

TEST Group custom battery supply for the *LI-COR* 6400 Portable Photosynthesis System

Andrew McMahon* & Alistair Rogers

Terrestrial Ecosystem Science & Technology Group, Environmental & Climate Science Division,
Brookhaven National Laboratory, NY 11973-5000

www.bnl.gov/TEST

*technical point of contact amcmahon@bnl.gov



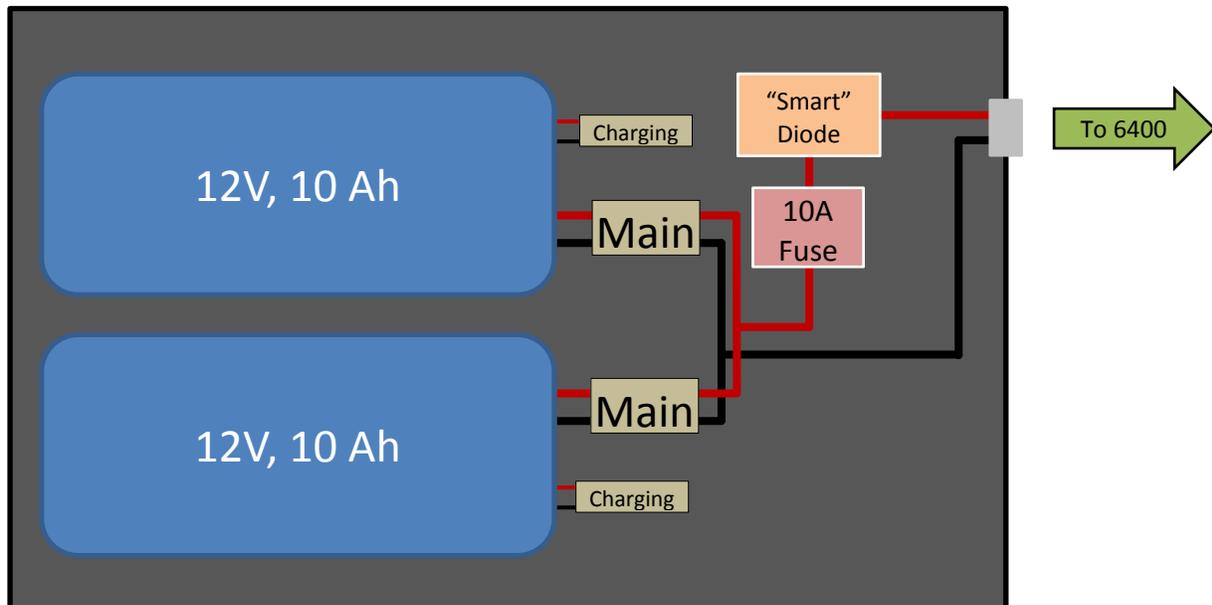
We designed and built a light weight (<4.5 kg), weatherproof, portable, battery supply (McMahon battery) for the *LI-COR* 6400 Portable Photosynthesis System that is compatible with air travel and shipping and enables the use of the 6400 for c.7h (3A) in hostile field conditions. New stock 6400 batteries can only provide about 2h of power (3A) and recharge at a rate that is much slower than they are depleted requiring

multiple pairs of batteries for extended measurements. Each McMahon battery pack consists of 20 D Size 1.2V NiMH cells contained in a weatherproof box which is connected to the 6400 through either a short (0.5m) or long (2m) cable allowing flexibility in placement of the battery pack when required. The short cables should be used when possible to minimize voltage drop. In our Arctic and tropical field trials a single McMahon battery pack was able to power a 6400 being used to measure light saturated CO₂ response curves (close to ambient temperature) for over 8h. It is possible to run for longer using two McMahon batteries. McMahon batteries, just like the *LI-COR* stock batteries, need to be changed when they cannot supply the 6400 with more than 10.5V and ideally more than 10.9V (beeps of death). McMahon batteries are charged using a four channel universal battery charger which takes around 4h to fully charge a battery pack that is removed from the 6400 before the beeps of death. Estimated total costs for a charger and associated cables (\$265) and two battery packs (\$245 each) is just under \$800. Here we provide a full parts list and instructions on how to build and use the McMahon battery packs.



Overview

- 12V NiMH Batteries (10x 1.2V cells)
- Normal operating range: 10V to 14.5V
- Two 10 Ah batteries per Pelican case, connected in parallel (giving 12V, 20 Ah per box)
- Each box has 10 A fast blow fuse and a “smart” diode to prevent large current surges when hot-swapping boxes



Construction

The battery boxes are Pelican 1150 cases. The only penetration that needs to be made is for the Conxall Mini connector for the power connection to LI-CORs. The foam insert that comes with the 1150 can be cut out to accommodate the two battery packs side by side with a small margin around the sides for protection. The packs sit towards one side of the box to leave space for the other components and wiring.



For the internal wiring, two Anderson power connectors are joined in two Y-connections (one for each pole). The ground connection goes directly to the power outlet while the positive goes first to the fuse holder and then to the diode. The “smart” diodes are a surface mount component, so to make connecting relatively heavy wire to them easier, they were first attached to a small breakout board. The



connection pads on the breakout board are too small to actually insert the wires used, however the wires can easily be soldered across the top and bottom terminals with the board in place for support. The entire board/chip assembly can then be wrapped in heat shrink to protect the connections, with only the two leads coming out. As with the battery packs, the Pelican foam can be cut out to hold the diode and fuse holder in place, however, as much foam as possible should be left on the connector side of the batteries to provide support.

On the external side, the Conxall connectors with longer rubber grommets were used to provide bend protection and better sealing. An additional layer of heat shrink was added over the grommet (but under the screw on back cap) and extending a couple of inches down the wire to further reinforce the connection. When using a length of wire between the battery packs and instrument of greater than a foot or so, it is important to use a heavy gauge wire (16 AWG or larger) to prevent significant voltage drops (and hence, shorter run times).



Charger Configuration

A four channel, universal battery is used to charge up to two boxes (four batteries at once). The charger must be appropriately configured to match the battery type and charging parameters to function correctly and safely. The table below shows the configuration parameters loaded for the “Slow” and “Fast” saved programs.

Parameter	Slow Charge (Program 0)	Fast Charge (Program 1)
Battery Type	NiMH	NiMH
Charge Mode (Auto/Manual)	Auto	Auto
Current Limit	1.8 A	4 A
Battery Voltage	12V	12V
Capacity Cutoff	On, 10000 mAh	On, 10000 mAh
Safety Timer	On, 360 mins	On, 180 mins
Temperature Cutoff	On, 70°C	On, 70°C

Item	Description	Manufacturer	Part #	Distributor	Distributor Part #	Qty
Battery Box						<i>(per box)</i>
Box	9.44" x 7.8" x 4.29", Watertight	Pelican	1150	PelicanCasesForLess.com	1150	1
Batteries	12V, 10 Ah, NiMH, Mini & Standard Tamiya	AA Portable Power Corp.	RB-HD10R2T-MT	BatterySpace.com	2357	2
Battery Connectors	15 Amp Permanently Bonded Red/Black Anderson Powerpoles (sold in sets of 25)	Anderson		Powerwerx	WP15-25	4
Fuse Holder	Inline ATO/ATC, 16 AWG Wire	Parts Express	070-670	Parts Express	070-670	1
Fuses	10A ATO	Littlefuse	ATO10	Parts Express	071-360	1
Breakout Board	Breakout board for DPAK 3 + tab package	IC Breakout, LLC Texas	ICB00180	IC Breakout, LLC	ICB00180	1
OR-ing Diode	Smart Bypass Diode	Instruments	SM74611KTTR	Mouser	595-SM74611KTTR	1
External Connector	Standard Circular, Male (Plug), 2 Pin	Conxall	6282-2PG-522	Digikey	SC1892-ND	1
Bulkhead Connector	Standard Circular, Female (Socket), 2 Pin	Conxall	7282-2SG-300	Mouser	502-7282-2SG-300	1
Charging System						<i>(for 4 channels)</i>
Adaptor	Male tamiya to mini female tamiya	AA Portable Power Corp.	CN-Adaptor(F- M)MTM	BatterySpace.com	400	4
Battery Charger	X4 Plus AC/DC Multi-Charger	Hitec	44167	Tower Hobbies	LXBKAK	1
Temp Sensor	Temp Sensor for X4 Plus Charger	Hitec	44159	Tower Hobbies	LXAEGR	4
Charger Connector	Charge Lead Banana Plugs to Standard	Duratrax		Tower Hobbies	LXVJW0	4