Power Systems Design for Long Duration Ballooning

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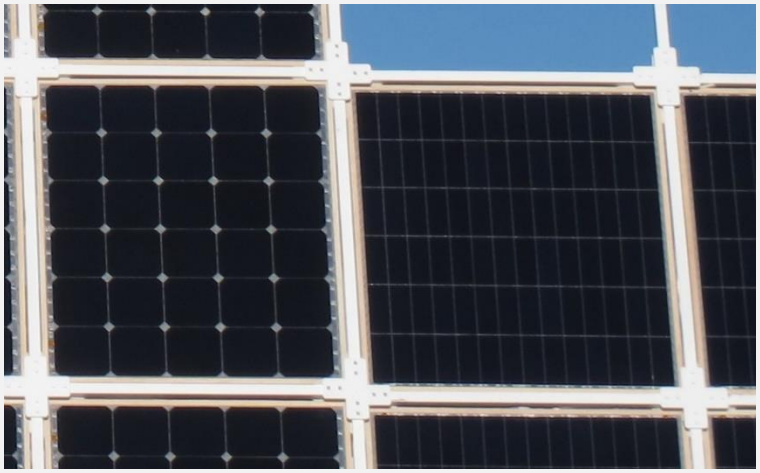
SunCat Solar PV Panels

- SunCat Solar, focuses on development and fabrication of "custom" low weight photovoltaic modules for a variety of applications including ballooning, solar cars and solar planes/UAVs.
- SunCat Solar has a 12+ year of history of providing custom solar modules directly to various Science groups and CSBF. As of today, our "standard" product for ballooning has comfortably survived up to 55 days at float (Super-TIGER 2012/2013).
- Typical panels are configured with SunPower cells
  - >23% efficiency, ~.6V/6A per cell
  - For 24V system: 80-90 cells in series for a 100W panel
  - Typical Panel size is 31”x27”



COTS MPPT Charge Controller

Project Initiative

- Develop a Maximum Power Point Tracker (MPPT) “buck type” charge controller as well as a replacement for current LDB charge controller.

Uses

- MIP flights where support systems to be kept to a minimum weight.
- Smaller PV arrays (80 cell vs. 100 cell).
- LDB replacement charge controller.

Features

- Lower voltage PV input required to produce system voltage (24V or 12V).
- Inexpensive to build.
- More reliable, more efficient, and better charge control than previous LDB controller.

Morningstar
SunSaver MPPT

COTS Boost MPPT Charge Controller

Orbital ATK

Project Initiative

- Develop a low cost voltage boosting power system.

Uses

- Smaller PV arrays (16.75” x 21.5”).
- LDB SIP power system.

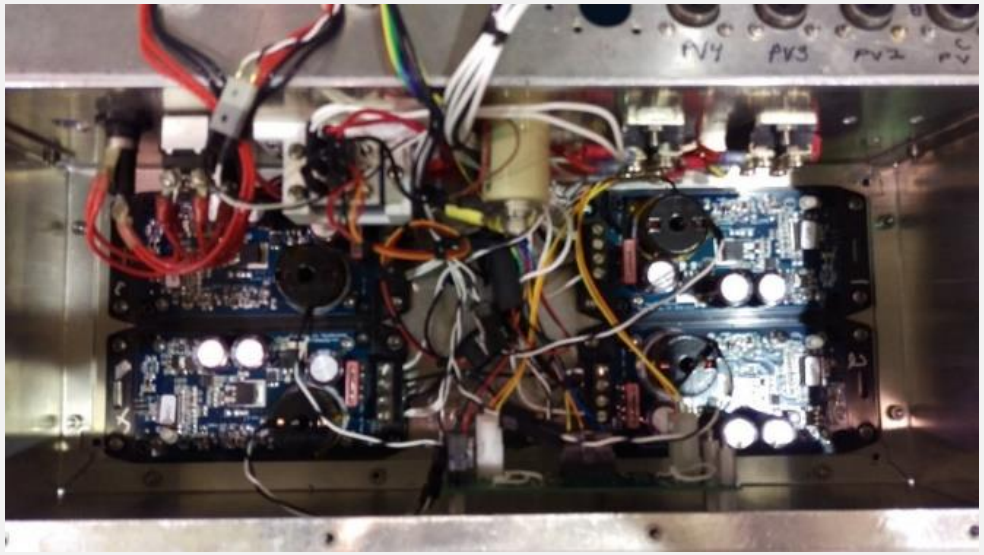
Features

- Reliable and efficient power system.
- Inexpensive to build.
- Much lower voltage PV input (5-14V) required to produce system voltage (12V or 24V).
- MPPT 8 Amp charge controller.

Testing Progress

- Incorporated into LDB charge controller box.
- Thermal-vacuum testing.
- Test flown on LDB test flights in Ft. Sumner.
  - Boost controller for each panel (1 panel per side = 4 total).
  - 12 SunPower cells in series – nominal ~40W each panel

Genasun
GV-Boost MPPT



COTS MPPT High Current CC

Project Initiative

- Develop a Maximum Power Point Tracker (MPPT) "buck type" charge controller primarily for large science power requirements (1kW).

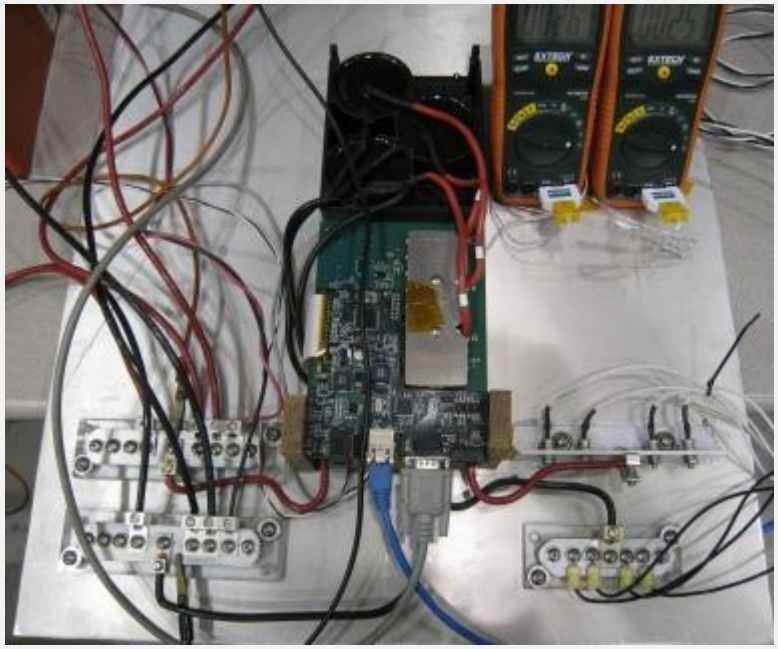
Uses

- Turn key solar power systems for science users.

Features

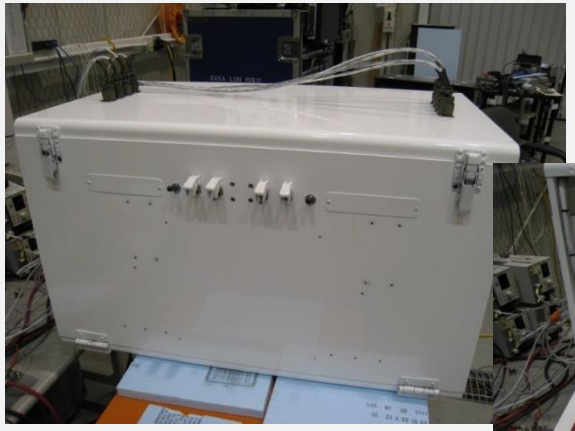
- Lower voltage PV input required to produce system voltage (24V).
- Same company as SunSaver MPPT (LDB controller).
- Inexpensive to build.
- More reliable, more efficient, and better charge control than legacy controllers.

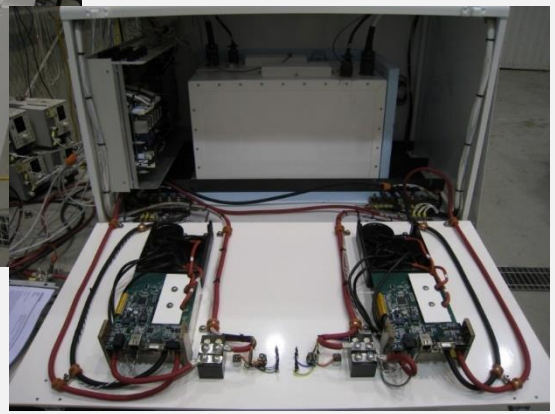
Morningstar
TriStar 60 MPPT

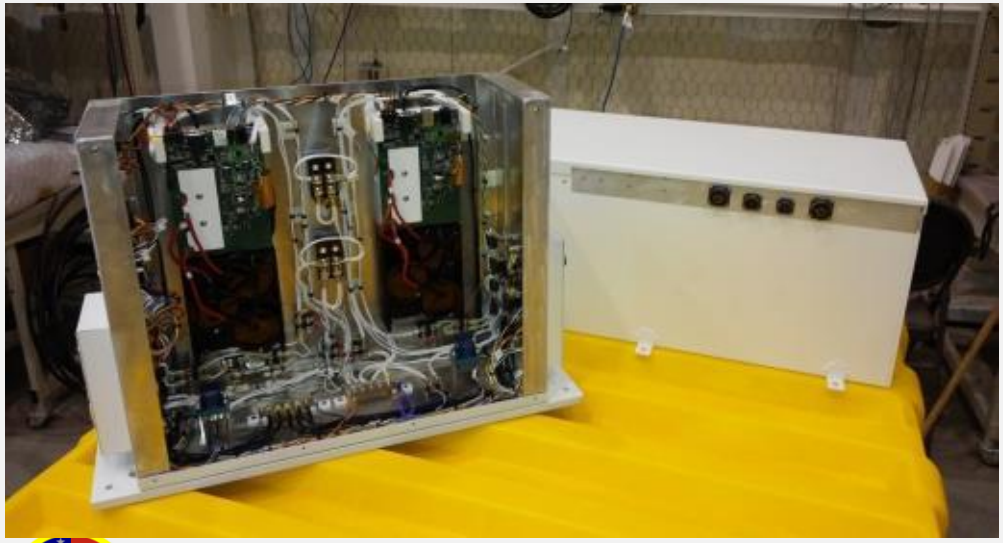


Science High Current Power System

- **Specifications**
  - Rated for 1000 watts
  - **For Wanaka COSI, 14-hour night runtime**
    - **408 Ah Battery pack (2 batt boxes)**
  - LDB Power out (backup power)
  - LOS Camera box power out
- **Components**
  - Morningstar TriStar 60 MPPT (2)
  - Odyssey PC1100 Pb-Acid batteries (12)
  - Standalone board and charge controller status board
- ***Features***
  - *Inexpensive*
  - *Incorporates high voltage lithium ion or lead-acid batteries*
  - *12 switchable 10 A circuits (24V) – BACCUS only*
- ***System Builds***
  - *700W system built for PoGo-Lite*
  - *1kW system being built for CREAM/BACCUS*
  - *600W system built for COSI/Boggs*







Valence Li Phosphate (LiFeMgPO4) Battery

- Valence Lithium Iron Phosphate Battery
  - 12 V Battery Modules, marketed as a lead-acid battery replacement.
  - Similar size as a lead-acid battery, twice the run-time and half the weight.
  - Cost effective solution to other Lithium-Ion based batteries.
  - Uses a BMS (battery management system – module), scalable with charge management.
  - Monitoring software and various remote interface modules available from Valence.
  - Lithium Rechargeable batteries require a core temperature above -10ºC for charging and discharging to -20ºC is acceptable.
  - With proper thermal management and charging profile for the battery modules, they are a direct replacement to existing Pb-Acid Batteries.

- Valence Battery Testing
  - Performed multiple discharge and charge cycles with existing LDB flight charging system (MS SS MPPT).
  - Conducted multiple vacuum tests ~ 90hr with the battery modules, BMS and contactor.

- Flight Testing
  - Ft. Sumner – Fall 2013 – LDB New Systems Test Flight (642NT). Operational Success – 9 Hours, 22 Minutes of flight time.
  - Ft. Sumner – Fall 2014 – LDB New Systems Test Flight (651NT). Operational Success – 6 Hours, 38 Minutes of flight time.
  - Antarctica 2015 – SPB/COSI (659NT). Operational Success – 43 Hours, 21 Minutes of flight time.
  - Wanaka 2016 – SPB/COSI (669NT). Flight Ready

Valence Li Phosphate (LiFeMgPO4) Battery