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

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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

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

- The tests were conducted at the Paul Sherrer Institute in Villigen, Switzerland
- 200-MeV protons were used with a flux of $3 \times 10^8$ 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
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.
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
Thank You !