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Micro short circuit fault diagnosis in Li-ion cell

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ABSTRACT

Micro short circuits (MSCs) in lithium-ion battery cells are a critical safety concern, potentially leading to thermal runaway, internal short circuits, overheating, and battery degradation. Compared to normal cells, MSC fault cells exhibit reduced capacity with each charge-discharge cycle and an increasing state of charge (SOC) deviation over time. To differentiate normal cells from MSC fault cells, a fault diagnosis method based on remaining charge capacity (RCC) estimation is proposed. After each charge-discharge cycle, the cell's RCC is compared to a safe threshold value. The method uses the charge cell voltage curve (CCVC) of a fully charged reference cell to estimate RCC via standard CCVC hypothetical conversion. This approach's accuracy is validated in constant power and constant current charging scenarios. MSC leakage current is calculated by incrementing RCC after each charge, and then converted to MSC resistance. A MATLAB/Simulink model of a battery pack with an MSC fault was developed to test the method across various charge cut-off voltages. The diagnostic procedure's applicability to ageing cells, constant power, and multi-step charging is further confirmed through experiments with external resistance, enhancing MSC detection before thermal runaway becomes unmanageable.

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1. INTRODUCTION

High energy density, high power density, and extended lifespan, Li-Ion batteries have established themselves as the industry standard for electric vehicles (EVs). Since the late 1990s, demands from mobile devices, laptops, computers, mobile phones, and power tools have driven developments in lithium-ion rechargeable batteries. The battery electric vehicle (BEV) and hybrid electric vehicle (HEV) markets have benefited from these improvements in efficiency and energy density.

Battery energy storage efficiently balances supply and demand in real-time to facilitate the integration of renewable energy sources and stabilize the electric grid. In densely populated urban areas, where traditional storage techniques like compressed-air energy storage and pumped hydroelectric energy storage are typically impracticable, the value of such storage is particularly significant [1]-[5]. A battery pack's several defects must be diagnosed carefully because they often share the same traits [6]-[12]. It describes a hybrid approach for diagnosing sensor, relay, and cell parametric problems in a Li ion battery pack. By incorporating an equivalent circuit model (ECM) into hybrid automata, multi-fault detection and isolation are made possible. Utility-scale battery energy storage systems (BESS) are being used in many different projects all over the world [13], [14]. Finding defective battery cells is crucial for ensuring dependable and secure operation. This research suggests an understandable technique for Utility-Scale BESS faulty cell identification. There are many projects all around the world using Utility-scale battery energy storage systems (BESS) [15]-[18]. Finding faulty battery cells is of utmost importance for ensuring dependable and secure operation. In this study, a clear approach to faulty cell identification for Utility-Scale BESS is proposed.

In lithium-ion batteries, the capacity and resistance of the entire cell will decrease due to an ageing mechanism [19]. The detection of the voltage sensor and status of charge faults in an electric vehicle is proposed using an adaptive observer. A Li ion cell has been used in certain simulations to show how well the suggested approach works. The performance and safety of the battery are in danger due to several defects in the lithium-ion battery system [20]. Early defects are challenging to identify, and false alarms can happen because of the faults' shared characteristics. The merging of model-based and entropy approaches forms the basis of a suggested online multi-fault diagnosis strategy. Numerous Li-ion battery-related mishaps are frequently attributed to internal short circuits [21]. It is suggested to use a revolutionary technique based on an advanced machine learning methodology to detect internal short circuits in real time. The testing dataset's fault detection accuracy is shown to be greater than 97%. In power batteries, micro-short circuit (MSC) is a hidden risk that could result in thermal runaway and possibly catastrophic safety risks. MSC can initially be quantitatively examined, especially for lithium-ion batteries. The suggested technique has a minimal computational load for the state of charge (SOC) difference and short circuit resistance diagnosis. The safety of battery packs depends on the quick detection of micro-short circuit cells [15]-[17]. We discovered that terminal voltage differences can be roughly translated into open-circuit voltage differences by passing terminal voltage differences through low-pass filters. We use simulation data to confirm and evaluate the viability of the diagnosis approach. Battery packs may be at risk of micro short circuit (MSC) in lithium-ion battery cells.

A challenging issue is how to locate the cell with MSC in the latent phase before a thermal runaway occurs. We provide a method for diagnosing the MSC based on differences in the remaining charging capacities of the cells. The primary barrier to the widespread use of lithium-ion batteries in electric cars is thermal runaway [18]. The disintegration of the battery's component materials takes place during the chain reactions that make up the thermal runaway mechanism. In thermal runaway, requires thorough understanding. To know how to use an internal short-circuiting device to start a thermal runaway under control and on demand [19]. The talk was about ways to make 18650 batteries and cells safer. If it occurs in a battery pack or battery cell, it could have negative effects for electric car applications. [30]-[32]. Internal short circuits frequently cause thermal runaways (ISC). At the early latent phase, when a significant temperature rise on the battery surface of the cell is not yet detectable, ISCs are found in this study. Here, incremental capacity analysis (ICA) and differential voltage analysis are used to evaluate onboard battery SOC and capacity (DVA) [20], [21]. Traditional ICA/DVA systems that rely on cell terminal voltage are vulnerable to changes in battery resistance and polarization that occur during battery ageing processes. Results are promising, with a relative error of 2.0% and a maximum absolute error of 1.0%. Experimental research is done on the lithium-ion battery's external short circuit (ESC) failure characteristics [22]-[25]. It demonstrates that the issue may be identified in less than 5 seconds, with a model–measured data error of less than 0.36 V. Even with a 10% inaccuracy in SOC estimation, the suggested algorithm can still diagnose the problem correctly.

Lithium-ion batteries, in contrast to earlier battery chemistries like nickel-cadmium, can be discharged and recharged frequently and at any charge level. Most electric vehicles, including plug-in hybrids, use these lithium-ion batteries. The quick detection and diagnosis of issues is essential for the safe operation of battery packs in electric cars. To avoid major failures and enhance Li-ion battery maintenance schedules, innovations in prognostics and monitoring systems of Li-ion packs are needed, with a focus on problem diagnosis, rectification, and remaining-useful-life- life prediction. In this study, the remaining charge capacity (RCC) is used to diagnose a battery pack micro-short circuit issue. Micro short circuits are the root cause of all other problems, such as battery degeneration, thermal runaway, overheating, and internal short circuits.

Lithium-ion batteries are a dominant power source in the electric vehicle (EV) and energy storage fields. However, recent battery thermal runaway accidents seriously threaten people's lives and property safety. Extreme operating conditions and harsh environments can change the internal structure of a battery, generating excessive heat and leading to thermal runaway. Figure 1 shows the types of faults in a battery. Internal faults consist of overcharging, over-discharging, internal short circuit, external short circuit, thermal runaway, and overheating. External faults consist of sensor fault, cooling system fault, and cell connection fault. Lithium-ion batteries are susceptible to both internal and external short circuits. An internal short circuit occurs when the insulating barrier between electrodes fails. High-capacity cells are at a insulating barrier between internal electrodes fails greater threat of thermal runaway than normal-capacity cells. The heat produced by a short circuit is what largely causes thermal runaway.

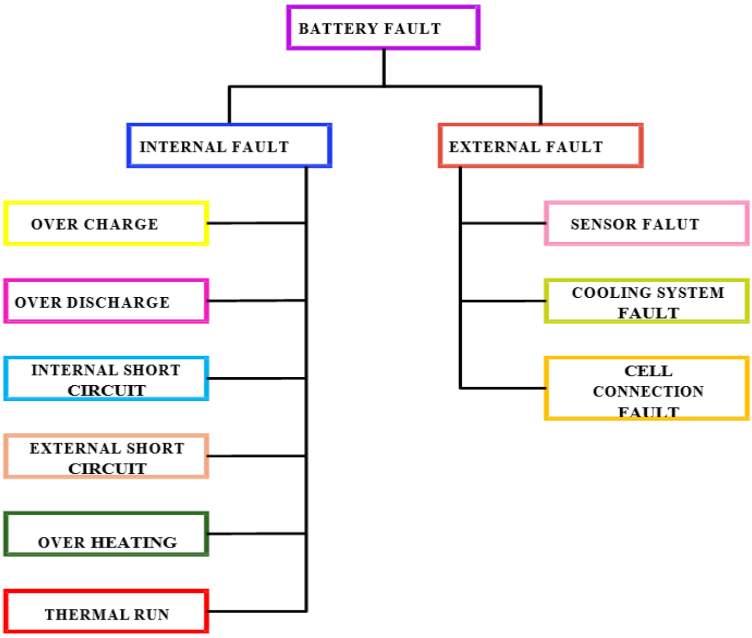

Figure 1. Types of battery faults

2. PROPOSED WORK

To verify the accuracy of the RCC estimation method, the Li-ion was tested by charging cells with varying initial states of charge (SOCs) sequentially. This approach minimizes the impact of internal resistance and capacitance differences among cells, ensuring a more precise RCC evaluation. By isolating these variables, the method enhances the reliability of detecting micro short circuits in battery packs.

2.1. MSC fault

Figure 2 shows the different capacities of the 8-cell battery pack. The green dashed line and red squares represent the capacitance mismatch and the initial electrical size mismatch. BMS stops charging to prevent overcharging even if other cells are not fully charged. This is because the presence of MSCs continuously depletes the energy stored in the cell. When the battery pack is discharged, cell X# is the first to fully discharge. This is because the MSC continuously depletes the electrical energy stored in the cell. When the cells are discharged again, cell X# becomes empty first, as shown in the state (4), and the remaining electric charge Y# further increases.

2.2. RCC estimation

A cell has its capacity to store charge, but in the case of a battery pack, where capacity and internal resistance of a cell may vary due to manufacturing errors. When a pack is charging, the rate of charging of an individual cell varies. In the end, all cells will have remaining charge capacity (RCC) to reach their total capacity. And RCC varies for each cell, considering internal resistance and capacity. In this proposed work, when MSC occurs either due to a manufacturing defect or faults, the RCC increases over and over for each charging cycle. RCC can be calculated as the remaining capacity left to full charge.

2.3. Simulation

In a simulation, charging and discharging cycles of the battery are carried out. While doing its regular cycles, there is a possibility of an MSC fault. If it does, the cell might not fully charge to its capacity in the given time. Say cell A fully charges in t sec, and cell B with an MSC fault in t sec, it reaches only 89% of SOC. This is the first charging cycle, and when it's discharged, cell B discharges at a faster rate than cell A.

After each cycle, cell B`s SOC drops with respect to its severity of the MSC fault. Hence, RCC increases due to the fault. Lithium-ion battery of 3.7 V 4.4 Ah is used in the proposed method. Internal resistance is the resistance of the cell material used inside it to separate, and the electrode's resistance also comes in account. A micro short circuit inside the cell starts when there is contact and charges between the positive and negative electrode or if internal resistance is nullified. Due to this, there is a depletion of charge stored in the cell even while charging the cell. In MATLAB, the battery model is simulated in different conditions as shown in Figure 3. To determine MSC resistance, added in parallel to the battery. An MSC fault cannot be created inside the battery cell, as that could be dangerous, so an external resistance is connected in parallel. The MSC resistance is determined by how it behaves to different conditions (temperature, SOC, load). Cell parameters such as SOC, temperature, and cell voltage are observed for different SOC levels while discharging. For the mentioned table SOC of 50 and 100 are set to determine the change in cell parameters. The temperature is set to 40 °C and a load of 1 Ohm. Due to discharging with 1 Ohm, the cell characteristics change slightly from normal. The conclusion is that a 1 Ohm load doesn't affect the cell characteristics. The graph of cell temperature, SOC, voltage with 1 Ohm load, and temperature of 40 °C. Starting at 50% while discharging, the cell voltage has a slight drop. At 50% SOC, this is clear that there is no difference. The same cell parameters at 100% SOC, and even at that SOC, there is a similar change. The cell parameters for a 0.1 Ohm load. For this load, the cell parameters have changed from before. The conclusion is according to the load cell characteristics, changes that decrease in load resistance increase the change in cell characteristics. Figures 4(a)-4(d) (see Appendix) depict the cell parameters with SOC of 50% and 100%. Discharging and charging time depends on charge current, internal resistance, cell temperature, and cell age. There is another case for the capacity of the battery. Consider cell A capacity is x, and cell B with 2x connected with the same load. Now the charging and discharging time of cell B will be longer compared to cell A.

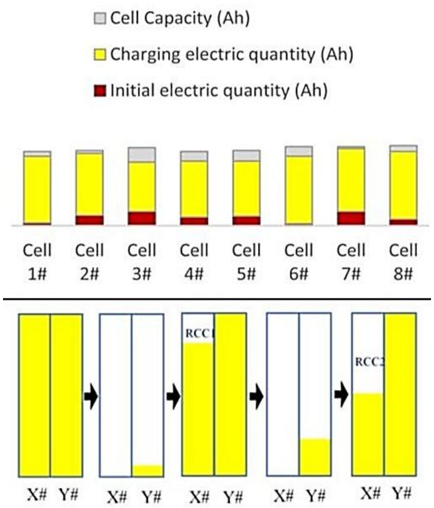

Figure 2. RCC variance in a battery pack

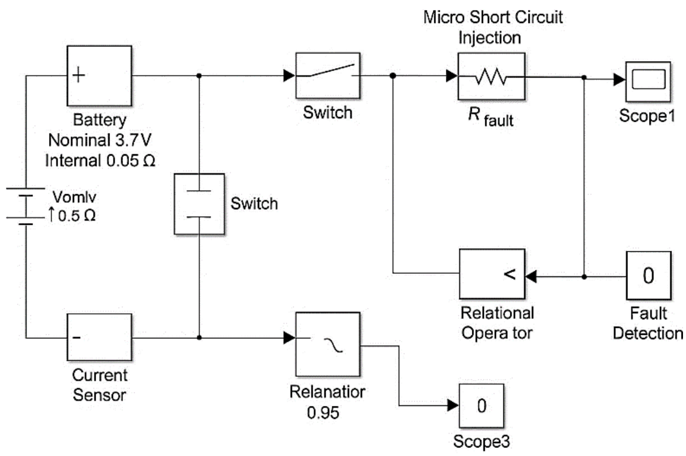

Figure 3. Simulate a battery short circuit fault

3. HARDWARE IMPLEMENTATION

The process of locating a fault in a Li-ion cell is initially determined by the cell's voltage level. This voltage value will be predetermined depending on the different types of cell parameters. And the voltage value is converted into a percentage of remaining charge capacity (RCC). The RCC method of estimation will be used to determine the state of charge (SOC) at different voltage levels, and cell specifications were considered as shown in Table 1. The value of the RCC was compared with a predetermined value. If the value exceeds the predetermined value, the condition will be treated as a fault, and it will display the fault in the cell. Otherwise, it will remain within the predetermined range as normal charging or discharging cycles occur. After that, the cell will be monitored with a voltage value that was previously fixed and checked for overcharge, over discharge, and thermal runaway as shown in Table 2. If any of the faults occur, the cell will be disconnected from the load, and the fault will be checked and displayed again. If not, disturbing the charging or discharging cycle will occur. Figure 5 depicts the workflow of the proposed work. Figure 6 shows the hardware implementation of a micro short circuit fault of a lithium-ion battery.

Table 1. Cell specifications

Specification	Value	Specification	Value
Average output voltage	3.7 V	Operation temperature	-10 - 45 C
Operation voltage range	3–4.3 V	Farm factor	18650
Discharge voltage	2.8 V	Weight, height, diameter	35 g, 65 mm, 18 mm
Capacity	1200 mAh	Lifecycle	200 cycles

Table 2. Result

Conditions	Voltage (V)	SOC (%)	RCC (%)
Charging	3.9	84	10
Over charging	4.2	>100	-
Discharging	2.8	10	90
Over discharging	2.5	<10	>90
MSC fault	3.3	50	50

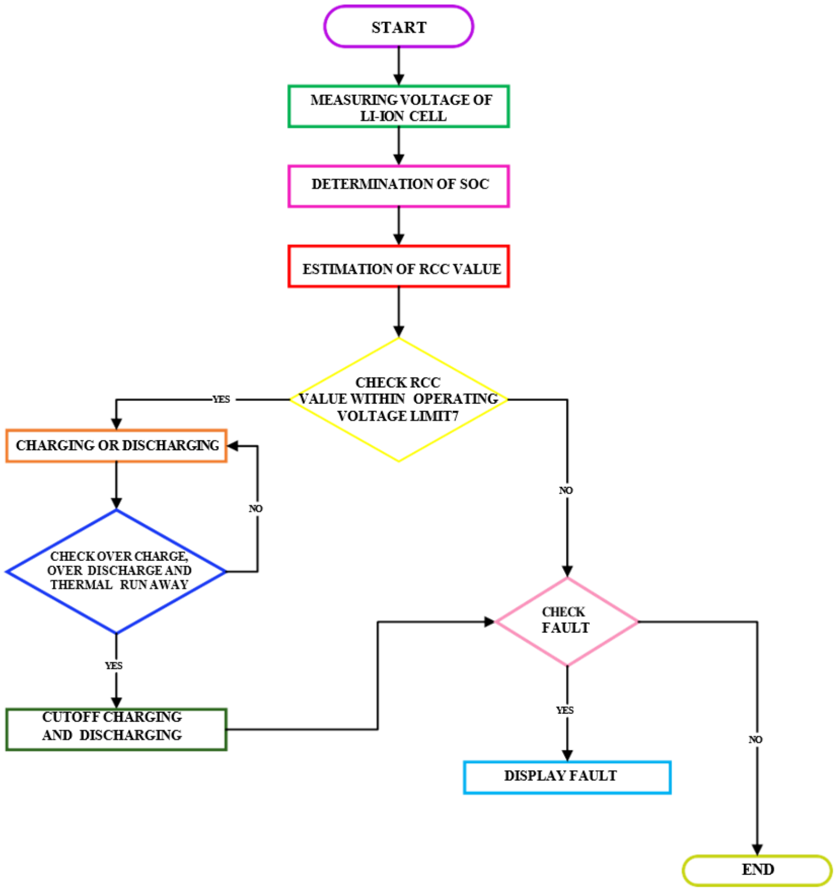

Figure 5. Workflow of the proposed work

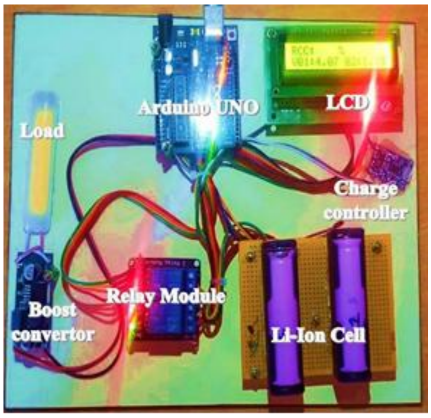

Figure 6. Hardware setup

4. CONCLUSION

MSC is a potential safety concern in lithium-ion battery packs. The RCC of the MSC cell increases each time the battery pack is fully charged, as the additional charge is depleted. This method can not only identify cells with MSC errors but also quantitatively estimate short-circuit severity. RCC can be obtained by translating the first fully charged cell into the first partially charged cell. The estimation results of RCC validate the effectiveness of the quantitative MSC diagnostic method. Continuing estimation results show that the method fits well even in the situation of not fully loaded cells. In the case of aging cells, multi-stage charging, and constant power, the accuracy of the estimation results is slightly degraded, but within a controllable range.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
S. Gomathy	✓	✓	✓	✓	✓	✓		✓	✓	✓			✓	✓
Boopathi Dhanasekaran		✓				✓		✓	✓	✓	✓	✓		
Sivabalakrishnan Ramasamy														
Radha Jayaram	✓		✓			✓				✓	✓		✓	✓
Sabarimuthu Muthusamy		✓	✓	✓			✓							
A. T. Sankara Subramanian	✓				✓	✓		✓		✓		✓	✓	✓

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

DATA AVAILABILITY

Data availability is not applicable to this paper as no new data were created or analyzed in this study.

REFERENCES

[1] X. Hu, C. Zou, C. Zhang, and Y. Li, “Technological developments in batteries: A survey of principal roles, types, and management needs,” *IEEE Power and Energy Magazine*, vol. 15, no. 5, pp. 20–31, 2017, doi: 10.1109/MPE.2017.2708812.
[2] Z. Chen, C. Zheng, T. Lin, and Q. Yang, “Multifault diagnosis of li-ion battery pack based on hybrid system,” *IEEE Transactions on Transportation Electrification*, vol. 8, no. 2, pp. 1769–1784, 2022, doi: 10.1109/TTE.2021.3121036.
[3] A. S. M. Jahid Hasan, J. Yusuf, L. F. Enriquez-Contreras, and S. Ula, “Bad cell identification of utility-scale battery energy storage system through statistical analysis of electrical and thermal properties,” *Proceedings of 2021 IEEE PES Innovative Smart Grid Technologies Europe: Smart Grids: Toward a Carbon-Free Future, ISGT Europe 2021*, 2021, doi: 10.1109/ISGTEurope52324.2021.9640168.
[4] S. Gomathy, M. Sabarimuthu, N. Priyadharshini, and M. S. Kamalesh, “Energy management system and peak shaving algorithm for smart home integrated with renewable energy,” *International Journal of Scientific and Technology Research*, vol. 9, no. 4, pp. 441–446, 2020.
[5] X. Hu, K. Zhang, K. Liu, X. Lin, S. Dey, and S. Onori, “Advanced fault diagnosis for lithium-ion battery systems: A review of fault mechanisms, fault features, and diagnosis procedures,” *IEEE Industrial Electronics Magazine*, vol. 14, no. 3, pp. 65–91, 2020, doi: 10.1109/MIE.2020.2964814.
[6] S. S. Ahooyi and F. Abdollahi, “Fault detection of lithium-ion battery in electric vehicles considering ageing effects,” *2022 8th International Conference on Control, Instrumentation and Automation, ICCIA 2022*, 2022, doi: 10.1109/ICCIA54998.2022.9737186.
[7] K. Zhang, X. Hu, Y. Liu, X. Lin, and W. Liu, “Multi-fault detection and isolation for lithium-ion battery systems,” *IEEE Transactions on Power Electronics*, vol. 37, no. 1, pp. 971–989, 2022, doi: 10.1109/TPEL.2021.3098445.
[8] A. Naha *et al.*, “Internal short circuit detection in Li-ion batteries using supervised machine learning,” *Scientific Reports*, vol. 10, no. 1, 2020, doi: 10.1038/s41598-020-58021-7.
[9] W. Gao, Y. Zheng, M. Ouyang, J. Li, X. Lai, and X. Hu, “Micro-short-circuit diagnosis for series-connected lithium-ion battery packs using mean-difference model,” *IEEE Transactions on Industrial Electronics*, vol. 66, no. 3, pp. 2132–2142, Mar. 2019, doi: 10.1109/TIE.2018.2838109.
[10] Z. Zhang, X. Kong, Y. Zheng, L. Zhou, and X. Lai, “Real-time diagnosis of micro-short circuit for Li-ion batteries utilizing low-pass filters,” *Energy*, vol. 166, pp. 1013–1024, 2019, doi: 10.1016/j.energy.2018.10.160.
[11] X. Kong, Y. Zheng, M. Ouyang, L. Lu, J. Li, and Z. Zhang, “Fault diagnosis and quantitative analysis of micro-short circuits for lithium-ion batteries in battery packs,” *Journal of Power Sources*, vol. 395, pp. 358–368, 2018, doi: 10.1016/j.jpowsour.2018.05.097.

[12] X. Feng, M. Ouyang, X. Liu, L. Lu, Y. Xia, and X. He, "Thermal runaway mechanism of lithium ion battery for electric vehicles: A review," *Energy Storage Materials*, vol. 10, pp. 246–267, Jan. 2018, doi: 10.1016/j.ensm.2017.05.013.
[13] D. P. Finegan *et al.*, "Characterising thermal runaway within lithium-ion cells by inducing and monitoring internal short circuits," *Energy and Environmental Science*, vol. 10, no. 6, pp. 1377–1388, 2017, doi: 10.1039/c7ee00385d.
[14] M. Schmid, J. Kleiner, and C. Endisch, "Early detection of internal short circuits in series-connected battery packs based on nonlinear process monitoring," *Journal of Energy Storage*, vol. 48, 2022, doi: 10.1016/j.est.2021.103732.
[15] L. Zheng, J. Zhu, D. D. C. Lu, G. Wang, and T. He, "Incremental capacity analysis and differential voltage analysis based state of charge and capacity estimation for lithium-ion batteries," *Energy*, vol. 150, pp. 759–769, 2018, doi: 10.1016/j.energy.2018.03.023.
[16] Z. Chen, R. Xiong, J. Tian, X. Shang, and J. Lu, "Model-based fault diagnosis approach on external short circuit of lithium-ion battery used in electric vehicles," *Applied Energy*, vol. 184, pp. 365–374, 2016, doi: 10.1016/j.apenergy.2016.10.026.
[17] X. Hu, K. Zhang, K. Liu, X. Lin, S. Dey, and S. Onori, "Advanced fault diagnosis for lithium-ion battery systems: a review of fault mechanisms, fault features, and diagnosis procedures," *IEEE Industrial Electronics Magazine*, vol. 14, no. 3, pp. 65–91, 2020, doi: 10.1109/MIE.2020.2964814.
[18] H. Wang, S. Simunovic, H. Maleki, J. N. Howard, and J. A. Hallmark, "Internal configuration of prismatic lithium-ion cells at the onset of mechanically induced short circuit," *Journal of Power Sources*, vol. 306, pp. 424–430, 2016, doi: 10.1016/j.jpowsour.2015.12.026.
[19] X. Feng, C. Weng, M. Ouyang, and J. Sun, "Online internal short circuit detection for a large format lithium ion battery," *Applied Energy*, vol. 161, pp. 168–180, 2016, doi: 10.1016/j.apenergy.2015.10.019.
[20] W. Gao, Y. Zheng, M. Ouyang, J. Li, X. Lai, and X. Hu, "Micro-short-circuit diagnosis for series-connected lithium-ion battery packs using mean-difference model," *IEEE Transactions on Industrial Electronics*, vol. 66, no. 3, pp. 2132–2142, Mar. 2019, doi: 10.1109/TIE.2018.2838109.
[21] X. Lai *et al.*, "Online detection of early stage internal short circuits in series-connected lithium-ion battery packs based on state-of-charge correlation," *Journal of Energy Storage*, vol. 30, 2020, doi: 10.1016/j.est.2020.101514.
[22] M. Zhang *et al.*, "Early Internal Short Circuit Diagnosis for Lithium-Ion Battery Packs Based on Dynamic Time Warping of Incremental Capacity," *Batteries*, vol. 10, no. 11, p. 378, Oct. 2024, doi: 10.3390/batteries10110378.
[23] Y. Guo *et al.*, "Fault diagnosis method for micro internal short circuits in lithium-ion batteries based on incremental capacity curve," *Energy Storage Science and Technology*, vol. 12, no. 8, 2023, [Online]. Available: https://esst.cip.com.cn/EN/abstract/article_2209.shtm.
[24] S. Ghosh, S. Mallick, and T. Roy, "Koopman Mode-Based Detection of Internal Short Circuits in Lithium-ion Battery Pack," *arXiv*, 2024, [Online]. Available: https://arxiv.org/abs/2412.13115.
[25] S. Chen, J. Sun, Y. Tang, and F. Zhang, "A fault diagnosis method of battery internal short circuit based on multi-feature recognition," *Transactions of the Institute of Measurement and Control*, vol. 46, no. 11, pp. 2186–2197, 2024, doi: 10.1177/01423312241233799.

APPENDIX

(a)

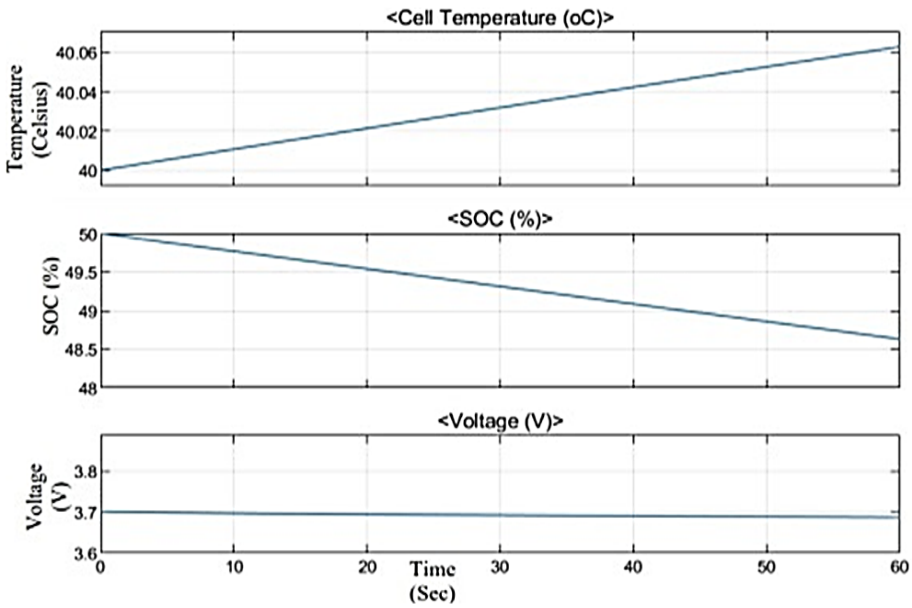
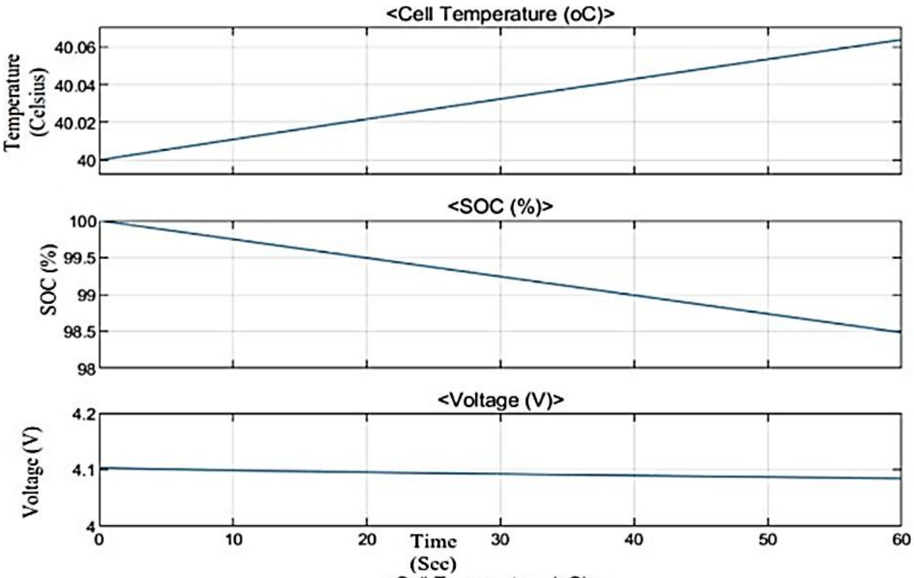
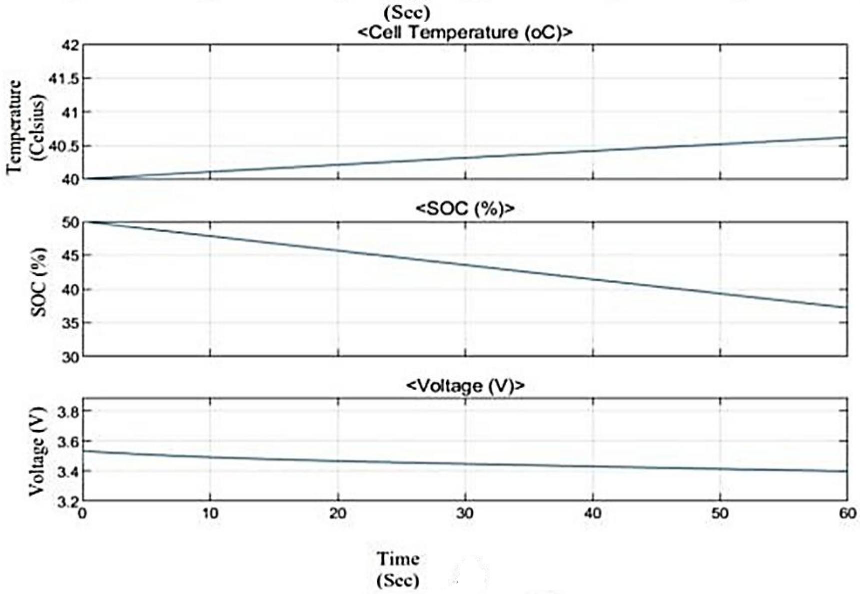


Figure 4. Cell parameters for (a) SOC 50% load resistance of 1 Ohm

(b)



(c)



(d)

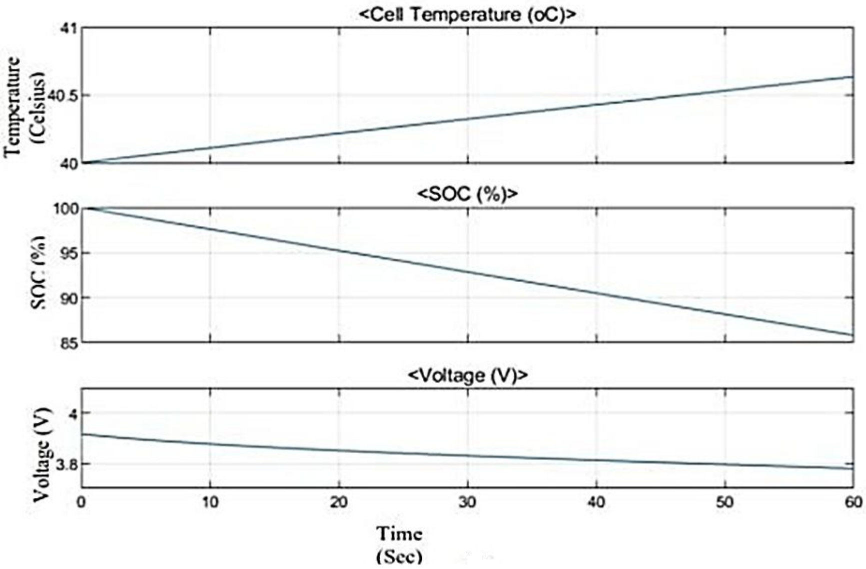


Figure 4. Cell parameters for (b) SOC 100% load resistance of 1 Ohm, (c) SOC 50% load resistance of 0.1 Ohm, and (d) SOC 100% load resistance of 0.1 Ohm *(continued)*

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