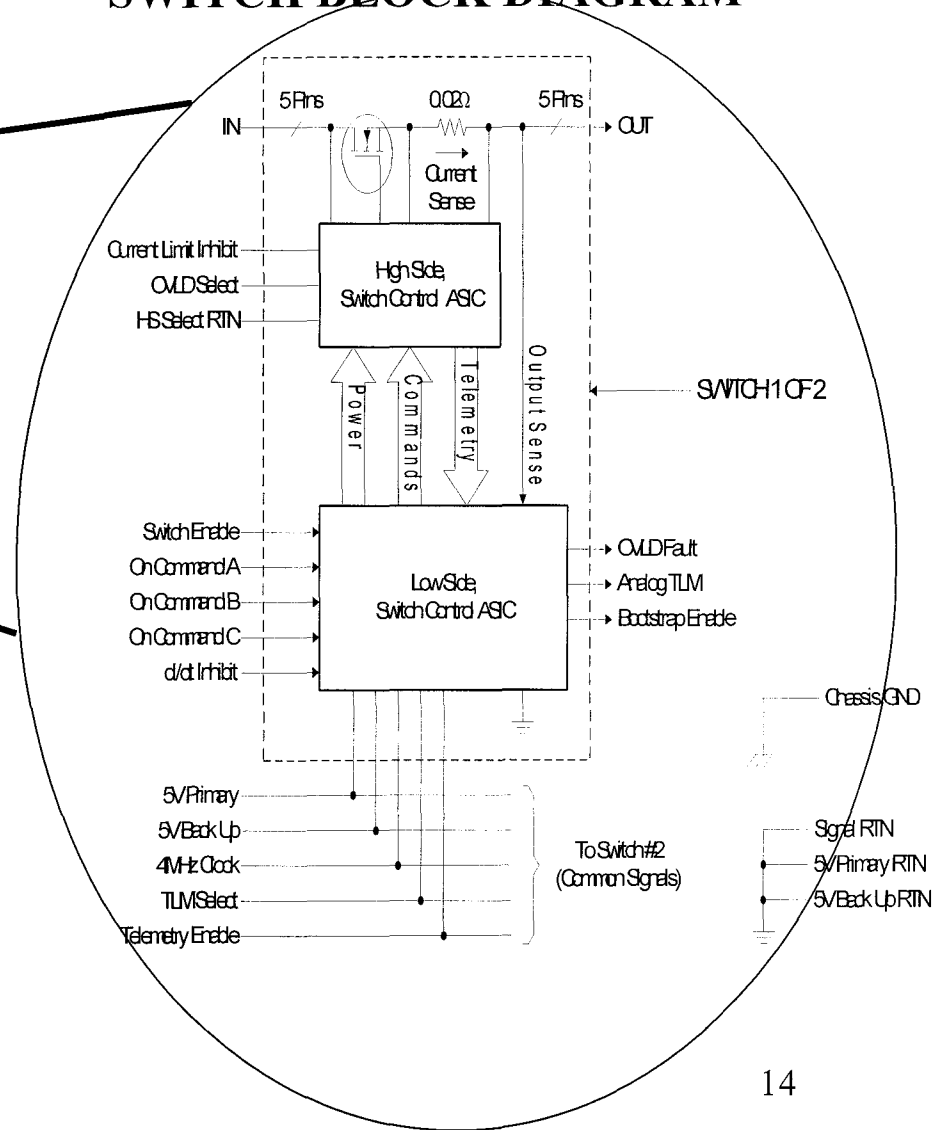
Switch Control ASIC High Side (SCAH)
   Floating High speed linear MOSFET control
   Low offset current sense
Switch Control ASIC Low Side (SCAL)
   Ground Referenced Power Switch Control
   Charge Pump, Level Shifting (40V)

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Status

- **CIA/AIA designed by JPL - Manufactured by Honeywell**
  - Preliminary Design Review   CIA (8/01)   AIA (5/01)
  - Critical Design Review   CIA (10/01)   AIA (7/01)
  - PODs available   CIA (5/02)   AIA (1/02)

- **SCA designed by Boeing/JPL - Manufactured by Honeywell**
  - Preliminary Design Review   9/00
  - Critical Design Review   6/01
  - PODs available   11/01

- **PASMs designed by LM-CSS/JPL - Manufactured by Lockheed Martin**
  - Peer Review   11/01
  - Manufacturing Readiness Review   3/02
  - Prototype PASMs available   6/02
  - Prototype PCS/PSS available   9/02