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Battery Modelling.

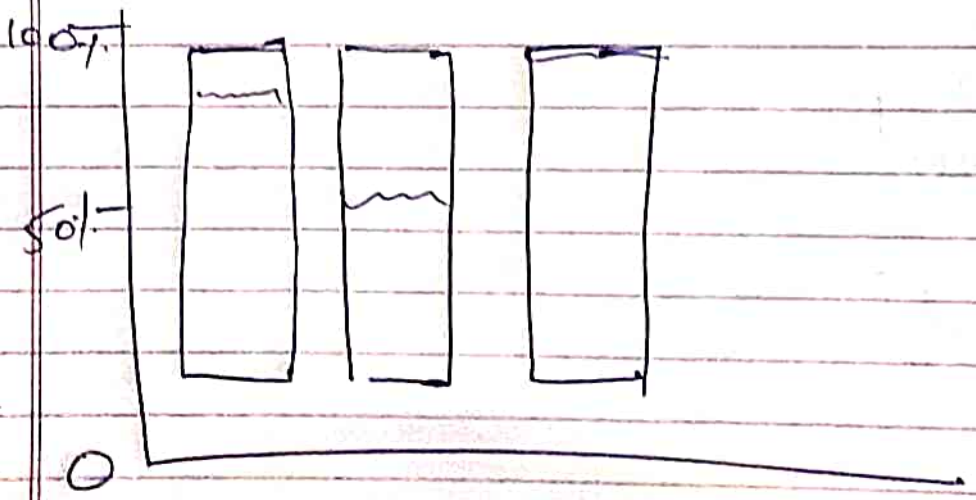
→ What is thermal runaway, how it occurs?

Cell failure → Thermal Runaway → Propagation

→ 1. Mechanical Abuse.
2. Electrical Abuse.
3. Separator failure.
4. Environmental effect.

SOC = State of Charge.

→ After several Charge - discharge cycle the difference appear among the SOC of the individual cell of the battery, due to manufacturing tolerance, uneven temp. distribution. The battery then become unbalance



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Introduction to Battery Management System :-

Why is BMS Needed ?

1. Protects the safety of the battery operated device. operator. Detect unsafe operating condition & responds.
2. Protect cells of battery from damages in abuse/ failure cases.
3. Prolongs life of battery (normal operating cases).
4. Maintain battery in a state in which it can fulfills its functional design requirement.
5. Informs the application controller how to make the best use of the pack right now. power limits, control charger etc.

Application Domain of BMS

1. Hybrid Electric Vehicle. (HEV).
Battery is smaller in size but needs to provide high power delivery for the time period to assist engine.

2. Plug in Hybrid Vehicle.
The battery pack is slightly large or of the same size, but functionality is same with addition to charging safety.

9100
1400
7700

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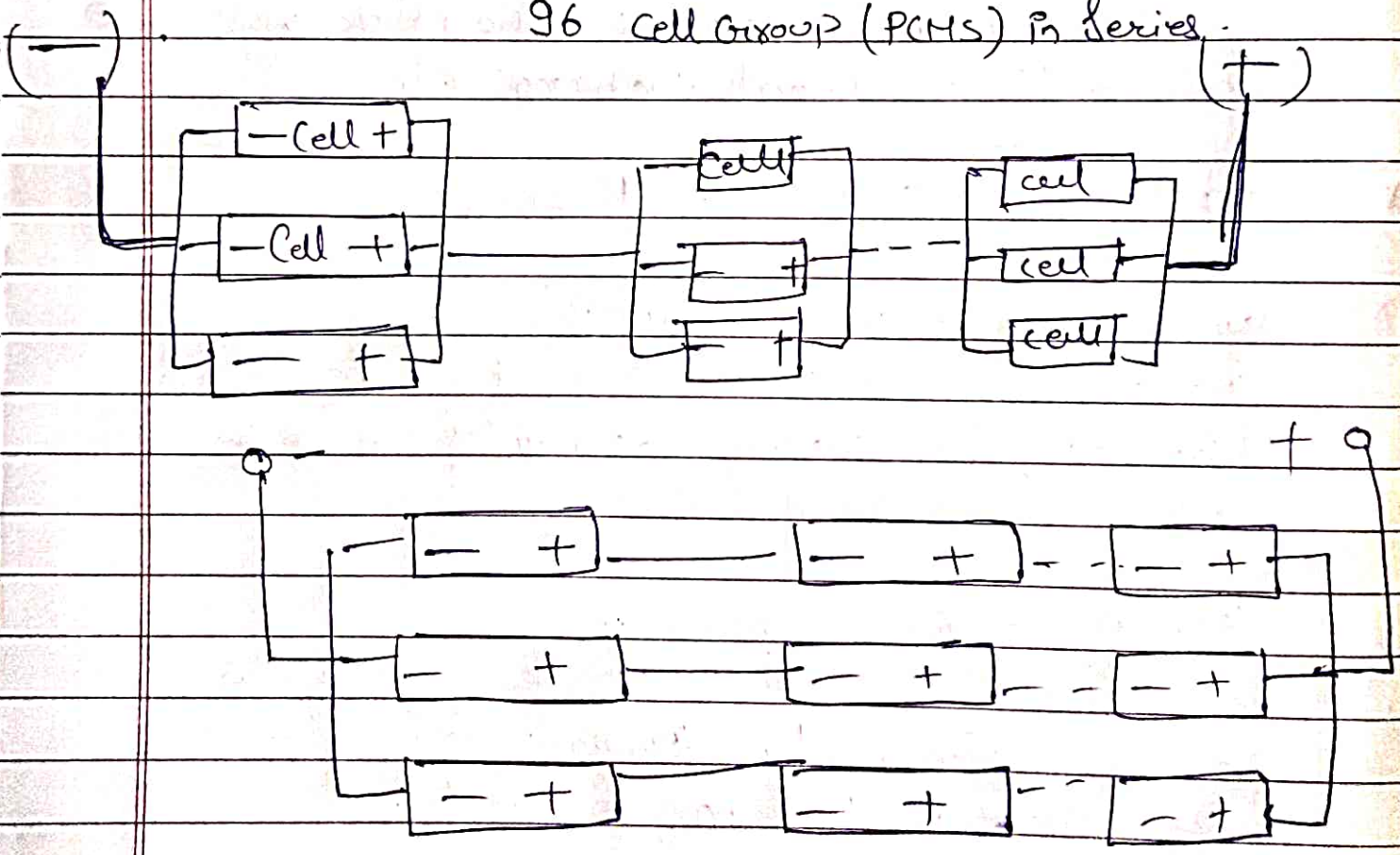
* Large Extended Electric vehicle :-).
Battery will be larger than HEV/PHEV but due to range extender present, it need to have provision to charge while discharging.

* Electric vehicle.
Large battery Pack will have to provide energy for motion unlike HEV.

* Introduction to BMS functionality :-).



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Cell Arrangement in a Pack.

(1) Chemistry of cells fixes the voltage range, thus for high voltage we have Series Stack.

$$V_{pack} = N_s \times V_{cell}$$

↳ No. of cells in Series in an array.

2. Cell construction limits the cell current so for high current the cells need to stacked in parallel.

$$I_{pack} = N_p \times I_{cell}$$

3. Cells are grouped to form a module & each module is placed together to form a cell.

4. Module voltage < 50V for safety.

5. Pack voltage < 600V as power electronic is expensive above that.

* Cell Arrangement in a Pack.

→ Generally we want to keep current small.
1. To reduce wire dia.
2. To reduce resistive heat loss.

→ Modules helps in reusable design.

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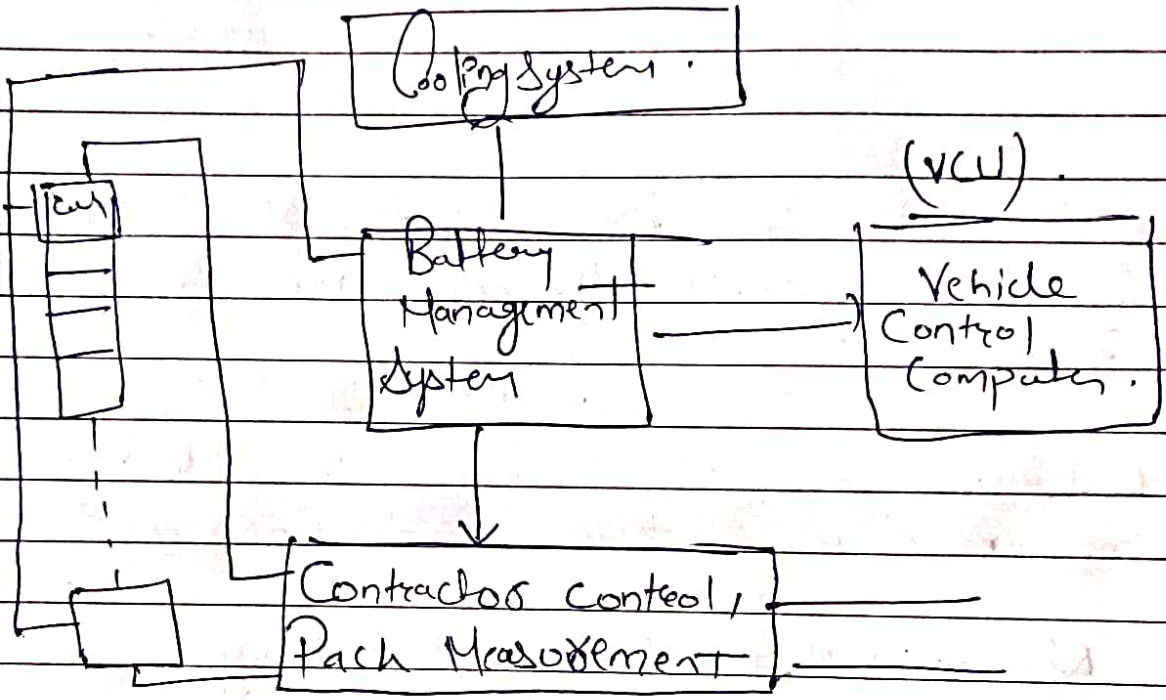
BMS functionality

1. Sensing & High Voltage Control.
2. Protection Against
3. Interface.
4. Performance Management
5. Diagonstic.



Sensing.

BMS Sensing functionality.

1. Voltage
2. Current
3. Temperature.

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Sensing.

⇒ Sensing Voltage :→

All cell voltage are measured in a Li Ion Pack.
→ Indicator of relative balance of cells.
→ Input to most SOC & SOH estimation algorithm.

* Overcharging cells can cause — Thermal runaway.

① Sample BMS shown over here — one of the ways to measure voltage.
2 Monitors upto 12 cells in series.
3 Built in isolated Communication b/w parts.

⇒ Temprature Measurement.

① Battery Pack operational characteristic & cell degradation are function of temp^{r}.

2. Keep temp^{r} in safe region.

3 we can't measure cell internal temperature thus, we measure external temp & calculate internal temp. accordingly.

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* Sensing

(A) Temperature Measurement

1. Thermistor datasheet gives resistance as a function of temperature.
2. The Thermistor is applied to a circuit in order to generate a plot for voltage as a function of temp.
3. The plot is inverse to gain temperature as a function of voltage & thus served as lookup table for reference.

(B) Current Sensing

Battery Pack Current Sensing is important —

1. To ensure safety.
2. Log abuse condition
3. SOC & SOH conditions.

- Current Sensing is done either in 2 ways.

(A) Shunt Sensor

(B) Hall Effect.

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* High Voltage Contactor Control :→.

① High Voltage battery pack are isolated from the chasis ground for protection & safety purposes.

2. When the battery is not in use the high voltage bus terminal are disconnected from the terminal.

3 The negative Contactor is activated first.

Isolation Circuit & Thermal Control

A Isolation Sensing.

① Isolation Sensing detect presence of a ground fault.

2 Primary Concern is safety. Is it safe to touch a battery terminal & chasis ground at same time.

3 Battery 'should' be completely isolated from chasis ground, so should be no problem.

4. As per AIS (Automotive Industry Standard) - Isolation resistance of 100 ohm/volt of working voltage of DC Bus & 500 ohm/volt of working voltage of AC Bus is to be used.

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* State of charge Estimation

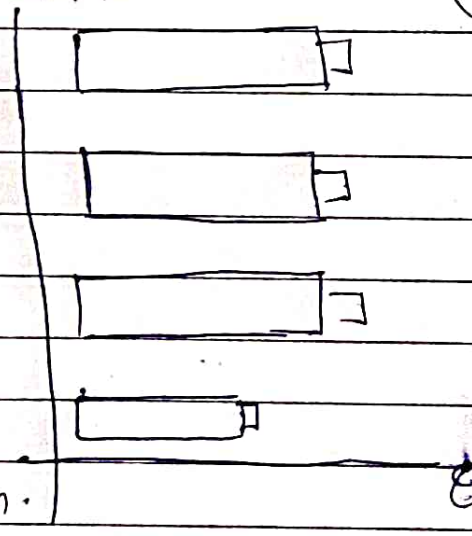
what is State of charge?

1. Charging & discharging is inoolved within moving the lithium ion b/w electrode

2 Electrochemically, cell State of charge is amount of Lithium ion concentration in negative electrode Solid ~~wo~~ particle.

$$\theta = \frac{C_{s\,avg.}}{C_{s\,max}}$$

θ_{100} C_{smax}. $\quad Z_k = \left(\frac{\theta - \theta_0}{\theta_{100} - \theta_0}\right)$.

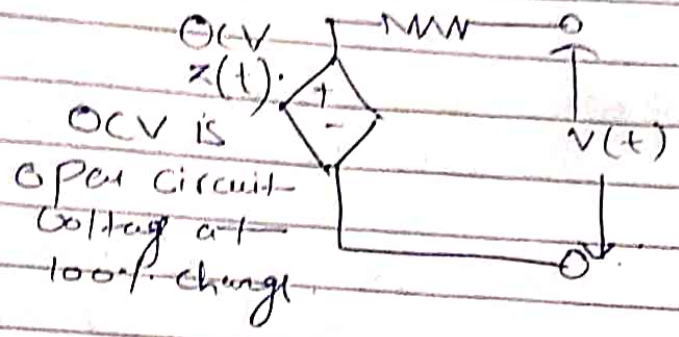


* Energy & Power Estimation :-).

① Cell Energy V/s Power

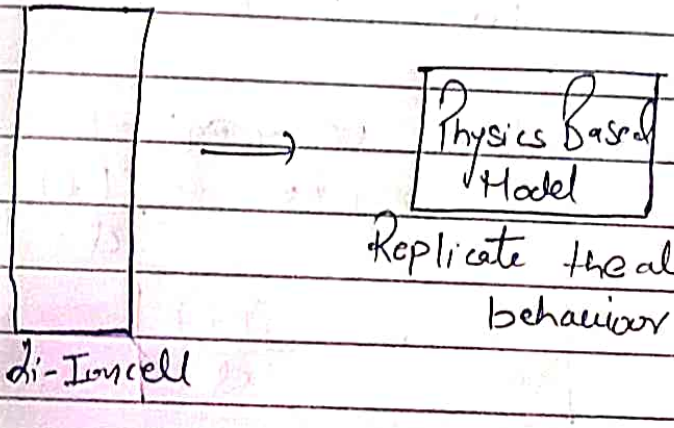
→ Energy is ability to do work & Power is rate of moving energy.

→ Discharging / charging at high rates leads to cells degradation.

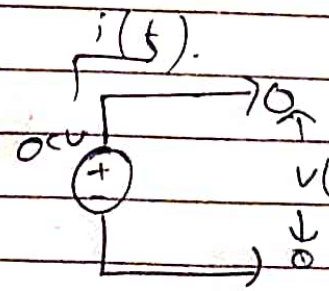


Battery Pack Simulation - OCV & SOC of cell.

Equivalent circuit cell models :-



(1) Open Circuit Voltage (OCV).



ideal voltage source.

→ Voltage is not a f(RH).

→ Voltage is not a f(past usage).

→ Voltage is constant

OCV = VCH