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2- MODE BATTERY BALANCER FOR ELECTRIC VEHICLES

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ABSTRACT

Transportation sector is found to be the largest user of oil. It is the second largest producer of CO_2, contributing to environmental pollution. Electric Vehicle came into existence as a solution to this problem. It was necessary to balance the battery pack in the electric vehicles to achieve the requisite driving range. This paper proposes a 2-mode battery balancing system with renewable energy integration. The 2 operating modes are: solar-balancing, charge-balancing. When the vehicle is moving, solar cell charges the cell with the lowest SOC and the system is said to be in solar balancing mode. In charge balancing mode vehicle will be parked in the charging station and the cell with lowest SOC will be charged. If the sun's energy is available when the vehicle is parked, it will be stored in the storage system. The proposed system will eliminate the wastage of energy that occurs in the conventional battery balancing system thereby improving the efficiency of the system and increasing the driving range. Keywords – Renewable system, solar power, electric vehicle, state of charge, battery balancing, battery management system (BMS).

I. INTRODUCTION :

A number of researchers are trying to design a system that can be used for different types of batteries and vehicles for various performance requirements [2].The battery bank should be properly balanced otherwise it leads to catastrophic failure [1]-[5]. To overcome these problems, a number of control algorithms have been developed [6]. Battery system can be active or passive balancing, in which balancing is considered as the widely used method for battery management system in regard of its low cost [5]. In passive balancing, when one of the modules reaches the threshold limit, using power resistor, it will transfer the energy to other modules and thus they get charged.

The three different forms of balancing active circuits include balancing by capacitors, inductors or in combination as in hybrid balancing [1]. In capacitive based active balancing, capacitor is connected parallel to a module. In this form no complex algorithm is required for the control of balancing circuit. But the process of balancing takes a lot of time. These are the merits and demerits of capacitive balancing. But in case of inductive balancing, transformer with magnetic cores having air gaps or inductors helps in transferring energy between the cells. Inductive balancing can be used for charging a cell having comparatively high voltage or equal voltage, than other cell. The hybrid form of balancing uses dc-dc converters. In hybrid active circuit of balancing, because of the resistance, the power loss cannot be neglected. A unique optimum-cost nature of charging, management of power and mitigation methods for battery degradation in PHEVs has also been developed [3]. Considering all the facts, a 2-mode battery balancing system is proposed. The vehicle will be charged using a plug-in charger and during driving conditions, sun's energy is utilized to charge cells having low charge value. This system increases the capacity of each and every individual cell in the battery bank and thereby increases the durability of the battery.

II. BATTERY MANAGEMENT SYSTEMS

Battery management system is an electronic system which is capable of managing a rechargeable battery from outside its safe protecting area. This helps in state monitoring, secondary data calculation, data reporting and most importantly cell balancing. A battery bank which is built together with a battery management system with external communication is said to be "SMART BATTERY PACK". These systems are of utmost importance in urban areas where conventional form of storage systems like hydroelectric pumped storage of energy and compressed energy storage of air are often not a good solution. The absence of these systems leads to conserved use of batteries. Catastrophic hazards and premature failure occurs in the systems without BMS which leads to poor thermal and electrical properties. A BMS may be able to monitor the total voltage, voltage of individual cells, minimum value and maximum value of cell voltage, charge level of the battery, current in or out of the battery.

III. CELL BALANCING :

Cell balancing is a function performed by the management system in batteries to increase the capacity of a battery bank. Thousands of cells will be arranged to form a single battery pack, but each cell in the battery pack will have different capacity. This can be due to manufacturing variances and assembly variations that occur unintentionally or intentionally by the manufacturer as part of maximizing the life and service. Hence each cell charges and discharges at slightly different rate. When one cell is charged the whole charging

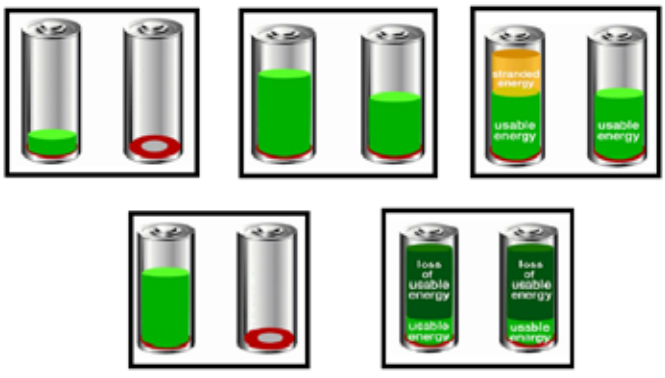

Fig 1: Unbalanced Cells

process in the battery pack should terminate. Similar is the case of discharging, when one of the cells in the battery pack reaches its discharge threshold

the whole discharging process should stop. From fig–1, we can infer that when unbalanced cells are continuously charged and discharged the level of imbalance increases. That is as the charging and discharging cycle increases the amount of stranded energy increases. Hence that much amount of energy will not be available for use. This can reduce the driving range. To avoid this we should continuously check the voltage or the SOC levels and equalize them. In unbalanced cells the discharging should stop when the cell with lowest capacity is empty. But in balanced cells we can charge a cell with highest capacity without overcharging any other cell and vice versa.

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IV. SYSTEM CONFIGURATION :

Fig-2 shows the block diagram of the proposed system. This system comprises of a solar panel, buck- boost converter, storage system, plug source, battery bank, sharing a single dc line. The converter should be able to find out the input and also the

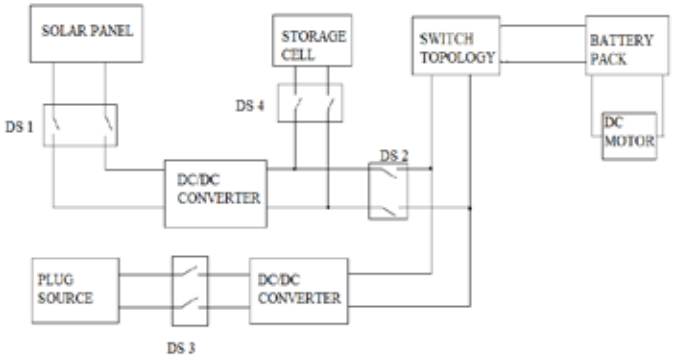

Fig 2: Block Diagram

output terminal voltage, thereby battery will be charged accordingly. Switch box is arranged in such a way that it links the lowest voltage battery to the dc bus and then charge the battery. Storage system is used to store the surplus energy powered by the solar cell. Fig-3 shows the arrangement of switches and cells.

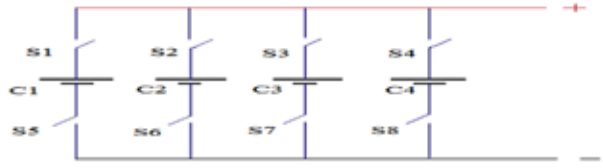

Fig 3: Switch Topology

V. MODES OF OPERATION :

The mode of balancing will be chosen based on the condition of vehicle, that is whether moving or not.

MODE 1: SOLAR MODE

In this mode vehicle will be in motion and switch DS1 and DS2 will be closed. Battery bank will be discharged for powering the electric vehicle. The cell with the lowest level of charge will be in connection with the dc bus and will be charged by

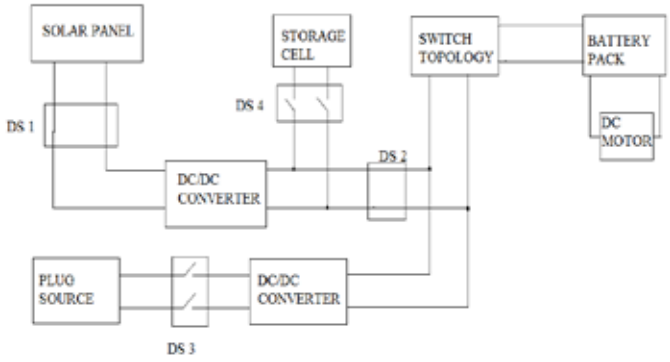

Fig 4(a): Solar mode

the PV cell. When cells reaches the same voltage or SOC the complete battery bank containing the cells will be in connection with the dc line. Then it will be charged by the PV panel. Hence the solar energy can be used until the vehicle is in motion.

MODE 2: CHARGER MODE

In this mode the vehicle will be in the parked state and the switch DS3 will be closed. The battery bank will be charged by an external plug source, after balancing the complete battery bank will be connected. In addition to this if sun's energy is available when the vehicle is parked, it can be stored into the storage cell by closing the switch DS1 and DS4.

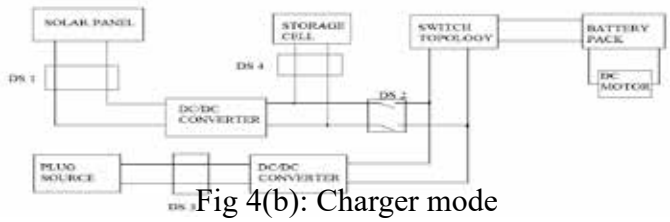

Fig 4(b): Charger mode

VI. CONTROL FLOWCHART

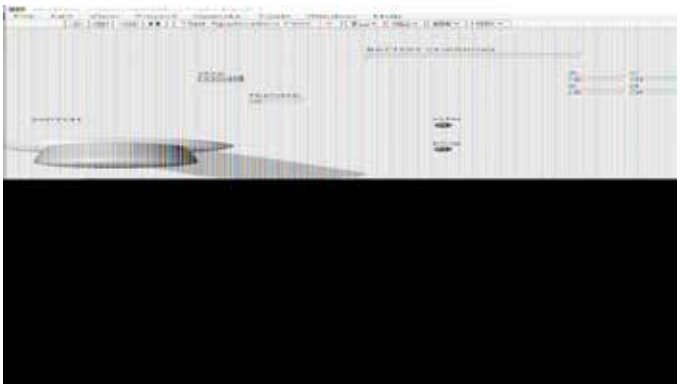

Fig 5: Control flowchart of the system proposed

All the switches will be open and the voltage is measured. Cell with lowest voltage is found and that cell will be connected to the dc line. If the vehicle is moving solar mode of balancing will be switched manually and the cell with low voltage will be charged. Similar is the case of charge balancing mode, but here the source is a plug in charger at the charging station. The module with minimum voltage will come across the dc bus and will be charged and once the entire cell reaches the batteries SOC, the whole battery bank will be connected to the line. If the sun's energy is available for harvesting, it will be stored in the storage system.

VII. LAB VIEW PROGRAM :

National Instrument Data Acquisition (NI DAQ) is the control unit of the proposed system. The program has been implemented using NI lab-view software. Lab-view is graphics based programming software, so logics can be easily implemented without any unnecessary codes. The program includes case structures, while loop, delay etc. The program consists of 3 parts: source selector, voltage reading and comparison of voltage, selection of battery that has to be charged. A case structure is used in the beginning of the program for selecting the source, it also consist of a feedback unit to disconnect sources from charging the battery. There are four cases in this case structure; a digital output is given from respective ports to connect different sources. The next phase is voltage acquiring, since the acquired data is combined, the signal has to be splitted using signal splitter .The data coming from the DAQ will be dynamic data so it has to be converted to scalar data type, for that dynamic data type to scalar data type converter is used. When voltages are available in scalar they are

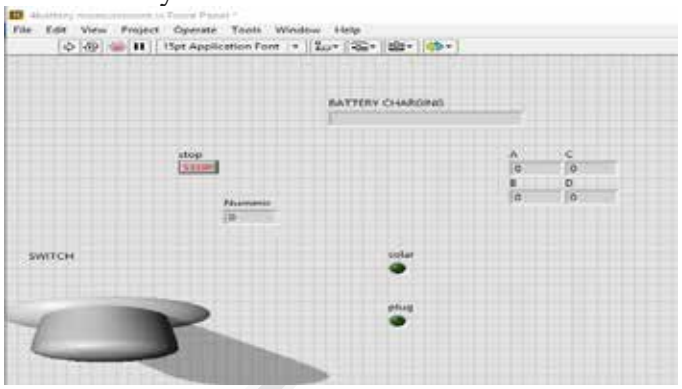

Fig: 6(a)

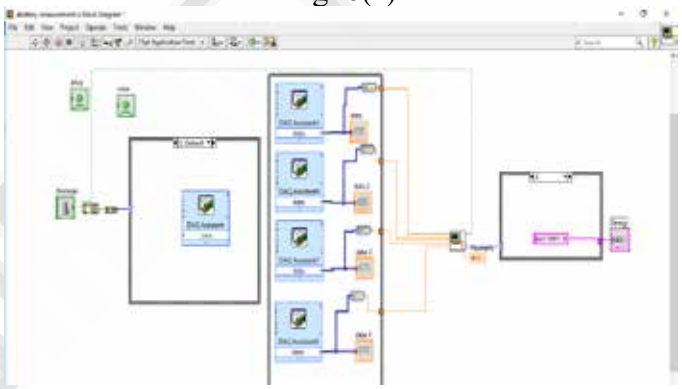

Fig: 6(b1)

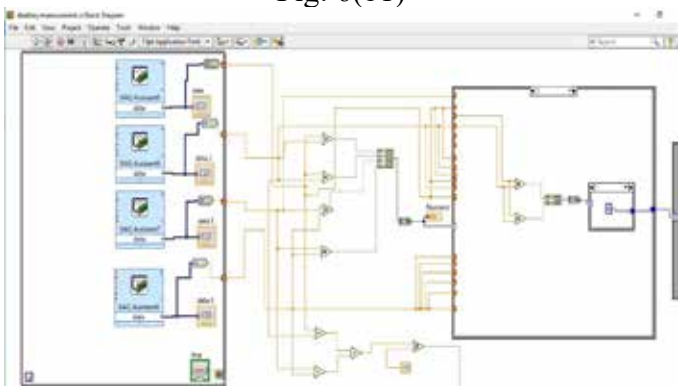

Fig: 6(b2)

Fig 6(a): Lab view Front Panel
Fig 6(b1) & 6(b2): Lab view Block Diagram

compared using' = ' and '>' operators. The output is given to an array which outputs a 4-bit Boolean number for each condition. There will be 16 such 4-bit numbers of which only 9 numbers are valid conditions. This 4-bit Boolean is converted into

numeric and then given to case structure, inside these 9 cases there is another 3 cases making total of 27 cases. Further these 27 cases determine which battery is to be charged.

VIII. FUTURE SCOPE :

Pollution in our country is being increasing day by day, for that electric vehicle is a best solution. If we are able to increase the life of battery used in electric vehicles by balancing the cells, then the difficulty in replacing the position of the battery every 6 months or a year can be reduced. If cells are arranged in parallel the voltage of each cell should be equal, otherwise there is chance of circulating current to flow through them. This system also provides maximum energy utilization of energy which helps in increasing the driving range and efficiency. This is done by reducing the energy loss due to unbalanced cells.

IX. CONCLUSION :

Battery systems connected in series or parallel is affected from various imbalances. This paper proposes a 2-mode battery balancer for electric vehicles. System provides technical support to the battery pack by providing effective balance between each cell in the battery bank. System reduces the energy losses by reducing the use of passive components. Solar balancing mode and charge balancing mode are the 2 modes in the proposed system. If the cells are unbalanced, both the modes charges individual cells in the bank and when the cells are balanced both modes charges the battery bank which is discharged for running the electric vehicle. This system provides a great support for the electric vehicle.

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