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BATTERY MANAGEMENT SYSTEM FOR E-VEHICLES

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ABSTRACT

A Battery Management System (BMS) serves the purpose of an Electronic-regulator by performing the dual function of monitoring as well as controlling the charging-discharging phenomenon of Rechargeable batteries. The rising advancements in the Battery-technology have attracted the designers towards an effective management design for a battery. Battery design improvements are fuelling the wide-range requirements of today's electronic devices from Portable devices to Electric vehicles (e-Vehicles). As Environmental protection has given a loud call to e- vehicles so, BMS plays a significant role in this Eco-Friendly objective. In a simple way, BMS act as a watchdog on the key operational parameters during charging & discharging process of the battery (mainly used for Lithium-ion Battery). Performance Parameters involves Voltage, Current & the battery internal and ambient temperature which are to be kept within specified rating values in order to have a safe and reliable output.

Keywords

Ambient-temperature, Cell- balancing, Cell- monitoring, State-of-charge of Battery, State-of-Health of a battery, Depth-of-Discharge

1. INTRODUCTION

A battery management system [BMS] has very crucial role in electric vehicles. Its design is quite challenging because of two reasons. Primarily, the modeling of the battery behavior is very complicated and the other reason is that, the system has to supervise the battery parameters such as current, voltage and temperature [IVT] in real-time conditions. Electric vehicles (EVs) are powered using a large number of battery cells, requiring an effective battery management system (BMS) to maintain the battery cells in an operational condition while providing the necessary power effectively.

Battery management systems (BMS) acts as a decision-maker for charge & discharge rates on the basis of load demands, cell voltage, current, and temperature measurements, and on the ratings of estimated battery SOC, capacity, impedance, etc

2. CHANNELS TO APPROACH FOR BMS

Twenty-first century technology has came up with the objective of *Green Energy* i.e. focusing more on the renewable and eco-friendly means of energy use and their conservation strategies. Electrical Vehicles (EV)

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gives the advantage of zero tail-pipe emission but this advantage is compromised because of its long charging time. Thus, fossil-fuel based vehicles are used in majority leading to more environmental destruction. An effective BMS will enhance the reliability of the people on use of electric vehicles and help in shifting from the fuel based automotives to electric automotives.

2.1. Why there is need of electric Vehicles

Case study – INDIA

Electric vehicles make a lot of sense in India as recently World Health Organization (WHO) declared six Indian cities as the most polluted cities in the world. As per the report based on a survey of car users in India, almost 40% of the car users in India want to pay less for an electric vehicle as compared to the conventional sources, 30% are ready to pay the same amount while only 15% are affirmative to pay more. Electric vehicles will not only be cheaper i.e. pocket-friendly to operate but at the same time will also save our environment. Another survey suggests that, Electric Vehicles are ideal for India as around 75% of Indians travel less than 1000 kilometers in a month by cars. Thus, automobiles companies are set to revolutionize the two-wheeler sector by introducing an electric bike. This pulls attention towards a reliable, safe and Affordable battery design for the users.

2.2. Why there is need of Battery Management System for E-Vehicles

The battery management system (BMS), performing the multiple functions as of battery modeling, battery state estimation, and battery balancing etc., is one of the key points to protect the battery and optimize the utilization of the battery in Electric Vehicles. Electric car battery has an important task in electric car to keep it stably running on the road, thus the electric car battery pack needs to be secure from damage because of uneven temperature distribution. Depending on the electrochemical used in battery, the optimum range is different, but the ideal optimum temperature of electric car battery is 45°C in order to keep the performance and life for the battery at safe. It may provide a greater degree of comfort and satisfaction to the user with it's zero noise and zero pollution affirmations. Thus, it is Electric mobility for the upcoming generations.

3. Proposed Observations under Research

In the current work, the design & simulation of BMS for EVs is presented using *Mathwork's MATLAB* software. The entire model of BMS & all the battery parameters required to design and simulate the BMS are extracted from the experimental results and incorporated in the MATLAB model. Model-Based design (MBD) provides the ease of improving the product quality and short development cycle by quick responses. Here, it allows developers to create equivalent circuit of lithium battery and charging controller model in *Simscape* and *Stateflow* respectively. By using the *Simulink* toolbox, the simulation of equivalent circuit and charging control models can be virtually run on computer to quickly analyze the charging controller's performance.

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The up-gradation of following requirements is proposed for the new BMS system .BMS executes tasks which define the behavior of the system. Generally the tasks of the BMS - system were defined to:

• Protect & supervise the battery

• protect the user / driver

• estimate the battery´s state

• Protect the links in the energy chain

• Maximize the battery´s performance

• Share calculated data and control external devices

These tasks can be thought as separate categories which include the exact functions in order to fulfill the requirements. The primary purpose behind this allocation is that the first task (supervise the battery) is the base task which provides the information for the other tasks.

The following tasks are performed by the battery the Battery Management System in its base task of the battery Supervision as;

i. Measures and monitors cell currents in real -time

ii. Measures and monitors cell voltages in real -time

iii. Measures and monitors cell temperatures in real –time

According to the base measurements the BMS protects the battery;

1. By setting the maximum charge current limit / discharge current limit

2. By setting the maximum charge power limit / discharge power limit

3. By preventing the voltage of any cell from exceeding the fixed upper /lower limit provided by the manufacturer of the battery

4. By preventing the temperature of any cell from exceeding a fixed upper / lower limit provided by the manufacturer of the battery.

3.1. Mathematical Approach & Analysis

By processing the base data the BMS estimates battery´s state by:

• Determining the *state of charge* (SOC) state of the cells / battery

• Calculating the *depth of discharge* (DOD) state of the cells / battery

• Estimation of the values of internal resistances of the cells

• Calculation of the secondary data such as total energy, delivered charge, operating hours and battery cycles since first use.

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$$SOC\_cell\ [\%] = \frac{Available\ charge\ in\ the\ cell}{Nominal\ capacity\ of\ the\ cell}$$

There are three methods of calculation of SOC:

1) Through direct measurement: To measure the SOC directly, one could simply use a voltmeter because the battery voltage decreases more or less linearly during the discharging cycle of the battery.

2) Through coulomb counting: In the coulomb-counting method, the current going into or coming out of a battery is integrated to produce the relative value of its charge.

3) Through the combination of the two techniques: In addition, the two methods could be combined. The voltmeter could be used to monitor the battery voltage and calibrate the SOC when the actual charge approaches either end. Meanwhile, the battery current could be integrated to determine the relative charge going into and coming out of the battery.

3.2. Feedback Control

The feedback control & communication in the new battery management system between the system devices was carried out with two separate *CAN* buses. The primary *CAN* -bus (250 Kbit/s) was implemented between the BMS -master and the slave cards. The secondary bus is the faster CAN-bus (500 Kbit/s) called *CAN-A*. This is the largest *CAN* bus in the e-vehicle and the other *CAN* compatible devices except inverters were connected to this bus.

In practice the CAN -bus reduces a lot of wiring harness as a communication link because the information is transferred in serial format and according to the CAN -bus specification ISO 11898-1 it needs only two twisted wires for routing the data. Furthermore the CAN -bus is bidirectional and very fault-tolerant when correctly installed.

4. FIGURES AND GRAPH

4.1 Figures

4.1.1. Energy Chain

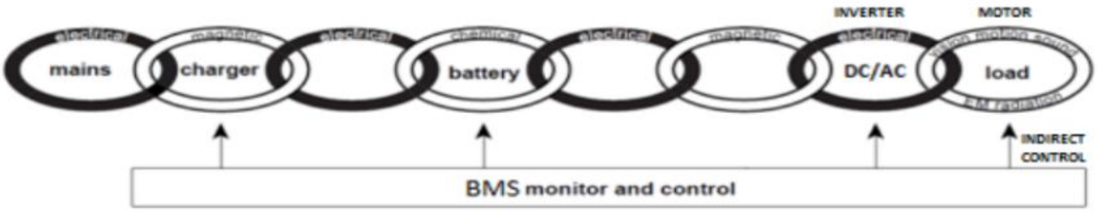

Fig1. Energy Chain in BMS

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4.1.2. Accurate Electrical Circuit for BMS

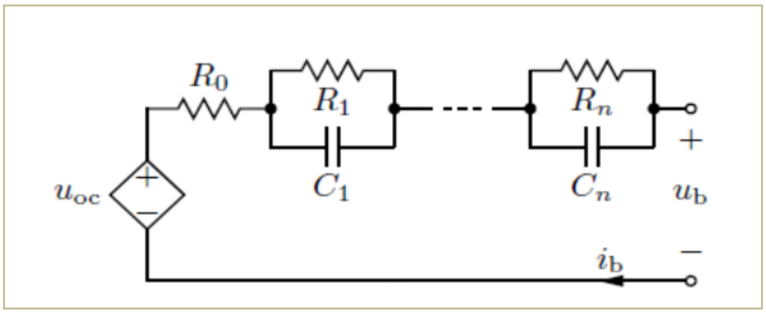

Fig2. Accurate Electrical Circuit for BMS

The Relaxation time is the period of the battery after bringing the cell current to a null value or at zero value. The relaxation time of a battery is needed to controlled and by proper modeling of the RC modules, this requirement can be fulfilled.

4.1.3. Control Flow of BMS

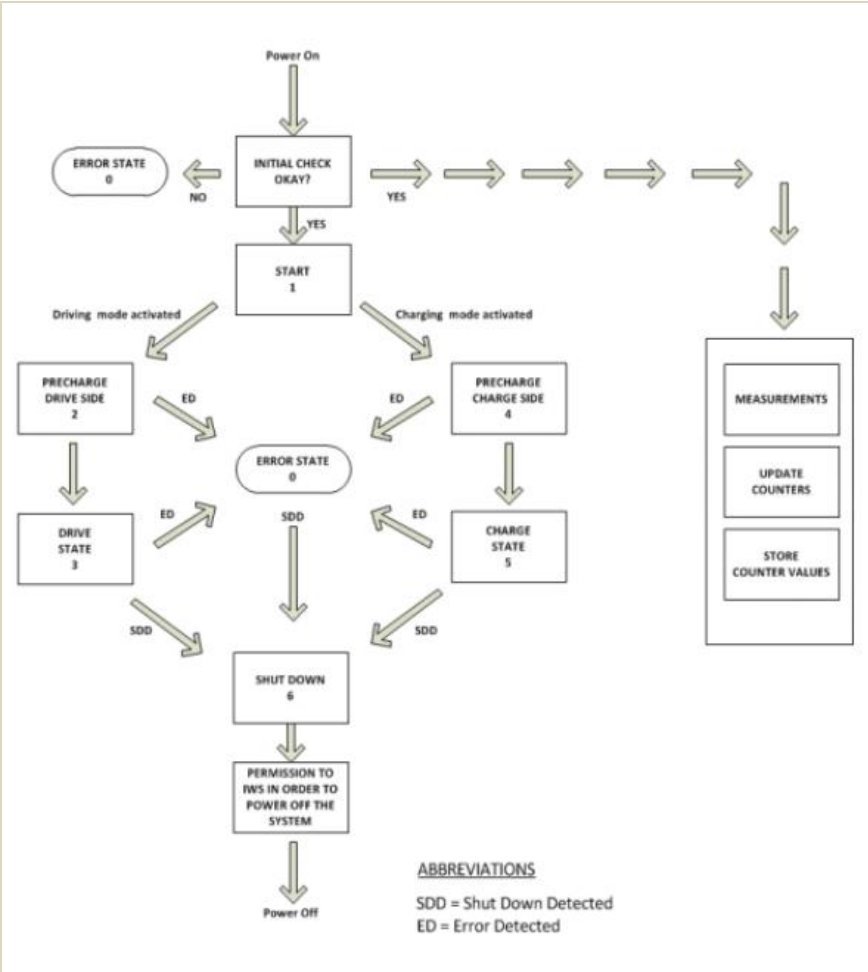

Fig3. Control Flow of BMS

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4.1.3. Complete Stateflow of BMS using MATLAB

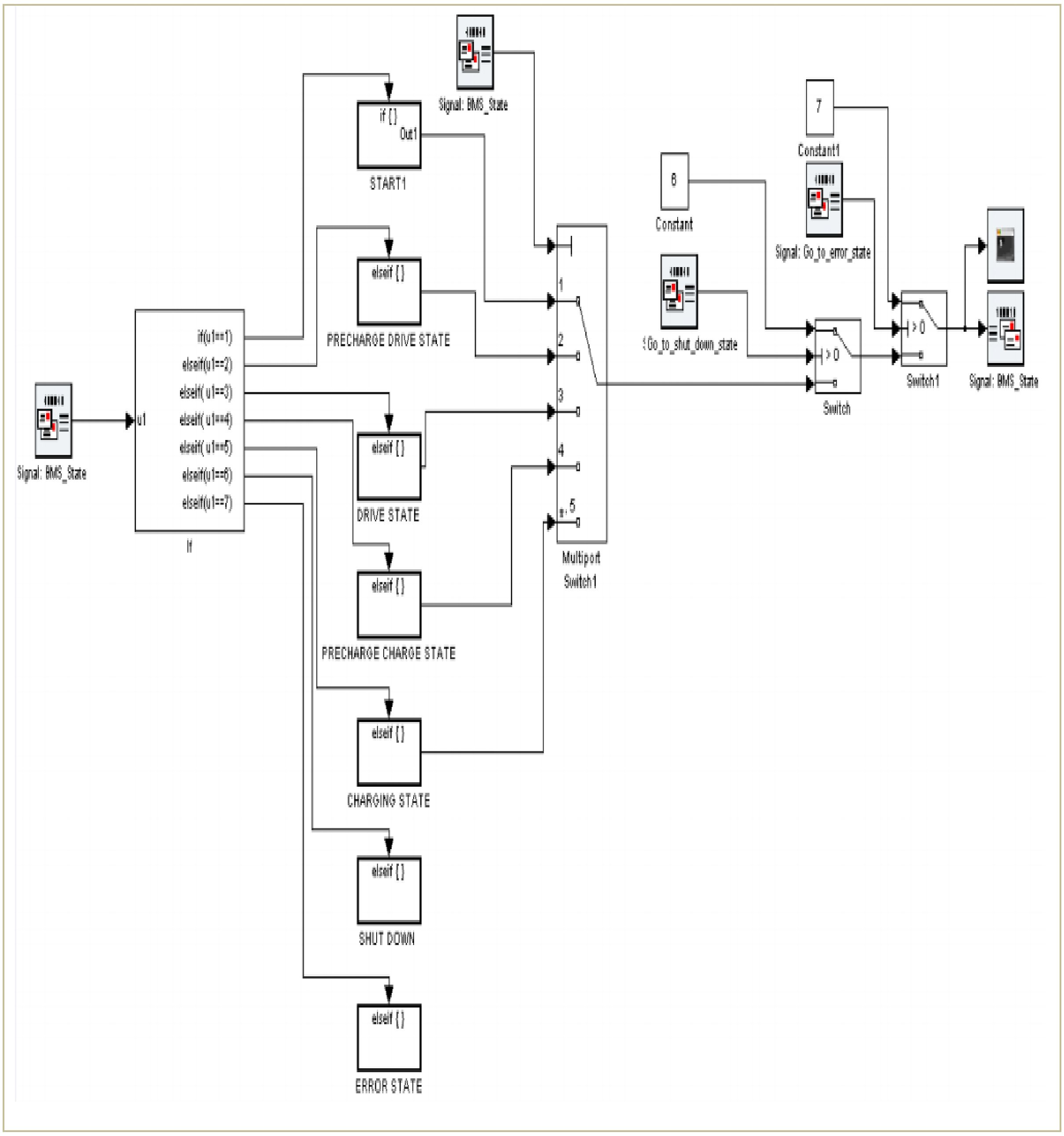

Fig5. Complete State flow of BMS using MATLAB

4.2 Graphical Observation

4.2.1. Observations on Capacity & Limits of the Battery

By adding the number of RC networks in Figure 2 the battery model could be made more accurate but this demands more calculation power from the BMS master. In the proposed BMS system, the BMS

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master was programmed to calculate the open circuit voltages for the minimum and maximum cell voltages by using the simple battery model that was shown in the above Figure 5. When the BMS master calculates and controls the battery according to open circuit voltages, it leads to IR compensation.

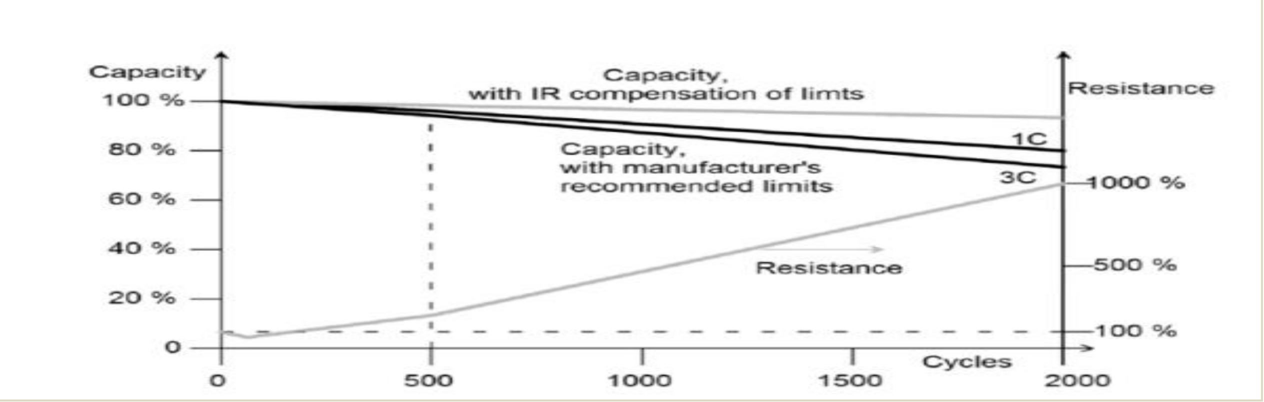
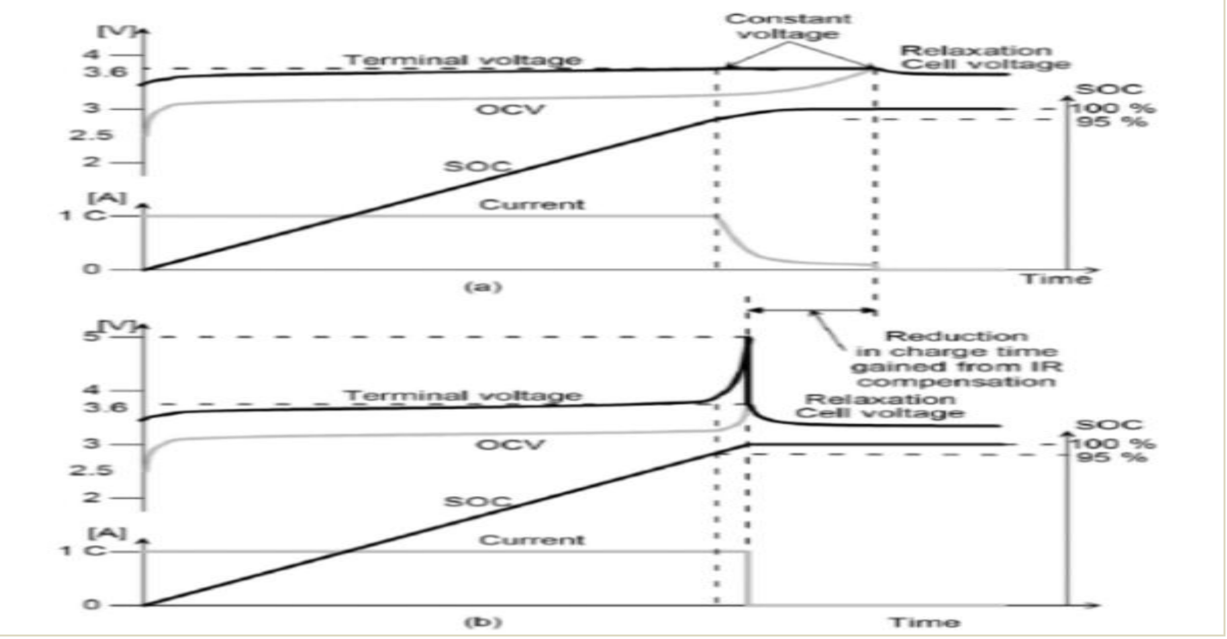


Fig6. Capacity & Limits of Battery



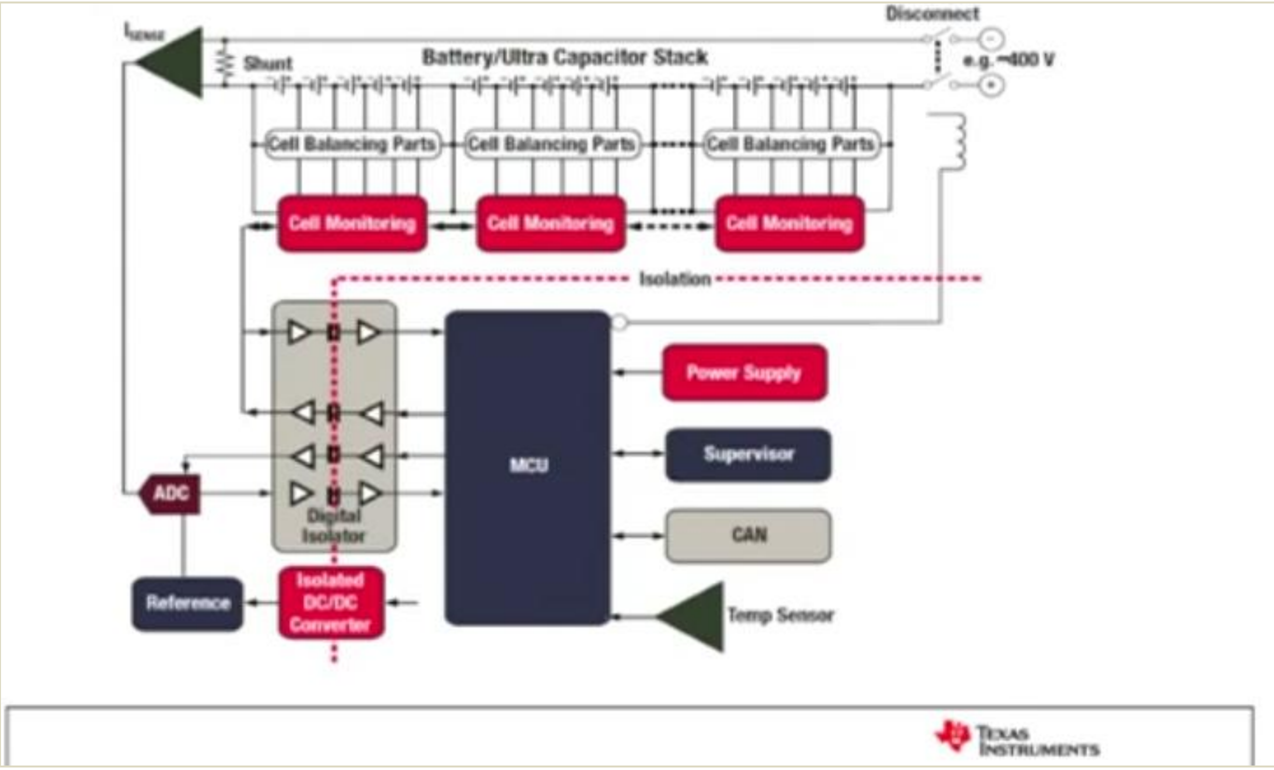


Fig 7. Basic Block Diagram of BMS

5. CONCLUSION

The control of the battery was based chiefly on the values of open circuit voltage and dynamic current limitation algorithm. The system intelligent response was based on a state machine which determined the control orders of the BMS master and ensured that the BMS master works in the right mode according to the environment variables given by the user and the other system devices.

There is safety enhancement in the system handling because all the high voltage measurements were designed to take place in the high voltage distribution box where all the high voltage connectors would be out of direct contact of hand. Furthermore, it provides the real-time based control made the system very fast in its responses and thus the system became more controllable also in error cases such as when crossing the over current limit.

The new BMS -system has the capability to supervise these batteries in future. This brings the opportunity to research the battery with the new BMS system and all the test can be produces by new code snippets & Simulink tools, this is a way to study the aimed - prototype level research and development work.

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REFERENCES

[1] Purushothaman B K, Landau U, "Rapid charging of lithium-ion batteries using pulsed currents," Journal of The Electrochemical Society, 2006, pp. 533–542

[2] Miller S, Wendlandt J, "Real-Time simulation of physical systems using Simscape," MATLAB News and Notes, 2010, pp. 1–13

[3] Zhao, J., et al., Design and full-car tests of electric power s9teering system, in Computer And Computing Technologies In Agriculture, Volume I, D. Li, Editor. 2008, Springer US. p. 729-736.

[4] Tie, S.F. and C.W. Tan, A review of energy sources and energy management system in electric vehicles. Renewable and Sustainable Energy Reviews, 2013. 20: p. 82-102.

[5] Electrical India Magazine e-edition

[6] https://www.themobileindian.com/news/is-india-ready-for-electric-vehicles-21469/

[7] http://www.pluginindia.com/bms.html/