CubeSat Electric Power System (EPS) Documentation

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1. Introduction

The Electric Power System (EPS) is a critical component of CubeSat and NanoSat missions, as it provides the necessary electrical power for all onboard systems and instruments. This documentation provides an overview of designing and implementing an EPS for CubeSat applications, covering power budget calculation, solar panel selection, battery choice, power distribution, and margin considerations.

2. Power Budget Calculation

2.1. Components of Power Budget

A power budget is essential for designing an efficient EPS. It involves estimating the power requirements for all CubeSat subsystems during various mission phases. Key components of a power budget include:

- **Payload Power**: Power consumed by scientific instruments and mission-specific payloads.
- **Communication Power**: Power required for communication systems (transmitters, receivers).
- **Onboard Computer Power**: Power for onboard computers, processors, and data handling.
- **Sensors and Actuators Power**: Power for sensors, actuators, and control systems.
- **Thermal Control Power**: Power for heaters, coolers, and temperature control systems.
- **Housekeeping Power**: Power for miscellaneous functions like timers, watchdogs, and sensors.
- **Margin Power**: Extra power for contingencies, in-flight anomalies, or uncertainties.

2.2. Sample Power Budget Calculation

Let's calculate a simple sample power budget for a CubeSat mission:

- Payload Power: 4 W

- Communication Power: 2 W
- Onboard Computer Power: 3 W
- Sensors and Actuators Power: 1 W
- Thermal Control Power: 2 W
- Housekeeping Power: 1 W
- Margin Power (20% of total power): 2 W

Total Power Required: 15 W

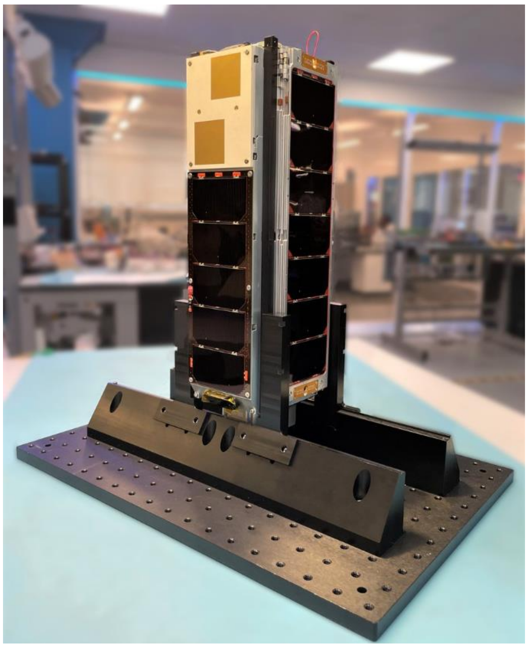
Calculating the actual power budget for a mission requires a much more in-depth analysis and consideration of several parameters like Battery capacity(Ah), Battery's total available energy(Wh), Depth of Discharge(DOD), Discharge rate(C-rate), Maximum DOD in lifetime(%) etc.

We also need to design several contingency strategies and modes in order to safeguard against unknown circumstances like subsystem failure, short circuit, power bus malfunction etc.

3. Solar Panel Selection

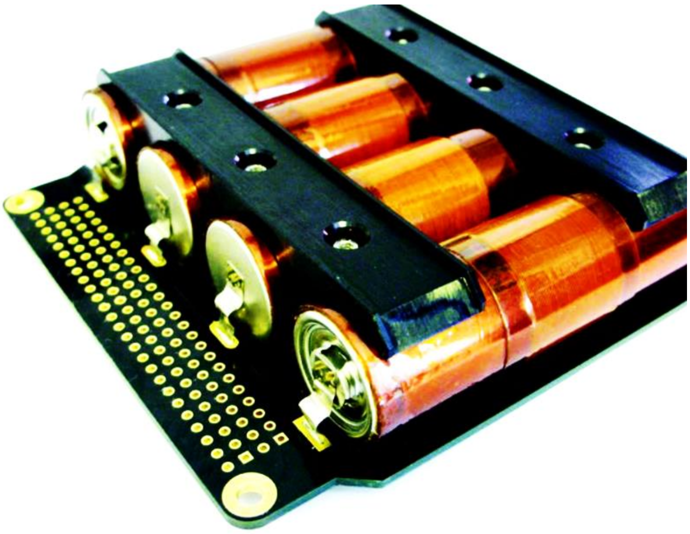
Selecting the appropriate solar panels is crucial for generating power in space. Considerations include:

- **Efficiency**: Choose high-efficiency solar cells to maximize power generation.
- **Size and Weight**: Balance power generation with CubeSat size and weight limitations.
- **Deployment**: Decide between deployable or fixed solar panels based on mission needs.
- **Radiation Resistance**: Ensure solar cells can withstand space radiation.
- **Orientation**: Plan for optimal sun exposure by orienting the panels correctly.



4. Battery Choice

Selecting the right battery is essential for storing and providing power when the satellite is not in sunlight (e.g., eclipse periods). Factors to consider include:



- **Capacity**: Choose a battery with sufficient capacity to meet the mission's energy requirements during eclipses.
- **Chemistry**: Lithium-ion or other space-qualified chemistries are common choices.
- **Temperature Range**: Ensure the battery can operate within the expected temperature range.
- **Voltage and Current**: Match the battery's voltage and current to the EPS requirements.
- **Reliability**: Opt for space-qualified and radiation-resistant batteries.
- **Thermal considerations**: the temperature may vary to large extremes during the life of the satellite therefore proper heating systems may be required to extend the life of the battery.

5. Power Distribution

Power distribution ensures that power is delivered reliably to all subsystems. Key aspects include:

- **Voltage Regulation**: Use voltage regulators to maintain a stable voltage supply.
- **Power Switching**: Implement switches for selective activation of subsystems.
- **Fuse Protection**: Install fuses to protect against overcurrent events.
- **Redundancy**: Consider redundant power paths for critical subsystems.
- **Monitoring**: Implement telemetry to monitor power consumption and system health.

6. Margin Considerations

Margins are essential to account for uncertainties and ensure mission success. Consider these margins:

- **Margin in Power Budget**: Add a margin to the power budget to account for unexpected power spikes or inefficiencies.
- **Margin in Battery Capacity**: Oversize the battery capacity to ensure it can handle longer eclipse durations.
- **Margin in Solar Panel Area**: Slightly increase the solar panel area to account for reduced efficiency over time.
- **Margin in Battery Voltage**: Select a battery with a voltage range that allows for variations due to aging or temperature changes.

7. Conclusion

Designing a CubeSat Electric Power System (EPS) requires careful consideration of power budget, solar panel selection, battery choice, power distribution, and margin considerations. A well-designed EPS ensures the reliable operation of CubeSat missions, providing power to essential subsystems and instruments throughout the mission.

By following these guidelines and tailoring them to your specific mission requirements, you can create a robust and efficient EPS for your CubeSat or NanoSat mission.

8. References

- "CubeSat Design Specification," California Polytechnic State University, San Luis Obispo, 2019.
- "NASA CubeSat 101: Basic Concepts and Processes for First-Time CubeSat Developers," NASA, 2018.
- "Small Satellite Power Systems," Aerospace Corporation, 2012.

This documentation provides a concise overview of the key considerations and steps involved in designing an Electric Power System (EPS) for CubeSat missions.