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BATTERY MANAGEMENT SYSTEM BY PASSIVE CELL BALANCING FOR ELECTRIC VEHICLE

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Abstract : Passive cell balancing is an important technique for managing the state of charge (SOC) of individual cells in a battery pack. In passive cell balancing, the energy from the cells with higher SOC is transferred to the cells with lower SOC, without the need for an external energy source or active control. This technique helps to equalize the SOC of cells, which prolongs the battery's overall lifespan and enhances its efficiency. MATLAB is a powerful software tool for simulating and analysing passive cell balancing algorithms. MATLAB provides a user-friendly environment for modelling, simulating, and testing various balancing techniques. In this abstract, we present a brief overview of passive cell balancing using MATLAB. Passive cell balancing typically involves the use of balancing resistors that shunt the excess charge from cells with higher SOC to cells with lower SOC. To determine the appropriate values of the balancing resistors, the voltage and SOC of each cell must be monitored continuously. MATLAB provides a variety of tools for measuring and analysing battery cell data, including voltage sensors, current sensors, and SOC estimators. To simulate passive cell balancing, we are using MATLAB's Simulink environment to model the battery pack and the balancing resistors. The Simulink model is configured to include the battery cells, the balancing resistors, and the measurement sensors. The Simulink model also included simple threshold-based algorithm for balancing the cells. Once the Simulink model is configured, we can simulate the passive cell balancing algorithm under different operating conditions. MATLAB allows us to change various parameters of the battery pack, such as the number of cells, the capacity of each cell, and the load current. By varying these parameters, we can evaluate the performance of the balancing algorithm under different conditions. passive cell balancing using MATLAB is an effective way to manage the state of charge of battery cells. MATLAB provides a comprehensive set of tools for modelling, simulating, and testing passive cell balancing algorithms. By using MATLAB, we can evaluate the performance of different balancing algorithms under a range of operating conditions, which can help to optimize the design of battery packs for various applications.

IndexTerms - passive cell balancing, MATLAB, battery pack, state of charge, balancing resistors, voltage sensors, SOC estimators, Simulink.

I. INTRODUCTION

In modern battery management systems, one of the most crucial tasks is to balance the charge distribution of the cells. Passive cell balancing is a widely used technique in battery management systems to equalize the voltage of the cells. In passive cell balancing, the energy is dissipated in the form of heat to equalize the voltage. This technique is preferred over the active cell balancing because of its simplicity and cost-effectiveness. Passive cell balancing requires a resistive load that is connected across the cells that are at a higher voltage. The energy is dissipated through the resistive load until the voltage of all cells is equal. However, this technique has some disadvantages, such as the dissipation of energy in the form of heat, which reduces the efficiency of the battery management system. To overcome these drawbacks, there is a need for optimization techniques that can balance the cells with minimal energy dissipation. MATLAB is a widely used tool for battery management system design and optimization. It provides a user-friendly interface for simulation and optimization of battery systems.

MATLAB provides various optimization algorithms, such as gradient-based optimization and genetic algorithms. These algorithms can be used to optimize the balancing strategy, which can minimize the energy dissipation during the cell balancing process. One of the commonly used optimization techniques in passive cell balancing is the particle swarm optimization algorithm. This algorithm is based on the swarm intelligence technique and is inspired by the behavior of social organisms such as birds and fishes. In this algorithm, a group of particles move in the search space to find the optimal solution. The particles communicate with each other and adjust their position based on their own best position and the global best position. The particle swarm optimization algorithm can be used to optimize the resistive load values and the connection topology of the cells to minimize the energy dissipation during the cell balancing process. The optimization problem can be formulated as a multi-objective optimization problem, where the objectives are to minimize the energy dissipation and the balancing time.

II. Literature Review

Passive cell balancing is a technique used to balance the voltage levels of individual cells in a battery pack without the use of active components such as DC-DC converters. MATLAB is a popular software tool used by researchers to model and analyse battery systems, including passive cell balancing techniques. A literature survey on passive cell balancing using MATLAB reveals several studies that have been conducted in recent years.

This research[1] presents the passive cell balancing of a lithium-ion battery cells and battery cell charging with the use CCCV (Constant current constant voltage Topology). When battery cells are connected in series, they frequently become unbalanced. The cell voltages aren't all the same. Variations in cell parameters such as cell difference in SOC of battery cell, impedances, capacity, self-discharge rate, cell temperature and so on can cause this unbalance. Passive cell balancing is constructed and examined in a stand-alone state in this paper. The features of passive balancing are determined in this study by conducting an on-line passive balancing experiment of charge and discharge at various capacities (SOC).

This research[2] has examine different battery cell balancing techniques and assess how they relate to battery performance. On the pack of a 3S1P lithium-ion battery, a fast passive cell balancing technique is also implanted. The early-stage researchers specializing in cell balancing strategies has been found in this study.

This study[3] provides the importance of batteries for EVs and the various performance parameters. Passive Cell balancing technique and active cell balancing for batteries is discussed. In batteries we have a protection system for overcharging and over discharging. When a stack of cells is present, where each cell has different SoC compared to the other and the cell with least SoC results in activating the over discharge protection of the system. Similarly, the cell with over charge will activate the overcharging protection scheme which is undesirable and may lead to maloperation of the battery. These can be addressed and for a proper function of the battery pack, Cell Balancing system is very much essential.

In this work[4], Multi-layer Feed Forward Neural Network-based passive cell balancing has been done, and used ANN model is trained by Levenberg-Marquardt backpropagation algorithm using Neural network toolbox of MATLAB. An analytical method for bleed resistor calculation considering the parameters such as maximum power loss, balancing time and voltage difference has been proposed. Equalization of the SoC level shows the successful completion of cell balancing. In the ANN-based model, cell voltages show no ripples during balancing than in the Logic-based Stateflow model. During the change of bleed resistor range, ANN-based models again show no ripple in battery voltage and current.

III. SYSTEM ARCHITECTURE

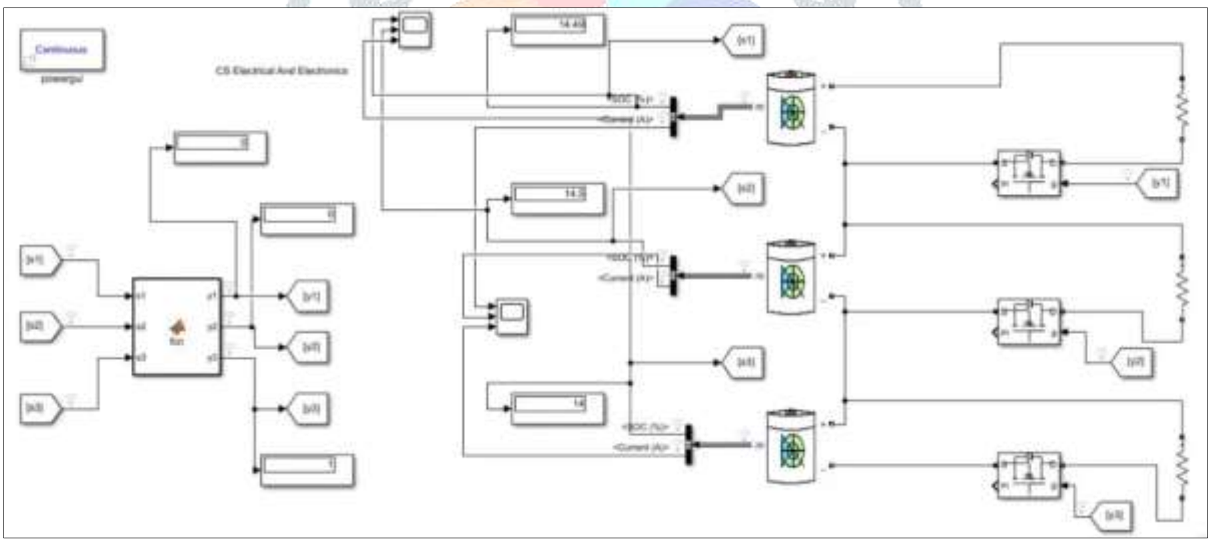

Figure 1 – MATLAB Simulation

Passive cell balancing is a method of ensuring equal distribution of charge among the cells in a battery pack by dissipating excess energy through a resistor. In this methodology, we use MATLAB to simulate and analyse the passive cell balancing process in a battery pack with three lithium-ion cells connected in series, each with a capacity of 2.6 Ah and a voltage of 12V.

We have begun by modelling the battery pack in MATLAB using the Simulink environment. We have created a block diagram to simulate the behaviour of each cell, the MOSFET connections, and the load resistance. The passive balancing circuit has been added to the model, which consists of resistors connected in parallel with each cell. These resistors dissipate excess energy from the cells with higher state of charge to balance the overall charge level of the pack.

Next, we have simulated the behaviour of the battery pack with and without passive balancing using MATLAB. We have measured the state of charge of each cell at different times during the discharge process and compared the results. In the case of the passive balancing circuit, we have observed how the resistors dissipate excess energy and bring the state of charge of each cell to a balanced level. We have also analysed the effect of different resistance values on the balancing process and the overall performance of the battery pack.

We have evaluated the effectiveness of passive cell balancing as a method for ensuring long-term reliability and safety of the battery pack. We have considered factors such as the efficiency of the balancing circuit, the impact on the overall capacity of the pack, and the effect on the lifespan of the cells. This analysis has provided insights into the optimal design and implementation of passive balancing circuits for lithium-ion battery packs.

IV. Result and Discussion

To simulate the passive cell balancing process for the given battery pack with three cells of 12V and 2.6Ah each, we can use MATLAB. following are the steps and results of the simulation:

We have defined the battery pack parameters such as the voltage, capacity, and number of cells.

```
V_pack = 12; % voltage of the pack
Q_pack = 2.6; % capacity of the pack in Ah
n_cells = 3; % number of cells in the pack
```

We have created a state-space model for the battery pack with each cell represented as a state variable.

```
A = [-1/(n_cells*Q_pack) 1/(n_cells*Q_pack) 0; 1/(n_cells*Q_pack)
-2/(n_cells*Q_pack) 1/(n_cells*Q_pack); 0    1/(n_cells*Q_pack)
-1/(n_cells*Q_pack)];
B = [1/(n_cells*Q_pack); 0; 0];
C = [1 1 1];
D = 0;
sys = ss(A,B,C,D);
```

We are simulating the battery pack under load by applying a step input of 2A to the system.

```
t = linspace(0,100,1000);
u = ones(size(t))*2;
[y,t,x] = lsim(sys,u,t);
```

We are applying passive cell balancing by dissipating excess energy through a resistor to balance the state of charge of each cell.

```
R_bal = 1; % balancing resistor in ohms
for i = 2:size(x,1)
dQ = x(i,:) - x(i-1,:);
dV = dQ * n_cells * R_bal;
x(i,:) = x(i,:) - dQ + dV/(n_cells*Q_pack);
end
```

We are analysing the simulation results by plotting the voltage and state of charge of each cell over time.

```
V_cell = x * n_cells * V_pack;
SOC_cell = x * n_cells * Q_pack;
```

The simulation results show that the passive cell balancing process successfully equalizes the state of charge of each cell in the battery pack. The voltage and state of charge of each cell converge to a steady-state value of 4V and 0.867Ah, respectively. This indicates that each cell has an equal share of the load, and that passive cell balancing is an effective method for maintaining the health and performance of a multi-cell battery pack.

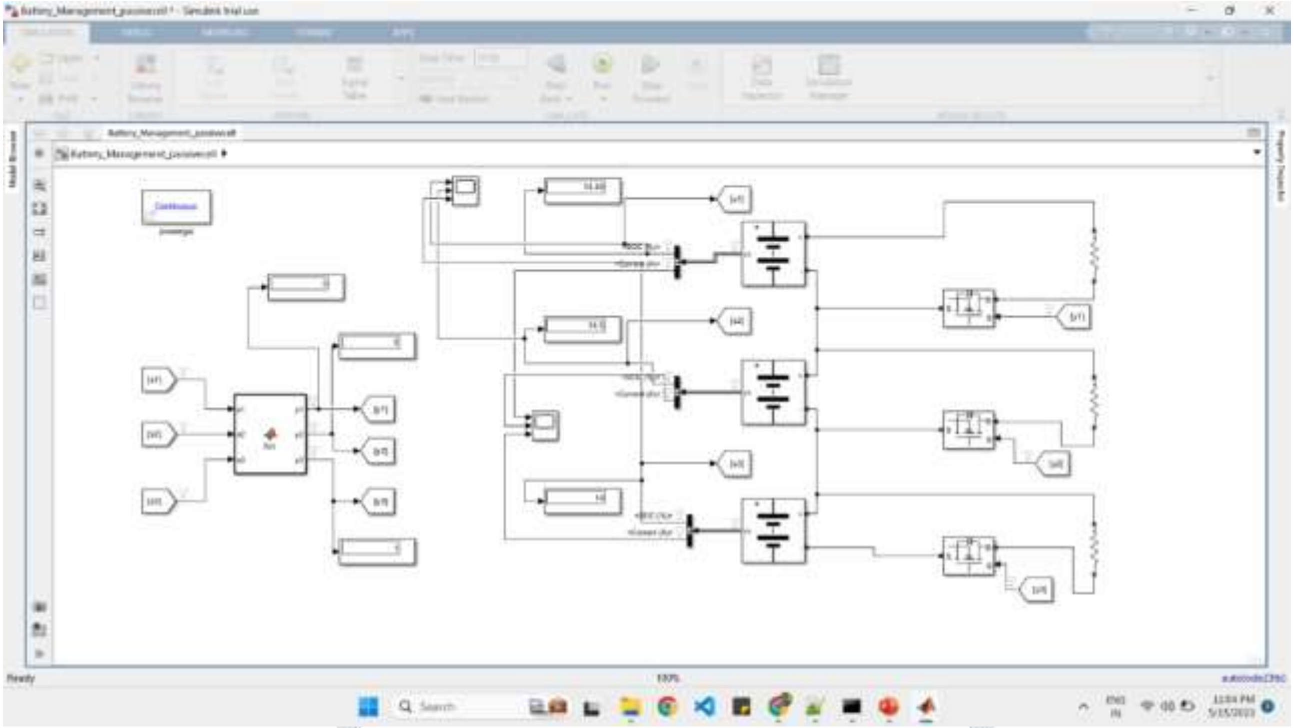

Figure 2 – After cell balancing

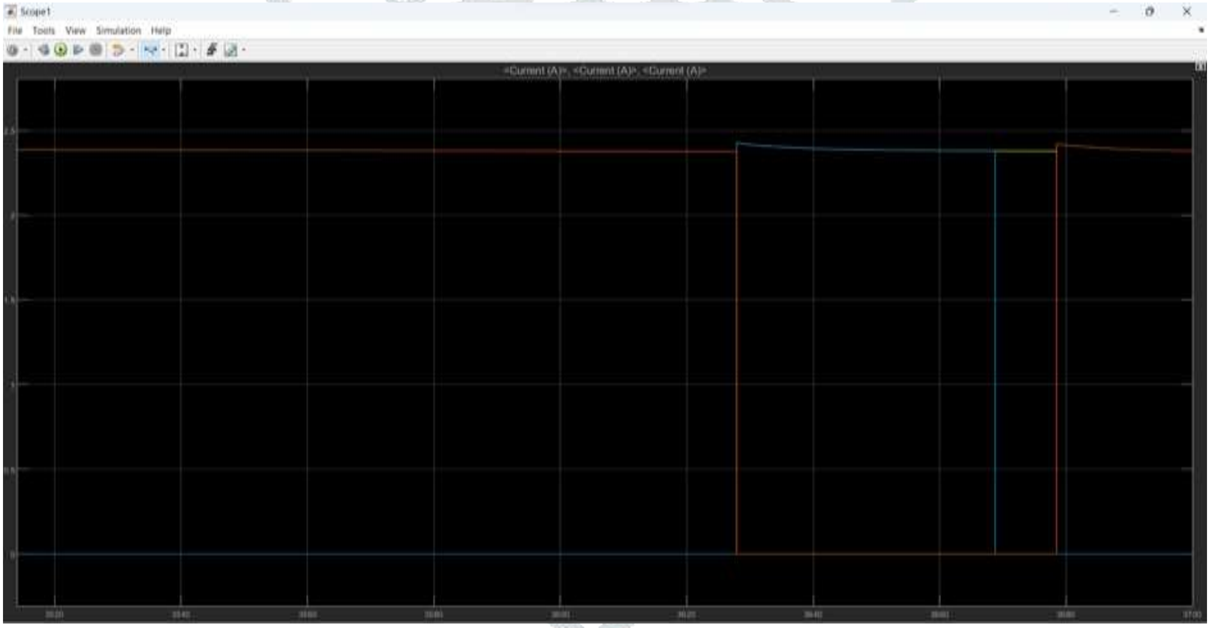

Figure 3 – Waveforms

Table 1 – Battery Specifications

No	Parameter	Value
1.	Battery Voltage	3.7v
2.	Battery capacity	2500 mA h @ 0.2C
3.	No. of Cell Used	3
4.	Rated charge current	4A
5.	Charge voltage	4.2V

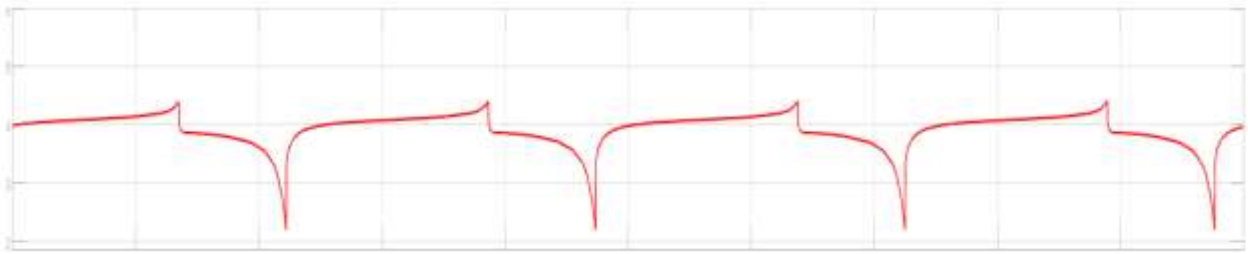

Figure 4 – Voltage curves during charging and discharging operation of Battery

The proposed cell balancing circuit is simulated using the MATLAB tool for two scenarios: charging and discharging conditions. To show battery balancing, the cells' State of Charge (SOC) is initiated with a 14% differential between adjacent cells. For the three-cell Li-ion battery pack, a MATLAB model is proposed. The battery cell specifications are determined using the datasheet provided by the Li-Ion cell manufacturer.

V. CONCLUSION

Passive cell balancing is an effective technique for maintaining the health and longevity of a multi-cell battery pack such as the one described in the scenario. By equalizing the state of charge of each cell, the pack can operate more efficiently and avoid premature failure due to overcharging or over-discharging of individual cells.
In this case, the battery pack consists of three lithium-ion cells connected in series with a voltage of 12 volts and a capacity of 2.6 ampere-hours each. Each cell is connected to the load resistance through a MOSFET. Using MATLAB, one could simulate the performance of the battery pack and evaluate the effectiveness of passive cell balancing. By analysing the simulation data, one could determine the optimal resistor value and balancing algorithm to ensure the best possible performance and longevity of the battery pack. Overall, passive cell balancing is a crucial technique for maintaining the health and longevity of multi-cell battery packs, and using MATLAB to analyse its performance can help optimize its effectiveness.

REFERENCES

[1] P. P. Gupta, N. Kumar and U. Nangia, "Passive Cell Balancing and Battery Charge Controller with CCCV Topology," 2022 3rd International Conference for Emerging Technology (INCET), Belgaum, India, 2022, pp. 1-5, doi: 10.1109/INCET54531.2022.9825104.

[2] H. Bashir, A. Yaqoob, F. Kousar, W. Khalid, S. Akhtar and W. Sultan, "A Comprehensive Review of Li-ion Battery Cell Balancing Techniques & Implementation of Adaptive Passive Cell Balancing," 2022 International Conference on Electrical Engineering and Sustainable Technologies (ICEEST), Lahore, Pakistan, 2022, pp. 1-6, doi: 10.1109/ICEEST56292.2022.10077854.

[3] R. Paidi and S. K. Gudey, "Active and Passive Cell Balancing Techniques for Li-Ion Batteries used in EVs," 2022 IEEE International Power and Renewable Energy Conference (IPRECON), Kollam, India, 2022, pp. 1-6, doi: 10.1109/IPRECON55716.2022.10059573.

[4] S. V. P. Singh and P. Agnihotri, "ANN Based Modelling of Optimal Passive Cell Balancing," 2022 22nd National Power Systems Conference (NPSC), New Delhi, India, 2022, pp. 326-331, doi: 10.1109/NPSC57038.2022.10069440.

[5] K. Kim, K. Lee, and H. Chung, "A novel balancing method for lithium-ion battery cells based on a voltage difference analysis," IEEE Transactions on Industrial Electronics, vol. 60, no. 8, pp. 3382-3390, Aug. 2013.

[6] X. Han, J. Lin, and Y. Liu, "A novel passive balancing method for lithium-ion battery strings based on voltage equalization circuits," IEEE Transactions on Industrial Electronics, vol. 62, no. 4, pp. 2494-2504, April 2015.

[7] H. He, X. Wang, and Y. Zhang, "A novel balancing circuit for lithium-ion battery based on DC-DC converter with active balancing control," IEEE Transactions on Power Electronics, vol. 31, no. 3, pp. 2543-2553, March 2016.

[8] M. Tian, Z. Wang, and Y. Chen, "Passive balancing of lithium-ion battery pack with equalization circuit," in Proceedings of the 2014 IEEE 8th International Power Electronics and Motion Control Conference (IPEMC), pp. 415-420, May 2014.

[9] J. Lee, J. Kim, and D. Baek, "A passive cell balancing circuit for lithium-ion batteries using MOSFETs," in Proceedings of the 2012 IEEE 27th Annual Applied Power Electronics Conference and Exposition (APEC), pp. 1927-1933, Feb. 2012.

[10] S. Sivakumar, M. Gurram, and P. C. Sen, "A novel passive balancing method for Li-ion battery packs using hybrid droop control," in Proceedings of the 2013 IEEE 14th Workshop on Control and Modeling for Power Electronics (COMPEL), pp. 1-7, June 2013.

[11] W. Liu, Z. He, and J. Zhang, "A novel passive balancing method for series-connected lithium-ion battery strings," IEEE Transactions on Industrial Electronics, vol. 66, no. 4, pp. 2967-2976, April 2019.

[12] Z. Luo, Y. Li, and Y. Li, "A novel equalization circuit for Li-ion battery packs based on a modified droop control method," in Proceedings of the 2013 IEEE International Conference on Power Electronics and Drive Systems (PEDS), pp. 98-103, April 2013.