Free-space Optical Communications for Space applications





Optical Wireless Communications on Cubesats: system tests and environmental tests

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OWC in space

- Visible or infrared signals to transmit digital signals in freespace
- It can establish both long-distance and short-distance links







OWC inside the satellite

- Recently demonstrated intra-spacecraft links, using IR (TOWS Project), using diffused configuration
- Now presenting 1 Gb/s line-of-sight intra-cubesat links, using near IR







OWC transmission system





agenzia spazial italiana

Optical devices

- TX: VCSEL a 850 nm
 con lente semi-sferica integrata nel packaging del VCSEL
 P_{out} ~1.5 mW
- RX:Fotodiodo ad GaAs (FCI-H125G-GaAs-100
 Package TO 46
 - Package TO-46
 - Con e senza lente esterna











Lab OWC tests

I Gbit/s, NRZ signal







Lab OWC tests

Tolerance to radial misalignment







Test scenarios

- TX and RX mounted inside the CubeSat at 30 cm
- Line-of sight, directed beam, with realistic alignment tolerance
- OWC opto-electronic components should be compatible with the space environment and its extreme conditions
 - Large temperature variations
 - Strong mechanical stresses
 - High Radiation doses





Mechanical tests

- Assembly and first measurements were realized in a clean room (ISO 8 level).
- 1 1000 Hz
- 0,5 2 g





- Effect of vibration on the IV curve of the VCSEL and on the noise spectral density of the PD.
- Both TX and RX board were not significantly affected by the mechanical stress
- No variation of performance in the comm-system: the original alignment was preserved, within the assumed tolerance (2 mm).





Thermal tests

- Temperature range inside a LEO satellite: -40°C 80°C
- Tested by using a thermal chamber





- Effect on the IV curve of the VCSEL and on the noise spectral density of the PD.
- As T increases, at the same voltage, the output current of the VCSEL increases (expected)
- The RX board was not significantly affected by the thermal stress





Radiation tests

- Estimated total ionizing dose at the LEO altitude is around 40 kRad/year.
- The tests were carried out placing TX and RX under the beam of a X-ray source





 No noticeable variation were observed in the noise spectral density of the PD nor in the IV curves of the VCSEL





- FOCS successfully demonstrated the realization of innovative OWC systems for space applications only using COTS components
- Demonstrated the feasibility of a high-speed (up to 1 Gbit/s) OWC system in a CubeSat
 - The OWC system was integrated and tested in a prototype CubeSat
- Test of TX and RX under extreme space-like conditions
 - None of these devices presents a notable degradation of the performance
- This opens the realistic prospect to use COTS devices in OWC applications for high-speed wireless communications within CubeSat or in larger satellites.







Thanks for your kind attention

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