HEAVY ION SINGLE EVENT EFFECTS RADIATION TEST REPORT

Part Type :

UC1901 Isolated Feed-back Generator

Manufacturer :

Unitrode

Programme :

Rosetta

Report Reference : ESA_QCA0205S_C

Issue : 01

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The work described in this report was done under ESA contract.
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Heavy ion SEE characterization of Unitrode UC1901 Isolated Feed-back Generator for Rosetta programme

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1 Abstract

Under ESA Contract No 13528/99/NL/MV COO-11 dated 21/05/01 covering "Radiation Evaluation of COTS Semiconductor Components: "Radiation SEE Testing for ROSETTA ", four different linear device types were radiation assessed. Results from these assessments, primarily focusing on the sensitivity of these devices to Single Event Effects (SEE), are reported in four different reports. The below summary table lists for each report, manufacturer and evaluated types, along with some device features.

ESA Report Reference	Device	Function	Manufacturer	Case	Datecode
ESA_QCA0203S_C	UC1823	PWM Controller	Unitrode	16-Lead Cerdip	9640
ESA_QCA0204S_C	UC1844A	PWM Controller	Unitrode	8-Lead Cerdip	9917
ESA_QCA0205S_C	UC1901	Isolated Feed-back Generator	Unitrode	14-Lead Cerdip	9849A
ESA_QCA0206S_C	RH1011	Comparator	Linear Technology	8-Lead Cerdip	

2 INTRODUCTION

This report presents the results of a Single Event Effects (SEE) test program carried out on UC1901 Isolated Feed-back Generator from Unitrode.

The main objective of this evaluation was to evaluate the sensitivity of this device using a test configuration representative of actual Rosetta design.

Test was conducted on hi-rel samples delivered by ESA.

These devices were used for heavy ion test at the European Heavy Ion Irradiation Facility (HIF) at Cyclone, Université Catholique de Louvain, Belgium.

This work was performed for ESA/ESTEC under ESA Contract No 13528/99/NL/MV COO-11 dated 21/05/01.

3 REFERENCE DOCUMENTS

RD-1. Saab Ericsson Space Fax 22/10/01 ref. RO-SES-2170/01 "Rosetta, Test setup for UC1901 and UC1823".
RD-2. The Heavy Ion Irradiation Facility at CYCLONE, UCL document, Centre de Recherches du Cyclotron (IEEE NSREC'96, Workshop Record, Indian Wells, California, 1996).
RD-3. Single Event Effects Test method and Guidelines ESA/SCC basic specification No 25100.
RD-4. UC1901 Unitrode datasheet

4 DEVICE INFORMATION

Relevant device identification information is presented here after.

Part type:	UC1901
Manufacturer:	Unitrode
Package:	14-Lead Cerdip
Quality Level:	Hirel
Date Code:	9849A
Die Technology:	Bipolar
Top Marking:	TPR-08-093 01B Δ 117 U 6A 9849A
Die Marking	KY 1901
S/Ns	112, 117, 118

4.1 Samples preparation

Samples were mechanically opened by Hirex Engineering and photos of both the prepared sample and the die identification are presented in Figure 1.

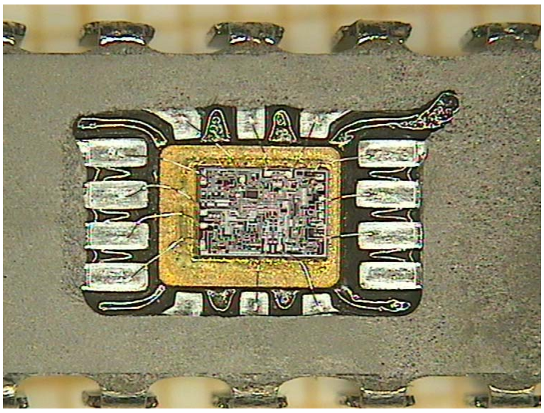


Photo # 1 :

Prepared Sample

Part Type : UC1901

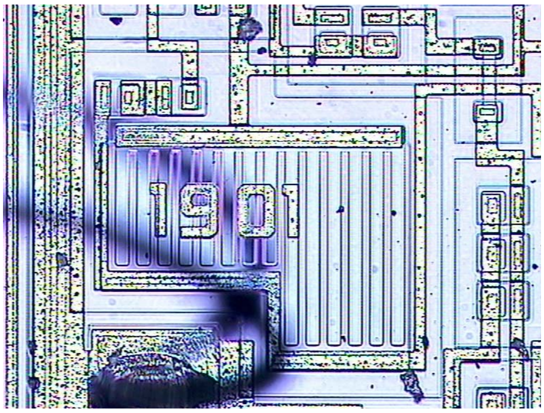


Photo # 2 :

Die Identification

Part Type : UC1901

Figure 1 - UC1901 Unitrode sample photos

5 Test Set-up

Hirex test equipment is composed of a modular rack coupled with a generic test board plus a specific device interface board which provides the desired test configuration :

- This modular rack is derived from Hirex BILT modular instrumentation system and presents 8 slots for modular instruments. In addition to the power supply modules which cover the SEE test needs for precision measurements, this rack allows for remote control, LU detection, data storage, via a communication link with a generic control board (IL220 : 25MIPS 16-bits micro-controller, 100kgates FPGA) installed inside the test chamber and close to the DUT.
- Inside the chamber and dedicated to the test of analog devices, a generic test board (IL240) can be coupled with the control board. The IL240 board can receive 4 device interface boards (DIBs) and assure :
  - The multiplex operation of the DIBs
  - The DUT power supply with latchup detection and process,
  - The monitoring of one DIB output analog signal with a triple window comparator (with three programmable detection thresholds)
  - The amplification of one DIB output signal for a remote scope observation with an adequate bandwidth.
- Each Device Interface Board (DIB) is specifically designed to provide a test configuration representative of the actual application (bias conditions, load, etc)

Figure 2 here below gives a synoptic of the test hardware used for this set-up as well as a photo of the boards.

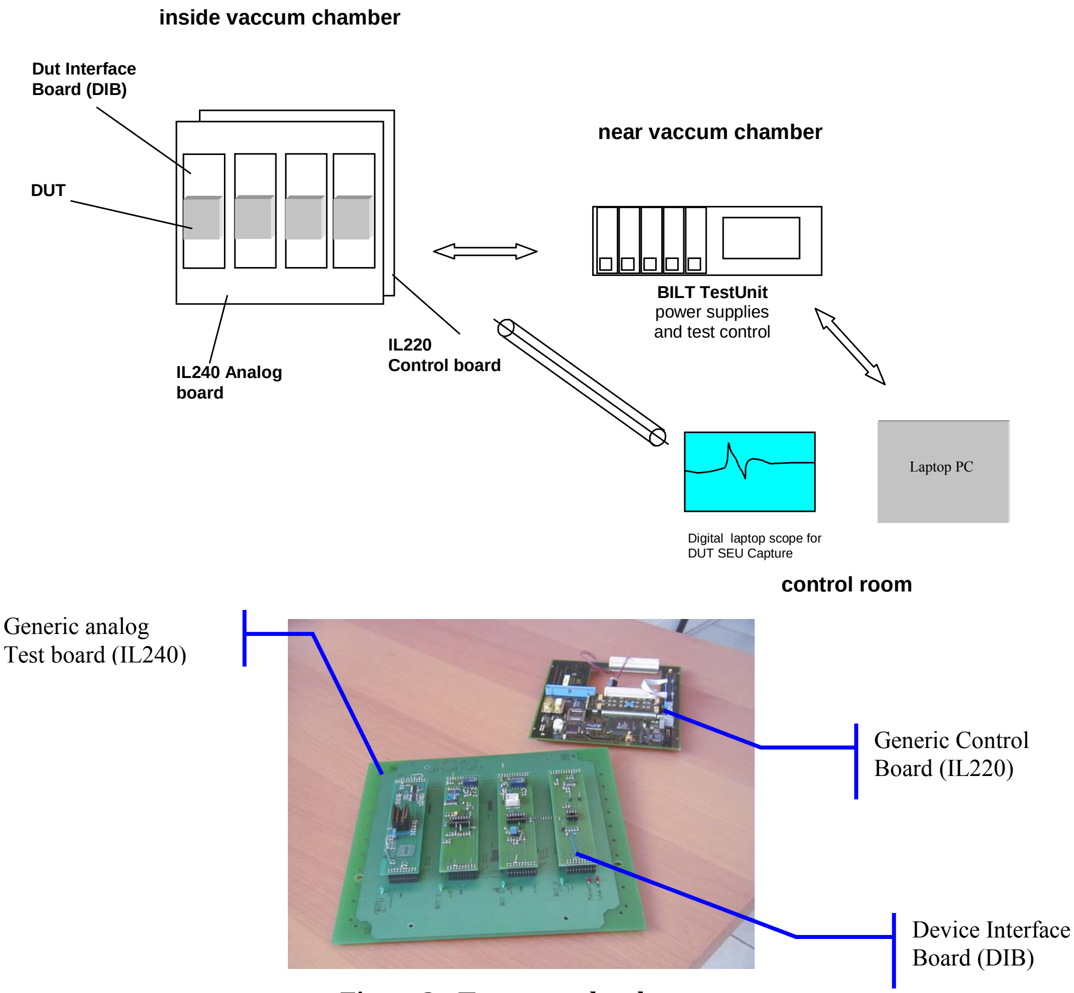
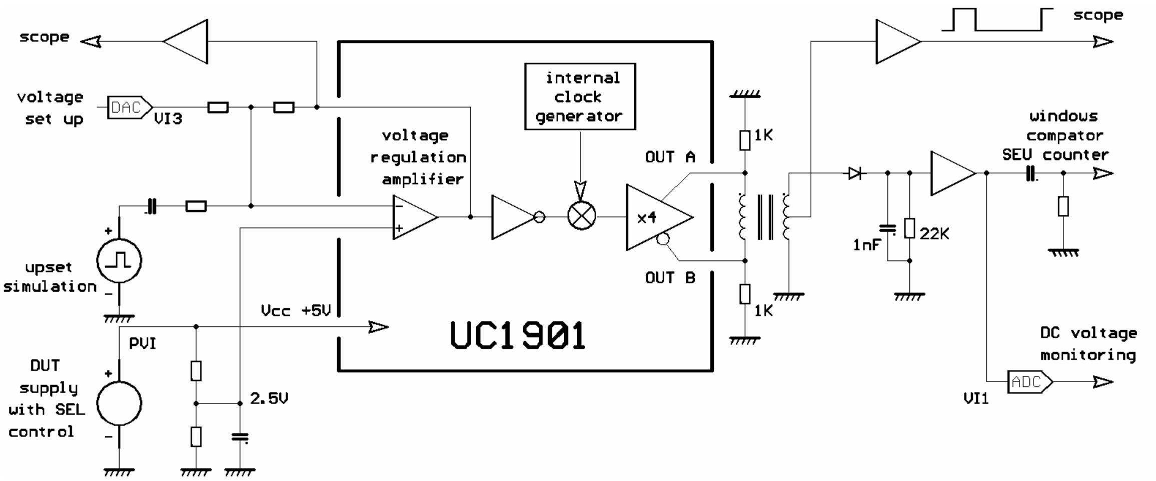


Figure 2 - Test set-up hardware

5.1 Tests Configuration

5.1.1 Test set up (IL242 test board) (see RD-1)

- Complementary outputs are used to drive a transformer, thus allowing ground referenced amplitude monitoring.
- Both outputs are equally loaded by 1K resistors
- After single phase amplitude detection, signal is both monitored with respect to DC value and transient values.
- The voltage regulation amplifier is operated with a simple resistor feedback network.
- Internal voltage reference and status comparator are not used.
- Non inverted amplifier input is biased with a resistor divider from Vcc.



5.1.2 Main upset monitoring

The amplifier used to monitor transients at the output, is AC coupled. It is then possible to trig on small amplitude upset pulses regardless to the value of the device voltage gain accuracy.
At this point, voltage ripple at modulation frequency is 40 mV cc.
A Windows comparator will deliver separate SEU count for small, medium and large amplitude by setting three different programmable detection analog thresholds.
Threshold nominal setup is : small = 80mV, medium = 400mV, large = 1V.
This set-up allows the counting upsets due to amplifier, modulator and driver.

5.1.3 Other monitoring features

- Scope monitoring of the Output A signal
- Scope monitoring of the voltage regulation amplifier output
- DC measurement of the demodulated output voltage.
- Upset simulation with AC coupled narrow pulses at voltage regulation amplifier inverting input.

5.1.4 Working point description

- 1.25MHz switching frequency .
- 4.4V voltage set up at VI3 DAC output (non inverting amplifier input) produces :
  - 1.4V at VI1 ADC input (DC output voltage monitoring ±100mV)
  - 3.5V / 1.5V switched square signal at driver A & B outputs
  - +2V / - 2 V alternative signal at transformer output
  - +1V / - 1 V alternative signal at scope input

6 TEST FACILITIES

6.1 UCL

Test at the cyclotron accelerator was performed at Université de Louvain (UCL) in Louvain-La-Neuve (Belgium) under HIREX Engineering responsibility.

6.1.1 Beam Source

In collaboration with the European Space Agency (ESA), the needed equipment for single events studies using heavy ions was built and installed on the HIF beam line in the experimental hall of Louvain-La-Neuve cyclotron.
CYCLONE is a multi particle, variable energy, cyclotron capable of accelerating protons (up to 75 MeV), alpha particles and heavy ions. For the heavy ions, the covered energy range is between 0.6 MeV/AMU and 27.5 MeV/AMU. For these ions, the maximal energy can be determined by the formula:
$110\ Q^2/M$,
where Q is the ion charge state, and M is the mass in Atomic Mass Units.

The heavy ions are produced in a double stage Electron Cyclotron Resonance (ECR) source. Such a source allows producing highly charged ions and ion "cocktails". These are composed of ions with the same or very close M/Q ratios. The cocktail ions are injected in the cyclotron, accelerated at the same time and extracted separately by a fine tuning of the magnetic field or a slight changing of the RF frequency. This method is very convenient for a quick change of ion (in a few minutes) which is equivalent to a LET variation.

6.1.2 Dosimetry

The current UCL Cyclotron dosimetry system and procedures were used.

6.2 Beam set-up

The UCL ions used are listed in the table below.

Ion Species	Energy	LET	Range in Si
	(MeV)	(MeV.cm²/mg)	µm
10-B	41	1.7	80
20-Ne	78	5.85	45
40-Ar	150	14.1	42
84-Kr	316	34	43
132-Xe	459	55.9	43

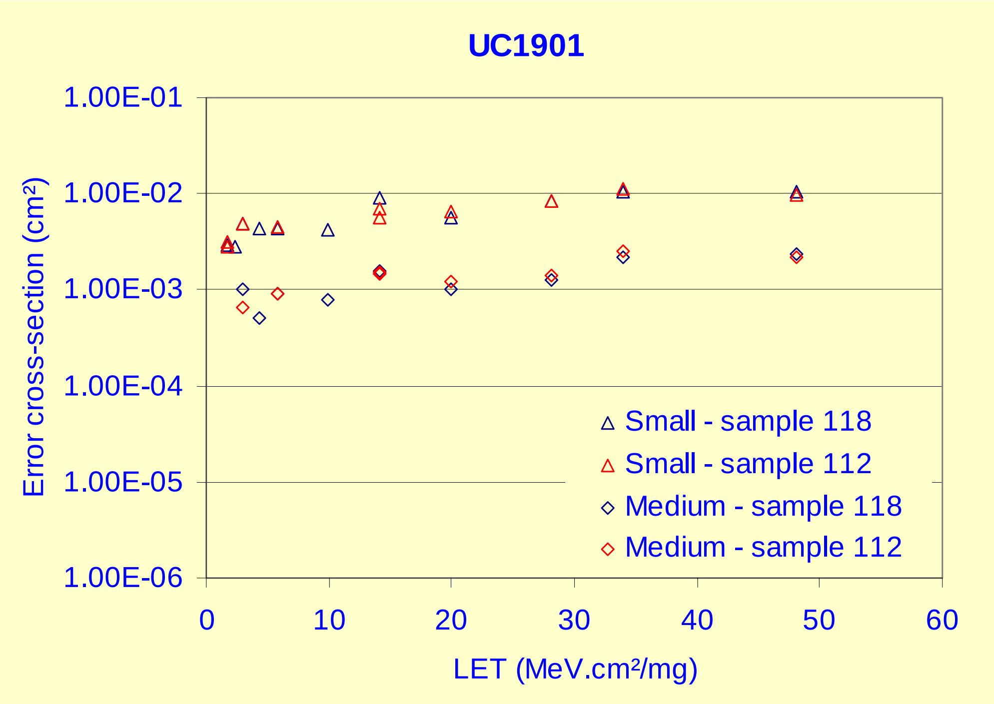
The LET range is obtained by changing the ion species and incident energy and changing the angle of incidence between the beam and the chip.

For each run, the following information is given in the detailed results tables provided in the next paragraph (paragraph 7) :

- Ion type
- Ion energy
- LET
- Range
- Tilt angle
- Effective LET
- Averaged flux
- Fluence
- Equivalent dose received by the DUT sample

7 RESULTS

Detailed results per run are presented in paragraph 7.1 and the corresponding errors cross-sections are plotted in Figure 3 here below.



	Threshold (mV)
Small	80
Medium	400

Figure 3 - UC1901 SEU error cross-section versus LET

To illustrate the different errors observed, 2 examples of SEUs have been recorded with the oscilloscope and are shown in Figure 4 and Figure 5.

Detection is performed on the DC measurement of the demodulated output voltage with a programmable detection level threshold (upper curve Figure 4 a, b, Figure 5 a, b)

Scope records allow to observe either the output signal (lower curve in Figure 4 a and Figure 5 a) or the output of the voltage regulation amplifier (lower curve in Figure 4 b and Figure 5 b)

All the upsets seem to be originated in the DUT voltage amplifier

Figure 4 represent a typical event while Figure 5 show the worst case observed where the oscillator is blocked (saturation) during 8 µs, period which correspond to the voltage amplifier slew rate.

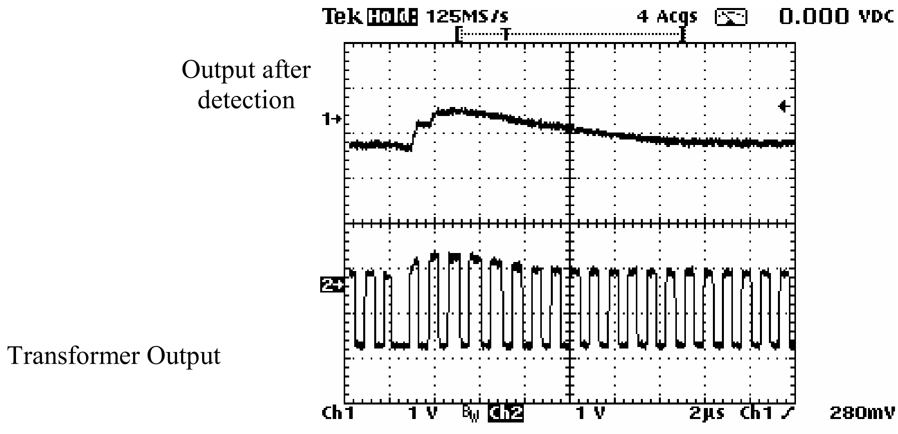


Figure 4 - a

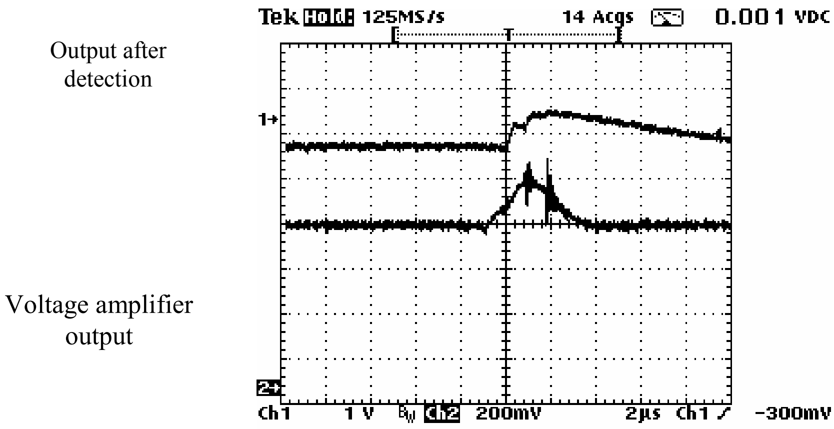


Figure 4 - b

Figure 4 - UC1901, SEU scope record of a typical SEU

Output after detection

Transformer Output

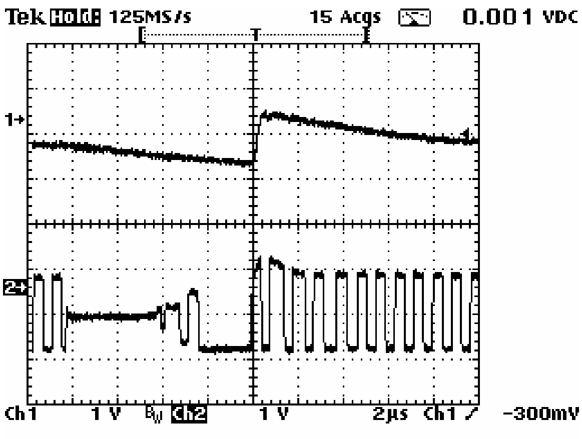


Figure 5 - a

Output after detection

Voltage amplifier output

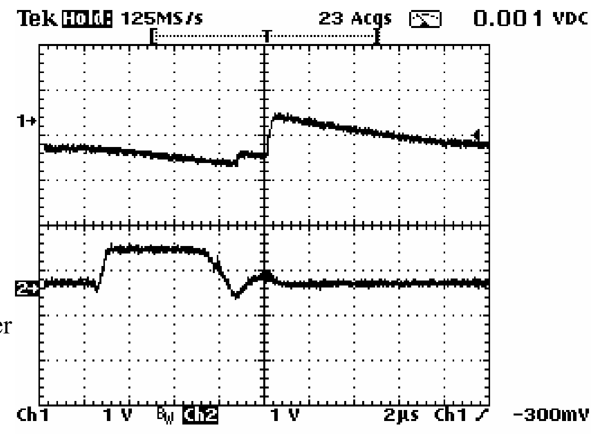


Figure 5 - b

Figure 5 - UC1901, Worst case SEU scope record

7.1 UCL Detailed Results

Run #	Sample	Ion	Energy	LET	Range	Angle	Eff_LET	Time	Flux	Run TID	Sample TID	Fluence	Small errors	x/s Small	Medium errors	x/s Medium
			MeV	MeV(mg/cm²)	µ	deg.	MeV(mg/cm²)	s	Ions/cm².s	Rads(Si)	Rads(Si)	Ions/cm²		cm²		cm²
R00080	118	10-B	41	1.7	80	0	1.7	139	7.19E+03	2.72E+01	4.18E+02	1.00E+06	2894	2.89E-03	0	
R00081	118	10-B	41	1.7	80	43	2.32	204	4.90E+03	3.72E+01	4.56E+02	1.00E+06	2838	2.84E-03	0	
R00044	118	15-N	62	2.97	64	0	2.97	121	8.26E+03	4.76E+01	3.14E+02	1.00E+06	4893	4.89E-03	1024	1.02E-03
R00043	118	15-N	62	2.97	64	47	4.35	83	6.12E+03	3.54E+01	2.67E+02	5.08E+05	2175	4.28E-03	254	5.00E-04
R00070	118	20-Ne	78	5.85	45	0	5.85	52	5.85E+03	2.85E+01	3.43E+02	3.04E+05	1341	4.41E-03	274	9.01E-04
R00071	118	20-Ne	78	5.85	45	54	9.95	91	3.32E+03	4.82E+01	3.91E+02	3.02E+05	1246	4.13E-03	238	7.88E-04
R00030	118	40-Ar	150	14.1	42	0	14.1	105	1.90E+03	4.52E+01	4.52E+01	2.00E+05	1782	8.91E-03	319	1.60E-03
R00031	118	40-Ar	150	14.1	42	45	19.9	159	1.89E+03	9.58E+01	1.41E+02	3.00E+05	1711	5.70E-03	304	1.01E-03
R00032	118	40-Ar	150	14.1	42	60	28.2	216	9.26E+02	9.04E+01	2.31E+02	2.00E+05	1653	8.27E-03	254	1.27E-03
R00101	118	84-Kr	316	34	43	0	34	89	1.12E+03	5.45E+01	5.10E+02	1.00E+05	1047	1.05E-02	220	2.20E-03
R00102	118	84-Kr	316	34	43	45	48.1	127	7.87E+02	7.70E+01	5.87E+02	1.00E+05	1037	1.04E-02	233	2.33E-03
R00087	112	10-B	41	1.7	80	0	1.7	90	1.11E+04	2.72E+01	4.10E+02	1.00E+06	2853	2.85E-03	0	
R00088	112	10-B	41	1.7	80	0	1.7	135	7.41E+03	2.72E+01	4.37E+02	1.00E+06	3148	3.15E-03	0	
R00050	112	15-N	62	2.97	64	0	2.97	100	1.00E+04	4.76E+01	2.96E+02	1.00E+06	4890	4.89E-03	652	6.52E-04
R00061	112	20-Ne	78	5.85	45	0	5.85	72	5.78E+03	3.90E+01	3.35E+02	4.16E+05	1860	4.47E-03	383	9.21E-04
R00009	112	40-Ar	150	14.1	42	0	14.1	641	7.50E+02	1.09E+02	1.09E+02	4.81E+05	3397	7.06E-03	716	1.49E-03
R00010	112	40-Ar	150	14.1	42	0	14.1	160	8.00E+02	2.89E+01	1.38E+02	1.28E+05	714	5.58E-03	185	1.45E-03
R00011	112	40-Ar	150	14.1	42	45	19.9	203	5.85E+02	3.79E+01	1.76E+02	1.19E+05	772	6.49E-03	147	1.24E-03
R00012	112	40-Ar	150	14.1	42	60	28.2	229	3.55E+02	3.67E+01	2.12E+02	8.12E+04	683	8.41E-03	113	1.39E-03
R00093	112	84-Kr	316	34	43	0	34	160	6.25E+02	5.45E+01	4.92E+02	1.00E+05	1104	1.10E-02	253	2.53E-03
R00094	112	84-Kr	316	34	43	45	48.1	258	3.88E+02	7.70E+01	5.69E+02	1.00E+05	965	9.65E-03	217	2.17E-03

8 CONCLUSION

Heavy ion tests were conducted on hirel samples of Unitrode UC1901 Isolated Feed-back Generator used in Rosetta programme, using the heavy ions available at the European Heavy Ion Irradiation Facility (HIF) at Cyclone, Université Catholique de Louvain, Belgium.

Test configuration was closed as possible to the actual application and the different error signatures have been identified and analysed.

Results obtained allowed for plotting the Single Event Upset error cross-section over an LET range from 2 to 50 MeV(mg/cm²).