"Performance Analysis of Battery Management System"

Minor Project Report

Submitted in Partial Fulfillment of the Requirements for the Degree of

BACHELOR OF TECHNOLOGY
IN
ELECTRICAL ENGINEERING

Submitted By:

Nistha Kumari (18BEE063)

Nisarg Pandya (18BEE062)

Department of Electrical Engineering
Institute of Technology
NIRMA UNIVERSITY
Ahmedabad 382 481

December 2021

CERTIFICATE

This is to certify that the Minor Project Report entitled "***Performance Analysis of Battery Management System*** "submitted by Nistha Kumari (18BEE063) and Nisarg Pandya (18BEE062) towards the partial fulfillment of the requirements for the award of degree in Bachelor of Technology in the field of Electrical Engineering of Nirma University is the record of work carried out by him/her under our supervision and guidance. The work submitted has in our opinion reached a level required for being accepted for examination. The results embodied in this minor project work to the best of our knowledge have not been submitted to any other University or Institution for award of any degree or diploma.

Date: 29-11-2021

Prof. Siddhartsingh Chauhan
Department of Electrical Engineering
Institute of Technology
Nirma University
Ahmedabad

Head of Department
Department of Electrical Engineering
Institute of Technology
Nirma University
Ahmedabad

Director
Institute of Technology
Nirma University
Ahmedabad

Undertaking for Originality of the Work

I, Nistha Kumari and Nisarg Pandya , Roll No. 18BEE063 and 18BEE062 , give undertaking that the Minor Project entitled "Performance Analysis of Battery Management System" submitted by me, towards the partial fulfillment of the requirements for the degree of Bachelor of Technology in Electrical Engineering of Nirma University, Ahmedabad, is the original work carried out by me and I give assurance that no attempt of plagiarism has been made. I understand that in the event of any similarity found subsequently with any other published work or any project report elsewhere; it will result in severe disciplinary action.

Signature of Students

Date: 29-11-2021

Place: Ahmedabad

Endorsed by: Prof. Siddhartsingh Chauhan

(Signature of Faculty Guide)

TABLE OF CONTENTS

Acknowledgement

I must acknowledge the strength, energy and patience that almighty **GOD** bestowed upon me to start & accomplish this work with the support of all concerned, a few of them I am trying to name hereunder.

I would like to express my deep sense of gratitude to *all faculties of Electrical Engineering Department* for their valuable guidance and motivation.

I would like to express my sincere respect and profound gratitude to **Prof. (Dr.) S. C. Vora**, *Professor & Head of Electrical Engineering Department* for supporting and providing the opportunity for this project.

I would also like to thank all my friends who have helped me directly or indirectly for the completion of my project.

No words are adequate to express my indebtedness to my parents and for their blessings and good wishes. To them I bow in the deepest reverence.

Nisarg Pandya
Nistha Kumari

LIST OF FIGURES

LIST OF TABLES

LIST OF ACHRONYMS

DC	: Direct Current
AC	: Alternating Current
SVC	: Static VAR Compensator
MOSFET	: Metal–oxide–semiconductor field-effect transistor

LIST OF NOMENCLATURE

V_i	: Input Voltage
V_o	: Output Voltage

Chapter 1: Battery Management System

1.1: Introduction:

Society's mobile devices usage grows on an everyday basis creating the study of batteries a extremely important subject. The longevity of battery charges is today an enormous issue for those who square measure usually outdoors. electrical Vehicles (EV), a worldwide growing market, square measure pretty obsessed with batteries capability and usage as EVs will solely go as so much because the battery permits.

Home battery devices that may store energy from either native renewable sources or from the grid are a promising technology extremely obsessed with battery usage patterns. In a battery pack, all cells square measure distinctive and as time passes by, each cell in a very battery pack can age particularly starting contrasts between one another whereas charging them. Albeit equal cells square measure self-adjusted, that does not occur once inserting them asynchronous. Some battery adjusting ways were projected in writing, to form a framework appropriate applying a charging calculation.

The strategy introduced during this paper is in lightweight of the foremost routinely utilized adjusting framework. The Li-particle cells utilized during this venture were meant to own a drop between three V and 4.3 V and if that voltage goes underneath three V it'd go in a profound unharness specific that takes a really prolonged stretch of your time to recuperate from. in addition, if the voltage involves values higher than four.3 V the cell is obliterate thanks to warming. This makes it actually important to know about every cell's voltage and to play it safe to forestall extreme harms. To have a larger limit we will while not a lot of of a stretch suppose adding a couple of equal cells to the battery transferral a couple of important increment of the battery size.

Imagine a situation within which it was possible to "increment" the batteries limit by coping with its charge to allow it to store some a lot of energy? To forestall crossing battery safe voltage limits, a couple of batteries square measure utilized somewhere within the vary of two hundredth and eightieth of their ability utilizing simply hr of it. With the correct charging the executive's framework it's possible to utilize batteries somewhere within the vary of fifty and ninety fifth of the battery limit increasing its ability use to ninetieth, that addresses associate growth of half of the beforehand accessible energy. Thus, BMS comes into image, that helps within the achievement of the higher than mentioned options additionally to the rise in time period of the cells along with perpetually watching its different parameters which ends up in utilization of cells to it's maximum safe limit. Below shown in Fig.1 is that the schematic of battery management system. It shows however every module of cell is connected to BMS for watching it's current and temperature, and this knowledge is forwarded to the central microcontroller that contains the formula for the calculator of SoC, SoH, and lots of different parameters.

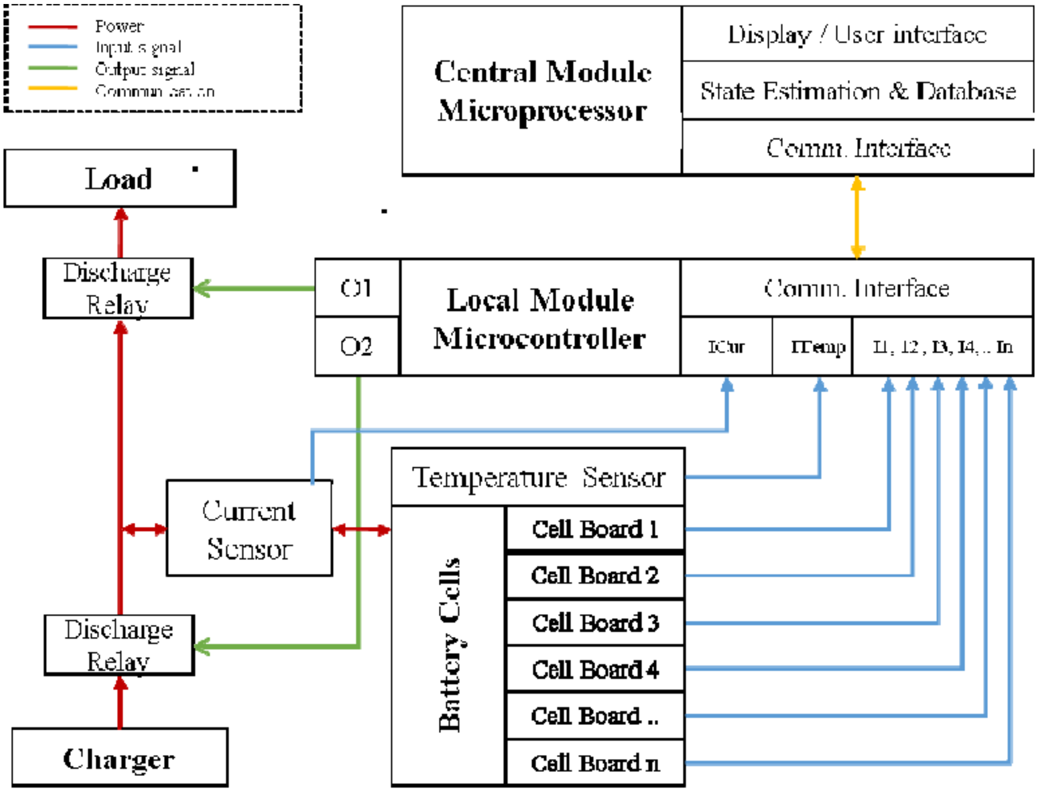

Figure 1. Schematic diagram of the BMS

Chapter 2: Balancing methods

2.1: Types of Balancing method:

There are 2 main strategies for battery cell charge reconciliation: passive and active balancing. The natural methodology of passive reconciliation a string of cells asynchronous is used just for lead-acid and nickel-based batteries. These varieties of batteries is brought into lightweight overcharge conditions while not permanent cell injury. once the overcharge is little, the surplus energy is released by increasing the cell vital sign. the surplus energy is free by the external circuit affiliation in parallel to every cell. This circuit consists of an influence resistance connected asynchronous with a sway MOSFET semiconductor device. This methodology is used for all sorts of batteries, however is effective for a little range of cells asynchronous. The active reconciliation methodology is predicated on the transport of the energy among the cells. This balancing methodology doesn't rely on the chemical characteristics of the cells, and might be used for most varieties of fashionable batteries. There square measure many varieties of active reconciliation strategies supported the type of energy transfer.

The energy is transmitted from the strongest cell to the entire battery or other cells, and then back to the weakest cell.

The balancing of lithium-ion batteries achieved by passive balancing is presented in this paper. The main premise is depicted in Figure 2. A charger and protection block, as well as a balancing circuit and analogue MUX, are shown in the balancing schematic, which are semiconductor switching networks for selective charge transfer, cell voltage measurement, and charge balancing, respectively.

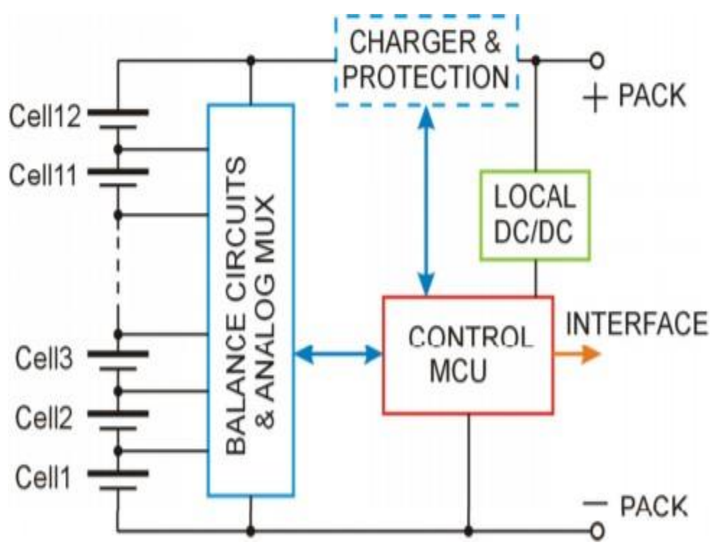

Figure 2. Balancing Schematic

2.2: Passive Balancing:

In this project, we have designed and implemented the passive balancing system of a BMS. In passive balancing, the efficiency is not as good as that of Active balancing in addition to many positive factors favoring active balancing over passive balancing, but the simplicity of passive balancing circuit is one of the main reasons of BMS designers to favor it over active. In passive balancing, a semiconductor switch that connects the battery to a resistor through which excess energy is to be dissipated is controlled by a control algorithm that is based on some basic requirements. The requirements for control are split into two main sections:

1. The charging state's requirements:
a) Monitor the charging process
b) Avoid overcharging any cell
c) Maintain cell balance during charging
d) Monitor the battery temperature

2. The discharging state's requirements are as follows:
a) Limit the battery pack's maximum output current
b) Avoid deeply draining any cell
c) Balance the cells during discharge
d) Monitor the battery's temperature

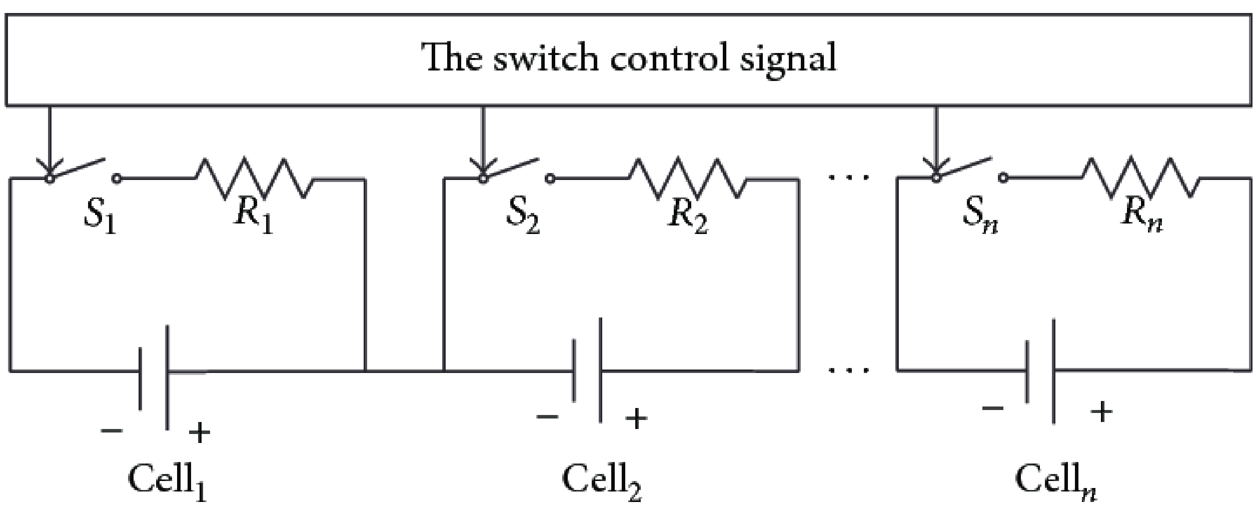

Figure 3:- Passive balancing Schematic

In Fig 3, the basic schematic of a common shunting resistor passive cell balancing is presented. This design allows several cells to be balanced at the same time by dissipating energy from energy-filled cells in the appropriate resistors.

In this design example, the battery charger and protective circuitry are not implemented. In this location, the control MCU provides sufficient resources for control.
Each cell's voltage is measured by the analogue multiplexer, which then sends this information to the control MCU. The MCU uses a specific algorithm to detect which cell is strong and which is weak, as well as which cell has to be charged to bring the SOC of all the cells to the same level. The maximum and minimum cell voltages are both checked at the same time. The control MCU turns off the charging state when all of the cells are fully charged.

The MCU periodically monitors the voltage of each cell and the temperature of the entire battery in the discharge state. Only if the protection module is present is the current drawn from the battery verified.

This safeguard prevents the entire battery pack from shorting out or overheating. Individual cell voltages are monitored periodically, just as they are in the charging stage. The weaker cells are charged after all values are compared. This algorithm balances the discharge states of all cells in order to get the greatest power out of the battery pack. The MCU delivers a warning signal through the external interface if the majority of the battery cells are below the low voltage limit.

This type of charge distribution control between all battery cells ensures that the battery lasts the longest, that the battery is charged with the most energy, and that the battery is fully charged. Battery could thus supply full energy to the appliances

Chapter 3: Simulating Passive Balancing

3.1: Design approach:

The BMS is executed utilizing detached adjusting approach because of its effortlessness and simplicity of control. Inactive adjusting utilizes a resistor, likewise called draining resistor, across each phone to disseminate the charge after the phone is completely energized. This forestalls the cheating of the cell and gives different cells access the pack (the more fragile cells) to get charged to 3.8 V. Li-particle batteries are charged utilizing a strategy called CCCV charging (Constant Current Constant Voltage Charging). This strategy supplies steady current to the cell until the cell arrives at 3.8 V, after which the consistent voltage mode begins which keeps up with 3.8 V across the cell and current diminishes dramatically. This technique ensures that the cell is completely energized (100% SoC).

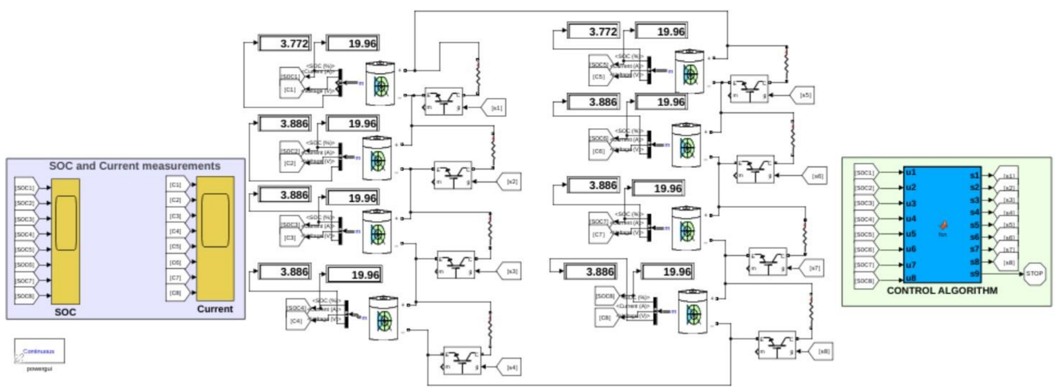

Figure 4. Passive balancing SIMULINK model

The final simulation diagram of passive balancing and monitoring voltage, current, and SoC of the cells is shown in the diagram above. Each cell has a resistor and a semiconductor switch, both of which are controlled by the control algorithm. The control algorithm compares the SoC of each cell one at a time, and if the SoCs are not equal, the higher-valued cell is discharged through the resistor to equalize the value of the lowest-valued cell.

3.2 : Simulation results:

Figure 5 presents the SoC graphs of the 8 cells, with the breakpoint being the turning off of the charging switch. A similar approach is implemented in battery management integrated chips in which the voltages are measured and compared using comparators and appropriate action is taken to balance all the voltages and bring them to 19.96 Volts.

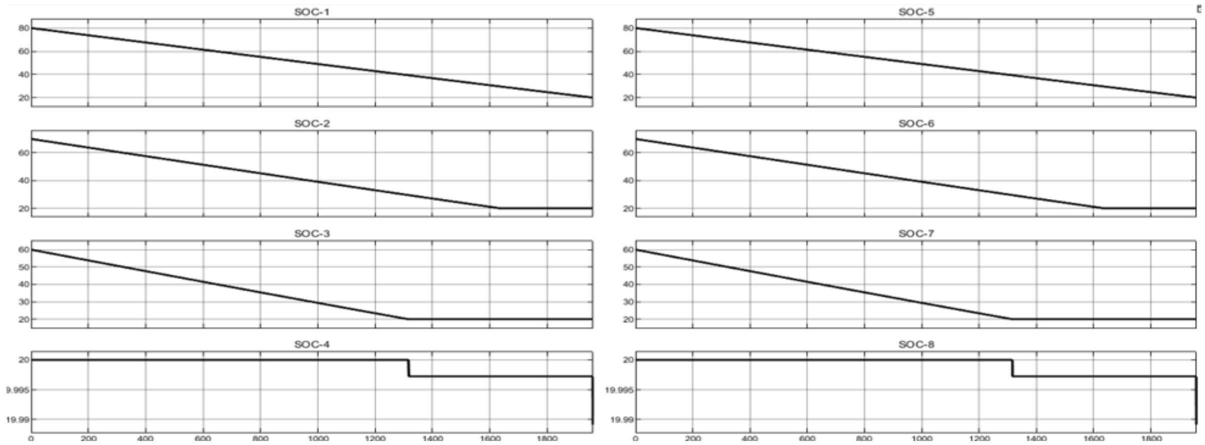

Figure 5. SOC graph for balancing

In scope, the waveforms of the SoC of the cells can be seen as shown in Fig 5. As it can be observed by the waveforms, at last, all the cells achieve the same state of charge which is equal to the initial charge of the least charged cells (cell 4 and cell 8). Furthermore, in the scope of the current, the current waveforms of cells can be observed as shown below in Fig 6.

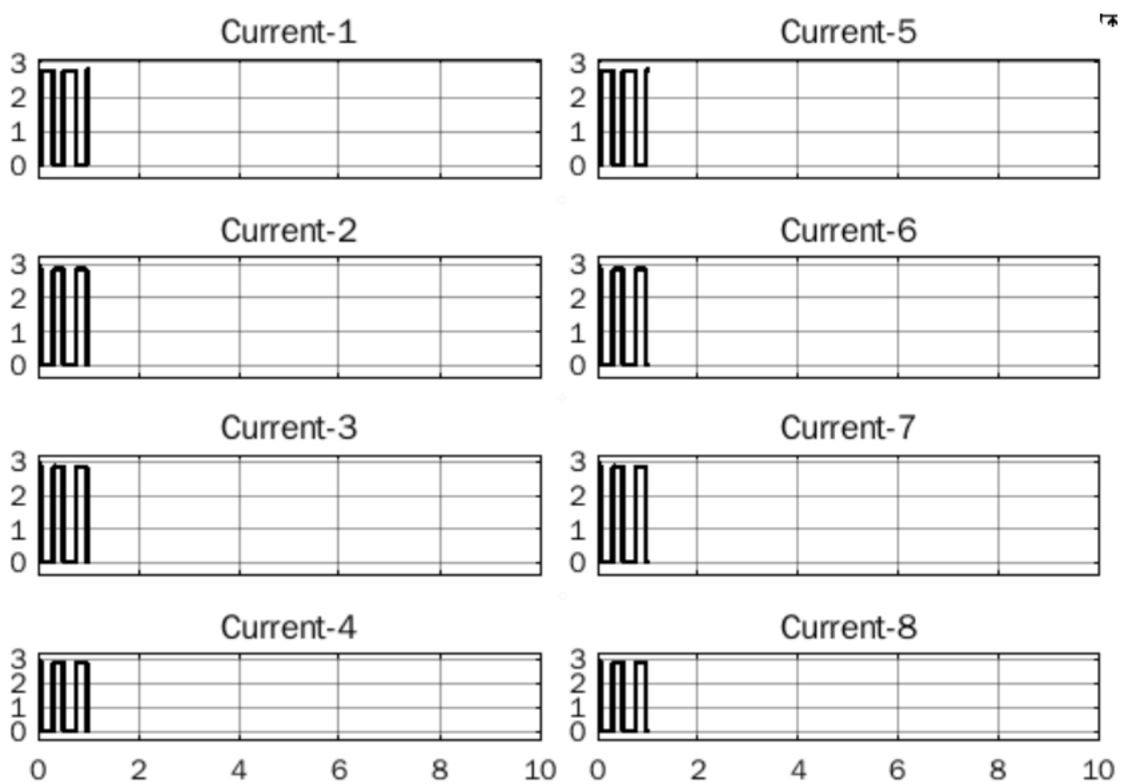

Figure 6. Current graph of individual cells

Chapter 4: Conclusion

Batteries are based on electrochemical cells which will deliver electrical energy as an output. In most electrochemical batteries, the cells deteriorate over time as the electrical energy is a product of the chemical breakdown of the chemical components, whereas, in care of the revolutionary lithium-ion batteries, the charge is produced by ions of lithium moving back and forth between electrodes, thus it’s lifetime is much longer. But to be used in vehicles that is supposed to be in average condition for years, the battery cells should be maintained so the lifetime of the cells is not reduced by careless charging or over-discharging.

For the purpose of maintaining a battery pack in a long run and to use the lithium-ion battery pack in safe conditions for both the user and the battery pack, the Battery Management System is used. It also maximizes the performance of the battery pack along with maximizing battery life. The BMS has many functions such as sensing the voltage and controlling it, protecting the cells from overcharge and over-discharge, monitoring the health of the pack, communicating between the different monitoring systems and the main control network, performance management (SoC, power,etc), and diagnosis (SoH, SoL).

In the present work, we gathered knowledge about different phenomena of Li-ion battery cells and used that knowledge to design a simulation circuit that will not only balance the cells of a battery pack but also monitor. By balancing cells in a battery pack we mean when the cells have different SoC individually, to prevent overcharge of the battery which would result in the formation of dead beds in the cells rending the cell damaged permanently resulting in a fast charge-discharge and lowered voltage capacity, but the circuit will also balance out the extra charge by comparing the state of charge of each cell by the other, thus determining the lowest charge present in any cell, after that gate pulse control commands are generated by the control algorithm, which allows the IGBT’s to complete the discharge circuit and thus the extra charge from all the cells is dissipated through the resistor.

Monitoring of the cells includes constantly monitoring different parameters of the cells and a modified model of our current circuit, apart from voltage, current, and SoC, many other Real-Time components like temperature, discharging current, charging current, estimated time the battery would last which would be varying with the rate of utilization of charge.

Chapter 5: Future Scope

A functioning adjusting framework coordinates converter as power controlling unit speed regulator for dynamic exercises assessing the SOCs of every cell, the regulator appropriately directs the DC-DC converters to appropriately move the charge starting with one cell then onto the next, such that the charge unevenness among limited. In the present work, a functioning cell adjusting framework has been created utilizing a multi-twisting fly-back converter. The converter chips away at the very rule that is followed by a regular flyback converter A variety is to utilize buck-support converters in corresponding with a gathering of battery cells that are in a series association as shown in Fig 7. This lessens part overhead while giving a steady DC voltage and disposing of the charge lopsidedness.

Subsequently, cells can try not to be cheated or over discharged with this equal setup. An extra benefit to this arrangement is that a totally depleted or harmed cell can be confined or supplanted without intruding on the framework activity. The significant downside of this technique is the absolute energy transformation effectiveness in equal activity might diminish, particularly when the information voltage of the converter is much lower than the result voltage. Despite the fact that there are a few benefits to the plan, the general expense and the diminishing in energy proficiency dispose of it as a potential decision for the exploration in this theory.

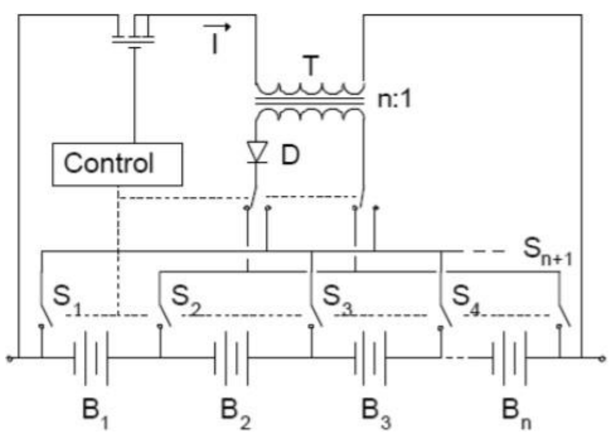

Figure 7. Switched transformer method used to balance series-connected batteries

Two other energy change strategies, are the exchanged transformer and the common transformer. The exchanged transformer, takes current from the whole pack and the transformer yield is redressed through a diode. Clever switches are utilized to convey the charge to the lower charged battery cells. This technique can quickly adjust the lower cells at the expense of taking energy from the entire pack. The disadvantage is the low productivity because of the exchanging misfortunes also, magnetics. The common transformer has a solitary attractive center with optional taps for every cell. It additionally takes current from the pack into the transformer essential also, prompts flows in every one of the optional taps.

References

[1] https://d1.amobbs.com/bbs_upload782111/files_36/ourdev_618134W9PIAM.pdf

[2] https://www.ionenergy.co/resources/blogs/cell-balancing-better-performance/

[3] http://web.mit.edu/nouyang/Public/Batteries_2.007_Notes_v3.pdf

[4] https://www.ti.com/download/trng/docs/seminar/Topic%202%20-%20Battery%20Cell%20Balancing%20-%20What%20to%20Balance%20and%20How.pdf

[5] https://www.adb.org/sites/default/files/publication/479891/handbook-battery-energy-storage-system.pdf

[6] https://redmine.fe.up.pt/attachments/download/550/A_Comparison_of_Active_and_Passive_Cell_Balancing_Techniques_for_Series_Parallel_Battery_Packs.pdf

[7] https://www.researchgate.net/publication/340777901_Optimizing_State_of_Charge_SOC_temperature_and_State_of_Health_SOH_of_lithium-ion_batteries

[8] https://www.researchgate.net/publication/319605164_SOC_Estimation-Based_Quasi-Sliding_Mode_Control_for_Cell_Balancing_in_Lithium-Ion_Battery_Packs

[9] https://www.researchgate.net/figure/Block-diagram-of-the-cell-voltage-balancing-in-a-stack-of-EDLCs_fig2_263789027

[10] https://www.automotivepower.com/battery-management-systems/?gclid=Cj0KCQiAkZKNBhDiARIsAPsk0WiPpKOqmMenN8J1JC4yr9mHxHjaAbd8gT3Xz_OJFXyJms8Zmol6jx4aAoVsEALw_wcB

[11] https://www.researchgate.net/figure/Schematic-diagram-of-BMS-Cell-Monitoring-Protection_fig1_281977506