TID and SEE evaluation of EEE parts for COROT DPU and STEREO SEPT/IMPACT

1. STEREO SEPT/IMPACT: overview, SEPT instrument
2. TID results: TLC2262, LMC6062, MAX478, ADP3300, ADG704, ADG713, PDFE
3. SEE results: MAX892, ADG704, ADG713, TLC2262, SEPT EM
4. COROT DPU: overview, MDPU
5. SEE results LP2953A

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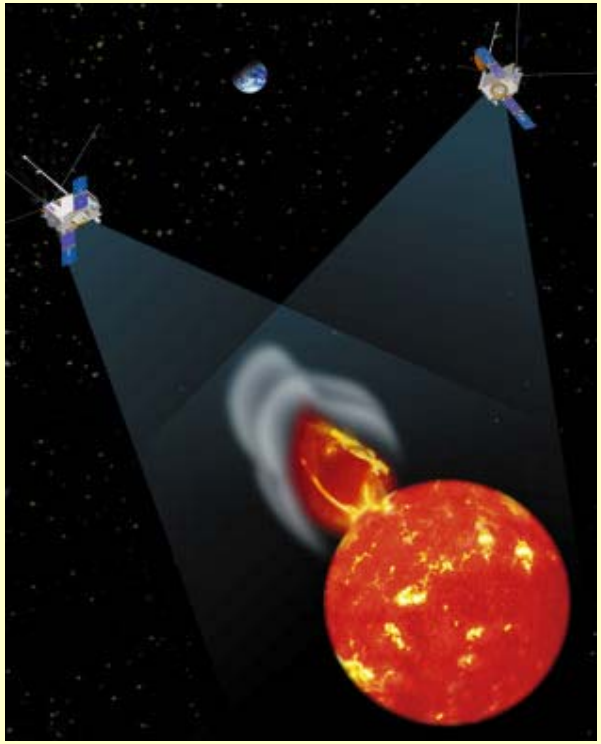
STEREO – Solar Terrestrial Relations Observatory

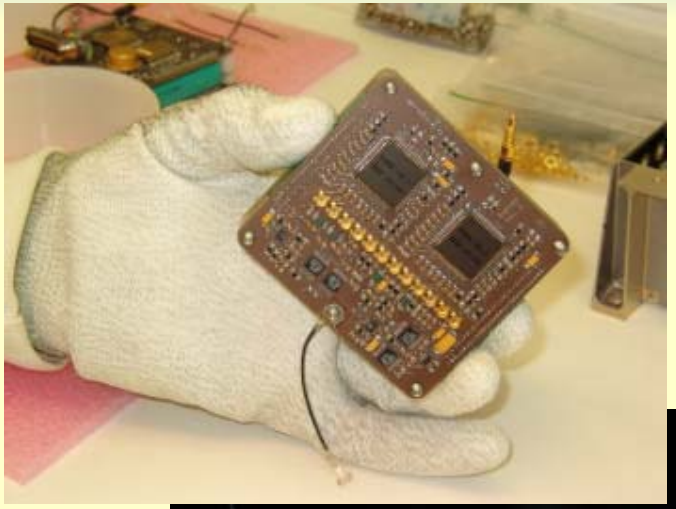


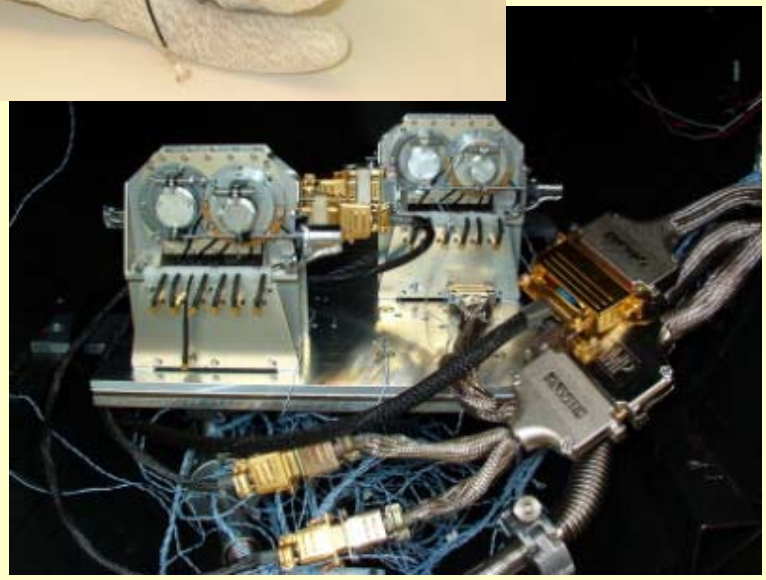
- NASA/GSFC program
- John Hopkins APL prime contractor
- Twin 610 kg S/C
- Launch Feb. 2006
- Minimum two years operations
- Approx. 400 MEuro program

First 3-D stereoscopic images to study CME

SEPT- Solar Electron and Proton Telescope

- Part of In-Situ instrumentation suite (IMPACT)
- Scientific collaboration Univ. of Kiel (D) and Research and Scientific Support Dept. (ESA)
- Measures Electrons 60 – 400 keV
- Measures Protons 40 – 7000 keV
- Complete instrument: 550 g
- Electronics: 90 g (highly integrated, several up-screened commercial plastic parts)

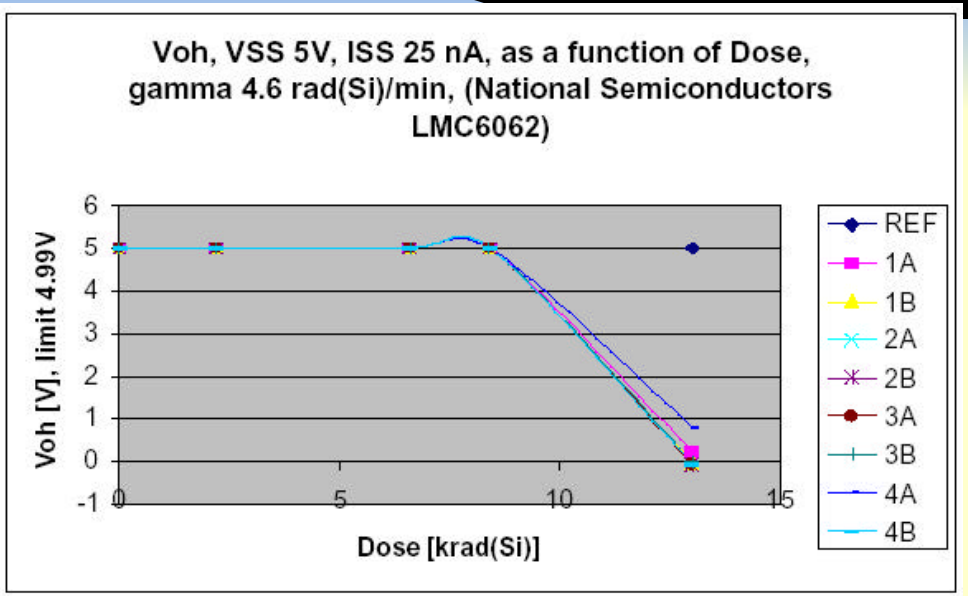


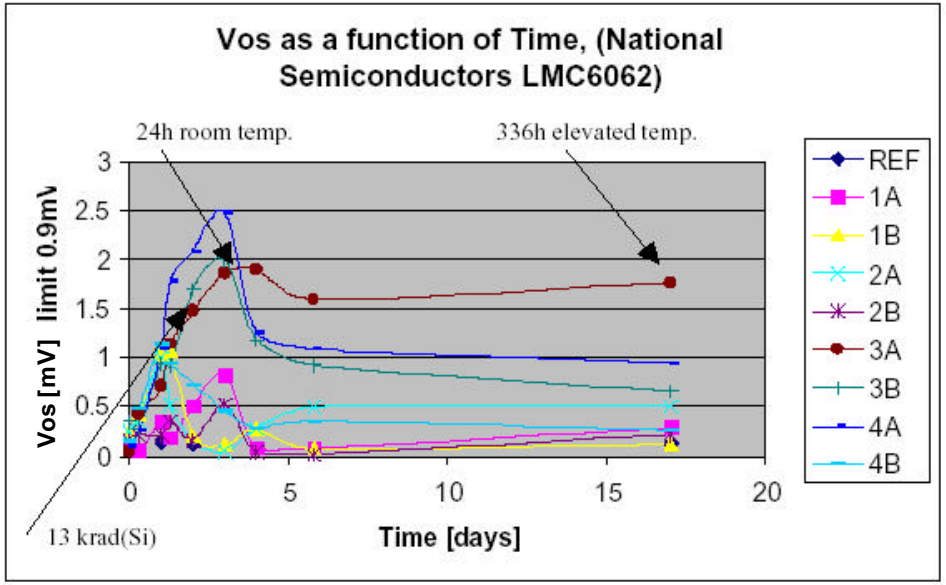


Science Payload and Advanced Concepts Office

TID testing (1)

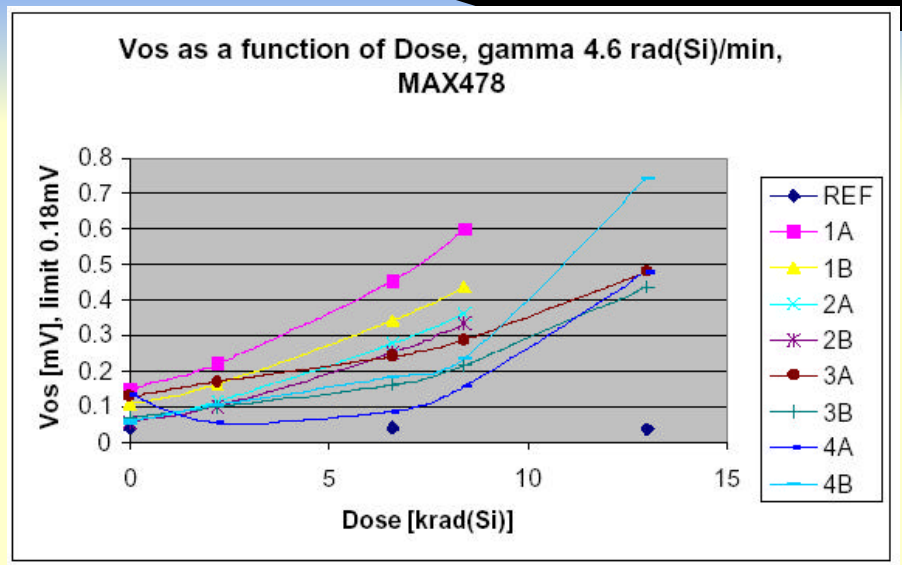
- National Semi LMC6062
- Micro power Dual OP-AMP, rail – rail output, low offset and low input bias current
- Output stage fails around 8.5 kRad but recovers during anneal
- Large spread in offset voltage, also during anneal
- Not selected.

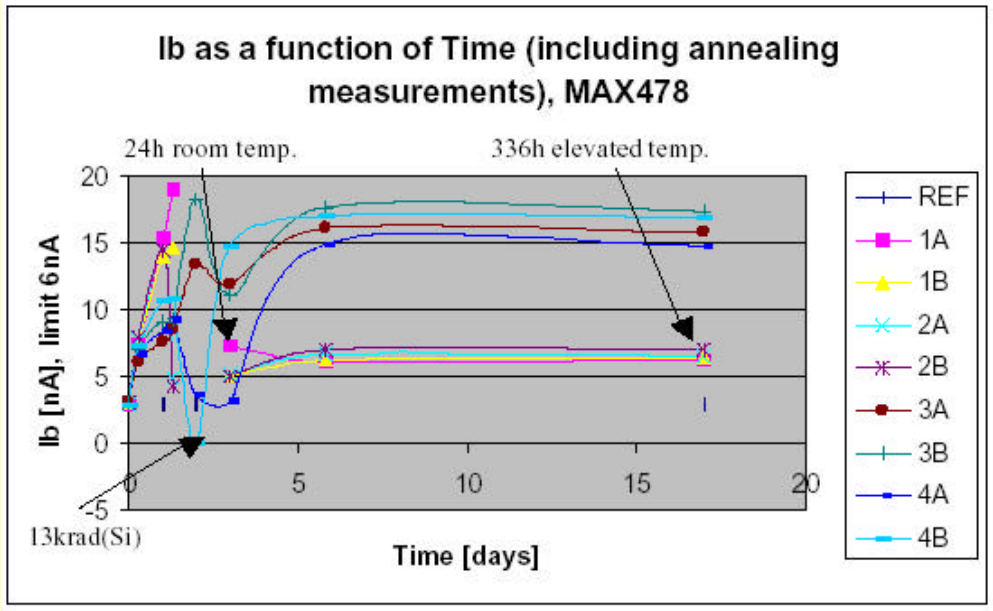




TID testing (2)

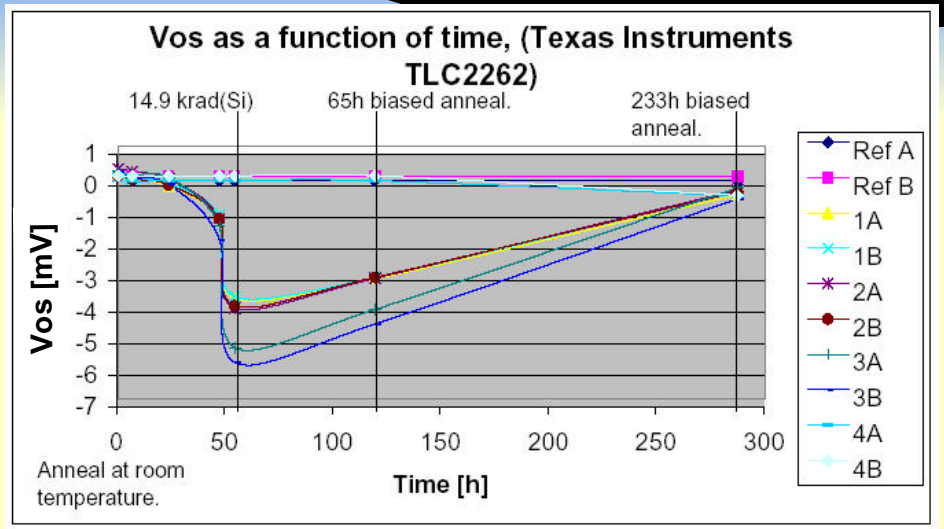
- Maxim MAX478
- Micro-power Dual OP-AMP, rail – rail output, low offset and low input bias current
- Two parts not functional at 8-13 kRad
- Ib outside limit at 2.2 kRad
- Large spread
- Not selected.

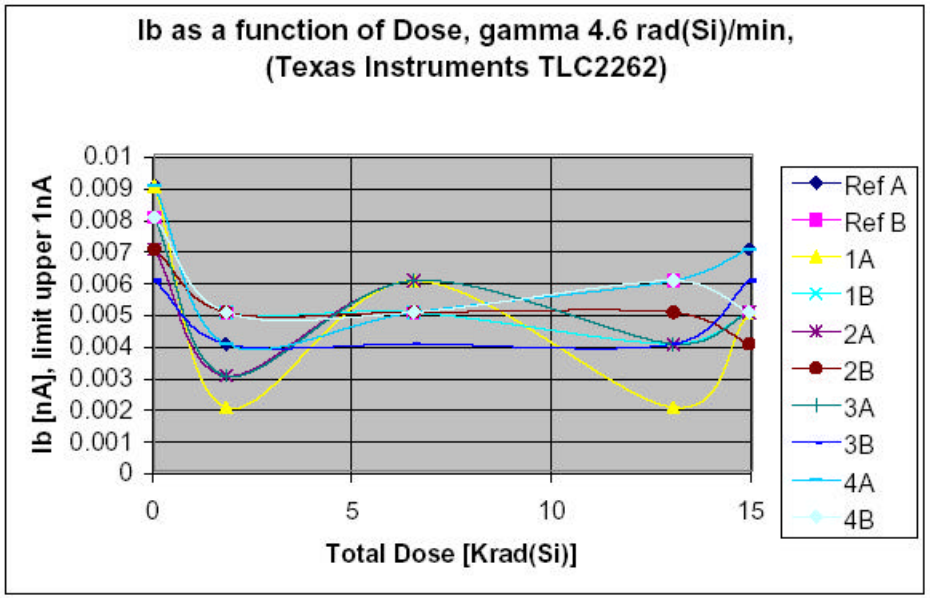




TID testing (3)

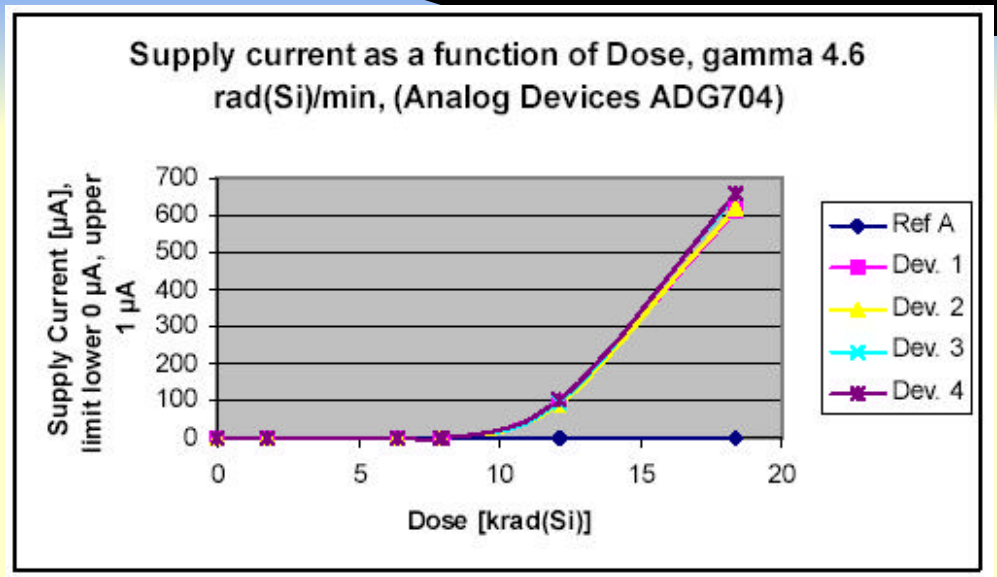
- Texas Instruments TLC2262
- Micro-power Dual OP-AMP, rail – rail output, low offset and low input bias current
- High input impedance (Ib) OK at 15 kRad
- Offset voltage recovers after annealing, small spread
- Selected for SEPT

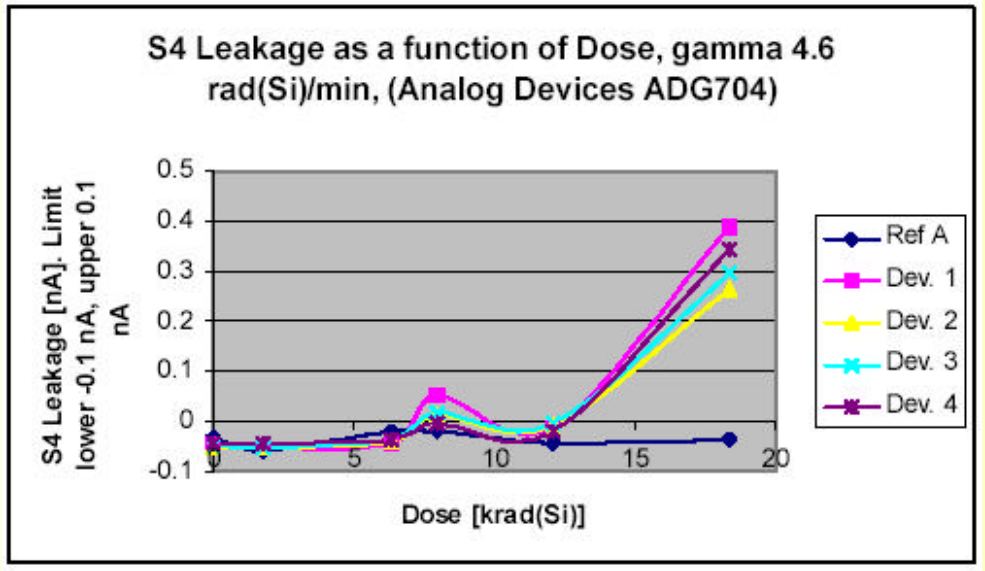




TID testing (4)

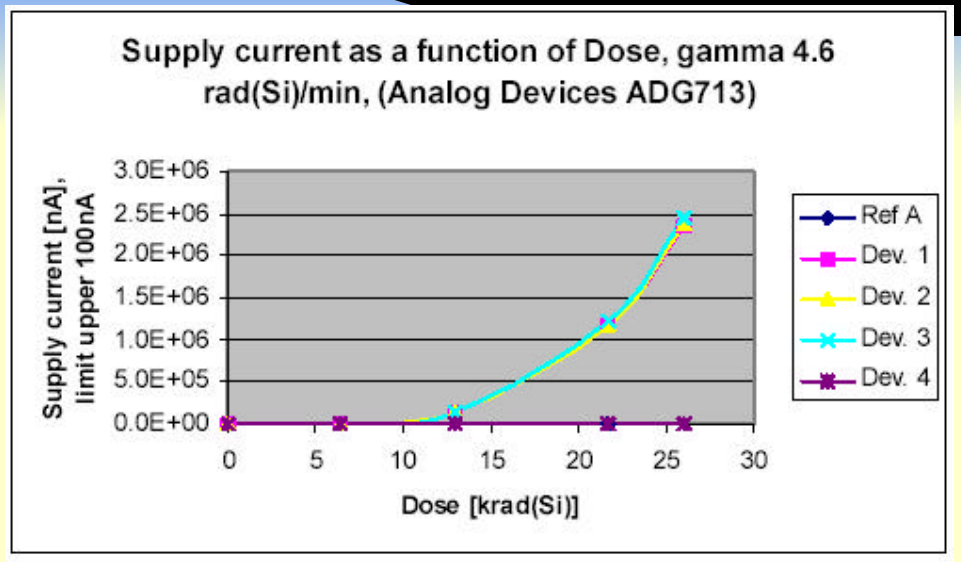
- Analog Devices ADG704
- CMOS, 2.5 Ohm, 4 channel analog multiplexer
- Large increase supply current but acceptable
- Leakage current increase but acceptable
- Small spread.
- Selected.

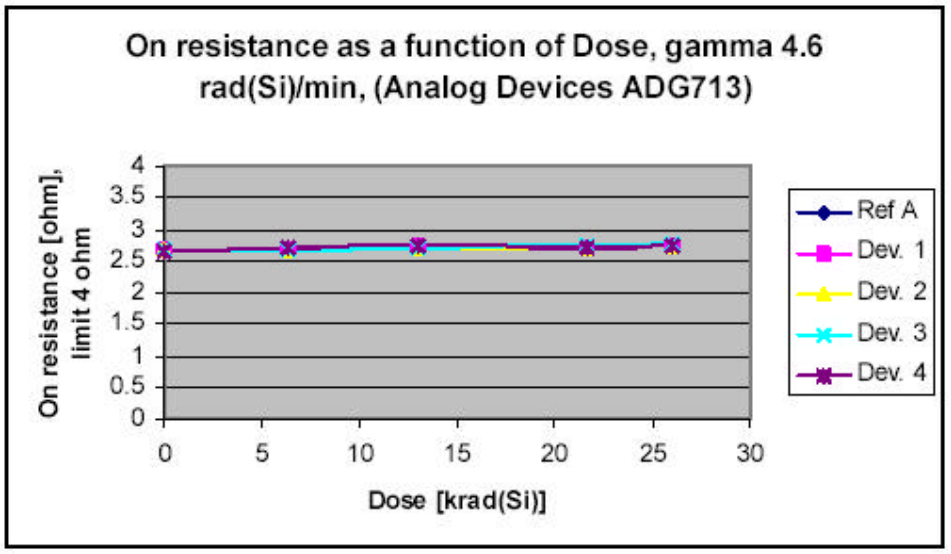




TID testing (5)

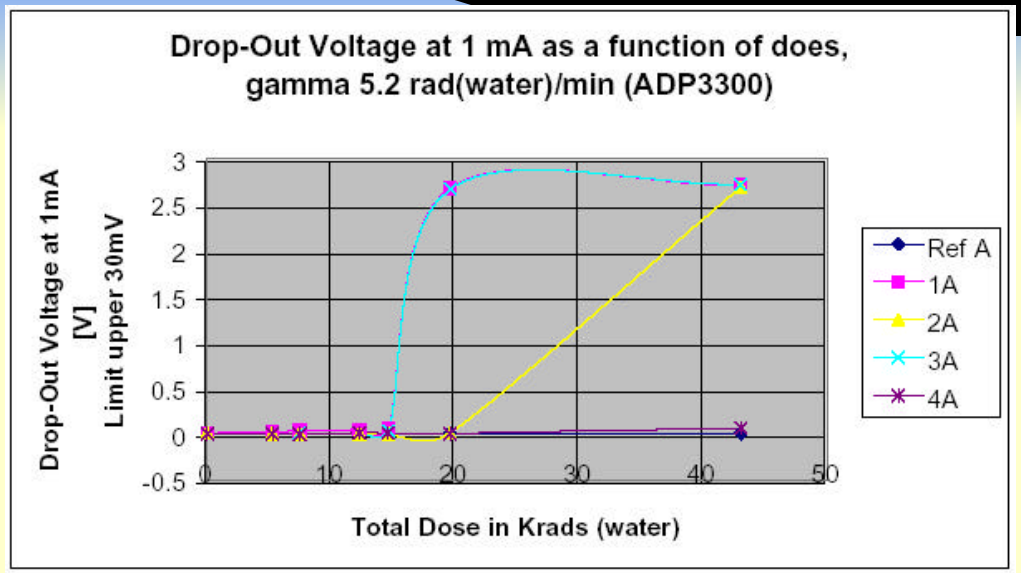
- Analog Devices ADG713
- CMOS, 2.5 Ohms, Quad analog SPST switch
- Large increase in supply current but acceptable
- On resistance stable
- Small spread
- Selected.

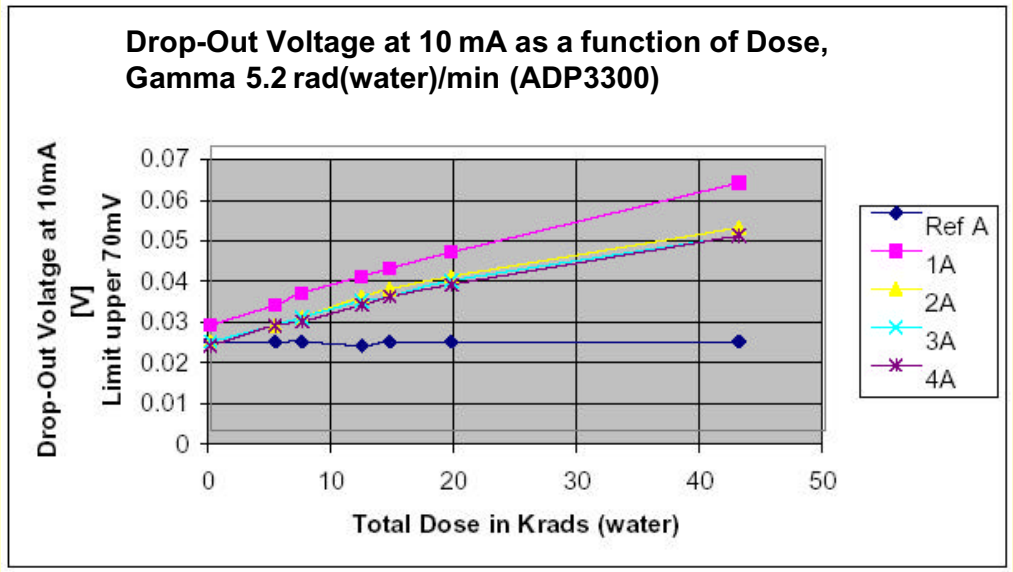




TID testing (6)

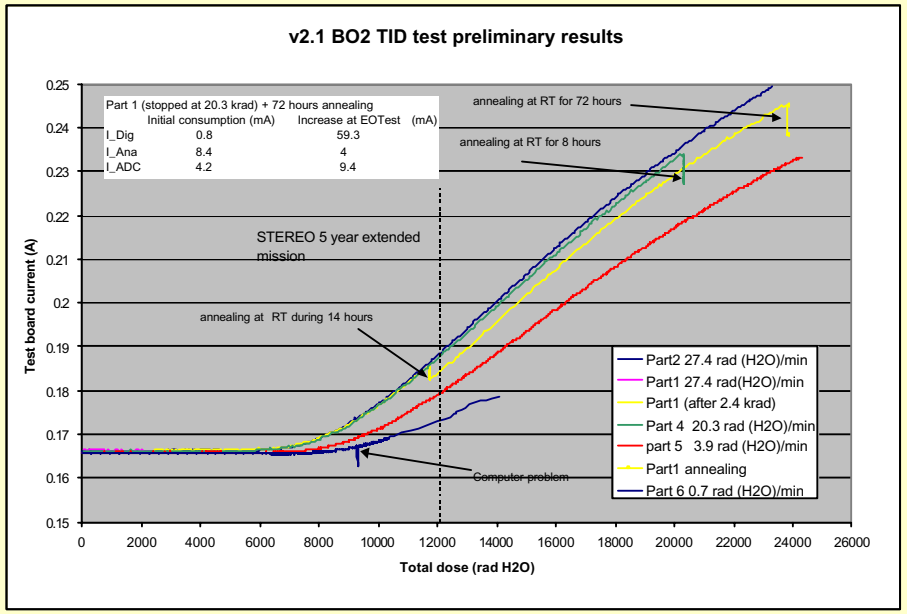
- Analog Devices ADP3300
- 50 mA low drop-out, 5V linear regulator
- Drop-out voltage for small loads most affected, considered acceptable
- Accuracy and ground current OK to >20 kRad.
- Selected.





TID testing (7)

- Particle Detector Front End ASIC (PDFE)
- Mixed CMOS ASIC, Dual charge amplifier/shaper, programmable discriminators and 8-bit ADC
- Current consumption for analog and digital supply increase from 8 kRad, functional at 24 kRad.
- Iso-chronal Annealing test give activation energy of 0.32-0.51 eV.
- Estimated max allowed supply current for in orbit dose rate is reached around 20 kRad.

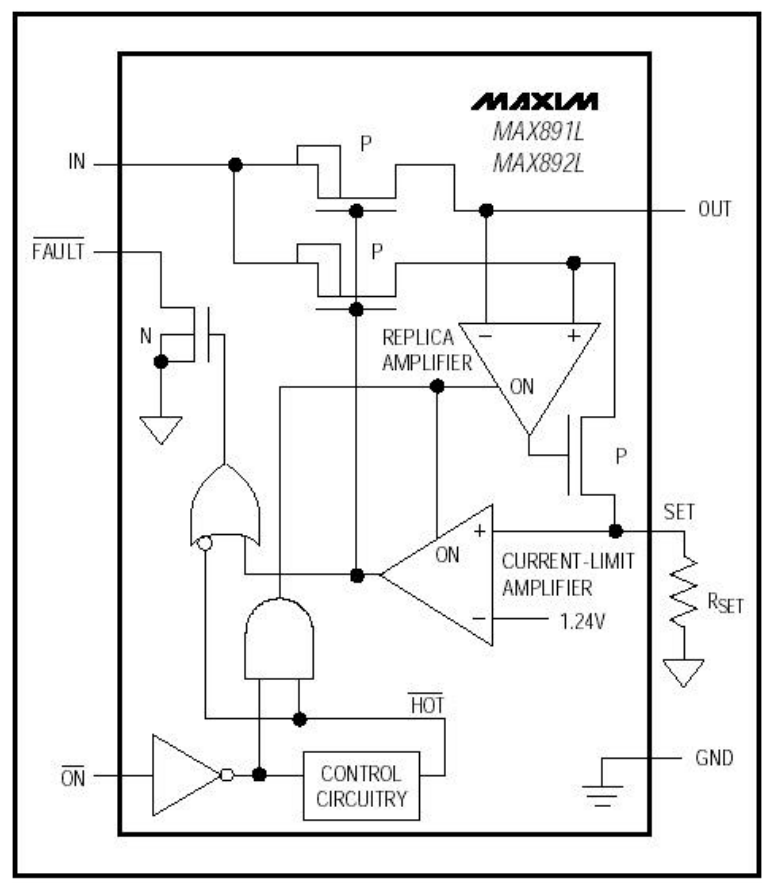


SEPT Single Events Effects Mitigation Strategy

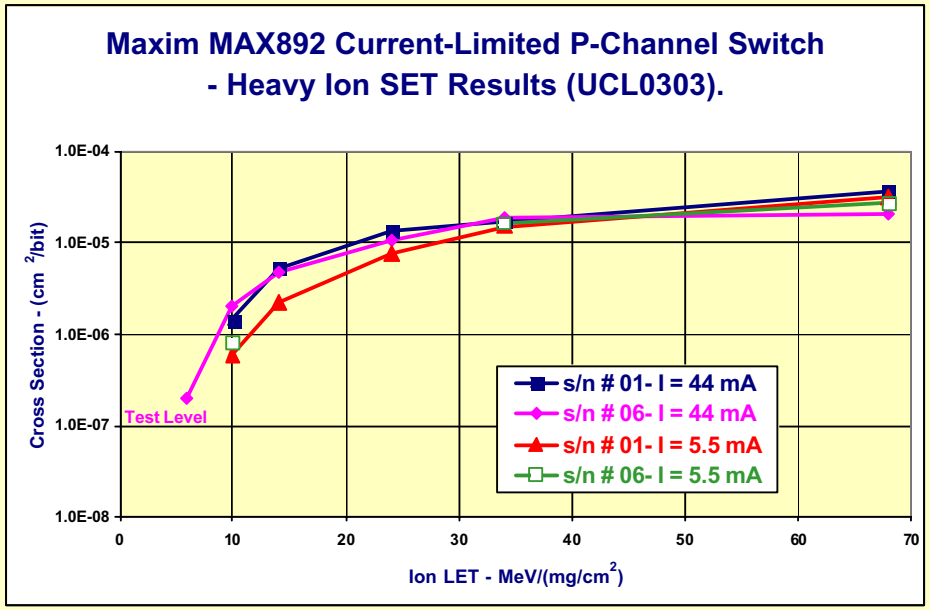
- PDFE ASIC known to be SEL sensitive (GCR) => on-board SEL protection necessary
- All digital control functions selected (FPGA, SOI memory…) and designed (e.g. SET filtering) to be SEE insensitive.
- Analog parts analysed for in-circuit SEE effects and classified
- Complete instrument re-configuration after each measurement integration (1 min)
- Verification of critical SEE effects for parts and SEL mitigation strategy of complete instrument.

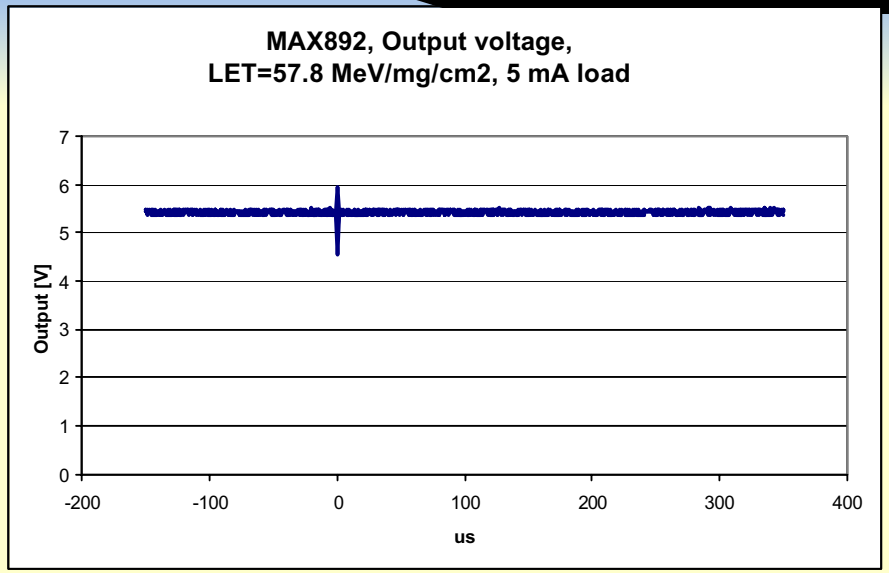
SET effects in SEL protection circuitry

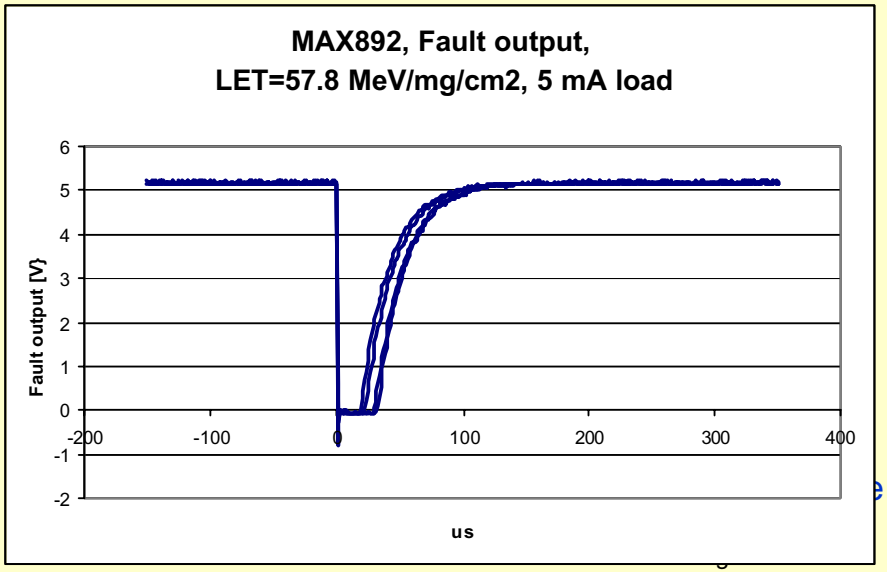
- Maxim MAX 892
- High side, low resistance, P-channel switch with adjustable current limit
- Critical SET effects: false indication of current overload and/or output voltage drop-out
- Test results: SET on error output depends on load, < 65 us. Probably SET in current-limit amplifier.
- No SET effect on P-channel switch (no output drop-out).



MAX 892 SET test results







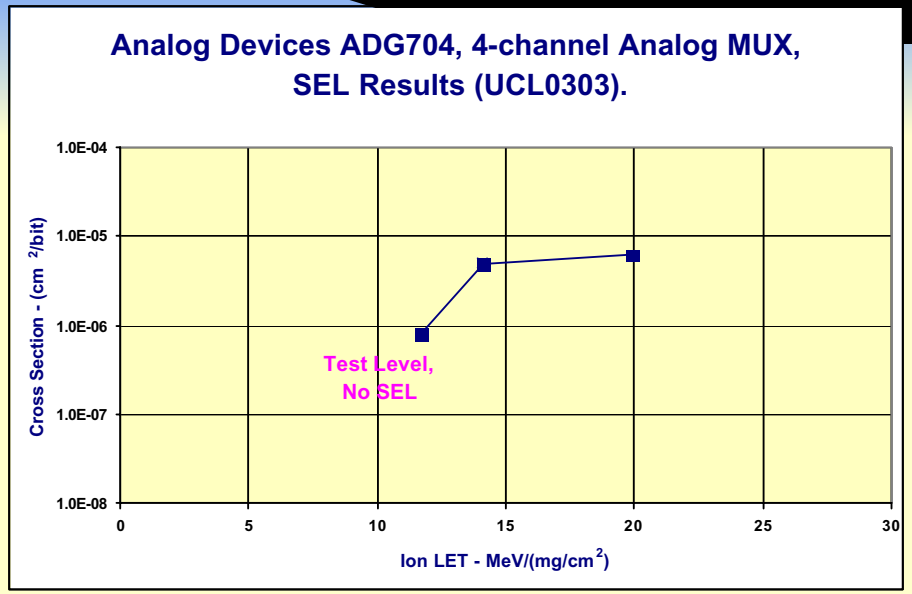
B. Johlander, 11-05-2004

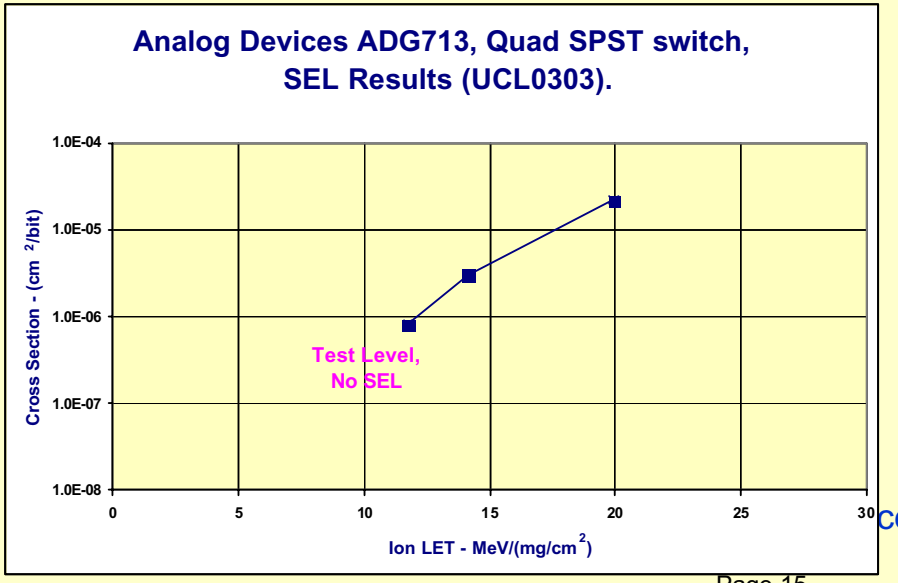
SEL testing Analog integrated parts

- Analog IC's used for house keeping and calibration pulser, not critical for SET, only SEL.
- Texas TLC2262 Dual OP-amp: No Latch-up for LET=68 MeV/(mg/cm^2).
- Analog Devices ADP3300 (linear voltage regulator): No Latch-up for LET=58 MeV/(mg/cm^2).
- Analog Devices ADG704 (4-channel MUX) and ADG713 (Quad SPST switch) Latch-up sensitive.

SEL results ADG704 and ADG713

- Estimated maximum event rate (SEL):
- ADG704: < 0.7 SEL/Year
- ADG713: < 0.9 SEL/Year
- Parts protected by MAX892.





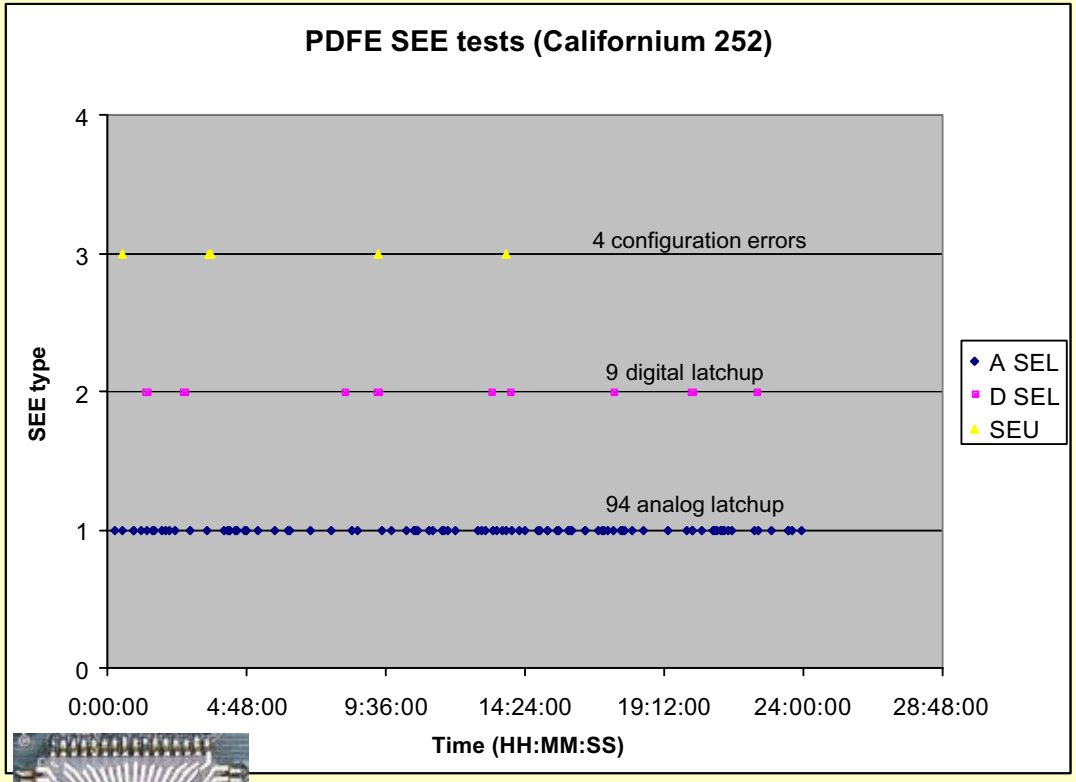
PDFE SEL protection verification

- Cf-252 testing performed on complete instrument breadboard.
- No performance degradation.

  Digital part: 4.0E-6 cm^2/device

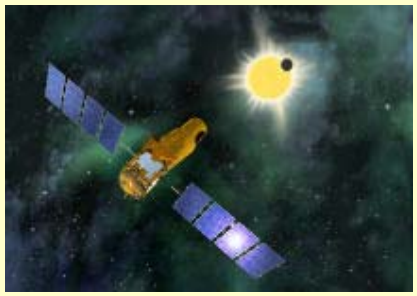
  Analog part: 4.2E-5 cm^2/device

  SEU Cross Section - Digital/Analog part: 1.8E-6 cm^2/device



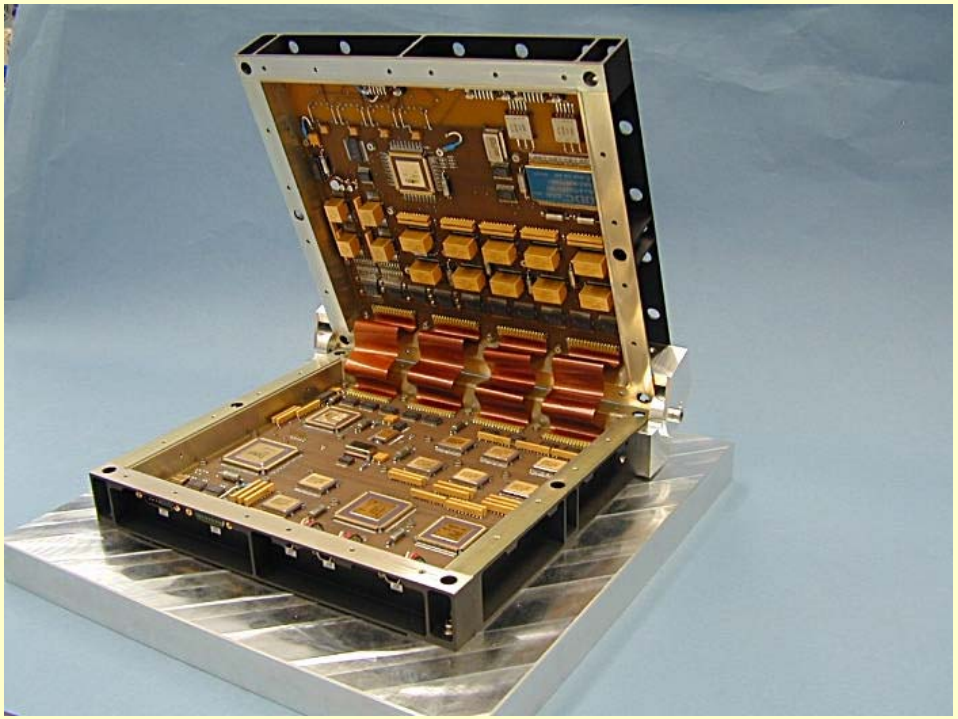
COROT – Convection, Rotation and Planetary Transits

- CNES program with ESA support
- Proteus mini-satellite (670 kg), polar orbit
- The detection and the study of stars vibrations (stellar seismology).
- The search for extrasolar planets and more particularly the telluric planets.
- Launch June 2006



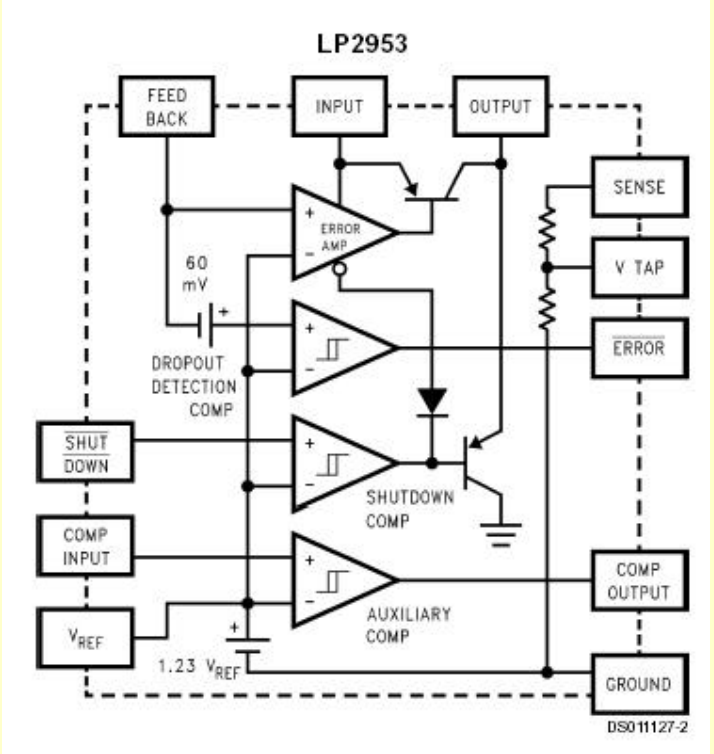
COROT Data Processing Unit

- Based on Mosaic-20 (20 MHz 21020 DSP). EADS/Astrium responsible for electronics design and electronics assembly. SCI-A overall responsible, components, mechanics and environmental tests.
- Participation to COROT as Scientific collaboration with Research and Scientific Support Dept (ESA).
- 16 Mbit R/H SRAM (Honeywell HX 6228), 320 Mbit rad tolerant SRAM (Samsung 4008V1C), 32 Mbit EEPROM (Hitachi HN58C1001)
- Telecommand I/F: MIL-STD-1553, Data I/F: Spacewire
- 2.2 kg, typical 7 W. Two hot redundant units on COROT.

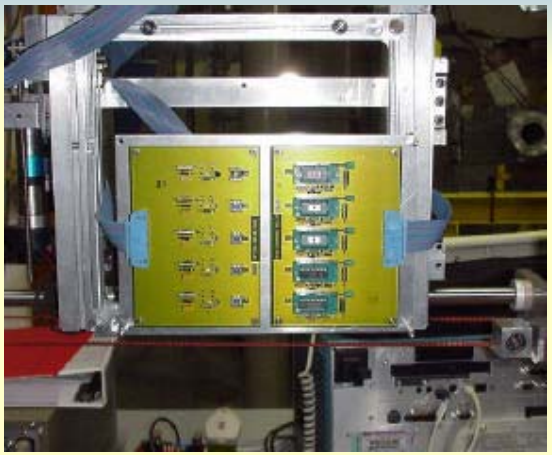


National Semi LP2953A voltage regulator

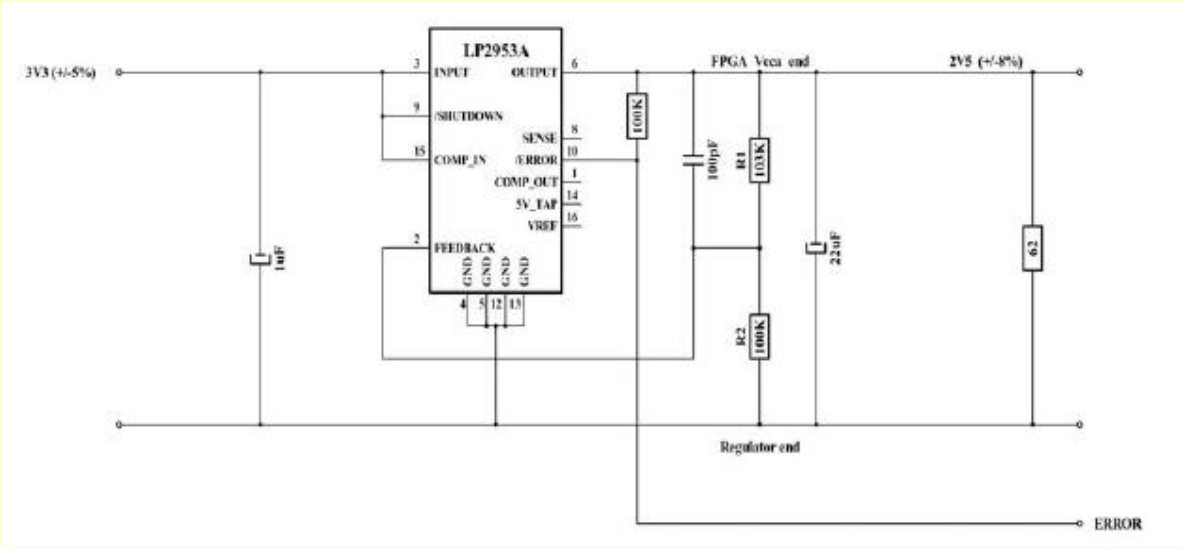
- LP2953A: adjustable, micro-power, low drop-out linear regulator
- Used to supply Actel RT54SX32S core, 2.5V
- Critical SET effect: output voltage drop-out or over voltage spike.



LP2953A SET test setup

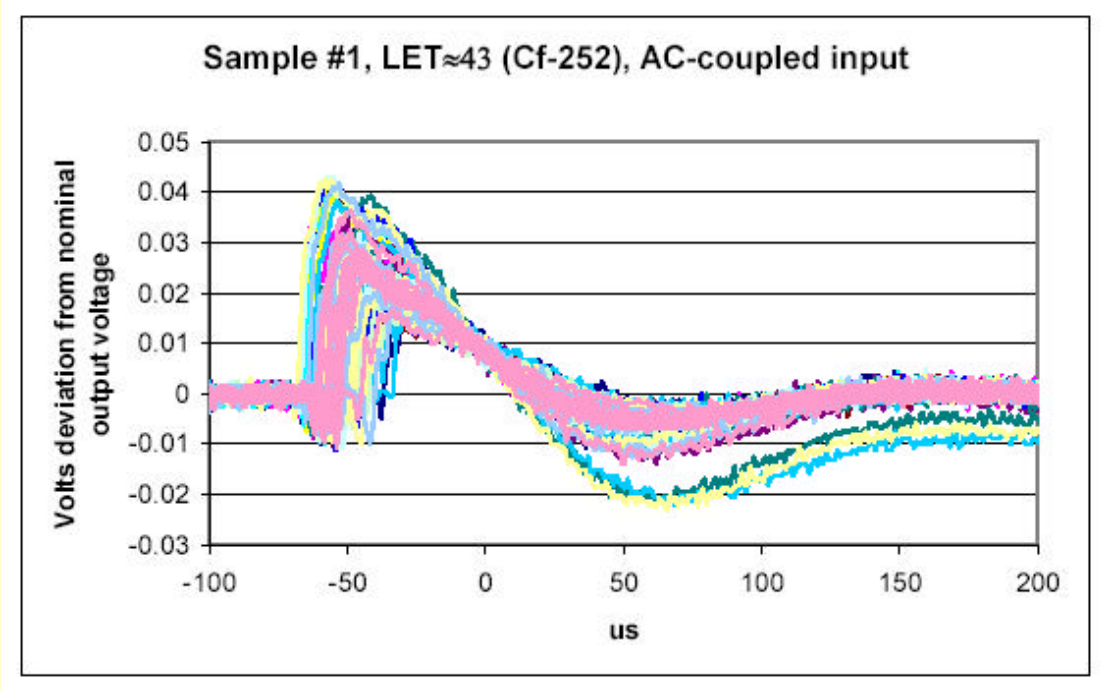


- 3.3V input voltage, 2.5 V output
- 40 mA load
- Monitor input voltage, output voltage and Error output.

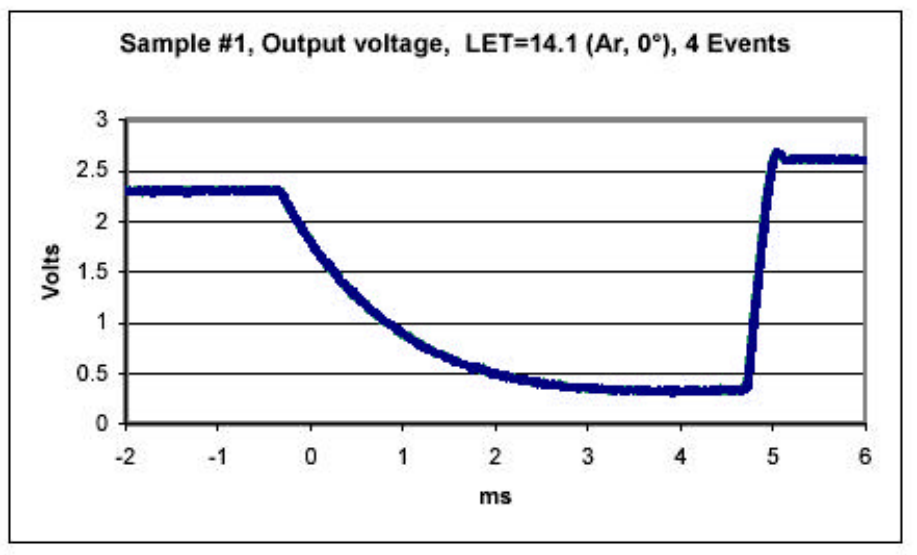


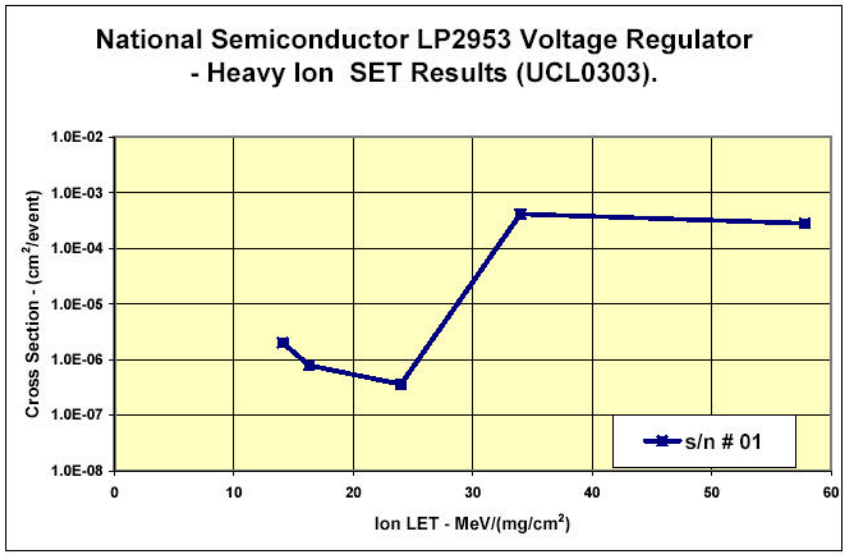
LP2953A initial SET test results

- Cf-252 pre-testing showed small (<50 mV) output spikes



LP2953A LLN SET initial results

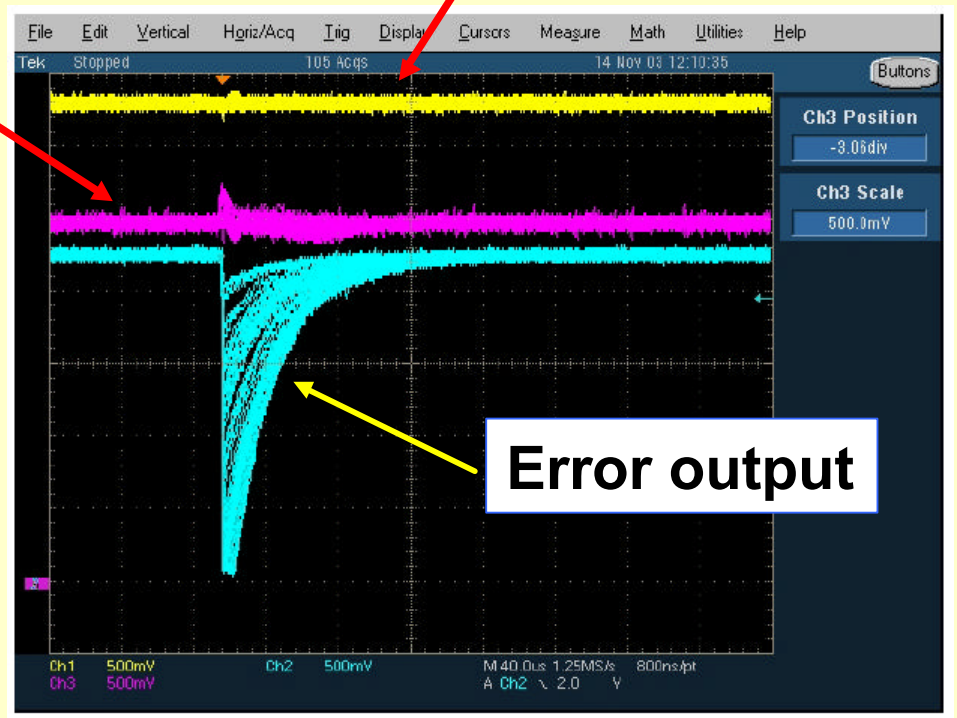




- Out of two tested samples, one sample displayed large output voltage drop-outs with a strange cross section….

LP2953A LLN SET re-test

- Three additional samples were tested for SET, no large drop-outs observed for 1E6 particles/cm^2.
- When triggering on Error output, <50 mV output spikes were observed.



Electrical test LP2953A

- The single sample LP2953A that was found to be sensitive to large output voltage drop-outs was also found to be sensitive to light illumination (not the case for other samples).
- Electrical parametric testing showed the same sample internal bandgap reference was defective that is turned caused the regulation loop to switch off the output when hit by ion.
- No physical evidence for damage has been found but damage from de-capsulation suspected cause.
- Remaining flight lot has been 100% electrically re-tested, no failures.