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A novel MIMO BMS design for user-friendly replacement of batteries

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Abstract

The proposed design introduces an innovative Multiple-Input Multiple-Output (MIMO) based Battery Management System (BMS) design that facilitates convenient battery replacement in battery packs. The technology allows for real-time monitoring of battery health through separate communication channels, making it easier to identify and replace batteries without the need for complicated disassembly. Granular control of charging/discharging and cell balancing allows for the achievement of enhanced safety and increased pack performance.

Subject Classification: *28-XX.*

Keywords: *Replaceable, Battery, MIMO, BMS.*

1. Introduction

A battery management system (BMS) is an electrical system that oversees the operation and maintenance of a battery or a group of cells [1].

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It oversees and regulates crucial variables. A battery is a crucial component in various industries such as transportation and communication, particularly in portable equipment like electric vehicles and appliances[2][3]. The rechargeable electric battery is the predominant and extensively utilised device employed for the storage of electrochemical energy for power[4][5]. Here a battery management system design is proposed which can be charged from different sources and can supply power to multiple devices[6]. This solution can facilitate users in seamlessly replacing the battery in the battery pack in operational mode.Many adaptive techniques like fuzzy,neural,ANFIS etc are also used for control mechanism of BMS of EVs or in power systems[7],[8].

2. Schematic Employment

The System is composed of batteries and switches arranged in a grid-like layout. Each battery will be encircled by six switches (S1, S2, S3, S4, S5, S6) arranged in an H-bridge configuration shown in Figure 1. The switches S1, S2, S3, and S4 will operate in pairs, specifically S1 with S4 and S2 with S3.

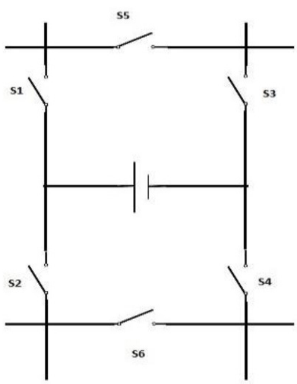

Figure 1

Single cell unit of grid like structure

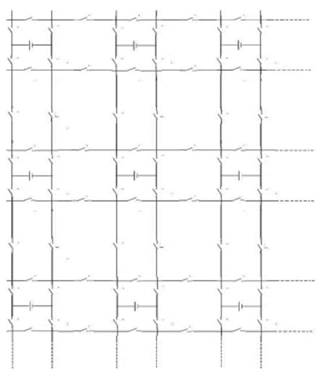

Figure 2

Grid like structure of battery management system

These pairs will be responsible for altering the direction of the electric current in the output. Additionally, they can be utilised to change the voltage from alternating current (AC) to direct current (DC) and vice versa.

The triacs will be used as switches S1, S2, S3, and S4. Switches S5 and S6 are bi-directional triacs, which provide enhanced regulation of electrical current depicted in grid like structure in Figure 2. To replace the batteries, just turn off switches S1, S2, S3, and S4.

3. Simulation study of Sequential structure of batteries

The simulation of the case study is designed for 9 batteries of different ratings.it also comprises of 3 different loads and 2 input (refer paper {9]).

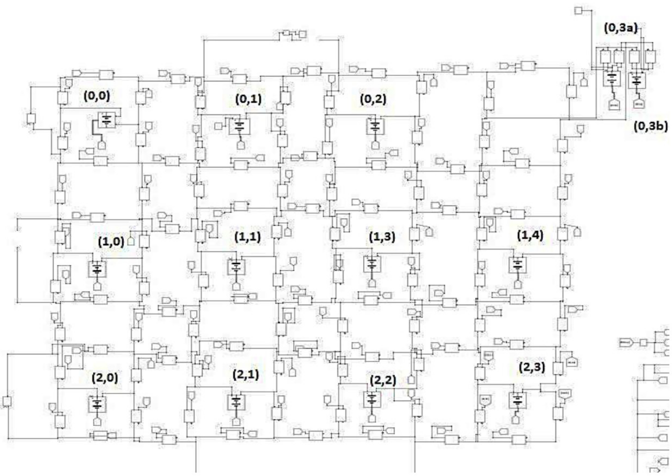

Figure 3

Sequential structure of different batteries in Grid Module

The designed sequential structure is shown in Figure 3, where the sequential operation of different batteries are in following manner:

- The battery on (0,0) is charged from input 1.
- The battery on (2,0) is getting charged from input 2.
- The load 1 is fed by battery on (1,0) and the load 2 is fed by batteries (1,1), (1,2), (2,1) and (2,2).
- The battery on (0,1) is having fault die to high temperature while seeding load 3, the load 3 is fed by battery (0,2) and battery (0,1) got isolated from system.
- Battery (0,3a) is getting replaced by battery on (0,3b) while the other system is working.

5. Result

As the battery temperature increases, the risk of it causing harm to the system also increases, as shown in Figure 4. To avoid this, a signal is sent when the temperature exceeds a specific threshold, which in this case is 30 degrees Celsius

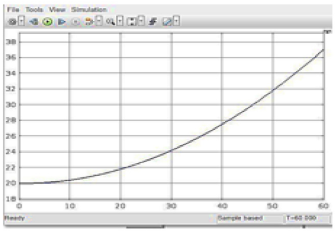

Figure 4

Temperature rise of battery (0,1)

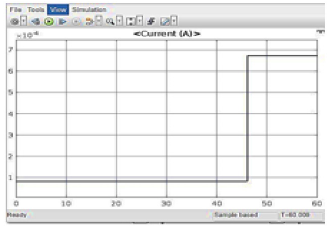

Figure 5

Current of (0,2)

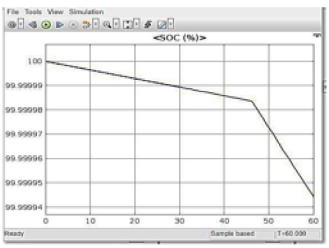

Figure 6

Voltage of (0,2)

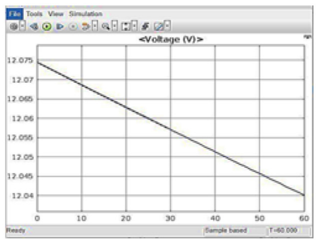

Figure 7

SOC of (0,2)

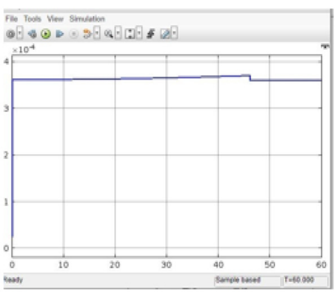

Figure 8

Current passing through load connected to (0,1)

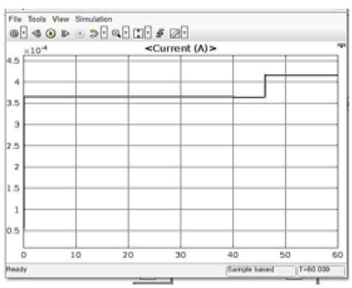

Figure 9

Current of (1,0)

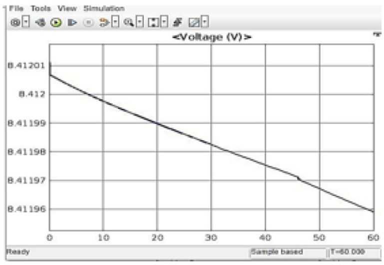

Figure 10

Voltage of (1,0)

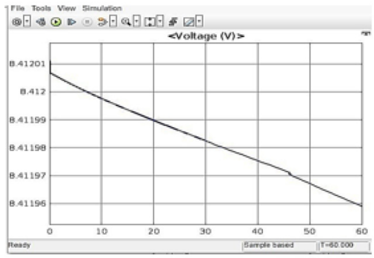

Figure 11

SOC of (1,0)

Once this signal is reached, the switches surrounding the battery (0,1) will separate it from the system, and the battery (0,2) will take over to supply power to the load that was previously powered by the original battery.

Figure 5 and Figure 9 show the current of battery (0,2) and of battery (1,0), similarly Figure 6 and Figure 10 show the voltage across battery (0,2) and battery (1,0).

The load is connected to sequence (0,1) and the current passing through it is presented in Figure 8.

The State of charging (SOC) of battery (0,2) and battery (1,0) are shown in Figure 7 and Figure 11.

6. Conclusion

The proposed novel battery system design not only enhanced the utility capacity by efficiently distributing electricity to various loads but also resulting in the cost savings through the reduction of battery packs and battery management systems required for supplying power to multiple loads. The project aims to streamline the battery replacement process, making it more user-friendly and efficient. This will be achieved by enabling the

References

[1] S.P.G. Krishna Teja, “Smart battery management system with active cell balancing ,”journal, vol. 8(9) (August 2015).

[2] Kusum Tharani, Abhishek Gandhar , Ankita Gupta,“ Performance analysis and comparison of batteries using off-grid PV system”,

Asian Journal of Water, Environment and Pollution, vol. 17, no. 02 (2020), pp. 23-28 (May 2020) print: 0972-9860; ISSN online: 1875-8568 DOI: 10.3233/AJW200016.

[3] S. B. Kumar et al.," Design and analysis of triangular patch antenna with enhanced bandwidth for RF energy harvesting, *Journal of Information and Optimization Sciences*, 43:1, 101-106, DOI: 10.1080/02522667.2022.2036356

[4] Deepshikha Shrivastava , Priyanka Sharma, "optimization of battery parameters for automotive applications", *Suraj Punj Journal For Multidisciplinary Research,* Volume 11, Issue 5 (2021) ISSN NO: 2394-2886.

[5] Kailong Liu, Kang Li, Qiao Peng, Cheng Zhang, "A brief review on key technologies in the Battery Management System of Electric Vehicles".

[6] Rahimi- Eichi, H., Ojha, U., Baonti, F. & Chow, M. Y., "Battery Management System: An Overview of Its Application in the Smart Grid and Electric Vehicles," *IEEE Industrial Electronics Magazine*, vol. 7. no. 2, pp. 4-16 (2013).

[7] Shashi Gandhar, Jyoti Ohri,Mukhtiar Singh "Dynamic reactive power of optimization hybrid microgrid in islanded mode using fuzzy tune UPFC", *Journal of Information and Optimization Sciences*, Vol 41 issue 1, pp 305-315 (Feb 2020), doi.org/10.1080/02522667.2020.1721620.

[8] Mostafa Ahmed and Krishna Pattipati, "Battery Management Systems—Challenges and Some Solutions by Balakumar Balasingam", Energies 13(11) : 2825 (June 2020) DOI:10.3390/en13112825.

[9] M. Mathew, Q.H. Kong, J. McGrory, M. Fowler, "Simulation of lithium-ion battery replacement in a battery pack for application in electric vehicles" https://doi.org/10.1016/j.jpowsour.2017.03.010.