Off-the-Shelf, Deployable Solar Panels for CubeSats

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Outline

1. The CubeSat power challenge
2. Power from a standard CubeSat
3. Deployable panels for CubeSats
4. Power Management
5. Conclusion
CUBESAT POWER CHALLENGE
**Introduction**

- Power is always precious on a CubeSat.
- Solar panel area must be increased to meet the orbit average power demands of new missions.
- Tailored solar panel configuration to match orbit/mission is more important than solar cell area.
- Good power management is also vital to maximise efficiency and safety onboard.
- The most common failure of CubeSats is negative power budget.
Increased utility; Increased power demand

- CubeSat missions are becoming increasingly sophisticated.
  - Increasing payload power consumption and duty-cycles
  - More data storage and on-board processing
  - High downlink speeds
  - More sensors and actuators for attitude control.
  - Heaters, propulsion, etc.

Ye cannae change the laws of physics, captain!
POWER FROM A STANDARD CUBESAT
3U CubeSat with Body Mounted Solar Panels

- 3U Panels have 7 large area UTJs
- Top Panel has 2 UTJs

+X & -X (Side) Solar Arrays 10W
+Y & -Y (Side) Solar Arrays 10W
USB +5V-
+Z & -Z Top/Bottom Solar Arrays 3W

BCR1
BCR2
BCR3

Separation switch
Battery Bus
Pull-Pin-

5V REG
3.3V REG

Over-Current Protection
Standard 3U Power Profile and Performance

- Orbit average power of 4.9W (including 10% Albedo).
- Peak power is 9W over the poles.
Productization is our focus

• One reason that CubeSats are attractive is the product nature of subsystems.
• All panels are designed to work with standard structures and standard mechanical/electrical interfaces.
  – 3D models
  – Stock of components.
• This not only keeps down the product cost, it reduces the resource/effort required by the customer.
2 main deployable panel variants

Single Deployed

Double Deployed
Ukube-1 – Single Deployable

- Both variants of single deployed are on Ukube-1.
  - Our own mission for the UK Space Agency.
  - 3U CubeSat with 6 payloads.
- All deployed panels are double sided.
- Passed NASA GEVS qualification and a student encounter.
- Integrated Thermal Knives and thermal knife drivers (dual redundant).
- Available in 90° and 135° configurations
- Integrated MTQ and sensors.
- CubeSat assembly jig allows deployment tests
  - (also for antenna)
Power from a CubeSat with deployed panels.

- **Solar Arrays 10W**
  - +X & -X (Side)
  - +Y & -Y (Side)
  - -Zlead & +xdep
  - -Ztrail & -xdep
  - +xside & -xside (deployed one off)
  - +xside & -xside (deployed one off)

- **Separation switch**
- **Battery Bus**
- **Over-Current Protection**
- **5V REG**
- **3.3V REG**
- **USB Charge**
- **+Z & -Z Top/Bottom Solar Arrays 3W**
Power Profile and Performance

- Orbit average power of 20.8W (including 10% Albedo).
- Power profile more spread-out over orbit.
- Peak power is 40W.
Double Deployable

- Up to 4 faces of solar cells (front and back).
- Integrated MTQ, TKD and thermal knifes.
- Tested at -40°C and +80°C.
- Designed for P-POD specification and clearance (fits within 6.5mm envelope).
- Works without need for modification to standard structures.
Solar Panel Deployment
POWER MANAGEMENT
EPS

• Over 200 Clyde Space CubeSat EPS shipped to date.
  – Many missions on orbit are now using our EPS, solar panels and battery very successfully.
• Now on 6th\textsuperscript{th} Generation design.
  – Improved efficiency.
  – Solid state separation switches.
• BCRs 90\%+ efficient and 95-98\% efficient for 5V and 3.3V Regulators (2.5A nominal, 4A max)
• Multiple XUEPS variants can handle 12 Solar panels of 12W
  – For deployed panel systems and also 6U, 8U and 12U CubeSats.
Power Distribution

• Most satellites have a ‘Power Distribution Module’ (PDM).
• PDM provides functions essential to mission survival in times of anomaly.
  – Over-current protection.
  – Load management (switch things ON and OFF)
  – Battery under-voltage protection (or Unloading Function).
• Switch Board opposite has 24 power switches at 4 different voltages.
  – (Note, our EPS protects each power bus with a switch and this has under-voltage protection)
In development: Fine Sun-sensor for CubeSats

- Analog output
- 2 axis (azimuth and elevation)
- Solar panel mountable (surface mount).
- Flying on UKube-1
  - We are in the process of widening the FoV of the sensor and doing some more testing.
- Expected performance better than 0.1° knowledge.
- Size is 16mm x 8mm x 3mm
- Mass of less than 5g
- Power consumption of a few mW (including interface circuit)
More Power!

- Deployed panels as an off-the-shelf product help increase on board power at an affordable cost.
- Single and double deployed panels available for all CubeSat sizes.
  - Can be single or double sided.
- Different configurations to suit varying mission requirements.
- Panel integration is the same as for a body mounted panel.
  - No need for custom structures.
- Scalable power management products also available.
- Problems:
  - Thermal management!
Questions?

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