CLYDE SPACE

Plug-n-Play, Reliable Power Systems for Nanosatellites.

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CLYDE SPACE
solutions for a new age in space

The Power Problem

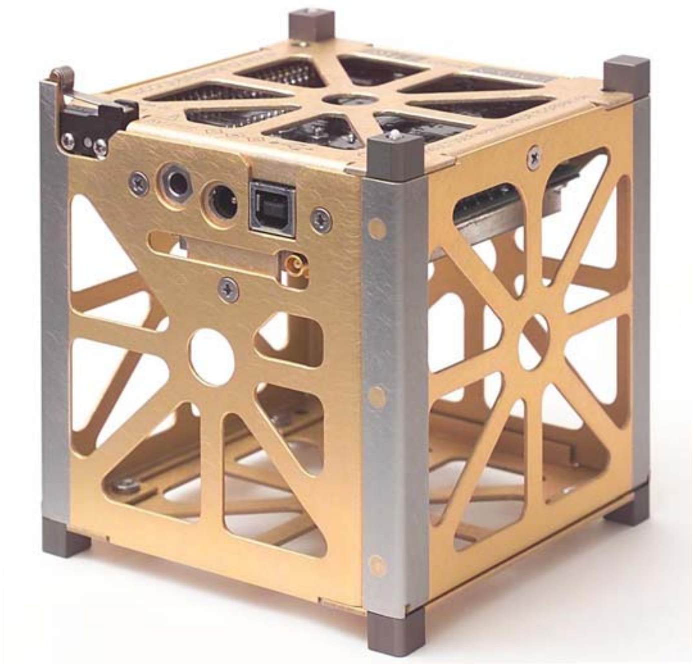
- The power system is probably the most underestimated system on a spacecraft.
  - It is required first for spacecraft integration.
  - It needs to work autonomously and seamlessly.
  - If doing its job properly, it should never be noticed.
  - It is not a 'sexy' subsystem so 'perhaps' doesn't always get the attention it deserves.

Nanosatellite Programmes

- There is a growing number of organisations preparing or planning their own mission.
- The power system is a big problem for these missions.
  - The mission designers know they need one.
  - They know it needs to be reliable.
  - They are learning that it is not easy and a cause of concern.
  - Budget limitations prevent outsourcing.
- Clyde Space has recognised this issue and we are developing a standard solution for nanosatellites.

The Standard Interface

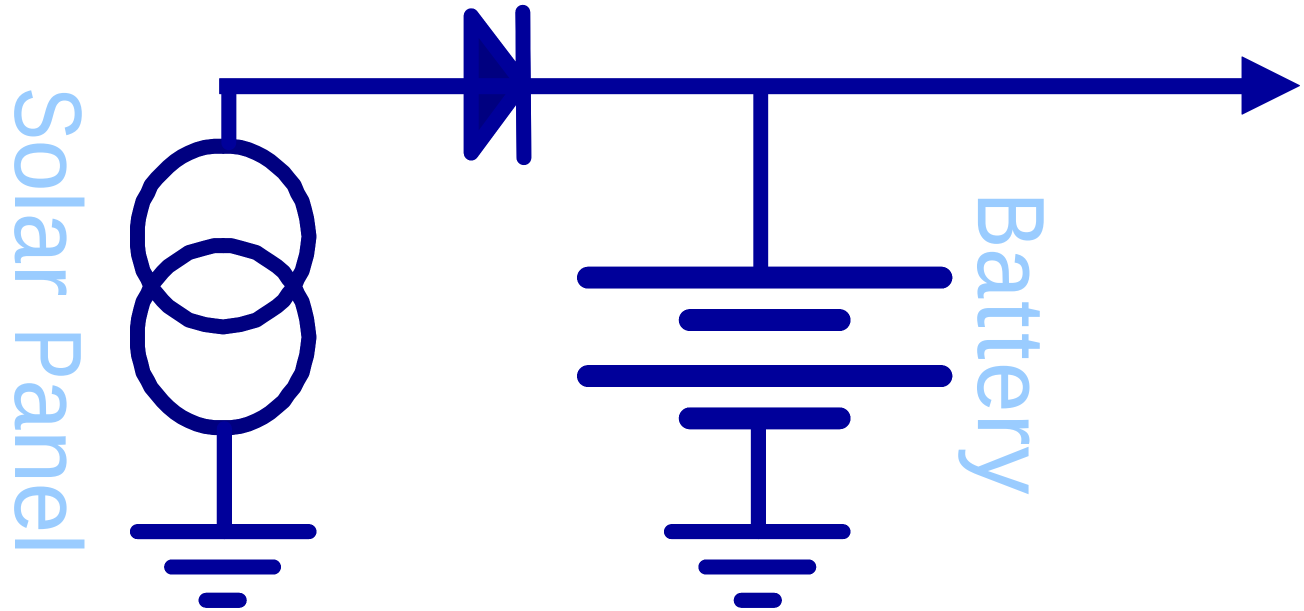
- One of the biggest cost drivers in space hardware is NRE.
- To avoid NRE costs, there is a need to adopt a standard mechanical and electrical interface.
- The CubeSat community have done an excellent job of introducing a standard that can be used for this purpose.
- For this reason, Clyde Space decided to adopt the CubeSat Kit standard for our power system.



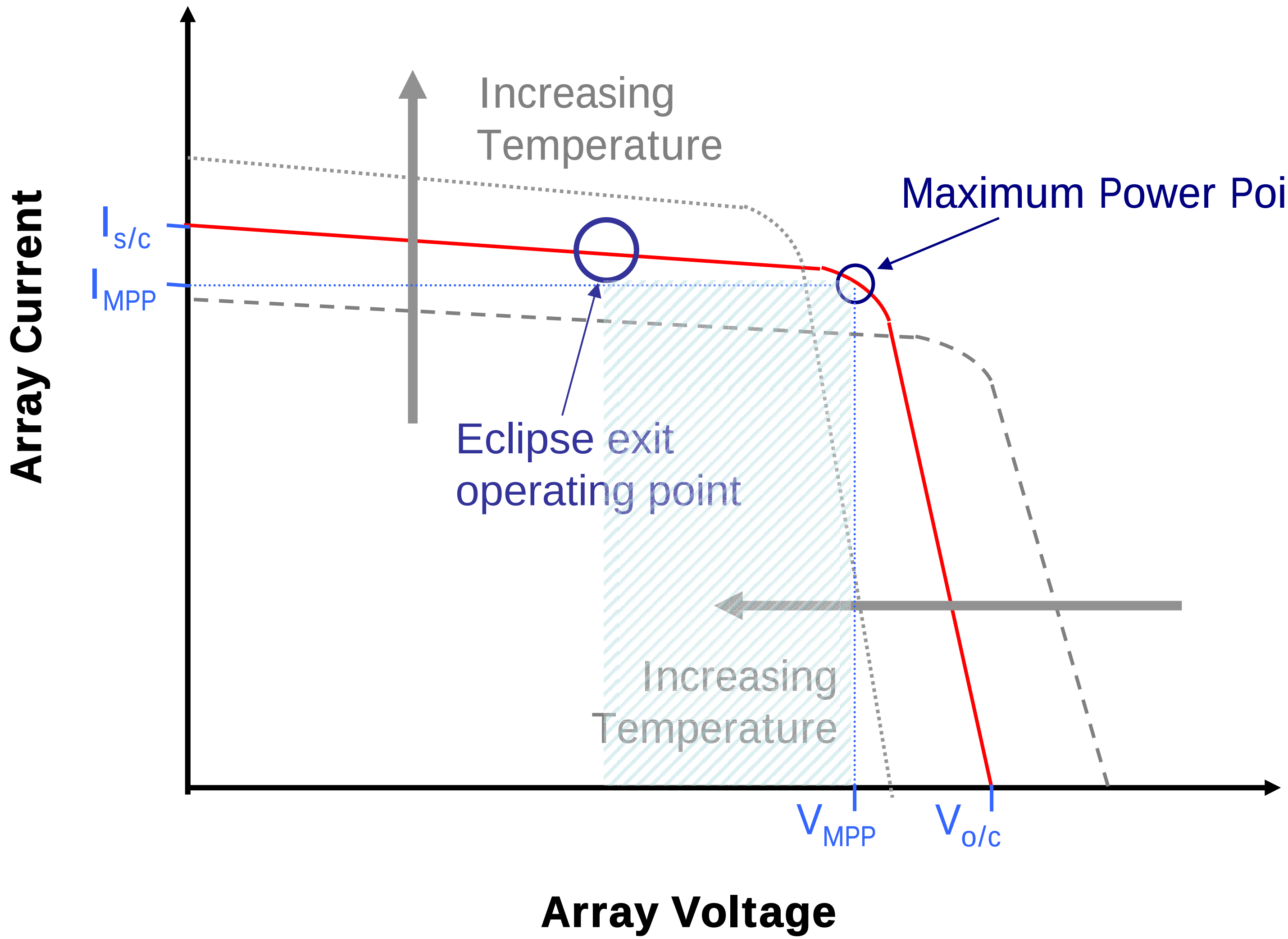
Power System Architectures

- Many different approaches to configuration.
  - Battery Bus DET
  - Fully Regulated DET
  - Hybrid
  - MPPT
  - Etc.
- Our challenge was to select an architecture that works across the board.

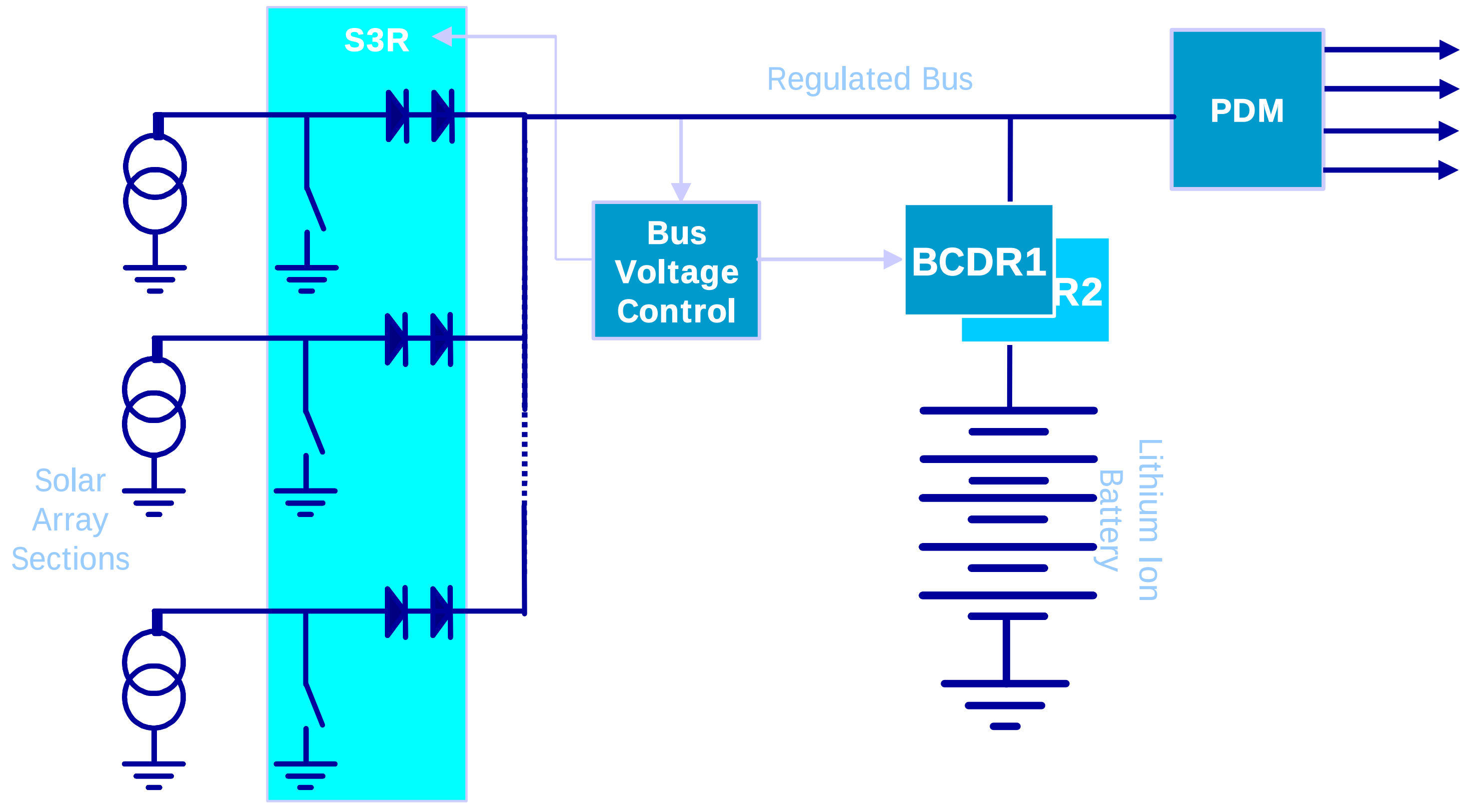
Battery Bus DET



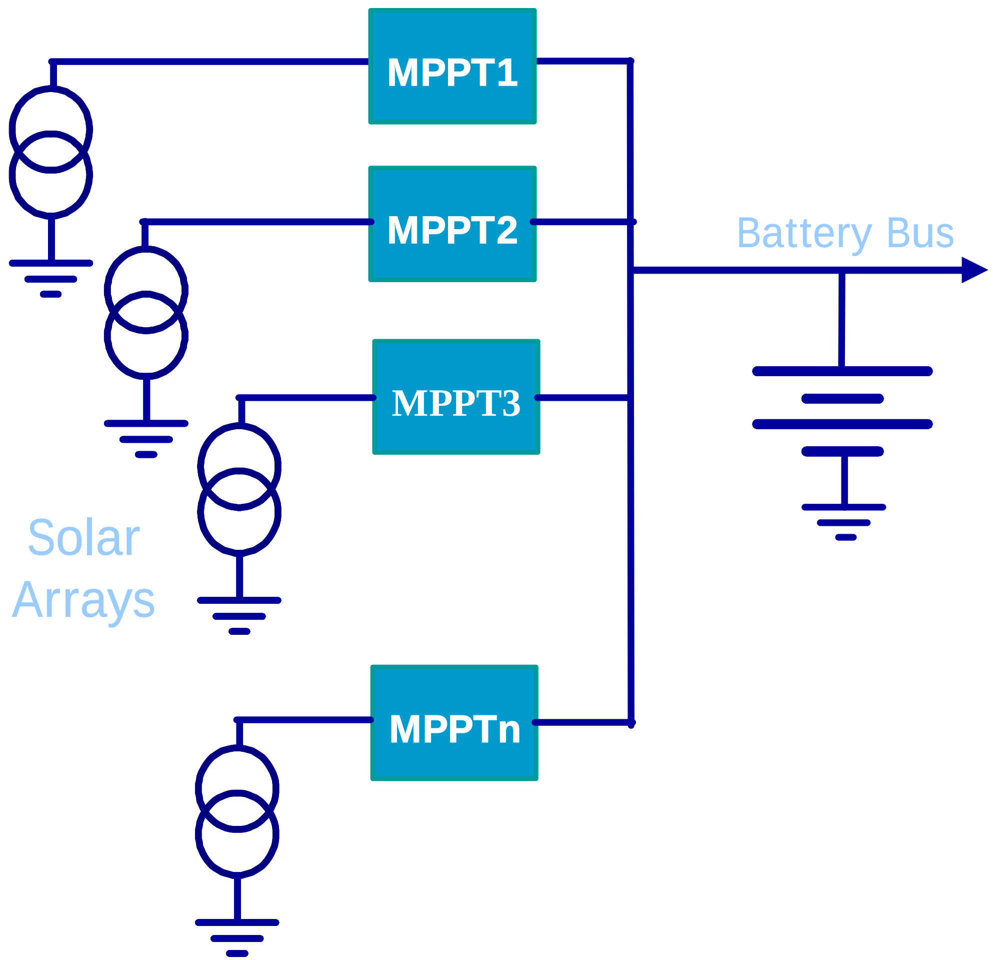
Solar Array Characteristic



Regulated Bus



Maximum Power Point Tracker



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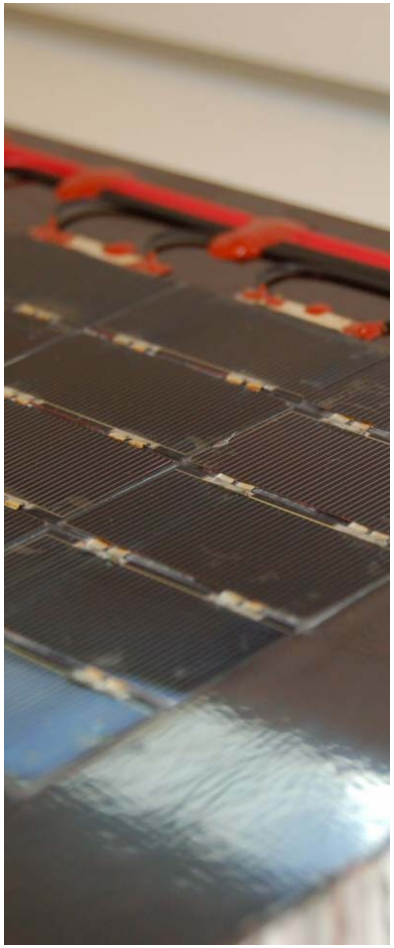
Benefits of MPPT

- Maximises power when it is needed most.
- Can interface to multiple arrays with different characteristics.
- Reduces solar array size.
- Manages charge control effectively and simply.
- Battery bus is stable, simple and offers excellent impedance characteristics.
- The MPPT technique that we are implementing does not require any user set-up; it is plug-n-play.

Solar Array Design and Selection

- For most nanosatellite missions, solar panels will be the most costly item.
- There are a number of solar cell technologies available.
  - Silicon (12% eff.)
  - Single Junction GaAs (19% eff.)
  - Multi-junction GaInP/GaAs/Ge. (27% eff.)
- A useable voltage must be achieved (4V or above).
  - Si ~ 0.5V. For a 4V array at least 10 cells are needed.
  - SJ GaAs ~ 0.9V. 6 cells needed.
  - MJ ~ 2.2V. 2 cells needed.
- Multi-junction technology is really the most obvious choice.



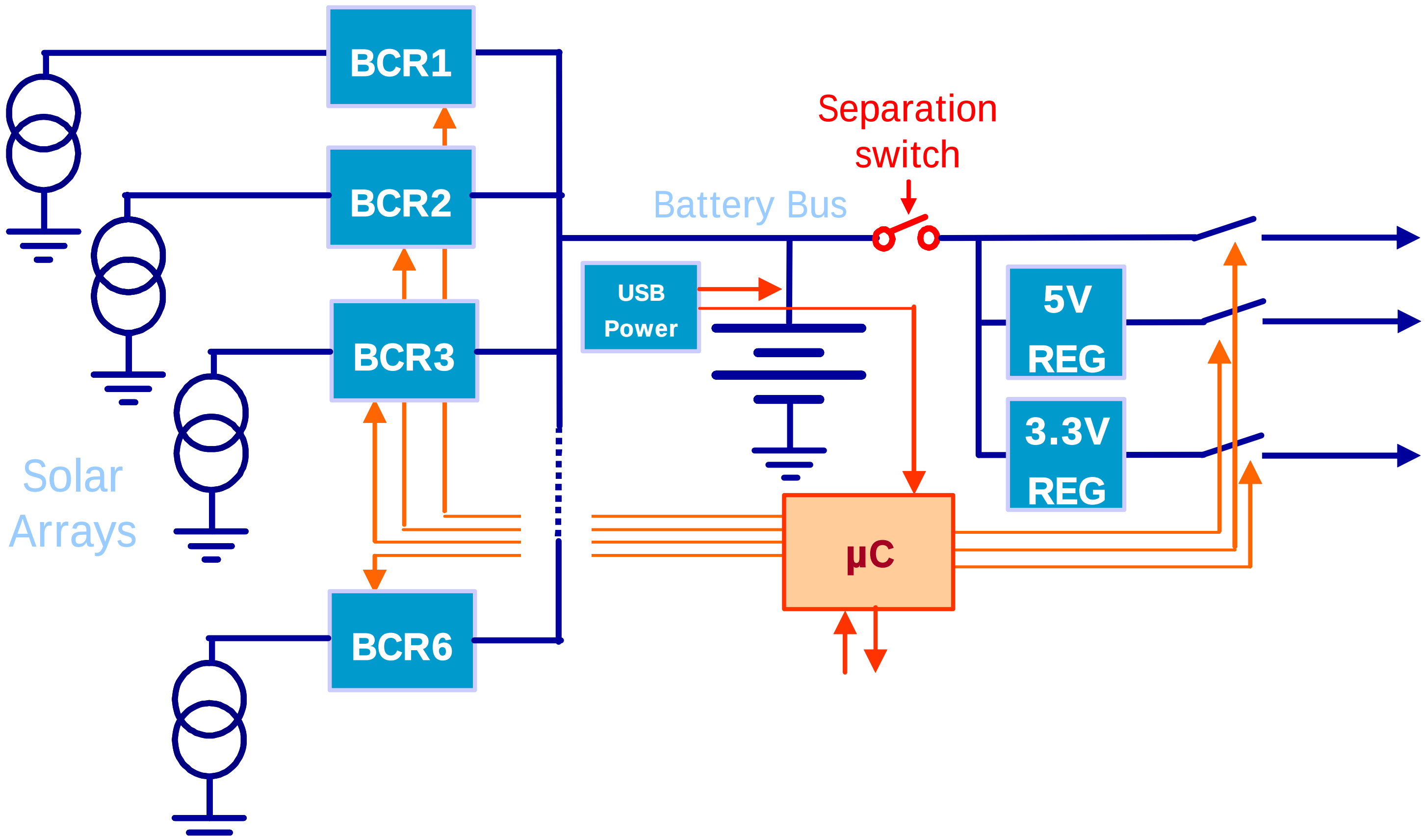
Battery Selection

- NiCd was the choice battery technology until recently.
  - Good cycling characteristics.
  - High discharge current capability.
- For today's small and miniature satellites a more mass and volumetric efficient technology is required.
- Lithium Ion and Lithium Polymer are the choice technologies.
  - 100+Whrs/kg (li-ion) vs 25Whrs/kg (NiCd).
  - Lithium Polymer offers geometric flexibility.
  - The technology is now mature enough to be used in space.

Lithium Ion/Polymer

- Commercial lithium ion cells are used by ABSL
  - The SONY HC18650 cell is used.
  - SSTL and ESA regularly use the ABSL battery.
- Lithium Polymer cells look ideal for miniature spacecraft.
  - Initial life-tests have look good for some cells
  - Energy density of ~170Whrs/kg.
  - Structural configuration makes the technology inherently structurally robust and volume efficient.
  - ‘Bulging’ issues can be easily overcome.
  - End of Charge remains constant over temperature.

CubeSat Power



Key Features

- Versatile, non-sequential solar array interface
  - 6 Independently controlled maximum power point trackers.
  - Each interface handles up to 3W.
  - Compatible with multiple solar array configurations.
  - >90% efficient.
- Centralised battery charge control.
  - Compatible with Li-ion and Lithium Polymer cell technologies.
- Integrated1Ahr (7.5Whr) Lithium Polymer battery
  - Battery Bus 5.5V – 8.4V
  - Integrated battery heater
- Regulated 5V and 3.3V buses
  - 1A output at >90% efficient.

Key Features Cont.

- Bus over-current protection
  - Retry until fault clears.
- Battery under-voltage protection.
  - With hysterisis to allow battery charge recovery.
- USB charge and power interface for ground test.
- Scalable, modular, stackable design to allow easy power handling and battery capacity increase.
- I2C digital interface.
  - Bus reset/run command facility.
  - Telemetries include Array Voltage, Battery Voltage, Battery Temperature, BCR output current Bus currents, Battery Current and Array temperature.
  - Battery state of charge indicator also available.

Schedule and Price

- Development activities well underway
  - Regulator and BCR prototypes in test.
- Full prototypes planned for October 06.
- Flight model production (25 units) in Dec 06/Jan 07.
- The system is being developed under a grant from the Scottish Executive called SMART.
- Target price is $2000 for complete CubeSat EPS (including battery).

Conclusion

- Clyde Space are using extensive small sat power system expertise to develop a reliable off-the-shelf EPS solution for nanosatellites.
- Our target specifications allow a great deal of flexibility, functionality, ease of use and scalability.
- The technology is robust and simple to understand.
  - The system is plug-n-play with no user set-up required.

Our Mission

- The mission of Clyde Space is to provide spacecraft hardware to customers with requirements for low-cost, reliable, small satellite subsystems.
- Within the next 3 years of operation we aim to be established as a leading provider of power subsystems for small satellites.

Clyde Space People

- Director - Craig Clark:
  - 11 years with SSTL: 7 years as head of the Power Systems.
- Senior Engineer – Alex Lopez:
  - Talented and respected Analogue Electronics Specialist.
- Engineer – Andrew Strain
  - Graduate electronics design engineer.

Our Facilities

- Located on the West of Scotland Science Park
  - Facilities are purpose built for technology companies.
- Office facilties
  - 400 sqft of office space
  - Typical usage includes design, documentation and administration activities.
- Lab facilities
  - 400 sqft of electronics lab facilities
  - Typical usage includes bread-boarding and general engineering activities.
- Cleanroom facilities
  - Class 10,000, open-plan cleanroom area.
  - ESD compliance for handling sensitive devices.
  - Clean compressed air and nitrogen throughout.
  - Typical usage includes flight assembly.