ESA/ESTEC D/TEC-QCA Final Presentation Day – January 23, 2007

SEE Verification Test of VPT DC/DC power supply hybrids – Using Application Test conditions

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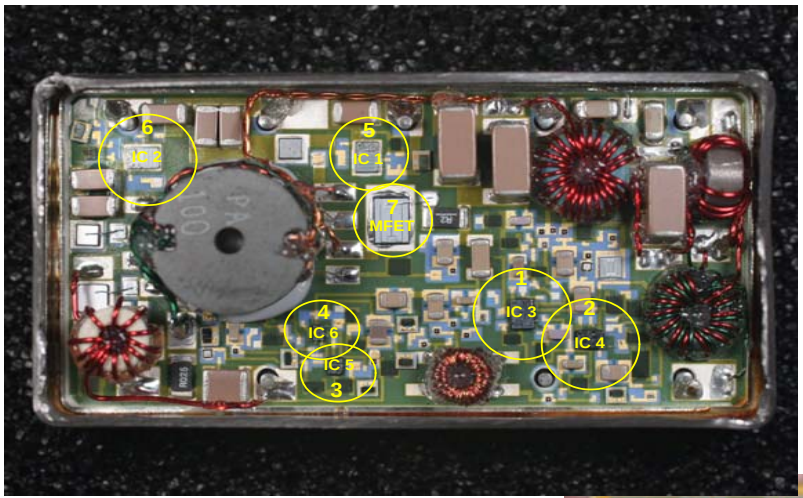
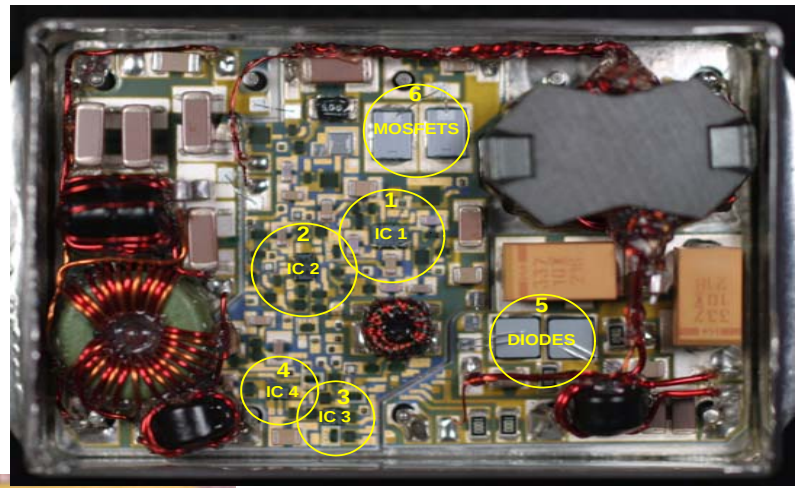
Abstract:
Three different DC/DC converter hybrids by DELTA/VPT were assessed against He-Ion Single Event Effects. All DUT were taken from the same batch as the FM components in the PROBA-II application. All test set-ups have been made with PROBA-II application load conditions of DC load current and decoupling capacitance. Soft Error transient events were characterised for output voltages and input current.

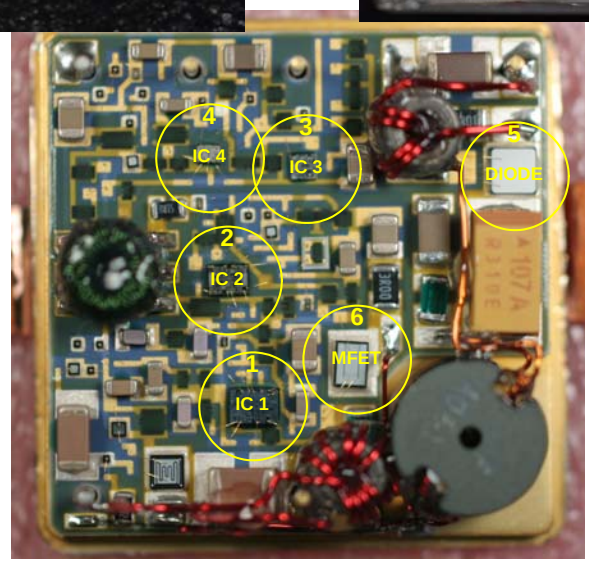
TESTED DC/DC HYBRIDS

DVEHF28512S-ES



DVETR283R3SF-ES





DVSA2805S-ES

MAIN OBJECTIVES FOR THE TESTING

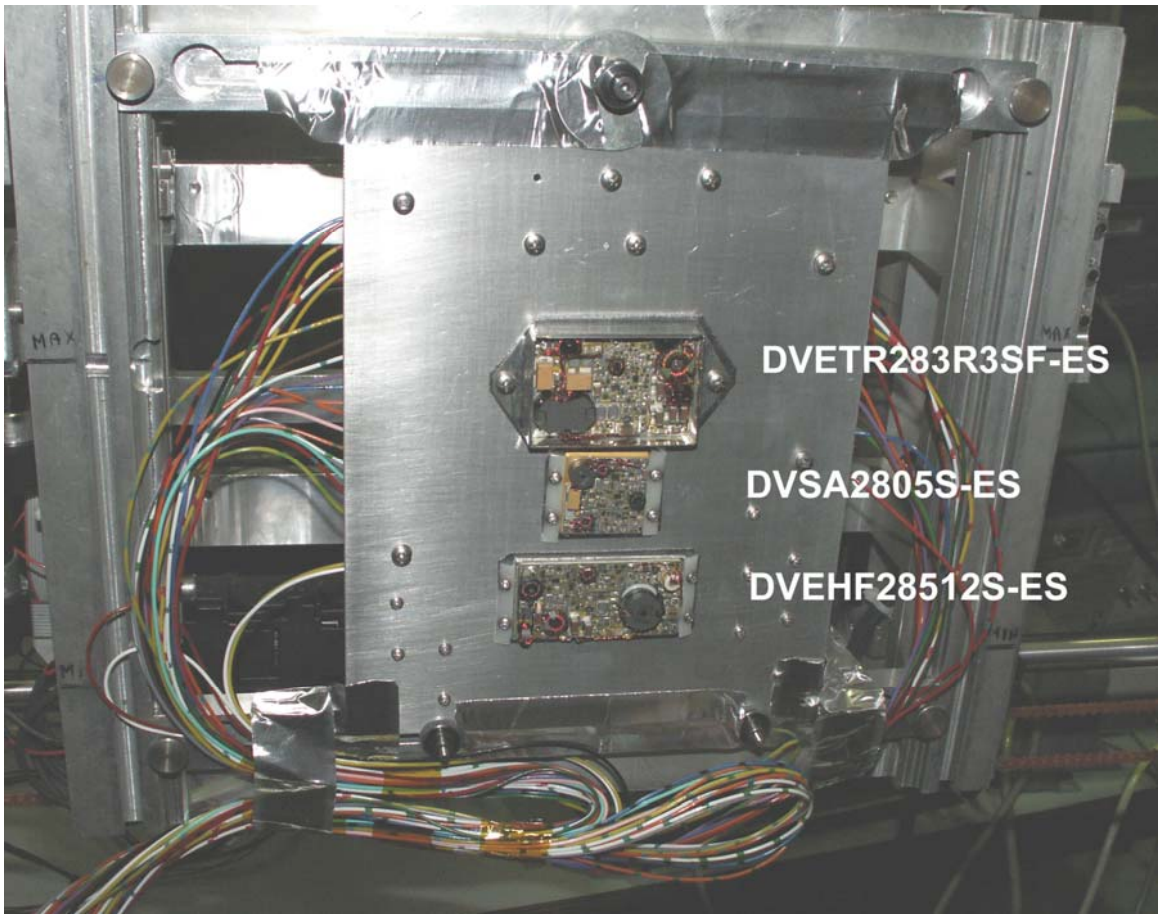
Given the limited test time available, the main objectives for the test campaign were reduced to:

- Irradiation of all linear circuits + diodes, with Ions achieving a LET value = 55.9MeV/mg/cm2 (only one LET value was feasible wrt testing time)
- Irradiation of MOSFET components, with Ions achieving a LET value up to 32.4 MeV/mg/cm2 with high penetration depth, range = 92 μm
- For the tested Ion LET levels: Proving that no latch-up behaviour is exists in linear circuit components and no SEB in MOSFET components
- Characterise, quantify and assess the criticality of all soft-error behaviours on output voltages and input current

Objectives that cannot be met with this test campaign:

- Since only one LET value is used for linear circuit tests, no "normal" cross-section curve is obtained over different LET values, and thus we obviously do not know if we have entered the saturated region of the cross-section curve with our test
- As a consequence of this, the test data cannot be used for any good in-flight prediction of the soft-errors for the PROBA-II mission.

ELECTRICAL SET-UP

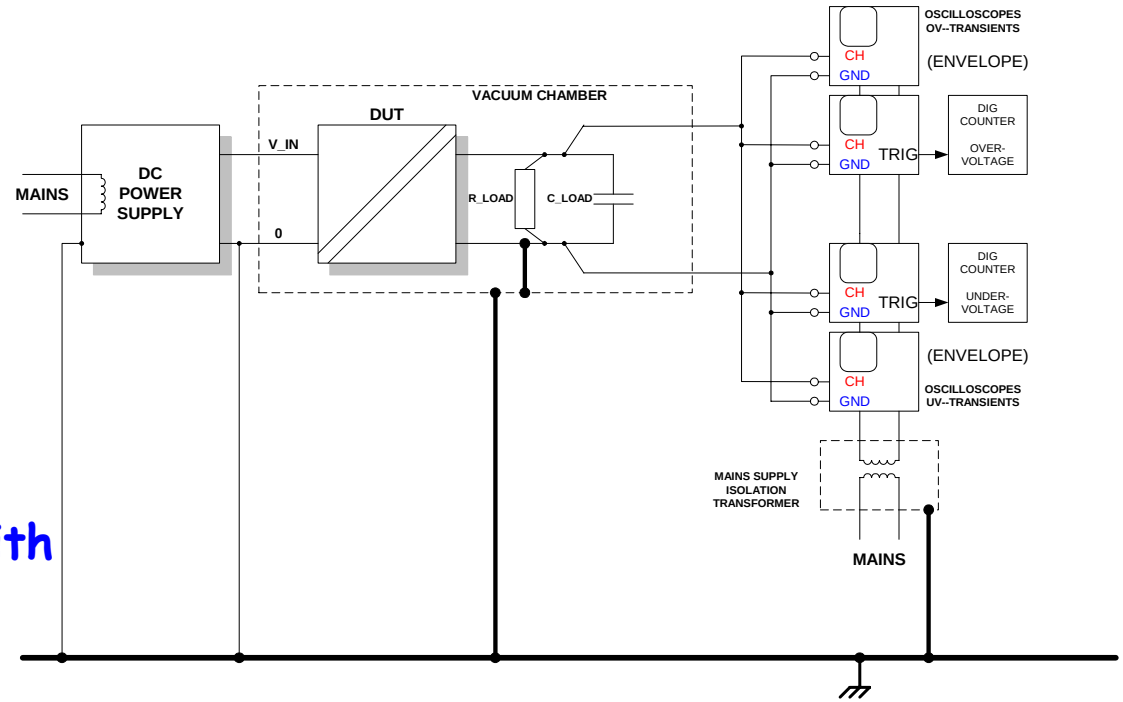


Example on load condition
(DVSA2805S-ES)

Load definition:
R_LOAD = 10.2 Ohm
C-LOAD = 30.0 uF
Input voltages:
V_IN_1 = 19.0 V
V_IN_2 = 29.4 V
Output voltage:
V_OUT = +5.00 V
Output power:
P_OUT = 2.45 W
Input DC Current:
I_IN @ 19.0 = 0.197 A
I_IN @ 29.4 = 0.136 A

The Basic test set-up monitors:

-Negative output voltage transients pulse by pulse + trigger counter
-Negative output voltage transients in envelope mode
-Positive output voltage transients pulse by pulse + trigger counter
-Positive output voltage transients in envelope mode

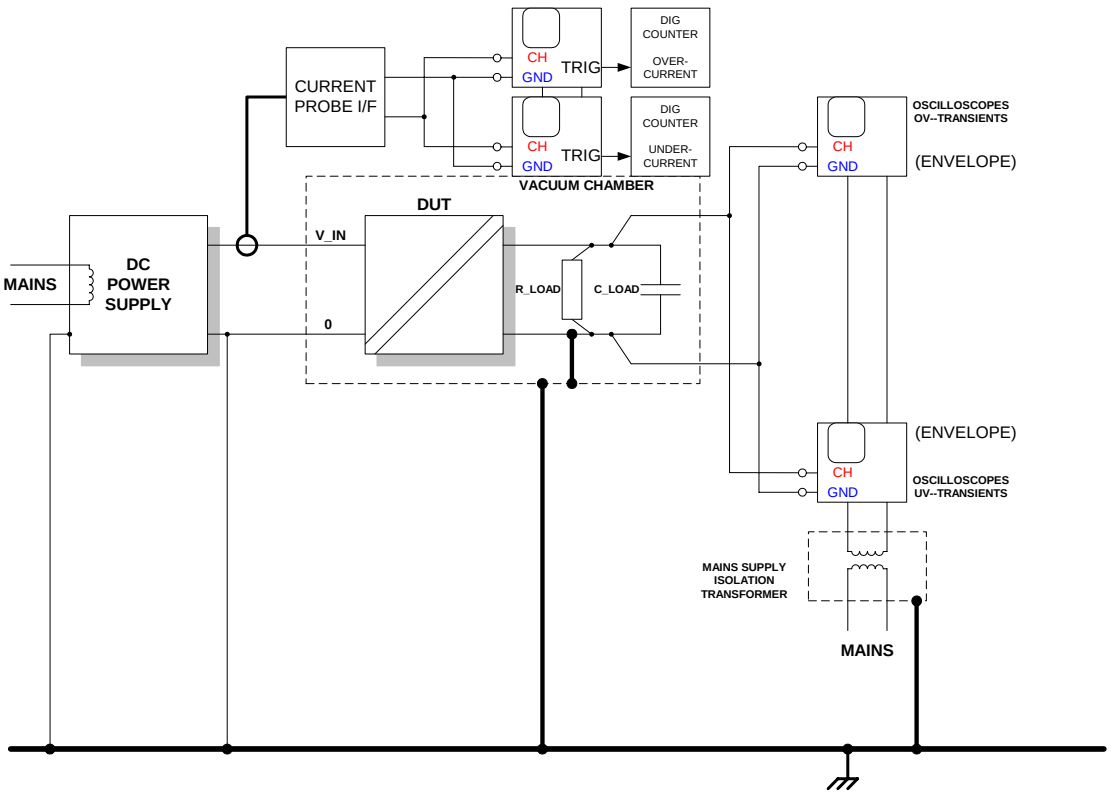


Used during tests with High LET HIF Ion

Alternative test set up:

-Negative input current transients pulse by pulse + trigger counter
-Negative output voltage transients in envelope mode
-Positive input current transients pulse by pulse + trigger counter
-Positive output voltage transients in envelope mode

While measuring the transient input currents (trig) the output voltages was simultaneously monitored in envelope mode.



Used during tests with High Penetration HIF Ion

TEST RESULTS

"THE HIGHLIGHT AND CONCLUSIONS"

DVSA2805S-ES

All integrated circuits, and the rectifying diodes, where tested with high LET Ions having a LET of 55.9 Mev/(mg/cm^2).

- Only **positive output voltage transients** were recorded for irradiation of IC1 – IC3.
- Both **positive and negative transients** were detected for irradiation of IC4

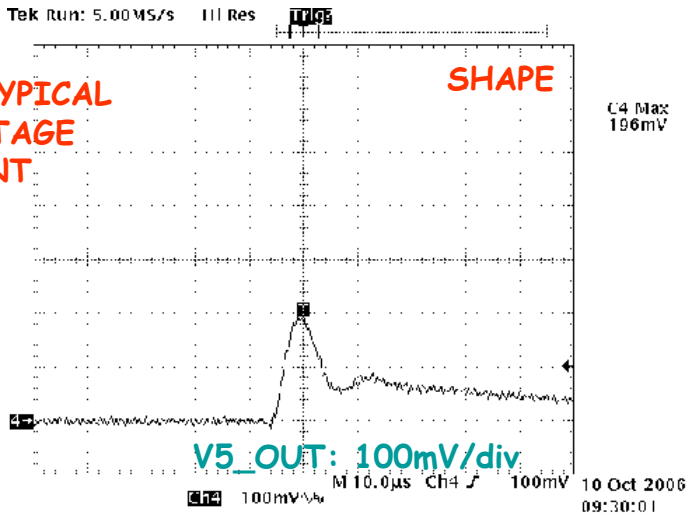
Area	**Results (output voltage)**
Area 1, IC1 = PWM controller UC1843	Positive transients < +300 mV
Area 2, IC2 = Comparator LM119C	Positive transients < +200 mV
Area 3, IC3 = Reference LT1009C	Positive transient < +170 mV
Area 4, IC4 = OP-Amp LM158	Positive transient < +230 mV Negative transients < -120 mV
Area 5, Rectifying Diodes	No Transients

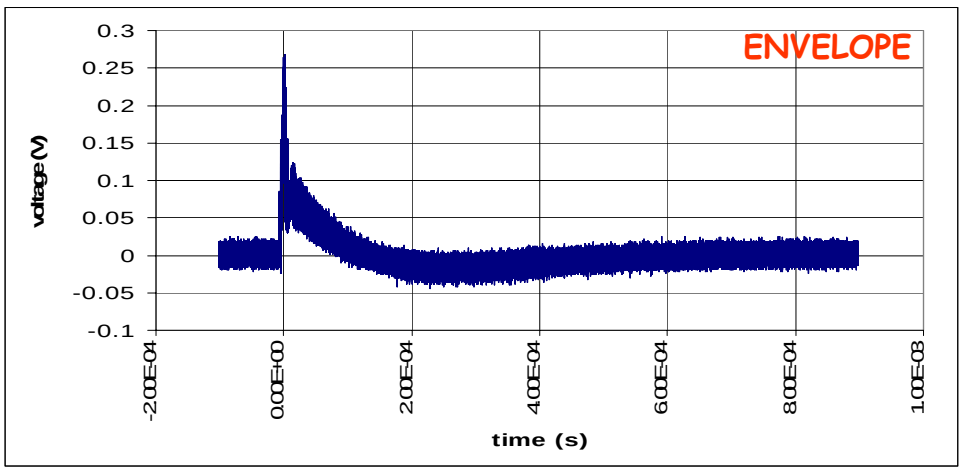
The Switching MOSFETS were tested with high penetrating Ions having LETs of 10.1, 20.6 and 32.4 MeV/(mg/cm^2).
- Only positive **input current transients** were recorded with characteristics as listed in the Table below.

Area	**Results (input current)**
Area 6, MOSFETS = HEXFET IR gen III (Mask id 527453/1986)	Large positive transients < +400 mA (Compared with DC current = 136 mA)

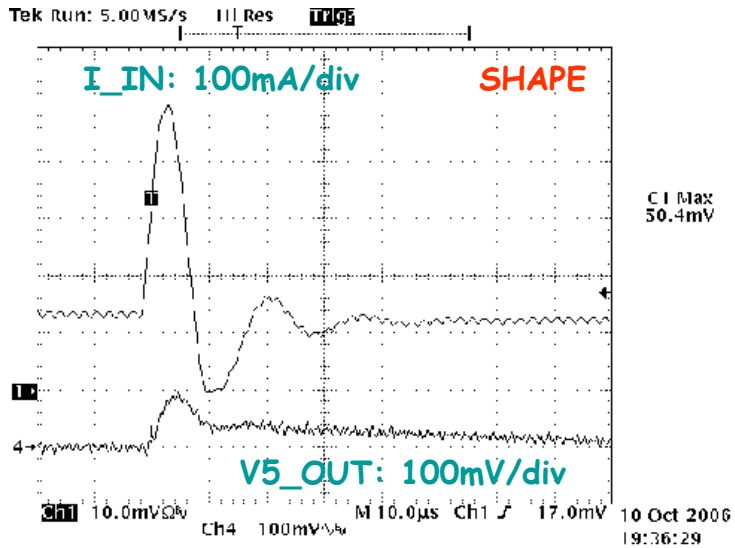
DVSA2805S-ES

EXAMPLE OF TYPICAL OUTPUT VOLTAGE TRANSIENT





EXAMPLE OF INPUT CURRENT TRANSIENT



NOTA BENE:
Peak value is 400mA, to be compared with the application DC steady-state current of 136 mA.

Occurrence is very low: 1 event measured with fluence=1E6 p/cm2, and flux = 5000 p/(cm2*s)

DVSA2805S-ES

- High LET heavy-ion irradiation of all active components, integrated circuits and diodes, resulted in both positive- and negative transient behaviour on the output voltage (+5.0V). The transient occurrence was low.

- The maximum amplitude of the positive voltage transients was < +300mV and the time duration until nominal output voltage is restored, is in all cases < 50 us.

- The maximum amplitude of the negative voltage transients was < -120mV and the time duration until nominal output voltage is restored, is in all cases < 50 us.

- High penetrating heavy-ion irradiation of the power MOSFETs, resulted in positive input current transients with high amplitude (400 mA compared with 136mA S-S current), with duration of ca 10 DC/DC clock-pulses (ca 20-30 us). The transient occurrence was very low.

Main Conclusion:

All test runs are non-destructive. Only "soft-errors" were observed.

Considering the low number of voltage and current transients per test fluence, the high LET level used and the magnitude and durations of the events, it can be concluded that little or no risk exist concerning SEE in the DVSA2805S-ES DC/DC Converter – to be used during the PROBA-II mission.

DVETR283R3SF-ES

All integrated circuits, and the rectifying diodes, where tested with high LET Ions having a LET of 55.9 MeV/(mg/cm^2).

- Only positive **output voltage transients** were recorded with characteristics as listed below

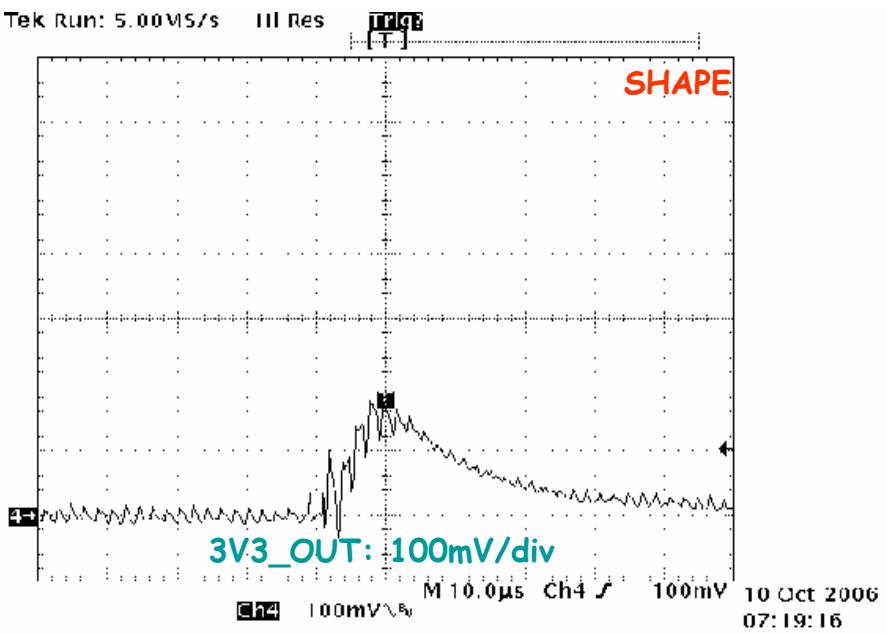
Area	Results
Area 1, IC1 = PWM controller UC1843	Positive transients < +200mV
Area 2, IC2 = Comparator LM119C	Positive transients < +200mV
Area 3, IC3 = Reference LT1009C	No transients
Area 4, IC4 = OP-Amp LM158	No transients
Area 5, Rectifying Diodes	No Transients

The Switching MOSFETS were tested with high penetrating Ions having LETs of 10.1, 20.6 and 32.4 MeV/(mg/cm^2).
- Only positive **input current transients** were recorded with characteristics as listed below

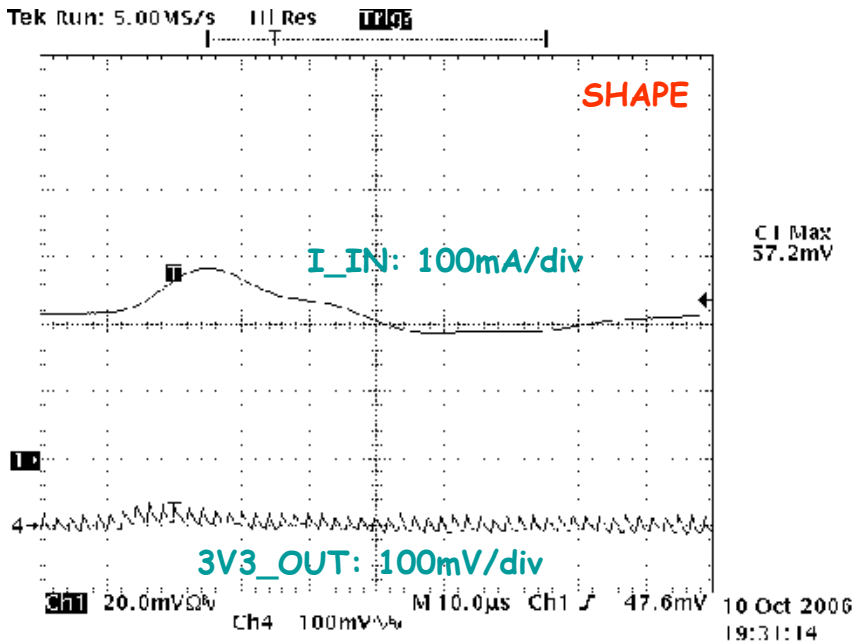
Area	Results
Area 6, MOSFETS = HEXFET IR gen III (Mask id 527497/1986)	Positive transients < +100mA

DVETR283R3SF-ES

EXAMPLE OF TYPICAL OUTPUT VOLTAGE TRANSIENT



EXAMPLE OF INPUT CURRENT TRANSIENT



DVETR283R3SF-ES

- High LET heavy-ion irradiation of all active components, integrated circuits and diodes, resulted in positive transient behavior on the output voltage (+3.3V). No negative voltage transients were recorded. The transient occurrence was very low.
- The maximum amplitude of the positive voltage transients were < +200mV and the time duration until nominal output voltage is restored, is in all cases < 50 us.
- High penetrating heavy-ion irradiation of the power MOSFETs, resulted in positive input current transients that persists for ca 10 clock-pulses (ca 20-30 us), however, the transient occurrence was very low.
- The maximum amplitude of the positive input current transients were < +100mA and the time duration until nominal input current is restored is in all cases < 30 us.

Main Conclusion:

All test runs are non-destructive. Only "soft-errors" were observed.

Considering the low number of voltage and current transients per test fluence, the high LET level used and the magnitude and durations of the events, it can be concluded that little or no risk exist concerning SEE in the DVETR283R3SF-ES DC/DC Converter – to be used during the PROBA-II mission.

DVEHF28512S-ES

All integrated circuits where irradiated with high LET Ions, and all with LET = 55.9 MeV/(mg/cm^2).

- Only **positive output voltage transients** were recorded when irradiating IC1, IC3
- Only **Negative output voltage transients** were recorded when irradiating IC2
- Both **positive and negative transients** were detected when irradiation IC5 – IC6

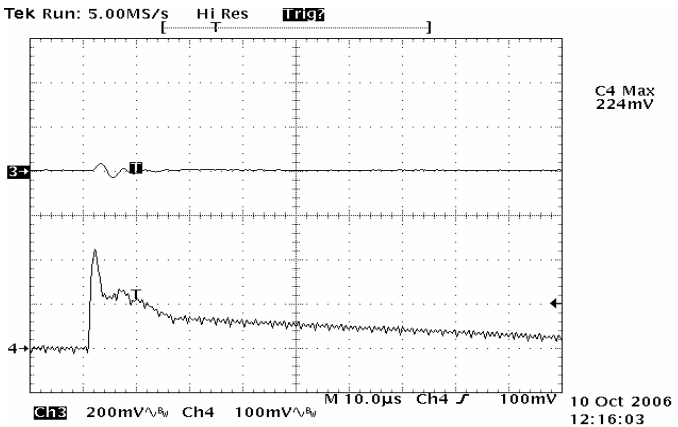
Area	Results
Area 1, IC1 = Linear Regulator LM1940	V12: Positive transients < +370 mV
Area 2, IC2 = Linear Regulator LM1940	VN12: Negative Transients < -670 mV
Area 3, IC3 = PWM Regulator UC1843	V5: Positive transients < +170 mV
Area 4, IC4 = Comparator LM119C	No transients
Area 5, IC5 = Reference LT1009C	V5: Positive transient < +150 mV V5: Negative transient < -70 mV
Area 6, IC6 = OP-Amp LM158	V5: Positive transient < +200 mV V5: Negative transient < -80 mV

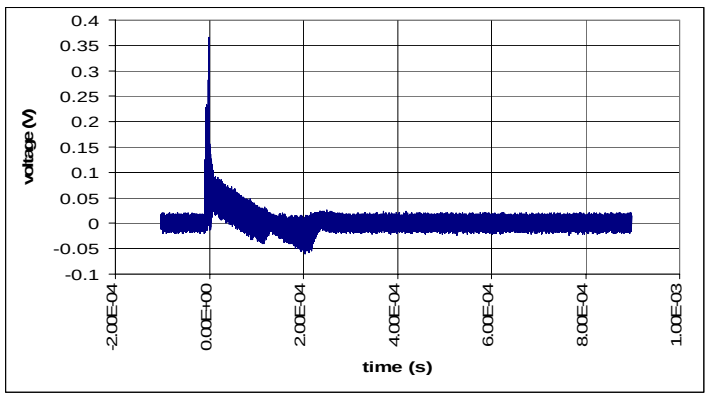
The Switching MOSFETS were beamed with high penetrating Ions, and with LET = 10.1, 20.6 and 32.4 MeV/(mg/cm^2).
- Only positive **input current transients** were recorded, as following:

Area	Results
Area 7, MOSFETS = HEXFET IR gen III (Mask id 527453/1986)	Positive transients < +230 mA

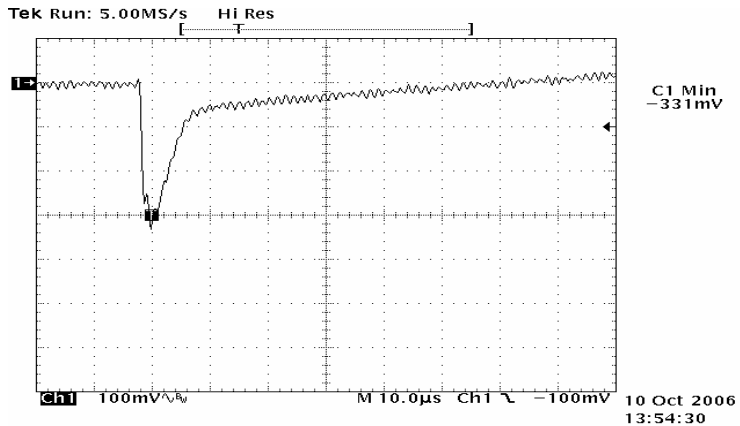
DVEHF28512S-ES

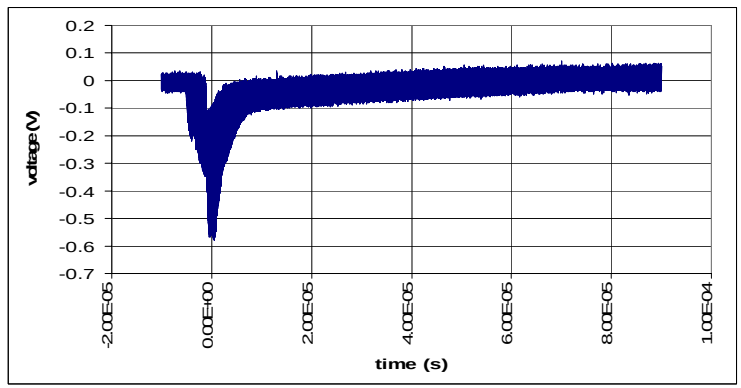
EXAMPLE OF TYPICAL OUTPUT VOLTAGE TRANSIENT +12V Regulator





EXAMPLE OF TYPICAL OUTPUT VOLTAGE TRANSIENT -12V Regulator





DVEHF28512S-ES

Main Conclusion:

All test runs are non-destructive. Only "soft-errors" were observed.

Considerable voltage transient are found on the +/-12V outputs, with +370/-670 mV amplitudes and quite high occurrence rate (500-700 event of fluence 1E6 p/cm2), that has to be critically assessed.

Considering the high LET level used and the magnitude and durations of the events, it can be concluded that little risk exist concerning SEE in the DVSA28512S-ES DC/DC Converter – to be used during the PROBA-II mission.

However, special assessments have to be taken for the +/-12V powering of ADC and analogue measurement electronics.