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**Research Paper**

# SIMULATION OF PASSIVE CELL BALANCING FOR BATTERY MANAGEMENT

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**Abstract—** This project explores the application like electric vehicles and renewable energy storage, battery management systems (BMS) are crucial for preserving the effectiveness, durability, and safety of battery packs. Cell balancing, which balances charge levels among individual cells to avoid overcharging and deep discharging, is one of a BMS's primary functions. The cost-effective technique of passive cell balancing, which uses resistors to discharge surplus energy from higher-charged cells as heat, is the subject of this paper. A passive balancing circuit is modelled using MATLAB simulation in order to examine the balancing procedure, voltage fluctuations, energy dissipation, and overall efficacy. The findings show that although passive balancing successfully lowers voltage differentials between cells, heat dissipation causes energy losses. Cell balancing, which balances charge levels among individual cells to avoid overcharging and deep discharging, is one of a BMS's primary functions. The cost-effective technique of passive cell balancing, which uses resistors to discharge surplus energy from higher-charged cells as heat, is the subject of this paper. A passive balancing circuit is modelled using MATLAB simulation in order to examine the balancing procedure, voltage fluctuations, energy dissipation, and overall efficacy. The findings show that although passive balancing successfully lowers voltage differentials between cells, heat dissipation causes energy losses.

**Keywords:** Renewable Energy Storage Systems, Consumer Electronics, Medical Devices, Battery Development and Testing

## 1. INTRODUCTION

Modern energy storage systems rely heavily on battery technology, which powers everything from portable gadgets to renewable energy storage and electric vehicles (EVs). Maintaining a consistent charge distribution across each cell in a battery pack is one of the major issues in battery management. Unbalance caused by variations in cell capacity, internal resistance, and charge/discharge rates can shorten lifespan and overall efficiency. Battery management systems (BMS) use cell balancing approaches to solve this problem. These methods aid in balancing the charge levels of cells, guaranteeing peak performance and averting hazards like deep discharging or overcharging. Passive cell balancing is a popular technique in low- to medium-power applications because it is straightforward and reasonably priced compared to other balancing techniques.

By using resistors to dissipate excess energy from higher-charged cells as heat, passive cell balancing works. Despite being simple and cost-effective, this method has inherent energy losses because the energy that is lost cannot be retrieved or used again. When cost considerations exceed efficiency concerns, passive balancing is still a feasible option in spite of this drawback. Compared to active balancing

techniques, passive balancing is easier to install and requires less control circuitry and fewer components. To avoid overheating, especially in large-scale battery packs, the increased thermal dissipation calls for appropriate thermal management. A number of variables that affect the overall performance of the battery pack, including the balancing current, resistor levels, and balancing duration, affect how successful passive balancing is.

Electrical systems, particularly battery management techniques, are frequently modelled and analysed using MATLAB, a potent simulation tool. Engineers can examine how various parameters affect charge equalisation, energy loss, and balancing efficiency by modelling passive cell balancing in MATLAB. The simulation sheds light on the amount of time needed to reach equilibrium, the degree of energy dissipation, and the efficiency of various resistor arrangements. Additionally, by enabling parameter changes without the need for physical prototype, MATLAB simulations aid in the optimisation of the balancing circuit design while cutting down on development time and expense. In order to better understand the benefits and drawbacks of passive balancing circuits in practical applications, this study uses MATLAB to simulate and assess their behaviour.

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Even though passive balancing is frequently used, it's crucial to evaluate its viability for various applications by contrasting it with other balancing strategies. By reducing energy loss, active balancing techniques—which entail moving extra energy from overloaded cells to lower-charged ones—offer greater efficiency. These techniques are more expensive and more difficult to use since they call for intricate circuitry, such as inductors, capacitors, and control electronics. To strike a compromise between cost and efficiency, hybrid balancing strategies—which incorporate aspects of both passive and active balancing—are being investigated. By understanding the trade-offs between these methods, engineers can select the most appropriate balancing strategy based on the specific requirements of a battery system.

Passive cell balancing in MATLAB ensures equal battery cell voltages by dissipating excess energy as heat using resistors. The process begins by measuring cell voltages and identifying the highest one. If a cell exceeds a predefined threshold, a resistor is activated to discharge it until balance is achieved. This cycle repeats until all cells reach equilibrium. The flowchart follows these steps: **Start** → **Measure Voltages** → **Identify Highest Voltage Cell** → **Activate Resistor** → **Monitor and Repeat** → **End**. MATLAB simulates this process using logical conditions to control resistors, ensuring safe and efficient battery performance. This method is simple but results in energy loss as heat, making it suitable for low-power applications where efficiency is less critical.

### 1.1 OBJECTIVES OF THE PAPER

This project's main goal is to use MATLAB simulation to install and analyse passive cell balancing in order to increase battery packs' longevity and performance. In order to assess the efficacy of passive balancing, this study will build a battery pack with unbalanced cells and simulate the procedure. It focusses on examining important factors including energy dissipation, voltage fluctuations, and balancing time. The initiative also aims to examine the cost, complexity, and efficiency of active and passive balancing strategies. Optimising resistor values and balancing circuits to maximise performance and reduce thermal losses is another goal. Finally, this study contributes to the creation of effective and affordable battery management systems by shedding light on the viability of passive balancing for various applications.

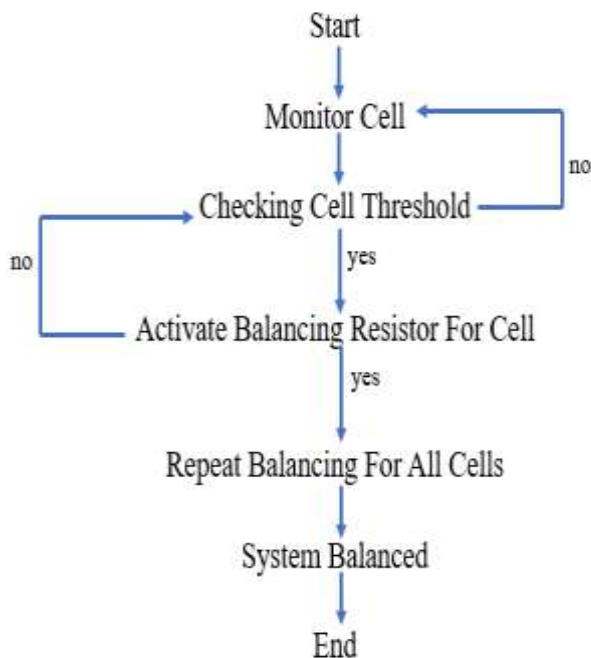


Fig:1.1: Flow Chart

### II.METHODOLOGY

This project's methodology entails using MATLAB simulation to implement and analyse passive cell balancing. Creating a mathematical model of a battery pack with several cells with different initial states of charge (SOC) is the first stage. Important aspects including internal resistance, cell voltage, and self-discharge properties are included in this model. The simulation framework is designed using MATLAB Simulink and includes passive balancing circuits made up of resistors that release surplus energy as heat. A thorough examination of the effectiveness of passive balancing is made possible by the model's incorporation of real-world variables including energy losses and balancing time.

After the battery model is constructed, MATLAB Simulink is used to design a passive balancing circuit. To release extra energy from higher-charged cells, this circuit uses balancing resistors connected in parallel with each cell. In order to minimise needless energy dissipation and

maximise the balancing process, the resistance levels are carefully chosen. A battery management system (BMS) model is then integrated with the circuit to track SOC levels and cell voltages. To determine how different resistor configurations and balancing currents affect the overall system performance and energy efficiency, tests are conducted.

The next stage is to perform simulations to see how the passive balancing process behaves over time. Important variables are noted, including heat dissipation, balancing time, and voltage equalisation rate. The effectiveness of the passive balancing technique in maintaining uniform charge distribution among the cells is assessed by analysing the results. Additionally, balancing currents and energy dissipation patterns may be visualised using the MATLAB simulation, which offers important insights into how the system behaves under various operating situations.

The trade-offs between passive and active cell balancing strategies are then evaluated using a comparative study. To illustrate the benefits and drawbacks of active balancing techniques, which reroute excess energy to lower-charged cells instead of releasing it as heat, a brief model is created. Efficiency, cost, implementation complexity, and applicability for various applications are the main topics of the comparison. Despite its energy losses, this research aids in identifying situations in which passive balancing is a more sensible option.

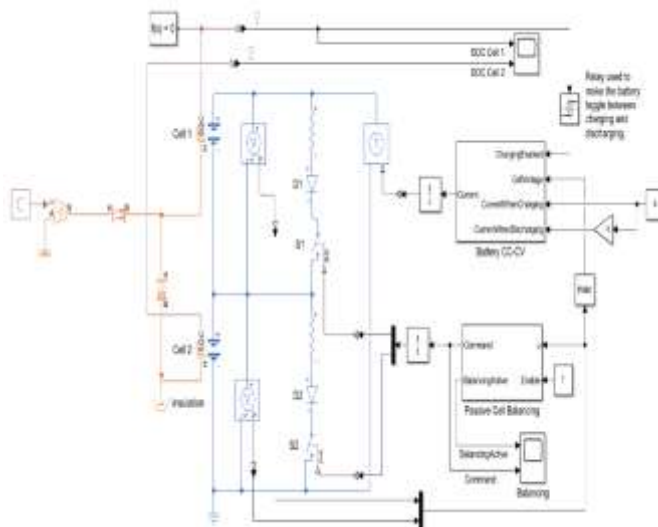
Resistors and balancing thresholds are among the design characteristics that are changed to further optimise the passive balancing technique. To determine the most effective arrangement, the effects of various balancing techniques on battery pack performance are examined. Thermal management issues are also covered to make sure that too much heat produced during passive balancing doesn't compromise the safety and health of batteries. The results of these optimisation attempts aid in improving the balancing method for real-world application.

The project culminates with a thorough assessment of passive balancing's performance in practical applications. In order to advise battery system designers on the viability of passive balancing in different use situations, the simulation results are analysed. Potential advancements for the future are also covered in the paper, including hybrid balancing strategies that incorporate aspects of active and passive techniques. This study advances the creation of more economical and effective battery management solutions by utilising MATLAB simulation.

The creation of a battery pack mathematical model is the first step in this project's modelling and simulation of passive cell balancing. To replicate imbalances found in the real world, the model simulates a sequence of lithium-ion cells with varying beginning states of charge (SOC). Nominal voltage, internal resistance, capacity, and self-discharge rate are characteristics of each cell. MATLAB Simulink, which offers a framework for modelling electrical circuits and battery management techniques, is used to model the battery pack. Variations in cell characteristics and the effect of passive balancing on the equalisation of charge distribution over time are taken into consideration in the simulation.

Parallel resistor networks are used in the construction of a balancing circuit to provide passive cell balancing. A resistor that dissipates excess energy from overcharged cells as heat is linked to each cell in the battery pack. The intended balancing current and power dissipation limits are taken into consideration while choosing the resistor values. A control mechanism that keeps an eye on the voltage variations between cells and initiates the balancing procedure when required is also included in the model. This circuit can be incorporated into the battery pack model so that the simulation can examine how well passive balancing lowers differences in cell voltage and enhances charge uniformity.

The balancing process is seen over a predetermined length of time by running the MATLAB simulation. The model monitors important variables such SOC levels, energy dissipation, balancing currents, and cell voltages. The simulation results provide light on the rate at which charge levels are equalised by passive balancing as well as the magnitude of energy loss from heat dissipation. To assess their effects on the system's overall efficiency, different scenarios are explored by adjusting the resistor values, balancing thresholds, and initial cell imbalances. This step helps in understanding the limitations and advantages of passive balancing.



### III.MODELLING AND SIMULATION

Fig.1.2: Simulink model of Passive Cell Balancing

Analysing the thermal consequences brought on by energy dissipating as heat is an essential component of the simulation. Excessive heat generation could be problematic since passive balancing constantly drains surplus charge through resistors, particularly in big battery packs. To estimate temperature rise in balancing resistors and determine whether additional cooling devices are required, the MATLAB model integrates thermal analysis. The simulation aids in the design of a system that reduces overheating while preserving efficient charge equalisation by balancing currents and optimising resistor values.

The simulation enables a comparison with active balancing methods in addition to isolated passive balancing. For performance comparison, active balancing models are used, which move energy between cells instead of releasing it as heat. Time balance, energy efficiency, and cost consequences are among the key performance factors that are assessed. The trade-offs of passive and active balancing techniques are better understood thanks to this comparison analysis, which aids in choosing the best strategy for various battery applications.

Lastly, the simulation's outcomes are examined and verified to determine how well passive cell balancing works. To increase balancing efficiency, the results are utilised to recommend design enhancements such resistor value optimisation and control logic refinement. A reliable framework for testing various balancing solutions prior to physical implementation is provided by the MATLAB-based simulation, which lowers development costs and increases design accuracy. Future investigations into hybrid balancing strategies that combine the advantages of passive and active approaches for the best battery performance can build on the findings of this study.

### 3.1 Efficiency and Power Losses

Energy dissipation as heat is the main factor limiting the effectiveness of passive cell balancing, which leads to intrinsic power losses. By draining excess energy through resistors, passive balancing lowers system efficiency as a whole. This method's power loss is proportional to the circuit's resistance value and the voltage differential between cells. Passive balancing equalises charge levels and stops cell deterioration, although it costs energy that could be used for other purposes. In order to prevent overheating, thermal management systems could also be necessary when excessive heat generation occurs. Despite these drawbacks, passive balancing remains a viable option for applications where cost and simplicity outweigh efficiency concerns. Optimizing resistor values and balancing current can help minimize power losses while maintaining effective charge equalization in battery packs.

## IV.SIMULINK RESULTS

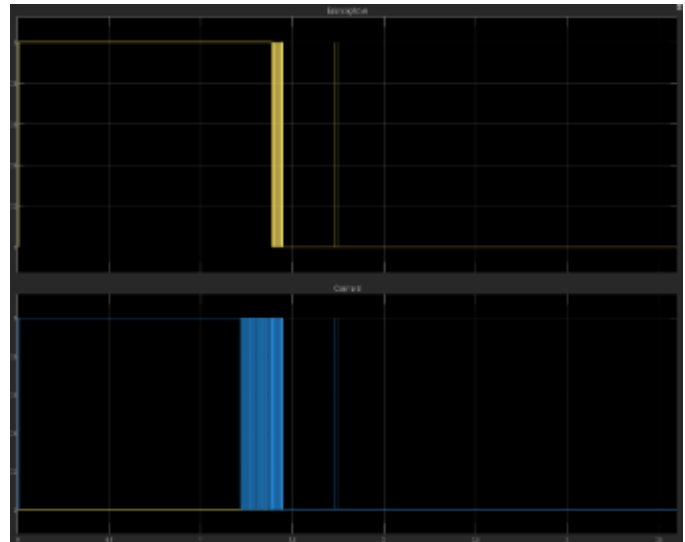


Fig.1.3: Cell Balancing Waveform

Here in the figure 5.3 The MATLAB Simulink results of passive cell balancing is shown and it offers important information about how well this method equalises cell voltages in a battery pack. A battery pack with several cells in different initial states of charge (SOC) is used to start the simulation. Successful charge redistribution is shown by a gradual decrease in the voltage differences across cells as the balancing process goes on. Individual cell voltage curves are tracked, demonstrating a consistent drop in higher-charged cell voltages as a result of energy dissipation via balancing resistors. The findings also show that the resistor values and beginning imbalance levels affect how long it takes to reach full balance; lower resistance values result in faster balancing but higher energy dissipation.

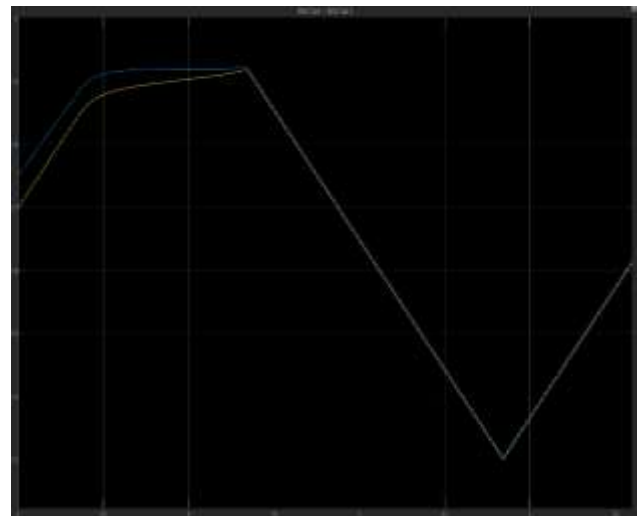


Fig.1.4: Stabilizing of SOC levels

Passive balancing's power loss is another significant finding from the Simulink results. The simulation monitors energy losses and calculates the thermal impact on the system because surplus energy is released as heat. According to the power dissipation graphs, the first phase of balancing, when the voltage discrepancies are greatest, is when most energy loss takes place. Heat generation is reduced as the cells get closer to equilibrium because of a decrease in power dissipation. To balance speed and efficiency, resistor values must be carefully chosen because cumulative power losses in big battery packs can be substantial. Overall, the findings show that although passive balancing equalises cell voltages adequately, it is less efficient than active balancing techniques.

#### IV. CONCLUSION

Maintaining a consistent charge distribution in battery packs may be done easily and affordably with passive cell balancing utilising MATLAB simulation. The Simulink results show that passive balancing improves battery longevity and dependability by successfully reducing voltage imbalances between cells. Energy dissipation as heat, which results in efficiency losses and possible thermal management issues, is the method's main disadvantage. The study emphasises that resistor levels and beginning charge variances affect balancing speed, necessitating careful optimisation for real-world uses. Active balancing is still a preferred option for high-efficiency systems, even though passive balancing works well for low-cost applications where simplicity is valued. All things considered, MATLAB-based simulation is a useful tool for evaluating and refining passive balancing techniques, which aids in the creation of effective battery management systems.

#### V. FUTURE SCOPE

The goal of passive cell balancing in the future is to maximise its effectiveness while reducing energy losses. To increase energy efficiency while lowering costs, research can concentrate on creating hybrid balancing strategies that blend passive and active approaches. Battery management systems (BMS) can incorporate sophisticated control algorithms that use machine learning (ML) and artificial intelligence (AI) to dynamically predict and optimise balance tactics. Efficiency can also be increased by using energy recovery circuits rather than basic resistors. To address heat dissipation problems, more research can examine materials with superior thermal characteristics. Real-world situations, such as various battery chemistries and extensive energy storage applications, can be modelled using MATLAB models. These developments will increase the viability of passive balancing in energy storage systems of the future.

#### REFERENCES

1. Battery Management Systems: Design by Modelling" by J. Marco, A. Simon, and S. D. John (Springer, 2020).
2. "Simulation and Modelling of Lithium-Ion Batteries Using MATLAB/Simulink" by J. Liu, M. Pecht (Wiley, 2017).
3. "MATLAB/Simulink for Digital Signal Processing" by A. K. Pal, A. S. N. (CRC Press, 2016).
4. "Battery Management Systems for Large Lithium-Ion Battery Packs" by D. P. H. Jones (Wiley, 2015).
5. "Passive and Active Cell Balancing for Lithium-Ion Battery Packs" by M. A. R. Hassan, A. T. B. Aziz (IEEE Transactions on Industrial Electronics, 2018).
6. "Simulation-Based Design for Power Electronics Systems: MATLAB/Simulink Approach" by F. C. Lee, R. T. B. Johansen (Academic Press, 2018).
7. Chen, M., & Rincon-Mora, G. A. (2006). Accurate electrical battery model capable of predicting runtime and I-V performance. *IEEE Transactions on Energy Conversion*, 21(2), 504-511.
8. Rahman, M. A., Imtiaz, S. A., & Dey, S. (2019). Passive and active cell balancing techniques for lithium-ion battery: A comparative study. *Journal of Energy Storage*, 23, 447-456.
9. Kim, J., Lee, S., & Cho, B. H. (2011). Complementary control of active and passive balancing circuits for lithium-ion batteries. *IEEE Transactions on Power Electronics*, 27(1), 436-447.
10. MATLAB Simulink Documentation. (2024). *Battery Modeling and Simulation in Simulink*. Retrieved from [www.mathworks.com](http://www.mathworks.com)
11. Dubarry, M., & Devie, A. (2018). Battery cell balancing: How to do it and is it worth it? *Journal of Power Sources*, 396, 246-252.
12. Chaturvedi, N. A., Klein, R., Christensen, J., Ahmed, J., & Kojic, A. (2010). Algorithms for advanced battery management systems. *IEEE Control Systems Magazine*, 30(3), 49-68.
13. Omar, N., Monem, M. A., Hegazy, O., & Van Mierlo, J. (2014). Lithium-ion battery management systems: State-of-the-art review and future trends. *Renewable and Sustainable Energy Reviews*, 61, 478-500.