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Passive Cell Balancing Using Arduino

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Abstract— Passive cell measurement system for lithium-ion battery packs designed to resolve the instability of individual cells without the need for complex control systems. Through comprehensive analysis and subsequent optimization of different technologies, the most suitable methods were identified and incorporated into real battery. Performance measurements under various conditions, including security monitoring and thermal management, will show the impact on capacity, energy efficiency and overall reliability. This research aims to extend the life of lithium - ion batteries, reduce maintenance costs and promote energy solutions that benefit the environment and consumers.

Index Terms- BMS, SOC

I. INTRODUCTION

Electric cars are a good alternative to current polluting fossil fuel cars. These electric vehicles consist of some main components: chassis, battery, battery management system (BMS) and driver assistant. The battery is the powerhouse of these vehicles, and protecting the battery is critical as per safety and performance and BMS solves this problem. The main features of BMS, including thermal management, battery monitoring and power limiting. Each cell in the battery pack supports full power. It's important to remember that not all batteries ratings are equal. Batteries with the same body size, chemical composition, and shape produced by the same manufacturer may have different internal dimensions, discharge rates, and capacities. Research also says that each cell has different lifespan hence Cellular measurement is necessary. Batteries with higher SOC experience more stress during charging, while batteries with lower SOC experience more stress during discharging. This must be balanced. Active and Passive are the important techniques of Cell balancing .It particular Emphasis on passive cell equalizing and achieving to balance all cells by reducing the SOC of higher SOC cells, passive cell balancing attempts to redistribute the load to balance the SOC[1]

The battery pack typically contains cells with varied capacities, each linked to distinct states of charge. If there is no cell balancing or charging, the discharge of the battery pack will stop when the lowest capacity of the cell is exhausted or the full battery capacity of the cells equals the weak cells in the battery pack. Therefore, inadequate charging of cells in series will lead to a shortened lifespan of all battery packs. During charging, the battery with high voltage will reach full charge and the indicator will turn off, while the battery with low voltage will not be fully charged.[2] These are undesirable situations because the entire capacity of the battery pack becomes unusable. The internal battery capacity, battery temperature, charge/discharge with equal voltage and aging characteristics lead to situations where the fuel light is uneven.

II. CELL BALANCING METHODS

A. Active cell balancing:

The low voltage on the pack is powered by the high voltage on the battery. In other words, power is transferred from a battery with a higher SOC to lower SOC. Instead of wasting thermal energy, the active cell balancing method uses converters or shuttles to balance the energy levels of cells with different voltages. Charging shuttle technology moves the charges around to balance the battery. Instead, energy is transformed before being transmitted through conductors and transformers.[3]

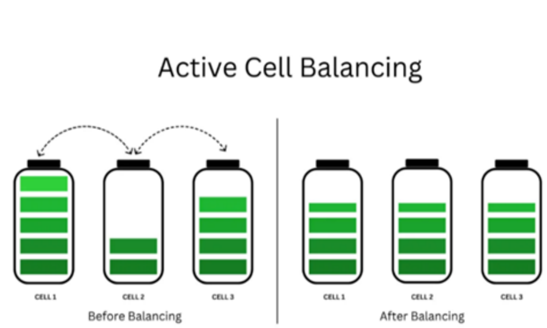

Fig.1 Active cell balancing

B. Passive cell balancing:

Passive cell balancing technique is used to burn excess energy from the high power battery until it is matched or balanced by the lower battery.

Consider the three cells in a battery pack in series: cells 1, 2, and 3. The pre-equilibrium SOC levels of batteries L1, L2, and L3 are 50%, 70%, and 90%, respectively. The balanced cell strategy stabilize the SOC through releasing energy from the high SOC cell and creating each cell with a SOC equal to the lower SOC level of the cell (i.e., the SOC level in cell 2 is 50% of L1).[4] Two different shunt resistance methods can be used for passive cell stabilizers: fixed and variable.

1) FIXED SHUNT RESISTOR METHOD:

Circuit for balancing a fixed shunt resistor cell is shown below. The following V1, V2, V3,... Vn are the voltages of each series-connected cell R1, R2, R3, .. Rn stands for the fixed shunt resistor of each cell.

By connecting the fixed resistor in parallel with each series¬ connected cell in accordance with necessary cell balancing current, this technique balances voltage of each cell. The resistor controls each cell's voltage while dissipating the balancing current.[4]

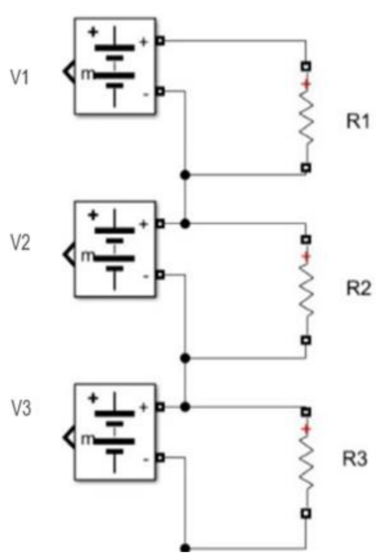

Fig. 2 Fixed shunt resistor cell balancing circuit

This process is appropriate for lead-acid and nickel-cadmium batteries in balancing circuits because they may be overcharged without experiencing any negative effects. Because of its simplicity, this circuit uses fewer components and is less expensive. The disadvantage of this approach is that during the balancing process, energy is lost since it is wasted as heat in all of the cells.

2) SWITCHING SHUNT RESISTOR METHOD:

The diagram below shows the circuit for balancing switching shunt resistor cells. V1, V2, V3,...Vn are used in circuit. These are voltages series-connected cell's and Y1, Y2, Y3, Y4,.. Yn are Electronic switches, and its D1, D2, D3,……Dn are each cell's fixed shunt resistors. Semiconductor switches or relays with controlled on/off capabilities are used to link the resistor in parallel with each cell that is connected in series, this technique balances the voltage of each cell. This approach accurately selects the resistor value depending on the necessary balancing current This method, which is frequently employed for Li-ion battery balancing circuits, is also known as the charge shutdown technique. Compared to a fixed shunt resistor balancing circuit, circuit is more dependable. Additionally, this method reduces energy losses brought on by greater currents running through switches and resistors during balancing operations.[4]

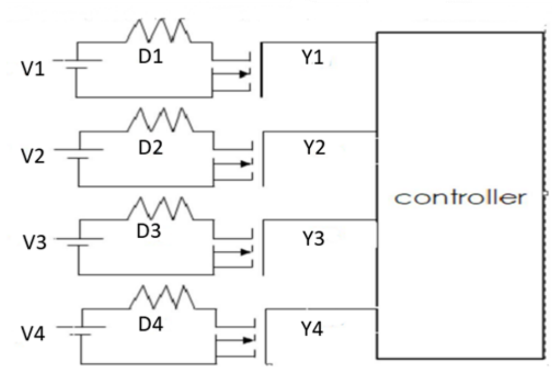

Fig no.3 Switching Shunt resistor method

III. PROBLEM STATEMENT

The battery pack is designed to use three connected lithium-ion cells. SOC of first cell is 78.50% and for second cell 78.50% and for third cell 79.50%. These three cells must have balanced or equal SOC

IV. CONTROL STRATERGY

1.Voltage Sensing: Connect the positive terminal of each battery cell to an analog input pin on the Arduino through appropriate voltage dividers. Read the voltage of each cell using the analog Read function in Arduino.
2.Comparison: Compare the voltage of each cell with a reference voltage (determined by the desired balancing threshold).
3.Activation of Balancing Circuit: If a cell voltage exceeds the reference voltage, activate the corresponding balancing circuit. Use transistors or MOSFETs to control the discharge path through balancing resistors.
4.Balancing Resistors: Connect balancing resistors in parallel with each cell. When activated, these resistors provide a discharge path for the overcharged cell, allowing excess energy to dissipate as heat.
5.Discharge Control: Control the duration and intensity of balancing by adjusting the activation time of the balancing resistors. Monitor the cell voltages continuously and deactivate the balancing circuit when the voltages are within in range.

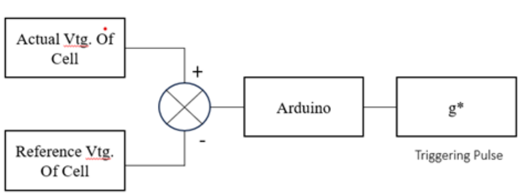

Fig.4 Control strategy

The battery pack will initially be stable, but the SOC balance of the cells will decrease due to temperature, aging, and power cycling. Resistor-based passive cell balancing using resistance and key(switch) to distribute the supply of cells with upmost SOC. During charging, a small amount of energy is used by the max state of charge of battery by applying a small current to ensure that the entire battery is charged to the highest SOC. The extreme path to balance battery packs with uneven SOC is to use shunt resistors. Battery management manages this balance by accepting various devices to drain the battery. The design uses a resistor and switch (in this case a metal oxide silicon filed effect transistor) in parallel with the battery.[5] Passive cell measurement is done using switches and resistors parallel to each cell. The driver drives the gate of the MOSFET. When the operator's output is high, the battery is discharged through the resistor. All battery power is constantly monitored. When the battery with maximum capacity is larger than the battery with minimum capacity, the battery begins to discharge. Consequence of this measurement is heat loss from the battery is not reusable. It does not make any sense. Another disadvantage is the need to constantly monitor each mobile phone. But it operates at minimum battery cell SOC.

V. SIMULATION MODEL

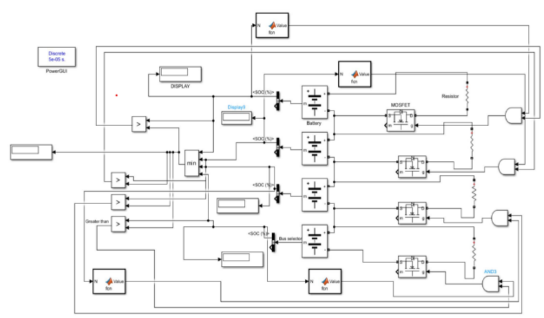

Fig.5Simulink model of passive cell balancing

Fig 4 shows SIMULINK model in MATLAB, battery pack is consist of three cells connected in series with each other as shown in fig.4, In the present paper new control strategy is proposed where MOSFET is used as switch and triggering pulse is developed using Arduino for hardware implementation and for SIMULINK by using M function block and writing script is mentioned below. In fig.4 overall MATLAB model is shown where min and max block is used to get the value of SOC. Logical operators are also used to developed control strategy.

M script code:

```
function [s1s2,s3]= fcn (u1,u2,u3)
u1=int32(u1)
u2=int32(u2)
```

```
u3=int 32(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
    if (u3 = = u2= = u1)
  s1 = 0;
  s2 = 0;
  s3= 0;
    end
```

VI. HARDWARE MODEL

Fig no.6 is the Hardware model of passive cell balancing. In hardware lithium-ion cells are connected to Arduino for taking analog input signals. Arduino is connected to MOSFET for triggering, then Series connected resistors is used to discharge energy from cell .Display is connected to Arduino for giving continuous readings of SOC of all the cells.

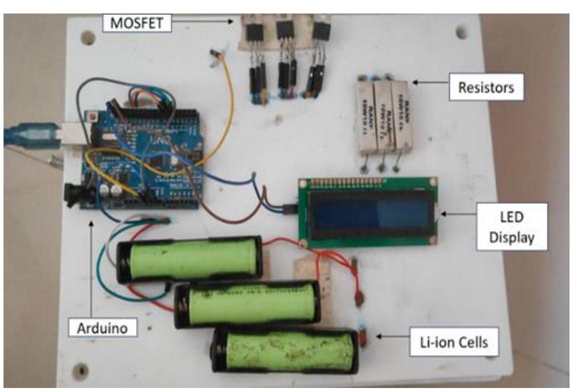

Fig.6.Hardware model of Passive cell balancing

VII. RESULTS

I. SIMULINK RESULTS:

Cell No.	Initial soc	SOC after cell balancing	Time required
Cell 1	30	30	
Cell 2	45	30	300 sec
Cell 3	62	30	640 sec

Table no.1 Simulation Results

II. HARDWARE RESULTS:

Before passive Cell Balancing:

	Cell 1	Cell 2	Cell 3
Voltage (volt)	3.47	3.47	3.48
SOC (%)	78.50 %	78.50 %	79.50%

Table no.2 before cell balancing readings

In table no.2, before passive cell balancing readings of voltage and state of charge of cell1, cell2, cell3 respectively.

After Passive cell Balancing:

	Cell 1	Cell 2	Cell 3
Voltage (volt)	3.47	3.47	3.49
SOC (%)	78.50	78.50	80.50
MATLAB Balancing Time (Min.)	1	1	1
Hardware Balancing Time (Min.)	4	4	4

Table no.3 After Passive cell Balancing

In table no.3 after passive cell balancing readings of voltage, SOC, Simulink balancing time and hardware balancing time.

CONCLUSION

Balancing of lithium-ion cells in battery management system is discussed in this Paper, then different techniques of cell equalizing are covered and mainly focusing on passive balancing. The battery pack having 3 cells connected in series is mentioned. It includes both hardware and MATLAB simulation for Equalizing SOC.

In above Result Table , The first and second cell minimum value of SOC is 78.50%. Third cell SOC is 79.50%. among all three cells third Cell having largest SOC .

MOSFET across Third cell got triggered and start discharging. After 4 minutes all three cells SOC will be equal and balance for the hardware model and in case of MATLAB simulation cell balancing time is 60 sec.

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