Characterization and Radiation Testing of Low Mass High Voltage Converters for MicroThrust

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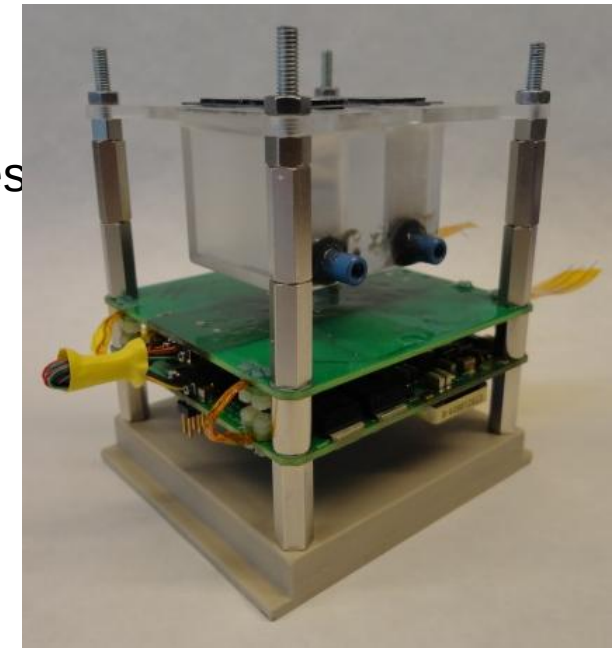
Introduction

MicroThrust

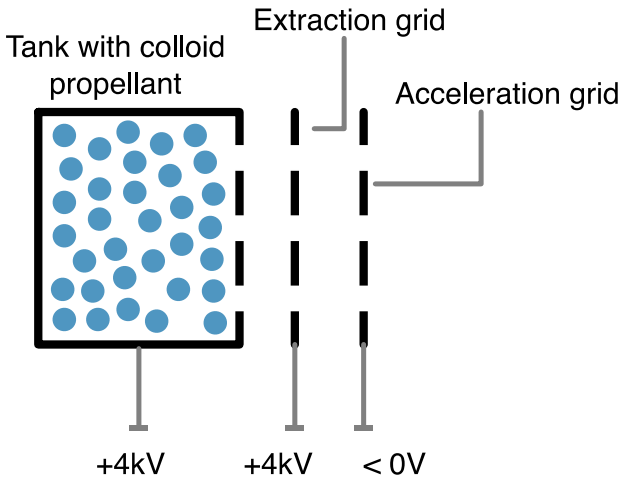
- EU-funded project (through FP-7)
- Development of a micro-propulsion module for nano-satellites
- Colloid thruster (similar in principle to ion propulsion)

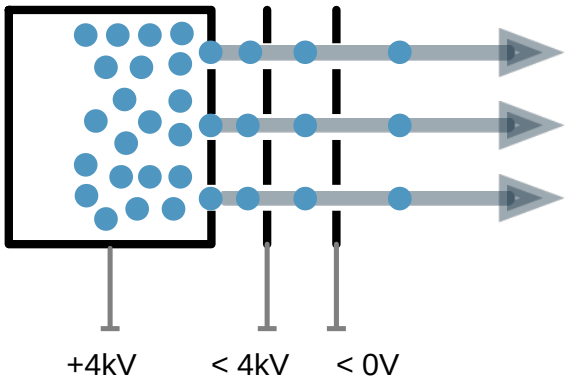


Need for high voltage converters in micro-propulsion

- Low voltages from batteries and/or solar panels
- High voltages required to operate the thrusters

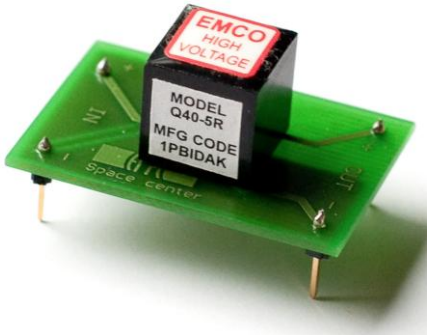
=> Need for a small, light and low power component

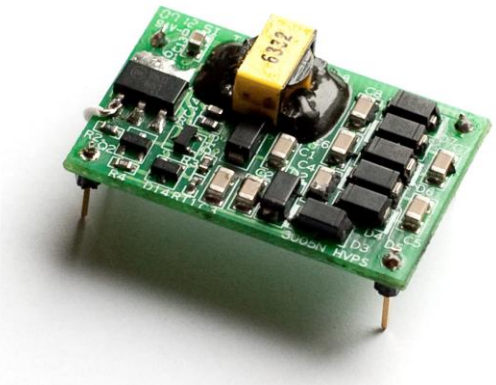




The components

	EMCO Q40-5	AM-Power 3005
Input voltage [V DC]	0 to 5	0 to 5
Output voltage [kV DC]	0 to 4	0 to 3
Max output current [µA]	125	330
Max output power [W]	0.5	1
Dimensions [mm]	12.7 x 12.7 x 12.7	27 x 40 x 15
Mass [g]	4	29
Temperature range [°C]	-10 to +60	-10 to +60
Internal feedback loop	NO	YES





Problems caused by radiation

Radiation in Space

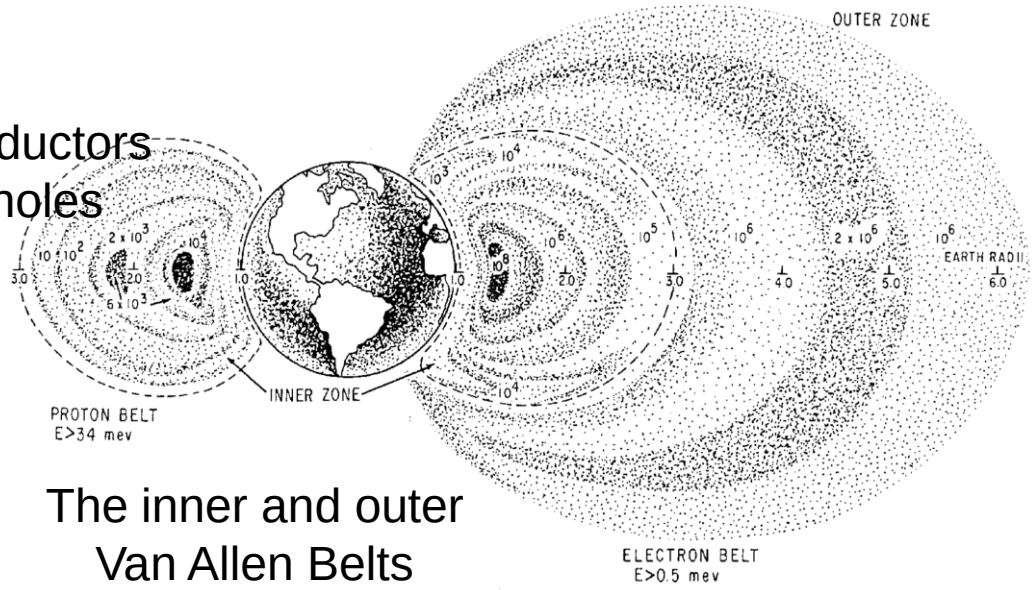
- Van Allen Belts (electrons and protons with energies up to 200 MeV) DOMINANT
- Galactic cosmic rays (protons with energies up to 10 GeV) RARE NEAR EARTH
- Solar proton events (protons with energies up to 10 GeV) RARE NEAR EARTH

Some effects of radiations

- Shift of threshold voltage in semiconductors
- Change of mobility of electrons and holes
- Reduction of gain
- Latch-up current

Test objectives

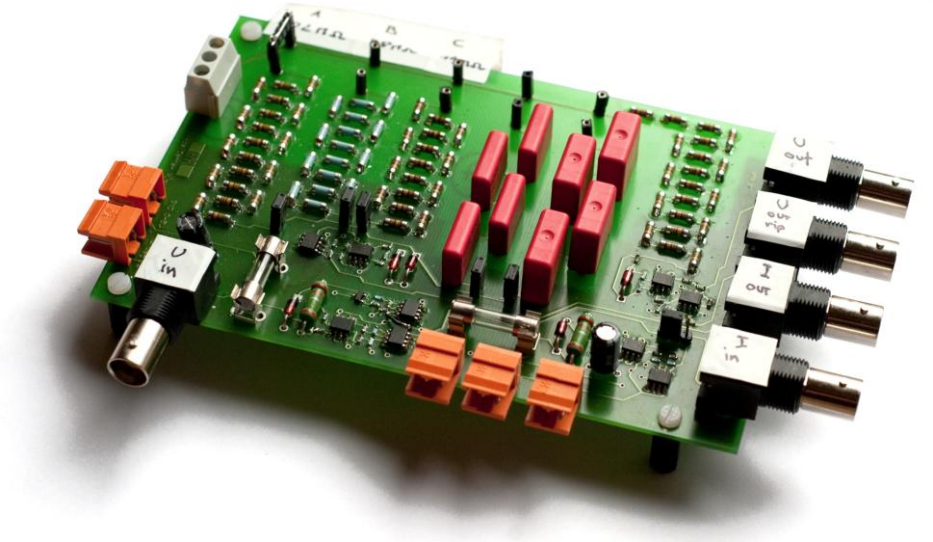
- Test the performances of off-the-shelf converters under radiation
- Because no mission was decided yet, the resistance to high dose had to be tested



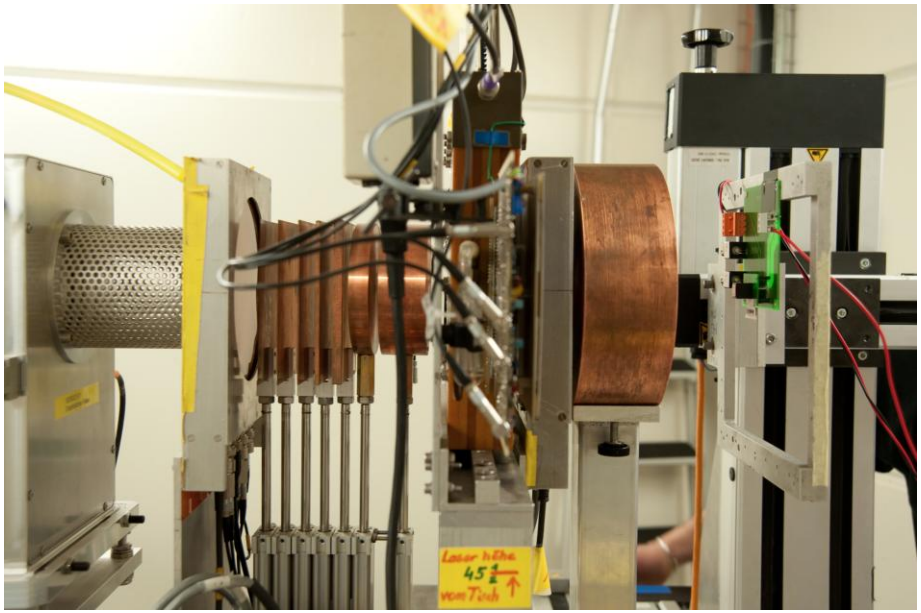
The inner and outer Van Allen Belts

Test set-up

- The tests were conducted at the Paul Sherrer Institute in Villigen, Switzerland
- 200-MeV protons were used with a flux of 3 x 10^8 protons/cm^2, emitted from
- The components were tested during 3h before radiation and during 3h under radiation
- 2 of each converters were tested
- The converters were supplied with a constant voltage throughout the test

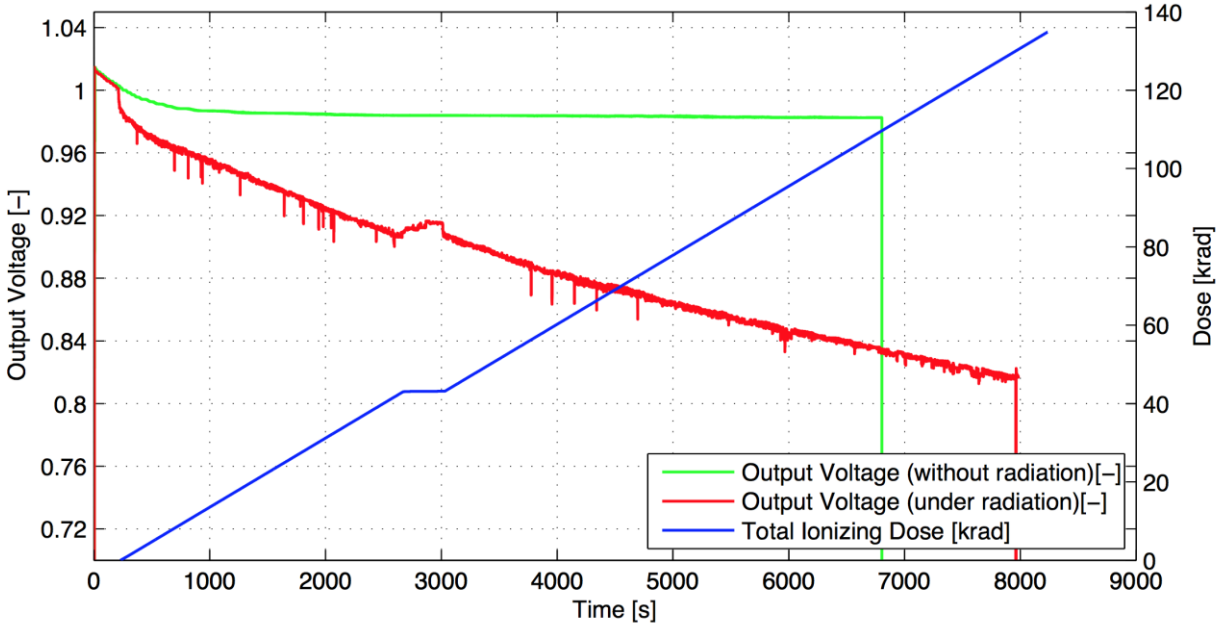


The “load board” was designed and built to emulate the typical loads the converters will work with

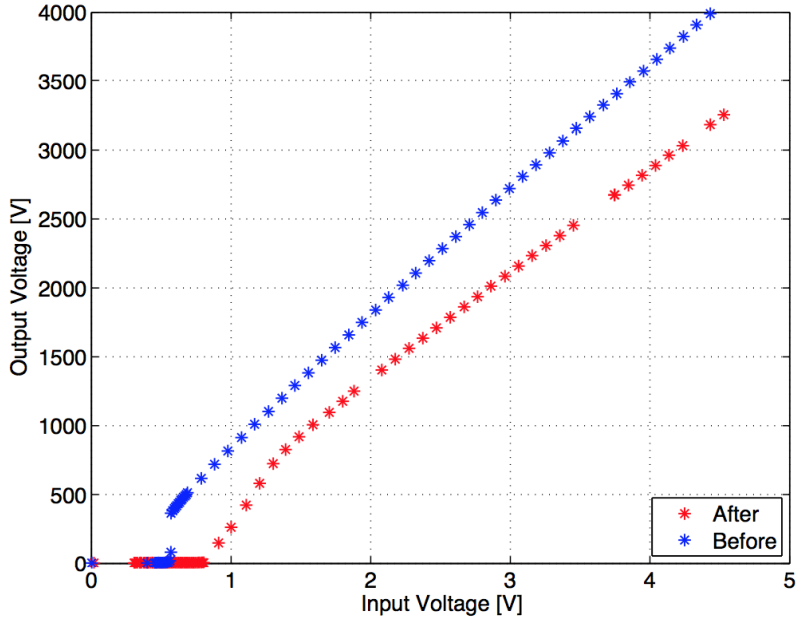


Test set-up in the beam room

Results (EMCO)

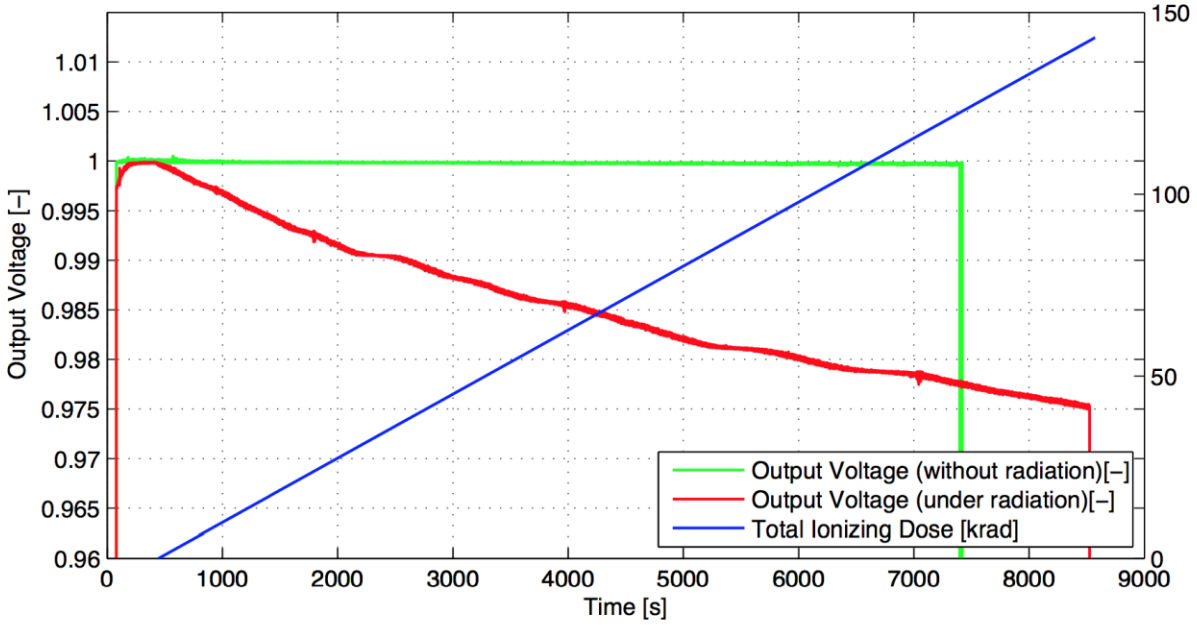


The presence of radiation creates a degradation on the output voltage. The maximum degradation is almost of 20%. The device seems to recover from the radiation effect when the ionization stops

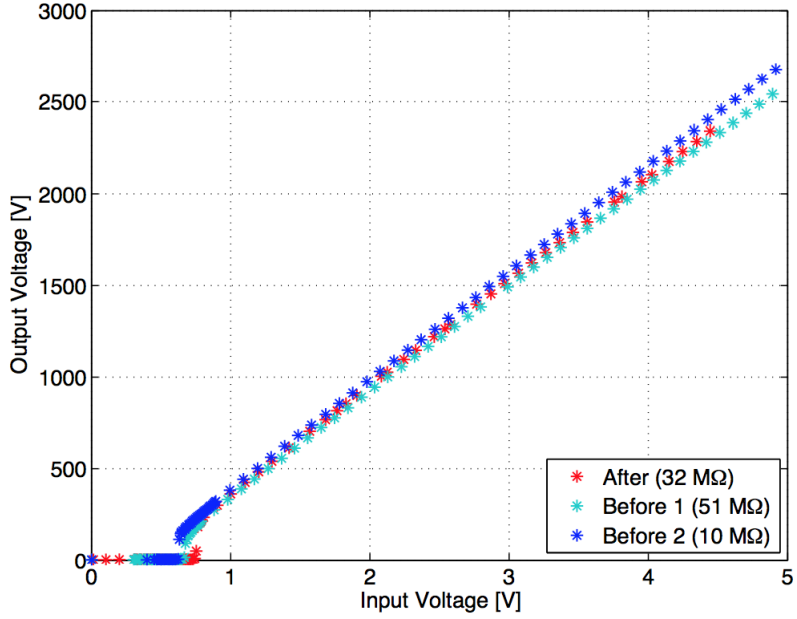


A permanent damage is clearly observed after the exposition to the radiation

Results (AM Power)



The presence of radiation creates a degradation on the output voltage. The maximum degradation is only of 2.5%



A permanent damage is not clearly observed after the exposition to the radiation

Conclusions

- 2 different candidates HVPC for a novel micro-propulsion system were tested under radiation
- Very high total ionizing dose (TID) were reached: more than 120 krad
- Both components showed a drop of the output voltage during the exposition to the radiation
- The AM Power, which has an internal feedback loop could limit the drop and keep its output voltage within 97% of its nominal capacity
- The EMCO, which was operated in open loop, presented a drop of voltage down to 80% of its nominal capacity
- Moreover, the EMCO presented permanent damage after the irradiation
- The components were kept at the PSI due to the high exposition

swiss space center

Thank You !