Battery Management System (BMS)

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Smart Battery Management Systems with 18650 Lilon Battery Cell Matrix
Lithium Ion Battery characteristic peculiarities & charge management

- Li-Ion Batteries are attractive since they excel in energy storage density & charge life cycle
- Li-Ion Battery 18650 Cells are light weight, but have charge control concerns… Thermal runaway (TR) hazard if mistreated.
- Batteries have no Power Switch to turn off
- **NEED BATTERY MANAGEMENT SYSTEM (BMS) to control charge/discharge**
- Need Cell temperature monitoring to avoid kicking into TR
- Need Cell charge Balancing and control for equipotential battery terminal voltage
- Can sustain 20,000 Charge/Discharge cycles
- Reliable Battery Charging rate shall be C/2 maximum
General Battery characteristics

- amps, amp-hours, watt-hours, C ratings
- amps and amp-hours are two completely different things.
- Ah – measure of capacity. Helps to estimate the amount of energy that the battery can hold – simple way of estimating battery life in hrs.
- Battery has internal impedance.
- Internal impedance of the battery limits the amount of current that the battery can deliver and from electronics perspective. It effectively becomes the source of heat when the battery is delivering current.
- Capacity divided by the load in Amps gives the battery life in hrs.
Lithium Ion Battery cell characteristics

We measure current in amps (A)

We can measure battery charge/capacity in amp-hours (Ah)
Lithium Ion Battery characteristics

- Only a guideline
- This internal impedance of the battery limits the amount of current that the battery can deliver and from electronics perspective it effectively becomes the source of heat when the battery is delivering current.
- Ah – measure of capacity. Helps to estimate the amount of energy that the battery can hold – simple way of estimating battery life in hrs.
- Capacity divided by the load (in Amps) gives the battery life in hrs.
Lithium Ion Battery characteristics

- Only a guideline
- C rating. They look the same 20C rating and the other is rated at 40C.
- The C rating is an informal way of describing how much current the battery can safely deliver.
- So marketers like use C ratings instead.
- The "C" refers to the battery’s capacity in amp-hours.
- 20C battery can deliver 20xC, or 20 x 2.2Ah, so this battery can safely deliver up to 44 amps.
- 40C battery can safely deliver 88 amps.
- C ratings are confusing because they redistribute the units.
Real Life Battery with smart BMS
Real Life Battery with smart BMS Functions

- BMS function boils down to
- To operate battery system - safe & Reliable operation
- It takes in V, Temp, I Inputs – inside it runs # of algorithms & gives estimation of following outputs

Outputs:
- SOC – Fuel Gage
- SOH – How much charge battery pack can store
- SOE safe operating envelope how much you can be allowed either to charge or discharge at a given time
- Cell Charge Balancing (if applicable)
- Outputs faults/status signals that app controller needs to be aware of
Smart BMS Basic main Functions
Real Life Battery Pack with smart BMS
BMS Safety & Fault Management (SafeOArea)
Calculating State of Charge (SOC)

\[
\text{SOC} = \frac{\text{Capacity Remaining (Ah)}}{\text{Total Capacity}} = \frac{70 \text{ Ah}}{100 \text{ Ah}} = 70 \%
\]
Calculating State of Charge (SOC)

Coulomb counting looks at every single time slice in integration fashion (current X time interval) & summing them up.

Open circuit voltage (OCV) lookup is to compare what is integrated w/actual voltage.

Accurate estimate of Ah is coulomb count.

Current sensor has drift & integration error.

Area Under the Curve corresponds to actual charge capacity removed (Ah).
Depth of Discharge

**OV lookup & the Coulomb counting will give us an accurate estimate of SOC**

Use BMS algorithm Lookup table to estimate open circuit voltage for a given temperature that will equate that to determine what corresponding to DOD, then that will reseed SOC function in the algorithm for accurate understanding of where to start the coulomb counting again.
BMS State of Health

SOH = \frac{Total \ Capacity \ (Ah)}{BOL \ Capacity \ (Ah)}

Battery holding/useful charge decreases over time
SOH is 100% for new cell phone after 700 discharge cycles may be it is at 60%.

ESR = 10mohm

Capacity (Ah)

SOH Impedance

SOC = 70%
SOH cap = 80%
Total BOL Range = 260 mi
Current Max range 160 mile
Range Remaining 70% x 160 mile = 112 mile

Impedance Growth

Cycles
Cell Balancing is another Important task of BMS

- Weakest Cell Limits the amount of charge that can be drawn from the system
- The strongest cell limits the extent that the system can be charged to
- TI’s BQ chip allows cell balancing implementation of this algorithm
Cell Balancing – Passive & Active

- Dissipative method – commonly called passive balancing
- Non dissipative method – commonly called active balancing
- BMS circuit bleed resistors & transistors selectively switch the bypass branch on & off according to the relative SOC of battery cell
- TI gas gauge chips bq78PL114 & bq76PL102 allows implementation of this algorithm
BMS Safe Operating Envelope

• SOE – Algorithm defines Max Charge and Discharge Current allowed in any given time in the battery pack
• i.e. BMS will broadcast Allowance of let’s say 12A Charge & 40A discharge
• The actual discharge path is the blue line.
• Any deviation above and below limits of charge or discharge allowance creates a fault condition within BMS for fault avoidance
• It helps the battery pack to have increased lifetime operation in a long run