CENTRE NATIONAL D'ÉTUDES SPATIALES

Compendium of 2006 radiation evaluation tests results on commercial integrated circuits

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OUTLINE

- Converters : ADC, DAC and CSP
- Operational amplifiers
- Interfaces
- Others integrated circuits
- Conclusion / Trends

ADC & DAC & CSP : Tested components

Part Number	Manufacturer	Description	SEL	TID
ADC12181CIVT	NSC	12-Bit, 10 MHz ADC	**By CNES**	**By CNES**
LTC1407A-1	LT	Serial 14-Bit, 3Msps ADC	**By TRAD**	No
LTC2297IUP	LT	Dual 14-Bit, 40Msps Low Power 3V ADC	**By TRAD**	No
LTC1608ACG	LT	16-Bit, 500ksps ADC	**By CNES**	**By CNES**
AD7621AST	AD	16-Bit, 2 LSB INL, 3 MSPS PulSAR® ADC	**By TRAD**	**By CNES**
VSP1221PFB	TI	CCD Signal processor	**SEL by CNES** **SEE by TRAD**	**By CNES**
TLV5618A	TI	2.7-V to 5.5-V Low power Dual 12-BIT DAC	**By CNES**	**By CNES**

ADC : ADC12181CIVT from NSC

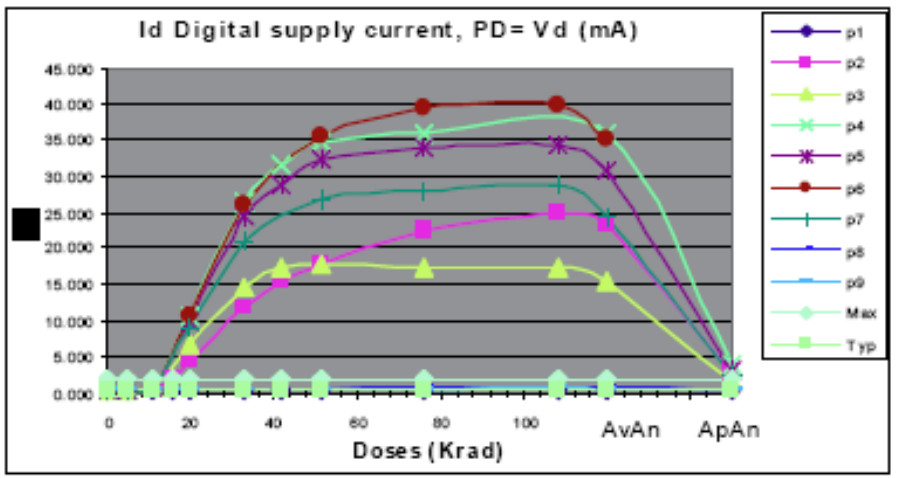
Description : 12-Bit, 10MHz Self-Calibrating, Pipelined ADC
Package : TQFP32
Technology : CMOS - CS065 process
Date code : 0052

SEL :

- IPN (limited range)
- **No SEL for LET=60MeV/mg.cm²**

TID :

- 200 rad/h up to 100Krad
- Annealing 24h/25°C & 168h/100°C
- 8ON+2OFF +1 ref
- **At 10Krad, biased parts exceedeed Icc. Partially recovery after annealing.**
- **Unbiased parts passed all tests up to 108Krad.**



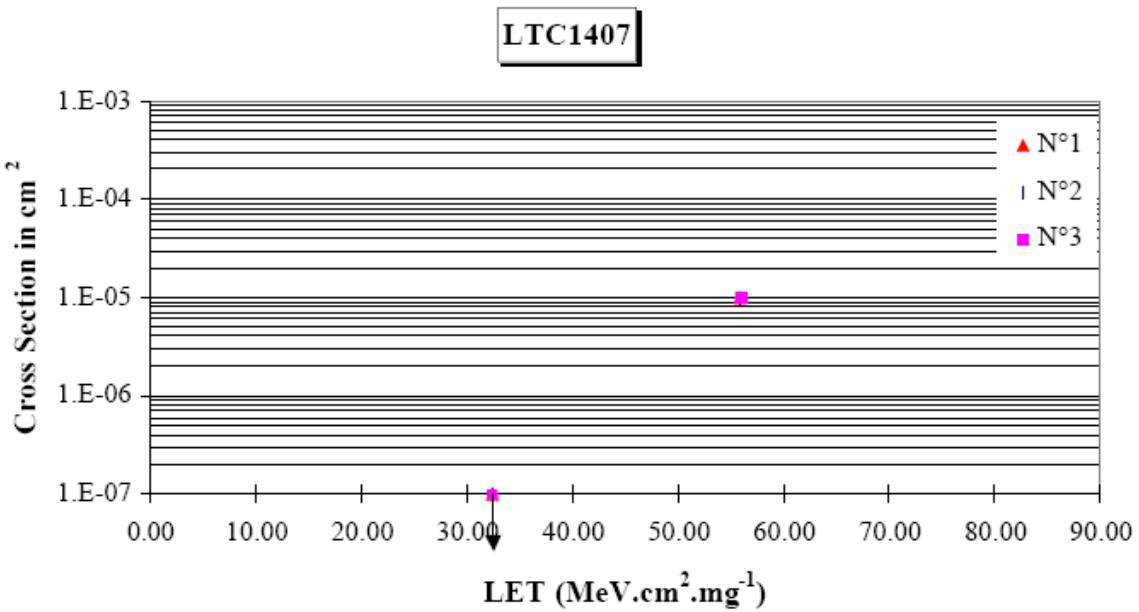
ADC : LTC1407A-1 from Linear Tech

Description : Serial 14-Bit, 3Msps Simultaneous Sampling ADC

Package : MSOP10

Technology : CMOS Date code : ?

- **SEL :**
  - UCL M/Q=5 & M/Q=3.3
  - **Few SEL → 32,4<LETth< 55MeV/mg.cm² ; σsat~1E-5cm²**



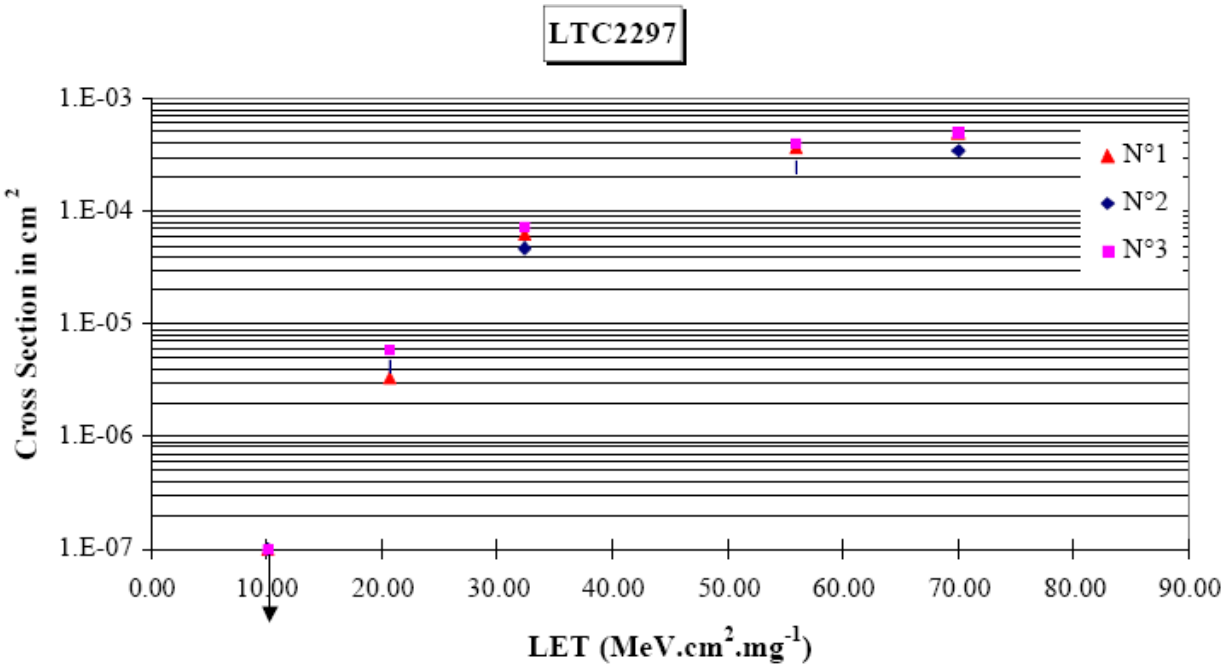
ADC : LTC2297IUP from Linear Tech

Description : Dual 14-Bit, 40Msps Low Power 3V ADC
Package : QFN64
Technology : CMOS
Date code : 0452

- **SEL :**
  - UCL M/Q=5 & M/Q=3.3
  - **SEL Sensitive :**

LETth~10MeV/mg.cm² ;

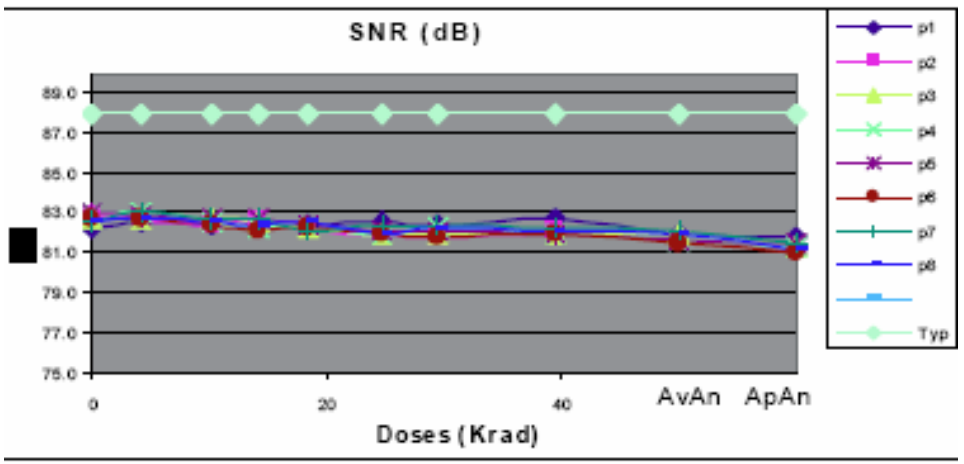
σsat=4E-4cm²



ADC : LTC1608ACG from Linear Tech

Description : High Speed,16-Bit, 500ksps Sampling A/D Converter
Package : SSOP36
Technology : CMOS 1,2µm
Date code : 0224

- SEL :
  - IPN (limited range)
  - **No SEL for LET=60MeV/mg.cm²**



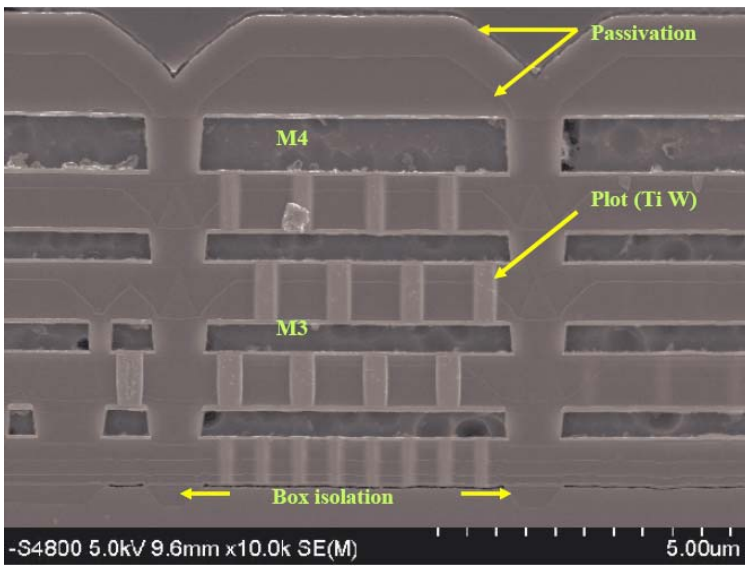
- **TID :**
  - 90 rad/h up to 39,6Krad
  - Annealing 24h/25°C & 168h/1,5 month
  - 5ON+2OFF +1 ref
  - **All parts passed all tests up to 39,6Krad**

ADC : AD7621AST from Analog Devices

Description : 16-Bit, 2 LSB INL, 3Msps PulSAR® ADC
Package : LQFP48
Technology : CMOS 0,25µm
Date code : 0501 & 0617

- **SEL :**
  - UCL M/Q=5 & M/Q=3,3
  - **No SEL for LET=55,9MeV/mg.cm²**

- **TID :**
  - 200 rad/h up to 40Krad
  - Annealing 24h/25°C & 168h/100°C
  - 8ON+2OFF +1 ref
  - **On going**



CSP : VSP1221PFB from Texas Instruments

Description : 12-BIT, 21Msps, Ultralow-power, CCD Signal Processor
Package : TQFP48
Technology : CMOS 0,5µm
Date code : 0501

- **SEL :**
  - IPN (limited range)
  - **No SEL for LET=60MeV/mg.cm²**

- **TID :**
  - 30 rad/h up to 30Krad
  - Annealing 24h/25°C & 168h/100°C
  - 8ON+2OFF +1 ref
  - **At 30Krad, biased parts exceedeed Icc and Iozh. No recovery for Icc after annealing.**
  - **Unbiased parts passed all tests up to 30Krad.**

- **SEL/SET/SEU/SEFI :**
  - UCL M/Q=3.3
  - **Test results :**
    - **No SEL for LET=32,4MeV/mg.cm²**
    - **SEU sensitive**
    - **SET sensitive**
    - **SEFI sensitive**
  - **But** after chemical opening, parts showed functional failures ; so we **couldn't conclude on SEE test results**
  - The irradiated parts will be expertised
  - A new test should be performed in 2007

DAC : TLV5618A from Texas Instruments

Description : 2.7-V to 5.5-V Low-Power Dual 12-BIT DAC

Package : SO8

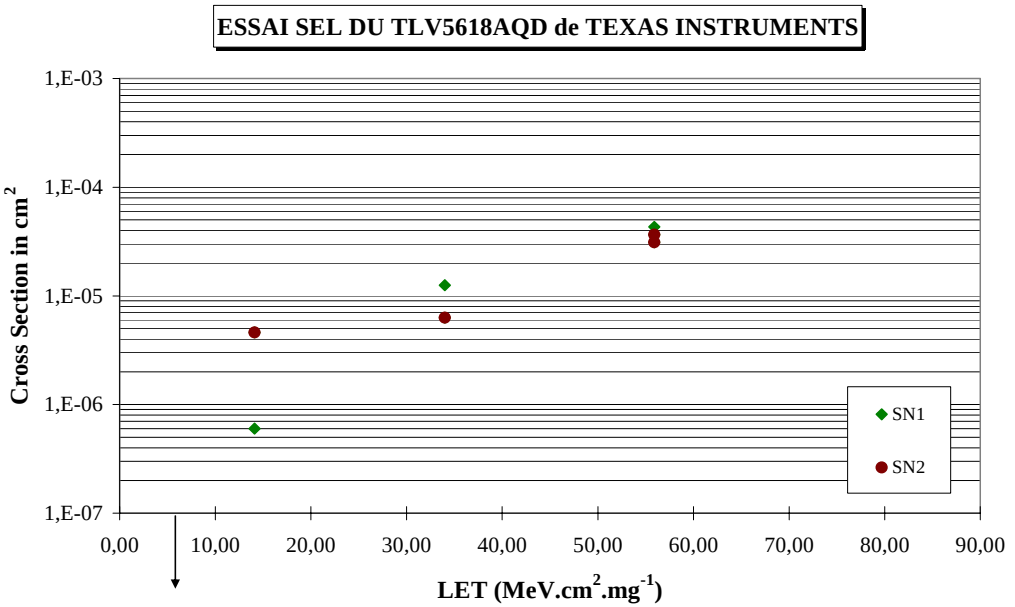
Technology : CMOS Date code : ?

- **SEL :**
  - UCL M/Q=5
  - **SEL sensitive :**

    LETth ~ 6 MeV/mg.cm² ;

    σ sat ~ 4E-5cm².

- **TID :**
  - 200 rad/h up to 40Krad
  - Annealing 24h/25°C & 168h/100°C
  - 8ON+2OFF +1 ref
  - **On going**



AOP : Tested components

Part Number	Manufacturer	Description	SEL	TID
AD8661	AD	Low Noise, Precision 16 V CMOS, Rail-to-Rail Op Amp	**By CNES**	**By Hirex**
TLV2254AI	TI	Rail-to-Rail very low power Op Amp	**By CNES**	**By Hirex**
LMP7701	TI	Precision, CMOS Input, RRIO, Wide Supply Range Amp	**By TRAD**	**By Hirex**
OP727ARU	AD	Precision Micropower Single-Supply Op Amp	No	**By CNES**
THS4304	TI	Wideband, voltage-feedback Op Amp	**By TRAD**	**By Hirex**
OPA683	TI	Very Low-Power, Current Feedback Op Amp	No	**By Hirex**
AD822AR	AD	Single-Supply, Rail-to-Rail Low Power FET-Input Op Amp	No	**By CNES**

AOP : AD8661 from Analog Devices

Description : Low Noise, Precision 16V CMOS, Rail-to-Rail Operational Amplifiers

Package : SO8

Technology : BiCMOS – iCMOS process

Date code : 0511

- **SEL :**
  - UCL M/Q=5 & M/Q=3,3
  - **No SEL for LET= 55,9MeV/mg.cm²**

- **TID :**
  - 100 rad/h up to 40Krad
  - Annealing 24h/25°C & 168h/100°C
  - 8ON+2OFF +1 ref
  - **At 13Krad, Vos, Voh, SR, GBP, Avol, CMRR and PSRR were out of spec and the biased parts were no more functional**
  - **No recovery was observed after annealing steps**

AOP : TLV2254AI from Texas Instruments

Description : Advanced LinCMOS Rail-to-Rail very low power Operational Amplifiers

Package : SO14

Technology : CMOS –Advanced LinCMOS process

Date code : ?

- **SEL :**
  - UCL M/Q=5 & M/Q=3,3
  - **No SEL for LET= 55,9MeV/mg.cm²**

- **TID :**
  - 100 rad/h up to 40Krad
  - Annealing 24h/25°C & 168h/100°C
  - 8ON+2OFF +1 ref
  - **All parts failed functionaly at 22 Krad. Irradiation steps were stopped at this stage.**
  - **Biased parts didn't return functionaly after annealing contrary to unbiased samples.**

AOP : LMP7701 from NSC

Description : Precision, CMOS Input, RRIO, Wide Supply Range Amplifier
Package : SOT23-5
Technology : VIP50 (commercial SOI process)
Date code : ?

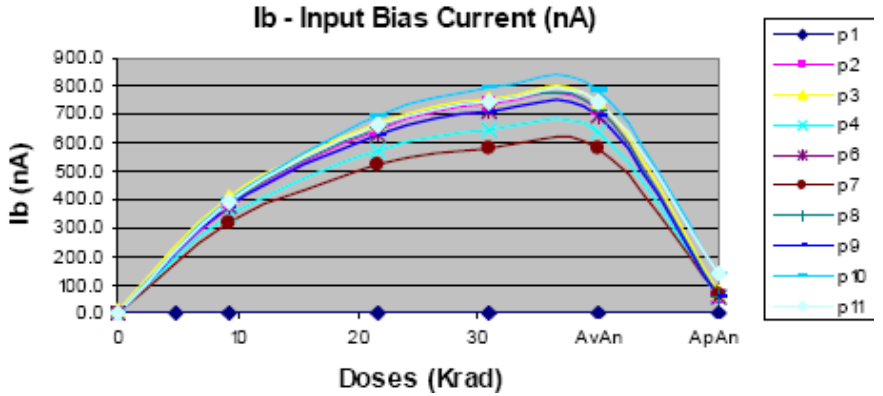
- **SEL :**
  - After chemical opening, parts showed an increase of Icc
  - As parts show functional failures, we cannot conclude on SEL test results
  - A new test is planned in 2007

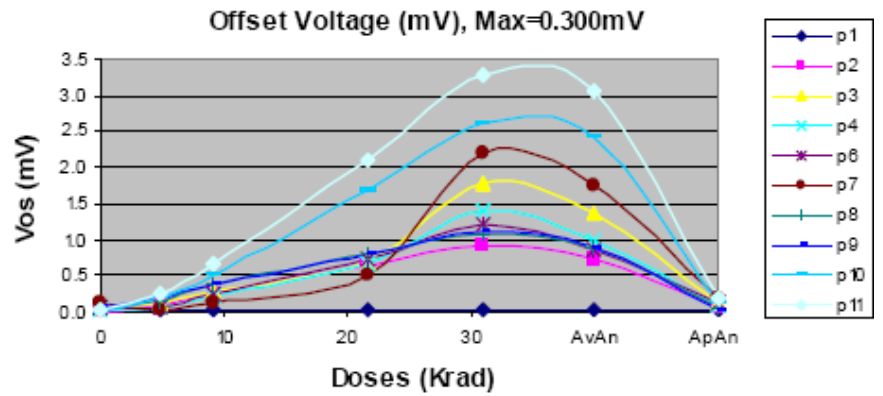
- **TID :**
  - 50 rad/h up to 40Krad
  - Annealing 24h/25°C & 168h/100°C
  - 8ON+2OFF +1 ref
  - **At 27 Krad, Ib failed spec. These parameter returned within spec after annealing.**
  - **All others parameters remained within spec all along testing.**

AOP : OP727ARU from Analog Devices

Description : Precision Micropower Single-Supply Operational Amplifiers
Package : TSSOP8
Technology : BiCMOS
Date code : 0543

- **TID :**
  - 140 rad/h up to 30,9Krad
  - Annealing 24h/25°C & 168h/100°C
  - 8ON+2OFF +1 ref
  - **Ib outside limit at 4,8Krad**
  - **Ios and Vos out of spec at 9,2Krad**
  - **No recovery after annealing**





AOP : THS4304 from Texas Instruments

Description : Wideband, voltage-feedback operational amplifier
Package : SO8
Technology : BiCom3 with Silicon germanium (commercial SOI process)
Date code : ?

- **SEL :**
  - UCL M/Q=5 & M/Q=3,3
  - **No SEL for LET= 55,9MeV/mg.cm²**

- **TID :**
  - 50 rad/h up to 40Krad
  - Annealing 24h/25°C & 168h/100°C
  - 8ON+2OFF +1 ref
  - **A rebound effect was observed on Ios during the last annealing step.**
  - **All others parameters remained within spec all along testing.**

AOP : OPA683 from Texas Instruments

Description : Very Low-Power, Current Feedback Oparational Amplifier with Disable

Package : SOT23-6

Technology : Bipolar – CBC10 process

Date code : ?

- **TID :**
  - 50 rad/h up to 40Krad
  - Annealing 24h/25°C & 168h/100°C
  - 8ON+2OFF +1 ref
  - **All parts passed all tests up to 40Krad**

AOP : AD822AR from Analog Devices

Description : Single-Supply, Rail-to-Rail Low Power FET-Input Op Amp

Package : SO8

Technology : Bipolar

Date code : 0605

- **TID :**
  - 150 rad/h up to 32,4Krad
  - Annealing 24h/25°C & 168h/100°C
  - 8ON+2OFF +1 ref
  - **Ib was out of spec at 5.1Krad for one unbiased part and at 9.75Krad for all others parts.**
  - **All the parameters returned within spec after 168h/100°C annealing**

INTERFACES : Tested components

Part Number	Manufacturer	Description	SEL	TID
ADM3485	AD	3.3V RS-485/RS-422 Transceivers	**By CNES**	**By CNES**
TPS2830	TI	MOSFET Drivers	**By / CNES**	**By Hirex**
BU-65170G1	TI	MIL-STD-1553A/B Notice 2 RT and Bus Controller / Remote Terminal / Monitor Terminal, Advanced Communication Engine	**HI + Protons by TRAD**	**By Hirex**

INTERFACES : ADM3485E from Analog Devices

Description : 3.3 V Slew Rate Limited, Half- and Full-Duplex, RS-485/RS-422 Transceivers

Package : SO8

Technology : CMOS 0,8-2µm Date code : 0614

- **SEL :**
  - UCL M/Q=5
  - **No SEL for LET= 55,9MeV/mg.cm²**
- **TID :**
  - 150 rad/h up to 32,4Krad
  - Annealing 24h/25°C & 168h/100°C
  - 8ON+2OFF +1 ref
  - **At 9,7Krad biased parts exceeded spec for ViLmax; at 20Krad these parts failed the functional test**
  - **At 20Krad unbiased parts exceeded spec for ViLmax. At 32Krad, parts are not functional**
  - **No functional nor parametric recovery after annealing.**

INTERFACES : TPS2830 from Texas Instruments

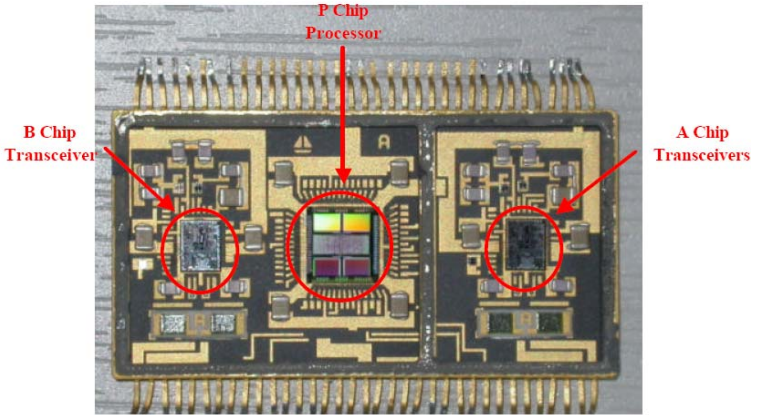
Description : Fast Synchronous Buck MOSFET Drivers with Dead-time control
Package : SO14
Technology : CMOS Date code : ?

- **SEL :**
  - UCL M/Q=5
  - **No SEL for LET = 55,9MeV/mg.cm²**

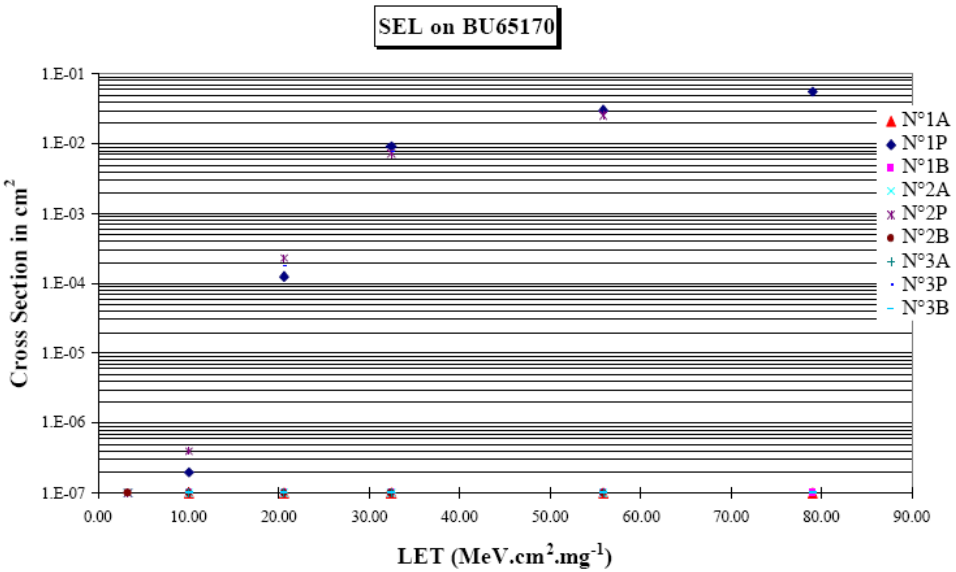
- **TID :**
  - 100 rad/h up to 40Krad and Annealing 24h/25°C & 168h/100°C
  - 8ON+2OFF +1 ref
  - **At 13Krad, biased parts were out of limit for Icc1 and VIL . These parameters returned within spec after 168h/100°C annealing.**
  - **At 20Krad, unbiased parts failed spec for VIL_4.5V_SYNC and VIL_15V_SYNC. No recovery after annealing.**
  - **A rebound effect was observed on IL_Sink and RL_Sink during last annealing step.**

INTERFACES : BU-65170G1 from DDC (1/2)

Description : MIL-STD-1553 Advanced Communication Engine
Package : KSO70
Technology : CMOS
Date code : 0605

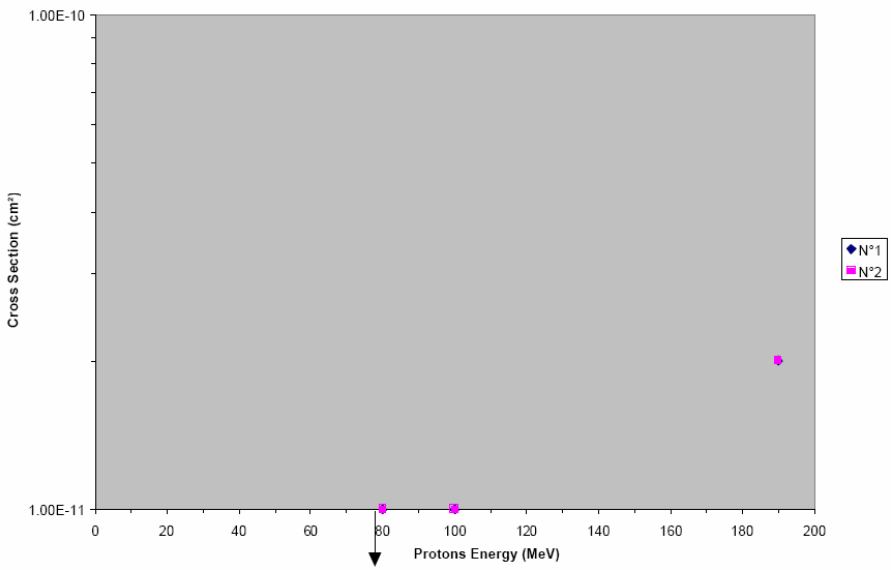


- **SEL / HI :**
  - UCL M/Q=5 & M/Q=3.3
  - **Processor die : SEL sensitive → LETth~3,3MeV/mg.cm² and σ sat~5,6E-2cm²**
  - **2 transceivers dies : No SEL for LET = 55,9MeV/mg.cm².**



INTERFACES : BU-65170G1 from DDC (2/2)

- **SEL / Protons :**
  - KVI - 190MeV ; 100MeV ; 80MeV
  - **Few SEL for 190MeV : σ sat~2E-11cm²**
  - **No SEL for 80MeV**



- **TID :**
  - 50 rad/h up to 30Krad
  - Annealing 24h/25°C & 168h/100°C
  - 5ON+1OFF +1 ref
  - **On going**

OTHERS ICs : Tested components

Part Number	Manufacturer	Description	SEL	TID
LM2743	NSC	N-Channel MOSFET Synchronous Buck Regulator Controller	**SEL by CNES SEE planned in 2007 by TRAD**	**By Hirex**
ADG901BMR	AD	SPST Switches	No	**By TRAD**
DS1100Z-200	Dallas	Delay line	No	**By TRAD**
NB100LVEP91DW	ON	2.5 V/3.3 V Any Level Positive Input to −2.5 V/−3.3 V LVNECL Output Translator	No	**By TRAD**

OTHERS ICs : LM2743 from NSC

Description : Low Voltage N-Channel MOSFET Synchronous Buck Regulator Controller

Package : TSOP14

Technology : BiCMOS – ABCD150 process Date code : ?

- **SEL :**
  - UCL M/Q=5 & M/Q=3.3
  - **No SEL for LET=55,9MeV/mg.cm²**
- **SEU/SET :** Planned in 2007

- **TID :**
  - 100 rad/h up to 40Krad and Annealing 24h/25°C & 168h/100°C
  - 8ON+2OFF +1 ref
  - **All samples were out of spec at 30 Krad for IQ_VCC3. Parts remained within spec after annealing.**
  - **At 40Krad biased parts exceeded spec for VFB, IEOA, Iss and FSW. After annealing, these parameters, except VFB, remained within spec.**
  - **All others parameters remained within spec all along testing.**

OTHERS ICs : ADG901BRM from Analog Devices

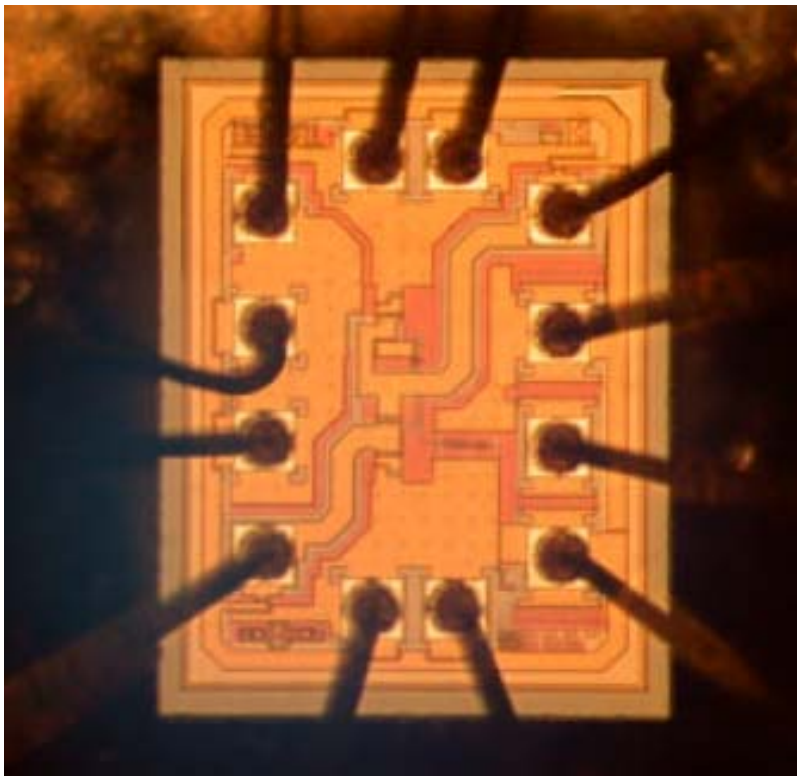
Description : Wideband, 40 dB Isolation at 1 GHz, CMOS 1.65 V to 2.75 V, SPST Switches

Package : MSOP8

Technology : CMOS

Date code : 0405

- **SEL :**
  - UCL M/Q=5 & M/Q=3.3
  - **No SEL for LET=55,9MeV/mg.cm²**



OTHERS ICs : DS1100Z-200 from Dallas

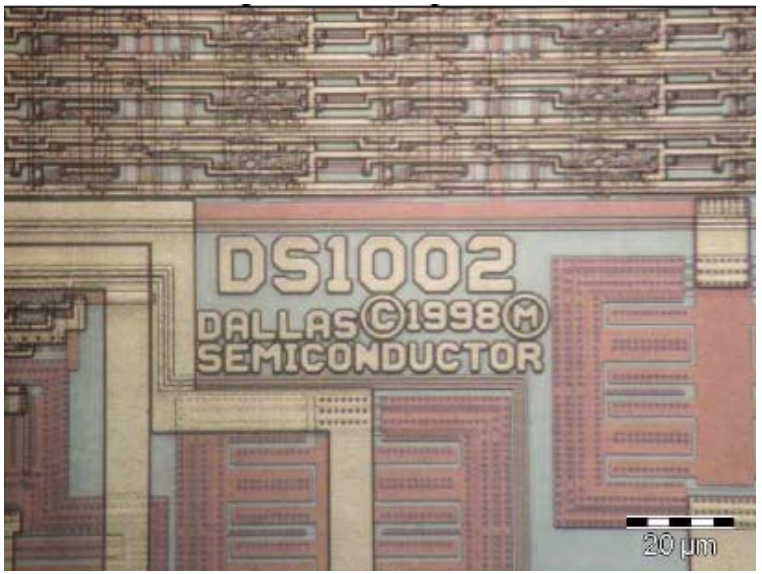
Description : 5-Tap Economy Timing Element (Delay Line)

Package : SO8

Technology : CMOS

Date code : 0537

- **SEL :**
  - UCL M/Q=5 & M/Q=3.3
  - **No SEL for LET = 55,9MeV/mg.cm²**



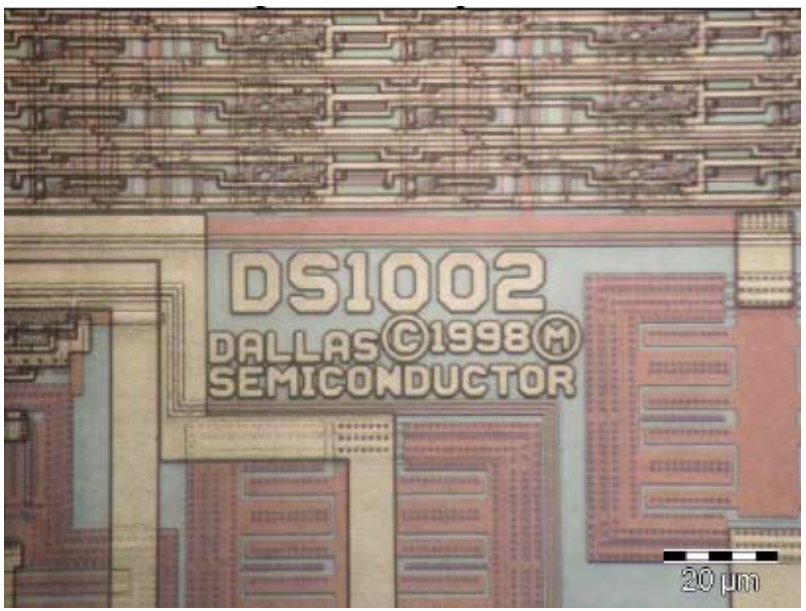
OTHERS ICs : NB100LVEP91DW from ON Semi

Description : 2.5 V/3.3 V Any Level Positive Input to −2.5 V/−3.3 V LVNECL Output Translator

Package : SO20

Technology : ECL - Process MOSAIC5

Date code : 0422



- **SEL :**
  - UCL M/Q=5 & M/Q=3.3
  - **No SEL for LET = 55,9MeV/mg.cm²**

CONCLUSION / TRENDS

- Various commercial ICs have been irradiated under heavy ions, protons or Co60 dose in the frame of CNES R&D or space programs
- SEL sensitivity is product and technology dependant
- For heavy ions tests, the major issue is to check the device functionality after the chemical opening
- The tested commercial products showed different behaviours under Co60 dose. The worst result is first parametric drift at 5Krad or functional failure at 13Krad.

More information…

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