Simulation of CubeSat energy systems for evaluation of power interfaces

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Contents

• CubeSat Electrical Power System
• Modeling EPS components
  – Model of Photovoltaic cell
  – Model of battery
• Comparing DET and MPPT
• Conclusions
• References
CubeSat Electrical Power System (EPS)

- The Electrical Power System (EPS) is a critical subsystem for all CubeSats.
- The EPS must satisfy the specific requirements for each CubeSat.
- Either a custom or a commercial EPS must provide reliable and safe power to the CubeSat.
- It is important to evaluate the behavior of the EPS for the analysis and the design, considering the power sources.
Modeling EPS component

- Photovoltaic cell model (Ortiz-Rivera)

\[ I = \frac{I_x}{1 - \exp\left(-\frac{1}{b}\right)} \left[1 - \exp\left(\frac{V}{bV_x} - \frac{1}{b}\right)\right] \]

**Typical IV Characteristic**
AMO (135.3 mW/cm²) 28°C, Bare Cell

![Graph showing comparison between Spectrolab Datasheet and Mathematical Model](graph.png)
Modeling EPS component

• Battery model (Tremblay)

\[
V_{\text{bat}} = E_0 - R \cdot i - K \frac{Q}{\int_0^t i \, dt + 0.1Q} \left( i^n - K \frac{Q}{Q - \int_0^t i \, dt} \int_0^t i \, dt + Ab \cdot \exp\left(-Bb \cdot \int_0^t i \, dt\right)\right)
\]

\[
V_{\text{bat}} = E_0 - R \cdot i - K \frac{Q}{Q - \int_0^t i \, dt} \left( \int_0^t i \, dt + i^n \right) + Ab \cdot \exp\left(-Bb \cdot \int_0^t i \, dt\right)
\]
Orbit environment

Irradiance

Temperature (Erb, 2011)
Comparing DET and MPPT
Results of Comparison

DET

MPPT
Conclusions

• Behavioral models for photovoltaic cell and Li-Ion batteries were described and used for CubeSat power system simulation

• In DET photovoltaic cells does not operate at maximum power point, the voltage is determined by the battery

• Using power converter the photovoltaic cells operate at maximum power point, thus the battery reaches a greater state of charge (7%).

• Future work must consider efficiency of power converter, as well as, a trade off between complexity and energy increment.
References

- Oliver Tremblay and Louis-A Dessain, "Experimental Validation of a Battery Dynamic Model for EV Applications," vol. 3, 2009
- Daniel Erb, "Evaluating the effectiveness of peak power tracking technologies for solar array on small spacecraft," Lexington, KY, 2011
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Question?, Suggestions!

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