HIGH-FIDELITY BATTERY OVERSIGHT SYSTEM FOR ELECTRIC VEHICLE

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ABSTRACT: -

With the increase in scope for electric vehicles, the durability and quality of batteries have become a major concern. The battery is an elemental component of an electric vehicle. Lithium cells are most widely used because of their high-power density. Proper battery management is critical to maintaining battery health and productivity. As Lithium cells undergo continuous charge and discharge in their lifetime, we have to monitor their state of health, state of charge and act accordingly to increase their life span and efficiency. A Battery Management System is the process in which we monitor various parameters of each cell and take a decision for the efficient working of the battery

Keywords: li-ion battery, state of charge, MATLAB/Simulink

DOI: 10.48047/ecb/2023.12.8.741

I-INTRODUCTION

1. ELECTRIC VEHICLE

An electric vehicle is one that runs on an electric motor, unlike ic engines which generate power from the combustion of fuel. The power to the electric motor is supplied by the batteries that store electricity. Most electric vehicles use Li-ion batteries as these batteries have more power density and have longer life span. An electric vehicle can become an alternative to ic engines as they do not emit any gases and hence are less pollutant and do not depend on natural sources for their operation as they depend on electrical energy that can be derived from renewable sources like solar, wind, hydro, etc.

There are two types of electric vehicles: hybrid electric vehicles and plug-in electric vehicles. Hybrid electric vehicles house an ic engine along with an electric engine. The hybrid electric vehicle provides better mileage. Plug-in electric vehicle runs purely on electricity.

1.1 BATTERY MANAGEMENT SYSTEM

Batteries play an important role in the performance of the electric vehicle especially in determining the driving range. Usually, Ii-ion batteries are used in most of electric vehicles. A huge number of cells are connected in series, to sum up a required voltage according to the application.

As Li-ion cells are sensitive to deep discharge and overvoltage, which can damage the battery, reduce its life span, and can even cause hazardous situations. This calls for an efficient battery management system to maintain each and every cell of the battery to work within its safe and reliable operating region. Apart from battery protection BMS has to analyze the state of charge, state of health, and how much energy it can deliver to the load.

1.1.1 STATE OF CHARGE (SOC)

State of charge is defined as the current battery capacity relative to its nominal capacity. It is defined as a percentage. It gives the current state of the battery and assists in the proper level of charging and discharging of the battery to improve battery performance which helps protect the battery. Coulomb counting method is most widely used for estimation of SOC.

1.1.2 STATE OF HEALTH (SOH)

State of health of a battery is measurement of deviation of battery performance compared to its ideal conditions. It is measured in percentage. During the course of its lifetime a battery gradually deteriorates due to chemical and physical changes.

1.1.3 TEMPERATURE

Temperature is an important factor that performance of Li-ion batteries so it is important to keep temperature in control for the efficient use of battery. Due to continuous charge and discharge the temperature of the cell increases which results in deteriorating state of health of the battery.

1.1.4 CELL BALANCING

As a battery consists of number of cells connected in series it is important that each should be equally charged as the cell with least charge determines the output voltage.

1.1.4.1 PASSIVE CELL BALANCING

Passive cell balancing is the simplest way of cell balancing, in this process the excess charge from the battery having highest charge is removed and is made equal to the battery having lowest charge, the charge is removed through resistor.

1.1.4.2 ACTIVE CELL BALANCING

Active cell balancing is the process in which external circuits are used to transfer charge from higher voltage cells to lower voltage cells.

1.2 CHARGING STATION

As electric vehicle runs on electricity availability of charging station is hindering the growth of ev industry. As a car say Tesla has a range of 500 km which is sufficient for a long run but it requires a lot of time to get charged. So, a charging station should be there at regular interval and should charge the car quickly.

II-FORMULATION

2. BASIC BLOCK DIAGRAM

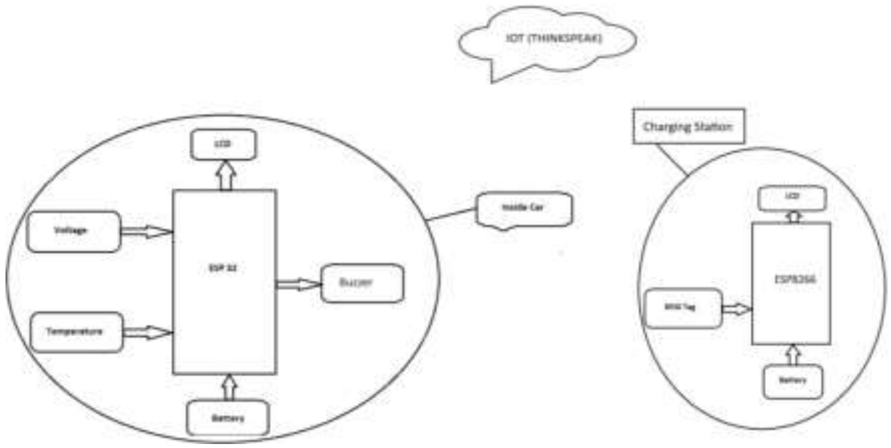

Fig 2: Basic block diagram

The overall basic block diagram of the project is shown above. It consists of two main parts i.e., the vehicle part and the charging station part. In the vehicle part, the main intention is to monitor battery parameters like voltage, temperature and State of charge of the electric vehicle and the monitored data is sent to cloud to make it accessible to the user. The purpose of charging station part is to read the RFID tag and display vehicle details.

The vehicle part consists of a main component called ESP32 microcontroller along with other components like voltage and temperature sensors connected to the vehicle's battery. It also contains buzzer and 16*2 LCD display for indications.

2.1 PROBLEM STATEMENT

- Monitoring and measuring battery voltage, temperature, humidity, state of charge (SOC) and range of the vehicle.
- Sending monitored data to could to make it accessible to the user.
- Programming RFID tags with vehicle and owner information.
- Identifying whether the vehicle is registered or not for charging station through RFID reader.

III-SIMULATIONS

3.1 STATE OF CHARGE (SOC)

SOC is the relative measure of amount of power that stored in a battery.

3.1.1 MATLAB SIMULATION

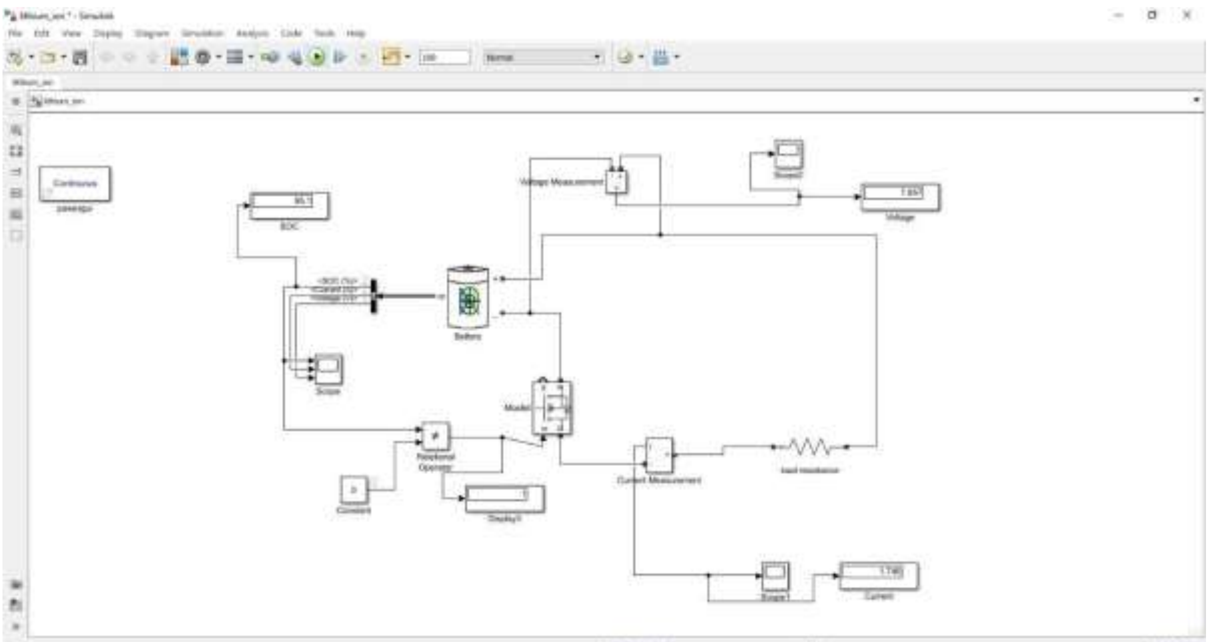

Fig 3.1 SOC Matlab model

The Fig 3.1 illustrate the estimation of SOC, Voltage and Current, the model includes Lithium-ion battery of nominal voltage 3.7V with rated capacity 2.6Ah, Relational operator for comparing SOC value with constant value, Resistant of 4.4ohm, Busbar and MOSFET.

3.1.2 RESULT

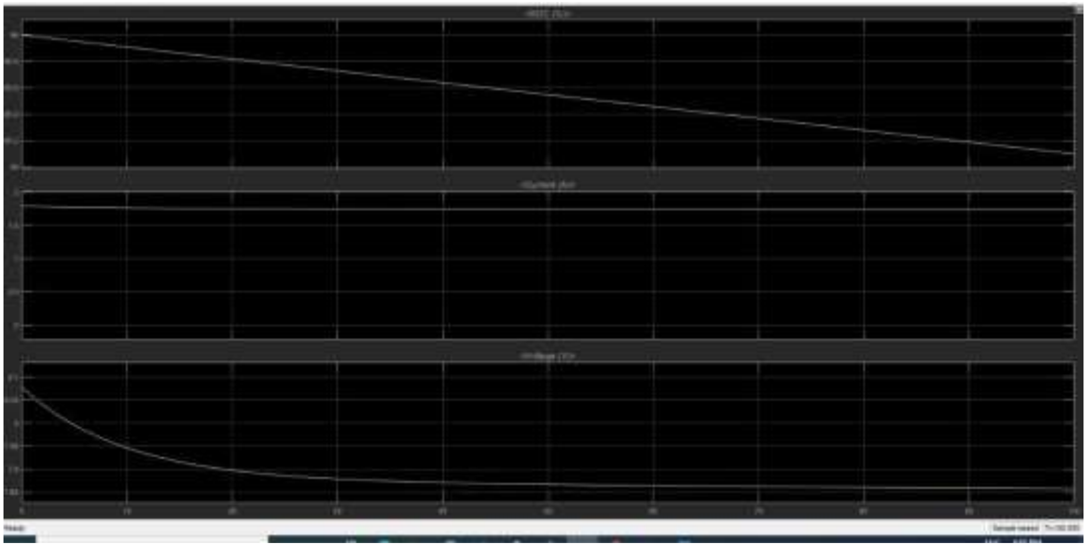

Fig 3.1.2 SOC model output

3.1.3 ANALYSIS

The Demonstration will show the Estimation of SOC, Voltage and Current of a lithium -ion battery.

At t = 0 sec, The SOC will be 96%, Voltage = 8.10V, Current = Negligible

At t = 150 sec, The SOC will be 94.65%, Voltage = 7.85V, Current = 1.744A

At t = 1000 sec, The SOC will be 87.06%, Voltage = 7.77V, Current = 1.744A

At t = 4000 sec, The SOC will be 60.95%, Voltage = 7.43V, Current = 1.744A

At t = 8000 sec, The SOC will be 28.86%, Voltage = 6.433V, Current = 1.744A

At t = 15000 sec, The SOC will be 0, Voltage = Negligible, Current = Negligible

3.2 TEMPERATURE

Effect of temperature on Battery leads to reduction in performance of a battery. Change in temperature of battery due to increase in ambient temperature or travelling longer distance without resting results in reduced in EV battery life cycle.

3.2.1 PROBLEM STATEMENT

Using mat lab, Illustrate the temperature effect on lithium-ion battery

3.2.2 MATLAB SIMULATION

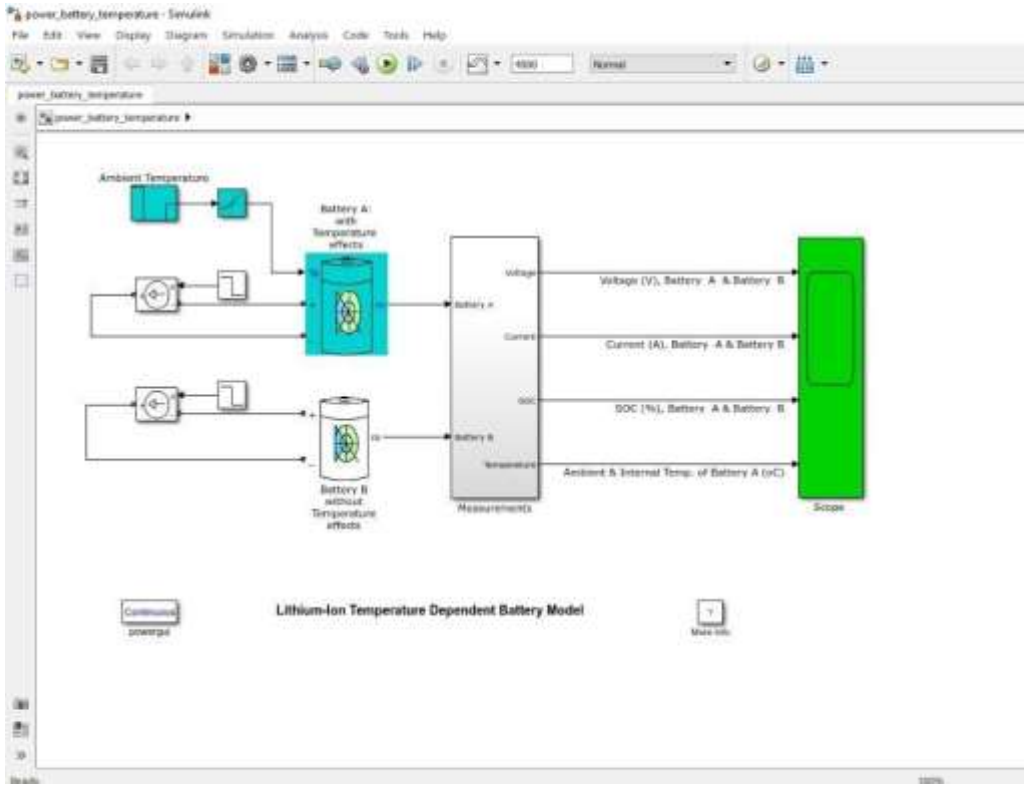

Fig 3.2.2 Temperature mat lab model

The fig 3.2.2 illustrate the temperature effect on lithium-ion battery of a 7.2 V, 5.4Ah. The model includes the effect of ambient temperature on voltage, resistance and capacitance**.** Its performance value is compared with another model where impact of temperature is neglected. As shown in Figure 3.2.2, the temperature of the battery performance is close to reality. As the internal temperature increases or decreases due to discharge or charging, the temperature drops, and as the temperature changes, the output voltage and capacity also increase or decrease.

3.2.3 RESULT

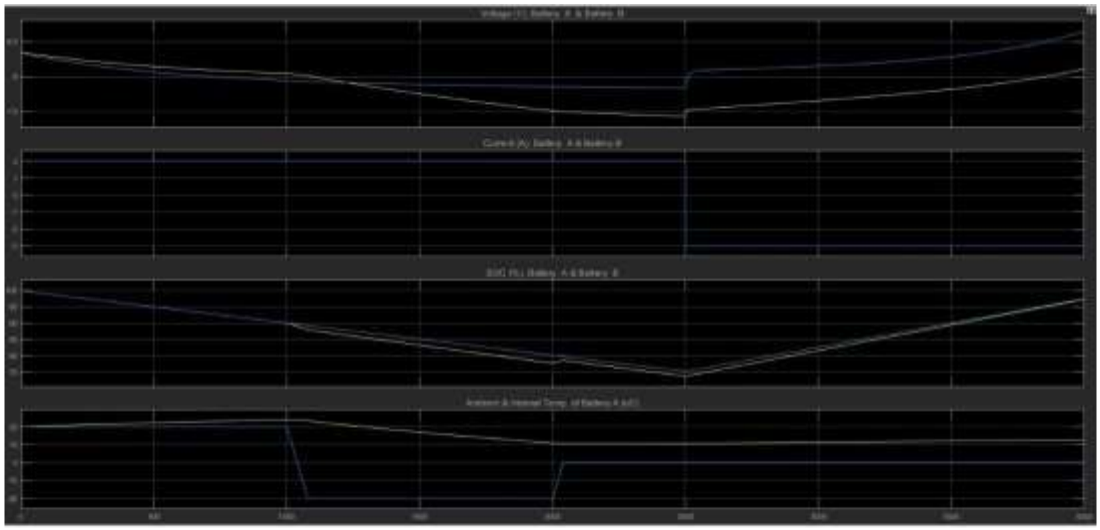

Fig 3.2.3 Temperature model output

3.2.4 ANALYSIS

This will show the performance of the temperature depending on the Li-ion battery model. At t = 0 seconds, batteries A and B are discharged at 2A at 20 degrees Celsius. At t = 150 seconds, the temperature of the battery increased its constant value by 29.2 degrees due to the temperature drop during discharge. This causes battery A's voltage to rise slightly while battery B's output continues to drop. Ambient temperature drops to -20°C in t = 1000 seconds this causes the output power of battery A to drop as the temperature inside drops rapidly. Battery B's output continues to drop to steady state value.

3.3 BUCK BOOST CONVERTER

A Buck Boost converter is a DC-DC converter whose output voltage is greater or less than the input voltage. It is like fly back converter where the difference is inductor is used in place of transformer.

3.3.1 PROBLEM STATEMENT

* Using Mat lab, Illustrate the buck boost converter.

3.3.2 MATLAB SIMULATION

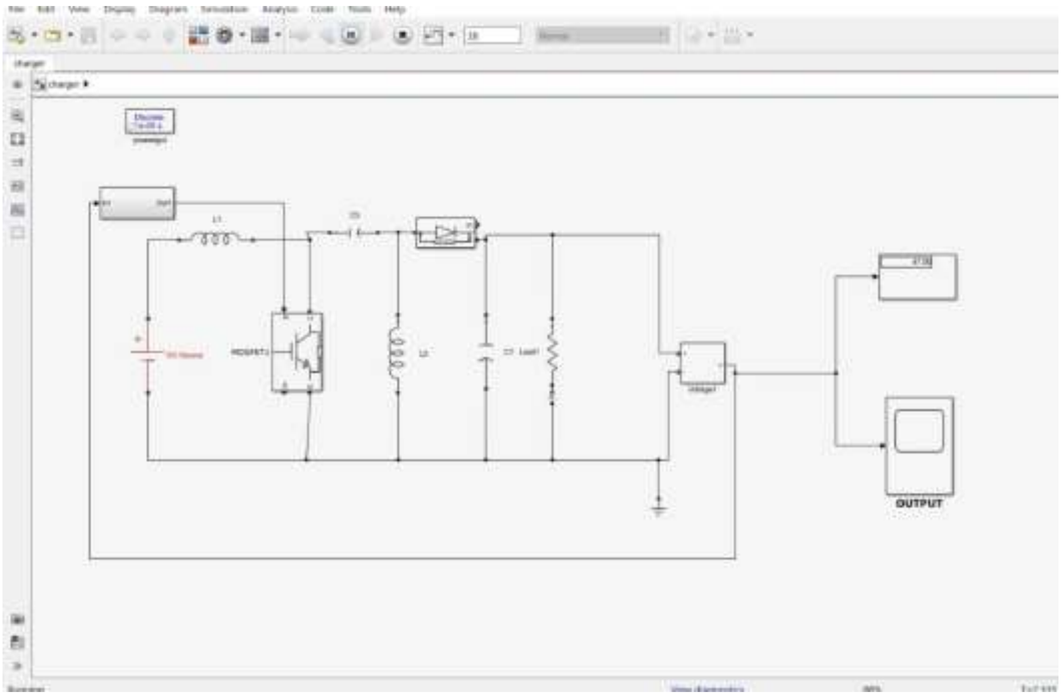

Fig 3.3 Buck boost converter model

Figure 3.3 shows the Buck Boost converter model, which is a diode parallel to the series RC circuit and a MOSFET device parallel to the series RC circuit. Figure 3.3(a) and Figure 3.3(b) it clearly shows that how voltage was boosting.

3.3.3 RESULTS

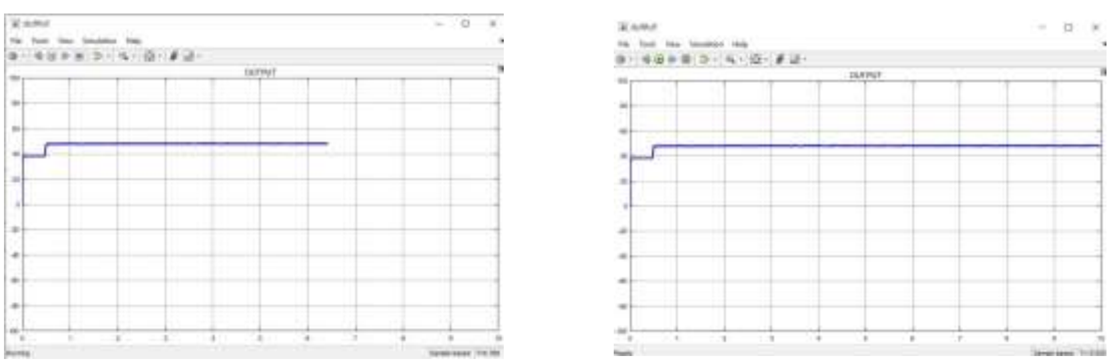

figure 3.3(a) figure 3.3(b)

Buck boost converter output

3.3.4 ANALYSIS

The Demonstration will show the performance of Buck boost converter

At t = 0 sec, Voltage will be 40V

At t = 6.39 sec, The Voltage is slightly boosting shows in fig 3.3(a).

At t = 10 sec, The Voltage is boosted completely shows in fig 3.3(b).

3.4 CHARGING AND DISCHARGING MODEL OF BATTERY

Inside the battery at given time Charging and Discharging is always occurring.

3.4.1 PROBLEM STATEMEMENT

Using Mat lab, Illustrate the charging and discharging model of a battery

3.4.2 MATLAB SIMULATION

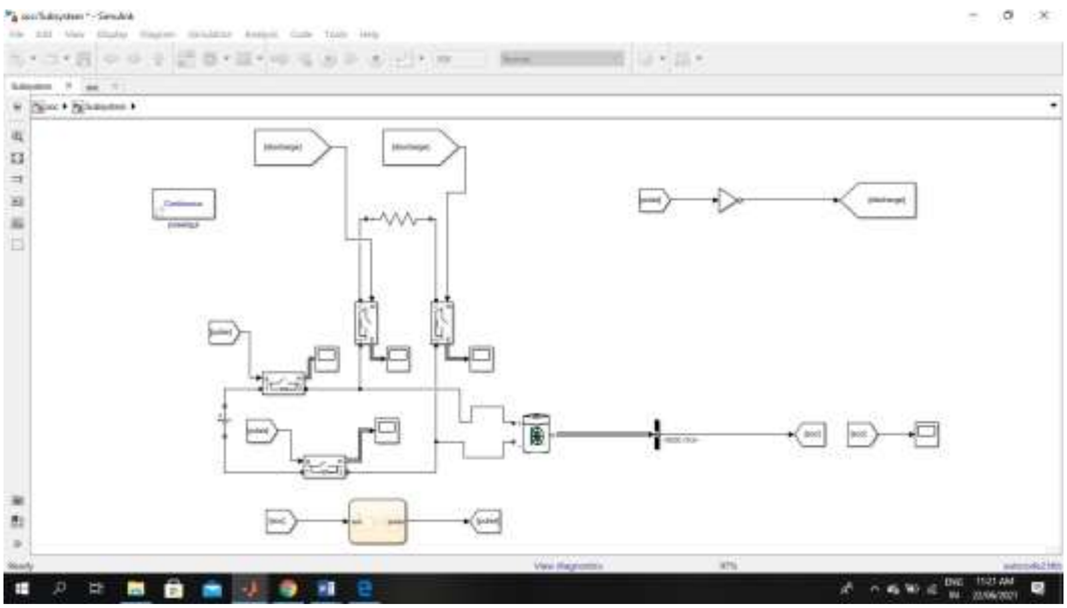

Fig 3.4.2 Battery Charging and discharging model

Fig 3.4.2 illustrate the battery charging and discharging model, the model includes lithium-ion battery of 7.2V, 5.4Ah capacity and MOSFET.

3.4.3 RESULTS

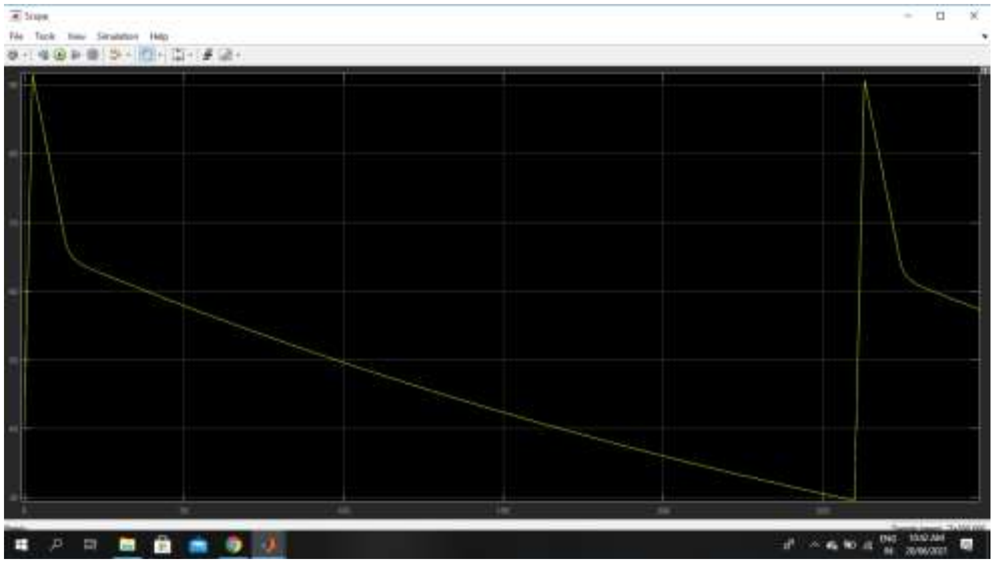

Fig 3.4.3 Charging and discharging model of battery output

3.4.4 ANALYSIS

The Demonstration will show charge and discharge of a battery with respect to SOC

At t=0 sec, SOC=40%, battery is charging

At t=50 sec, SOC=55%, battery is discharging

At t=260 sec, SOC=79%, battery is charging

3.5 CELL BALANCING

The purpose of cell balancing feature is to protect the battery cells from over discharging and avoiding the possible race issue where BMS removes alternating cells from charge. Cell balancing of battery pack is to balancing voltage of each cell in a battery.

3.5.1 PROBLEM STATEMENT

* Using Matlab, Illustrate the passive cell balancing of lithium-ion battery pack model

3.5.2 MATLAB SIMULATION

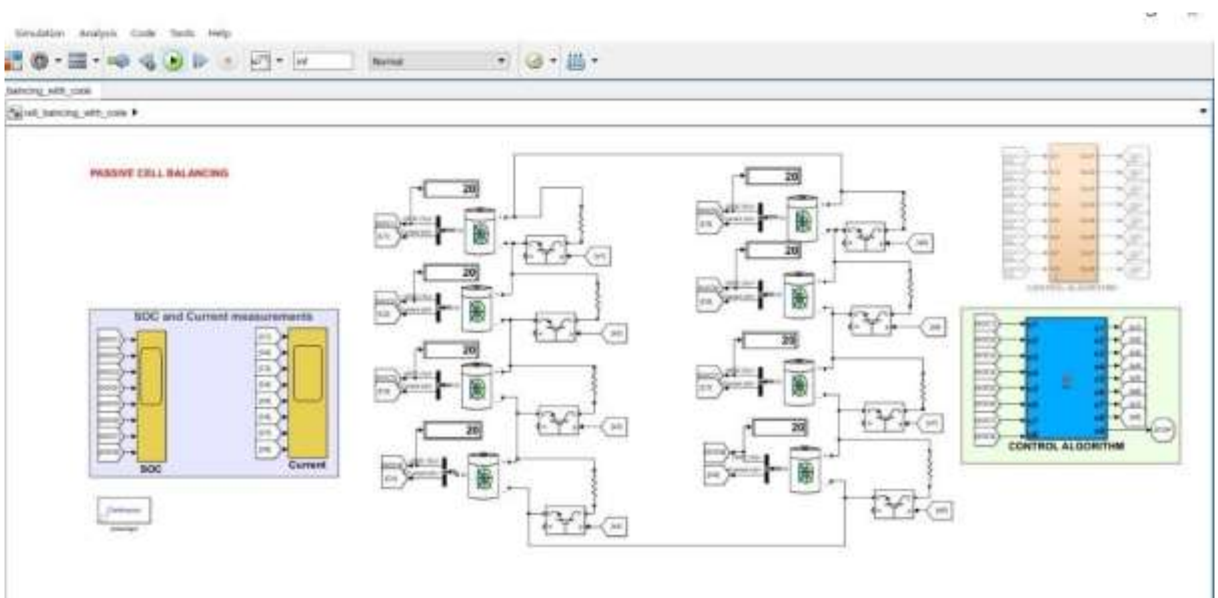

Fig 3.5.2 Cell balancing mat lab model

The fig 3.5.2 illustrate the passive cell balancing of a battery model, it includes four lithium-ion cells connected in series and four in parallel to form battery pack. Initial soc of each battery is set, the soc is taken as input to a program and is coded such that each cell should have equal soc by using passive cell balancing that is battery having higher soc is made to battery having lower soc by discharging charge through resistor. As soon as soc of all cells become equal discharging stops and corresponding Results shown in fig 3.5.3(a) and fig 3.5.3(b).

3.5.3 RESULTS

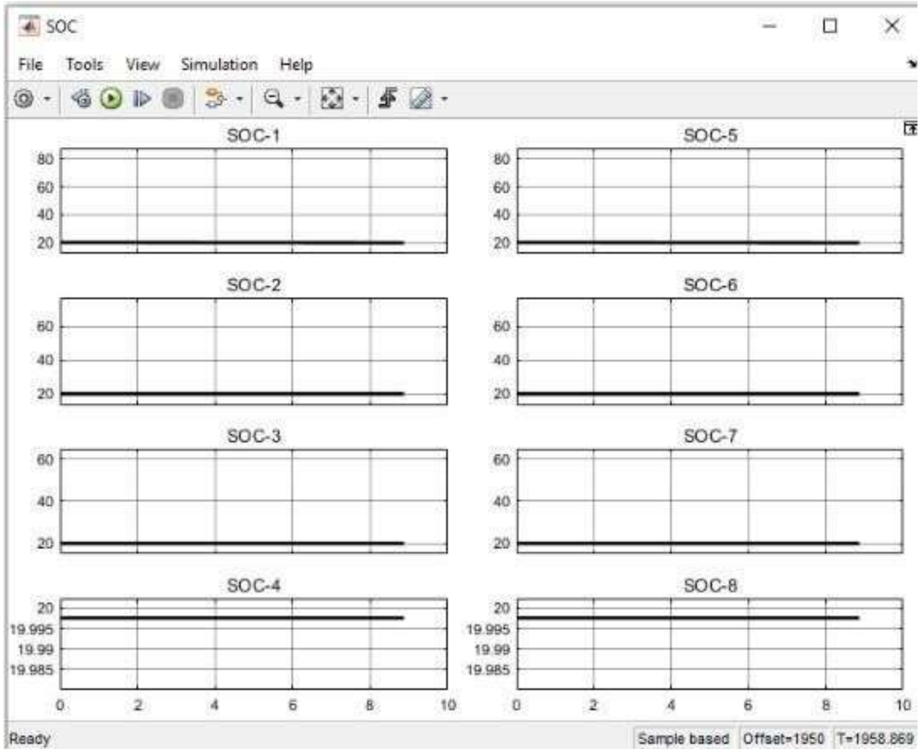

Fig 3.5.3(a) Battery SOC output

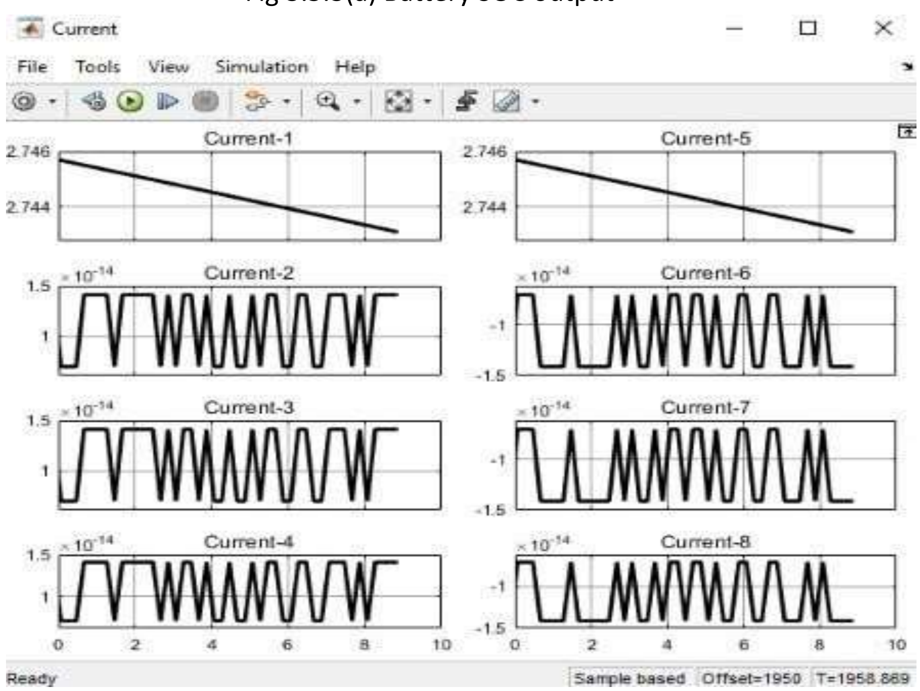

Fig 3.5.3(b) Battery Current output

3.5.4 ANALYSIS

At t=0 sec, cell 1soc=80%, cell2 SOC =70%, cell 3 SOC =60% and cell 4 SOC =20%

At t=1000 sec, cell 1soc=48.97%, cell 2 SOC =39.14%, cell 3 SOC =29.39% and cell 4 SOC =20%

At t=2100 sec, cell 1soc=18.06%, cell2 SOC =18.06%, cell 3 SOC =18.06% and cell 4 SOC =18.06%

IV-WORKING MODEL

4. VEHICLE UNIT BLOCK DIAGRAM AND CHARGING STATION

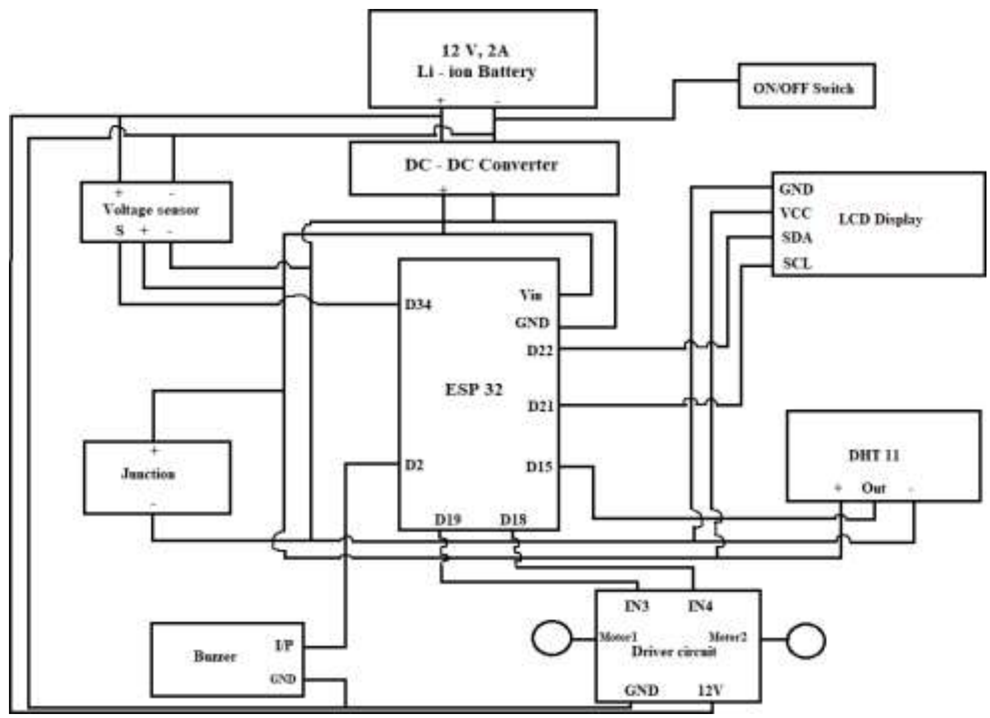

Fig 4.1(a) Vehicle Unit Block Diagram

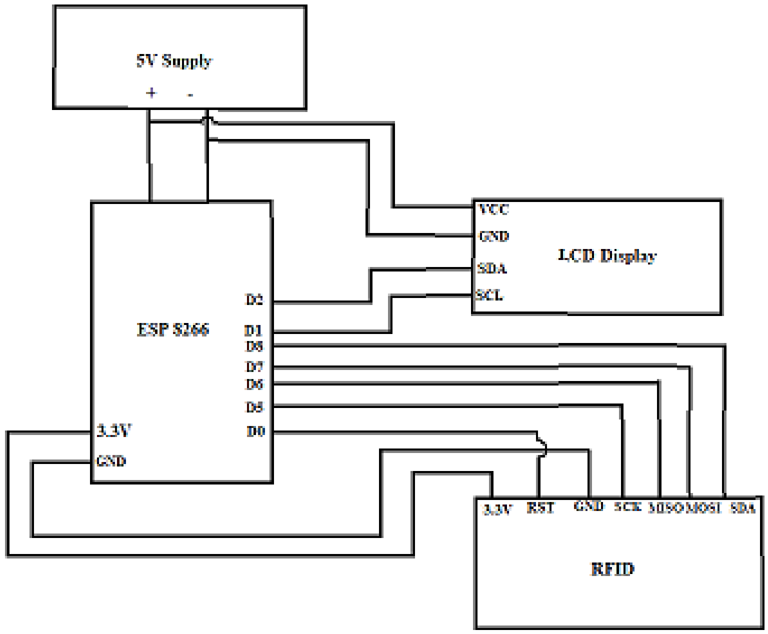

Fig 4.1(b) Vehicle Unit Block Diagram

4.1 WORKING

Charging station mainly consists ESP 8266, RFID module and 16x2 LCD display. This module is designed mainly to identify whether owner name and car number are registered or not. The details i.e. owner name and car number are entered in the program.

ESP 8266 is used because it has dual I2C connection capability. When the car owner swaps the RFID tag in the charging station, the data is transferred to the RFID reader through radio waves. RFID reader transmits data to the RFID program. Each RFID tag has a unique key. When the transmitted data is matched with the stored data the owner gets the access. The owner's name and the vehicle number are displayed in LCD

V-CONCLUSION

5.1 CONCLUSION

In this work we made an attempt to know the importance of battery management system in electric vehicle, how it works and what and all should be monitored for an effective battery management system. Through simulations we learnt how cell balancing works, importance of SOC, SOH, and effect of temperature on battery performance.

From the simulations done so far we conclude that state of charge plays an important role in battery performance and cell balancing should be employed for the better results. We learnt how bms coupled with iot is helpful.

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