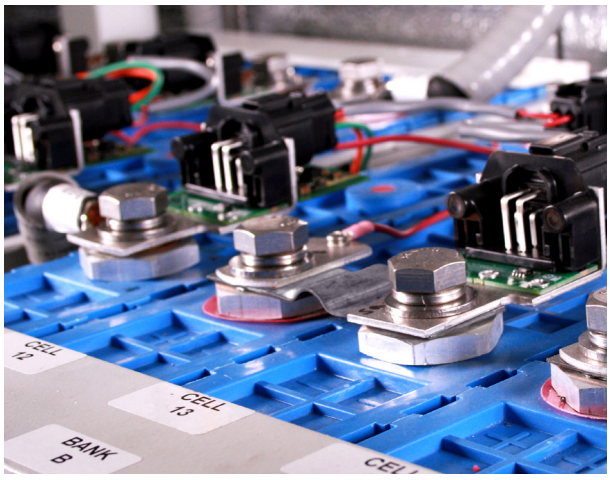
POLAR POWER INC.

Polar Li-Ion Battery Systems

Lithium Ion Iron Phosphate Batteries with BMS

Polar Power is now providing Lithium Ion Iron Phosphate Batteries with its Power Systems. Polar DC Generators can monitor charging and discharging of Lithium Ion Batteries on a cell by cell basis using an advanced Battery Management System (BMS).

Telecommunications
Military
Marine
Hybrid Power Systems
Hybrid Vehicles



Li-Ion Advantages over Lead Acid

- **Higher Cell Voltage**
Lithium Ion = 3.2 V vs. Lead Acid = 2.0 V
Fewer Cells enhances reliability

- **Considerably Lighter Weight**
Saving transportation cost especially if a helicopter is required

- **Much Smaller Footprint**
Uses only a fraction of the space required by Lead Acid.
Reduces enclosure and site land cost

- **Tolerates Higher Temperatures**
Saves energy and equipment costs by eliminating the air conditioning requirement

- **Faster Recharge Time With Higher Charging Efficiency**
Reduces solar array size and generator fuel consumption

- **Twice the Discharge Cycle Life**
Reducing Operating Costs

- **Deeper Discharge Tolerance in Cycling**
70% of the amp hour rating for Lithium Ion vs. 20% for Lead Acid

- **State of Health and State of Charge is Monitored**
For improved reliability

- **Longer Service Life**
Li-Ion 6-8 years vs. Lead Acid 2-4 years

Polar Power
249 E. Gardena Blvd
Carson, CA 90248 USA
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Fax: (310) 830 - 9825

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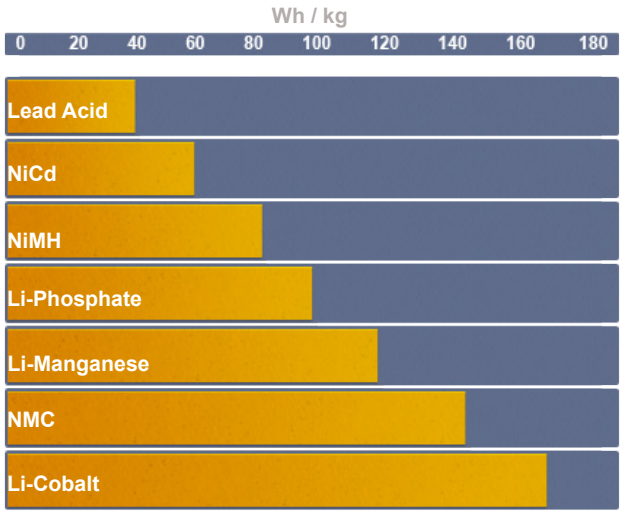
The Lithium Ion Iron Phosphate Battery, LiFePO4, LFP Safety

There are quite a few chemistries for the Lithium Ion battery on the market. A noteworthy one is the Cobalt Oxide (LiCoO2) chemistry which has gained notoriety in the media for exploding under certain circumstances. Lithium Cobalt Oxide Batteries (LCO) are susceptible to a process called thermal runaway. Once the compound has reached a certain temeperature (above 150C), it begins to self heat, creating pressures that allow the battery to explode. Additionally, Cobalt Oxide is highly toxic to the environment, irritating to the skin, harmful if swallowed and a carcinogen.

A chemistry that is far safer than the LCO battery is the Lithium Iron Phosphate (LiFePO4) or LFP. This battery is less prone to thermal runaway due to strong intra-molecular bonds, and the phosphate based cathode is not flammable. So if abused, the battery will not combust. Additionally, the battery is non-toxic. The iron phosphate can come in contact with skin, although prolonged exposure is not recommended, and the battery is not toxic to the environment.

There is a minor trade off for the increased thermal stability of the LFP battery; a decreaesed energy density. Higher energy densities allow longer runtimes with the battery. However, this disadvantage is offset over time as the batteries lose their capacity. The LCO battery degrardes quicker than the LFP. so the LFP will have higher energy density for a longer amount of time. Slower decay also leads to a greater cycle life for the LFP batteries.



The Lithium Ion Iron Phosphate Battery	
Nominal Amperage Capacity Available	72, 90, 180, 400, 700, 1000 (Ah)
Nominal Voltage	3.2 V - 3.3.V
Internal Impedance (1khz AC)	≤0.4 mΩ
Charging Cut-off Voltage	3.8 V
Generator starts charge cycle at Voltage	2.9 V - 3.1V
Discharge termination Voltage	2.75 V
Reccomend Charging-Discharging Current	0.3C Amp
15 Cells in Series comprise 48 V battery, Voltage Range	57 ~ 43.5
Life Cycle (0.32 Charging-Discharging 80% DOC)	80% = 3000 70% = 5000
Operating Thermal Ambient	Charging 0° ~ 60°C Discharging -20° ~ 60°C
Storage Thermal Ambient	-20° ~ 45°C
Service Life	6 to 8 years
Shell Material	Plastic, stainless steel (72Ah only)

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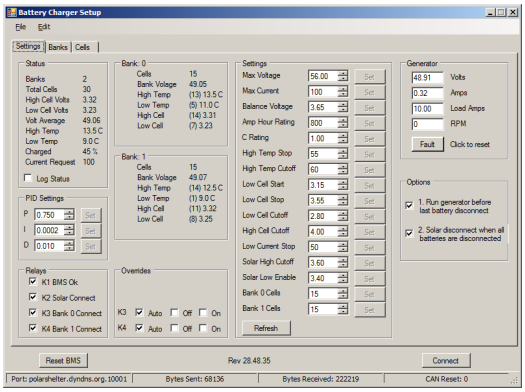
Battery BMS

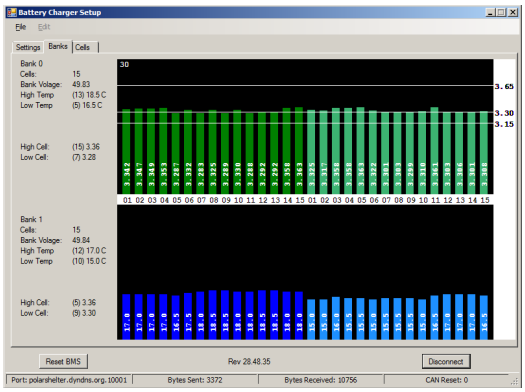
Polar's Supra Control System incorporates a CAN bus communications module that provides communication and control between the Lithium Ion battery and the DC generator set.

With the Polar Battery Management System (BMS) installed on the Lithium Ion Battery bank, the Generator can monitor and charge the batteries based on the individual battery cell requirements. Each cell in each of the battery packs are continually monitored for voltage and each battery pack is monitored for temperature.

- Charging continues until one of the following two conditions are met:
  - The Charging current drops below a preset value
  - The highest cell reaches a high cell cutoff voltage 3.78 Vdc (adjustable) and the lowest cell reaches 3.60 Vdc (adjustable).
- During discharge, a single cell reaching 2.9 Vdc (adjustable) will determine when to start the generator's charging cycle.
- There is a pilot relay available that can disconnect the load from the battery should the lowest cell reach 2.75 Vdc (adjustable).
- A second pilot relay that can disconnect other charging sources (i.e. Photovoltaic) when the highest cell voltage reaches 3.9 Vdc. The charging source will automatically reconnect when the highest cell voltage drops below 3.6 Vdc.
- High voltage alarm relay will trigger at the highest cell voltage of 4.2 Vdc.
- In high-temperature conditions the charge rate is reduced. If temperatures continue to rise to the point of over temperature, the charging cycle is suspeneded and the generator will stop.

The BMS system is adjustable in the field and is presently not able to be adjusted remotely. Only the battery bank voltage can be monitored remotely.





Battery Specifications

BATTERY AMPS	WEIGHT KG (LBS)	LENGTH MM (INCHES)	WIDTH MM (INCHES)	HEIGHT MM (INCHES)	# CELLS IN PACK	NOMINAL VOLTAGE
72A	1.9 (4.2)	135 (5.3)	29 (1.2)	222 (8.8)	8	25.6
100A	31.8 (70)	553.7 (21.8)	177.8 (7)	254 (10)	8	25.6
180A	47.7 (105)	447.7 (17.6)	308 (12.1)	301.6 (11.9)	5	16
400A	86.4 (190)	546 (21.5)	356 (14)	338 (13.3)	5	16
700A	120.5 (265)	719 (28.3)	366 (14.4)	353 (13.9)	5	16
1000A	138.7 (307)	645 (25.4)	424 (16.7)	353 (13.9)	3	9.6

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