Lithium-ion Batteries Technology Introduction

EVB Technology (HK) Limited

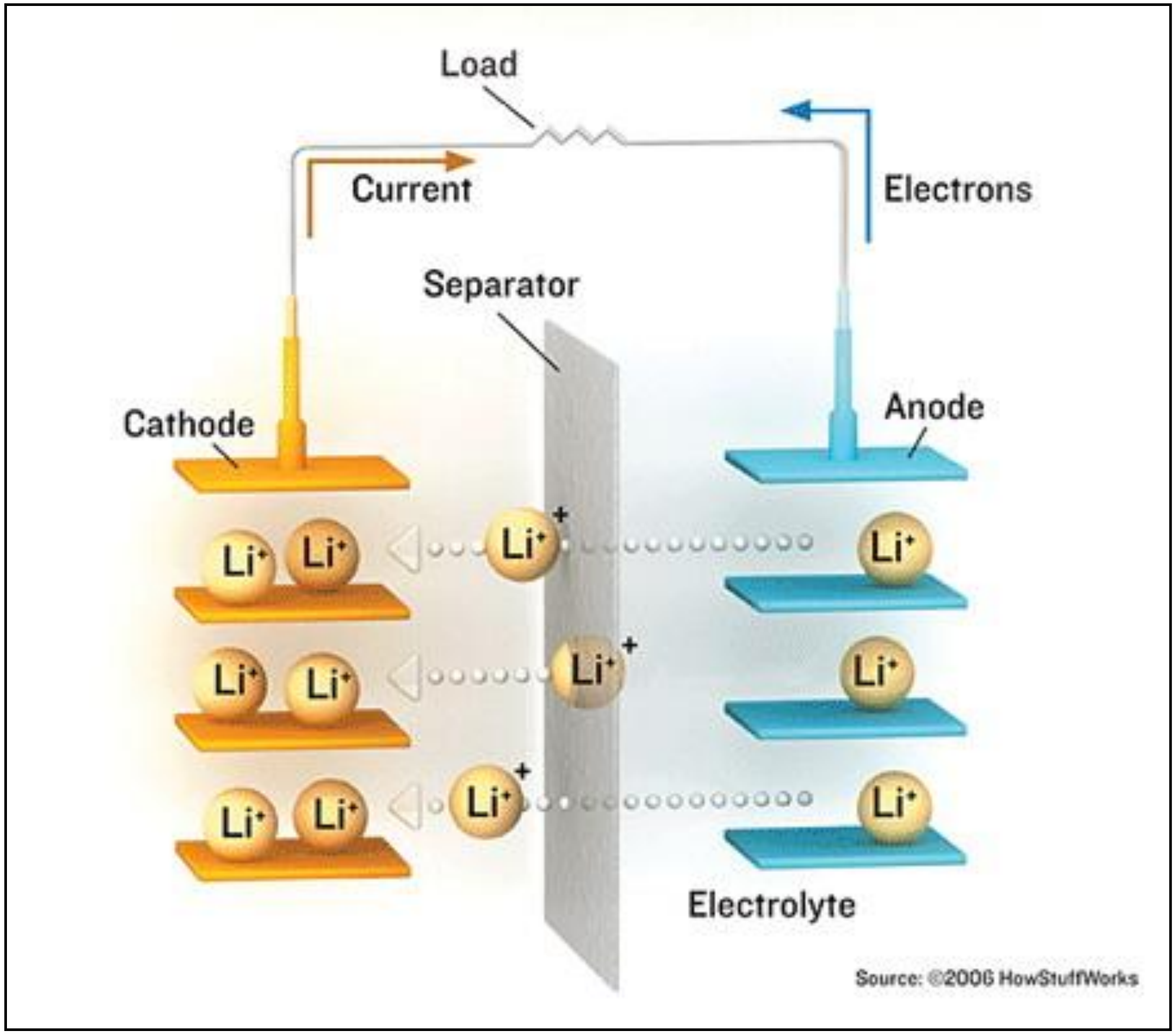
Lithium Ion Technology

- Lithium-ion batteries are common in portable consumer electronics because of their high energy-to-weight ratios, lack of memory effect, and slow self-discharge when not in use.
- In addition to consumer electronics, lithium-ion batteries are increasingly used in defense, automotive, and aerospace applications due to their high energy density.

Lithium Ion Technology

- A variety of positive electrode materials has been developed for satisfying number of application requirement.
- All the Li-ion cells operate by reversibly incorporating lithium in an intercalation process.

Lithium Ion Technology

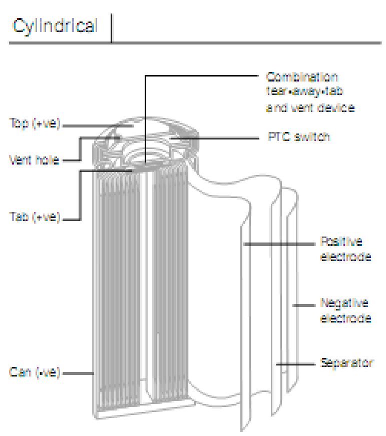


Characteristics of different Cathode Materials

	Li(NiMnCo)O2	LiMn2O4	LiFePO4
Voltage (V)	3.6	3.8	3.2
Energy density (Wh/kg)	150	140	115
Volumetric energy density (Wh/L)	330	300	240
Cycle life	1000	1000	2000
Safety	Good	Good	Very good
High-Temp stability	45^{o}C	40^{o}C	60^{o}C
High-rate capability	Good	Good	Moderate
Unit cell cost (raw material + manufacturing cost)	Moderate	Low	Moderate to low
Battery management system	1 PT/cell		

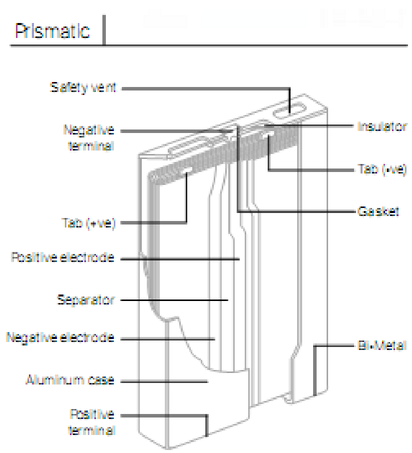
Prismatic vs Cylindrical

- Cylindrical: Robust design, structurally strong for handling, shock and vibration. However, as their size gets larger, their external surface area to volume decreases and thus the heat transfer abilities goes down. The temperature gradient from inside to outside goes up.



Prismatic vs Cylindrical

- Prismatic: Higher heat transfer surface area to volume and can be thermally managed easier. Also, prismatic cells could be packaged with better volume efficiency than cylindrical cells.



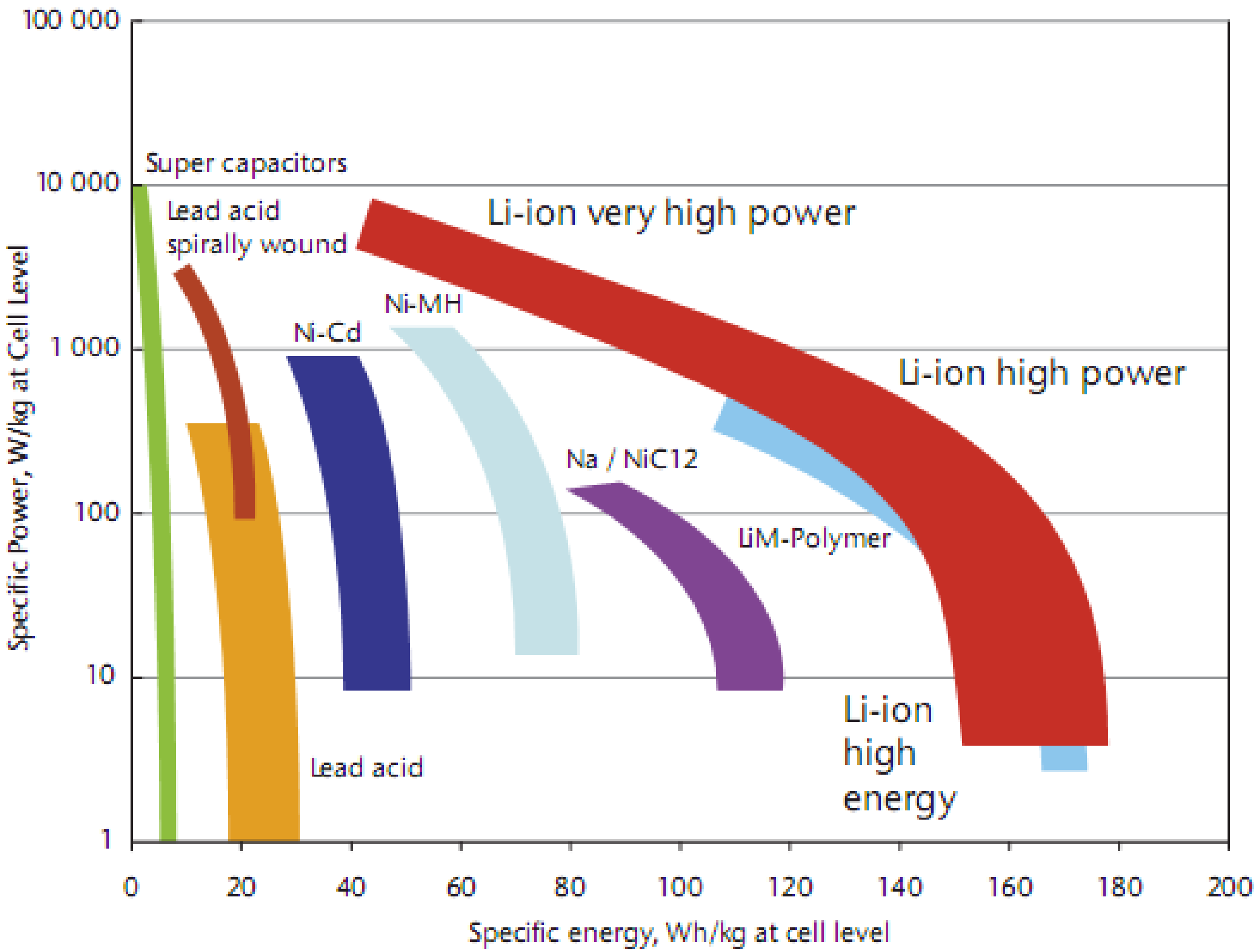
EVB Prismatic Product Table

Model	GP18EVLF	GP30EVLF	GP45EVLF
Capacity (min)	16Ah	30Ah	42Ah
Voltage	3.2V	3.2V	3.2V
Specific power at 5C	396W/kg	427W/kg	459W/kg
Specific energy at 0.5C	78Wh/kg	87Wh/kg	96Wh/kg
Dimensions	181(H)x95(W)x18(Th) mm^3	176(H)x95(W)x30(Th) mm^3	226(H)x95(W)x30(Th) mm^3
Weight	0.66kg	1.1kg	1.4kg
Cycle life	>1500 cycles	>1500 cycles	>1500 cycles

GP18650 Table

Description	LiCoO2	Li(NMC)O2	LiFePO4
Model	GP1865L220	GP1865T220	GP1865A120
Cell Capacity (mAh)	2200	2200	1200
Nominal Voltage	3.70	3.65	3.20
Max Charging Voltage	4.20	4.20	3.65
Volumetric Energy Density (Wh/Ltr)	492	492	232
Gravimetric Energy Density (Wh/Kg)	185	185	100
Cycle Life	500	500	1000
Max. Discharging Current (A)	2.2	2.2	10

Specific Energy and Specific Power of different battery types



Source: Johnson Control – SAFT 2005 and 2007.

Pack Configuration

Small Capacity Cell vs Large Capacity Cell

- Small Capacity Cell:

  Advantages: lower cell cost (commodity market), improved safety (faster heat rejection), and higher quality production

  Disadvantages: many interconnects, much higher integration and assembly cost, lower weight and volume efficiency, lower reliability as well as the costly electrical management.

Small Capacity Cell vs Large Capacity Cell

- Large Capacity Cell:

  Advantages: lower assembly cost, higher weight and volume efficiency, better reliability (lower number of components)

  Disadvantages: higher cell cost, tougher thermal management

Charging Methodology

- Stage 1 : Apply charging current limit until the voltage limit per cell is reached.
- Stage 2 : Apply maximum voltage per cell limit until the current declines below 1-3% of rated charge current.
- Stage 3 : Balancing

Discharging Methodology

- Different discharge modes

  - Constant Current: A battery discharge regime whereby the current drawn during the discharge remains constant

  - Constant Power: the amount of current will increase as the battery discharges electricity in order to maintain constant power

  - Constant Resistance: A battery discharge regime whereby the resistance of the equipment load remains constant throughout discharge

Balancing Technology

- Balancing can be **active** or **passive**
- In passive balancing, energy is drawn from the most charged cell and is wasted it as heat, usually through resistors
- In active balancing, energy is drawn from the most charged cell and transferred to the least charged cells, usually through DC-DC converters
- Active balancing is usually more efficient than passive balancing

BMS

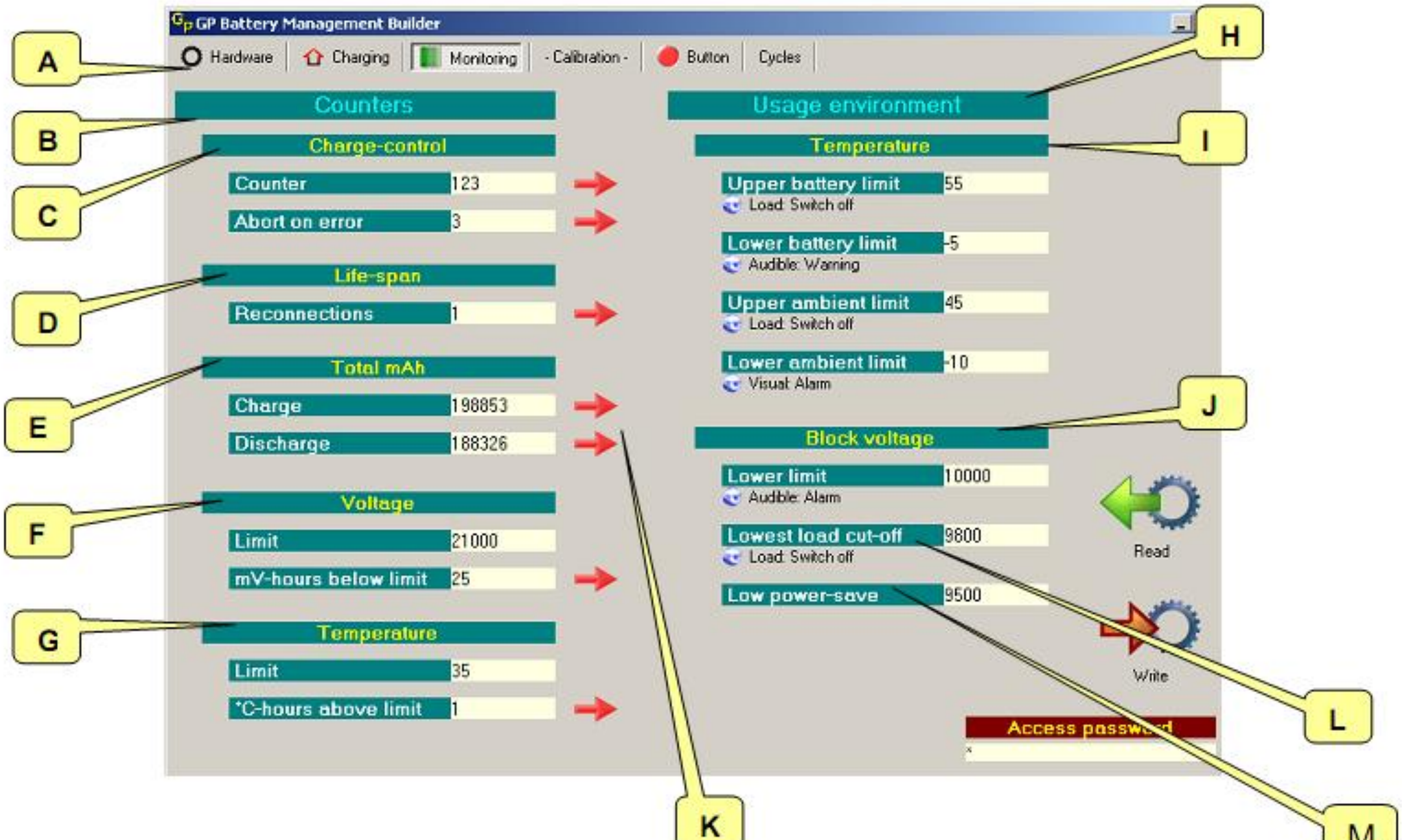
- BMS should design for

  - Protect the cells or the battery from damage

  - Prolong the life of the battery

  - Maintain the battery in a state in which it can fulfill the functional requirements of the application for which it was specified

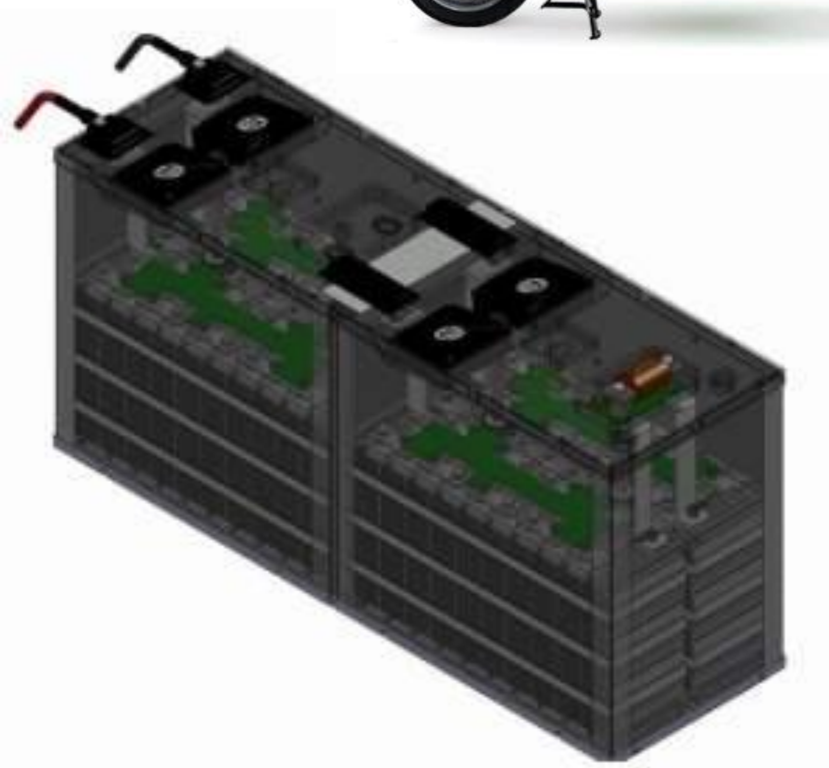
Example: Parameters we are looking at



Large capacity cell pack spec and photo (Vectrix)

$LiFePO_4$ System

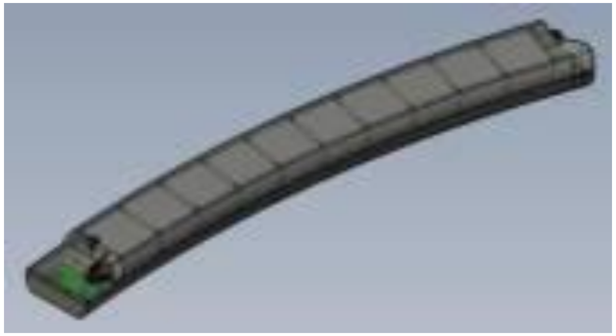
- Acceleration (0-80km): 5.8sec
- Capacity: 3.84kWh
- Battery Pack Weight: 45kgs
- Cells/System: 40
- Configuration: 10s1p
- Number of Layers: Single

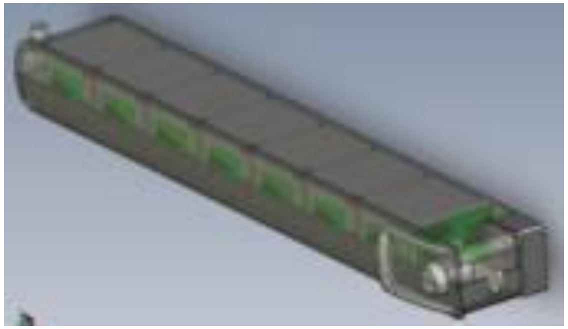


Small capacity cell pack spec and photo (Sparta)

Li(NMC)O2 System

- Configure : 7S / 10S
- Capacity : 10Ah
- Weight : 3.5Kg / 2.8Kg





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