Optimization of Electric Vehicle Battery Storage by Hybrid Energy Storage System

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Abstract: **Energy Conservation is becoming a major concern for environmental protection. Along with the environmental effects depletion of fossil fuels is also affecting the comfortable human life adversely. This motivates us to innovate alternatives to develop the existing electrified transportation system which includes pure Electric vehicles (EV), Hybrid Electric Vehicles (HEV), Solar Powered Electric Vehicles, etc.,**

The effective and efficient electrified transportation system will be the future if and only if there is an existence of a good Battery Management System (BMS). Lithium-ion batteries are the most preferred energy storage devices for the EVs due to their high energy and current density. Proper maintenance and balancing of the Battery system is a key factory to have effective EV. So this paper deals with the simulation and design of the prototype model of the Optimized Lithium-ion battery balancing and managing system for Electric Vehicle which gives efficient, safe charging and discharging the lithium-ion battery in a closed-loop control by the selection of input source to charge the battery of EV.

Keywords: BMS, DOD, EVs, HEV, IC Engine, LCD, Relay and SOC

I. INTRODUCTION

The 19th century led wave of innovation of electric vehicle [1]. Bruton states that the definition of electric vehicle is that "Any vehicle that runs partially or completely on electricity as compared to vehicle that run on fossil fuels" [2]. Electric vehicles can be classified based on the proportion of form of electricity used such as Mild hybrid electric vehicle, Plug-in hybrid electric vehicle, pure electric vehicle, and solar powered hybrid electric vehicles [3], [4]. The effective BMS leads to the efficient electrified transportation system, which overcomes the problems of different types of EVs such as cost, capacity and range of the battery, time required to charge, adverse effects on grid due to continuous charging, management of energy sources and mainly life span of the battery[5], [6], [7].

So this paper proposes the optimal selection of battery charging system to have effective lithium ion battery management system for electric vehicle .The solar powered electric vehicle consists of solar panel, dc-dc voltage converter, voltage divider circuit, boost converter, charge controller, relay circuit, LCD display, motor, motor driver and the battery. The electric supply to the motor is obtained from a set of 3 batteries rated 3.7 ~4.2v, 7.4Wh, solar panel of capacity 10w is attached to the top of the vehicle to grab the solar energy and then it is connected to boost converter to get regulated dc voltage which is used as a main source of energy to charge the battery through charge controller. The household electric supply of 230V is reduced with a step down transformer to 12V and then it is converted it to DC with a rectifying unit to charge the battery. This is used as an alternate source of energy to charge the battery during the non-availability of solar power. The proposed method helps the battery of EV to operate in a safer zone. This paper deliberates the optimized lithium ion BMS with the help of simulation and designed prototype model.

II. BLOCK DIAGRAM

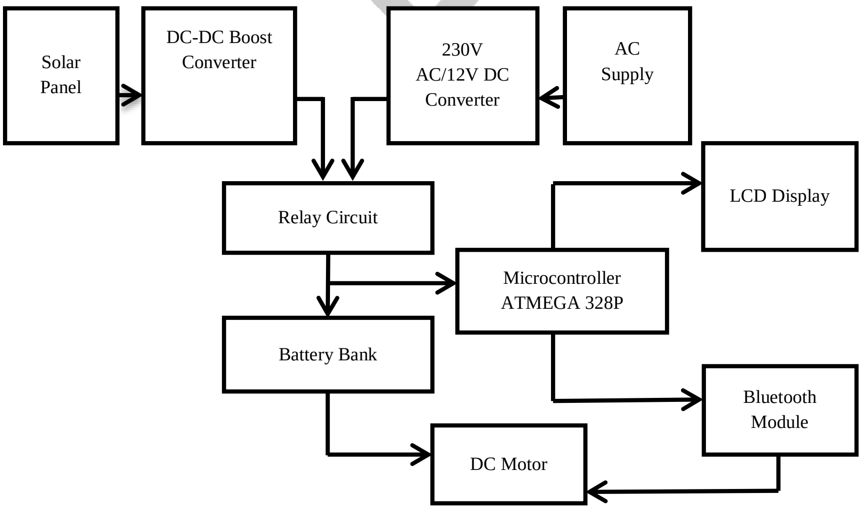


Fig. 1 Block diagram of proposed project work

Fig. 1 gives an overview of the working of hybrid electric vehicle. Electricity can be drawn either from AC supply or from solar panel depending upon the availability.

The proposed block diagram operates in two modes to have economical and eco-friendly battery management system.
Mode 1: Operation of solar powered electric vehicle (SPEV)
Mode 2: Operation of electricity powered electric vehicle (EPEV)

Mode 1: Operation of (SPHEV)

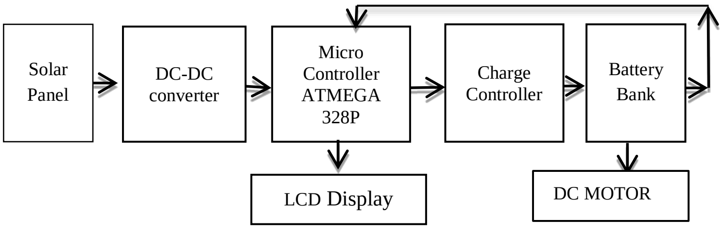


Fig. 2 Block diagram of SPHEV

Fig. 2 shows the block diagram of solar powered hybrid electric vehicle. In this mode battery is being charged by the solar energy. Then solar radiation falls on the solar cell there is a flow of electric current in the circuit [8]. The output from the solar panel is either stepped up or stepped down using DC-DC converter. The output of the converter is sent to the microcontroller. The controller checks the input voltage with the reference voltage, and it also gives signal to the LED to display the voltage and corresponding details. And the power is sent to the battery bank to charge the battery of electric vehicle through charge controller.

Mode 2: Operation of (EPHEV)

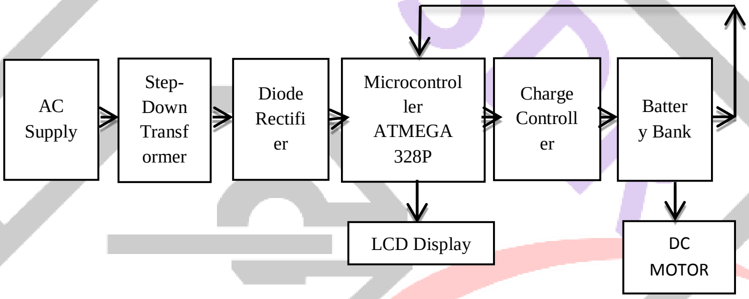


Fig. 3 Block diagram of EPHEV

Fig. 3 shows the block diagram of electricity powered hybrid electric vehicle. In this mode battery is being charged by the ac supply from the grid. 230V 50Hz ac supply is taken as an input to the system during the non-availability of solar energy.
The output energy is stepped down to 12V pulsating DC. At the output side of the transformer diode rectifier and capacitors are placed for filtering purpose that is to convert pulsating DC into pure form of DC signal. During the absence of solar energy the relay automatically switches to ac supply followed by micro-controller and there creates a closed path and battery begins to charge through charge controller.

III. METHODOLOGY

The optimization of input energy source to charge the battery of EV is modeled in the literature. This proposed model works on two modes to maximize the utilization of renewable energy in EV as an input energy source.
This has been modeled and described with PROTEUS DESIGN SUITE 8.9 [9].
The method described in this paper follows a switching operation of input energy source using relay circuit followed by microcontroller. The microcontroller has been programmed to select the preferred energy source as input followed by the methods as shown in Fig. 5.

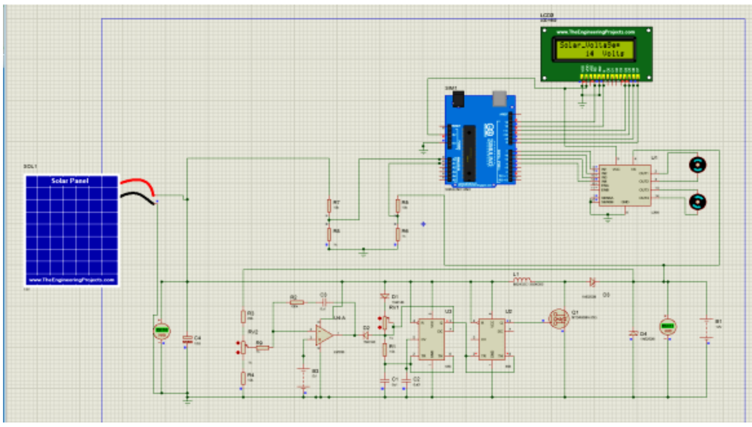


Fig. 4 Simulated model of the proposed system using PROTEUS

Simulation Process

Fig. 4 shows the simulation model of the project work. The steps involved in the simulation are listed below,

Step1: Downloaded and installed PROTEUS PROFESSIONAL 8.9 software and ran as administrator.

Step2: Created a new project and saved it. Selected the required components either from the toolbar or from the library and placed them on the project sheet. Made the connection properly.

Step3: Program has been written and compiled using Arduino software. As a result a hex file was created.

Step 4: Then that hex file was dumped in to the Arduino.

Step 5: Clicked on RUN simulation and observed the results displaying on LCD.

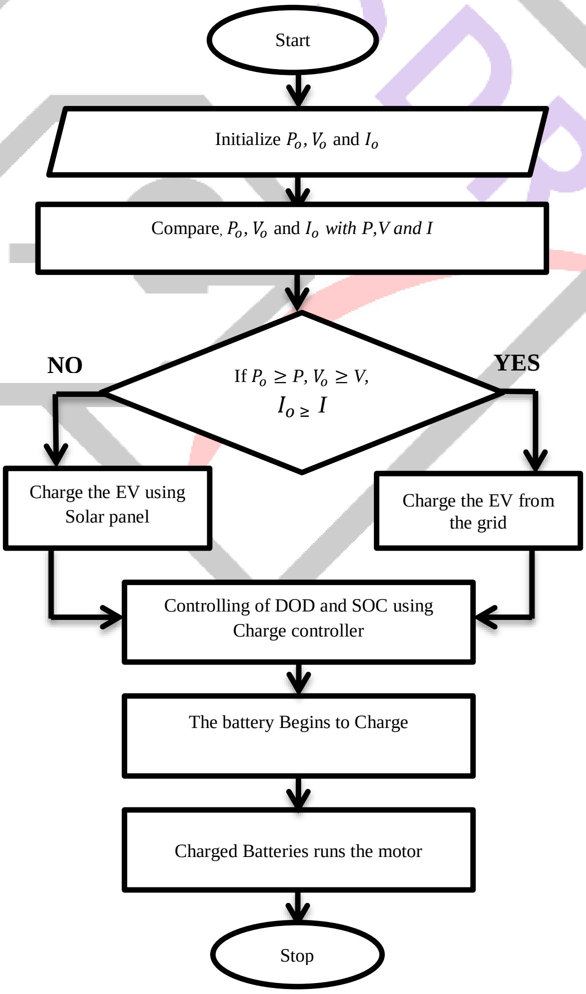
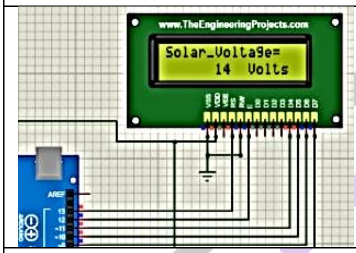
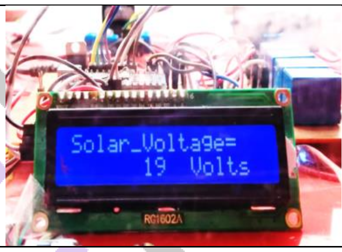
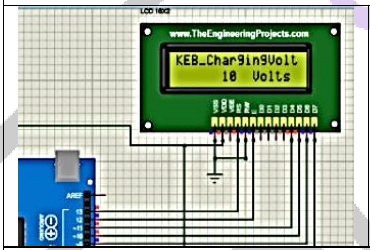
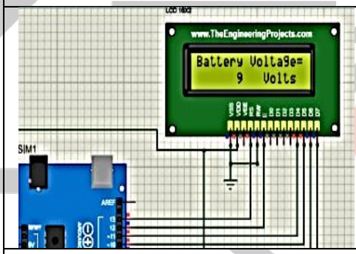
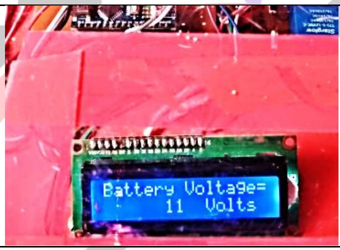
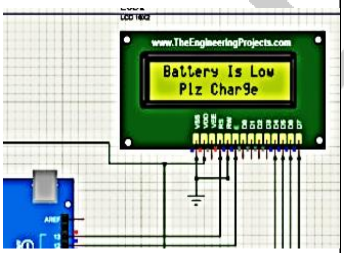


Fig. 5 Flowchart of the proposed system

The magnitude of solar output i.e., voltage (V), current (I), power (P) are sent to the microcontroller, which compares the output parameters with the redefined value .i.e., voltage (V_o), current (I_o), and power (P_o) which are initialized in the microcontroller. If the condition stated in the flowchart is true the relay switches to the solar side, if the condition fails means the relay switches to the ac supply to charge the battery. When relay switches to solar side output from the solar panel is fed to the dc-dc converter to step up the voltage at the required level and again it sends to the voltage regulator to get constant dc voltage. The regulated dc voltage is sent to the battery bank to charge the battery of electric vehicle through charge controller. If the relay switched to ac supply side then 230V 50Hz AC supply is converted in to 12V pulsating DC using a step down transformer and a rectifier circuit. Pulsating DC is fed to the filter circuit to get pure DC output voltage and that voltage is fed back to the voltage regulator to get constant DC voltage which is required to charge the battery of electric vehicle. The charge controller controls the state of charge (SOC) and depth of discharge (DOD) of the battery which helps to increase the life of the battery by preventing battery from over charging and under charging.

IV. RESULTS AND DISCUSSIONS

Table 1: Results of the proposed system

Simulation Results	Hardware Results
	
Measurement of voltage, when relay switches to Solar side	
	
Measurement of voltage, when relay switches to ac supply side	
	
Battery output voltage	
	
Battery Status	

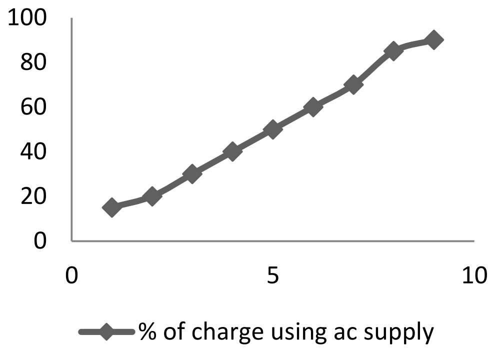


Fig. 6 Status of battery when it is charging through solar power

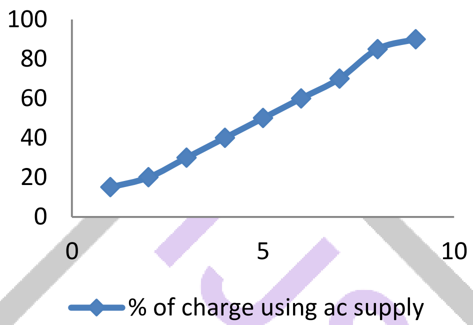


Fig. 7 Status of battery while it is charging through AC supply

Fig. 6 and Fig. 7 represent the graph of time required v/s percentage of charge of the battery which charges using solar power and ac supply respectively.
From the above two graphs it can be concluded that the time required to charge the battery using solar power is less compared to the time required to charge the battery using AC supply. In both graphs the curve originates from 15% and terminates at 85% of the total charge of the battery, why because in this system the relay has been programmed to indicate if the battery level falls below its DOD that is 15% and when it reaches the value of SOC, that is 85% of the total charge of the battery using Arduino Uno.

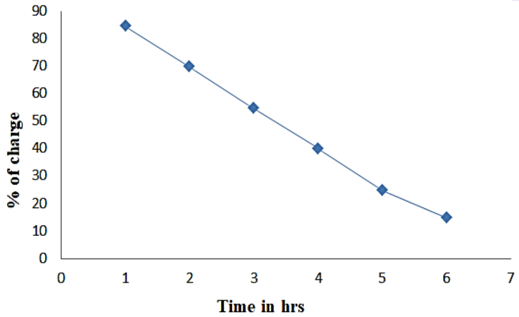


Fig. 8 Discharge characteristics of the battery when the load is connected

Fig. 8 shows the discharge a characteristic of the battery when motor starts to run that is while the vehicle is moving. The vehicle stops automatically when the battery reaches the value DOD. This can be noticed using LCD display.

V. ADVANTAGES AND DISADVANTAGES

Advantages

1. The main issue is to avoid grid interruptions when several EVs are simultaneously plugged into the system during very short period of time [10] can be solved by implementing this technique.
2. It is envisaged that more sophisticated energy management system is required to manage the charging stations for large number of EVs [11]. So by implementing this technique it is possible to overcome this problem up to some extent.
3. The proposed technique optimizes the EV charging based on the availability of the PV power, real time electricity demand and tariff structures.
4. This system leads to the safe charging of the battery that needs to be maintained to ensure long life of the EV batteries.
5. Maintenance cost will be negligible when compared to IC Engine vehicles.

Disadvantages

1. Hybrid transportation systems, unlike those in pure electric vehicles, cannot effectively utilize regenerative energy during braking.
2. Low power density and fast degradation of the cells in the battery under high charging currents
3. Even when using the battery management systems that directly control the charging and discharging rate, cell's state of charge (SOC), voltage and temperature, the lifetime of the common electric vehicle batteries does not exceed 4–5 years [12].
4. The electrical vehicles are less economical as the battery is the most expensive part of electric vehicle.

VI. CONCLUSION

An optimized EV storage system has been proposed, simulated and hardware implementation has been done. This optimized EV storage system solves many problems related to the environment. Pure solar vehicles do have some disadvantages like small speed range, discontinuous running depending upon the climatic conditions. But these disadvantages can be easily overcome by SEPHV. This multi charging vehicle can charge itself from both solar and electric power. In this work the vehicle has been successfully fabricated built in with internal components like solar panel, charge controller, battery, motor driver and motor as a load. Results showed that from optimized selection of input energy source to EV leads to the efficient and comfortable electrified transportation system.

The future of energy sector lies on alternative energy resources. The cost of HEVs is more than the conventional cars but they are more efficient and cause less exhaust emissions. This challenge now can turn out to be a good scope for further development of a pollution free vehicle.

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