

2019 Scientific Ballooning Technologies Workshop

Power Systems Design for Long Duration Ballooning

May 14th, 2019

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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 12+ years of history 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 modules are configured with "A" grade SunPower cells.
 - >23% efficiency, $\sim .6V/6A$ per full cell (terrestrial).
 - For 24V system: typically 80-90 cells in series with "off the shelf" controllers.
 - Typical module size is 31"x27" and can yield ~ 100 watts at float if pointed.



COTS MPPT Charge Controller

Uses

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

Features

- Lower voltage PV input required to produce system voltage (24V or 12V).
- Inexpensive to build.
- Reliable and efficient.

History

- Flown on all LDB flights for many years with “0” failures



Morningstar
SunSaver MPPT



COTS Boost MPPT CHARGE CONTROLLER

Project Initiative

- Develop a low cost voltage boosting power system.

Uses

- Smaller PV arrays (16.75" x 21.5")
- Hand Launch System

Features

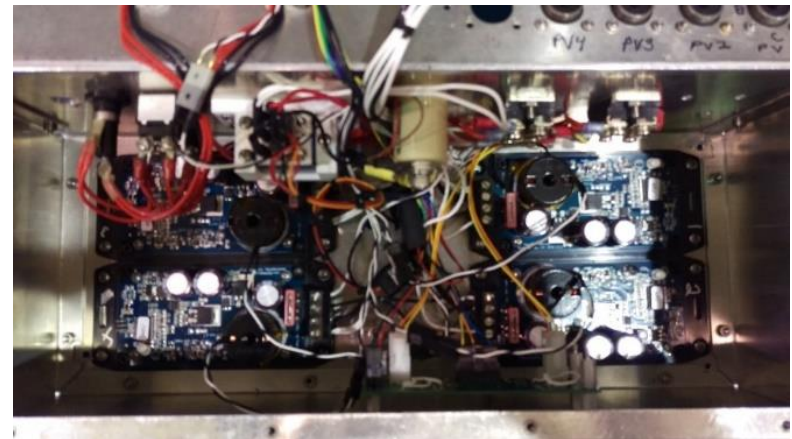
- Reliable and efficient power system.
- Inexpensive to build.
- Much lower voltage PV input (5-14V) required to produce system voltage (12V or 24V).
- MPPT 8 Amp charge controller.

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

- Solar power systems for science users.

Features

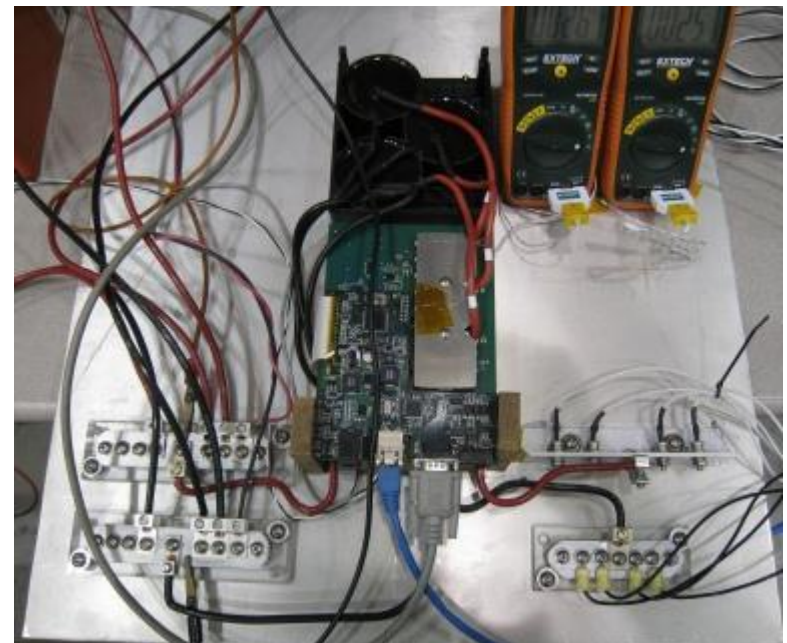
- Lower voltage PV input required to produce system voltage (24V).
- Same company as SunSaver MPPT (LDB controller).
- Inexpensive to build.
- Reliable and efficient.

History

- Flown on many LDB flights for science power systems.



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**

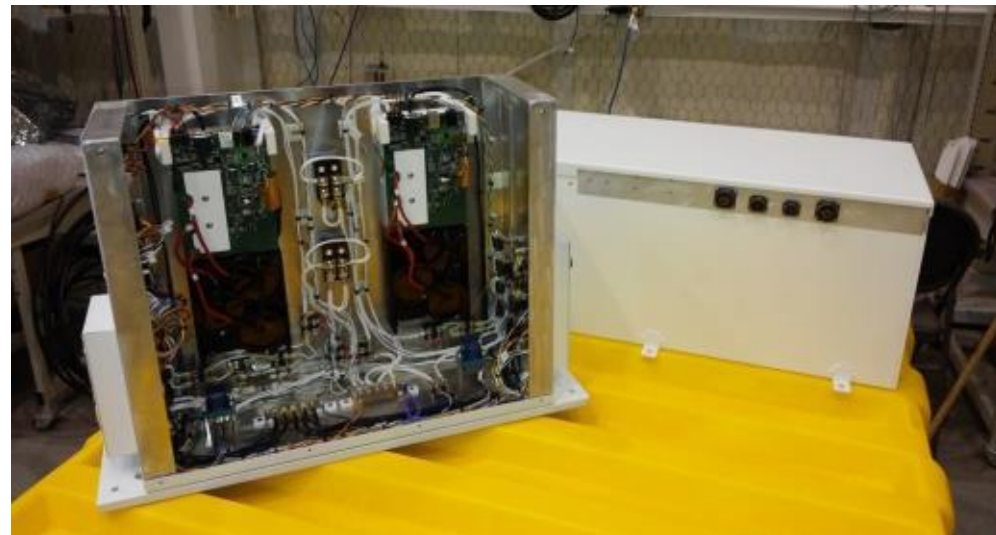
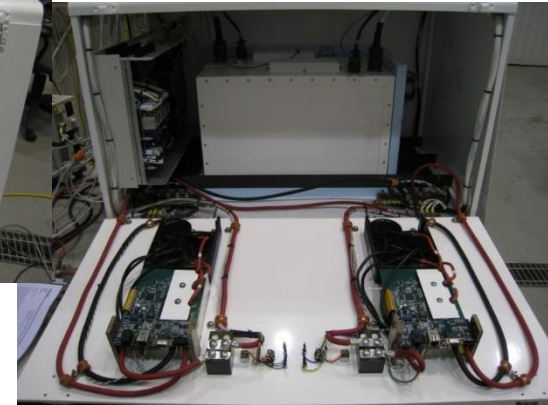
- Morningstar TriStar 60 MPPT (2)
- Odyssey PC1100 Pb-Acid batteries (24)
- Standalone board and charge controller status board

- **Features**

- Inexpensive
- Incorporates high voltage lithium ion or lead-acid batteries
- 12 switchable 10 A circuits (24V) – BACCUS only

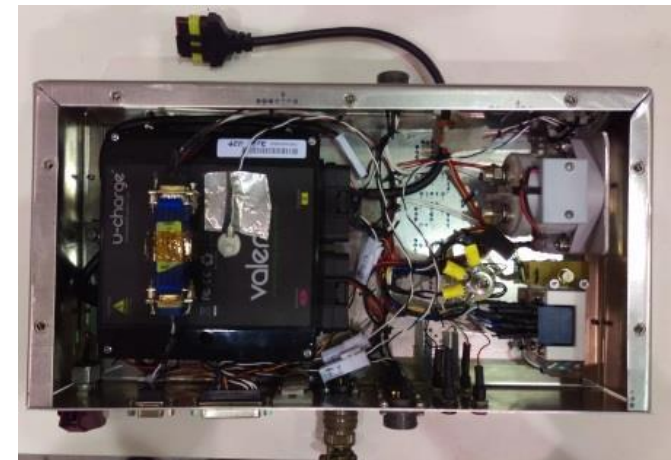
- **System Builds**

- 700W system built for PoGo-Lite
- 1kW fully redundant system built for BACCUS
- 600W system built for COSI/Boggs



Valence Li Phosphate (LiFeMgPO₄) Battery

- 12 V Battery Modules, marketed as a lead-acid battery replacement.
- Similar size as a lead-acid battery but approximately twice the energy density.
- 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 -10°C for charging and discharging to -20°C is acceptable.
- With proper thermal management and charging profile for the battery modules, they are a direct replacement to existing Pb-Acid Batteries.



Valence Li Phosphate (LiFeMgPO4) 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.
- CSBF has flown dual 40AH (14lb each) on all flights prior to FLT 679NT
- CSBF flew 110AH (35lb each) on FLT 679NT
- Flight Testing
 - Ft. Sumner 2013 – LDB Test Flight (642NT). Operational Success – 9 Hours, 22 Minutes of flight time.
 - Ft. Sumner 2014 – LDB 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). Operational Success – 46 Days, 20 Hours, 19 Minutes of flight time.
- Operational Usage/History
 - Wanaka 2017 – SPB/EUSO (679NT). Operational Success – 12 Days, 4 Hours, 34 Minutes of flight time.
 - Antarctica 2019 – X-Calibur/WASP (695N). Operational Success – 3 Days, 4 Hours, 19 Minutes of flight time.



U-Charge® XP Modules with External BMS

	Product	Voltage	Capacity	Weight	Dimensions	BCI Group Number	Max. Cont. Current	Charge Voltage	Energy
	U1-12XP	12V	40Ah	6.5 kg/ 14.3 lbs	7.76" x 5.12" x 7.17" 197mm x 131mm x 182mm	U1R	80A	14.6V	512 Wh
	U24-12XP	12V	110Ah	15.8 kg/ 34.8 lbs	10.2" x 6.77" x 8.86" 260mm x 172mm x 225 mm	Group 24	150A	14.6V	1408 Wh
	U27-12XP	12V	138Ah	19.5 kg/ 42.9 lbs	12.0" x 6.77" x 8.86" 306mm x 172mm x 225 mm	Group 27	150A	14.6V	1766 Wh
	UEV-18XP	18V	69Ah	14.9 kg/ 32.8 lbs	10.6" x 5.83" x 9.65" 269mm x 148mm x 245mm	-	120A	21.9V	1325 Wh
	U27-24XP	24V	69Ah	18.6 kg/ 40.9 lbs	12.0" x 6.77" x 8.86" 306mm x 172mm x 225 mm	Group 27	140A	29.2V	1766 Wh
	U27-36XP	36V	46Ah	19.6 kg/ 43.1 lbs	12.0" x 6.77" x 8.86" 306mm x 172mm x 225 mm	Group 27	90A	43.8V	1766 Wh

SAFT Xcelion 6T-E

- Possible future alternative to Valence, and/or redundant supplier of rechargeable lithium batteries
- Higher power density, built in battery management and heaters (fewer electrical components compared to Valence)
- Can be charged at lower temperatures (-40C vs. -10C for Valence)
 - Temperatures below -32C require use of built in heater
- NDA must be in place with SAFT for technical data
- Engineering unit on order for CSBF evaluation – should be at CSBF by mid May
- Higher cost vs similar Valence system
- Manufacturer testing and qualification much more comprehensive than Valence (SAFT Military and Space division product)
- Previously selected/evaluated (outside of CSBF) by GHAPS payload team, selected over Valence
- GUSTO (Pietro) considering using 6T for science power system



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