Lithium Iron Phosphate Batteries

An Ideal Technology for Ham Radio?

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A History of Battery Development

- 1791 – Luigi Galvani (“Animal Electricity” Frogs beware)
- 1800 – Alessandro Volta (Voltaic Cell)
- **1859** – Gaston Plante (Lead Acid Battery)
- **1899** – Waldmar Jungner (Nickel Cadmium)
- 1949 – Lew Urry (Alkaline-Manganese)
- **1970s** – Group (Sealed Lead Acid)
- **1990s** – Group (Nickel-metal-hydride)
- **1994** – Bellcore (Lithium-ion polymer)
- **1996** – U Texas (Lithium Iron Phosphate)
- 2002 – MIT (Nanotechnology applied to LiFePO4)

Comparing Properties 1

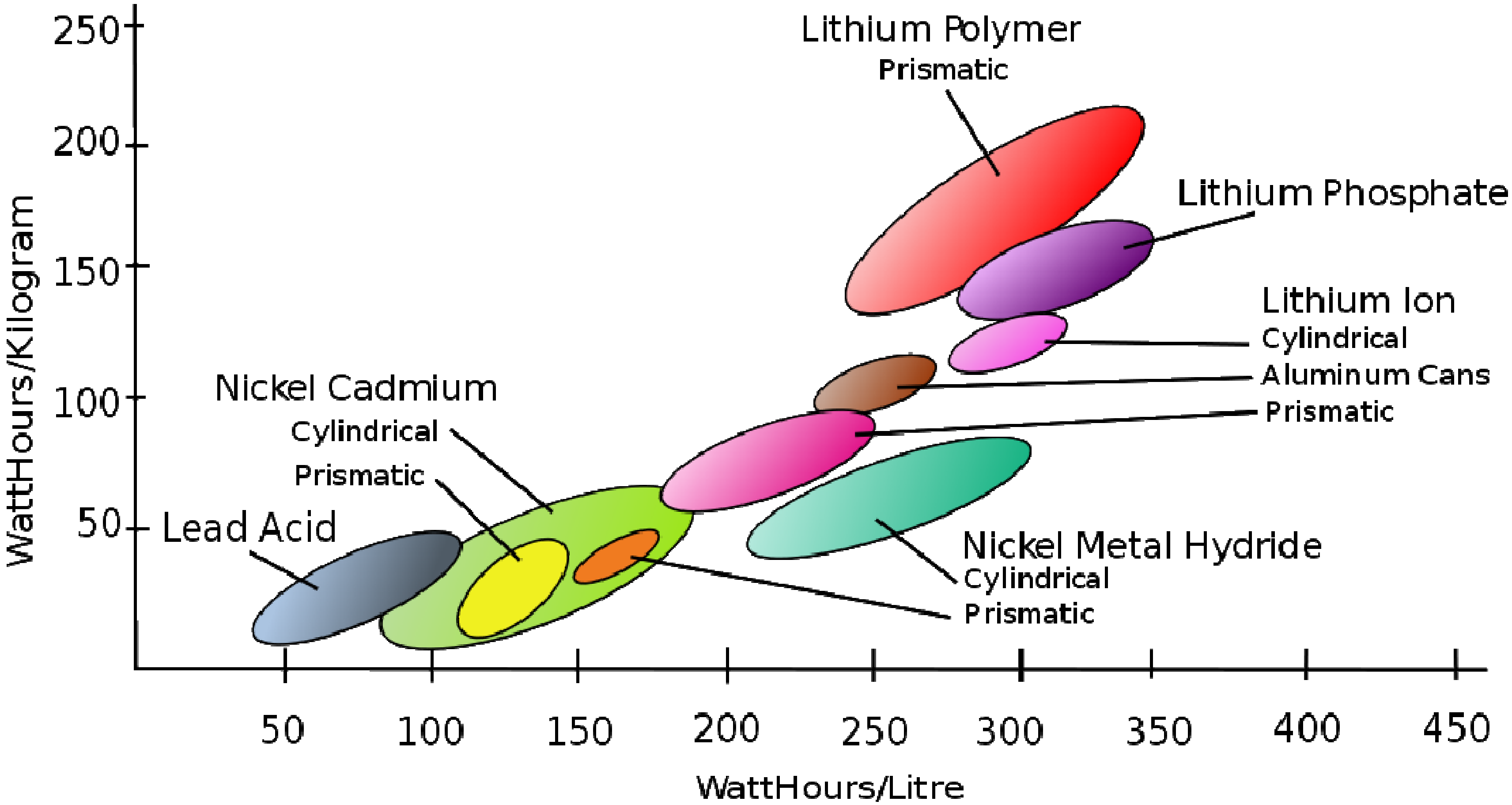
	Lead Acid	NiCad	NiMH	LiPo	LiFePO4
Cycle Life	300+	2000+	300+	1000+	3000+
Energy Density	25 WH/Kg	50 WH/Kg	75 WH/Kg	175 WH/Kg	150 WH/KG
Charge Efficiency	50%	70%	66%	99%	99%
Self-Discharge	20%/M	10%/M	30% & 2%	5%/M	3%/M
Nominal Voltage	2.1V	1.2V	1.2V	3.7V	3.3V
Initial Cost	Low	High	Medium	High	High
Life Cycle Cost	Medium	High	High	Low	Low

Comparing Properties 2

	Lead Acid	NiCad	NiMH	LiPo	LiFePO4
Toxic Materials	Yes	Yes	No	No	No
Explosion Risk	Yes	No	No	Yes	No
Flammable/Outgas	Yes	No	No	Yes	No
Transportation Risk	Yes	No	No	Yes	Yes*
Memory Effect	No	Yes	Less	No	No
Charger Complexity	High	Very High	Very High	Medium	Medium
Storage Complexity	High	Low	Very High	Low	Low

* Exemption being sought for LiFePO4. For now treated same as Li-Ion

Energy Density & Volume



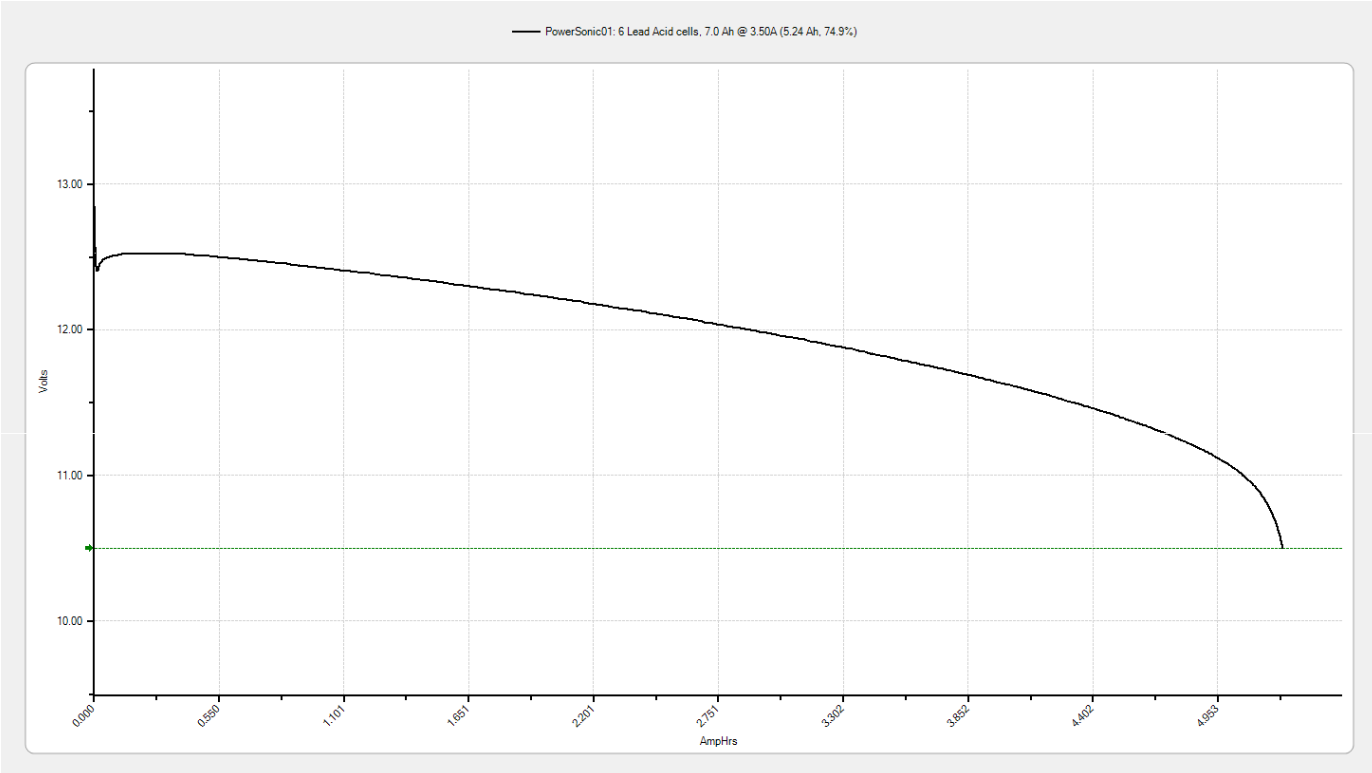
Comparing LiFePO4 and SLA

- 1/3 weight of a LA/SLA (20 lb vs 70 lb @ 60AH)
- 10x life of a SLA (2000 vs 200 cycles @ 100%)
  - LiFePO4 > 14K @ 30% depth of discharge vs SLA ~1K
  - LiFePO4 > 4K @ 50% depth of discharge vs SLA ~450
  - LiFePO4 > 2K @ 100% depth of discharge vs SLA ~200
- More usable power
  - SLA specified at C/20 rate vs LiFePO4 at C/1 rate (60%)
  - SLA limited to 50% for rated life

Comparing LiFePO4 and SLA

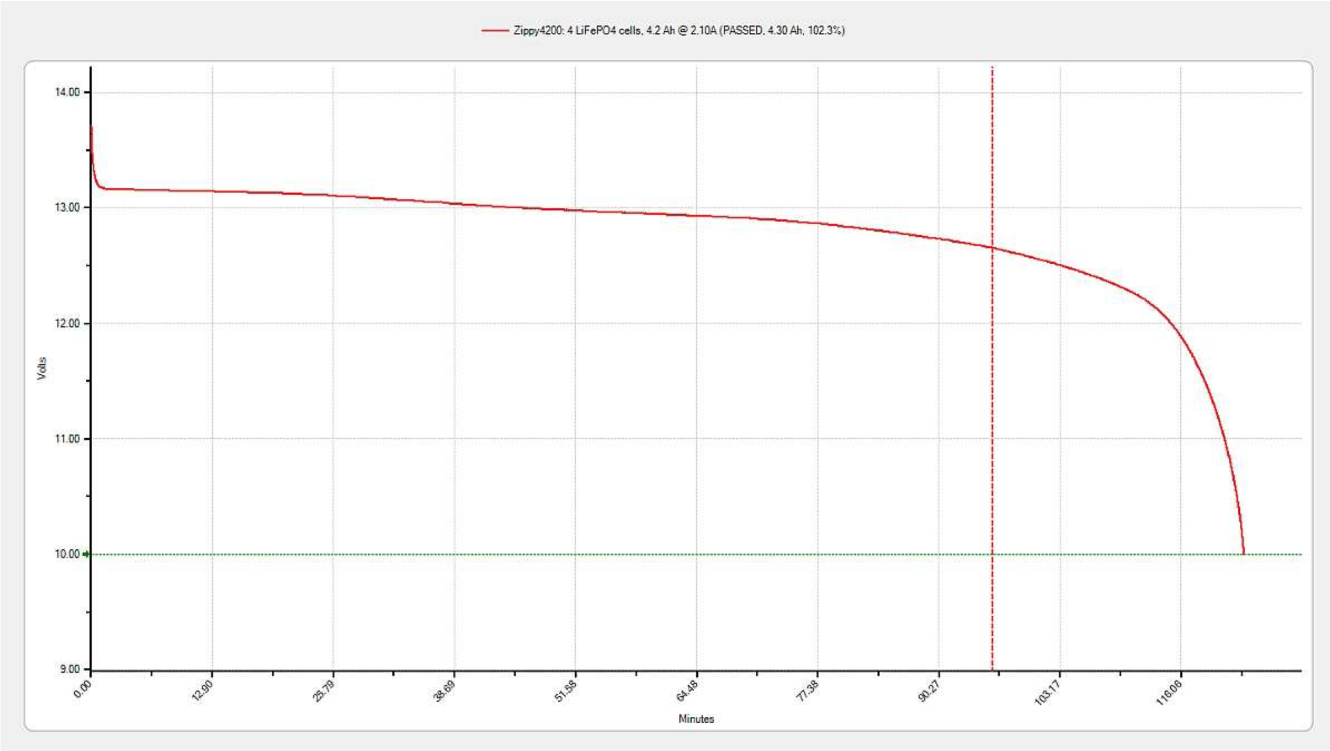
- Life cost about half
  - $400 vs >$1000 for 60 AH Usable Capacity
  - $80 vs >$100 for 7 AH Usable Capacity
- Higher voltage & flatter curve
- Low self-discharge (<3% LiFePO4 vs 20% SLA)
- Charge/Discharge efficient (99% vs 50%)
- No Hazmat, No out-gassing

7AH SLA Discharge Curve



Actual Capacity 5.25AH (New battery cycled 4 times)
Above 12.0 volts for only 50% of capacity (2.7AH)
Don’t discharge below 50% to meet life specifications!

4.2 AH LiFePO4 Discharge Curve



Actual capacity 4.3AH
Above 12.0 volts for 90% of capacity
Meets life specifications at 90-100% discharge

Temperature Impact on Capacity

(At C/1 Rate)

	-20ºC	-10ºC	0ºC	23ºC	55ºC
LiFePO4	50%	85%	98%	100%	92%
SLA	18%	30%	40%	60%	60%

NOTE: SLA capacity is 60% at room temperature because a higher C/1 discharge rate is being used. (Normal discharge rate is C/20. Ex: 3A for a 60AH battery). LiFePO4 is specified at C/1 rate. Ex: 60A for a 60AH battery.

Temperature Impact on Life

- Cycling at high discharge/charge rates at temperature extremes is not a good idea for most battery technologies.
- For SLA each $8^{o}C$ above $23^{o}C$ cuts life in half (life is pretty bad to begin with). At $55^{o}C$ expect SLA life of 40 cycles. A LiFePO4 battery will have a life of about 1000 cycles at $55^{o}C$.
- Low temperature cycling is worse for a LiFePO4 battery. At $-10^{o}C$, expect a life of about 500 cycles. The SLA life doesn't degrade at lower temperature. At $-20^{o}C$ both SLA and LiFePO4 cells have about the same cycle life (300 cycles).
- Unlike SLA, Charging/Discharging a LiFePO4 does not heat battery.

NOTE: "Life" is defined at 80% of initial capacity for a LiFePO4 and 60% for a SLA.

Drawbacks of LiFePO4

- Higher up front cost
- Electronics needed to maximize life & protect
- Can’t discharge below 2.0 v /cell
- Avoid cycling below 0^oC for maximum life
- Ground shipping only (no air)

Charging LiFePO4

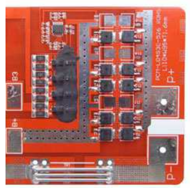
- Current limited (<2C) Constant Voltage (14.6) if battery has PCM, balancing charger otherwise. (MUCH less complicated than SLA: Bulk Charge/Absorption/float/desulfinating)
- No special concerns based on depth of discharge (Must slow charge SLA if <50%)
- IDEAL for solar charging due to charge/discharge efficiency of almost 100%

LiFePO4 Field Day GOTA System

- System comprised of:
  - 100 watt rigid panel (about 2.5 x 3.5 ft)
  - 60 AH LiFePO4 battery with PCM
  - MPPT 10 Amp Charge Controller
- Panel produced ~7.5 amps/hr in 8 hrs of full sun (60AH)
- Panel produced ~1.5 amps/hr in 6 hrs of shade (9AH)
- Battery made up peak demand and shade/dark draw
- GOTA use averaged ~3 amps/hr over 19 hours
- Surplus of 12AH generated during contest
- Could have made 36 AH more if panel moved
- Run Stations need 9.5AH x 24Hr = 230 AH

Cost of FD GOTA Power System ~ $650

- Four 60 AH Prismatic Cells $360
- PCM Charge/Discharge Controller $40
- MPPT 10 Amp Charge Controller $115
- 100 Watt rigid solar panel $135


Can you do a FD "Run" Station? (260 AH Battery)

- Run Station needs 9.5 Amps/Hour for 24 hours or 230 AH
- Two 130 AH LiFePO4 batteries in parallel would meet demand and cost $1700
- Weighs 40 pounds/battery (80 lbs total)
- Batteries would need to be solar charged prior to contest.
- Almost ZERO risk

Can you do a FD "Run" Station? (130 AH battery 300 W Panel)

- Need minimum of 95 AH for dark period
- Three 100 watt panels will produce 9 amps in heavy overcast = 126 Amp-hours (40% rated)
- Total power need is 228 Amp-Hours
- Battery (130 AH) plus 125 AH = 255 AH
- Battery cost \$650. Solar cost \$750 = \$1400
- Higher Risk if output lower or shaded too

Sources of LiFePO4 Batteries

- http://www.buddipole.com/portablepower.html (expensive but great company. Needs Balanced Charger. Smallest Solar Charge Controller)
- http://www.batteryspace.com (Competitive prices on LARGE Prismatic Cells, PCM boards, high output CV/CC chargers)
- http://www.bioennopower.com (Large choice of batteries/chargers)
- http://www.tenergy.com/Site/12-8V-LiFe-Battery-Packs (Good brand)
- http://www.k2battery.com/battery-packs-12v.html (Good brand)
- http://www.westmountainradio.com/product_info.php?products_id=cba4 (Battery Analyzer, Battery monitors, lots of PowerPole items)
- http://www.powerwerx.com (Power Monitors, PowerPole connectors, tools, adapters, accessories, bulk and custom cables)