HEAVY ION SINGLE EVENT EFFECTS
RADIATION TEST REPORT

Part Type :

RH1011 Comparator

Manufacturer :

Linear Technology

Programme :

Rosetta

Report Reference : ESA_QCA0206S_C

Issue : 01

Date : July 16, 2002

ESA Contract No 13528/99/NL/MV COO-11 dated 21/05/01

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Heavy ion SEE characterization of Linear Technology RH1011 Comparator 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 RH1011 Comparator from Linear Technology.

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. Patria Finavitec Fax 8/8/2000 ref. RO-FIN-3106/001 "RO PDU : RH1011 SEU issue update".
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. RH1011 Linear Technology datasheet

4 DEVICE INFORMATION

Relevant device identification information is presented here after.

Part type:	RH1011
Manufacturer:	Linear technology
Package:	8-Lead Cerdip
Quality Level:	Hirel
Date Code:	
Die Technology:	Bipolar
Top Marking:	
Die Marking	C 1011 1983
S/Ns	023, 024, 025

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.

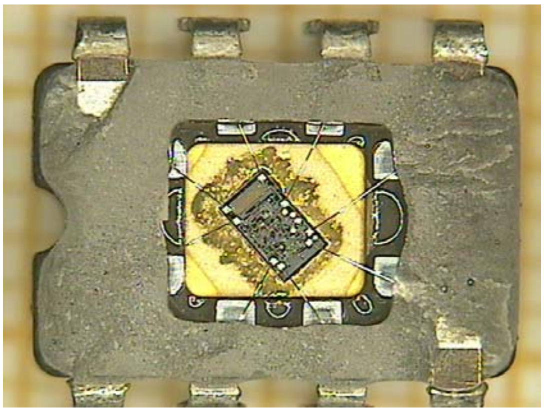


Photo # 1 :

Prepared Sample

Part Type : RH1011

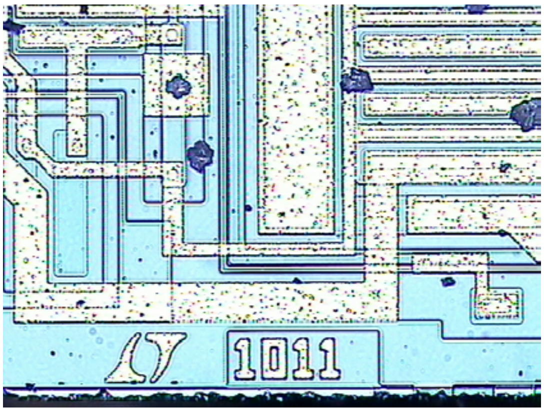


Photo # 2 :

Die Identification

Part Type : RH1011

Figure 1 - RH1011 Linear Technology 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.

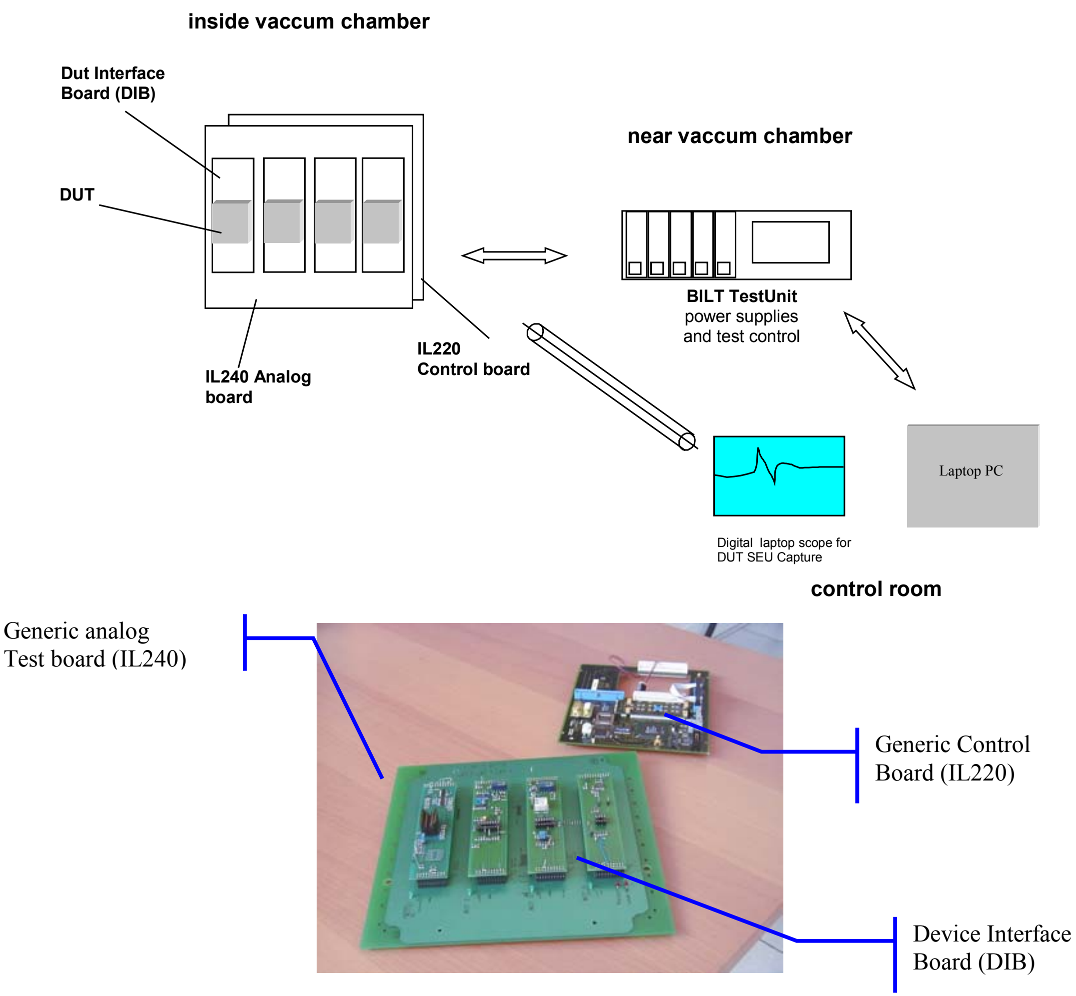
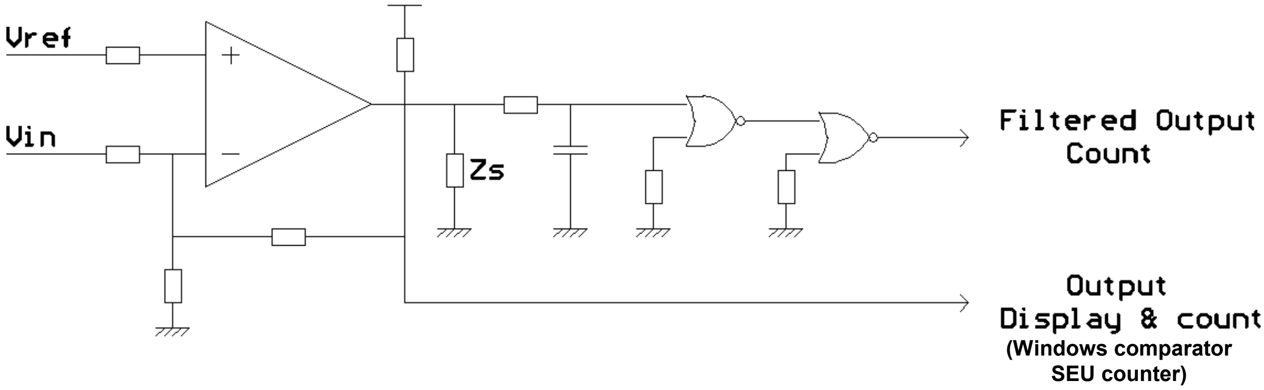


Figure 2 - Test set-up hardware

5.1 Tests Configuration

5.1.1 Test set up (IL243 test board), see RD-1

- This comparator is used to monitor a voltage bus : if the voltage bus goes under a fixed threshold limit, then the 0 level at the comparator level will switch OFF a current limiter power stage. There is no latch effect, and the current limiter will recover ON state as soon as the bus voltage will return above the threshold level.
- A dedicated protection against SEU is implemented with a low pass filter followed by two NOR 4000 logic gates.
  The transient at comparator output must be longer than 400µs to pass through the filter and reach the gate logic level.
- When the bus is powered on, a capacitor is used to transfer the rising edge of the comparator output to the SET input of the current limiter latch. This feature is not concerned by SEU effect as in steady state, the comparator has no effect on the latch, which is already in ON state. Then, this latch has not been implemented in the SEU test board).
- The purpose of this experiment is to show SEU sensitivity of the design with respect to initial conditions here above :
  - Current limit latch is ON
  - Bus voltage is above threshold, but close to the trip point.
  - The D27C NOR gate initial condition is output low because both inputs are High:
    - High level at the latch output (D27B gate)
    - High level at the filtered inverted comparator output (D27D gate).
- Resistor and capacitor values at comparator inputs, output & supplies pin are similar to the application values.
  This is necessary in order to obtain the same upset sensitivity : (R positive feedback 1M, Input divider 10K/10K, Output Pull Up 4.7K, non inverting Input filtered with capacitor).
  Output dynamic load is 15K max. in order to maintain monitoring amplifier bandwidth.



5.1.2 Comparator output monitoring

- A windows comparator used at the DUT output 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.

5.1.3 Other monitoring features

- Logic level SEU counter at NOR gate output : filter impact on SEU sensitivity.
- Scope monitoring of the comparator Output signal
- Upset simulation with AC coupled 1ms pulses at non inverting input : triggering of both comparator and logic gate SEU count.

5.1.4 Working point description

- Reference voltage at non inverting input is fixed to 2.5V.
- Using 5.1V set up at VI3 DAC output produces conditions closed to trig point (2.55V at inverting 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	100
Medium	500
Large	800

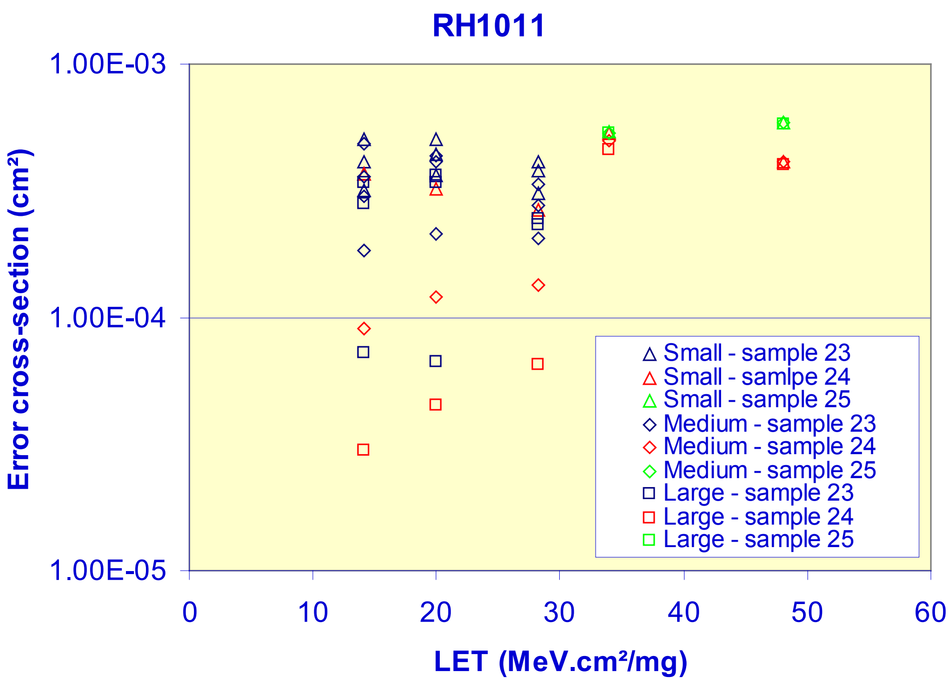


Figure 3 - RH1011 SEU error cross-section versus LET

All the single events are totally defined in terms of amplitude and duration.
No upset has been detected on the output of the application filter.

Figure 4 - a shows a typical upset event while Figure 4 - b shows the envelop (minimum and maximum)of all the upsets detected in a given run.

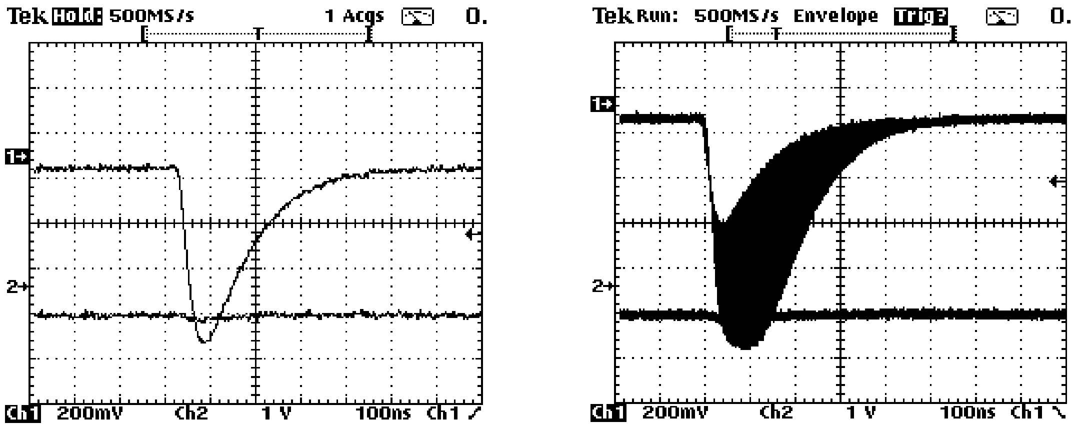


Figure 4 - a

Figure 4 - b

Figure 4 - RH1011, SEU scope records

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	Large errors	x/s Large	Filtered errors	x/s Filtered
			MeV	MeV(mg/cm²)	μ	deg.	MeV(mg/cm²)	s	Ions/cm².s	Rads(Si)	Rads(Si)	Ions/cm²		cm²		cm²		cm²		cm²
R00017	23	40-Ar	150	14.1	42	0	14.1	157	5.67E+02	2.01E+01	2.06E+02	8.90E+04	45	5.06E-04	43	4.83E-04	0		0	
R00018	23	40-Ar	150	14.1	42	0	14.1	200	5.15E+02	2.33E+01	2.30E+02	1.03E+05	38	3.69E-04	37	3.59E-04	35	3.40E-04	0	
R00021	23	40-Ar	150	14.1	42	0	14.1	206	8.74E+02	4.07E+01	3.33E+02	1.80E+05	74	4.11E-04	33	1.83E-04	13	7.22E-05	0	
R00019	23	40-Ar	150	14.1	42	45	19.9	201	3.65E+02	2.35E+01	2.53E+02	7.34E+04	37	5.04E-04	32	4.36E-04	25	3.41E-04	0	
R00022	23	40-Ar	150	14.1	42	45	19.9	250	5.40E+02	4.31E+01	3.76E+02	1.35E+05	49	3.63E-04	29	2.15E-04	9	6.67E-05	0	
R00016	23	40-Ar	150	14.1	42	60	28.2	486	2.84E+02	6.24E+01	1.86E+02	1.38E+05	57	4.13E-04	46	3.33E-04	34	2.46E-04	0	
R00020	23	40-Ar	150	14.1	42	60	28.2	266	3.25E+02	3.91E+01	2.92E+02	8.65E+04	33	3.82E-04	24	2.77E-04	20	2.31E-04	0	
R00023	23	40-Ar	150	14.1	42	60	28.2	286	3.60E+02	4.65E+01	4.22E+02	1.03E+05	32	3.11E-04	21	2.04E-04	0		0	
R00036	24	15-N	62	2.97	64	0	2.97	26	7.69E+03	9.52E+00	2.09E+02	2.00E+05	0		0		0		0	
R00037	24	15-N	62	2.97	64	0	2.97	166	6.02E+03	4.76E+01	2.57E+02	1.00E+06	0		0		0		0	
R00038	24	15-N	62	2.97	64	47	4.35	214	4.67E+03	6.98E+01	3.26E+02	1.00E+06	0		0		0		0	
R00072	24	20-Ne	78	5.85	45	0	5.85	53	5.68E+03	2.82E+01	3.55E+02	3.01E+05	0		0		0		0	
R00073	24	20-Ne	78	5.85	45	54	9.95	90	3.33E+03	4.78E+01	4.02E+02	3.00E+05	0		0		0		0	
R00033	24	40-Ar	150	14.1	42	0	14.1	129	1.55E+03	4.52E+01	4.52E+01	2.00E+05	74	3.70E-04	18	9.00E-05	6	3.00E-05	0	
R00034	24	40-Ar	150	14.1	42	45	19.9	176	1.14E+03	6.39E+01	1.09E+02	2.00E+05	64	3.20E-04	24	1.20E-04	9	4.50E-05	0	
R00035	24	40-Ar	150	14.1	42	60	28.2	245	8.16E+02	9.04E+01	1.99E+02	2.00E+05	53	2.65E-04	27	1.35E-04	13	6.50E-05	0	
R00096	24	84-Kr	316	34	43	0	34	163	6.13E+02	5.45E+01	5.34E+02	1.00E+05	53	5.30E-04	50	5.00E-04	46	4.60E-04	0	
R00095	24	84-Kr	316	34	43	45	48.1	240	4.17E+02	7.70E+01	4.79E+02	1.00E+05	41	4.10E-04	41	4.10E-04	40	4.00E-04	0	
R00051	25	15-N	62	2.97	64	47	4.35	155	6.45E+03	6.98E+01	6.98E+01	1.00E+06	0		0		0		0	
R00063	25	20-Ne	78	5.85	45	0	5.85	89	5.71E+03	4.76E+01	1.17E+02	5.08E+05	0		0		0		0	
R00064	25	20-Ne	78	5.85	45	0	5.85	141	3.57E+03	4.71E+01	1.65E+02	5.03E+05	0		0		0		0	
R00104	25	84-Kr	316	34	43	0	34	95	1.05E+03	5.45E+01	2.96E+02	1.00E+05	54	5.40E-04	53	5.30E-04	53	5.30E-04	0	
R00103	25	84-Kr	316	34	43	45	48.1	129	7.75E+02	7.70E+01	2.42E+02	1.00E+05	59	5.90E-04	59	5.90E-04	58	5.80E-04	0	

8 CONCLUSION

Heavy ion tests were conducted on hirel samples of Linear Technology RH1011 Comparator 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).