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Design and Hardware Implementation of Electric Bike with Active Cell Balancing Technique

U. Kavitha[1], M. Mahalakshmi[1], B. Murugan[2]
[1]Final Year, [2]HOD
Department of Electrical and Electronics Engineering, RAAK College of Engineering and Technology, Puducherry, India

ABSTRACT

In this paper, we are concerning about the growing demand of energy all over the world. In today's modernized world travelling is very essential for human beings in order to protract in this world. Our main focus is on automobile sector where we are converting old petroleum bike to electric bike. The electric bike which works on the battery that is powered by the motor is the general mode of transport for a local trip. In addition of lithium-ion battery was protected in this bike. The active cell balancing made of multiple cells connected in series and with battery management system (BMS) tend to be magnified with each cell are equally charging and discharging process in the cycle. The life of a rechargeable battery can be extended through the use of an intelligent charging system. The charging system must incorporate the proper charging method for appropriate battery and overcharge production to prevent battery damage. The main purpose of using e-bike is that it is user friendly, economical, relatively cheap and high efficiency.

I. INTRODUCTION

India is one of the top ten automotive markets in the world today and having highly increasing middle-class population with buying potential and the steady economic growth. But petrol price has increased more than 50% in 13 different steps in last two years. Here comes the potential need for alternative technologies in automobiles such as electric vehicles (EV)in India. Although the initial investment is around 1.5 times than conventional IC engine, but time has come when the cost of environment is now more concern than the cost of vehicle the purpose of this report is to describe the technology used to produce an electric vehicle and explain why the electric engine is better than the internal combustion engine. It includes reason why the electric vehicle grew rapidly and the reason it is a necessity to better the world today. The report describes the most important parts in an electric vehicle and hybrid vehicle. It compares the electric to the hybrid and internal combustion engine vehicle. The overall impacts of the electric vehicle ultimately benefit the people. Compared to gasoline powered vehicles, electric vehicles are considered to be ninety-seven percent cleaner, producing no tailpipe matter, carcinogens released into the atmosphere by gas -powered vehicles, "can increase asthma conditions, as well as irritate respiratory systems' [1]. The paper begins with a history of the electric vehicle, specifically the lows and highs of production and the reasons for the change. The next section provides a technical description of an electric vehicle, including the parts, their functions, and the theory of operation. The following section describes the hybrid car, including parts, their functions and the theory of operation Based on this understanding, I then compare the internal combustion engine, the hybrid engine, and he electrical engine in terms of efficiency, speed, acceleration, maintenance, mileage, and cost. The paper concludes with section of advantages and dis advantages of the electric vehicle. An electric vehicle (EV), also referred to as an electric drive vehicle, uses one or more electric motors or traction motors for population. An electric vehicle may be powered through a collector system by electricity from off- vehicle sources, or may be self-contained with a battery or generator to convert fuel to electricity.[1] EVs include road and rail vehicles, surface and underwater vessels, electric craft and electric spacecraft.

EVs first came into existence in the mid -19th century, when electricity was among the preferred methods for motor vehicle propulsion, providing a level of comfort and ease of operation that could not be achieved by the gasoline cars of the time. The internal combustion engine (ICE) has been the dominant propulsion method for motor vehicles for almost 100 years, but electric power has remained commonplace in other vehicle types, such as trains and smaller vehicles oh all types.

II. BLOCK DIAGRAM EXPLANATION

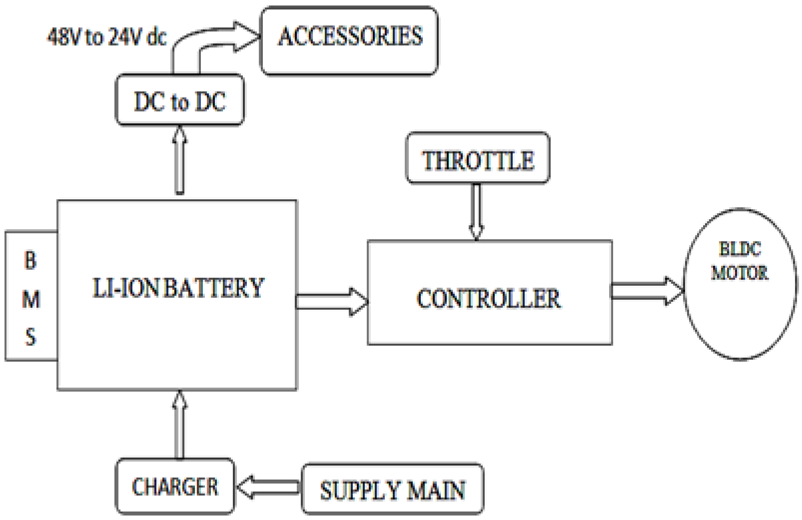

Fig.1: Block Diagram of 48V, Electric Bike

The electric motor gets its power from a controller and the controller gets its power from rechargeable battery. The electric vehicle operates on an electric\ current principle. It uses a battery pack (batteries) to provide power for the electric motor. The motor then uses the power (voltage)received from the batteries to rotate a transmission and the transmission turns the wheels. Four main parts make up the electric vehicle: the potentiometer, batteries, direct current (DC) controller. The three main component of electric bike are electric motor, controller and battery.when you switch on the bike, the current is passed from the battery. The controller takes power from the battery and passing the current to motor, before passing the current to motor.

The electrical motor the convert electrical energy to mechanical energy. The mechanical energy moves the vehicle.

Controller stands as the buyer of power from battery and gives out power to motor accordingly. Variables potentiometer are connected between accelerator and the controller. These potentiometers tell the controller how much power it is supposed to deliver. When the accelerator is released, it delivers 0v and the are fully present, its gives maximum output.

III. DESIGN OF VARIOUS EQUIPMENT USED FOR ELECTRIC BIKE

MOTOR

The motor receives power from the controller and turns a transmission. The transmission then turns the wheels, causing the vehicle to run.

Motor calculations-

Since the total EV weight is equal to 174 kg the normal reaction acting on each tire is equal to (87*9.81)Newton each.

Friction force acting on the tire-

$F=\mu NI$

$F=0.3*853$

$F=255$ N

Torque required-

$T=F\times r$

$T=255*0.19$

$T=49$ Nm

Speed calculation –

$\omega = v \div r$, $\omega = (10\times1000) \div (0.19\times3600)$

$\omega = 14.61$ rad\sec

$\omega = (2\pi N) \div 60$

$N = (60\times14.61) \div (2\pi)$

$N = 140$rpm

Power calculation –

$P = (2\pi NT) \div 60$

$P = (2\pi\times140\times49) \div 60$

P= 720Watt (App.)

DC CONTROLLER

The controller takespower from the batteries and delivers it to the motor. The controller can deliver zero power (When the car is stopped), fullpower (When the driver floors the accelerator pedal,) or any power level in between. If the battery pack containsfour 12-volt batteries, wired in series to create48volts, the controller takes in 48 volts direct current, and delivers it to the motor in a controlled way. The controller reads the setting of the accelerator pedal from the two potentiometers and regulates the power accordingly. If the accelerator pedal is 25 percent of the time and off 75 percent of the time. If the signals of both potentiometers are not equal, the controller will not operate motor.

BATTERIES

The batteries provide power for the controller. Three types of batteries: lead -acid, lithium ion, and nickel -metal hybrid batteries. Batteries range in voltage (power).

Battery Specification-

Power =voltage × current

P =V.I =>750=48×I

I=15.625 Ah

Hence according to the above calculation to drive motor of 750 W, 48V capacity we select 4 batteries of 12V 33Ah. We connect these batteries in series to achieve a voltage of 48V as we required by the motor

Electrical charging

Times required to fully charging the battery is calculated. Power supplied to battery during AC Charging: AC Adapter specification :48 V, 5A

P= V.I= 48×5

P =240 Watts

Therefore, the time required to charge the battery completely is:

t=720÷240 =>t=3hrs

hence, it is found that, the time required to charge the batteries completely in 3hrs.

PASSIVE CELL BALANCING ALLOWS ALL CELL TO APPEAR TO HAVE THE SAME CAPACITY

Initially, a battery stack may have fairly well matched cells. But over time, the cell matching degrades due to charge\discharge cycles, elevated temperature and general aging. A weak battery cell will charge and discharge faster than stronger or higher capacity cells and thus it become the limiting factor in the run- time of a system. Passive balancing allows the stack to look like every cell has the same capacity as the weakest cell. Using a relatively low current, it drains a small amount of energy from high SoC cells during the charging cycles so that all cells charge to their maximum SoC. This is accomplished by using a switch and bleed resistor in parallel with each battery cell.

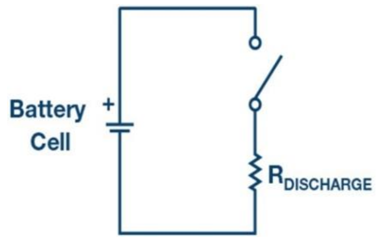

Fig. 2: Basic passive cell balancing circuit

The high SoC cell is bleed off (power is dissipated in the resistor) so that charging can continue until all cell are fully charged.

Passive cell balancing allows all batteries to have the same SoC, but it does not improve the run-time of a battery-powered system. It provides a fairly low-cost method for balancing the cells, but it wasted energy in the process due to the discharge resistor. Passive balancing can also correct for long- term mismatch in self discharge current from cell to cell.

ACTIVE CELL BALANCING DURING DISCHARGE

The diagram in figure 3 represents a typical battery stack with the whole cell starting at full capacity. In this example, full capacity is shown as 90% of charge because keeping a battery at or near its 100% capacity point for long periods of time degrades its lifetime faster. The 30% discharge represented being fully discharged to prevent deep discharge of the cell.

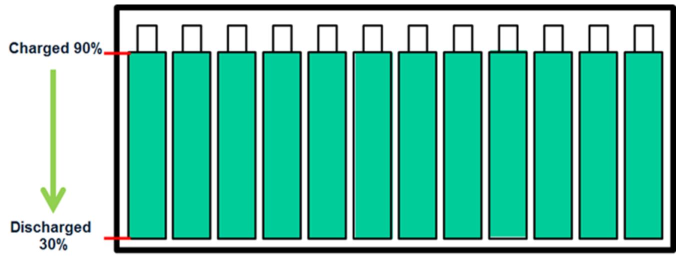

Fig 3:Fully capacity

Over time, some cells will become weaker than others, resulting in a discharge profile, as represented by figure 4.

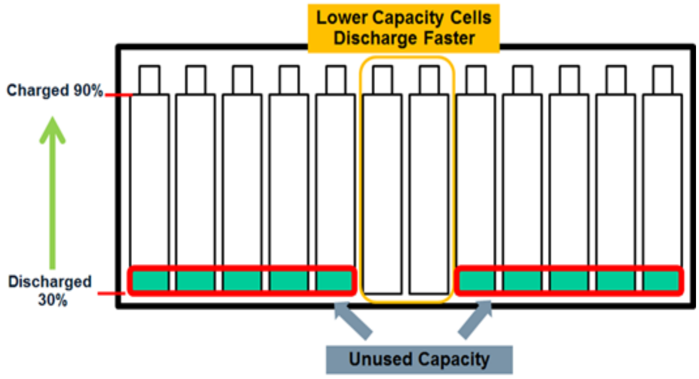

Fig 4:Mismatched discharge

It can be seen that even through there may be quite a bit of capacity left in several batteries, the weak batteries limit the run time of the system. A battery mismatched of 5% results in 5% of the capacity being unused. With large batteries, this can be an excessive amount of energy left unused. This becomes critical in remote system and systems that are difficult to access. As a result, there is a portion of energy that cannot be used, which results in an increase in the number of battery charge and discharge cycles. Furthermore, this unused energy reduces the lifetime of the battery and leads to higher costs associated with more frequent replacement.

With active balancing, charge is redistributed from the stronger cells to the weaker cells, resulting in a fully depleted battery stack profile.

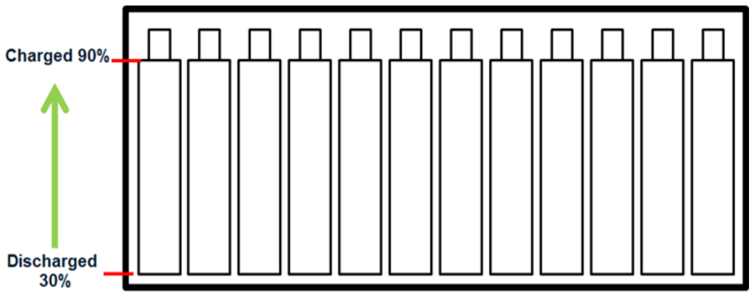

Fig 5:Full depletion with active cell balancing

ACTIVE CELL BALANCING WHILE CHARGING

When charging the battery stack without balancing, the weak cells reach full capacity prior to the stronger batteries. Again, it is the weak cells that are the limiting factor, in the case they limit how much total charge our system can hold. The diagram in figure 6 illustrates charging with these limitations.

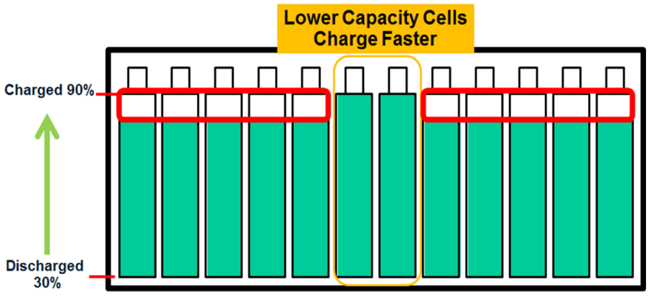

Fig 6:Charging without balancing

With active balancing charge redistributed during the charging cycle, the stack can reach its capacity. Note that factors such as the percentage of this allotted for balancing and the effect of the selected balancing current on the balancing time are not discussed here, but are important considerations.

IV. SIMULATION AND EXPERIMENTAL RESULTS

In this project, we have implemented active cell balancing technique. Before implementing the same, it has been simulated using MATLAB/ Simulink with three cells in series. The figure shows the Simulink model along with the balanced output SoC's. The algorithm is given as a function to the model which controls the ideal switches. It compares the SoC's of all the batteries and take the SoC which has the lowest value as reference. The excess energy stored in the other two batteries are dissipated as heat in the resistor. The value of the resistor must be as low as possible because to reduce the voltage drop due to the balancing circuit. The corresponding graphs are shown in the figure.

The main disadvantage of this cell balancing technique is wastage of power while charging and discharging of the battery. To overcome this drawback, another technique with different algorithm is developed which is more effective than the passive cell balancing technique.

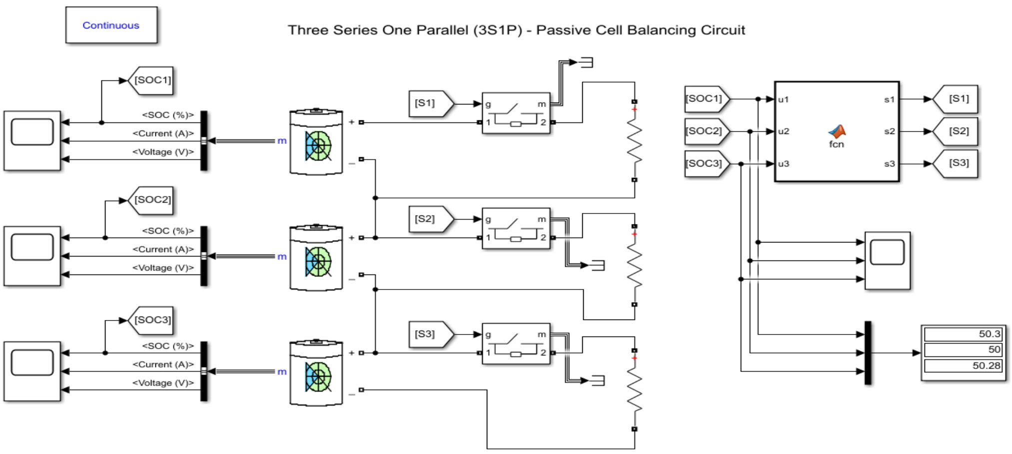

Figure 7: Passive Cell Balancing Technique

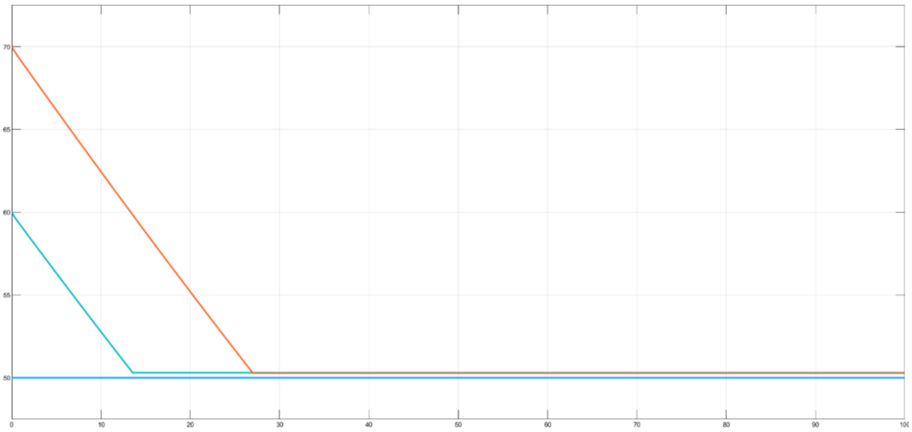

Fig 8:Waveforms showing the SoC's of batteries balanced with Passive Cell Balancing

The circuit is designed for three Li-ion batteries in series a done parallel (3S1P).It consists of two inductors and three capacitors with freewheeling diodes inparallel with fast acting switches. A controller is designed to maintain the SOC's of all the batteries constant. The SOC's and voltages are balanced in all the batteries before connecting it to the load.

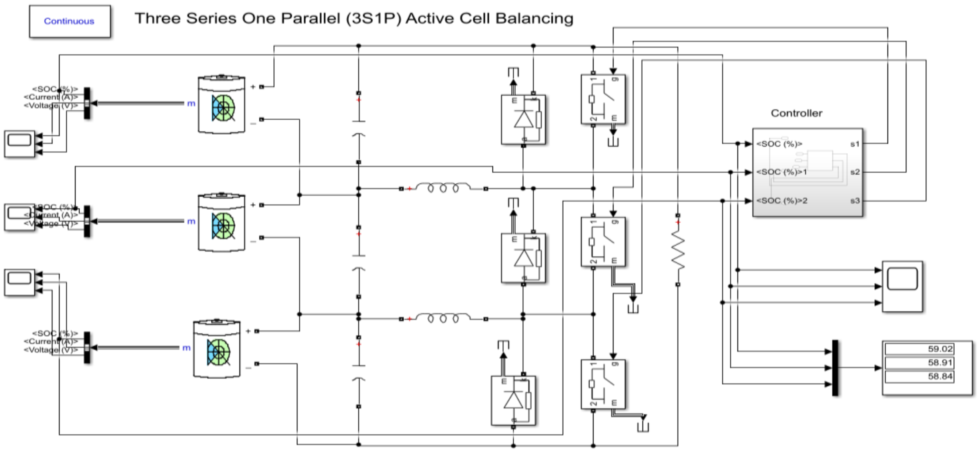

Figure 9: Active Cell Balancing Technique

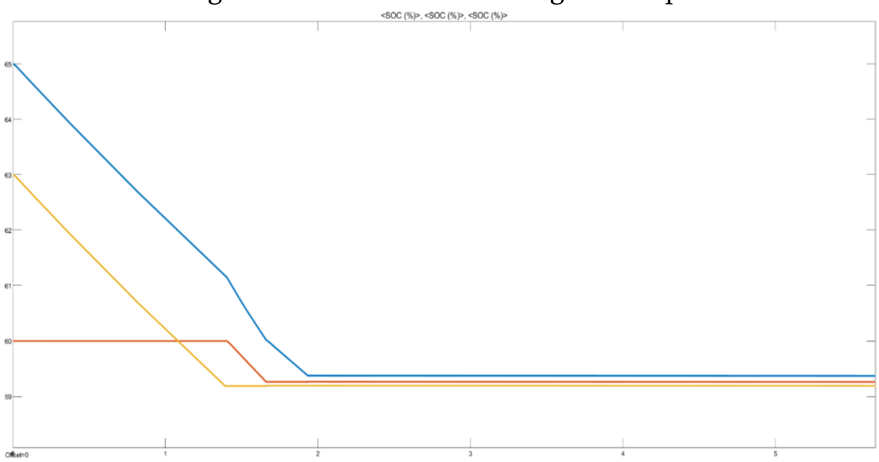

Fig 10:Waveforms showing the SoC's of batteries balanced with Active Cell Balancing

V. CONCLUSION

With the increasing consumption of natural resources of petrol, diesel it is necessary to shift our way towards alternate resources like the electric bike and others because it is necessary to identify new way of transport. Electric bike is a modified of the exciting cycle by using electric energy. Since it is energy efficient, electric bike cheaper and affordable to anyone. It can be used for shorter distances by people of any age. It can be contrived throughout the year. The most vital features of electric bike are that it does not consume fossil fuels thereby saving crores of foreign currencies. The second most important features are it is pollution free, eco- friendly and noiseless in operation. For offsetting environment pollution using of on- board electric bike is the most viable solution. It can be charged with the help of AC adapter if there is an emergency. The operating cost per\km is very less and with the help of solar panel it can lessen up more. Since it has fewer components, it can be easily dismantled to small components, thus requiring less maintenance.

Tabulation: Specification of the developed Electric Bike

Parameters	**Values**
Motor calculation	F=255N
Torque	T=49Nm
Speed calculation	N=140rpm
Power calculations	P=720Watt
No. of cell in parallel	10
No. of cell in Series	3
Nominal Voltage	3.7V
Cell capacity	2200mAh
Range (in Kms)	58Kms
Charging time	4 Hrs.

Prototype Model of Electric Bike developed:

Fig 11: Prototype model showing Hub motor and Li Ion battery

Fig. 12: Internal wiring connection of battery and motor

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