Battery Management System (BMS) :-

BMS manages a battery pack by protecting the battery from operating outside its safe operating zone by monitoring its state, controlling its environment and balancing the Li-ion cells inside battery pack. It can additionally calculate data and report data via various communication protocols.

BMS monitoring :

BMS keeps a check on the key operational parameters during charging and discharging such as voltages and currents and the battery internal and ambient temperature. The monitoring circuits would normally provide inputs to protection devices which would generate alarms or disconnect the battery from load or charger should any of the parameters become out of limits.

Safe Enviroment for Batteries :

- Protecting and Preventing the batteries from damage.
- Increase battery life
- Maintaining battery system is reliable state (depends on battery temperature) (x)
- BMS = BMS doctor
- BMS is called the heart of the battery system.

Types of BMS :

- **Hardware BMS**

Performs basic protection functions to keep the battery pack functioning as healthy as possible. The basic functions includes :

1) Overvoltage cut-off
2) Undervoltage cut-off
3) Continous current
4) Over current detection
5) over temperature cut-off.

- **Software BMS / Smart BMS :**

It has all the features of hardware BMS but additionally can collect data, can have memory to store data and can transmit data via CAN, Bluetooth, etc.

Eg -> 16S-20S, 30A BMS (Smart BMS with bluetooth)

Battery Management System :

System that protects and manages rechargeable batteries.

characteristics :

- Monitor cell voltage and temperature.
- Estimate battery state of charge and state of health.
- Limit power input and output for thermal and overcharge ~~protection~~ protection.
- Control battery charging profile

- Balance the SOC of individual cells.
- Isolate battery pack from source and load when necessary

Basic Functionality of BMS :

① Overvoltage cut-off [very few reasons to battery catch fire]

Max. voltage of cell to which cell should be charged. The overvoltage cut-off for LFP cell is 3.6V and for NMC cell is 4.2V. Cells in a battery pack must use a BMS that cut off the cells once they are charged to this voltage. If cells are charged beyond the voltage, it can lead to thermal runaway. In case of NMC cells, Thermal runaway means fire

NMC - Lithium Nickel Manganese Cobalt oxide Batteries

LFP - Lithium iron phosphate battery

② Undervoltage cut-off :

Voltage which a cell needs to stop discharging any further. Undervoltage cut-off for LFP cell is 2.5V and for NMC cell is 2.75V. But I highly discourage touching till that point and prefer earlier cut-off. Multiple cycles of deep discharges can lead to battery swelling. Ever wondered why did sometimes cell phone battery swell? -> because

that person has a habit of discharging the battery till the end.

Continous current :

Parameter setting in a BMS that makes sure the BMS is functioning smoothly in all aspects when operated at a particular charge and discharge current.

For eg- A 14S, 40A CC BMS can allow 40A continous current during discharging and allow 20A continous current while charging

Over current detection (OCD) :

Maximum current the BMS can allow for very short period of time. For eg — 14S, 50A CC BMS can allow 100A OCD for one second. The battery will cut-off after one second of achieving OCD. The cut-off is done in case of controller failure in EV. The controller can ask for high — unregulated current.

- Over temperature cut-off :

Operating temperature of Li-ion cells affects its life cycle. A BMS enforces the max. temperature the battery can achieve during

charging and discharging. The temperature cut-off during charging is generally lower than temperature cut-off during discharging. Most cells manufacturer dont recommend charging the battery beyond 45°C and discharging beyond 55°C. BMS has Thermister to sense the battery temperature and its cut off the battery when it senses the max. temperature has been achieved.

BMS communication (only Smart BMS)

- Communication between devices.

For eg - CAN 2.0 BMS sends communication from battery to Vehicle control unit.

- It can continuously transmit data of the battery's Thermal profile and monitor its temperature.
- It uses collected data points (temp, V, I) to estimate the SOC, SOH, etc.. of battery pack.
- The data can either be stored (on-board storage) can be transmitted by CAN to VCU or sent to cloud.

Types of BMS communication in EV:

- **CAN (Controlled Area Network):**

Robust vehicle bus standard designed to allow microcontrollers and devices to communicate with each-other's applications without a host computer. It can also be implemented for communication between the battery charger and Battery managenet system.

- **UART with Bluetooth:**

Universal Asynchronous Receiver Transmitter and it works with bluetooth interface, which sends the data to the end users on their cell phones application.

- IOT cloud connectivity:-

It requires wireless internet and can transmit data to the cloud and it can be viewed remotely by anybody with an access.

Advanced Functionality of BMS:

- State of charge (SOC)

Red note

Why SOC not upto mark?

Battery is a chemical energy storage source. and its chemical energy cannot be directly accessed and its makes the estimation of SOC very difficult. High accuracy estimation of SOC remains very complex and it is difficult to implement because battery characteristics change with aging because of parametric uncertainities. Today's most practices have poor accuracy and reliability of estimation of SOC.

Types of SOC estimation:

- Direct measurement — Uses physical battery properties such as measuring voltages and internal resistance of battery.

- **Book - keeping estimation :**

Uses discharging current as input and integrates discharging current over time to calculate SOC.

- **Hybrid methods :**

Hybrid model benefits from advantages of each SOC estimation methods as their multiple data is understood and over-lapped for optimal results. Hybrid methods are known to produce good estimation of SOC.

SOC estimation by OCV measurement :

- This is one of the direct measurement method and most popular method. The relation between SOC and ~~SOC~~ OCV is not exactly the same for all Li-ion batteries. It varies with different chemistries and accuracy reduces as the batteries are aging.

Depth of Discharge (DOD): Fred note

DOD is linked to cycle life of battery. It is inversly proportional to cycle life. The lower the DOD the better the cycle life of the battery.

State of Available power :

Indicator of the backup time if the power output from battery is controlled to be at some level. It is an indicator popular in ESS where it can mean remaining time of power backup.

Energy delivered Since last charge :

Indicator to specify ~~from~~ energy delivered since the time the battery was disconnected from charging state.

No. of charge - discharge cycle :

Indicator to specify the no. of time the battery has been charged and discharged. It is different from definition of cycle life of battery because cycle life of battery has a specific depth of discharge until a specific SOH is reached.

Total operating Time since First use :

Indicator similar to total energy delivered since first use but in this case, instead of amount of energy it shows total time of energy delivered from battery since it was operational

Total energy delivered since first use :-

Indicator specifying total amount of energy delivered from the battery since it went operational.