

MAXIMIZING OVERALL
ELECTRICAL POWER SYSTEM
EFFICIENCY IN PICO/NANO-
SATELLITES WITH INNOVATIVE
PLUG-AND-PLAY BATTERY
CHARGING SYSTEM

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Contents

- Power Point Tracking
- The CubeSat Environment
- Constant Current-Constant Voltage (CC-CV) Charging on Orbit
- The Power Management System
- Adaptive Current Charging



What are Power Point Trackers?

- Power Point Trackers moderate power drawn from the solar panels so they are at their Maximum Power Point (MPP).
- Maximum Power Point:
 - The point on the IV curve where the most power can be drawn from the solar panel.

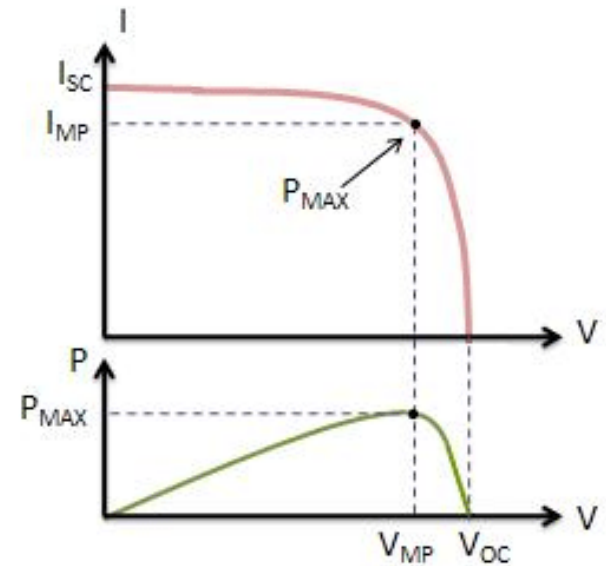


Fig 1: IV Curve of Solar Cell



- Thermal Environment
 - On orbit, the temperature can fluctuate from -40 to 40°C
- Variable Solar Power

Power Over 1 Orbit @ 500km, 51°, 1Hz tumble

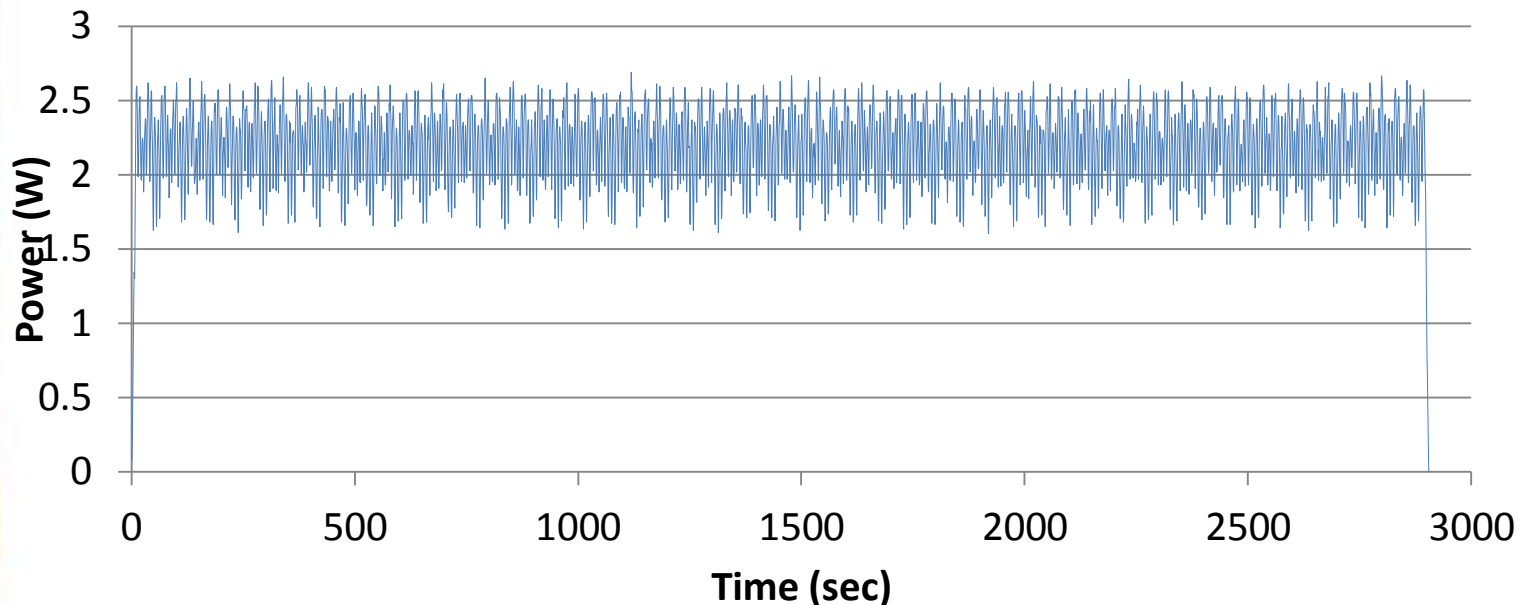


Fig 2: Available Power Over 1 Orbit (data collected using STK)



1. All power needed for constant current charging is available

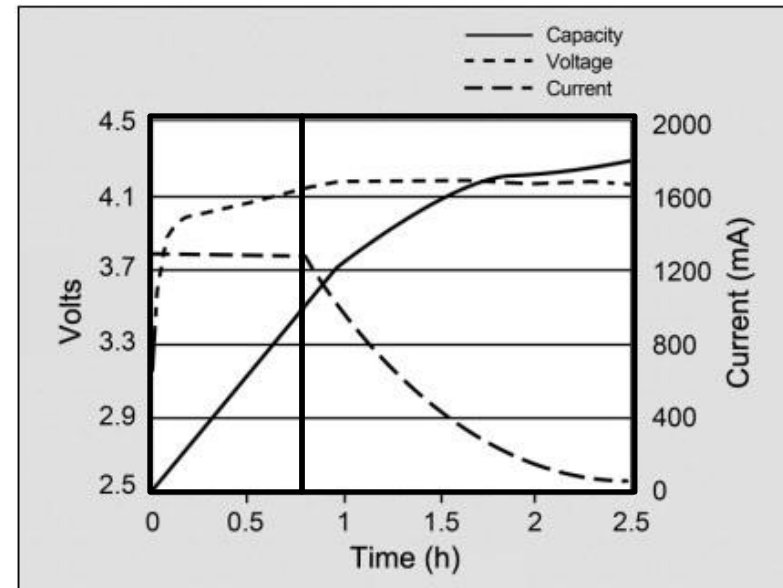


Fig 3: Capacity as a function of charge voltage on a lithium-ion battery

I. Buchmann, "Batteries in a Portable World: a handbook on rechargeable batteries for a non-engineer.", Cadex Electronics Inc. (2011).



Constant Current-Constant Voltage Charging on Orbit

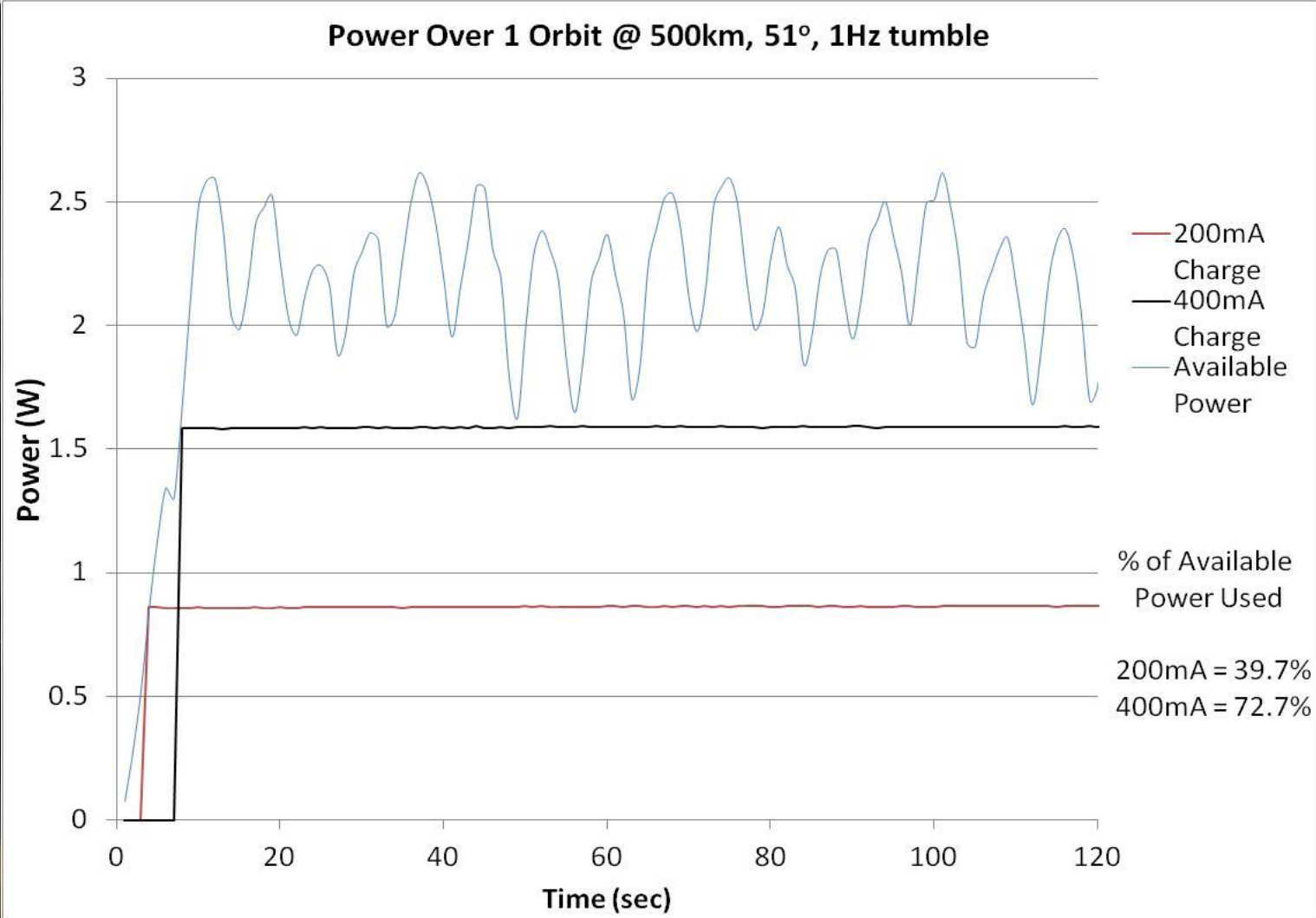


Fig 5: Available Power Over 2 Minutes



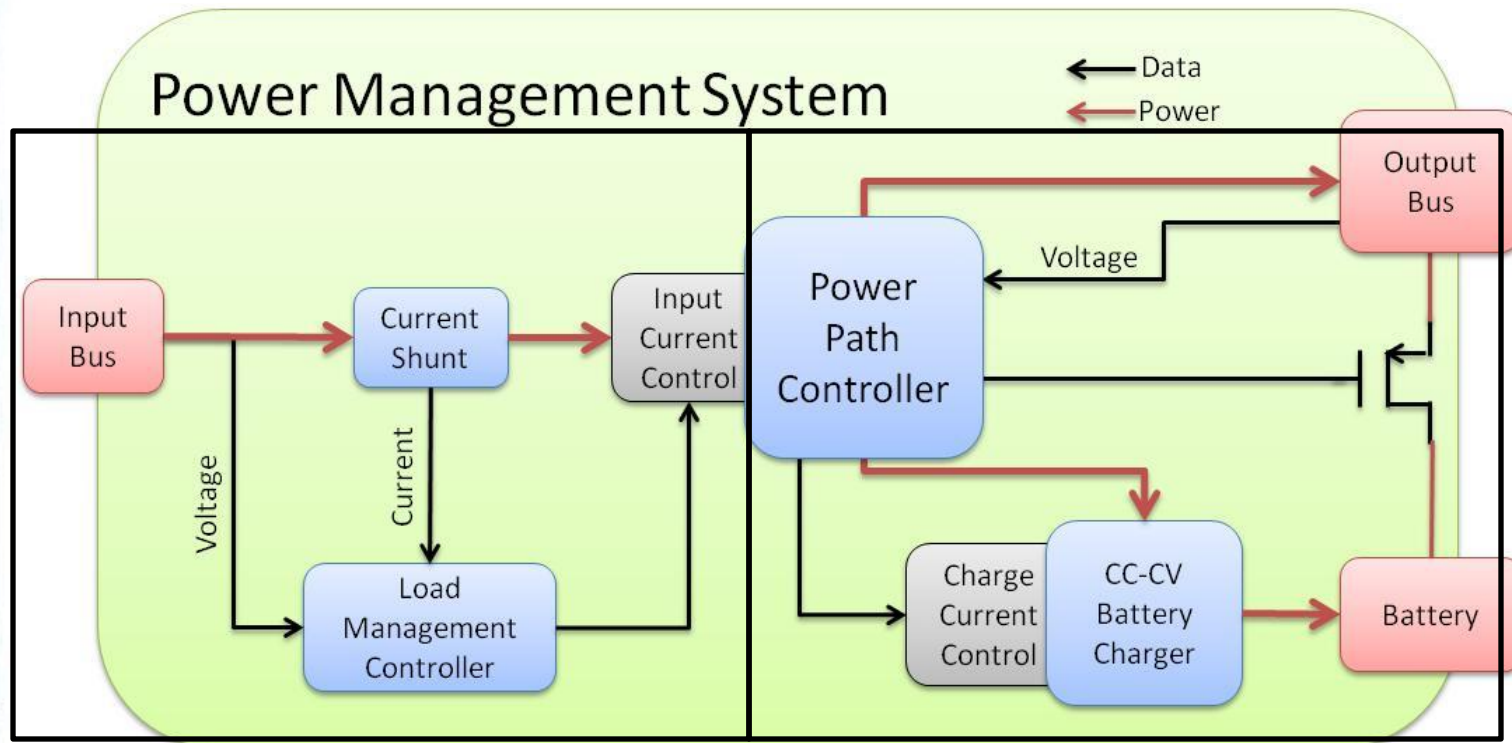


Fig 6: Simplest Form of the Power Management System

- The Power Management System is made up of 2 fundamental blocks
 - Load Matching System
 - Power Path Controller

- The Load Matching System
 - Reads the input voltage and current
 - Adjusts the amount of current that the power path controller can sink using dP/dt controller
- One load matching system can support multiple power path controllers

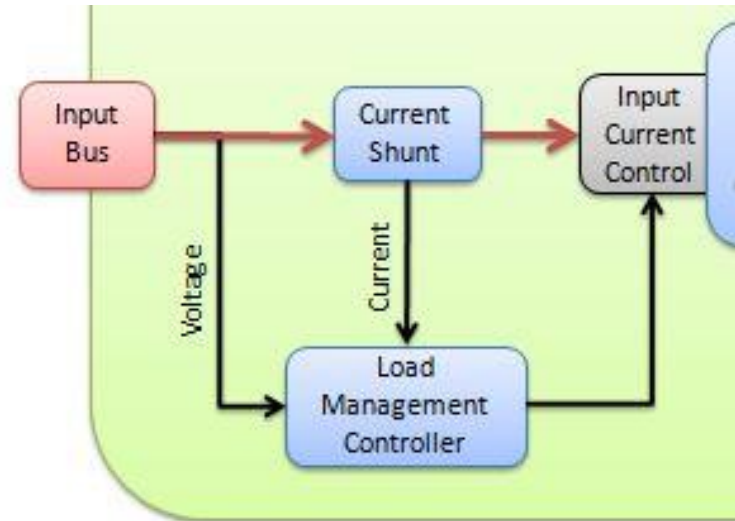


Fig 7: Load Matching System

- The Power Path Controller
 - Supplies needed current to the output bus, charging the battery with unused current
 - Provides power from the batteries when needed to maintain the output bus voltage

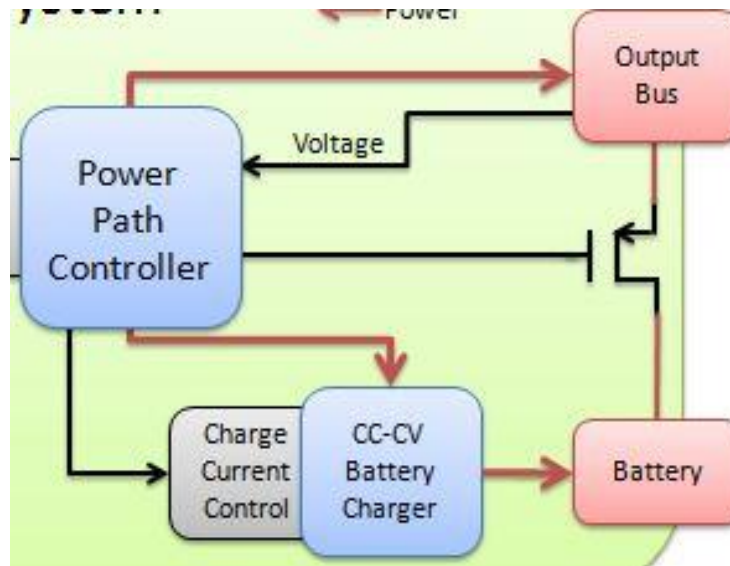


Fig 8: Power Path Controller

- Modified CC-CV charging profile
 - In “CC mode”, the Charger is allowed to charge the batteries up to a maximum safety current
 - The CV mode behaves identically to the normal CC-CV profile, unless power is needed at the output bus.

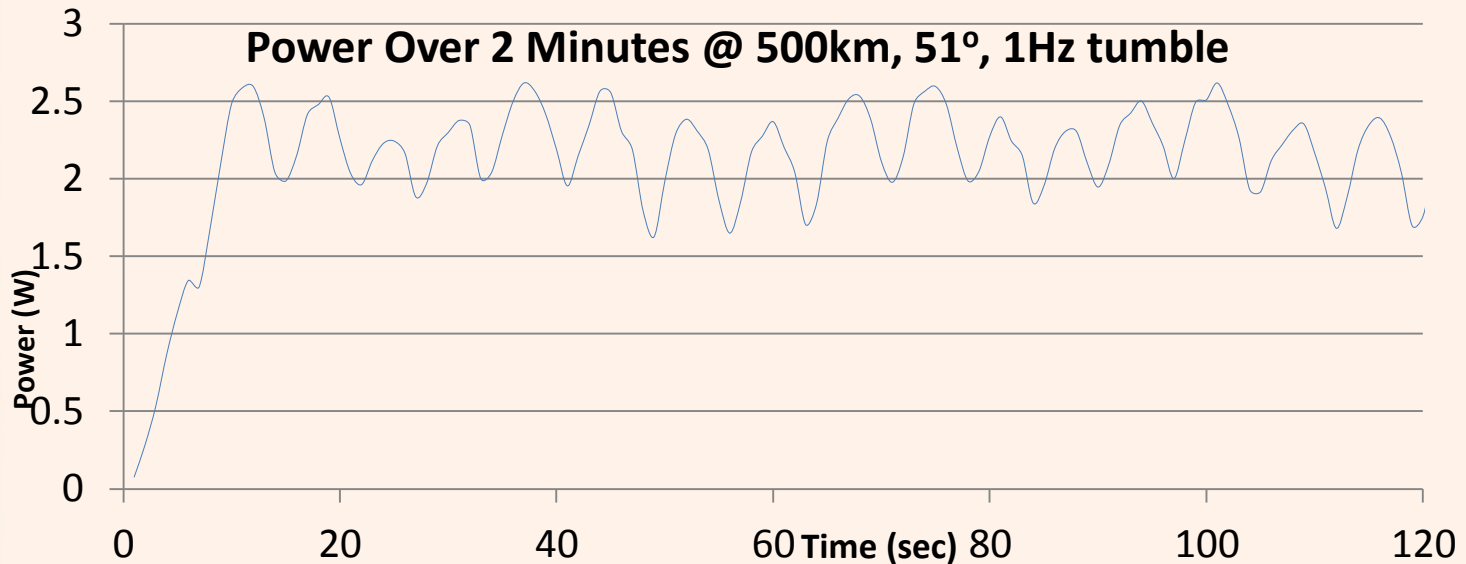


Fig 7: Available Power Over 2 Minutes



- Breaking the feedback loop
 - Available Current $>$ Maximum Safety Current
 - The power management system will not charge the batteries at a higher current than is safe.
 - Available power will go unused
 - For ChargerSat-1, this is a forbidden condition
 - In CV mode or if the battery is charged, the system is unable to sink current into the battery
 - The Power Management System will not attempt to charge a full battery
 - Available power will go unused



Conclusion

- +20% efficiency boost over CC-CV profiles
- Stand-alone System
- Automatically Optimizes Power Throughput
- TRL4
- Suitable, without modification, for use in any situation where input power <20W
 - Reduces the need for high fidelity models



- Office of VP of Research at University of Alabama in Huntsville
- Lockheed Martin
- Lufthansa
- Space Hardware Club at University of Alabama in Huntsville
- Alabama Space Grant

Any questions, comments, concerns?

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