Title: **SEU IRRADIATION TEST REPORT**

CLC501, CLC505, µPC2712B

CI-No. :

DRL-No. :

Model :

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Anz. *Quant.*	Name	Phone	Abt./Fa. *Dep./Comp.*	Anz. *Quant.*	Name	Phone	Abt./Fa. *Dep./Comp.*
x	Becker Thomas-M.	3137	EP 1		Richner Markus	4379	EP 1
	Bendl Helmut	9318	ED 511		Schmieder Lutz	9507	ED 512
	Best Rainer	3862	EP 1		Schmidt Rudolf	2004	EC 32
	Breuckmann Elisabeth	4261	ED 515		Schneider Karl-Heinz	4789	ED 543
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	Eilenberger Reinhard	9316	ED 512				
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	Gerndt Rüdiger	9669	ED 511				
x	Gottschlag Dirk	3837	ED 513	x	J. Ellwood		ESTEC
	Harris Rob	8097	EP 1		M. Warhaut		ESOC
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	Heinze Reinhold	8463	ED 513		P. Villefranche		MMS-T
x	Hell Hans-Martin	3953	ED 515		P. Musi		ALS
	Honold Hans-Peter	9355	EP 1		G.S. Sims		SAT
x	Keil Wolfgang	3600	ED 61		P. Holliday		TER (DK)
	Kerner Rudi	4131	ED 515	x	M. Dominguez		TLG
	Kettner Bernhard	9854	ED 515		J.P. Kermode		CAPTEC
	Knöbel Uwe	4244	ED 531				
	König Werner	3265	ED 513				
	Kolkmeier Arnd	5836	ED 533				
	Kommer Andreas	4708	ED 544				
	Kröger Timm	3692	ED 533				
	Lautenschläger Gunther	6730	ED 512				
	Leissle Thomas	3812	ED 513				
x	Lindekugel Volker	4786	ED 61				
	Lotz Gerhard	9150	EC 34				
x	Müdsam Udo	3026	EP 1				
	Müller Bernd	3025	EP 1				
	Osipenco Stephane	9006	ED 513				
	Pfaff Ulrich	9073	ED 511				
	Platzer Wilhelm	4664	EC 32				
	Pöckentrup Joachim	4784	ED 561				
	Reuß Friedhelm	9978	EP 1				
	* xx-49-89-607-xxxxx						

Ausgabe *Issue*	Datum *Date*	Blatt *Sheet*	Beschreibung der Änderung *Description of Change*	Freigabe *Release*
1	23.09.01	all	first formal issue	

Astrium GmbH

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ROSETTA

Änderungsregister

Register of Changes

Dok.-Nr.: RO-DSS-RP-1044
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LIST OF CONTENTS

1. INTRODUCTION

This test report details the results of the Heavy Ion Single Event Effects testing performed on µPC2712, CLC501, CLC501 on 21/22.09.2001.
Scope of these tests has been to investigate and verify heavy ion induced single event transients (SET) on selected amplifiers with respect to pulse width and pulse height.
This is part of answer on ROSETTA CDR RID EL-022.
As a result it was verfied that no SET pulse widths >100ns are occuring in the tested ROSETTA applications for CLC501, CLC505, µPC2712B (unit TRSP). Pulse widths up to 10µs are coped with the design of ROSETTA units.
Additionally the Xsection σ versus LET curves have been derived from the numerous successful tests.
The parts (DUTs) have been irradiated with the selected ion cocktail from UCL and under different tilt angles to get a quasi continous LET spectrum.
The test equipment has been prepared by ASTRIUM GmbH, Friedrichshafen.

Acknowledgements:
Thanks to the facility personal and Guy Berger.
Thanks to the testing team Klaus Haas and Dr Wolfgang Schaeper who is skilled to perform excellent workmanship even under “vacuum” conditions, Reno Harboe Sorensen whose assistance and knowledge led to these effective test results.

2. SUMMARY OF TEST AND RESULTS

Devices of the NEC µPC2712B, CLC501, CLC505 (3 test samples for each type) have been submitted to heavy ion testing at the Heavy Ion Test Facility (HIF) at UCL in Louvain-la-Neuve in Belgium.

The devices under test (DUT) are listed below

Type Designation	Manufac-turer	Origin	Datecode	Original SN	Test SN
µPC2712	NEC	ALENIA, ROSETTA TRSP	9948, DC23.02.2000	16	16
CLC501 Appl. A CLC501 Appl. B	NSC	ELYMAT Industries, INC:, USA	DC0101	N/A	1 2
CLC505	NSC	ALENIA, ROSETTA, TRSP	9947	132	132

Table 1: Tested Devices and Characteristics (DC, SN)

The bias conditions which have been applied to each of the DUTs are shown in Table 2 Equal circuits are used in space applications:

Type Designation	Manufac-turer	Supply Voltage	Bias	Test SN
µPC2712	NEC	± 5.2V	Fig. 6-43	16
CLC501 Appl. A/B	NSC	±5.2V	Fig. 6-3 and 6-4	1/2
CLC505	NSC	±5.2V	Fig. 6-30	132

Table 2: Operation Conditions

The characterising parameters $LET_{threshold}$ and Xsection $\sigma_{saturation}$ for positive transients are listed In Table 3. Negative transients have been observed as well, in those cases they have been logged.

Type	Manufac-turer	Application	LETthreshold	Xsection σ /device	REMARK	Test SN
			MeV cm²/mg	cm²		
µPC2712	NEC	ALENIA, ROSETTA TRSP	>11.7	2.8E-5	Spike >75µV	16
CLC501 Appl. A	NSC	ALENIA, ROSETTA TRSP	>1.7	5.7E-4	Spike >250mV	1
CLC501 Appl. B	NSC	ALENIA, ROSETTA TRSP	~1.7	1.5E-3	Spike >250mV	2
CLC505	NSC	ALENIA, ROSETTA TRSP	>2.4	2.7E-5	Spike >250mV	132

Table 3: Summary of Xsection vs LET Parameters (positive Transients)

Results

a) NSC CLC501, Application A, SN 1, 5.2V bias

The cross section curve for all events exceeding the voltage threshold of 250mV is shown in Figure 6-7. Screen shots of all of the transient events are provided in para. 6.2.3

No destructive events have occured up to LET = 68 MeV/mg/cm².

b) NEC CLC501, Application B, SN 2, 5.2V bias

The cross section curve for all events exceeding the voltage threshold of 250mV is shown in Figure 6-18. Screen shots of all of the transient events are provided in para. 6.2.4.

No destructive events have occured up to LET = 68 MeV/mg/cm².

c) NEC CLC505, SN 132, 5.2V bias

The cross section curve for all events exceeding the voltage threshold of 250mV is shown in Figure 6-33. Screen shots of all of the transient events are provided in para. 6.3.3.

No destructive events have occured up to LET = 68 MeV/mg/cm².

d) NEC µPC2712B, SN 16, 5.2V bias

The cross section curve for all events exceeding the voltage threshold of 75mV and 125mV is shown in Figure. 6-48. Screen shots of the oscilloscope of all of the transient events are provided in para 6.4.

No destructive events have occured up to LET = 68 MeV/mg/cm².

3. APPLICABLE DOCUMENTS

[AD1] ESA/SCC Basic Specification No. 21300, Terms, Definitions, Abbreviations, Symbols and Units

[AD2] ESA ESA/SCC Basic Specification No.25100, Single Event Effects Test Method, Oct 1995

[AD3] TEST Plan, RO-DSS-PL-1019

Reference Documents:

[RD1] ASTM FI 192-90, Standard Guide for the Measurement of Single Event Phenomena (SEP) Induced by Heavy Ion Irradiation of Semiconductor Devices.

[RD2] JEDEC 13.4, Test Procedure for the Measurement of Single Event Effects in Semiconductor Devices from Heavy Ion Irradiation.

[RD3] FAX: ALS/AQ/PA/009/01, 29.01.01

4. TERMS, DEFINITIONS, ABBREVIATIONS, SYMBOLS AND UNITS

-Linear Energy Transfer (LET) or Stopping Power

The amount of energy deposited per unit length along the path of the incident ion. Expressed in units of $MeV/mg/cm^2$ which is the energy per unit length divided by the density of the irradiated medium.

-Effective LET

The equivalent LET obtained by tilting the device under test with respect to the beam axis, hence increasing the path length of the ion and the total energy deposited. Effective LET = Incident LET x $1/\cos \Theta$ where Θ is the tilt angle of the device. Effective LET may also be used in referring to the actual LET in a sensitive volume after taking into account the energy loss in `dead layers' such as metallisation and passivation.

-Charge transfer or deposition

The LET expressed as charge deposited per unit length (by electron-hole pair creation). Expressed in units of pC per µm. A LET of $96 MeV/mg/cm^2$ will give 1pC per µm in silicon.

-Flux

The number of ions passing through a unit area perpendicular to the beam in one second. Units: $ions/cm^2/sec$.

-Fluence

The flux integrated over time. Units $ions/cm^2$.

-Cross section

The number of events per unit fluence. Expressed in units of cm^2/device or cm^2/bit. In the event of the device being tilted at an angle Θ, the fluence must be rected by multiplying the fluence by $\cos \Theta$.

-Ion species

Type of ion being used for irradiation (e.g. oxygen, neon etc).

-Range

The distance travelled, without straggling, in the target material by the specified ion of given charge state and energy.

-Energy

The energy imparted to the ion by the accelerator. This may be in units of total energy (MeV) or energy per nucleon (MeV per AMU)

-Single Event Upset (SEU) also known as a Soft Error

The change of state of a latched logic state from one to zero or vice-versa. A single event upset is non-destructive and the logic element can be rewritten or reset.

-Single Event Transient (SET),

The production of a temporary pulse, characterised by pulse height and pulse width. A single event transient is non-destructive, but may propagate and trigger malfunctions

-Latch-up

A permanent and potentially destructive state of the device under test whereby a parasitic thyristor structure is triggered and creates a low impedance, high current path.

-Soft Latch

A condition in which the device under test will not respond to external stimulus but with all other electrical conditions (e.g. supply current) being normal.

-Single Hard Error (SHE) or Stuck Bit

Permanent or semi-permanent damage of a cell by an ion strike.

-Threshold LET or Energy

The LET at which the cross-section is 1 % of the saturated cross-section.

-Saturated Cross Section,

also known as limiting or asymptotic cross-section

The cross section for which an increase in LET does not result in an increased number of upsets.

-Level of Interest

A cross section, energy, LET or fluence having some particular significance for a programme or project.

5. IRRADIATION FACILITY

The irradiation facility is UCL Belgium

The applied heavy ion beam cocktail is shown in Figure 1

Heavy Ion Beams at UCL

Beam	Ion	LET	Tilt Angle	LET_{eff}	Range in Si	Fluence
		MeV cm²/mg	degree	MeV cm²/mg	µm	$\#/cm^{-2}$
1	10 B 2+	1.7	0	1.7	80.0	1000000
2	10 B 2+	1.7	45	2.4	56.6	1000000
3	10 B 2+	1.7	60	3.4	40.0	1000000
4	20 Ne 4+	5.85	0	5.9	45.0	1000000
5	20 Ne 4+	5.85	45	8.3	31.8	1000000
6	20 Ne 4+	5.85	60	11.7	22.5	1000000
7	40 Ar 8+	14.1	0	14.1	42.0	1000000
8	40 Ar 8+	14.1	45	19.9	29.7	1000000
9	40 Ar 8+	14.1	60	28.2	21.0	1000000
10	84 Kr 17+	34	0	34.0	43.0	1000000
11	84 Kr 17+	34	45	48.1	30.4	1000000
12	84 Kr 17+	34	60	68.0	21.5	1000000

Table 5-1: Heavy Ion Beam Cocktail applied at UCL

6. TESTS

6.1. General

Parts are delidded in Munich facility of ASTRIUM. Photographs have been taken at Astrium GmbH, Friedrichshafen Dept. 62.
Tables on observed effects show the relevant test parameters and the observed effects (No of transients) depending on trigger levels. In the table column for UCL Run No, d1/d2 means day 1 or day 2 of the test campaign, because of the UCL counting, which is not continous in contrary to ASTRIUM logging counting. No measurable counting is indicated by “0”, whereas in case of no measurements the position is left blank.

6.1.1. Generic Test Set-up for Operational Amplifier

1. Voltages: All voltages are to be defined by DC average and time dependent (AC) variation (waveforms, amplitudes, frequencies, etc.).
   Vcc = Positive supply voltage
   Vss = Negative supply voltage
   V+ = Voltage applied Z+
   V- = Voltage applied to Z-
2. Impedances: All impedances are defined by their ohmic, capacitive and inductive constituents.
   Z+ = Impedance between V+ and the non-inverting input of the OpAmp
   Z- = Impedance between V- and the inverting input of the OpAmp
   Zr = Feed-back impedance (There might be a second feedback to the non-inverting input)
   Zc = Frequency compensation or offset balance
   Zout,cc = Output impedance to Vcc
   Zout,gnd = Output impedance to ground
   Zout,ss = Output impedance to Vss
   Ccc = Vcc bypass capacitor, including power supply output capacitor
   Css = Vss bypass capacitor, including power supply output capacitor

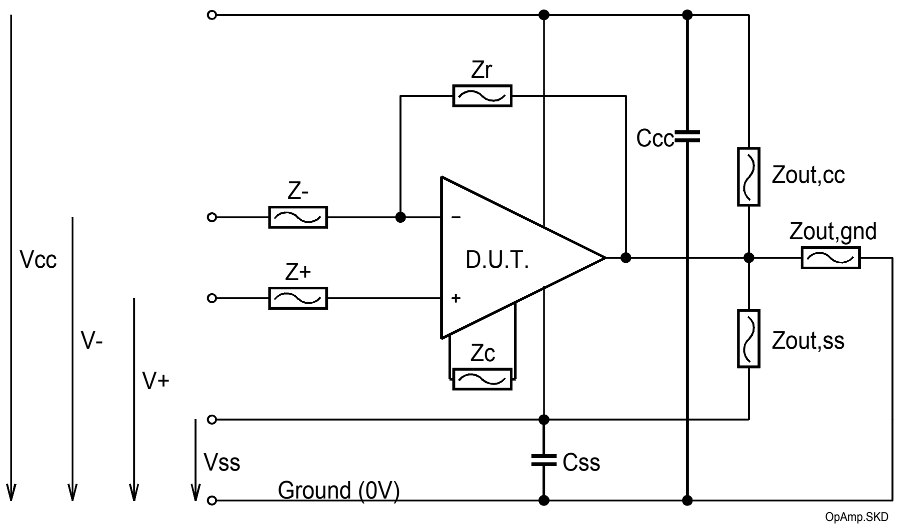


Figure 6-1: Generic test set-up for operational amplifier

6.1.2. Test Conditions for CLC501, CLC505 and µPC2712B

There are a total of four applications each with the

- high speed, output clamping op amp CLC501 (2 applications)
- high speed op amp CLC505 (1 application)
- wideband monolithic amplifier µPC2712B (1 application)
-

Another application with the CLC501 was made available. As this one was very similar to the one tested, it can be covered by similarity.
All circuits operate with low (some 10 ... 100 mV) DC input bias superimposed with a low (1 ... 30 mV) AC bias.
Expected single event effects under heavy ion irradiation are amplifier output glitches from 0 to ±Vcc amplitude (or to a fraction of these) with durations up to a few microseconds.
It can be assumed that the AC bias is of no influence on these effects. Therefore it is supposed to omit the AC bias during the SEU test. As the DC bias of the CLC505 is close to zero while the devices are supplied with ±5.2 V, the DC bias can be set to exactly zero. The CLC501 is operated at its real DC bias points. The µPC2712B is internally DC biased, input and output are decoupled by capacitors.

The detection of output glitches is done by the oscilloscope (HP 54825A, 500 MHz). fast voltage comparators. Because positive as well as negative glitches are possible, the detection has been done for both polarities. Trigger thresholds are set to 250 mV (CLC501, 505) or 75 ... 125 mV (µPC2712B) respectively. The trigger events are counted by a counter.

In case of the CLC501, both applications are assembled on a common test board.

Test Flow

A block diagram of the test flow is shown in Fig. 6-2.

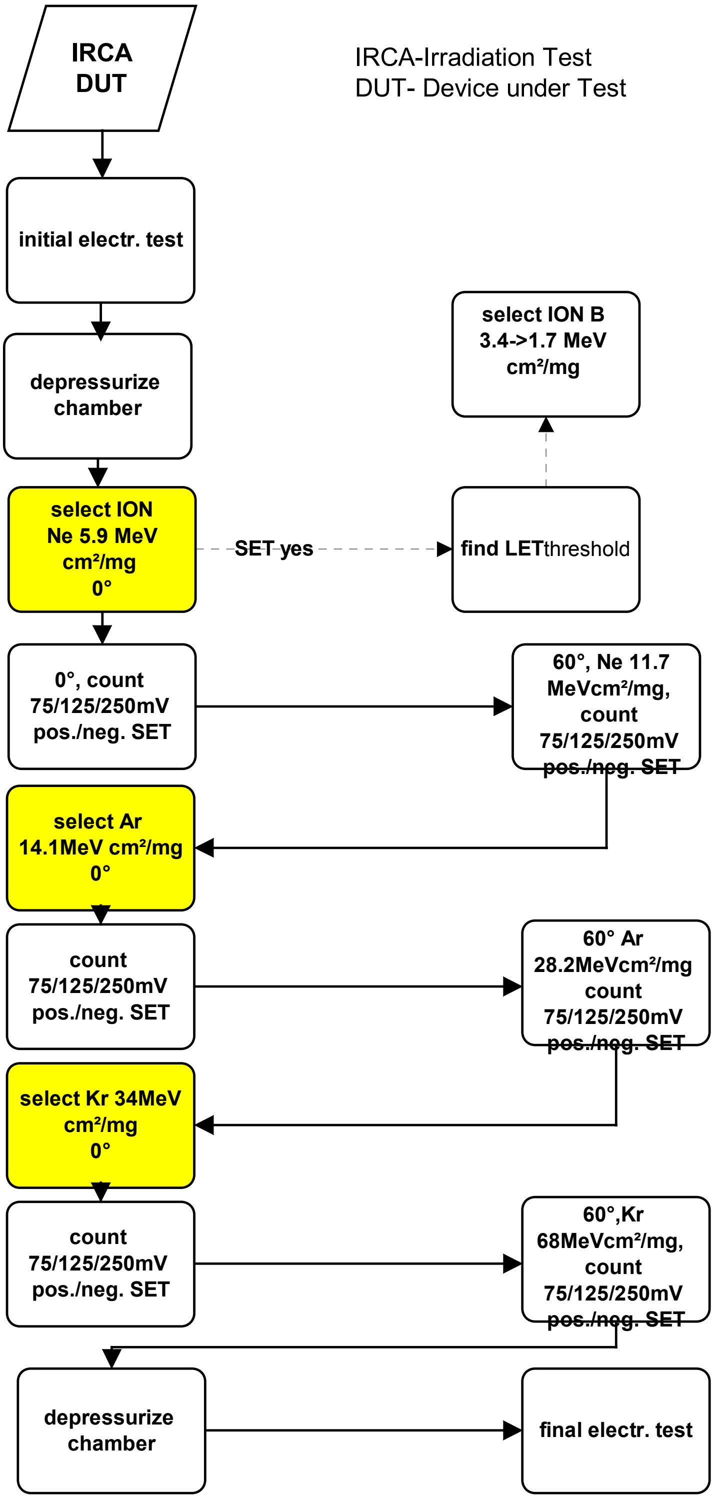


Figure 6-2: Test Flow

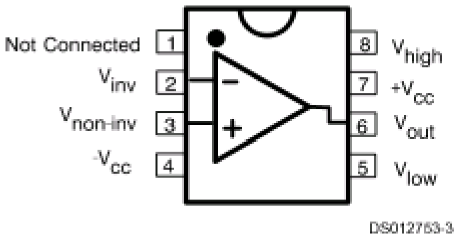
6.2. CLC501

6.2.1. General Description

The CLC501 is a high speed current-feedback op amp with output voltage clamping. This feature allows both the maximum positive (V_{high}) and negative (V_{low}) output voltage levels to be established. This is useful in a number of applications in which “downstream” circuitry must be protected from over driving input signals. Not only can this prevent damage to downstream circuitry, but can also reduce time delays since saturation is avoided. The CLC501’s very fast 1ns overload/clamping recovery time is useful in applications in which information containing signals follow overdriving signals.

CLC501 provides the residue function, settles quickly, and recovers from overdrive quickly, protects the second stage A/D, provides high fidelity at relatively high gain settings. The CLC501’s current feed-back design requires no external compensation

Connection Diagram



Pinout
DIP & SOIC

Electrical Characteristics

(A_V = +32, V_{CC} = ±5 V, R_L = 100Ω, R_f = 1.5Ω, V_H = +3V; unless specified)

Symbol	Parameters	Condition	Typ	Max & Min Ratings(Note 2)			Units
Ambient Temperature		CLC501AJ	+25°C	−40°C	+25°C	+85°C	
Frequency Domain Response							
SSBW	−3dB Bandwidth	V_{OUT} < $5V_{PP}$	75	>60	>60	>45	MHz
SS20	−3dB Bandwidth	@A_V = +20, V_{OUT} < $2V_{PP}$	110	>85	>85	>55	MHz
	Gain Flatness	V_{OUT} < $5V_{PP}$					
GFPL	Peaking	<15MHz	0	<0.1	<0.1	<0.1	dB
GFPH	Peaking	>15MHz	0	<0.2	<0.2	<0.2	dB
GFR	Rolloff	< 30MHz	0.2	<1.0	<1.0	<1.3	dB
LPD	Linear Phase Deviation	DC to 30MHz	0.2	<1.0	<1.0	<1.0	deg
Time Domain Response							
TRS	Rise and Fall Time	2V Step	4.7	<5.8	<5.8	<7.8	ns
TRL		5V Step	5.5	<6.5	<6.5	<8.0	ns
TSP	Settling Time to ±0.05%	2V Step	12	<18	<18	<24	ns
OS	Overshoot	2V Step	0	<5	<5	<5	%
SR	Slew Rate		1200	>800	>800	>700	V/µs
Distortion And Noise Response							
HD2	2nd Harmonic Distortion	$2V_{PP}$, 20MHz	−45	<−30	<−33	<−30	dBc
HD3	3rd Harmonic Distortion	$2V_{PP}$, 20MHz	−60	<−45	<−50	<−50	dBc
	Equivalent Input Noise						
SNF	Noise Floor	>1MHz	−158	<−156	<−156	<−155	dBm (1Hz)
INV	Integrated Noise	1MHZ to 100MHz	28	<35	<35	<40	µV
Clamp Performance							
OVC	Overshoot in Clamp	32x Overdrive	5	–	<15	–	%
TSO	Overload Recovery from Clamp	32x Overdrive	1	<3	<3	<3	ns
CDR	V_{io}Drift after Recovery		150	<200	<200	<200	µV
VOC	Clamp Accuracy(Note 3)	>2x Overdrive	0.1	<0.2	<0.2	<0.2	V
ICL	Input Bias Current on V_H, V_L		20	<100	<50	<50	µA
CBW	−3dB Bandwidth	V_L,V_H = $2V_{PP}$	50	–	–	–	MHz
CMC	Useful Clamping Range	V_H or V_L		<±3.0	<±3.3	<±3.3	V
Static, DC Performance							
VIO	Input Offset Voltage(Note 3)		1.5	<4.6	<3.0	<5.0	mV
DVIO	Average Temperature Coefficient		10	<20	–	<20	µV/°C
IBN	Input Bias Current(Note 3)	Non-Inverting	10	<37	<25	<35	µA

Electrical Characteristics (Continued)

(A_V = +32, V_{CC} = ±5 V, R_L = 100Ω, R_f = 1.5Ω, V_H = +3V; unless specified)

Symbol	Parameters	Condition	Typ	Max & Min Ratings(Note 2)			Units
Static, DC Performance							
DIBN	Average Temperature Coefficient		100	<150	–	<100	nA/˚C
IBI	Input Bias Current(Note 3)	Inverting	10	<46	<30	<40	µA
DIBI	Average Temperature Coefficient		100	<200	–	<100	nA/˚C
PSRR	Power Supply Rejection Ratio		70	>55	>60	>60	dB
CMRR	Common Mode Rejection Ratio		70	>55	>60	>60	dB
ICC	Supply Current(Note 3)	No Load	18	<25	<24	<24	mA
Miscellaneous Performance							
RIN	Non-Inverting Input	Resistance	150	>50	>100	>100	kΩ
CIN		Capacitance	4	<7	<7	<7	pF
RO	Output Impedance	at DC	0.2	<0.3	<0.3	<0.3	Ω
CMIR	Common Mode Input Range		3.0	>2.0	>2.5	>2.5	V
VO	Output Voltage Range	No Load	±3.5V	>±3.0	>±3.2	>±3.2	V
IO	Output Current	−40˚C to +85˚C	±60	>±35	>±50	>±50	mA
IO		−55˚C to +125˚C	±60	>±30	>±50	>±50	mA

Note 1: "Absolute Maximum Ratings" are those values beyond which the safety of the device cannot be guaranteed. They are not meant to imply that the devices should be operated at these limits. The table of "Electrical Characteristics" specifies conditions of device operation.

Note 2: Min/max ratings are based on product characterization and simulation. Individual parameters are tested as noted. Individual parameters are tested as noted. Outgoing quality levels are determined from tested parameters.

Note 3: AJ 100% tested at +25˚C, sample at +85˚C

6.2.2. Application in ROSETTA

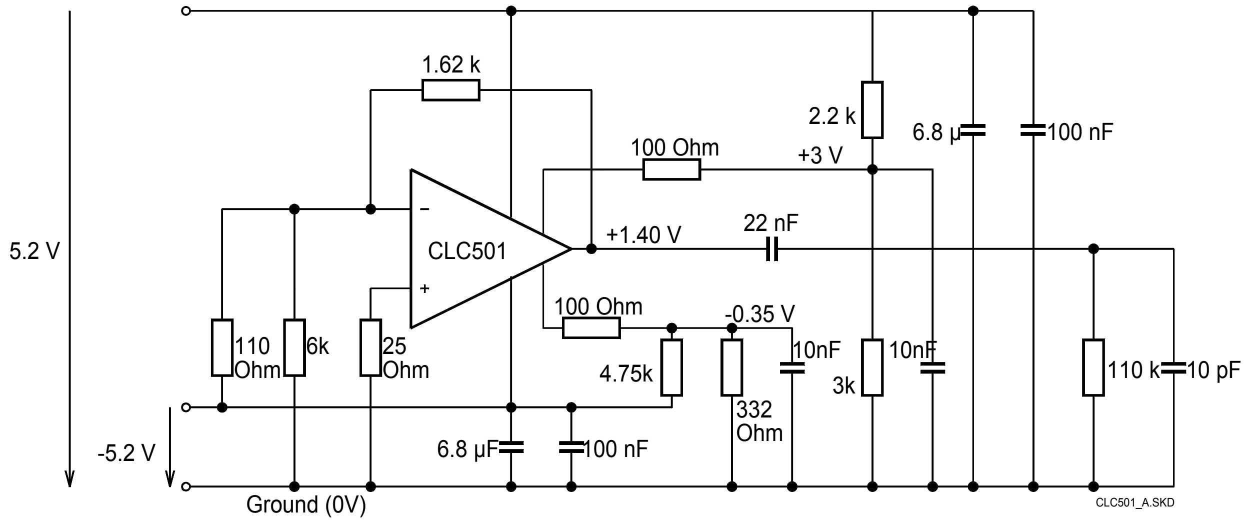


Figure 6-3: Bias circuit for CLC501, Application A

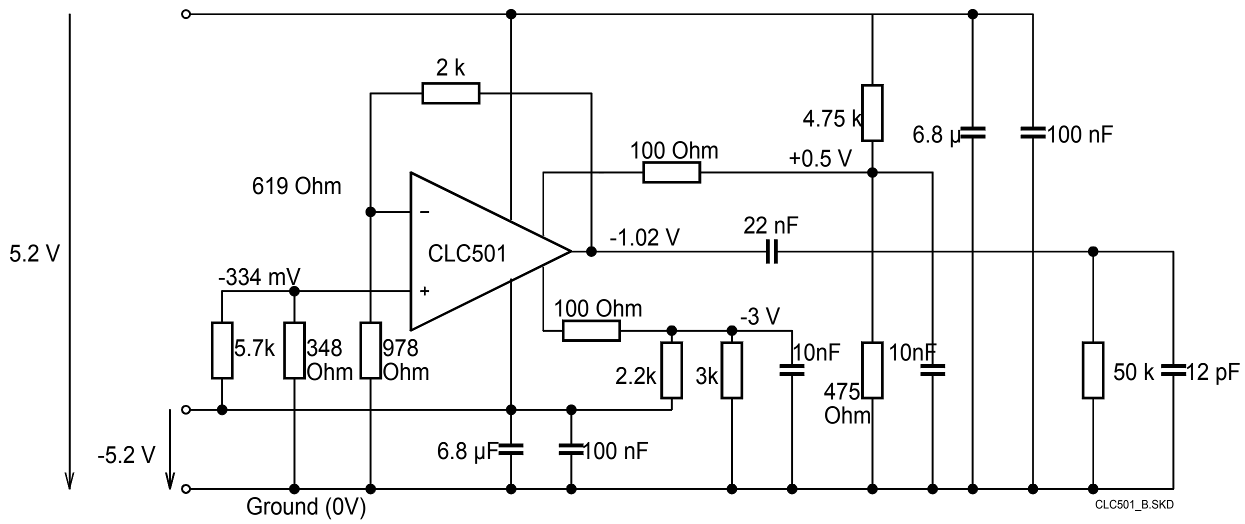


Figure 6-4: Bias circuit for CLC501, Application B

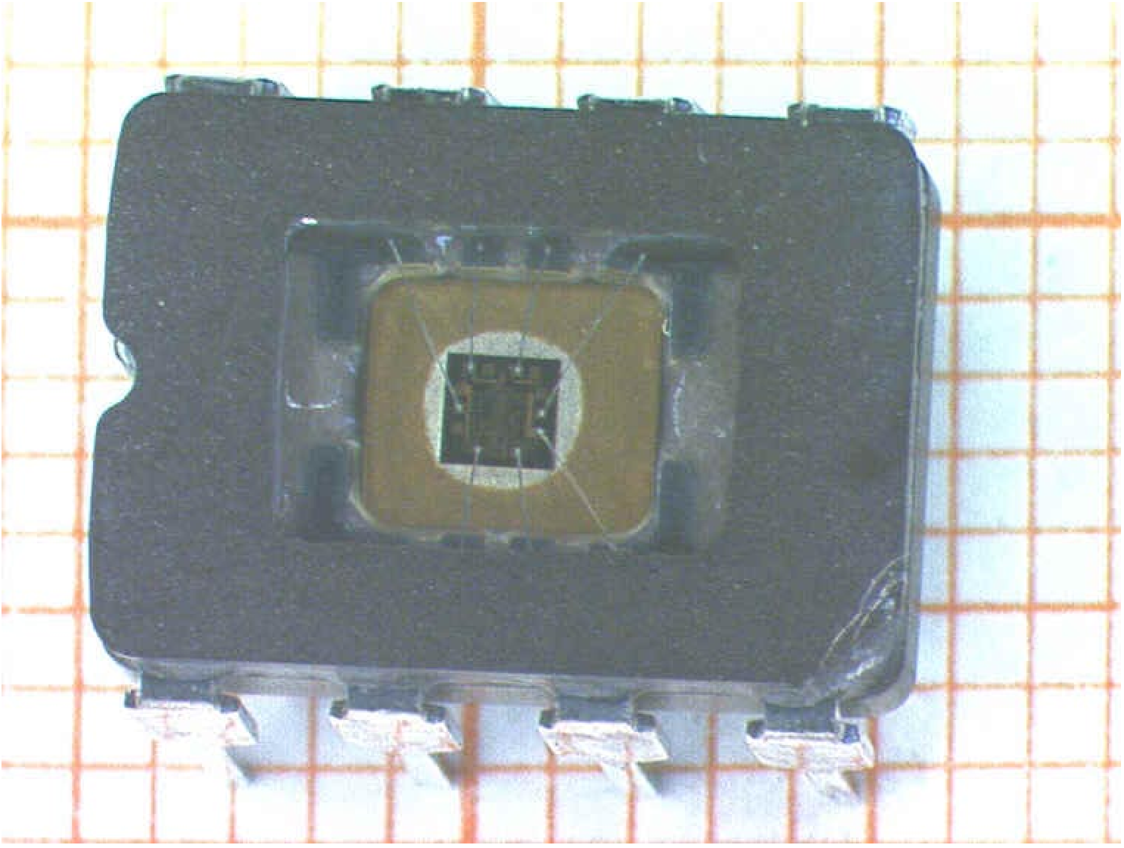


Figure 6-5: DUT CLC501 delidded

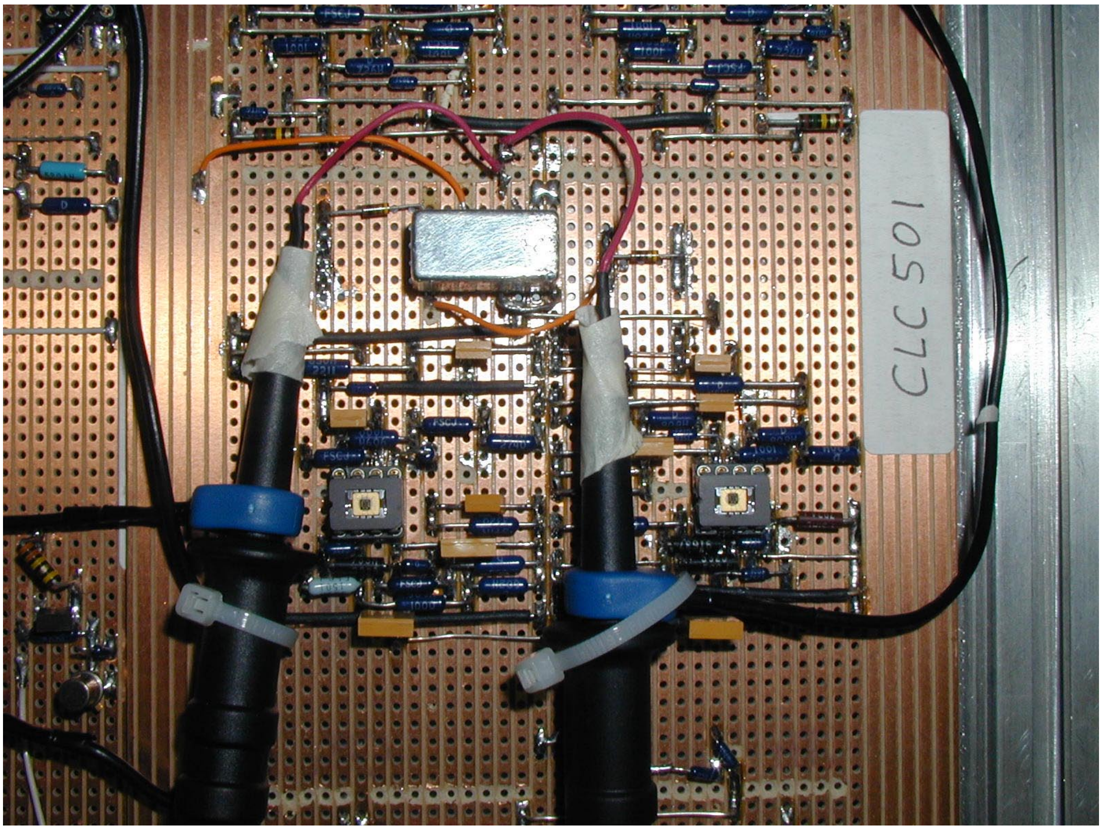


Figure 6-6: Test Board Setup for two DUT CLC501 for Switching of two Applications

6.2.3. Test Results CLC501 Application A

In Table 6-1 the test parameters and observed effects are listed for transient amplitudes >250mV and logged negative spikes.

ASTRIUM RUN	UCL Run	Device	ION	LETeff	Xsection		RunDose	Fluence	Theta	TRANSIENTS #		Comment
No	No			MeV cm²/mg	cm²			#/cm²	°	>250mV	<"-250mV"	
		S/N 1			>250mV	<-250mV						
44	24 d2	CLC501_A	10 B 2+	2.4	8.98E-06	0.00E+00	38.55	1002087	45	9	0	
42	22 d2	CLC501_A	10 B 2+	3.4	3.39E-05	0.00E+00	32.11	590310	60	20	0	
33	10 d2	CLC501_A	20 Ne 4+	5.85	1.66E-04	1.50E-05	93.76	1001697	0	166	15	
32	8 d2	CLC501_A	20 Ne 4+	8.27	1.91E-04	6.97E-05	132.92	1004181	45	192	70	
6	6 d1	CLC501_A	40 Ar 8+	14.1	2.61E-04		225.65	1000231	0	261	#N/A	
7	7 d1	CLC501_A	40 Ar 8+	19.94	3.01E-04		320.89	1005787	45	303	#N/A	
8	8 d1	CLC501_A	40 Ar 8+	28.2	1.65E-04		451.52	1000709	60	165	#N/A	Shielding effect
23	26 d1	CLC501_A	84 Kr 17+	34	4.71E-04		544.27	1000488	0	471	#N/A	
22	25 d1	CLC501_A	84 Kr 17+	48.08	5.66E-04		773.31	1005171	45	569	#N/A	
21	24 d1	CLC501_A	84 Kr 17+	68	2.84E-04		1093.41	1004972	60	285	#N/A	Shielding effect

Table 6-1: Observed SE Effects on CLC501 (ROSETTA APPLICATION A) Remark: at 60° tilt angle the die was partly shielded by the ceramic case

Figure 6-7 shows the Xsection vs LET curve for the transients and observed shielding effects due to tilted (60°) DUT

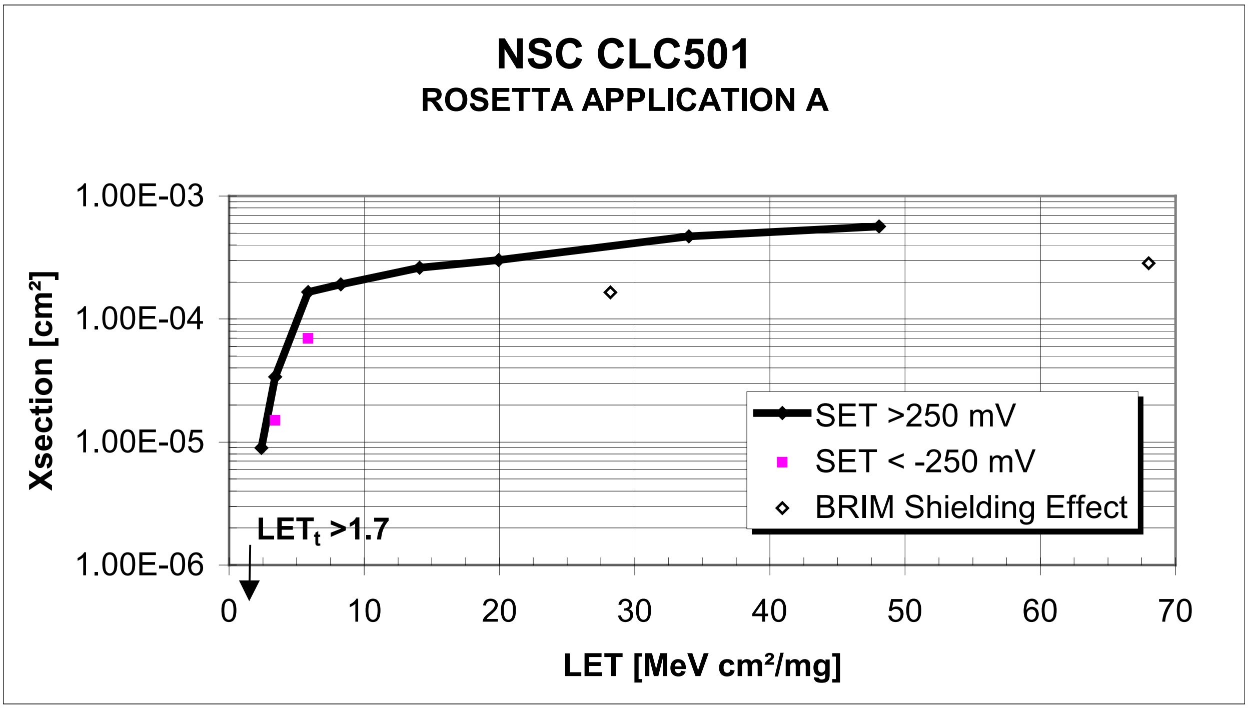


Figure 6-7: Xsection σ vs LET for SET on CLC501 (Application A ROSETTA, TRSP)

SET Characteristics

SET pulse height	$LET_{threshold}$	Xsection σ_{sat}
mV	MeV cm²/mg	cm²
> +250	>1.7	5.7E-4
< -250	>3.4	7.0E-5<σ_{sat}<5.7E-4

Table 6-2: Xsection vs LET (2 parameter method) CLC501 (Application A ROSETTA, TRSP)

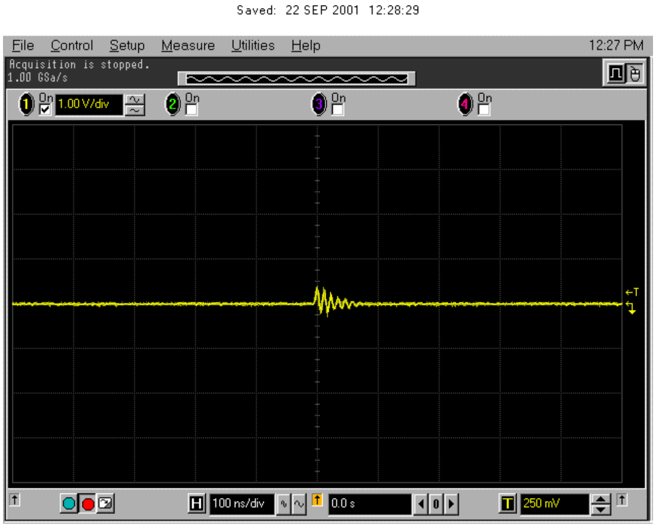


Figure 6-8: Run 44, SET Effects on CLC501 Appl. A (2.4 MeV cm²/mg, pulse height: 0.3V, pulse width: <100ns)

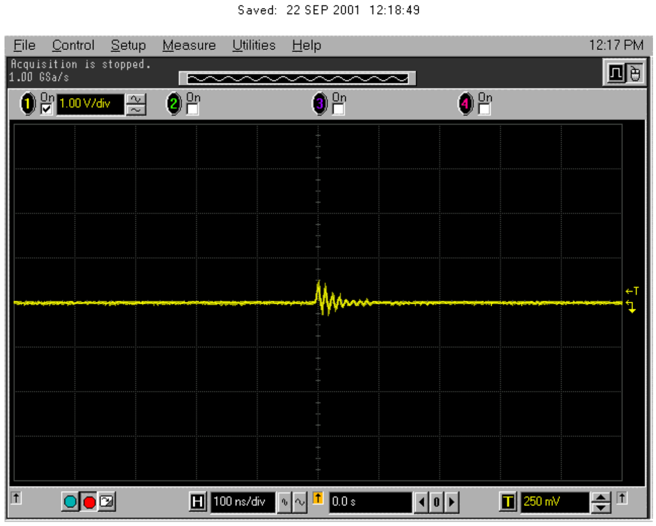


Figure 6-9: Run 42, SET Effects on CLC501 Appl. A (3.4 MeV cm²/mg, pulse height: 0.5V, pulse width: <100ns)

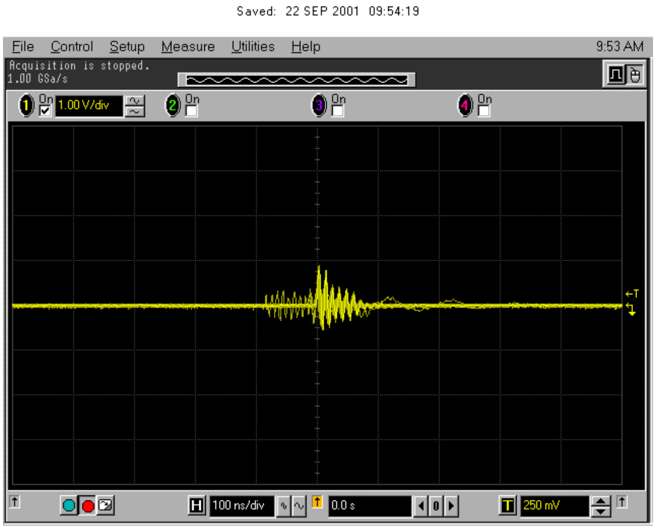


Figure 6-10: Run 33, SET Effects on CLC501 Appl. A (5.85 MeV cm²/mg, pulse height: 0.9V, pulse width: <100ns)

Possible triggers on ambient noise

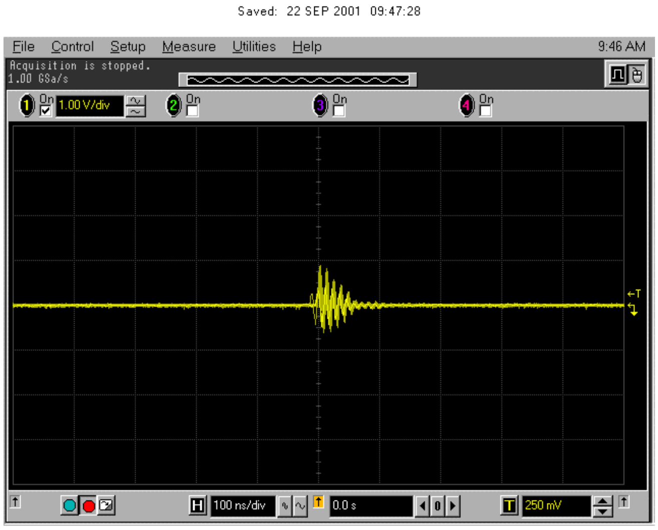


Figure 6-11: Run 32, SET Effects on CLC501 Appl. A (8.27 MeV cm²/mg, pulse height: 0.9V, pulse width: <100ns)

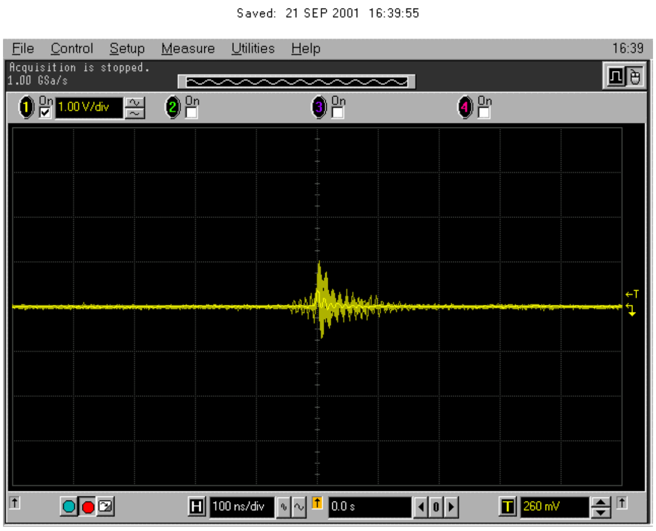


Figure 6-12: Run 6, SET Effects on CLC501 Appl. A (14.1 MeV cm²/mg, pulse height: 1V, pulse width: <100ns)

Possible triggers on ambient noise

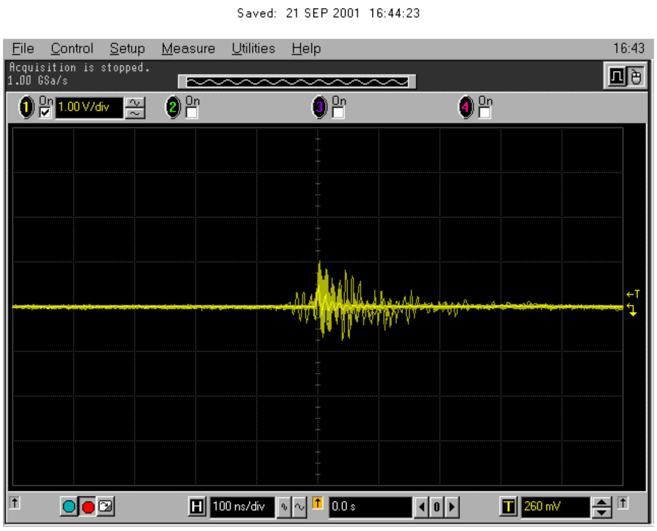


Figure 6-13: Run 7, SET Effects on CLC501 Appl. A (19.94 MeV cm²/mg, pulse height: 1V, pulse width: <200ns)

Possible triggers on ambient noise

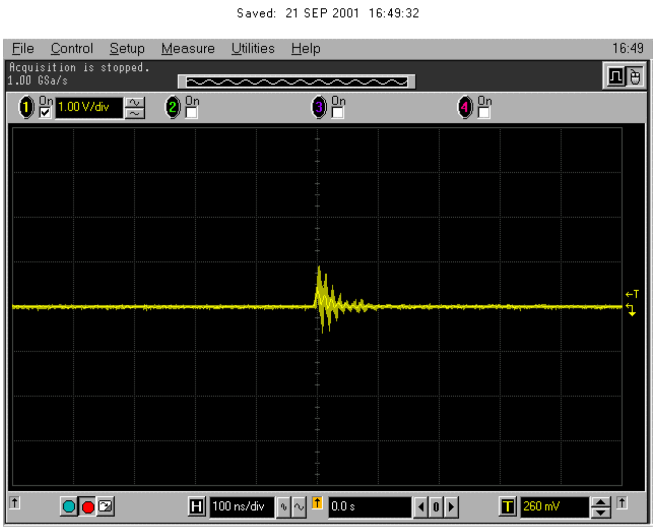


Figure 6-14: Run 8, SET Effects on CLC501 Appl. A (28.2 MeV cm²/mg, pulse height: 0.9V, pulse width: <100ns)

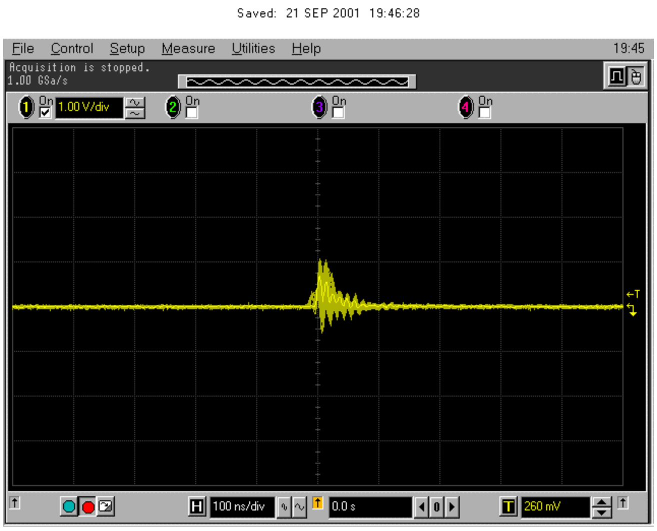


Figure 6-15: Run 23, SET Effects on CLC501 Appl. A (34 MeV cm²/mg, pulse height: 1.05V, pulse width: <100ns)

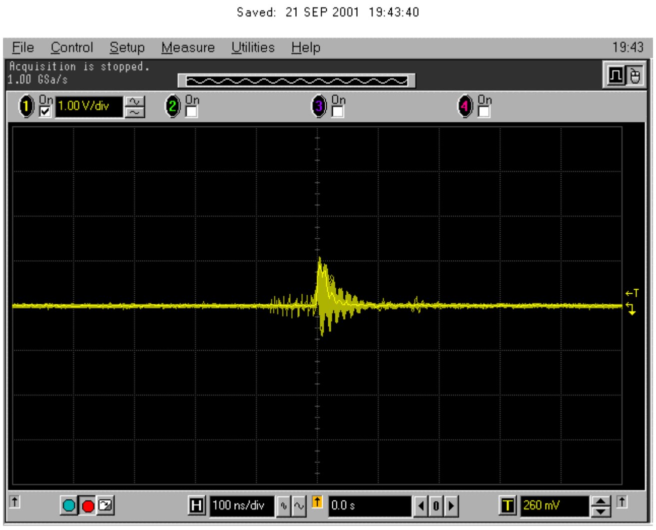


Figure 6-16: Run 22, SET Effects on CLC501 Appl. A (48.08 MeV cm²/mg, pulse height: 1.1V, pulse width: <100ns)

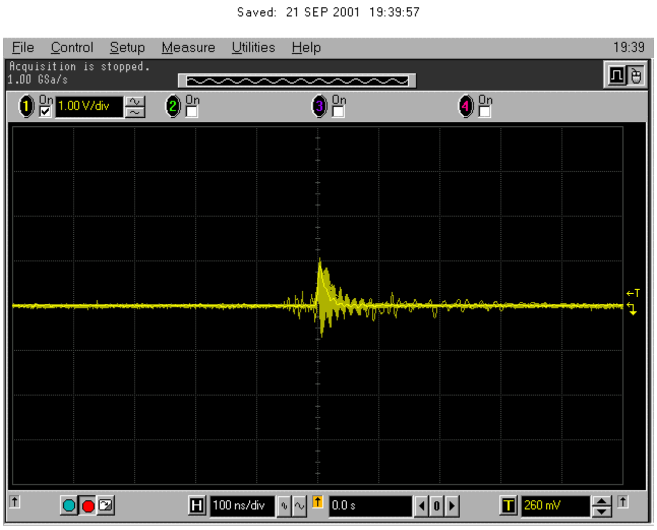


Figure 6-17: Run 21, SET Effects on CLC501 Appl. A (68 MeV cm²/mg, pulse height: 1.05V, pulse width: <100ns)

Possible triggers on ambient noise

6.2.4. Test Results CLC501 Application B

In Table 6-3 the test parameters and observed effects are listed for transient amplitudes >250mV and logged negative spikes.

ASTRIUM RUN	UCL Run	Device	ION	LETeff	Xsection		RunDose	Fluence	Theta	TRANSIENTS		Comment
No	No	ID No		MeV cm²/mg	cm²		rad(Si)	#/cm²	°	No		
		S/N 2			>250mV	<"-250mV"				>250mV	<-250mV	
46	26 d2	CLC501_B	10 B 2+	1.7	1.39E-05	0.00E+00	27.35	1005602	0	14	0	
45	25 d2	CLC501_B	10 B 2+	2.4	4.19E-05	1.70E-05	38.56	1002411	45	42	17	
34	12 d2	CLC501_B	20 Ne 4+	5.85	3.15E-04	1.92E-04	93.69	1000934	0	315	192	
35	13 d2	CLC501_B	20 Ne 4+	8.27	4.25E-04	3.02E-04	132.48	1000859	45	425	302	
11	11 d1	CLC501_B	40 Ar 8+	14.1	5.38E-04	see run12	226.32	1003185	0	540		
10	10 d1	CLC501_B	40 Ar 8+	19.94	7.74E-04		319.46	1001286	45	775		
9	9 d1	CLC501_B	40 Ar 8+	28.2	1.09E-03		451.41	1000470	60	1091		
24	28 d1	CLC501_B	84 Kr 17+	34	9.10E-04		548.24	1007797	0	917		
25	30 d1	CLC501_B	84 Kr 17+	48.08	1.30E-03		776.18	1008898	45	1315		
26	31 d1	CLC501_B	84 Kr 17+	68	1.51E-03		1092.66	1004284	60	1513		
12	12 d1	CLC501_B	40 Ar 8+	14.1		4.51E-04	226.94	1005944	0		454	

Table 6-3: Observed SE Effects on CLC501 (ROSETTA APPLICATION B)

Figure 6-18 shows the Xsection vs LET curve for the transients >250mV and <-250mV

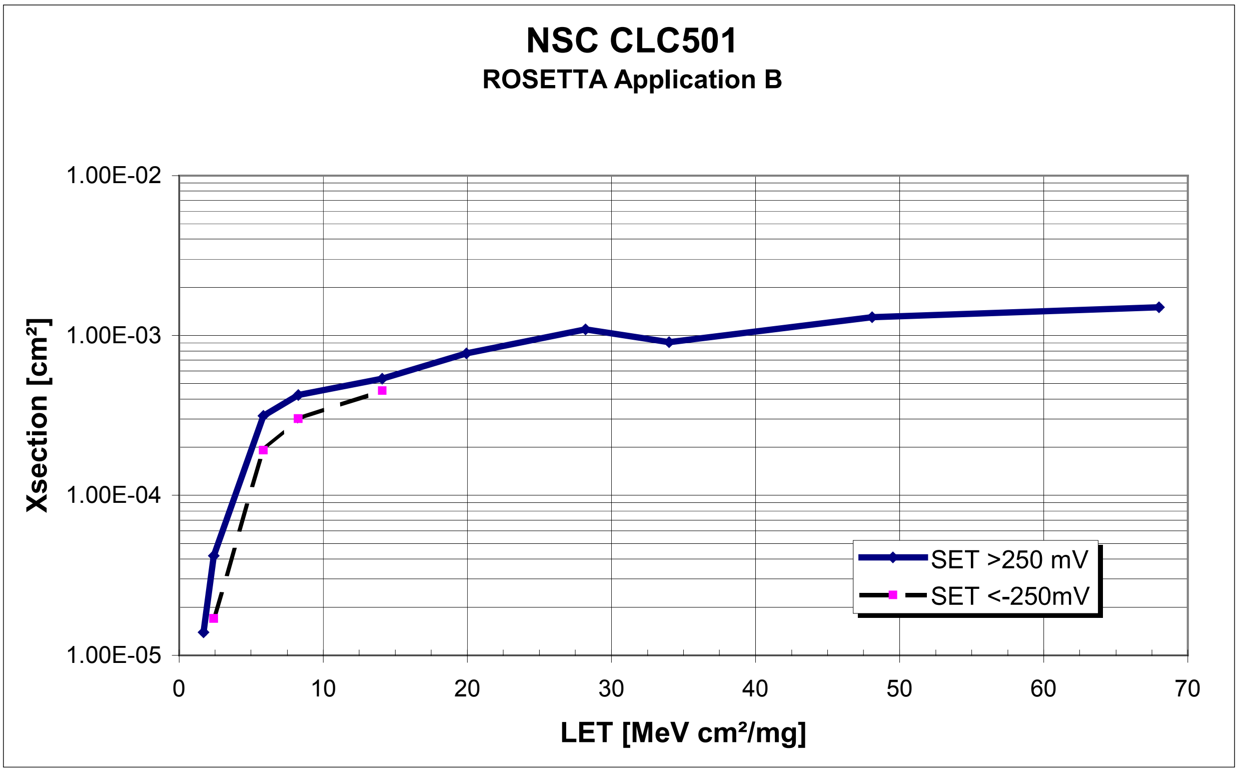


Figure 6-18: Xsection σ vs LET for SET on CLC501 B (Application ROSETTA, TRSP)

SET Characteristics:

SET pulse height	$LET_{threshold}$	Xsection σ_{sat}
mV	MeV cm²/mg	cm²
> +250	< 1.7	1.5E-3
< -250	> 1.7	<1.5E-3

Table 6-4: Xsection vs LET (2 parameter method) CLC501 (Application B ROSETTA, TRSP)

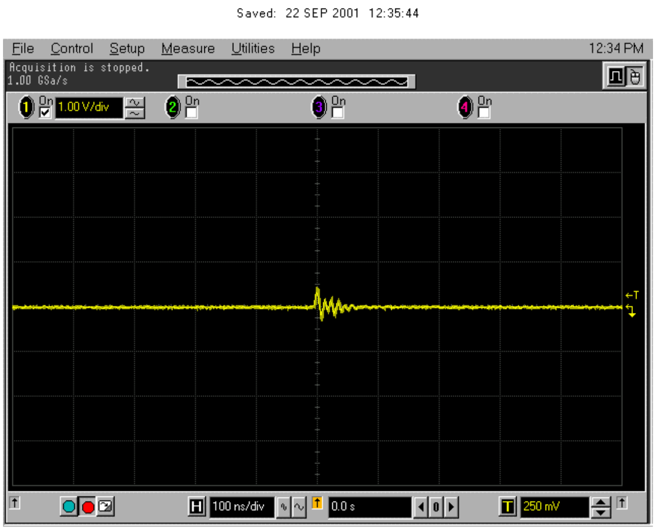


Figure 6-19: Run 46, SET Effects on CLC501 Appl. B (1.7 MeV cm²/mg, pulse height: 0.48V, pulse width: <100ns)

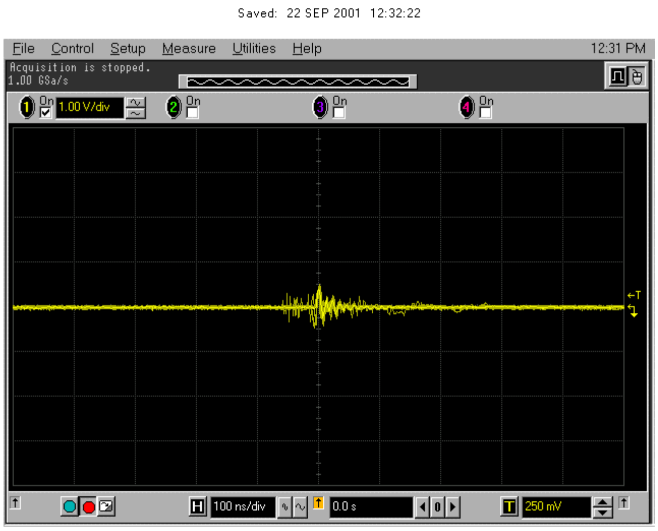


Figure 6-20: Run 45, SET Effects on CLC501 Appl. B (2.4 MeV cm²/mg, pulse height: 0.5V, pulse width: <100ns)

Possible triggers on ambient noise

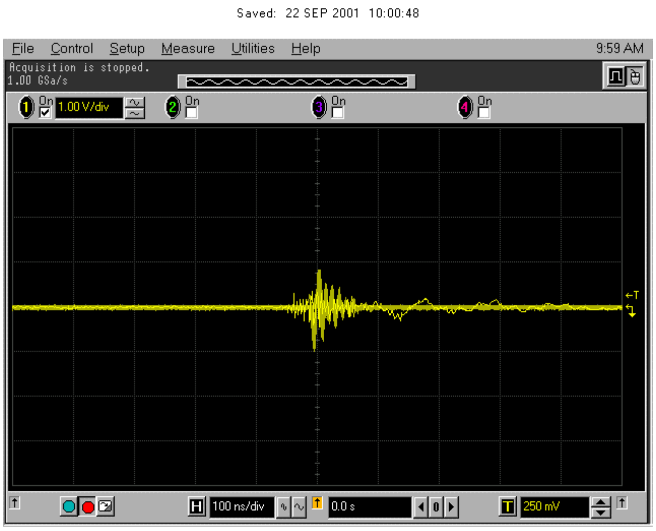


Figure 6-21: Run 34, SET Effects on CLC501 Appl. B (5.85 MeV cm²/mg, pulse height: 0.8V, pulse width: <100ns)

Possible triggers on ambient noise

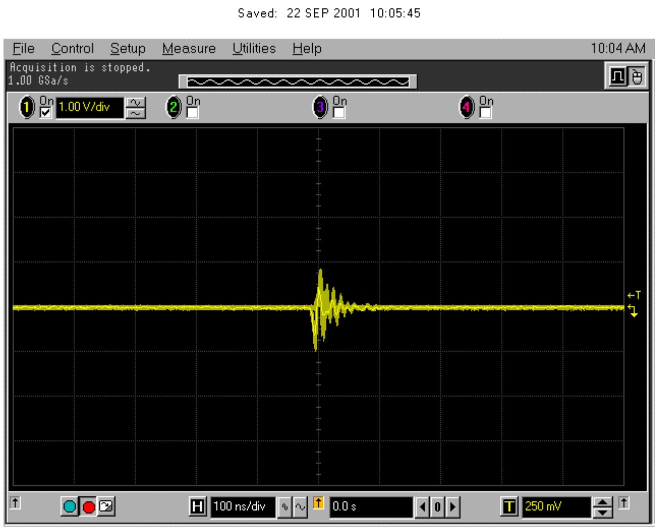


Figure 6-22: Run 35, SET Effects on CLC501 Appl. B (8.27 MeV cm²/mg, pulse height: 0.8V, pulse width: <100ns)

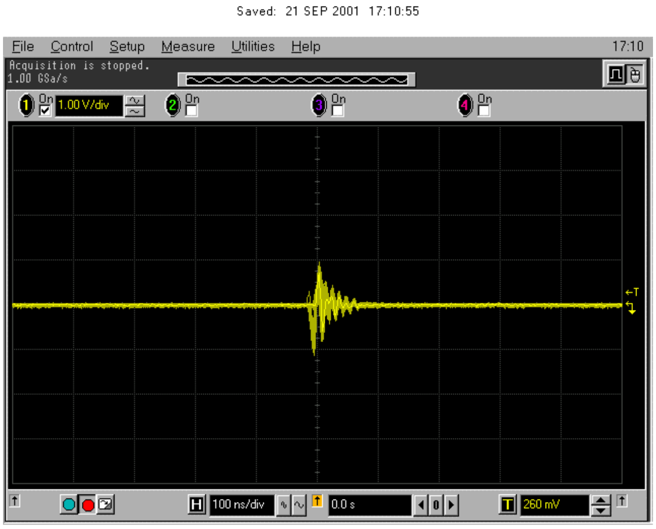


Figure 6-23: Run 11, SET Effects on CLC501 Appl. B (14.1 MeV cm²/mg, pulse height: 1V, pulse width: <100ns)

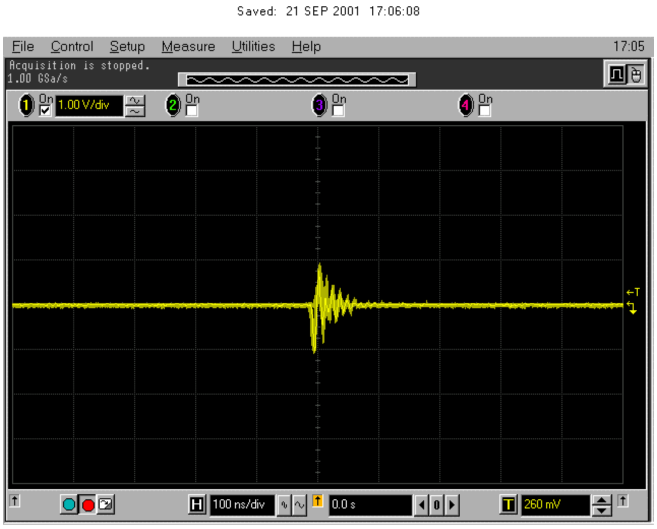


Figure 6-24: Run 10, SET Effects on CLC501 Appl. B (19.94 MeV cm²/mg, pulse height: 0.9V, pulse width: <100ns)

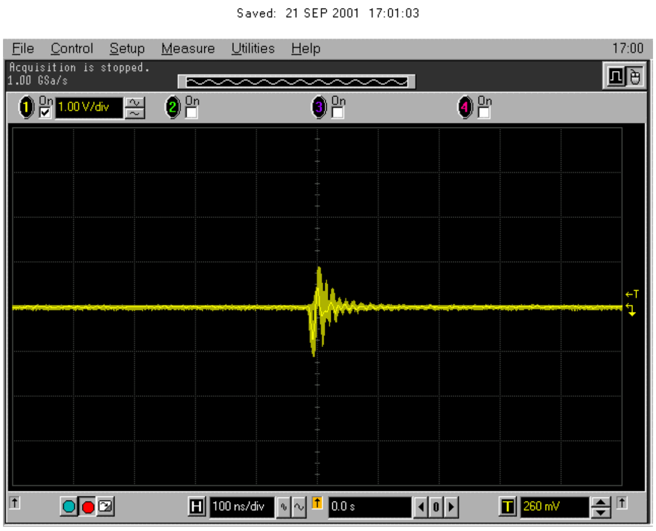


Figure 6-25: Run 9, SET Effects on CLC501 Appl. B (28.2 MeV cm²/mg, pulse height: 0.9V, pulse width: <100ns)

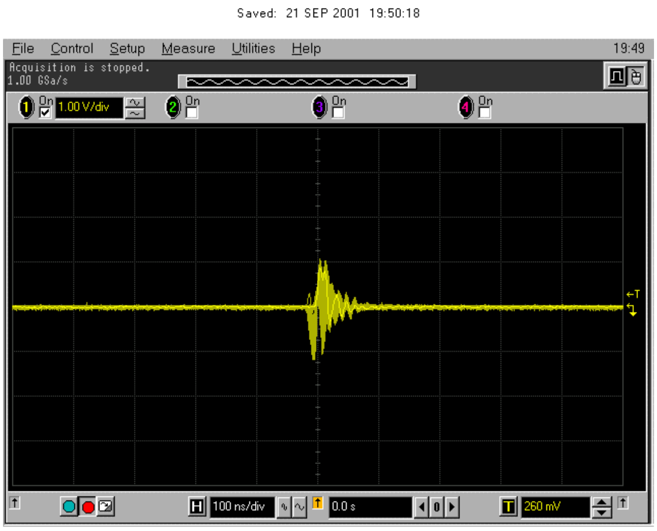


Figure 6-26: Run 24, SET Effects on CLC501 Appl. B (34 MeV cm²/mg, pulse height: 1V, pulse width: <100ns)

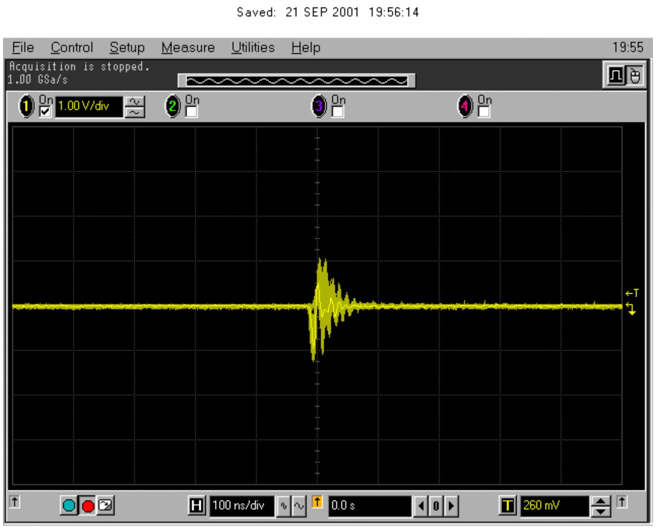


Figure 6-27: Run 25, SET Effects on CLC501 Appl. B (48.04 MeV cm²/mg, pulse height: 1V, pulse width: <100ns)

Figure 6-28: Run 26, SET Effects on CLC501 Appl. B (68 MeV cm²/mg, pulse height: 1.1V, pulse width: <100ns)

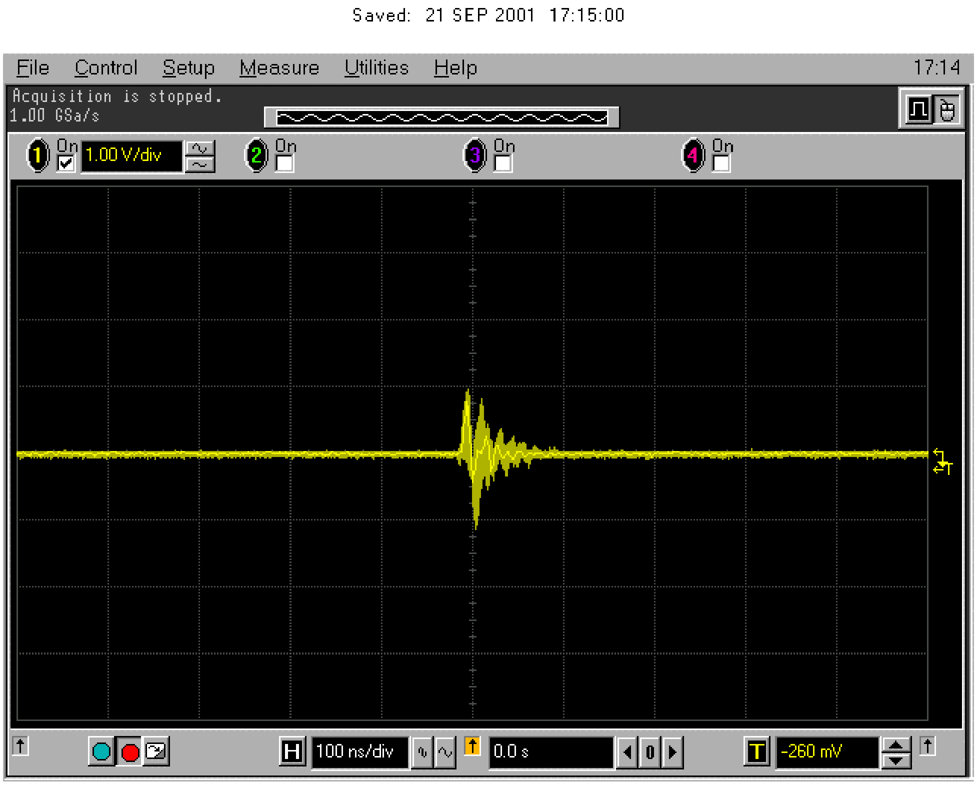


Figure 6-29: Example for "negative" SETs, CLC501 Appl. B, LET=14.1 MeV cm²/mg, 454 events, 0° tilt angle (Run 12, pulse height: -1.1V, pulse width: <100ns)

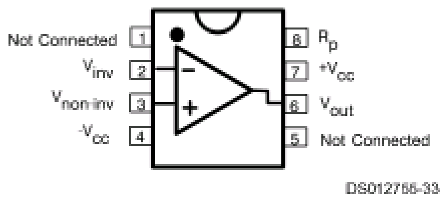
6.3. CLC505

6.3.1. General Description

The CLC505 is a monolithic, high speed op amp with a unique combination of high performance, low power consumption, and flexibility of application. The supply current is programmable over a 10 to 1 continuous range with a single resistor, R_p. This feature enables the amplifier to be used in a wide variety of high performance applications. Typical performance at any supply current is exceptional:

Parameter	Supply Current (I_{CC})			Units
	9mA	3.4mA	1mA	
−3dB Bandwidth	150	100	50	MHz
Settling Time	12	14	35	nsec
Slew Rate	1700	1200	800	V/µsec
Output Current	45	25	7	mA

The CLC505's combination of high performance, low power consumption, and large signal performance makes the CLC505 ideal for a wide variety of remote site equipment applications, such as battery powered test instrumentation and communications gear. Some other power applications are video switching matrices, ATE, and phased-array radar systems.



Pinout
DIP & SOIC

Electrical Characteristics

A_V = +6, V_{CC} = ±5V, R_f = 1000Ω, C_p = 100pF; unless specified

Electrical Characteristics (Continued)

A_V = +6, V_{CC} = ±5V, R_f = 1000Ω, C_p = 100pF; unless specified

Symbol	Parameter	Conditions	Typ	Max/Min Ratings (Note 2)			Units
Static, DC Performance							
ICC	**Supply Current** (Note 3)	**No Load, Quiescent**	**9**	**<11**	**<11**	**<12**	**mA**
Miscellaneous Performance							
RIN	Non-Inverting Input	Resistance	1200	>400	>800	>1600	kΩ
CIN		Capacitance	1	<2	<2	<2	pF
RO	Output Impedence	At DC	0.2	<1.2	<0.3	<0.2	ohm
VO	Output Voltage Range	No Load	±3.3	>±2.8	>±3.0	>±3.0	V
CMIR	Common Mode Input Range	For Rated Performance	±2.2	>±1.5	>±1.8	>±2.0	V
IO	Output Current	−40˚C to +85˚C	±45	>±20	>±36	>±36	mA

Electrical Characteristics

A_V = +6, V_{CC} = ±5V, R_f = 1000Ω, C_P = 100pF; unless specified

	SUPPLY CURRENT I_{CC} (TYP) = 3.4mA R_p =100kΩ, R_L = 500Ω				SUPPLY CURRENT I_{CC} (TYP) = 1mA R_p = 300kΩ, R_L =1000Ω				
Symbol	**Typ**	**Max & Min Ratings**			**Typ**	**Max & Min Ratings**			**Units**
	+25˚C	−40˚C	+25˚C	+85˚C	+25˚C	−40˚C	+25˚C	+85˚C	
SSBW	100	>80	>80	>65	50	>30	>35	>30	MHz
LSBW	80	>50	>50	>40	33	–1	>20	>18	MHz
GFPL	0	<0.3	<0.2	<0.3	0	<0.2	<0.1	<0.2	dB
GFPH	0	<0.5	<0.4	<0.5	0	<0.3	<0.2	<0.3	dB
GFR	0.2	<1.0	<1.0	<1.3	0.5	<1.0	<1.0	<1.3	dB
LPD	0.5	<1.0	<1.0	<1.2	0.2	<0.5	<0.5	<1.0	deg
TRS	3.5	<4.4	<4.4	<5.4	7	<12	<10	<12	ns
TRL	4.4	<7.0	<7.0	<8.8	9	–1	<18	<20	ns
TSP	14	<22	<22	<22	35	<70	<60	<60	ns
OS	2	<12	<10	<12	0	<8	<5	<8	%
SR	1200	>700	>800	>800	800	>500	>600	>600	V/µs
HD2	−55	<−40	<−45	<−45	−55	<−40	<−45	<−45	dBc
HD3	−65	<−55	<−55	<−55	−65	<−55	<−55	<−55	dBc
SNF	−155	<−153	<−153	<−152	−152	<−150	<−150	<−149	dBm (1Hz)
INV	56	<70	<70	<80	55	<70	<70	<80	µV
DG	0.04	–	–	–	0.1	–	–	–	%
DP	0.06	–	–	–	0.1	–	–	–	deg

Electrical Characteristics (Continued)

A_V = +6, V_{CC} = ±5V, R_f = 1000Ω, C_P = 100pF; unless specified

	SUPPLY CURRENT I_{CC} (TYP) = 3.4mA R_p =100kΩ, R_L = 500Ω				SUPPLY CURRENT I_{CC} (TYP) = 1mA R_p = 300kΩ, R_L =1000Ω				
IO	±25	>±10	>±18	>±18	±7	>±3.0	>±5	>±5	mA
IO	±25	>±9	>±18	>±18	±7	>±2.5	>±5	>±5	mA

Note 1: "Absolute Maximum Ratings" are those values beyond which the safety of the device cannot be guaranteed. They are not meant to imply that the devices should be operated at these limits. The table of "Electrical Characteristics" specifies conditions of device operation.

Note 2: Max/min ratings are based on product characterization and simulation. Individual parameters are tested as noted. Outgoing quality levels are determined from tested parameters.

Note 3: AJ-level: spec. is 100% tested at +25˚C = 3.4mA & parameter is 100% @25˚C in die form @ I_{CC}= 1mA, 3.4mA and 9mA.

Note 4: Not applicable due to output current limitations.

Note 5: See Text on the back page of data sheet.

Note 6: Differential gain and phase is characterized with a 1V_{PP} equivalent video signal, 0-100 IRE_{PP}, 40IRE_{pp}, and 0IRE = 0V at the load resistor and 3.58 MHz.

Note 7: xx/yy/zz MHz indicates that the CLC505 is specified at xxMHz for I_{CC} = 9mA, yyMHz for I_{cc} = 3.4mA, and zzMHz for I_{cc} = 1 mA.

Conditions are different for the three supply currents:

I_{CC}	R_L	R_{OUT}	A_V
9mA	75Ω	75Ω	+2
3.4mA	500Ω	0Ω	+6
1mA	1000Ω	0Ω	+6

6.3.2. Application in ROSETTA

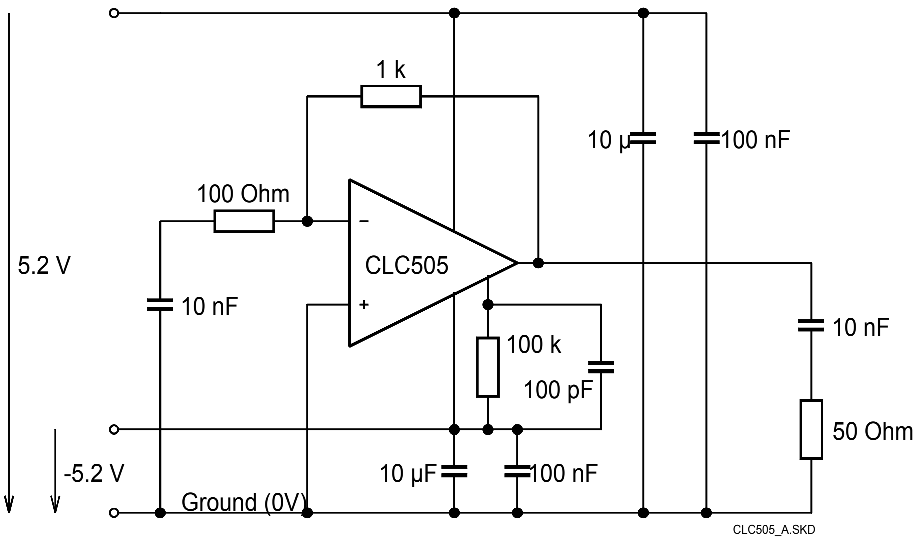


Figure 6-30: Bias circuit for CLC505

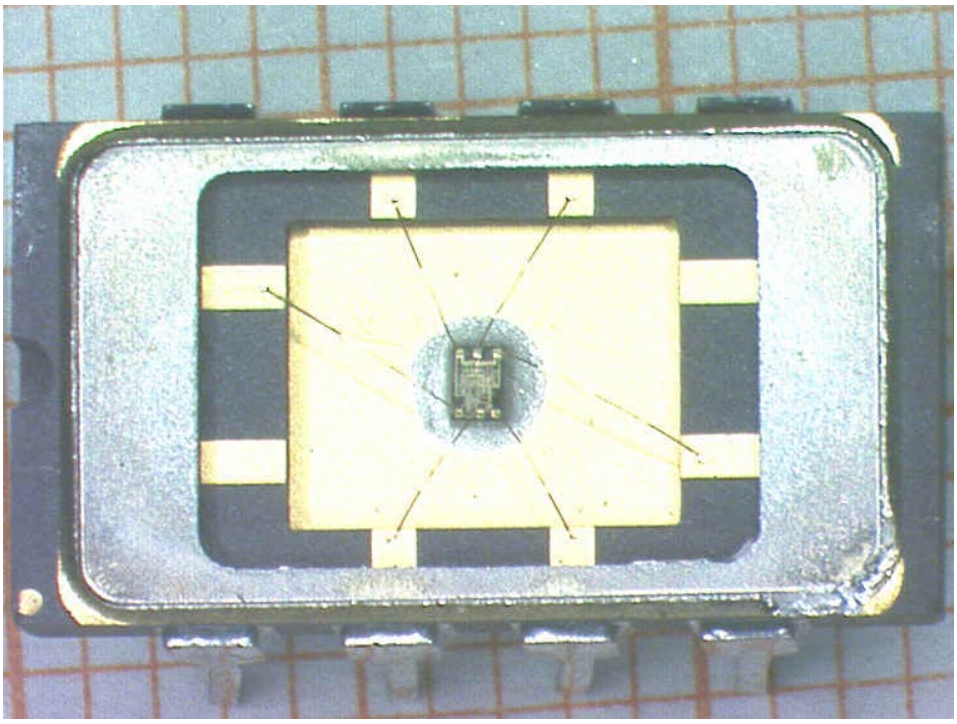


Figure 6-31: DUT CLC505 delidded

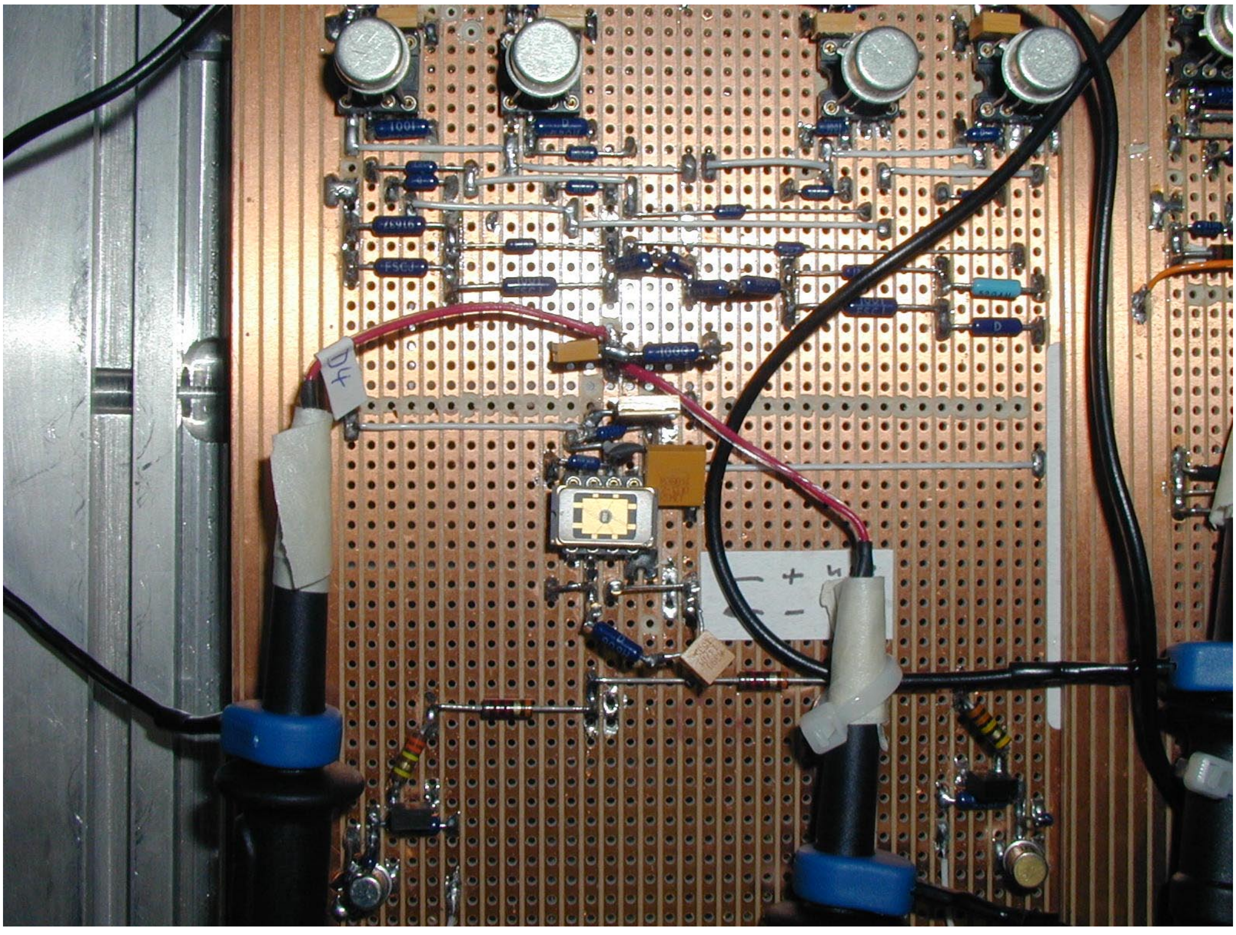


Figure 6-32: Test Board Setup for DUT CLC505

6.3.3. Test Results CLC505

In Table 6-5 the test parameters and observed effects are listed for transient amplitudes >250mV and logged negative spikes.

ASTRIUM RUN	UCL Run	Device	ION	LETeff	Xsection		RunDose	Fluence	Theta	TRANSIENTS		Comment
No	No	ID No		MeV cm²/mg	cm²		rad(Si)	#/cm²	°	No		
		SN132			>250mV	<-250mV				>250mV	<-250mV	
41	21 d2	CLC505	10 B 2+	3.4	2.69E-05	2.99E-06	54.5	1001918	60	27	3	
30	6 d2	CLC505	20 Ne 4+	5.85	7.48E-05	#N/A	93.85	1002625	0	75	#N/A	
31	7 d2	CLC505	20 Ne 4+	8.27	1.09E-04	9.86E-05	132.84	1003580	45	109	99	
5	5 d1	CLC505	40 Ar 8+	14.1	2.50E-04		226.39	1003487	0	251		
4	4 d1	CLC505	40 Ar 8+	19.94	2.88E-04		319.88	1002603	45	289		
3	3 d1	CLC505	40 Ar 8+	28.2	3.35E-04		452.49	1002854	60	336		
27	1 d2	CLC505	84 Kr 17+	34	3.92E-04		548.2	1007726	0	395		
28	2 d2	CLC505	84 Kr 17+	48.08	4.65E-04		773.3	1005162	45	467		
29	3 d2	CLC505	84 Kr 17+	68	4.96E-04		1091.88	1003565	60	498		

Table 6-5: Observed SE Effects on CLC505 (ROSETTA APPLICATION)

Figure 6-33 shows the Xsection vs LET curve for the transients on CLC505.

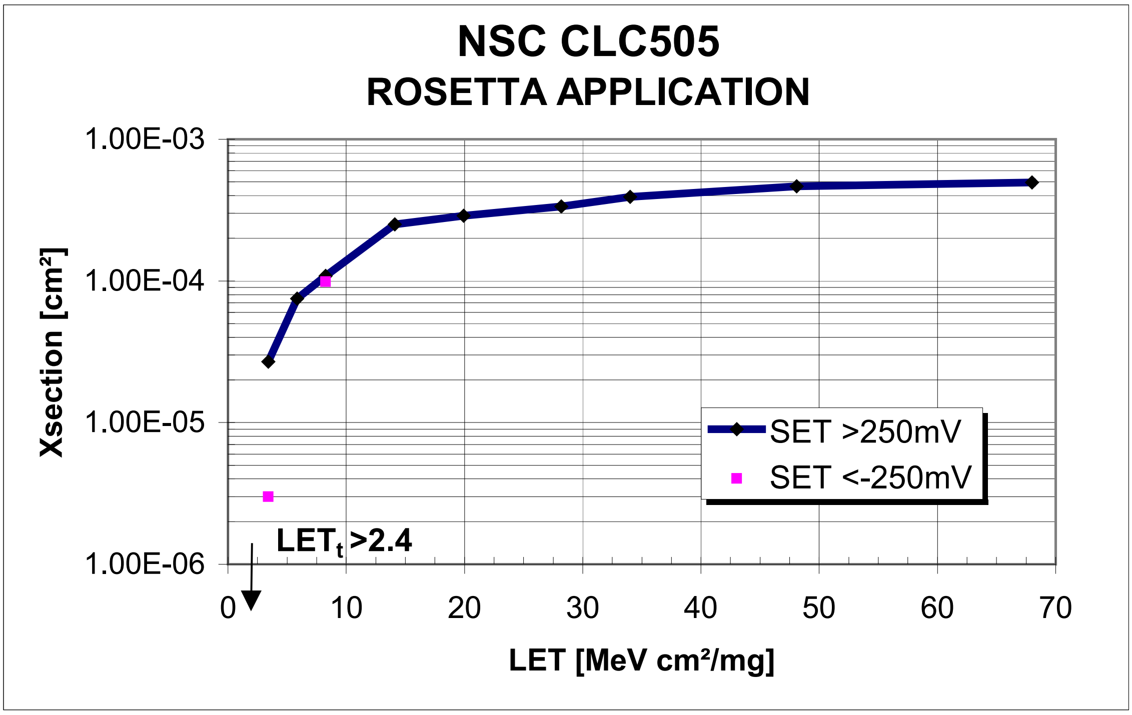


Figure 6-33: Xsection σ vs LET for SET on CLC505 (Application ROSETTA, TRSP)

SET Characteristics:

SET pulse height	$LET_{threshold}$	Xsection σ_{sat}
mV	MeV cm²/mg	cm²
> +250	> 2.4	2.7E-5
< -250	~3.4	<2.7E-5

Table 6-6: Xsection vs LET (2 parameter method) CLC505 (Application ROSETTA, TRSP)

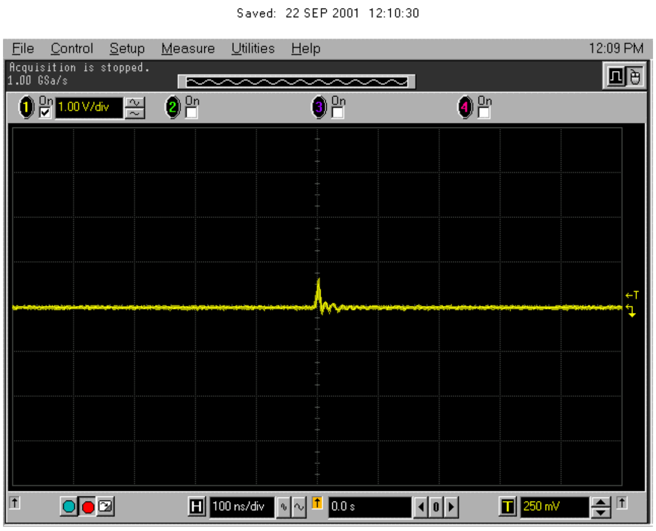


Figure 6-34: Run 41, SET Effects on CLC505 (3.4 MeV cm²/mg, pulse height: 0.7V, pulse width: <100ns)

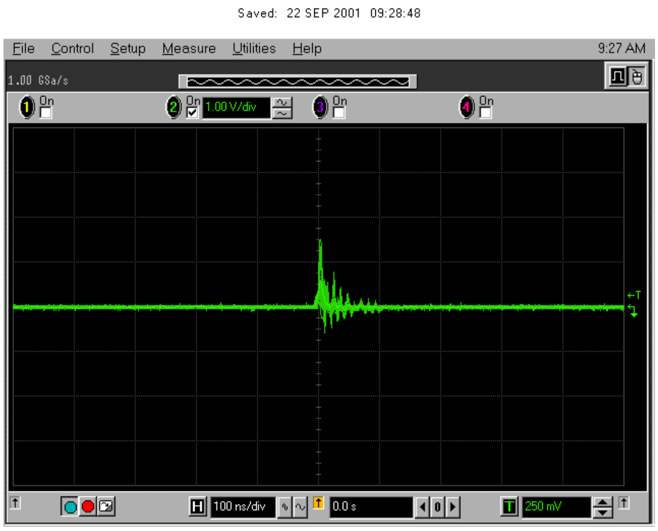


Figure 6-35: Run 30, SET Effects on CLC505 (5.85 MeV cm²/mg, pulse height: 1.5V, pulse width: <100ns)

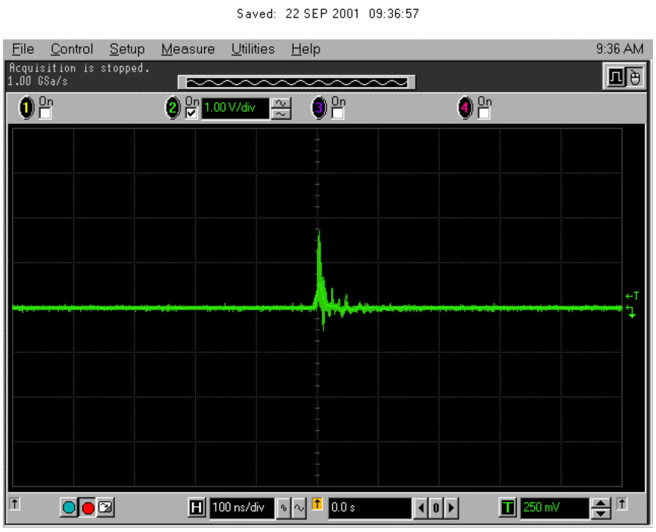


Figure 6-36: Run 31, SET Effects on CLC505 (8.27 MeV cm²/mg, pulse height: 1.75V, pulse width: <100ns)

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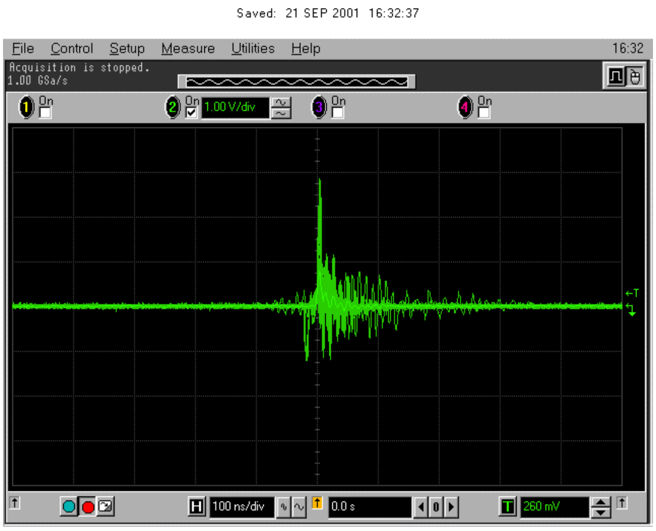

Figure 6-37: Run 5, SET Effects on CLC505 (14.1 MeV cm²/mg, pulse height: 2.9V, pulse width: <100ns)

Possible triggers on ambient noise

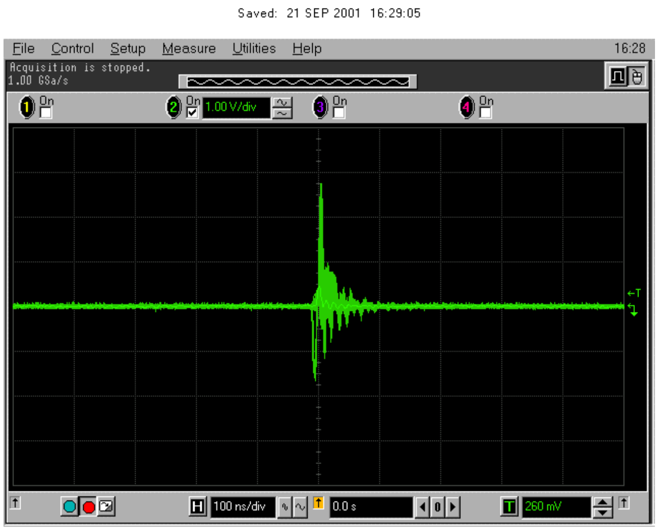

Figure 6-38: Run 4, SET Effects on CLC505 (19.94 MeV cm²/mg, pulse height: 2.75V, pulse width: <100ns)

Figure 6-39: Run 3, SET Effects on CLC505 (28.2 MeV cm²/mg, pulse height: 2.75V, pulse width: <100ns)

Figure 6-40: Run 27, SET Effects on CLC505 (34 MeV cm²/mg, pulse height: 3.2V, pulse width: <100ns)

Figure 6-41: Run 28, SET Effects on CLC505 (48.08 MeV cm²/mg, pulse height: 3.2V, pulse width: <100ns)

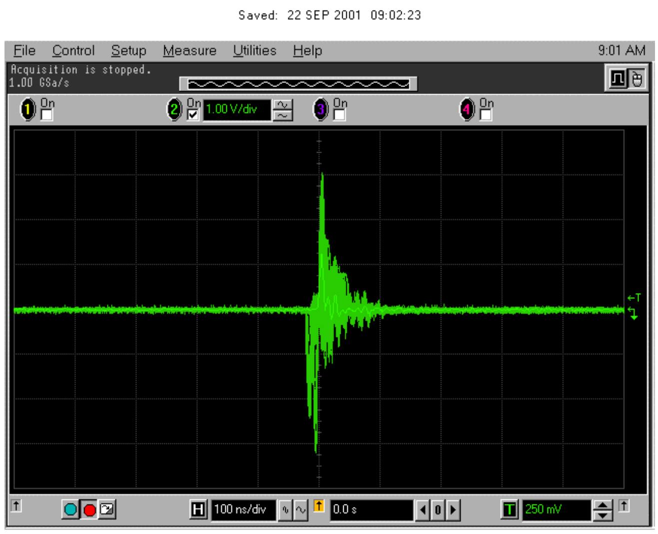

Figure 6-42: Run 29, SET Effects on CLC505 (68 MeV cm²/mg, pulse height: 3V, pulse width: <100ns)

6.4. µPC2712B

6.4.1. General Description

The µPC2712B is a silicon monolithic integrated circuit designed as buffer amplifier tuner. This IC is packaged in ceramic case which is smaller than conventional minimold.

The µPC2712B has compatible performance to µPC2712T of conventional minimold version.

RECOMMENDED OPERATING RANGE

Parameter	Symbol	MIN.	TYP.	MAX.	Unit
Supply Voltage	V_{CC}	4.5	5.0	5.5	V
Operating Ambient Temperature	T_A	–40	+25	+85	°C

ELECTRICAL CHARACTERISTICS (T_A = +25°C, V_{CC} = 5.0 V, Z_S = Z_L = 50 Ω)

Parameter	Symbol	Test Conditions	µPC2711TB			µPC2712TB			Unit
			MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
Circuit Current	I_{CC}	No signal	9	12	15	9	12	15	mA
Power Gain	G_P	f = 1 GHz	11	13	16.5	18	20	23.5	dB
Saturated Output Power	$P_{O(sat)}$	f = 1 GHz, P_{in} = 0 dBm	–2	+1	—	0	+3	—	dBm
Noise Figure	NF	f = 1 GHz	—	5	6.5	—	4.5	6	dB
Upper Limit Operating Frequency	f_u	3 dB down below from gain at f = 0.1 GHz	2.7	2.9	—	2.2	2.6	—	GHz
Isolation	ISL	f = 1 GHz	25	30	—	28	33	—	dB
Input Return Loss	RL_{in}	f = 1 GHz	20	25	—	9	12	—	dB
Output Return Loss	RL_{out}	f = 1 GHz	9	12	—	10	13	—	dB
Gain Flatness	ΔG_P	f = 0.1 to 2.5 GHz @µPC2711TB f = 0.1 to 2.0 GHz @µPC2712TB	—	±0.8	—	—	±0.8	—	dB

µPC2712B is manufactured using NEC's 20 GHz fr NESAT™III silicon bipolar process. This process uses silicon nitride passivation film and gold electrodes. These materials can protect chip surface from external prevent corrosion/migration.

6.4.2. Application in ROSETTA

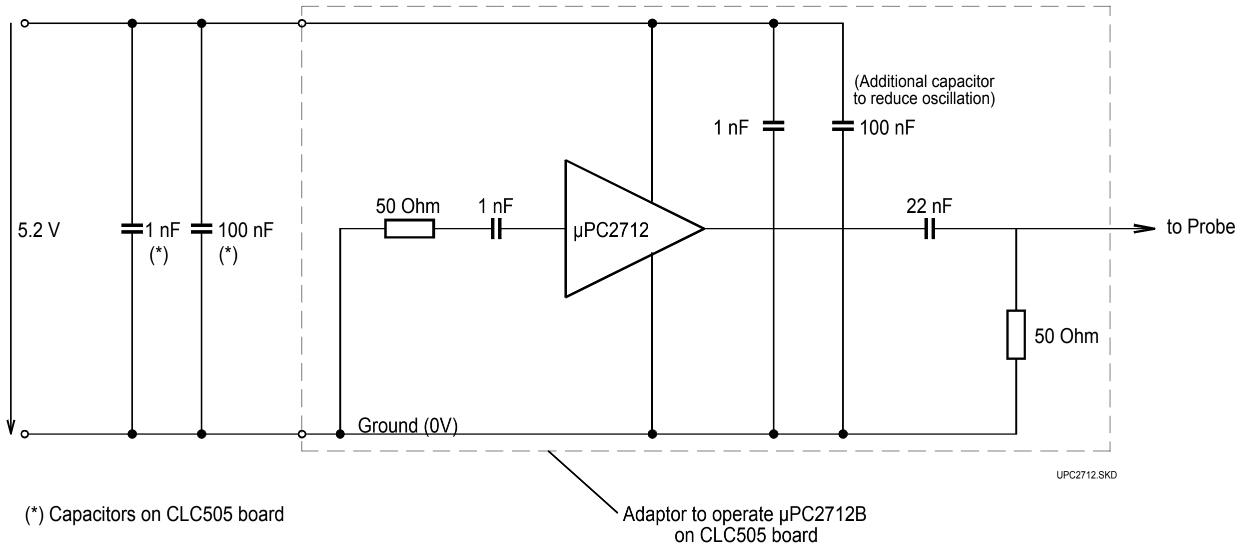

Figure 6-43: Bias circuit for µPC2712B.
(Unlike in the original RF application, an output capacitor of 22 nF (instead of 1 nF) is necessary to detect glitches of up to 1 µs duration)

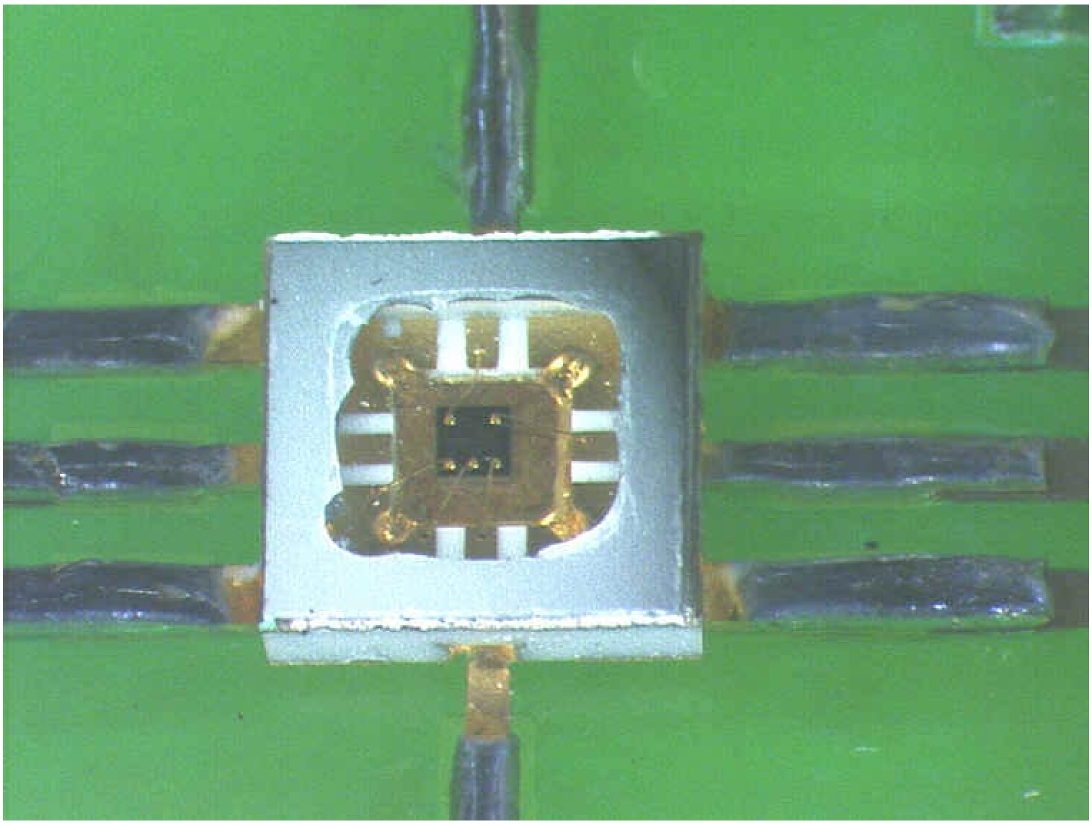

Figure 6-44: DUT µPC2712B delidded

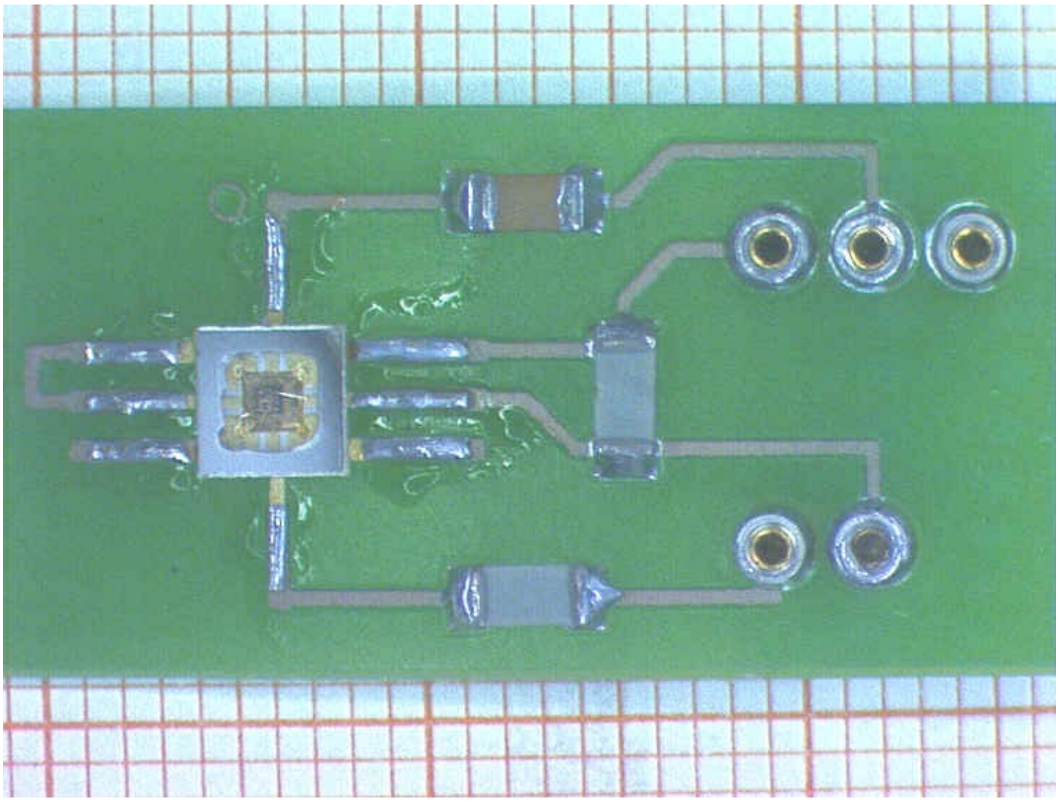

Figure 6-45: DUT µPC2712B on Test Adaptor delidded

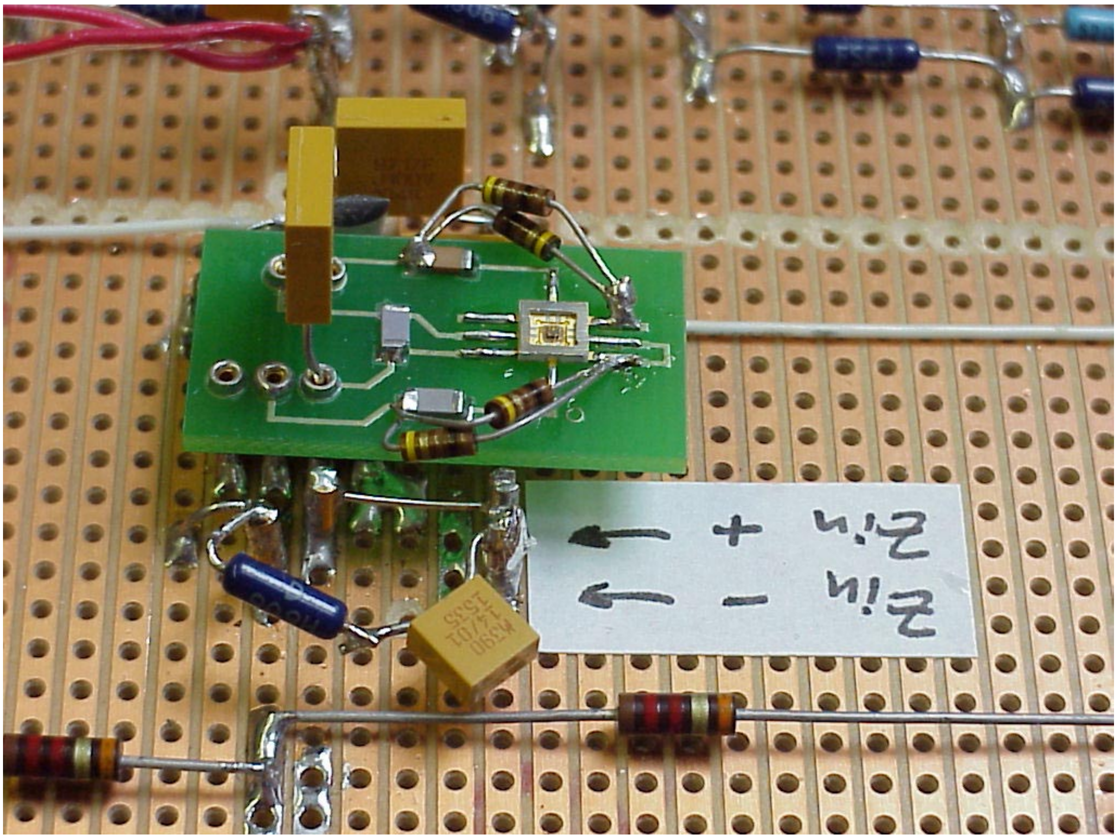

Figure 6-46: Test Setup for DUT µPC2712B

6.4.3. Test Results µPC2712B

In Table 6-7 the test parameters and observed effects are listed for transient amplitudes >75mV/125mV and logged negative spikes.

ASTRIUM	UCL	Device	ION	LETeff	Xsection	Xsection	Xsection	RunDose	Fluence	Theta	TRANSIENTS		
Run No	Run No	ID No		MeV cm²/mg	cm²	cm²	cm²	rad(Si)	#/cm²	°	No		
		SN 16			>75mV	>125mV	<"-125mV"				>75mV	>125mV	<-125mV
36	14 d2	2712	20 Ne 4+	5.85	0.00E+00	0	0	93.85	1002679	0	0	0	0
37	15 d2	2712	20 Ne 4+	8.27	0.00E+00	0	0	132.67	1002259	45	0	0	0
38	16 d2	2712	20 Ne 4+	11.7	0.00E+00	0	0	187.32	1000644	60	0	0	0
17	17 d1	2712	40 Ar 8+	14.1	9.95E-06	#N/A		226.75	1005098	0	10	#N/A	
16	16 d1	2712	40 Ar 8+	19.94	1.10E-05	#N/A		320.3	1003934	45	11	#N/A	
14	14 d1	2712	40 Ar 8+	28.2	1.99E-05	#N/A		452.48	1002841	60	20	#N/A	
18	20 d1	2712	84 Kr 17+	34		2.76916E-05		550.06	1011137	0		28	
19	22 d1	2712	84 Kr 17+	48.08		1.79211E-05		772.72	1004401	45		18	
20	23 d1	2712	84 Kr 17+	68		2.59856E-05		1088.6	1000555	60		26	

Table 6-7: Observed SE Effects on µPC2712B (ROSETTA APPLICATION)

Figure 6-47 shows the Xsection vs LET conditions for the transients >75mV and >125mV.

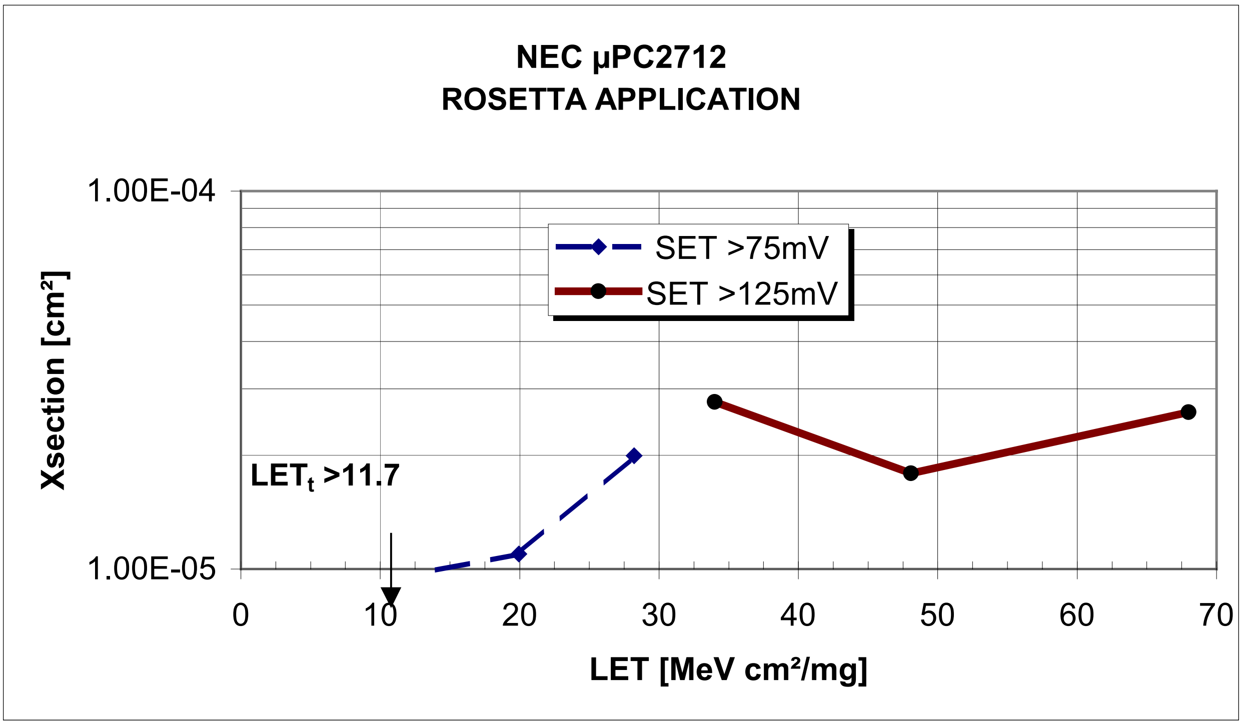

Figure 6-47: Xsection σ vs LET for SET on µPC2712B (Application ROSETTA, TRSP)

SET Characteristics:

SET pulse height	$LET_{threshold}$	Xsection σ_{sat}
mV	MeV cm²/mg	cm²
> +75	> 11.7	<2.8E-5 est.
> +125	> 11.7	2.8E-5

Table 6-8: Xsection vs LET (2 parameter method) µPC2712B (Application ROSETTA, TRSP)

Specific inherent oscillation has been observed on test arrangement for µPC2712B at UCL. This effect is shown in the next figure. However, the amplitude of the oscillation was smaller than the detector threshold so that detection of SEU transients was still possible.The characteristics of this behaviour are given in the screen shot below:

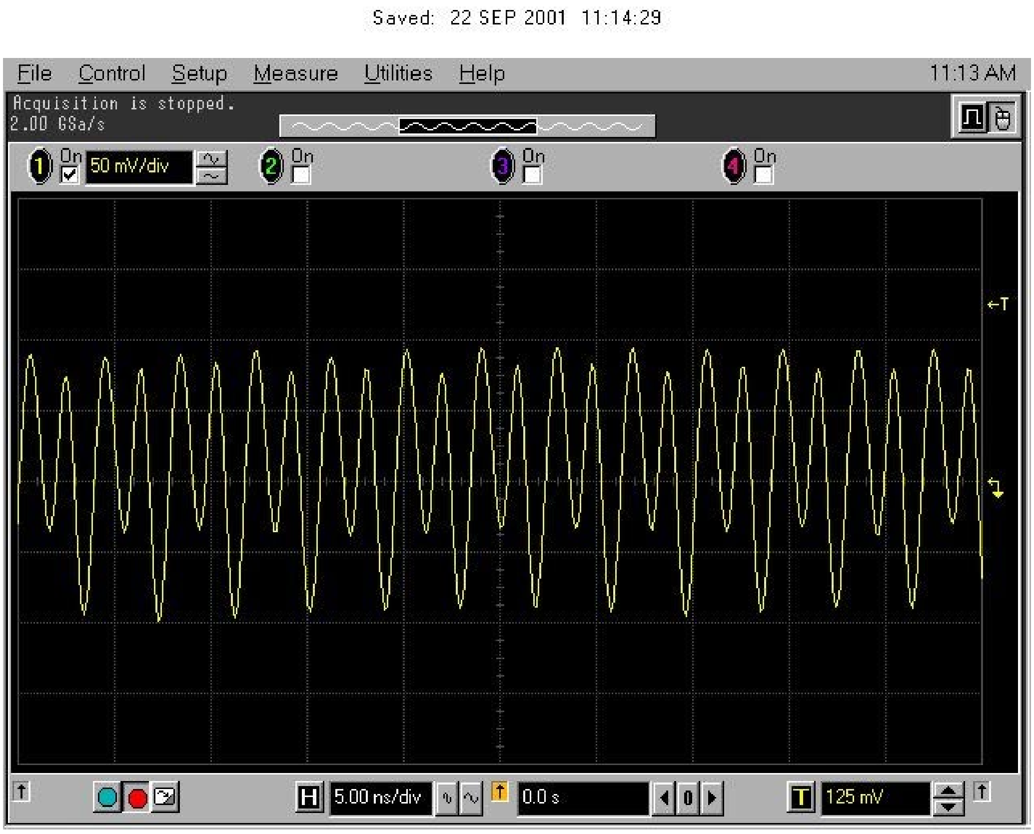

Figure 6-48: Oscillation on µPC2712B arrangement at UCL

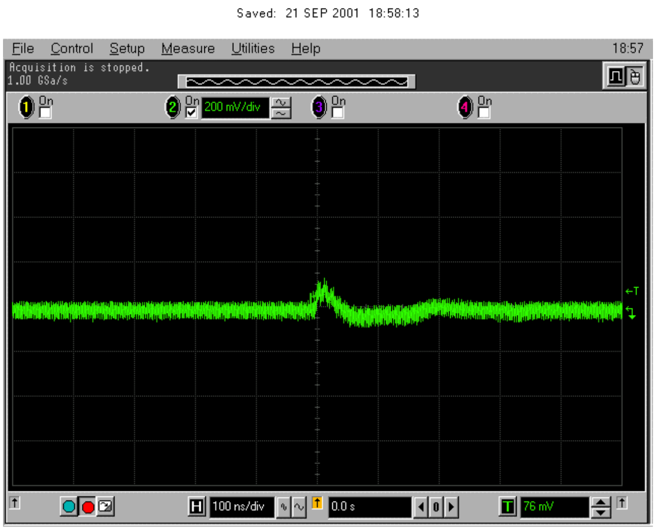

Figure 6-49: Run 17, SET Effects on µPC2712B (14.1 MeV cm²/mg, pulse height: 0.5V, pulse width: <100ns)

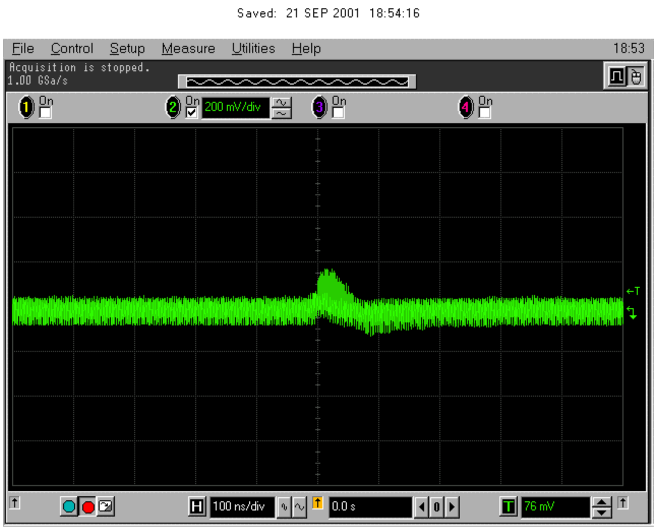

Figure 6-50: Run 16, SET Effects on µPC2712B (19.94 MeV cm²/mg, pulse height: 0.7V, pulse width: <100ns)

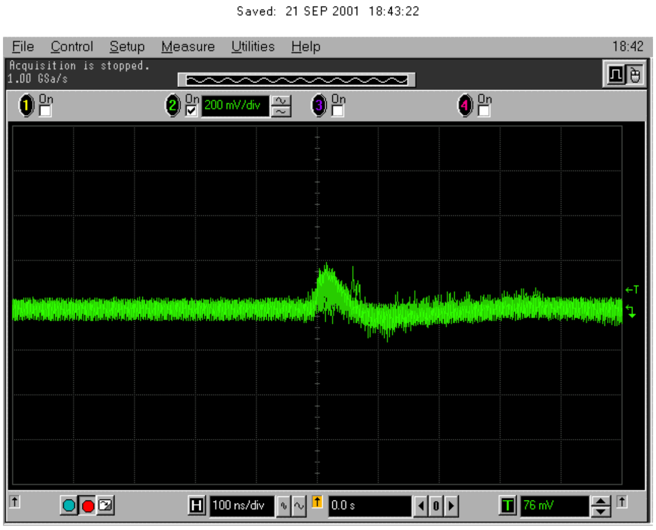

Figure 6-51: Run 14, SET Effects on µPC2712B (28.2 MeV cm²/mg, pulse height: 0.75V, pulse width: <100ns)

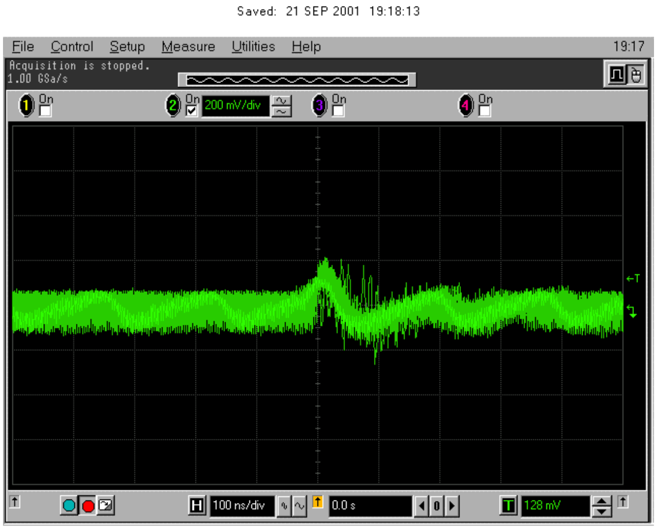

Figure 6-52: Run 18, SET Effects on µPC2712B (34 MeV cm²/mg, pulse height: 0.75V, pulse width: <100ns)

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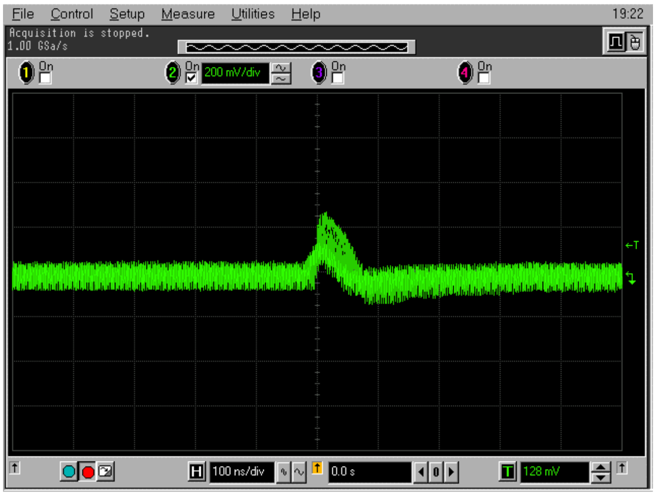

Figure 6-53: Run 19, SET Effects on µPC2712B (48.08 MeV cm²/mg, pulse height: 1.1V, pulse width: <100ns)

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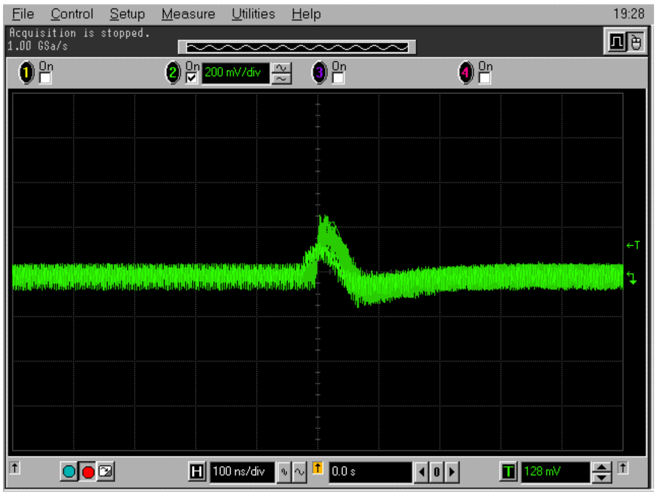

Figure 6-54: Run 20, SET Effects on µPC2712B (68 MeV cm²/mg, pulse height: 1.2V, pulse width: <100ns)

7. CONCLUSIONS

The tests on the four ROSETTA applications (CLC501A/B, CLC505, µPC2712B) have shown that no single event induced transients occur with pulse widths of >100ns, therefore the design of the related unit is able to cope with SET. No propagation of SET on system functionality is possible due to the precaution to filter SET with transients up to10µs on unit level.