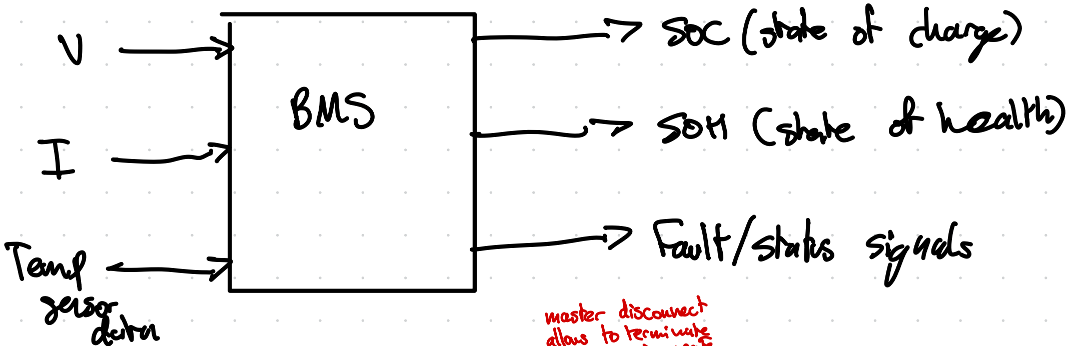
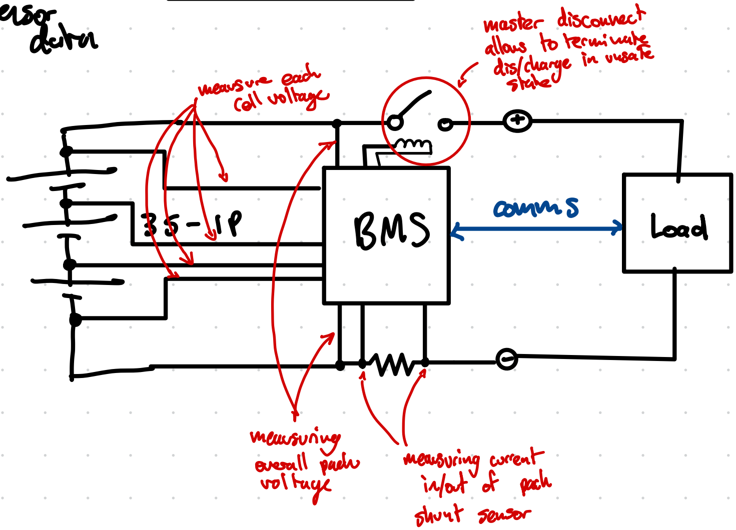
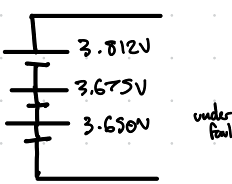
MS STUDY/ Research

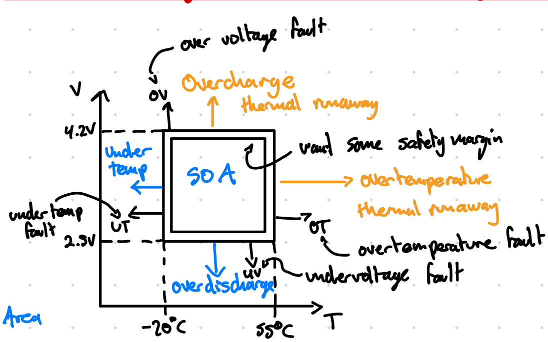
What is a BMS?

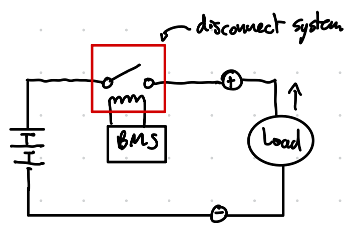




BMS Safety and Fault Management







SOA- Safe operating Area

The BMS will detect for a fault and disconnect in the case of said fault. Will need some sort of fault recovery sequence/reset of system.

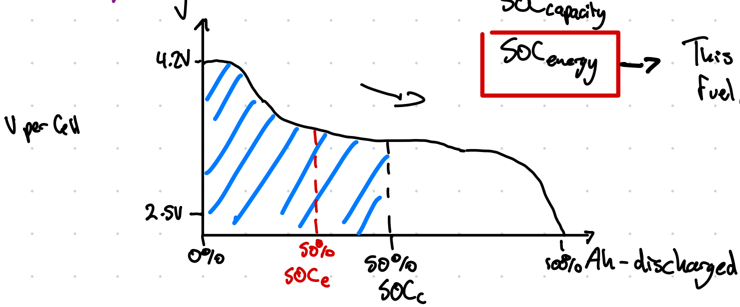
Calculating SOC of a Lithium Ion System Using BMS

$$SOC = \frac{\text{Capacity Remaining}}{\text{Total Capacity}} = \frac{70\,Ah}{100\,Ah} = 70\%$$

Discharge Curve

$SOC_{capacity}$

$\boxed{SOC_{energy}}$ → This is a more accurate gauge of fuel/ capacity

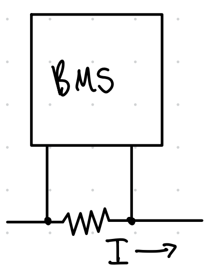


there is a lot more energy on the left side of the curve. This is important to highlight as you could be at 50% SOC_c but have 38% SOC_e due to the nature of the curve. SOC_e is therefore a more accurate representation of run time as it displays the amount of run time / energy we can use.

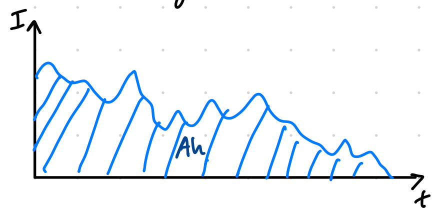
Coulomb Counting

Coulomb counting is the primary way state of charge is calculated. In the above example we discharged 30Ah from a 100Ah total capacity. But how did we determine / figure out we had discharged 30 Ah?

if we remember the current measuring aspect of our BMS from above:



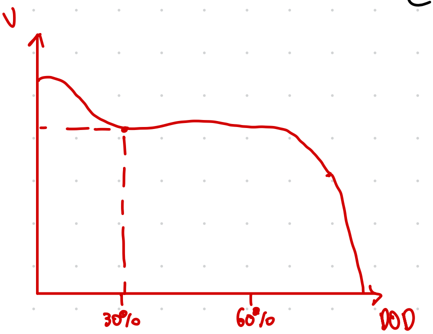
monitor the current flowing in and out of the battery pack across time and integrate.



INTEGRATION TO GET AREA UNDER CURVE

* Note: Current Sensor will have drift and integration error. So we will need an open circuit voltage lookup.

↳ OCV



DOD = depth of discharge, inverse of state of charge

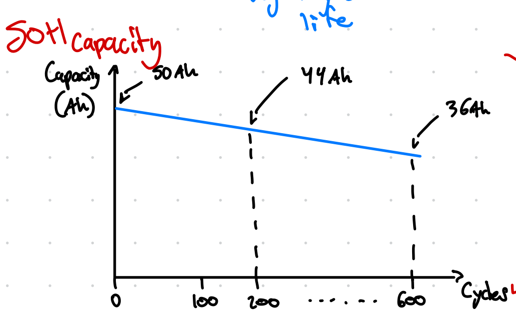
When the battery pack has been at rest for a considerable amount of time, the BMS will lookup, with a lookup table or something similar to see what the OCV is for a given temperature. And then will equate that to determine the corresponding SOC or DOD, and then it will reseed the SOC function, so we get an accurate basis of where we need to start coloumb counting again.

This whole readjustment is important as we don't want our fuel gauge being off / drifting off. Like being at 30% then all of a sudden its 0% because it didn't seed properly.

Calculating SOH for Lithium Ion BMS

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

Beginning of life

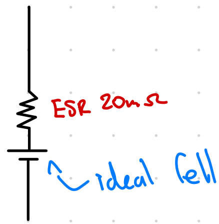


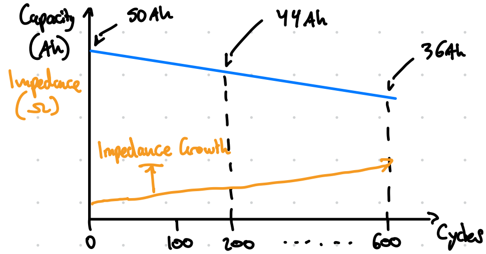
STATE OF CAPACITY OVER TIME

There are other different types of state of health:

$SOH_{IMPEDANCE}$

Lithium Ion Cell





ESR = Equivalent Series Resistance

ESR will increase over time / cycles

$SOH_{capacity}$ and $SOH_{impedance}$ are important to monitor because it gives you an estimated understanding of how much capacity we have left to discharge at any given cycle, as well as, as you discharge it, you will have more voltage drop than before leading to more temp rise than before.

Calculating Estimated Range

$SOC = 70\%$
$SOH_C = 80\%$
Total BOL Range : 200 miles

Current Max Range = 200 miles × 80%
= 160 miles

Range Remaining = 70% × 160 miles
= 112 miles

Cooling Performance

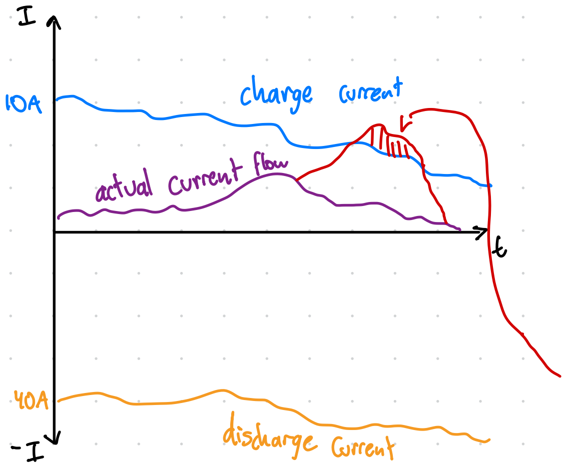
BOL Thermal limiting : 10 mins

Impedance Growth : 30%

Thermal limiting after Impedance growth : 5 mins

Safe Operating Envelope for Lithium Ion BMS

SOE = { Max Charge Current, Max Discharge Current }, available in any battery pack



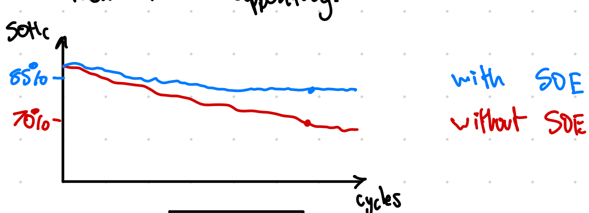
You can essentially figure out what your max charge and discharge current levels are, and then write an algorithm that keeps your battery charge flow within those bounds.

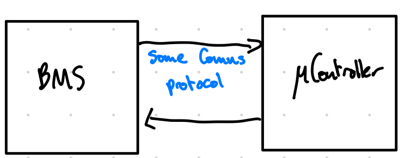
These spikes can be negated by cutting off the battery pack.

Benefits of SOE

- **Fault Avoidance** - although having faults is good as your pack and load remains safe, its not really good to be cutting power randomly. An example would be an electric car shutting off every now and then. Not exactly ideal for that to be happening.

- **Increased Lifetime** - You can maintain a target cycle life with an SOE as it will react to particularly damaging events and prevent them from happening.





The BMS can essentially update the μController and let it know how much charge is available to use.