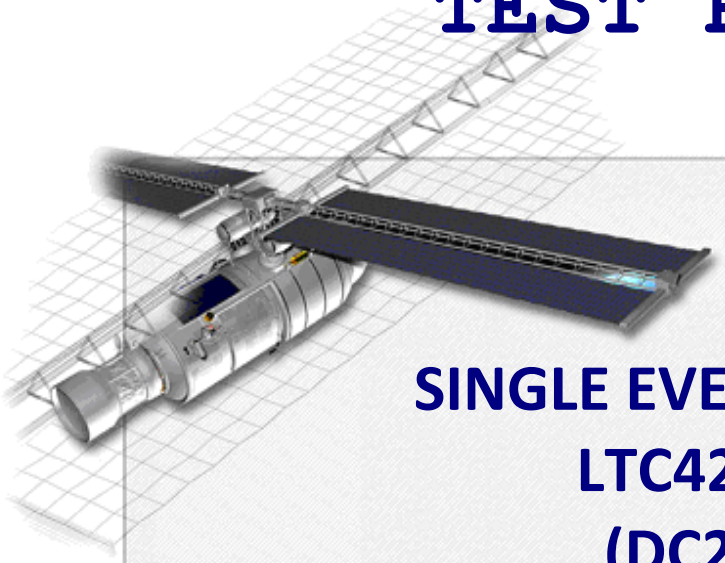
HEAVY ION
TEST REPORT



SINGLE EVENT EFFECTS
LTC4222CG
(DC2309)
Dual Hot Swap Controller with I²C Compatible Monitoring
From
Linear Technology

TRAD/TI/LTC4222CG/2309/ESA/MMB/2308		Labège, December 20th, 2023
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Abbreviations and acronyms

DUT	Device Under Test
LET	Linear Energy Transfer
SEE	Single Event Effect
SEFI	Single Event Functional Interrupt
SEL	Single Event Latch-up
SET	Single Event Transient
UCL	Université Catholique de Louvain
ESA	European Space Agency
VASCO	VAcuum System for Californium Operation

Abstract

The main objective of this test was to evaluate the sensitivity of the LTC4222CG, a Dual Hot Swap Controller with I²C Compatible Monitoring versus SEL, SET and SEFI.
The irradiation was performed at UCL with a maximum LET of 62.5 MeV.cm²/mg (see Test story section).
The main conclusions are the following.

A destructive event was observed during the test with a LET of 46.1 MeV.cm²/mg, Rhodium heavy ion under SET test conditions.

The SEL test was performed under SEL test conditions (see Table 6).

In SEL test configuration
No SEL was observed with LET of 62.5 MeV.cm²/mg, Xenon heavy ion up to 4.33×10^6ions/cm².
No SEL was observed with LET of 46.1 MeV.cm²/mg, Rhodium heavy ion 1×10^7ions/cm².

SET and SEFI were both monitored in the same time under SET test configuration with different test conditions.

The SET test was performed under SET test conditions (see Table 7).

In SET test configuration
SET_M1 were observed with a minimum LET of 16.1 MeV.cm²/mg, Chromium heavy ion.
SET_M2 were observed with a minimum LET of 16.1 MeV.cm²/mg, Chromium heavy ion.
No lower LET was tested during this test campaign.

The SEFI test was performed under SEFI test conditions (see Table 8). **Following SEFI occurrences, the device's functionality was recovered with a power cycle.**

In SET test configuration
SEFI_M1 were observed with a minimum LET of 16.1 MeV.cm²/mg, Chromium heavy ion.
SEFI_M2 were observed with a minimum LET of 16.1 MeV.cm²/mg, Chromium heavy ion.
No lower LET was tested during this test campaign.

1. Introduction

This report includes the test results of the heavy ion SEE test sequence carried out on the LTC4222CG, a Dual Hot Swap Controller with I²C Compatible Monitoring from Linear Technology, susceptible to show SEL, SET and SEFI induced by heavy ions.

This test was performed for ESA at UCL. Irradiations were performed from November 22nd, 2023 to November 23rd, 2023. During this test campaign, 4 samples were irradiated.

2. Documents

2.1. Applicable documents

[AD1] Technical proposal: TRAD/P/ESA/AO17950/AR/131222 Rev 0 dated 13/11/2022

2.2. Reference documents

[RD1] ESCC Basic specification No. 25100 Issue 2 of October 2014
[RD2] Datasheet: LTC4222CG, Rev. B by Linear Technology dated March 2012

3. Organization of activities

The devices were procured and delidded by TRAD. The testing board and testing software were developed by TRAD. Before the campaign the samples were checked-out and the test bench was validated with californium test at TRAD. The test campaign was performed by TRAD. The next table summarizes the responsible entity for each activity involved in this project:

1	Procurement of Test Samples	TRAD
2	Preparation of Test Samples (delidding)	TRAD
3	Preparation of Test Hardware and Test Program	TRAD
4	Samples Check out	TRAD
5	Accelerator Test	TRAD
6	Test Report	TRAD

Table 1: Organization of activities

4. Parts information

4.1. Device description

The LTC®4222 Hot Swap™ controller allows two power paths to be safely inserted and removed from a live backplane. Using external N-channel pass transistors, board supply voltages and inrush currents are ramped up at an adjustable rate. An I²C interface and onboard ADC allows for monitoring of current, voltage and fault status for each channel.

4.2. Identification

Part designation	LTC4222CG
Manufacturer	Linear Technology
Part function	Dual Hot Swap Controller with I²C Compatible Monitoring

Table 2: Part identification

4.3. Procurement information

Package	36-SSOP
Date code	2309
Lot code No.	AX56506.9
Number of tested parts	4 irradiated samples

Table 3: Part procurement information

4.4. Sample preparation

4 parts were delidded, no sample has been damaged during this operation.
A functional test was performed on delidded samples to check that devices were not degraded by the delidding operation.
All delidded samples available for the test campaign were irradiated.

4.5. Sample pictures

4.5.1. External view

The Figure 1 shows an external view of the parts. Left and right pictures are respectively the top and the bottom views of the package.

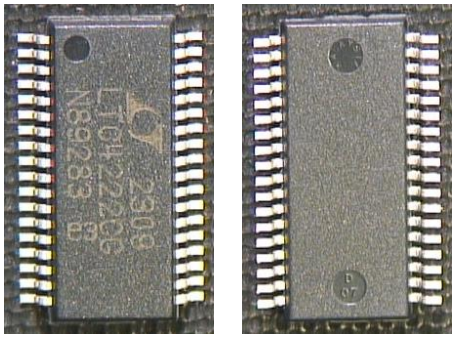

Figure 1: Pictures of the package

4.5.2. Internal view

Figure 2 gives an overview of the die. Figure 3 presents a view of the internal markings observed on the die (indicated by red rectangles on Figure 2).

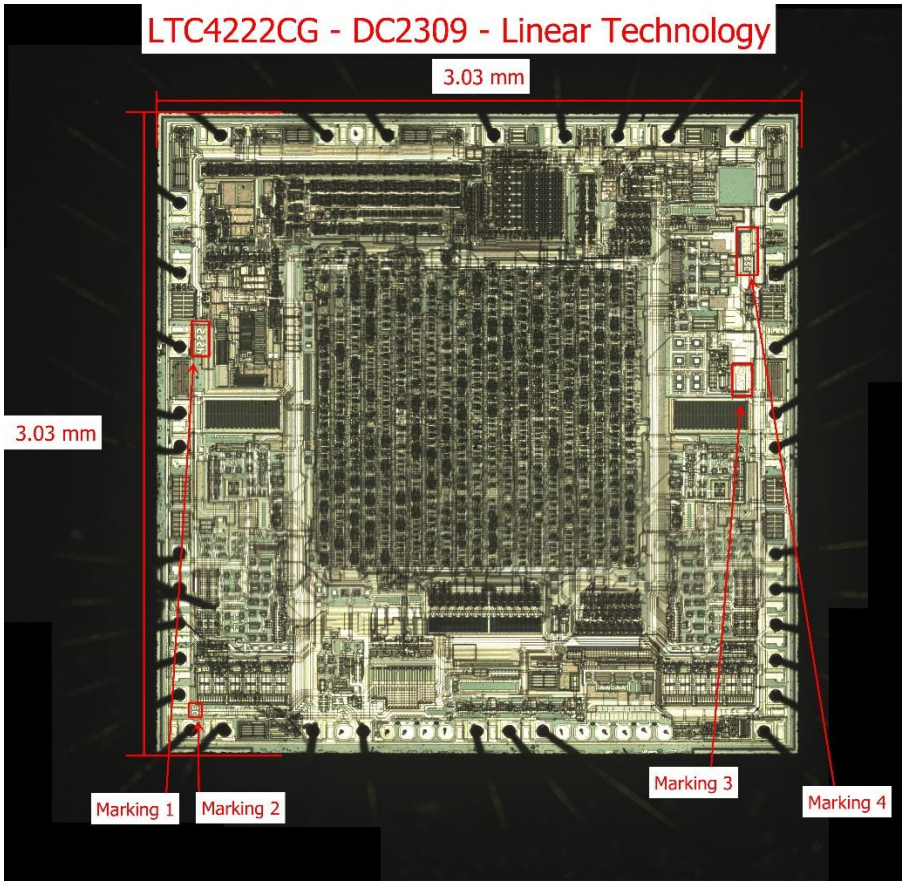

Figure 2: Picture of the internal overall view

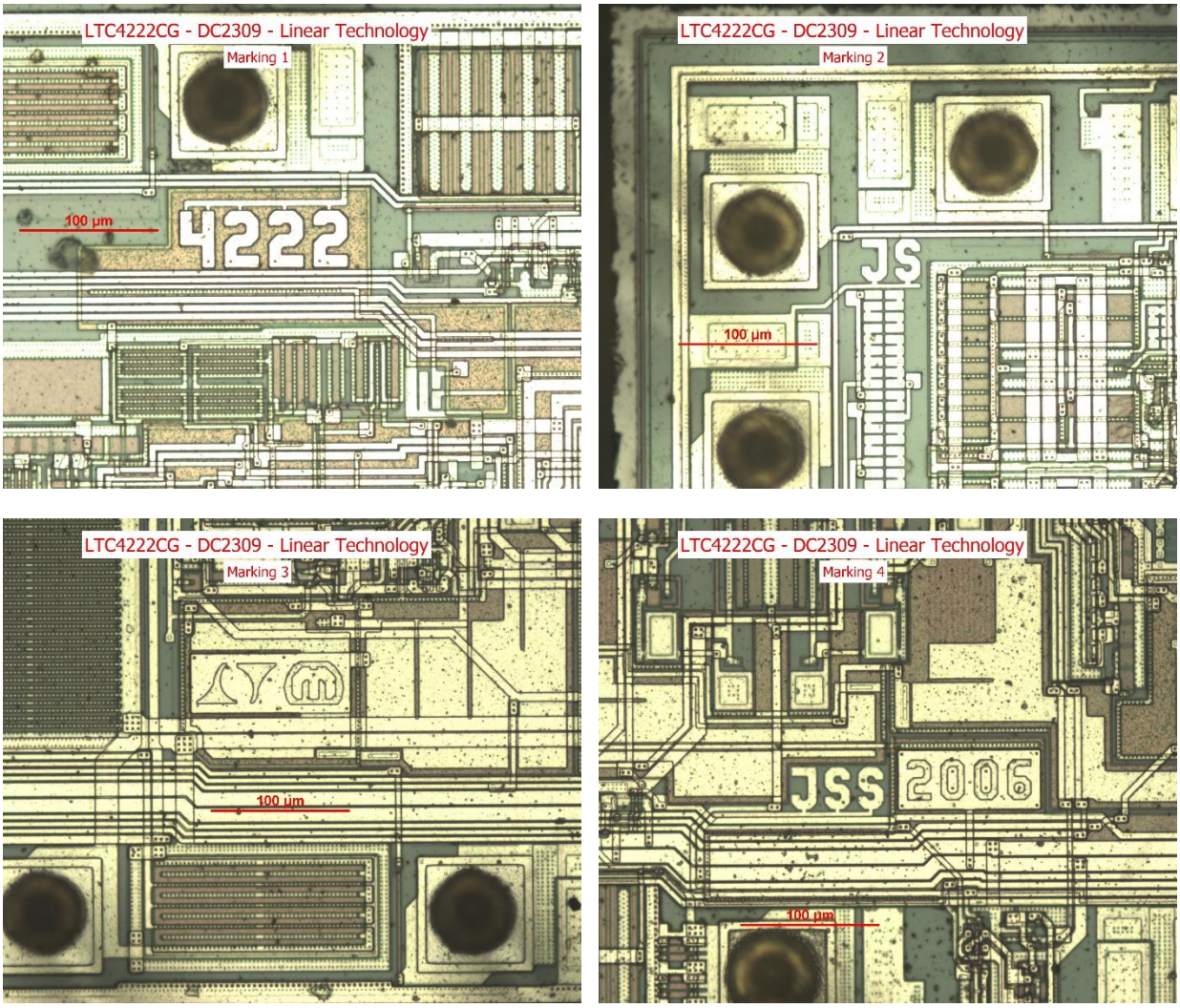

Figure 3: Pictures of the die markings

5. Dosimetry and irradiation facility

5.1. UCL heavy ion test facility

The CYClotron of LOuvain la NEuve (CYCLONE) is a multi-particle, variable energy, cyclotron capable of accelerating protons (up to 85 MeV), alpha particles and heavy ions.
For the heavy ions, the covered LET range is between 1.3 MeV.cm²/mg and 62.5 MeV.cm²/mg.

The chamber has the shape of a barrel stretched vertically; its internal dimensions are 71 cm in height, 54 cm in width and 76 cm in depth. One side flange is used to support the board frame (25 cm x 25 cm) and user connectors.
The chamber is equipped with a vacuum system.

Figure 4: Typical UCL HIF test bench setup

5.2. Dosimetry

In order to control and monitor the beam parameters, a dosimetry box is placed in front of the chamber. It contains a faraday cup and 2 Parallel Plate Avalanche Counters (PPAC). The faraday cup is used during beam preparation at high intensity. Two additional surface barrier detectors are placed in the test chamber.
A beam uniformity measurement is performed with a collimated surface barrier detector. This detector is placed on a X and Y movement. The final profile is drawn and the ± 10 % width is calculated. The homogeneity is ± 10 % on a 25 mm diameter. During the irradiation, the flux is integrated in order to give the delivered total fluence (particule.cm^{-2}) on the device.

5.3. Beam characteristics

The beam flux is variable between a few particles $s^{-1}cm^{-2}$ and 1.5E+4 $s^{-1}cm^{-2}$ and is set depending on the device sensitivity. Characteristics of heavy ions available at UCL during the test campaign are listed in Table 4 where heavy ions used for this test campaign are highlighted.

Ion	Energy (MeV)	Range (µm(Si))	LET (MeV.cm²/mg)
$^{124}Xe^{35+}$	995	73.1	62.5
$^{103}Rh^{31+}$	972	88.7	46.1
$^{84}Kr^{25+}$	769	94.2	32.4
$^{58}Ni^{18+}$	582	100.5	20.4
$^{53}Cr^{16+}$	513	107.6	16.1
$^{36}Ar^{11+}$	353	114.0	9.9
$^{27}Al^{8+}$	250	131.2	5.7
$^{22}Ne^{7+}$	238	202	3.3
$^{13}C^{4+}$	131	269.3	1.3

Table 4: UCL heavy ion list

6. Test procedure and setup

6.1. Test method

With respect to reference documents (see 2 Documents), runs were performed:

- Up to a fluence of 1E+7 cm^{-2} with only SEL monitoring.
- Up to a fluence of 1E+6 cm^{-2} for the SET and SEFI detection.

6.2. Test principle

6.2.1. SEL test principle

A SEL is a permanent event that results from the activation of a parasitic thyristor structure creating low impedance conduction path in the device. The consequent high current can potentially damage the device, possibly even leading to its destruction due to overcurrent. A power cycle is required to correct this situation.

GeV is a specific equipment developed by TRAD to protect the DUT and to perform SEL characterization. The power supply is applied to the DUT through GeV which protects the DUT against over consumption. Indeed, GeV continuously monitors and records the current. A programmable threshold current is set above the nominal operating value of the supply current. During irradiations, if the current consumption exceeds the threshold during a defined “hold time”, a SEL is counted and the DUT is switched off during a defined “off time”. Once the event is defused, the power supply is switched ON again with the nominal current consumption expected.

Figure 5 shows a common SEL characteristic, with and without the GeV system protection.

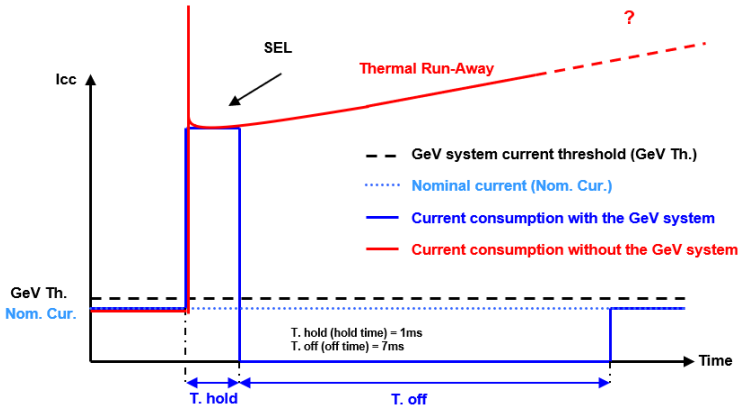

Figure 5: Common SEL characteristic

The SEL test was performed under SEL test conditions (see Table 6).
TRAD uses a dedicated system to heat and regulate the DUT temperature. The temperature is visualized and regulated from outside of the vacuum chamber during the irradiation.

6.2.2. SET test principle

A SET event is a temporary voltage excursion (voltage spike) at a node in a logic, or linear, integrated circuit, caused by a single energetic particle strike.
On static output signals, the SET can be a positive or negative amplitude variation. Two trigger thresholds (positive and negative) are used to detect the event when the monitored signal is out of the detection range (Figure 6). All SET are counted and their waveforms are recorded using an oscilloscope.

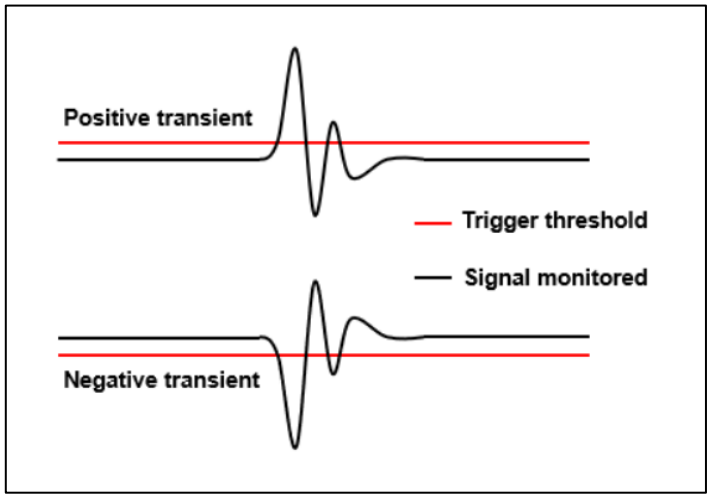

Figure 6: SET in static mode characteristic

SET were observed on SOURCE pin for both modules (M1 and M2) with the aim to observe events on GATE pins through bipolar transistors Q1 and Q2 (see Figure 10).

6.2.3. SEFI test principle

A SEFI is a partial or complete loss of the device's functionality due to a single energetic particle strike, which can be defused by a soft reset or a power cycle. In the context of this SEE test, for each module (M1 and M2), a SEFI is identified when the current sense measurement exceeds the specified range for a duration of 1 second. In such instances, a power cycle is implemented to address the issue.

6.3. Test bench description

6.3.1. Test bench overview

Figure 7 provides a global view of the test bench. It is composed by:

- A computer to control the test equipment and to record the SEE.
- A test board to bias and operate the DUT (schematic is shown in Figure 10).
- A power supply for the DUT and auxiliary components.
- A GeV System to protect the DUT, detect and record SEL.
- An oscilloscope to detect and record SET.
- An I²C communication to detect and record SEFI.

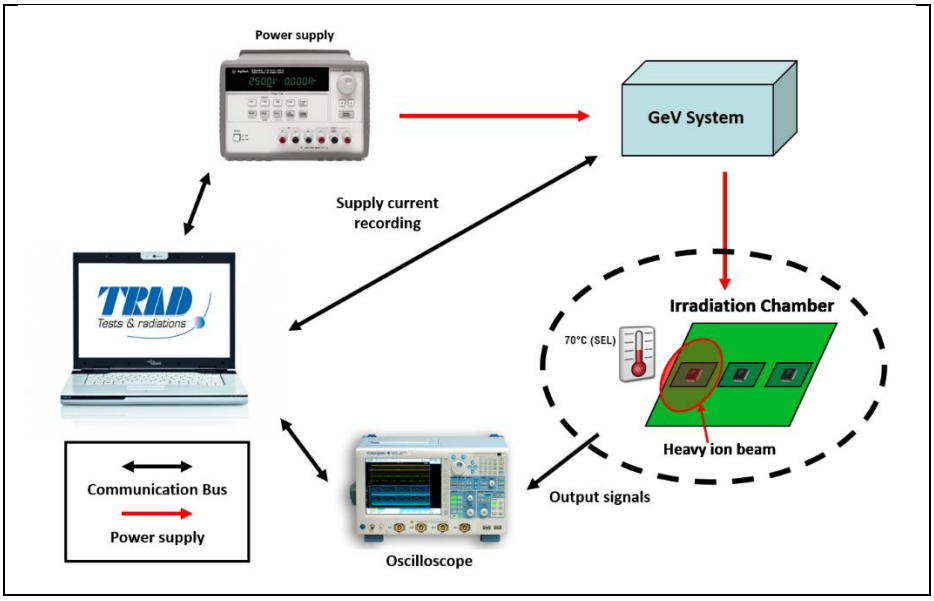

Figure 7: Test bench description

6.3.2. Validation of test hardware and program

Before performing the heavy ion test, the whole system (delidded sample, test board and software) was assembled and tested by TRAD in VASCO.

Figure 8: VASCO picture

The VASCO is a vacuum chamber developed by TRAD in order to test the complete setup in vacuum with all cables length and electrical feedthroughs as used on the irradiation site.
The VASCO main characteristics are:
Chamber dimensions: 400x400x400mm, pressure 5.10^{-2} mbar.
Electrical feedthroughs available:
16 isolated BNC, 16 isolated SMA, 16 isolated SMB, 4 DB25, 3 HE10-40.
Other possibility on request

Validation runs are performed using Californium-252 source.
Californium-252 is a fissionable, transuranic radionuclide which decays by alpha particle emission with a half-life of 2.72 years.
The source emits alpha particles, fission fragments and fast neutrons. The fission fragments are used for SEE testing and these have a mean LET of 43 MeV.cm²/mg (Si) with 95% of the particles having LETs between 41 and 45 MeV.cm²/mg (Si). The mean range of the fission particles in silicon is 14.2µm.

6.3.3. Heating system

TRAD has developed a specific heating system to heat and regulate the temperature of the DUT. Figure 9 shows a thermal image taken during the heating calibration of the DUT, the temperature of the die was set to 70°C as shown on the picture.

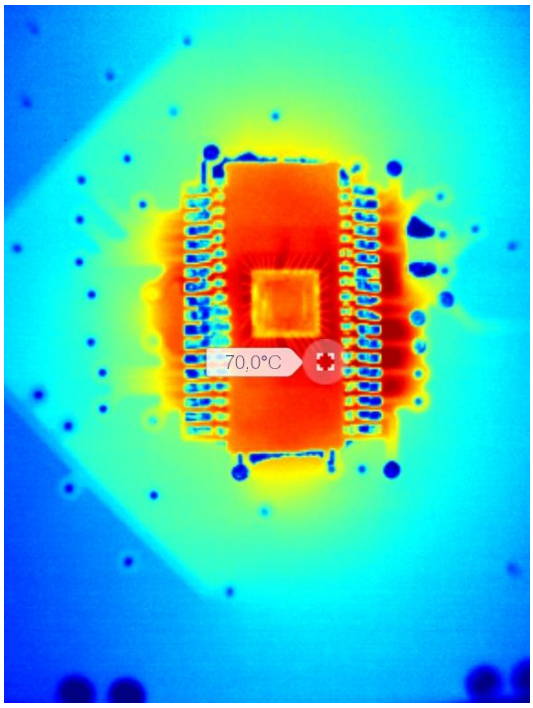

Figure 9: Thermal image of LTC4222CG heated to 70°C

6.3.4. Test equipment identification

TEST BOARD	TRAD/TA/I/LTC4222CG/SSOP36/MMB/2308/V5
EQUIPMENT	SM-86; ME-16; SM-92; LT-054
TEST PROGRAM	LTC422CG_I_DC2309_BI_SEL.spf

Table 5: Equipment identification

6.3.5. Test board description

The TRAD test board schematic referenced "TRAD/TA/I/LTC4222CG/SSOP36/MMB/2308/V5" is illustrated in Figure 10.

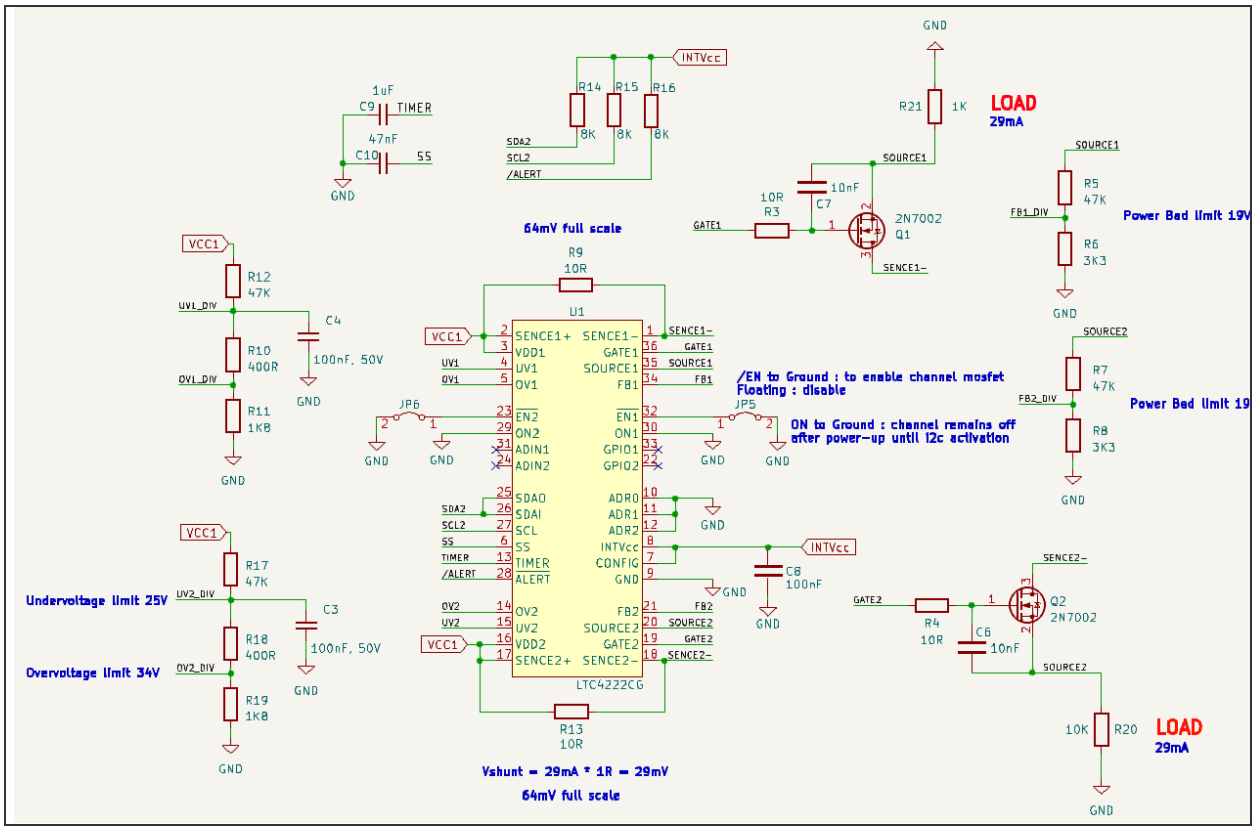

Figure 10: Test board schematic

6.3.6. Test conditions and event detection thresholds

SEL test

	VCC
Voltage	29 V
$I_{nominal}$	14 mA
$I_{threshold}$	30 mA
T_{hold}	1 ms
$T_{cut\ off}$	7 ms
Temperature	70°C

Table 6: SEL test conditions and detection thresholds

SET test

	VDD = 29V	
	V_{Sense1} (SET_M1)	**V_{Sense2} (SET_M2)**
$V_{nominal}$	29 V	29 V
Positive trigger threshold	29.5 V	29.5 V
Negative trigger threshold	28.5 V	28.5 V
Temperature	Ambient	

Table 7: Static SET test conditions and detection thresholds

SEFI test

	VDD = 29V	
	I_{Sense1} (SEFI_M1)	**I_{Sense2} (SEFI_M2)**
$I_{nominal}$	36 mA	36mV
Positive trigger threshold	38 mA	38 mA
Negative trigger threshold	35mA	35mA
Temperature	Ambient	

Table 8: Static SEFI test conditions and detection thresholds

7. Test story

At the end of the test campaign, with the limited remaining time, two test runs were conducted at a LET of 62.5 MeV.cm²/mg using Xenon heavy ions. The first run was performed under SET test conditions and indicated the absence of any destructive events. The second run, conducted under SEL test conditions, reached a fluence of 4.33e+6 cm². No SEL was detected during this run.

8. Non conformance

Test sequence, test and measurement conditions were nominal.

9. Results

In this chapter are presented the SEE test results.
First, test runs summary tables provides details of the runs performed during this campaign, their parameters and results.
Then, for each event type are given their corresponding LET threshold, cross section and worst cases when it is applicable.
On the cross section curves are plotted their corresponding error bars.
The following formulas is used to calculate these error bars. It can be found in ESCC Basic specification No. 25100.

$$\delta\sigma \times F = \sqrt{(\delta Nevents)^2 + (\mathrm{Nevents} \times \frac{\delta \mathrm{F}}{F})^2}$$

where :

- F is the fluence
- $\sigma = N_{events} / F$
- $\delta F/F$ is the uncertainty on the measured fluence (±10%).
- δN_{events} is the variance on the measured number of events.

Assuming that SEE events are random, the probability of events follows a Poisson distribution. The variance on the number of events is calculated from the chi-square distribution for a given confidence level. In this test report, we used a confidence level of 95%.

9.1. Test run summary

Run	Test configuration	Part	T° (°C)	Ion	Energy (MeV)	Range (µm)	LET (MeV.cm²/mg)	Flux (φ) ($cm^{-2}.s^{-1}$)	Time (s)	Run Fluence (cm^{-2})	Run Dose (krad)	Cumulated Dose (krad)	SEL	SEL Cross Section (cm²)	SET_M1	SET_M1 Cross Section (cm²)	SET_M2	SET_M2 Cross Section (cm²)	SEFI_M1	SEFI_M1 Cross Section (cm²)	SEFI_M2	SEFI_M2 Cross Section (cm²)	Destructive event	Destructive event Cross Section (cm²)
1	SEL	1	70	103 Rh 31+	957	87.3	46.1	8.22E+03	1216	1.00E+07	7.38	7.38	0	<1.00E-07	-	-	-	-	34	3.40E-06	41	4.10E-06	0	<1.00E-07
2	SEL	2	70	103 Rh 31+	957	87.3	46.1	1.03E+04	970	1.00E+07	7.38	7.38	0	<1.00E-07	-	-	-	-	15	1.50E-06	37	3.70E-06	0	<1.00E-07
3	SET	1	amb	103 Rh 31+	957	87.3	46.1	1.84E+03	544	1.00E+06	0.74	8.11	0	<1.00E-06	97	9.70E-05	114	1.14E-04	1	1.00E-06	13	1.30E-05	0	<1.00E-06
4	SET	2	amb	103 Rh 31+	957	87.3	46.1	3.14E+03	318	1.00E+06	0.74	8.11	0	<1.00E-06	37	3.70E-05	38	3.80E-05	3	3.00E-06	4	4.00E-06	1	1.00E-06
5	SET	3	amb	53 Cr 16+	505	105.5	16.1	3.22E+03	311	1.00E+06	0.26	0.26	0	<1.00E-06	91	9.10E-05	109	1.09E-04	5	5.00E-06	8	8.00E-06	0	<1.00E-06
6	SET	4	amb	53 Cr 16+	505	105.5	16.1	3.28E+03	305	1.00E+06	0.26	0.26	0	<1.00E-06	20	2.00E-05	98	9.80E-05	0	<1.00E-06	5	5.00E-06	0	<1.00E-06
7	SET	4	amb	124 Xe 35+	995	73.1	62.5	3.99E+03	258	1.03E+06	1.03	1.29	0	<9.71E-07	28	2.72E-05	86	8.35E-05	0	<9.71E-07	9	8.74E-06	0	<9.71E-07
8	SEL	3	70	124 Xe 35+	995	73.1	62.5	1.47E+04	295	4.33E+06	4.33	4.59	0	<2.31E-07	-	-	-	-	3	6.93E-07	8	1.85E-06	0	<2.31E-07

Table 9: LTC4222CG test run table

The part N°2 was destroyed at the end of run 4.
SEE detailed results are described in the following sections.

9.2. Cumulated dose table

Part No.	Cumulated Dose (krad)
1	8.11
2	8.11
3	4.59
4	1.29

Table 10: Cumulated dose table

9.3. SEL test results

9.3.1. SEL LET threshold

The SEL test was performed under SEL test conditions (see Table 6).

In SEL test configuration

No SEL was observed with LET of 62.5 MeV.cm²/mg, Xenon heavy ion up to 4.33x10⁶ions/cm².
No SEL was observed with LET of 46.1 MeV.cm²/mg, Rhodium heavy ion 1x10⁷ions/cm².

9.3.2. SEL cross sections

Hereafter are shown the SEL cross section values for each tested component.

In SEL test configuration

	LTC4222 SEL Cross Section (cm²) in SEL test configuration								
LET Eff (MeV.cm²/mg)	Part No. 1			Part No. 2			Part No. 3		
	error (-)	cross section	error (+)	error (-)	cross section	error (+)	error (-)	cross section	error (+)
62.5	-	*Not tested*	-	-	*Not tested*	-	0.00E+00	<2.31E-07	8.52E-07
46.1	0.00E+00	<1.00E-07	3.69E-07	0.00E+00	<1.00E-07	3.69E-07	-	*Not tested*	-

Table 11: LTC4222CG SEL cross section values in SEL test configuration

9.4. SET_M1 test results

9.4.1. SET_M1 LET threshold

The SET_M1 test was performed under SET test conditions (see Table 7).

In SET test configuration

SET_M1 were observed with a minimum LET of 16.1 MeV.cm²/mg, Chromium heavy ion.
No lower LET was tested during this test campaign.

9.4.2. SET_M1 cross sections

Hereafter are shown the SET_M1 cross section values for each tested component.

In SET test configuration

	LTC4222 SET_M1 Cross Section (cm²) in SET test configuration					
LET Eff (MeV.cm²/mg)	Part No. 1			Part No. 2		
	error (-)	cross section	error (+)	error (-)	cross section	error (+)
46.1	1.83E-05	9.70E-05	2.13E-05	1.09E-05	3.70E-05	1.40E-05
16.1	-	*Not tested*	-	-	*Not tested*	-

Table 12: LTC4222CG SET_M1 cross section values in SET test configuration 1/2

	LTC4222 SET_M1 Cross Section (cm²) in SET test configuration					
LET Eff (MeV.cm²/mg)	Part No. 3			Part No. 4		
	error (-)	cross section	error (+)	error (-)	cross section	error (+)
46.1	-	*Not tested*	-	-	*Not tested*	-
16.1	1.77E-05	9.10E-05	2.07E-05	7.78E-06	2.00E-05	1.09E-05

Table 13: LTC4222CG SET_M1 cross section values in SET test configuration 2/2

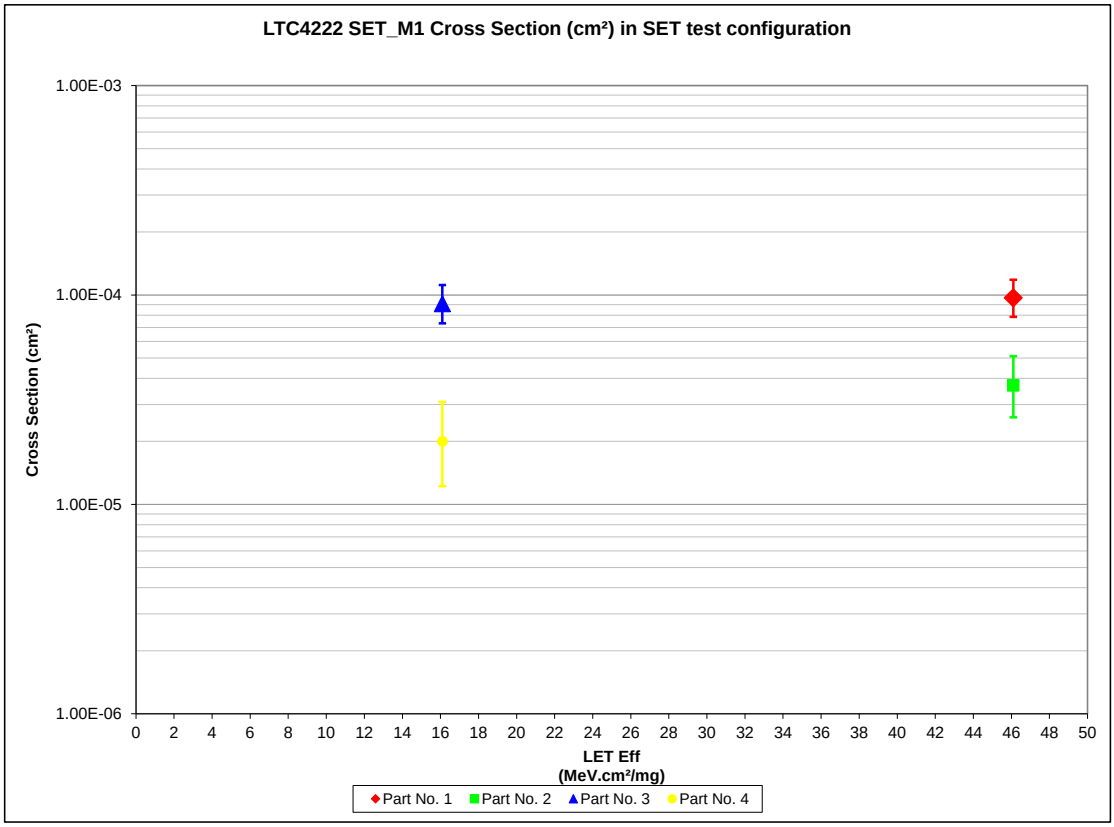

Figure 11: LTC4222CG SET_M1 cross section curve in SET test configuration

9.4.3. SET_M1 worst case

This section presents a selection of worst SET_M1 observed during the test of the LTC4222CG.

In SET test configuration

The worst duration event observed on Sense1 occurred during run No. 4 on part No. 2.

Run No.	4
Part No.	2
Test configuration	**SET**
Type event	Negative SET
Ion LET (MeV.cm²/mg)	46.1
Absolute amplitude	29 V
Duration	620 ms

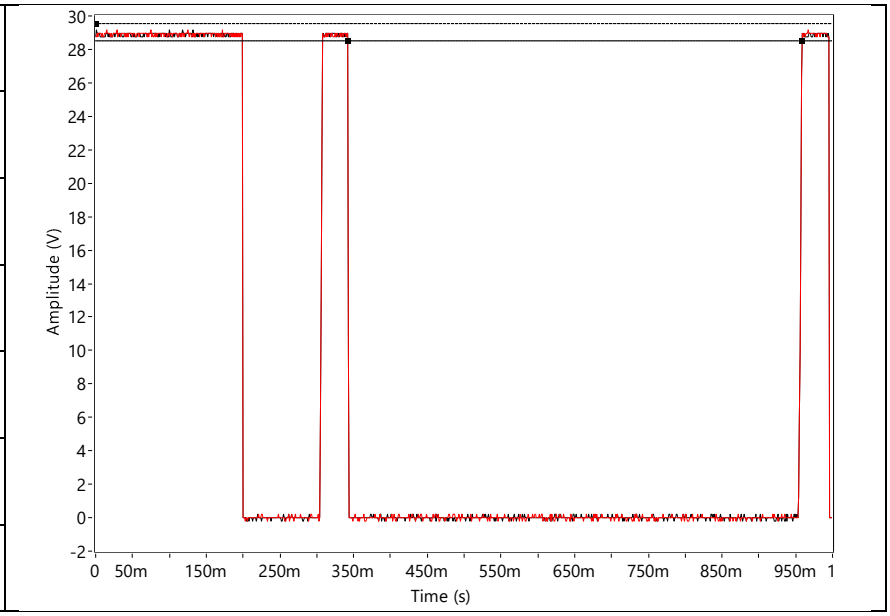

Figure 12: SET_M1 worst case No. 1

9.5. SET_M2 test results

9.5.1. SET_M2 LET threshold

The SET_M2 test was performed under SET test conditions (see Table 7).

In SET test configuration

SET_M2 were observed with a minimum LET of 16.1 MeV.cm²/mg, Chromium heavy ion.
No lower LET was tested during this test campaign.

9.5.2. SET_M2 cross sections

Hereafter are shown the SET_M2 cross section values for each tested component.

In SET test configuration

	LTC4222 SET_M2 Cross Section (cm²) in SET test configuration					
LET Eff (MeV.cm²/mg)	Part No. 1			Part No. 2		
	error (-)	cross section	error (+)	error (-)	cross section	error (+)
46.1	2.00E-05	1.14E-04	2.29E-05	1.11E-05	3.80E-05	1.42E-05
16.1	-	*Not tested*	-	-	*Not tested*	-

Table 14: LTC4222CG SET_M2 cross section values in SET test configuration 1/2

	LTC4222 SET_M2 Cross Section (cm²) in SET test configuration					
LET Eff (MeV.cm²/mg)	Part No. 3			Part No. 4		
	error (-)	cross section	error (+)	error (-)	cross section	error (+)
46.1	-	*Not tested*	-	-	*Not tested*	-
16.1	1.95E-05	1.09E-04	2.25E-05	1.84E-05	9.80E-05	2.14E-05

Table 15: LTC4222CG SET_M2 cross section values in SET test configuration 2/2

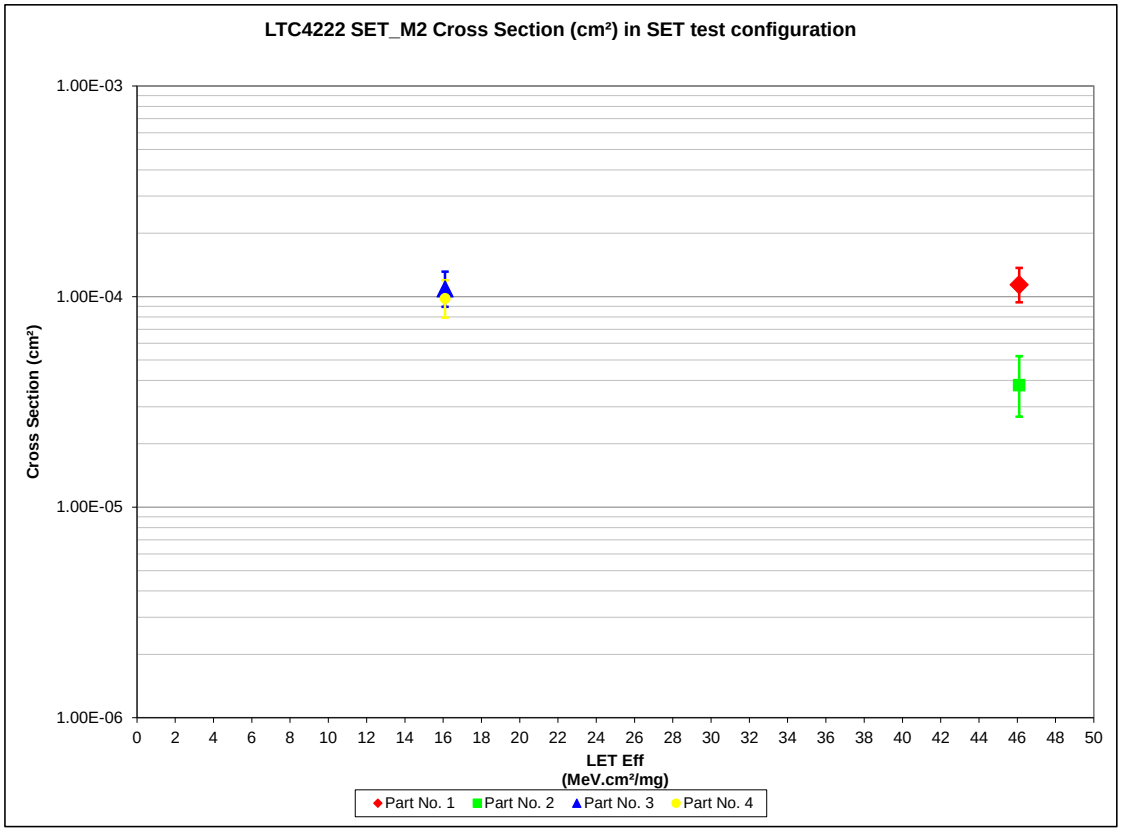

Figure 13: LTC4222CG SET_M2 cross section curve in SET test configuration

9.5.3. SET_M2 worst case

This section presents a selection of worst SET_M2 observed during the test of the LTC4222CG.

In SET test configuration

The worst duration event observed on Sense2 occurred during run No. 4 on part No. 2.

Run No.	4
Part No.	2
Test configuration	**SET**
Type event	Positive SET
Ion LET (MeV.cm²/mg)	46.1
Absolute amplitude	29 V
Duration	570 ms

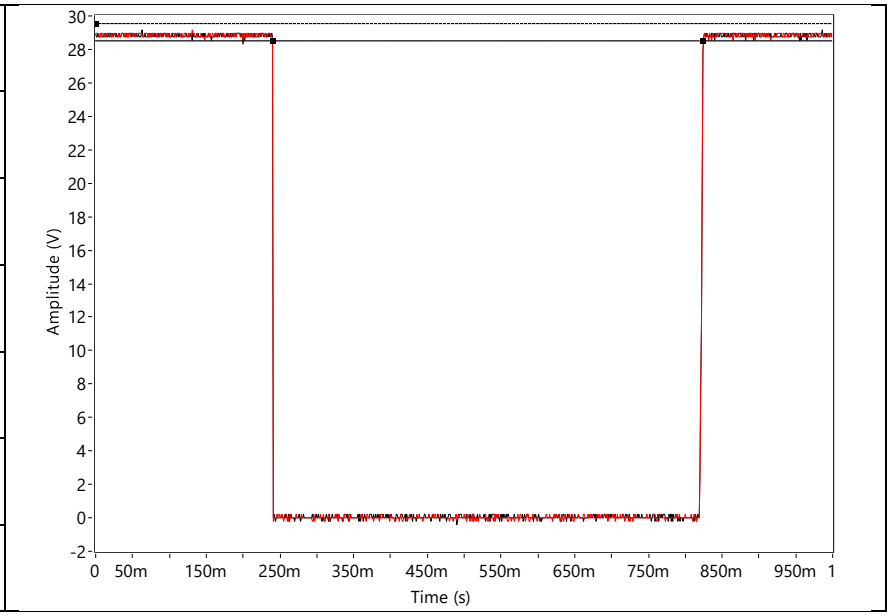

Figure 14: SET_M2 worst case No. 1

9.6. SEFI_M1 test results

9.6.1. SEFI_M1 LET threshold

The SEFI_M1 test was performed under SET test conditions (see Table 8).

In SET test configuration

SEFI_M1 were observed with a minimum LET of 16.1 MeV.cm²/mg, Chromium heavy ion.
No lower LET was tested during this test campaign.

9.6.2. SEFI_M1 cross sections

Hereafter are shown the SEFI_M1 cross section values for each tested component.

In SET test configuration

	LTC4222 SEFI_M1 Cross Section (cm²) in SET test configuration					
LET Eff (MeV.cm²/mg)	Part No. 1			Part No. 2		
	error (-)	cross section	error (+)	error (-)	cross section	error (+)
46.1	9.75E-07	1.00E-06	4.57E-06	2.38E-06	3.00E-06	5.77E-06
16.1	-	*Not tested*	-	-	*Not tested*	-

Table 16: LTC4222CG SEFI_M1 cross section values in SET test configuration 1/2

	LTC4222 SEFI_M1 Cross Section (cm²) in SET test configuration					
LET Eff (MeV.cm²/mg)	Part No. 3			Part No. 4		
	error (-)	cross section	error (+)	error (-)	cross section	error (+)
46.1	-	*Not tested*	-	-	*Not tested*	-
16.1	3.38E-06	5.00E-06	6.67E-06	0.00E+00	<1.00E-06	3.69E-06

Table 17: LTC4222CG SEFI_M2 cross section values in SET test configuration 2/2

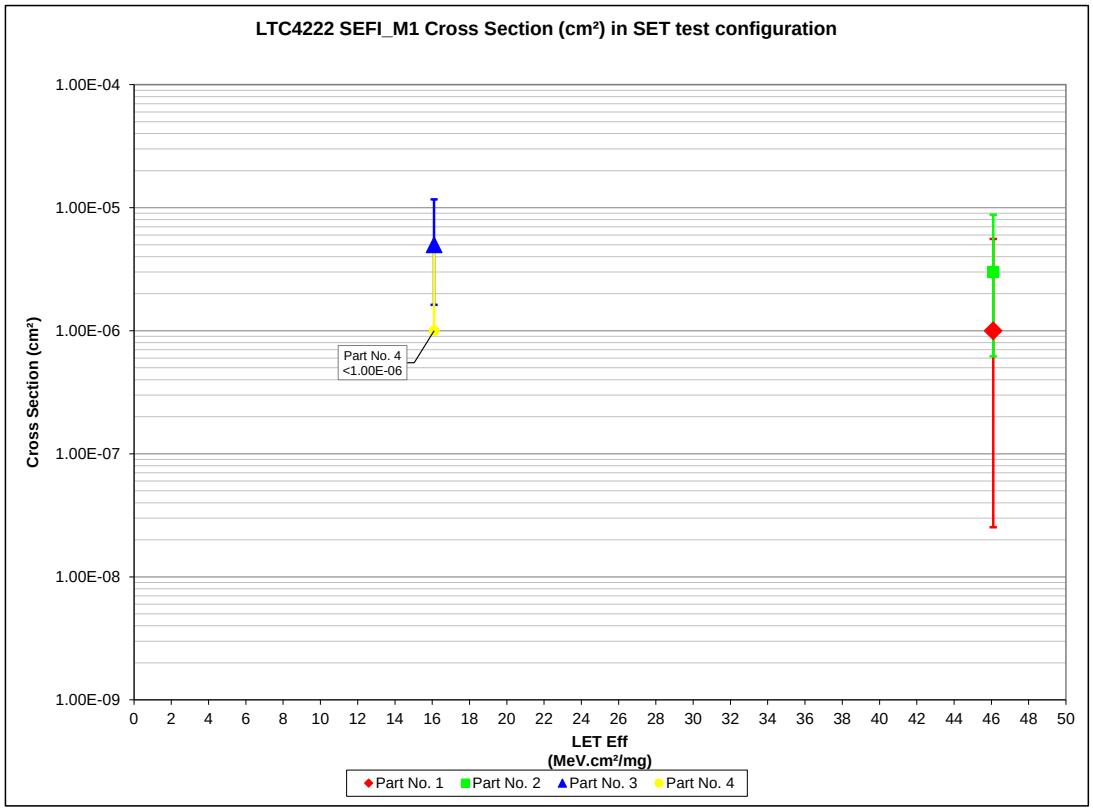

Figure 15: LTC4222CG SEFI_M1 cross section curve in SET test configuration

9.7. SEFI_M2 test results

9.7.1. SEFI_M2 LET threshold

The SEFI_M2 test was performed under SET test conditions (see Table 8).

In SET test configuration

SEFI_M2 were observed with a minimum LET of 16.1 MeV.cm²/mg, Chromium heavy ion.
No lower LET was tested during this test campaign.

9.7.2. SEFI_M2 cross sections

Hereafter are shown the SEFI_M2 cross section values for each tested component.

In SET test configuration

	LTC4222 SEFI_M2 Cross Section (cm²) in SET test configuration					
LET Eff (MeV.cm²/mg)	Part No. 1			Part No. 2		
	error (-)	cross section	error (+)	error (-)	cross section	error (+)
46.1	6.08E-06	1.30E-05	9.23E-06	2.91E-06	4.00E-06	6.24E-06
16.1	-	*Not tested*	-	-	*Not tested*	-

Table 18: LTC4222CG SEFI_M2 cross section values in SET test configuration 1/2

	LTC4222 SEFI_M2 Cross Section (cm²) in SET test configuration					
LET Eff (MeV.cm²/mg)	Part No. 3			Part No. 4		
	error (-)	cross section	error (+)	error (-)	cross section	error (+)
46.1	-	*Not tested*	-	-	*Not tested*	-
16.1	4.55E-06	8.00E-06	7.76E-06	3.38E-06	5.00E-06	6.67E-06

Table 19: LTC4222CG SEFI_M2 cross section values in SET test configuration 2/2

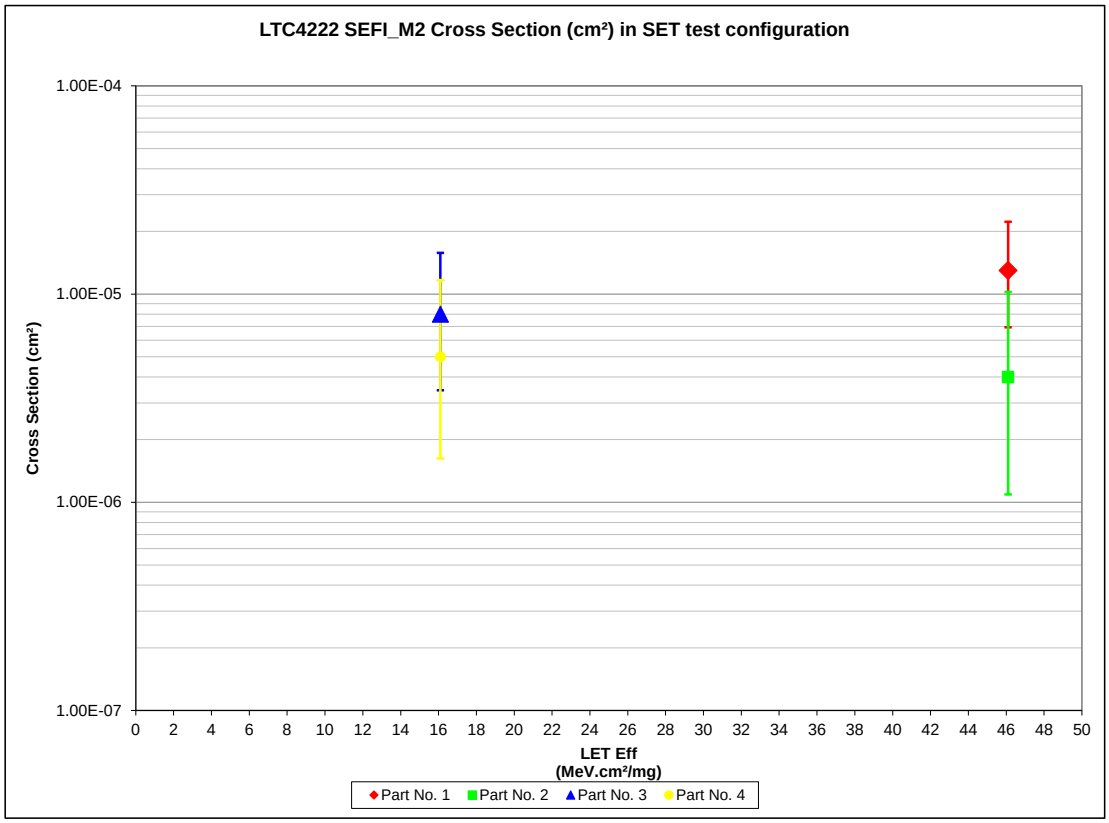

Figure 16: LTC4222CG SEFI_M2 cross section curve in SET test configuration

10. Conclusion

The heavy ions test was performed on LTC4222CG. The aim of the test was to evaluate the sensitivity of the device versus SEL, SET and SEFI.

A destructive event was observed during the test with a LET of 46.1 MeV.cm²/mg, Rhodium heavy ion under SET test conditions.

The SEL test was performed under SEL test conditions (see Table 6).

In SEL test configuration
No SEL was observed with LET of 62.5 MeV.cm²/mg, Xenon heavy ion up to $4.33x10^6$ions/cm².
No SEL was observed with LET of 46.1 MeV.cm²/mg, Rhodium heavy ion $1x10^7$ions/cm².

The SET test was performed under SET test conditions (see Table 7).

In SET test configuration
SET_M1 were observed with a minimum LET of 16.1 MeV.cm²/mg, Chromium heavy ion.
SET_M2 were observed with a minimum LET of 16.1 MeV.cm²/mg, Chromium heavy ion.
No lower LET was tested during this test campaign.

The SEFI test was performed under SEFI test conditions (see Table 8). **Following SEFI occurrences, the device's functionality was recovered with a power cycle.**

In SET test configuration
SEFI_M1 were observed with a minimum LET of 16.1 MeV.cm²/mg, Chromium heavy ion.
SEFI_M2 were observed with a minimum LET of 16.1 MeV.cm²/mg, Chromium heavy ion.
No lower LET was tested during this test campaign.