# Single Event Radiation Test Report

| | | |
|---|---|---|
| Type | : | FRC150R |
| Parts Description | : | N-Channel Power MOSFET |
| Manufacturer | : | Intersil |

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|---|---|---|---|
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WORD 97

Table of Contents

1 GENERAL INFORMATION ....4

1.1 Scope....4

1.2 Applicable Documents....4

1.3 Definition of Terms ....4

2 COMPONENT DETAILS ....5

3 TEST SETUP DETAILS ....5

4 TEST DETAILS ....10

4.1 Test Run Summary....10

4.2 Heavy Ion Beam Details ....11

5 SUMMARY ....12

# 1 GENERAL INFORMATION

## 1.1 Scope

This test report details the results of the heavy ion Single Event Effects (SEE) testing performed on the Intersil FRC150R, 100V, N-channel, enhancement-mode, silicon-gate, Rad-Hard power MOSFET. The MOSFET type has its application in the METOP, PPF/ENVISAT and CLUSTER II SSR Power Converter.

In particular Single Event Burnout (SEB) and Single Event Gate Rupture (SEGR) sensitivities of the MOSFET has been verified under and around original electrical conditions applicable for the METOP SSR Converter.

The testing was performed on the 20.12.00 at the ESA Heavy Ion Test Facility (HIF) at UCL in Louvain-la-Neuve, Belgium under support of Mr. Reno Harboe-Sorensen from ESA/ESTEC.

## 1.2 Applicable Documents

METOP, “Methodology for Radiation Hardness Assurance”, Doc. Reference: MO-NT-MMT-PA-001, Issue 02 of 20.10.98.

ESA/SCC Basic Specification No. 25100, “Single Event Effects Test Method and Guidelines”.

Astrium SAS (Mr. Guidal) fax ref.: MO.FX.MMT.1705/00 of 08.12.00, “FRC150 SEGR Testing at UCL”.

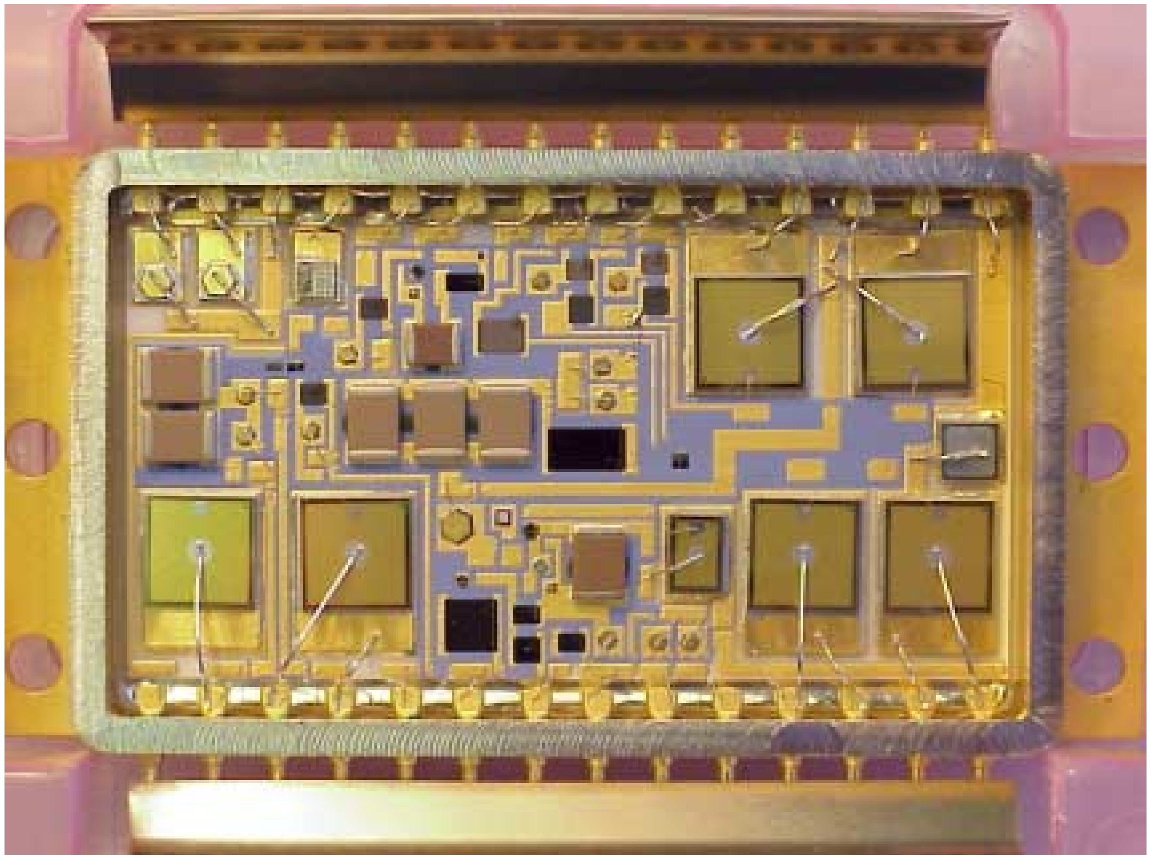
## 1.3 Definition of Terms

SEB:
Breakdown and subsequent burnout of the parasitic bipolar transistor inherent in the power MOSFET structure (resulting from a heavy ion hit of the parasitic transistor).

SEGR:
Direct breakdown and subsequent rupture of the gate dielectric of the power MOSFET along the track of a heavy ion hit.

## 2 COMPONENT DETAILS

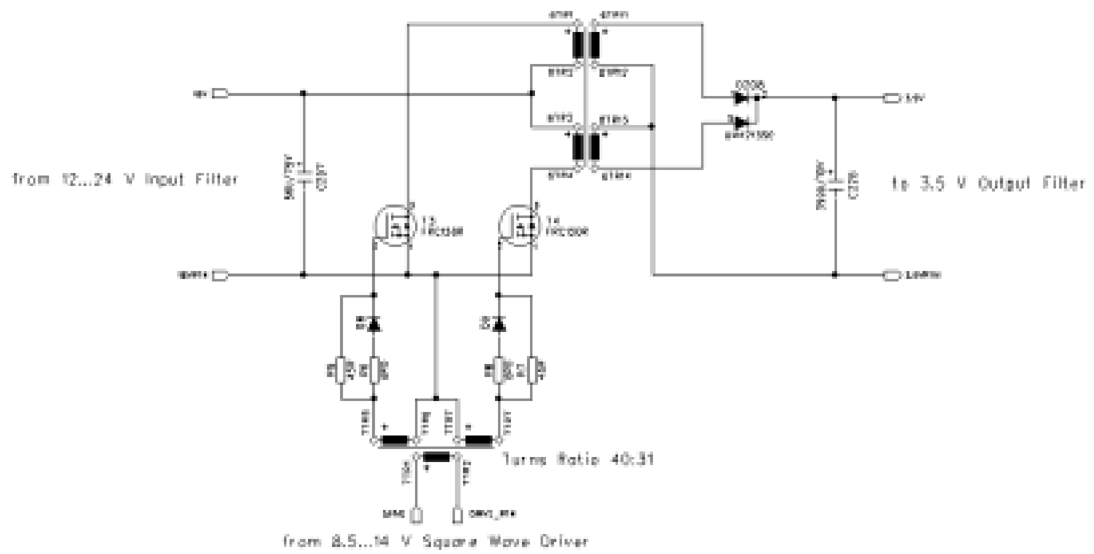
The two FC150R MOSFET test candidates are located inside a signal hybrid on the SSR power converter board. The MOSFETs, named T3 and T4, are the two large chips located next to each other in the upper right corner as shown below.



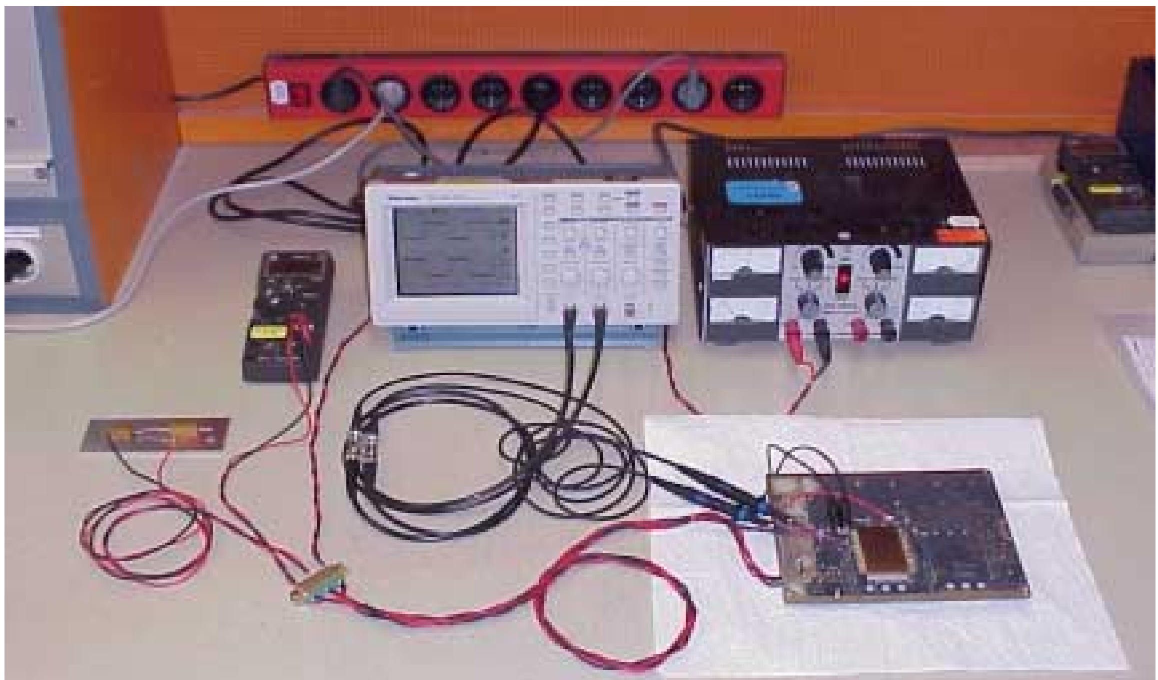
## 3 TEST SETUP DETAILS

A special SSR converter board with the hybrid was prepared for the SEE testing. The board was configured to provide the worst case METOP application conditions for the MOSFETs, i.e. VGS = -9V and VDS = 41V together with a converter output power of 12.25W at EOL under a switching frequency condition of 40 KHz. For experimental and test verification reasons the board was constructed such as to provide the possibility to exceed METOP worst case conditions and eventually during SEE testing the MOSFET operation was verified under VGS = -11V and VDS = 50V at a LET of 38.0 MeV/(mg/cm²).

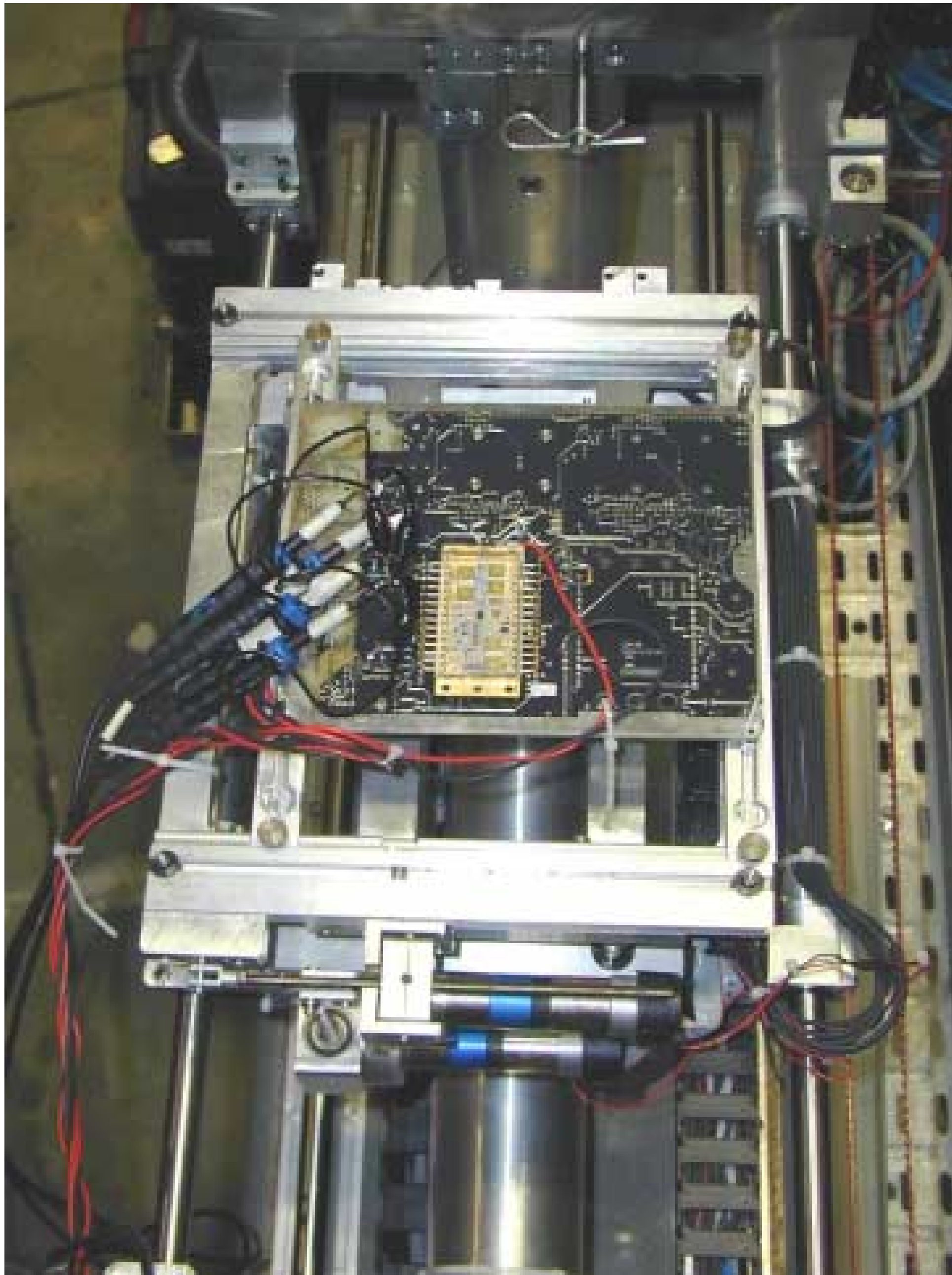
The basic bias condition during test for both MOSFETs is illustrated below:




An overall overview of the test set-up is shown below. The converter board is located in lower right corner of the picture and the hybrid with the test MOSFETs on the converter board is the large rectangular shaped block on the board:



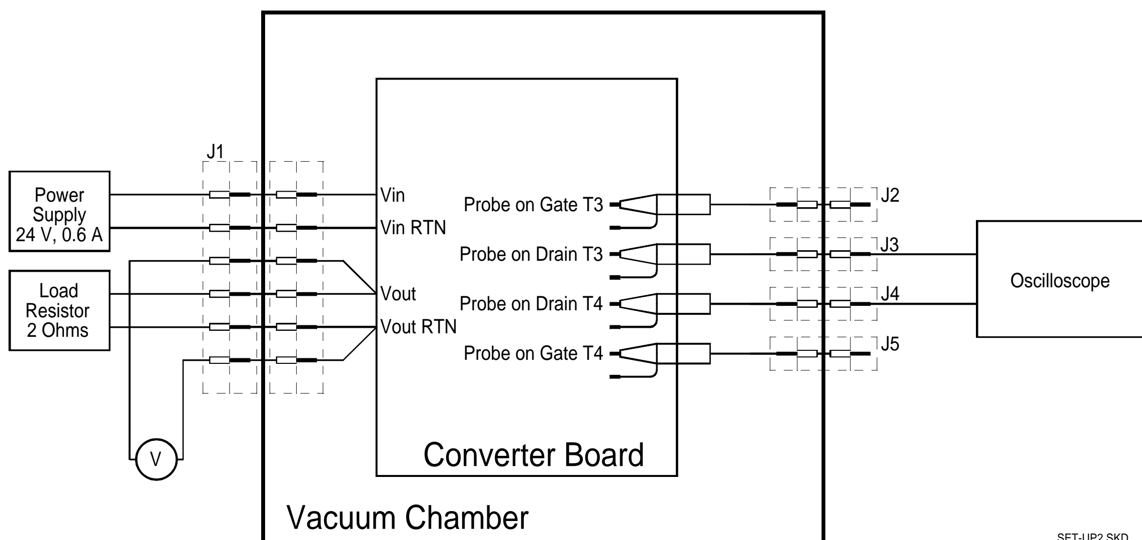
The following photograph shows the position of the board within the test chamber of the HIF facility. The probes and cables for external connection can clearly be identified on the photograph:



During irradiation both drains of the MOSFETs were constantly monitored to observe any changes in the switching VDS, thereby observing whether or not a SEGR or SEB occurred. In case either a SEGR or SEB occurred the VDS would become constant and hence no switching curve on the oscilloscope would be visible. The current limitation of the power supply was adjusted to about 500 mA to prevent thermal and/or physical damages of the MOSFETs in case of a SEE.

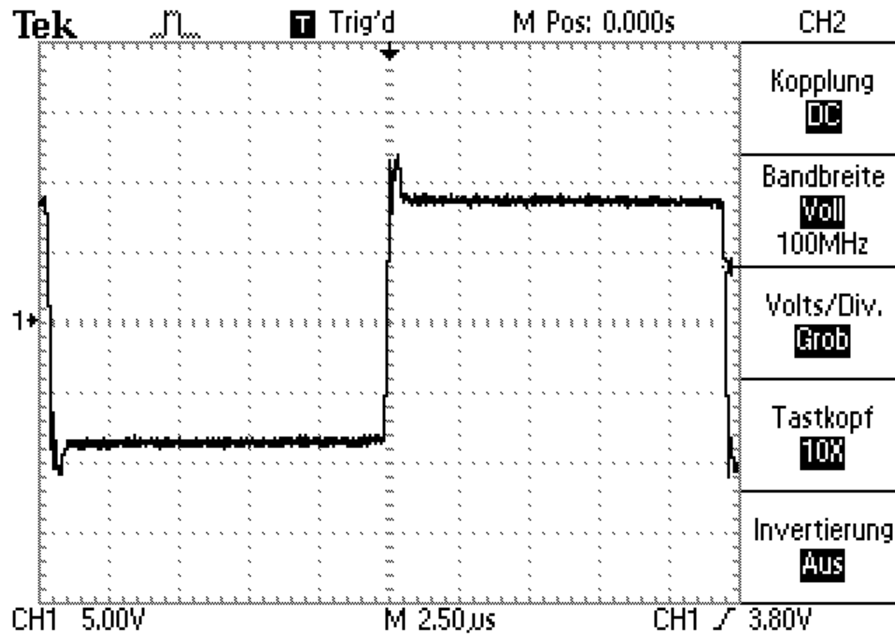
Oscilloscope probes were also connected to both gates of MOSFETs in order to be able to verify proper gate operation during testing.

The following schematic shows the power supply, load and monitor connections to the MOSFETs during SEE testing:

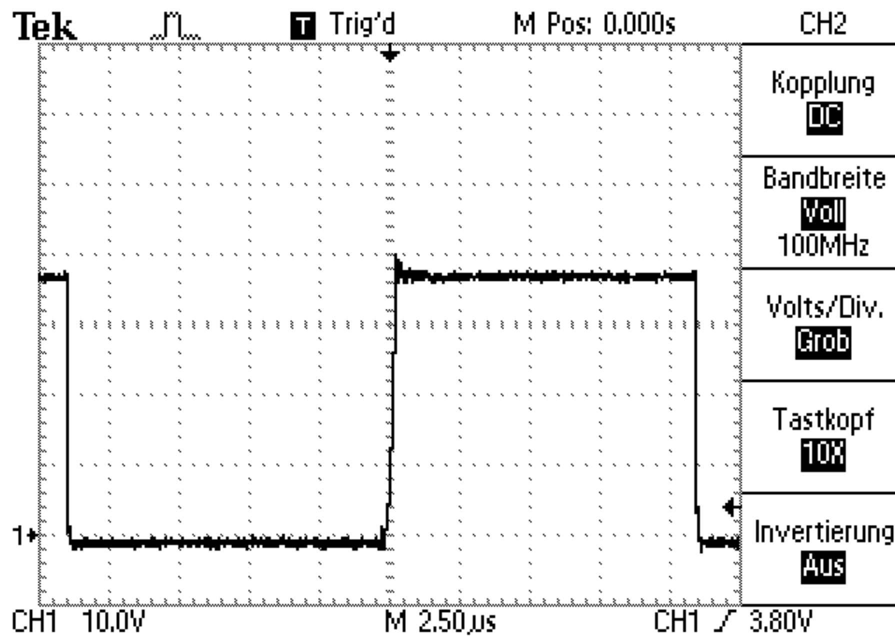



As shown below in the Test Run Summary table the VGS amplitude was varied between ±7V and ±11V and the VDS amplitude between 25V and 50V for the different test runs. The following two oscilloscope images presented below show typical VGS amplitude of ±9V and VDS amplitude of 41V. These bias conditions were used in test runs 2, 8 and 10 representing METOP flight conditions.

VGS = ±9V




VDS = 41V



# 4 TEST DETAILS

## 4.1 Test Run Summary

The test was performed at the ESA Heavy Ion Test Facility (HIF) at UCL in Louvain-La-Neuve in Belgium. The aim of the test was to verify device SEB and SEGR performance up to a LET of 38.0 MeV/(mg/cm²) using VGS = –9V and VDS = 41V.

A total of 15 test runs were performed in successive order as shown in the table below. The first three test runs were carried out using safe operation conditions and low LET of 14.1 MeV/(mg/cm²) in which different VGS and VDS voltage condition were applied. Using a LET of 34.0 MeV/(mg/cm²) similar voltage variations were applied. The final test runs used a LET of 38.0 MeV/(mg/cm²) which corresponded to METOP test level requirements.

It should be mentioned that the test voltage conditions used in test runs 2, 8 and 10 correspond to METOP flight conditions and the test voltages in final two test runs exceed the METOP flight conditions.

| TEST RUN SUMMARY | | | | | |
|---|---|---|---|---|---|
| **TEST RUN** | **VGS (V)** | **VDS (V)** | **ION** | **LETeff [MeV/mg/cm²]** | **FLUENCE [cm²]** |
| 01 | -7,0 | 41,0 | AR | 14,1 | 1000000 |
| 02 | -9,0 | 41,0 | AR | 14,1 | 1000000 |
| 03 | -9,0 | 50,0 | AR | 14,1 | 1000000 |
| 04 | -7,0 | 25,0 | KR | 34,0 | 1000000 |
| 05 | -7,0 | 41,0 | KR | 34,0 | 1000000 |
| 06 | -7,0 | 50,0 | KR | 34,0 | 1000000 |
| 07 | -9,0 | 25,0 | KR | 34,0 | 1000000 |
| 08 | -9,0 | 41,0 | KR | 34,0 | 1000000 |
| 09 | -9,0 | 50,0 | KR | 34,0 | 1000000 |
| 10 | -9,0 | 41,0 | KR | 38,0 | 1000000 |
| 11 | -11,0 | 25,0 | KR | 34,0 | 1000000 |
| 12 | -11,0 | 41,0 | KR | 34,0 | 1000000 |
| 13 | -11,0 | 50,0 | KR | 34,0 | 1000000 |
| 14 | -11,0 | 41,0 | KR | 38,0 | 1000000 |
| 15 | -11,0 | 50,0 | KR | 38,0 | 1000000 |

The following ions were used:

$^{40}Ar^{8+}$ 0° tilt implying a LET of 14.1 MeV/(mg/cm²)

$^{84}Kr^{17+}$ 0° tilt implying a LET of 34.0 MeV/(mg/cm²)

$^{84}Kr^{17+}$ 27° tilt implying a LET of 38.0 MeV/(mg/cm²)

**No SEB nor SEGR failures were observed in any of the 15 test runs.**

4.2 Heavy Ion Beam Details

The table below summarises all details related to the heavy ion beam being used during this SEE test and the test run numbers correspond to the test run numbers presented in the previous table.

| HEAVY ION BEAM DETAILS | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| TEST RUN | ION | ENERGY [MeV] | TILT [°] | LET [MeV/mg/cm²] | LETeff [MeV/mg/cm²] | RANGE [µm(Si)] | Test Time (sec) | FLUENCE [cm²] | FLUX (p/cm²/s) | DOSE (rad) |
| 01 | AR | 150 | 0 | 14,1 | 14,1 | 42,0 | 145 | 1000000 | 6897 | 226 |
| 02 | AR | 150 | 0 | 14,1 | 14,1 | 42,0 | 147 | 1000000 | 6803 | 226 |
| 03 | AR | 150 | 0 | 14,1 | 14,1 | 42,0 | 120 | 1000000 | 8333 | 226 |
| 04 | KR | 316 | 0 | 34,0 | 34,0 | 43,0 | 190 | 1000000 | 5263 | 545 |
| 05 | KR | 316 | 0 | 34,0 | 34,0 | 43,0 | 252 | 1000000 | 3968 | 547 |
| 06 | KR | 316 | 0 | 34,0 | 34,0 | 43,0 | 163 | 1000000 | 6135 | 547 |
| 07 | KR | 316 | 0 | 34,0 | 34,0 | 43,0 | 119 | 1000000 | 8403 | 547 |
| 08 | KR | 316 | 0 | 34,0 | 34,0 | 43,0 | 106 | 1000000 | 9434 | 544 |
| 09 | KR | 316 | 0 | 34,0 | 34,0 | 43,0 | 112 | 1000000 | 8929 | 548 |
| 10 | KR | 316 | 27 | 34,0 | 38,0 | 38,3 | 110 | 1000000 | 9091 | 610 |
| 11 | KR | 316 | 0 | 34,0 | 34,0 | 43,0 | 141 | 1000000 | 7092 | 548 |
| 12 | KR | 316 | 0 | 34,0 | 34,0 | 43,0 | 100 | 1000000 | 10000 | 545 |
| 13 | KR | 316 | 0 | 34,0 | 34,0 | 43,0 | 93 | 1000000 | 10753 | 546 |
| 14 | KR | 316 | 27 | 34,0 | 38,0 | 38,3 | 90 | 1000000 | 11111 | 611 |
| 15 | KR | 316 | 27 | 34,0 | 38,0 | 38,3 | 93 | 1000000 | 10753 | 613 |

## 5 SUMMARY

Two different Intersil FRC150R power MOSFETs, operated under original electrical conditions applicable for METOP, PPF/ENVISAT and CLUSTER II SSR Power Converter, have been submitted to SEB and SEGR testing using the ESA HIF at UCL, Louvain-la-Neuve, Belgium.

No SEB nor SEGR failures were observed in any of the test runs.

SEB and SEGR **worst case verification test conditions** were:

VGS = -11V and VDS = 50V at a LET of 38.0 MeV/(mg/cm²)

For comparison the METOP SEB and SEGR **minimum test requirements** were:

VGS = -9V and VDS = 41V at a LET of 38.0 MeV/(mg/cm²)

It has been demonstrated that this part type in its application fulfils the SEB and SEGR radiation requirements specified for METOP in “Methodology for Radiation Hardness Assurance”, Doc. Reference: MO-NT-MMT-PA-001, Issue 02 of 20.10.98.