PROJECT REPORT ON

" CELL BALANCING AND EV TECHNOLOGY"

SUBMITTED IN COMPLETE FULFILMENT OF THE
REQUIREMENTS FOR THE PROJECT EVALUATION
OF

ELECTRICAL ENERGY STORAGE SYSTEMS
IN
[] ELECTRICAL ENGINEERING []

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ABSTRACT

Electric vehicles are the future of Transportation. There has been an increase in EV purchases of 109% worldwide in 2021 and in the last decade, EVs have become popular because of their zero tailpipe emissions and least reliance on oil and its byproducts . The Latest fully Electric vehicles use Lithium-ion battery packs as their main energy source which comes with both merits and demerits. If the battery parameters are not maintained optimally in all conditions, catastrophic casualties can occur, e.g., toxic smoke or fire. The main aim of this project is to demonstrate ways to balance the voltages in every cell of the Battery pack using more than one technique. This ensures the optimum performance of the Battery pack by not allowing any cell to overcharge or over-discharge hence, increasing its life and usable capacity. Detailed models and simulations of different types of cell balancing techniques are shown in this project

CELL BALANCING

Cell balancing is a technique that improves battery life by maximizing the capacity of a battery pack with multiple cells in series, ensuring that all of its energy is available for use. A cell balancer or regulator is a functionality in a battery management system that performs cell balancing often found in lithium-ion battery packs electric vehicles and ESS applications.

Typically, individual cells of a battery pack have different capacities and are at different SOC levels. Without redistribution, discharging must stop when the cell with the lowest capacity is empty, even though the other cells are still not empty. This limits the energy delivering capability of the battery pack.

During balancing, higher capacity cells undergo a full charge/ discharge cycle. Without cell balancing, the cell of the slowest capacity is a weak point. Cell balancing is one of the core functions of a BMS, along with temperature monitoring, charging, and other features that help maximize the life of a battery pack.

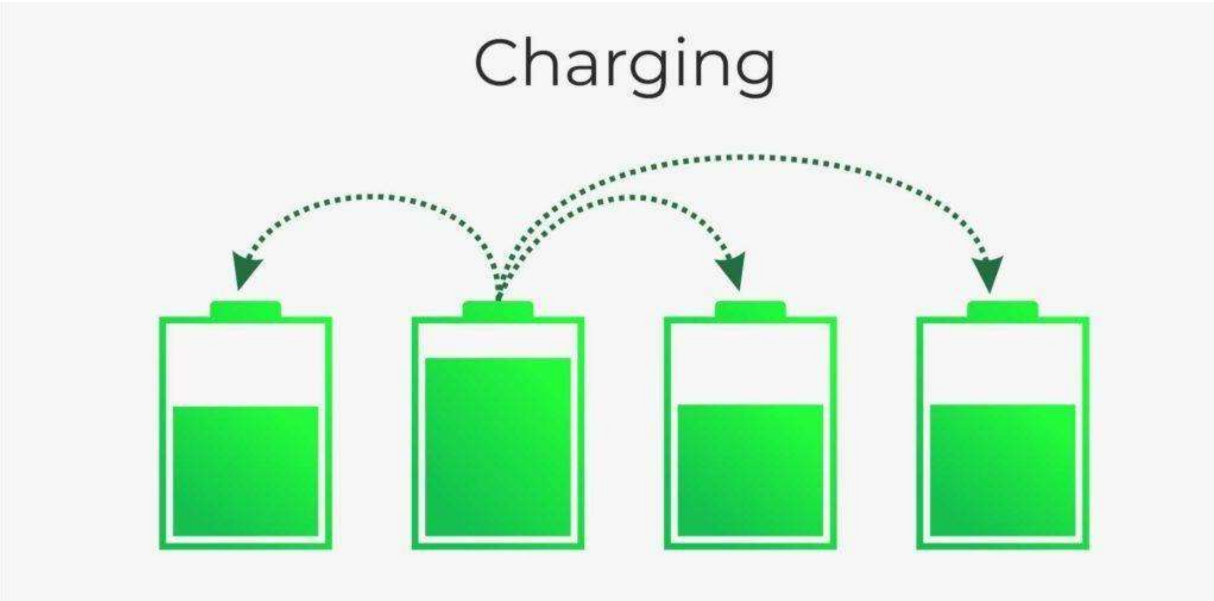
NEED FOR CELL BALANCING

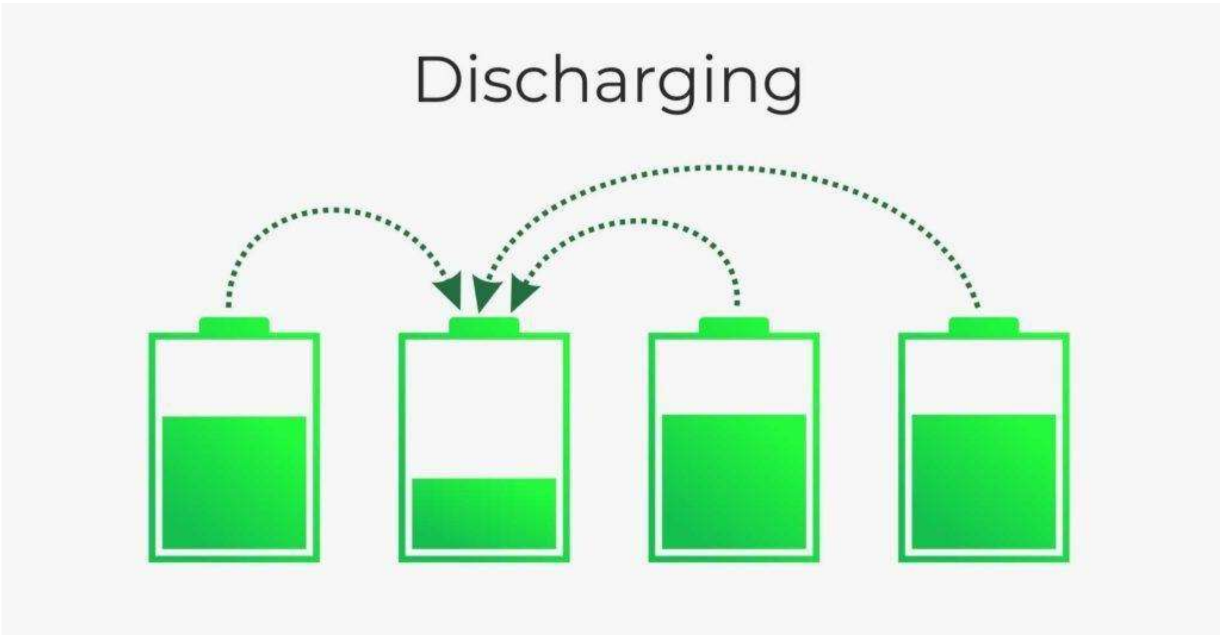
When you need several cells grouped together to power a device, you need to do some sought of balancing. The reason is that battery cells are fragile things that die or get damaged if they are charged or discharged too much. For your cells that have different SoC and you start using them, their voltage starts dropping until the cell with the least amount of energy stored in it reaches the discharge cut off voltage of the cell.

At that point, if the energy keeps flowing through the cell, it gets damaged beyond repair. Now, if you attempt to charge this group of cells to the correct combined voltage, the healthy cells get overcharged and thus get damaged as they will take the energy that the already dead cell is no longer able to store. Imbalanced lithium-ion cells die the first time you try to use them. This is why balancing is absolutely required.

Types of Cell Balancing

Active Cell Balancing





An active cell balancer generally transfers energy from one cell to another. That is from high voltage/ high SoC to a cell with a lower SoC. The purpose of an active balancer is that if you have a pack of cells with

lower capacity, you can extend the life or the SoC that you have on the pack by moving energy from one cell in the pack with more energy than the other cell.

Instead of wasting all that energy as heat, an active cell balancer efficiently balances cells with tiny converter circuits that pass energy from the highest voltage cells to the lowest voltage cells. There are two different categories of active cell balancing methods: charge shuttling and energy converters. Charge shuttling is used to actively transport charges from one cell to another to achieve equal cell voltage. Energy converters use transformers and inductors to move energy among the cells of a battery pack.

Other active cell balancing circuits are typically based on capacitors, inductors or transformers, and power electronics interface. These entail:

Based on capacitors

- **Single capacitors – this method is simple because it uses a single capacitor regardless of the number of cells connected in the battery. However, this method requires a large number of switches and intelligent control of the switches.**
- **Multiple capacitors – this method with multiple capacitors connected to each battery transfers unequal cell energy by multiple capacitors. It does not require a voltage sensor or closed-loop control.**

Based on inductors or transformers

- **Single/ multiple inductors – a cell balancing circuit with a single inductor has a small volume and low cost while multiple inductors have fast balancing speed and decent cell balancing efficiency.**

- **Single transformer – this method has a fast balancing speed with low magnetic losses.**
- **Multiple transformers – this cell balancer has a fast equalizing speed. However, it requires an expensive and complex circuit that prevents the transformer from being flooded.**

Based on Power Electronics Interface

- **Flyback/ forward converter – the energy of a high voltage cell is stored in the transformer. This cell balancer has high reliability.**
- **Full-bridge converter – this cell balancer has fast equalization speed and high efficiency.**

Active balancers are capable of pushing a lot of current from one cell to another.

Read more about 'Active cell balancing for maximum battery pack performance', here.

Advantages of Active Cell Balancing:

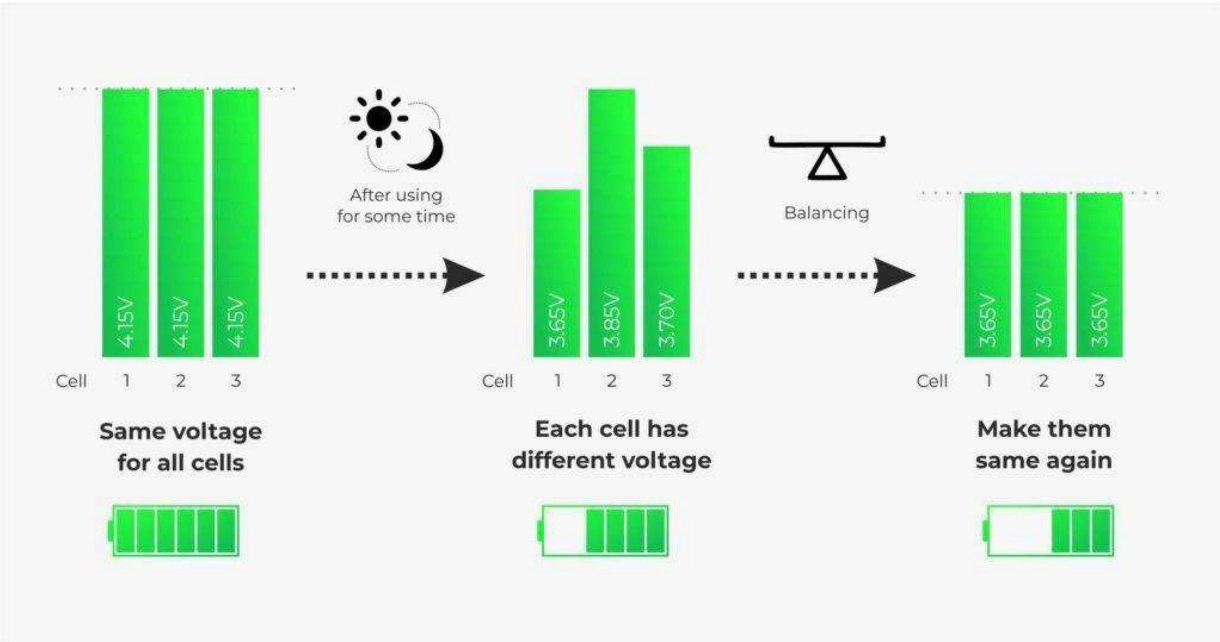
- **It improves capacity usage. It performs great when you have different cell capacities in a series.**
- **It increases energy efficiency. It saves energy instead of burning the excess energy in a cell by transferring the excess energy to a lower energy cell.**
- **Lifetime extension. It improves the life expectancy of a cell.**
- **Fast balancing.**

Disadvantages of Active Cell Balancing:

- **When you transfer energy from one cell to another, approximately 10-20% of the energy is lost.**

- **The charge could be transferred only from higher cell to lower cell.**
- **Although an active cell balancer has high energy efficiency, its control algorithm may be complex and its production cost is expensive because each cell should be connected with an additional power electronics interface.**

Passive Cell Balancing



A passive system potentially burns off excess energy from the high cells through a resistive element until the charge matches the lower energy cells in the pack. If you have cells packed in series and you notice that some of the cells have higher energy than the other lower energy cells, you can balance the cells in burning energy of the top cells simply by attaching a resistor to the cells which releases the energy into heat thereby equalizing the cell energy of the battery pack.

Initially, you burn off the excess energy until you have balanced cells. Passive cell balancing allows all cells to appear to have the same capacity. There are two different categories of passive cell balancing method: fixed shunting resistor and switching shunting resistor. A fixed shunting

resistor circuit is usually connected to the fixed shunting to prevent it from being overcharged. With the help of the resistors, the passive balancing circuit can control the limit value of each cell voltage without damaging the cells. Energy consumed by these resistors for balancing a battery may result in thermal losses in the BMS. This, therefore, proves the fixed shunting resistor method to be an inefficient cell equalizing circuit.

The switch shunting resistor cell balancing circuit is currently the most common method in cell equalizing. This method has a continuous mode and a sensing mode, where the continuous mode all switches are controlled to be turned on or off at the same time and in the sensing mode, a real-time voltage sensor is required for each cell. This cell balancing circuit consumes high energy through a balancing resistor. This cell balancing circuit is suitable for a battery system that requires a low current when it is charged or discharged.

Advantages of Passive Cell Balancing:

- **You should never have to balance a pack that is working perfectly.**
- **A cell cannot waste energy that it does not have. As soon as the energy bank is full, that is only when the cell has enough energy to balance.**
- **It allows all cells to have the same SoC.**
- **It provides a fairly low-cost method for balancing the cells.**
- **It can correct for long-term mismatch in self-discharge current from cell to cell.**

Disadvantages of Passive Cell Balancing:

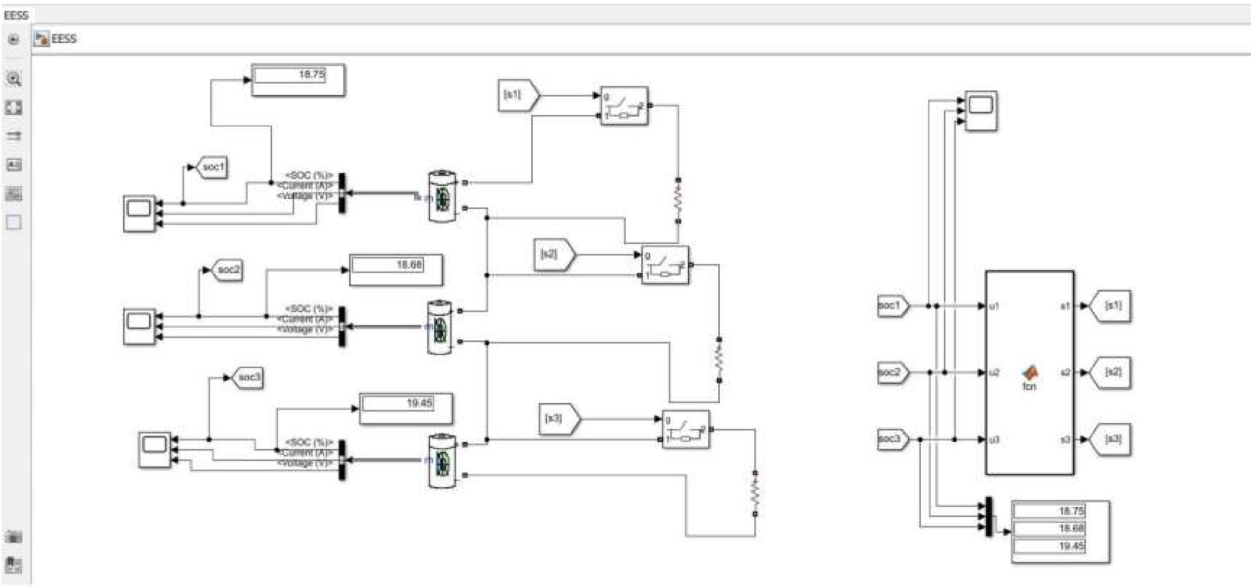
- **Poor thermal management.**
- **They do not balance during the full SoC. They only balance through the top of each cell at around 95%. This is because if you**

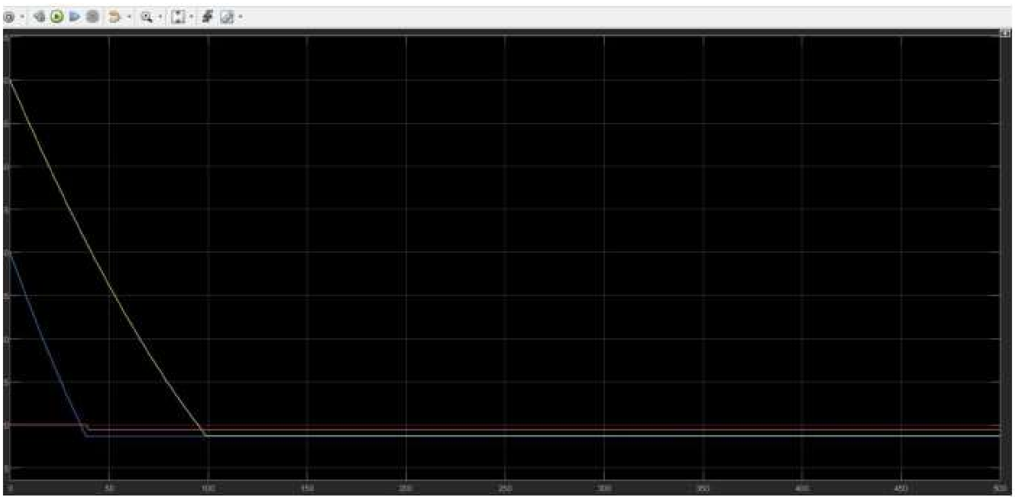
have different cell capacities, you are forced to burn off the excess energy.

- **Its energy transmission efficiency is usually low. Electrical energy is dissipated as heat in the resistors and the circuit also accounts for switching losses. In other words, it results in a high amount of energy loss.**
- **It does not improve the run-time of a battery-powered system.**

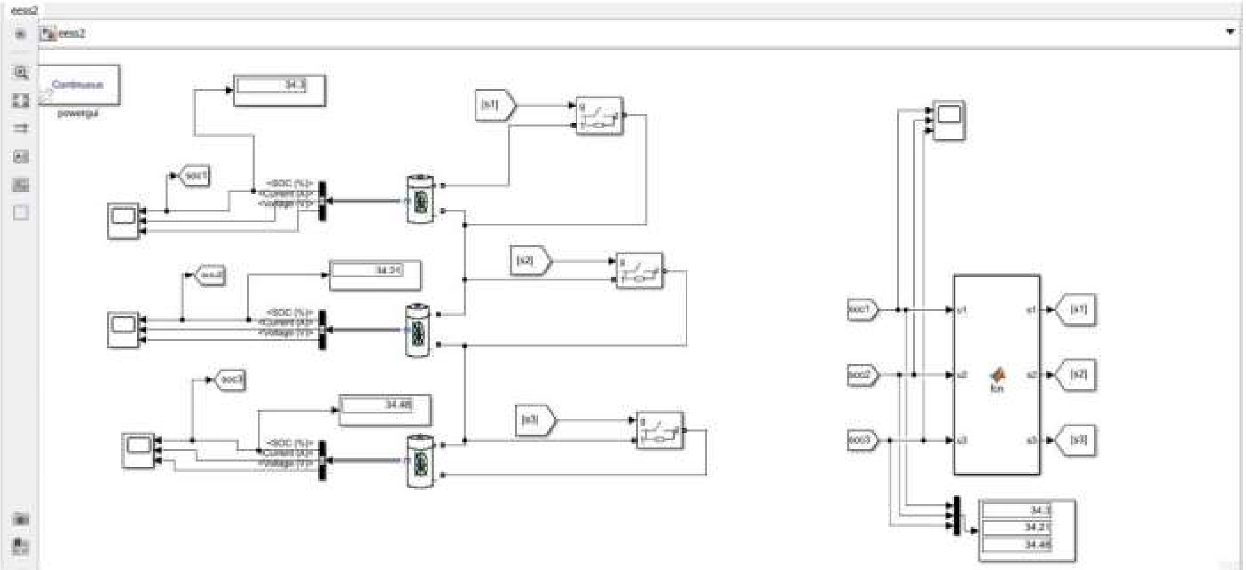
***MATLAB SIMULINK AND OUTPUTS:-**

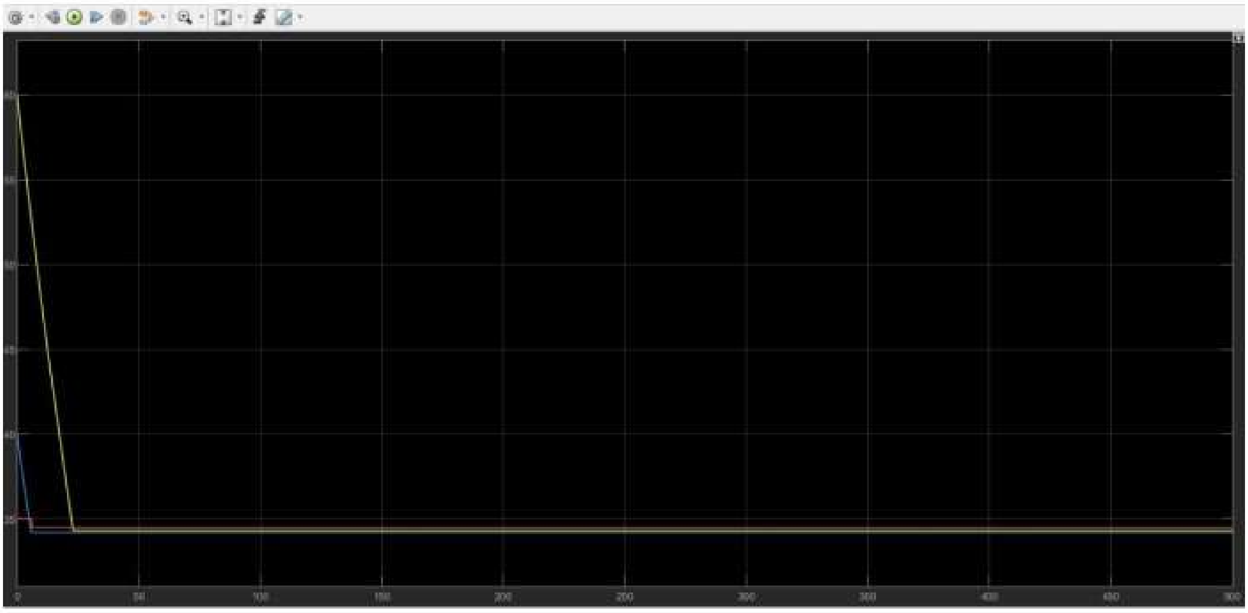
1) Passive cell balancing-Circuit and Graph of SoC





2) Active cell balancing-Circuit and Graph of SoC





➔ MATLAB PROGRAM FOR FUNCTION BLOCK

MATLAB Function

```
function [s1,s2,s3] = fcn(u1, u2, u3)

u1=int32(u1)
u2=int32(u2)
u3=int32(u3)

if((u1>u2) || (u1>u3))
    s1=1;
else
    s1=0;
end

if((u2>u1) || (u2>u3))
    s2=1;
else
    s2=0;
end
    if((u3>u1) || (u3>u2))
        s3=1;
    else
        s3=0;
    end
```

CONCLUSION

Balancing compensates for the SoC of individual cells, not the capacity imbalance. The good thing about a battery pack's balance is that if the pack is balanced in the factory, the BMS only needs to handle the balancing current. This makes more sense to build battery packs that are already balanced, to remove the need for a BMS that can perform gross balancing.

Balancing compensates for the SoC of individual cells, not the capacity imbalance. The good thing about a battery pack's balance is that if the pack is balanced in the factory, the BMS only needs to handle the balancing current. This makes more sense to build battery packs that are already balanced, to remove the need for a BMS that can perform gross balancing.

To minimize the effects of cell voltage drifts, imbalances must be properly moderated. The objective of any balancing scheme is to allow the battery pack to operate at its expected performance level and extend its useful capacity. For customers who wish to minimize cost and correct for long-term mismatch in self-discharge current from cell to cell, passive balancing is the best option. With passive cell balancing, a cell cannot waste energy that it does not have. Once the energy bank is full, it's only then that the cell has enough energy to balance ITSELF.