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Battery Management System by Passive Cell Balancing for Electric vehicle

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***Abstract* –Electric vehicle demand increase day by day. The lithium-ion battery is widely used in large-scale energy storage and electric vehicle. The first part of this paper represents the charging and discharging of capacitors. The second part of this paper represents the cell balancing process and the third part of this paper represents the constant current and constant voltage charging method for lithium-ion battery MATLAB simulation. This paper deal with the simulation of passive cell balancing technique using MATLAB and analysis results.**

Keywords – Lithium-ion battery, Cell balancing, Battery management, Electric vehicle, Passive cell balancing

I. INTRODUCTION

Lithium-ion batteries are the most widely used batteries in Electric vehicles (EV) due to their high performance [01]. for many years we use nickel-cadmium battery but its disadvantage is cost and its discharge rate is very fast. So, in 1990 manufacturer develop a lithium cell that has 2 types of Lithium-ion battery and one is a lithium polymer cell [01]. The advantages of Lithium-ion cells over nickel-cadmium batteries cost very little and discharge time is very slow [01]. When we compare Lithium-ion and polymer batteries so we analyze Lithium polymer battery energy density low and it is very expensive [01]. So, most people use Lithium-ion cells recently. In an electric vehicle, one of the battery packs uses is a lithium-ion battery pack [01]. In this battery pack, all batteries are connected in series connected [01]. Here we maintain all batteries at the same level by passive cell balancing.

II. BATTERY MODEL

As shown in fig. 1 it is the basic construction of a lithium-ion battery. During the initial condition assume the battery is pre-charged and now we can apply its energy to the electric vehicle. Now when the battery discharges so, that time electrons are transferred from the negative electrode to the positive electrode externally and at that time lithium ions transfer from the negative electrode to the positive electrode internally [01]. During the charging of the battery, this process is reversed now electrons flow from the positive electrode to the negative electrode externally and at that time lithium-ion flow from the positive electrode to the negative electrode internally. Here both electrodes are separated by a separator. The electrolyte is a medium in which Lithium ions flow easily. Here current collects at the end of electrodes [01]. The applications of lithium-ion batteries are that used in power electronic-based devices, renewable energy sources, etc.

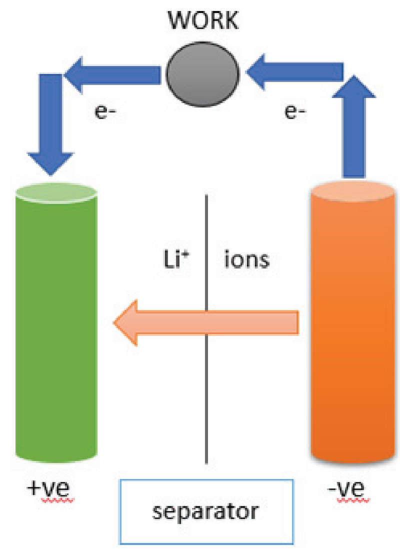

Fig. 1. Lithium-ion cell

III. THE STATE OF CHARGE

The State of Charge Indicate Voltage Level of Battery. It Is the Ratio of Battery Remaining Capacity to Battery Nominal Capacity.

If, Remaining Capacity = 65 Ah And Nominal Capacity = 80 Ah

So, State of Charge Is 81%

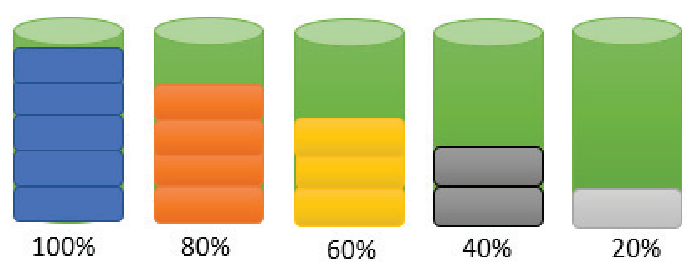

Fig. 2. soc of battery

If Battery Capacity 10 KWH And Cell Manufacturer Suggest Keep the Depth of Discharge 90% That Means Only 9 KWH Energy We Use and Then Charging Provide [01]. State of charge Depends on C Rate and E Rate. 1 C Rate Is Current at Which Battery Will Discharge In 1 Hour. For Example, As Shown in Fig. 3 Battery has a 1 c capacity of 10 ah so, it means the battery provides a 10-amp current in 1 hour.

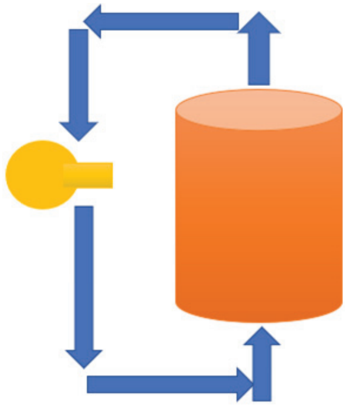

Fig. 3. C rate

Fig. 4. E rate

As shown in fig. 4 E rate indicates discharge power in 1 hour.

IV. CHARGING AND DISCHARGING OF BATTERY

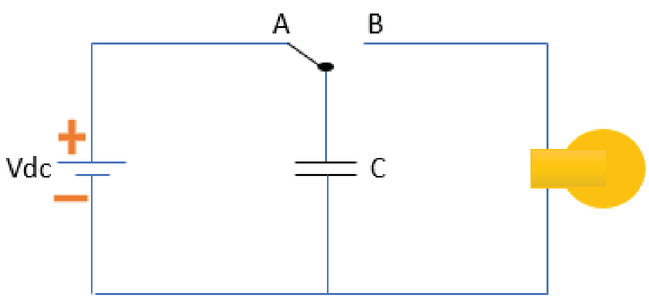

Fig. 5. Charging of Battery

As shown in fig. 5 this is the process of charging the battery. Here we take 2 batteries 1 battery is a simple voltage source that is connected to the lamp load and the other is an ideal voltage source which SOC is always 100%. Now assume our simple voltage source SOC decrease means fully discharge so, now disconnect this simple voltage source from lamp load and connect with ideal voltage source so, in simple voltage source now charging start. When charging is done in a simple voltage source so disconnect this from the ideal voltage source [12].

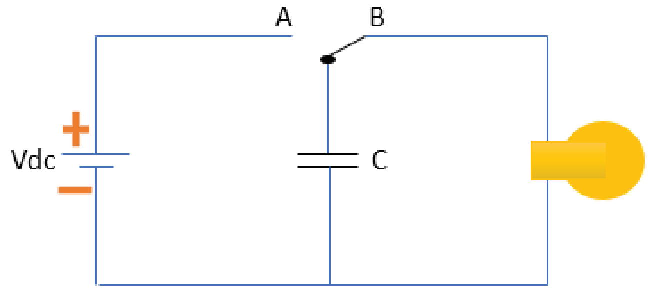

Fig. 6. Discharging of battery

After charging is done in a simple voltage source here, we connect this battery with the lamp load and here it is starting to discharge in the lamp load see this in fig. 6 [1].

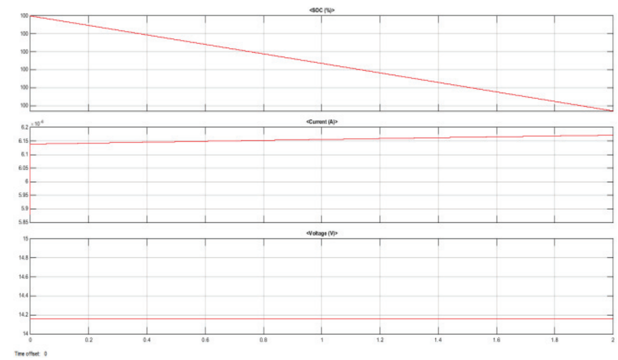

Fig. 7. output waveform of charging and discharging of the battery

As shown in fig. 7 here we see the output waveform of charging and discharging of battery using MATLAB simulation.

V. CELL BALANCING

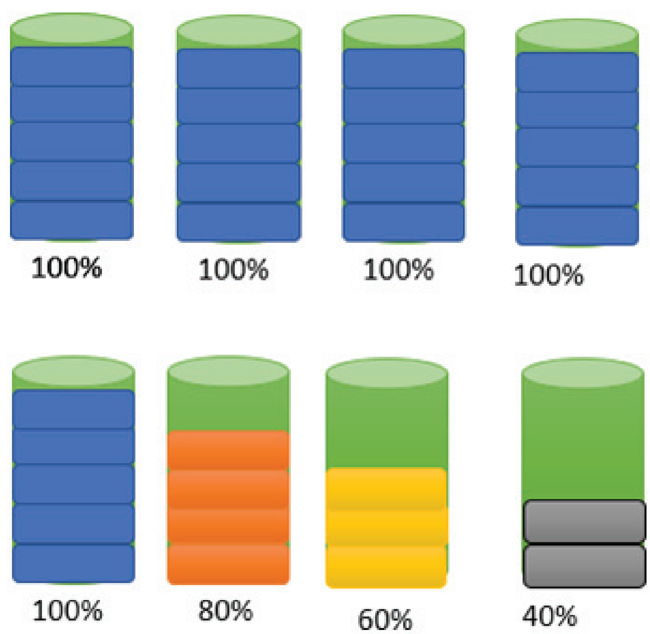

Fig. 8. cell balancing

Here as shown in fig. 8 there are 2 conditions first is the ideal condition and the second is practical. In Ideal conditions, all batteries have the same states of charge and voltage levels but it is not possible practically. In practically all batteries different states of charge and voltage level so, to make all batteries same level and provide in working we use the cell balancing process [11].

VI. NEED OF CELL BALANCING

Suppose I take 2 batteries and 1 battery soc 30% and other battery soc 70%. When I put both on charging so, there are chances to overflow in 70% soc battery and chance to burn the cell for that we need to cell balancing [10].

Fig. 9. Burn the battery due Continue Use

The second reason is cell degradation if we use one battery continuously for about 1-2 years so, after that slowly reduce its life span and works within 1 more year and damage. so, to use 1 battery for 2-3 years we use proper cell balancing.

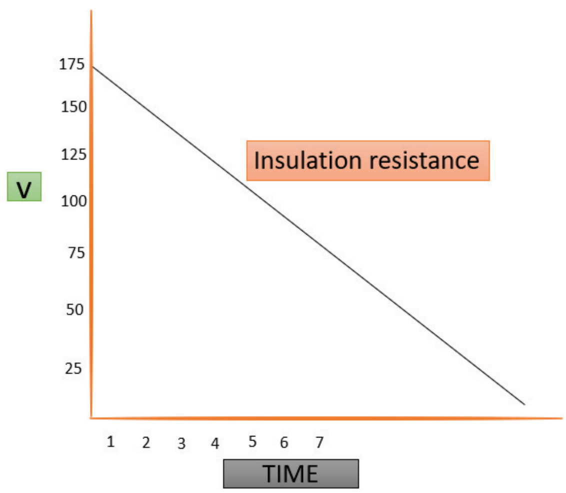

Fig. 10. Insulation resistance

The third reason is variation in internal resistance. Here when we take a new cell so initially its resistance is high but when we continuously use so, its resistance decreases, and the resulting efficiency of the battery decrease. For efficiency maintenance good we need cell balancing. Another reason is battery depends on the surrounding temperature. If the temp is hot and without cell balancing battery continuously working so, the chance to burn the battery fast and damage the system for that we need cell balancing.

VII. BATTERY MANAGEMENT SYSTEM

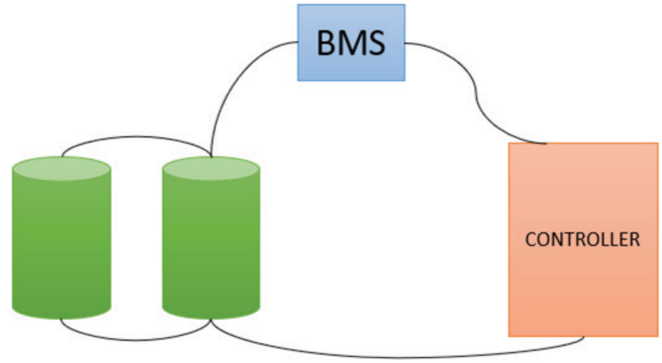

Fig. 11. BMS

It is a constant monitoring system so why is this monitoring required? In the battery pack, all batteries are series-connected. After charging measure voltage across the battery and if it is higher compare desired value then it chances to damage the system [7].

Over Voltage and Under Voltage Both Due to Temperature So, It Chances to Damage System. So, By This Monitoring, We Can Charge Every Battery at Equal Level and Effective Way to Maintain Operation Successful Take Smart Battery Management System.

VIII. HOW DOES BMS HELP TO KEEP THEBATTERY HEALTH

1) Discharge control = Primary goal of BMS is to keep the battery put in a safety zone so, BMS must protect the cell during discharging [8].

2) Soc determination = Primary goal of charge battery determined constant by direct voltage measurement or coulomb counting. Using voltage measurement by measuring the voltage across battery using voltmeter if voltage decrease so, soc also decrease. Using coulomb counting – here we can count how much current goes into charging in the battery through BMS after that observation we can conclude our decision. When the desired current meets the battery so, BMS informs the battery is fully charged and while discharging follow the same process [8].

3) State of health determination = Here battery health is measured by its internal resistance or conductance for during working how much energy waste or how

4) long battery survives in system check here [6].

5) Logbook = BMS continues to monitor new battery and old battery performance as a data sheet. it's a record comparison of both batteries [6].

6) Communication = The BMS system stores data very easily get and take decisions by humans [12].

IX. BMS TOPOLOGIES

1) Distributed topologies = Here monitor circuit communicates with master Controllers Of BMS.

Advantage = Simple, reliable Disadvantage = required Large No of SmallPCB difficulty mounting on every cell [5].

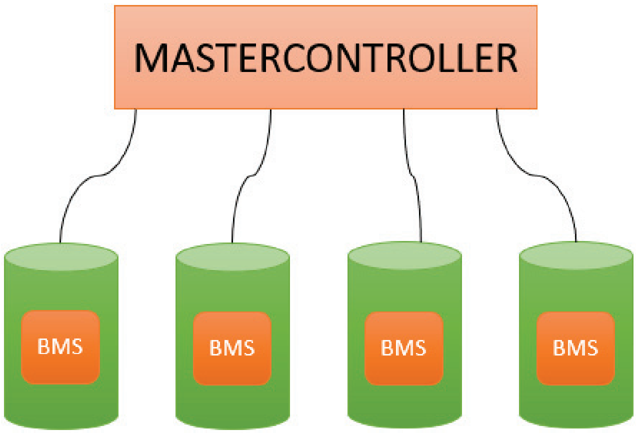

Fig. 12. distributed structure

2) Modular structure = Here multiple slave controllers to fetch data and forward Master controller.

Advantage = No special PCB need, lesshardware

Disadvantage = Heat generates due to continuing working as dependent on only one master controller circuit [6].

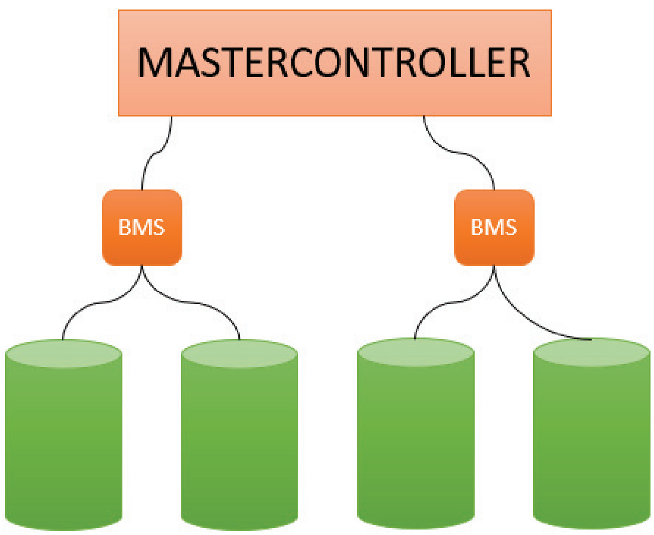

Fig. 13. modular structure

X. TYPES OF BATTERY CHARGING

1) Constant current method = Here we have 2conditions. First, our ideal voltage source value is high, and second is our battery capacity is low compared to ideal voltage sources like 6v, 12v, 24v, etc.

Now, if we connect the dc source with 230 volts with a battery whose capacity is 6 volts so, here we need to waste energy of dc source so, how can we drop that.

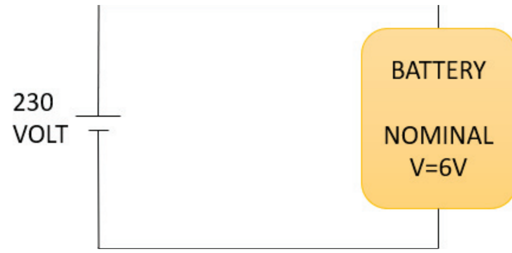

Fig. 14. Simple charging method

as shown in fig. 9 by using resistor series or Rheostat but we need current constant but here only voltage drop so, we use lamp load.

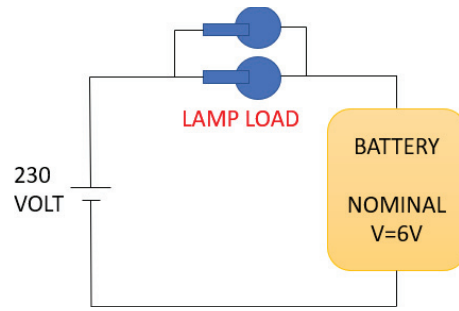

Fig. 15. Constant current charging

So, as shown in the figure now assume we required 2-ampere currents for charging the battery and overall lamp load has 1ampere capacity so, at that time 2 lamp switches close and here we get 2a current constant in circuit and it is provided in battery [2].

2) Constant voltage method = In this one condition which is dc source value is not much higher compared to the battery value [1].

If the dc voltage source is 16 volts so the battery value is near it like 12 volts.

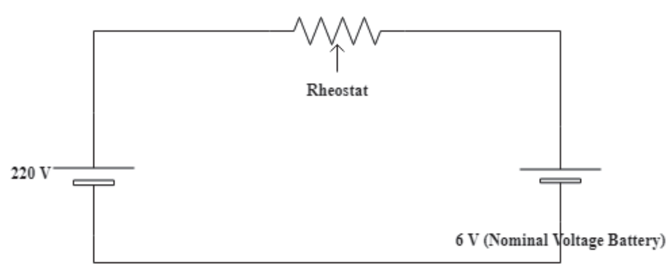

Fig. 16. Constant voltage charging

So, provide 12 Volt Here We Require some voltage drop of dc source for that we connect series rheostatic so it is waste energy 4-volt and 12-volt constant we get o/p.

XI. SIMULATION AND RESULT

- MATLAB simulation of constant current charging method

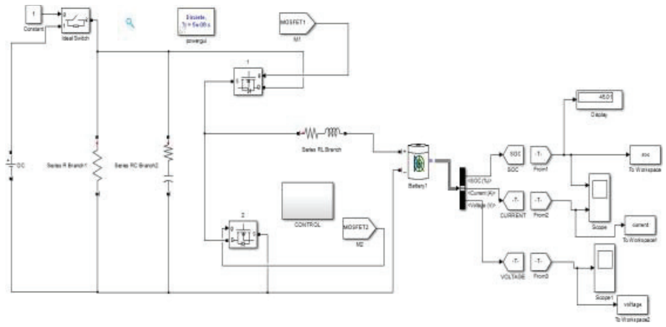

Fig. 17. simulation constant current charging method

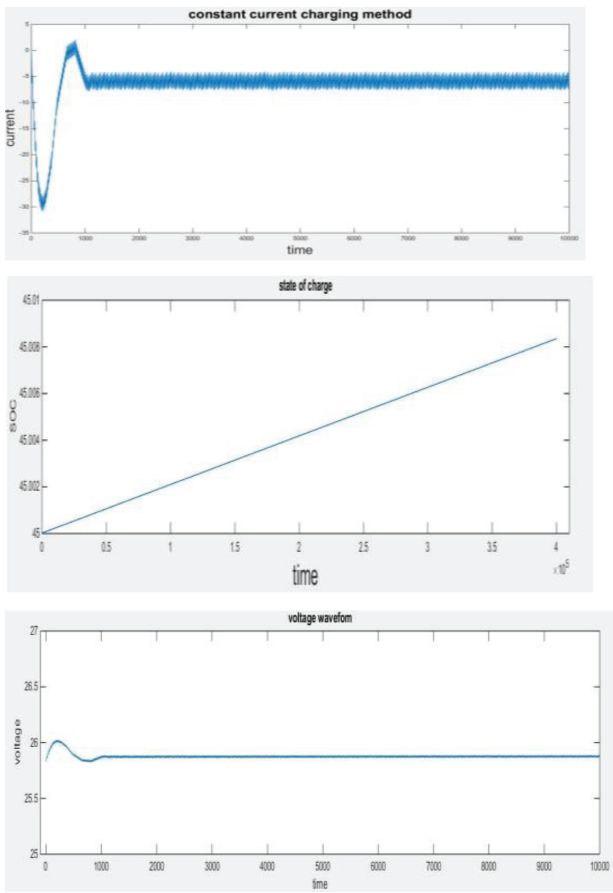

Fig. 18. constant current,soc and voltage waveform

- MATLAB simulation of lithium-ion battery discharge

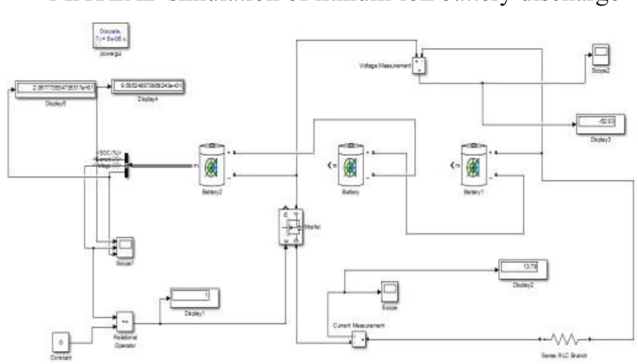

Fig. 19. output value for battery discharge module

- MATLAB simulation of passive cell balancing for batterymanagement

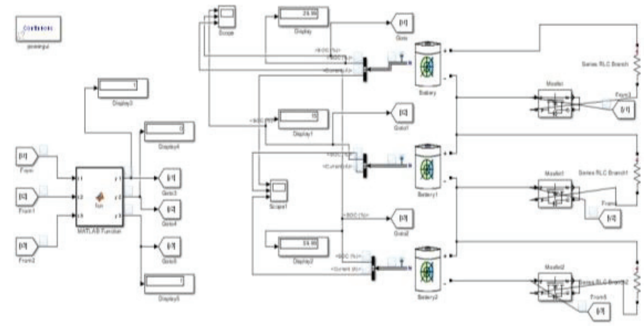

Fig. 20. MATLAB simulation of passive cell balancing

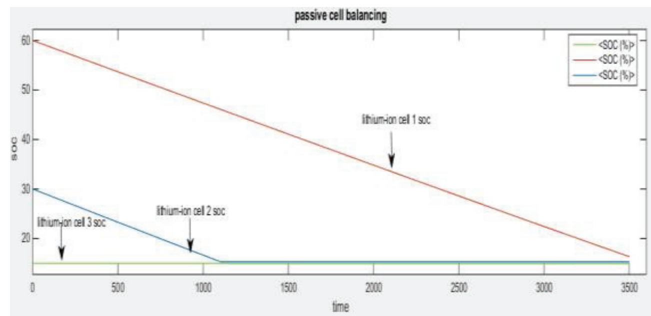

Fig. 21. Output waveform

XII. CONCLUSION

The constant current charging method is compared with the constant voltage charging method. It has been observed that the constant current charging method is the most suitable method for charging lithium-ion batteries. Passive cell balancing simulation results show that both cells are balanced simulation at 3700 seconds by wasting energy through the resistor using MOSFET switching operation. MOSFET switching is faster than IGBT or SCR switching.

FUTURE SCOPE

The world is going to the wireless side so, nowadays modification in the charger as a wireless charger. But in the first stage, not much is implemented in the future.

Automotive, healthcare and manufacturing industries improve the wireless technology to the IoT side.

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