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Implementation of a Charge Controller for Hybrid Electric Vehicle

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Abstract- A Hybrid electric vehicle (HEV) is a vehicle which is the combination of more than one supply source. In this HEV, two batteries each of 24 volts are used, one battery is connected to load which provide power to drive motor and another battery is connected to charging system which takes power for charging. In the present work, the main controller of HEV is based on Arduino software which is used by the microcontroller. The system uses a battery swap circuit which increases the performance of the electric vehicle. Battery swap circuit measure the voltage level of both batteries, if the voltage level of load connected battery gets lower than the changing connected battery then the connection of both the batteries get interchanged. The recharging system contains BLDC and Solar Panel which provides constant 24 volts to the battery.

Keywords- Hybrid Electric Vehicle, Brushless DC Generator, Solar Panel, Battery Swap Circuit, Microcontroller, Controller Behavior, Battery Management.

1. INTRODUCTION

In present time electric vehicles are the need for the transportation system. The demand of non-renewable energy (petrol, diesel, coal etc) is increasing day by day so, it is necessary to find out other energy resources. Renewable energy like solar is the most important and available in the large amount on earth which is very useful for hybrid electric vehicles. It provides an alternative source of energy which is used to feed extra energy to charge the battery or directly used to feed motor. Investigation of PV Fed Hybrid Electric Vehicles with Various Power Electronic Circuits (2017) [1]. In this paper, the hybrid electric vehicle is based on conventional and nonconventional energy sources. It is using solar PV modules and petrol or diesel based engine, which is not fully renewable energy based electric vehicle. The demand for non-conventional energy is increasing day by day so, it is necessary to find out another alternative source of energy which should be renewable based and it must be eco- friendly.

Energy Management in a Fuel Cell-based Hybrid Electric Vehicle using a Fuzzy Logic Approach (2017) [2]. An energy management strategy is provided for an HEV. This is based on a Fuel Cell as well as a Li-Ion battery. This energy management, based on the fuzzy logic approach, which aim is to increase the performances of the hybrid electric vehicle. Here the fuzzy logic based controller has three inputs: The power error, load power, and battery.

A Rapid Charging System with Bi-directional Power Flow for Plug-in Hybrid Electric Vehicle (HEV) (2017) [3]. In this paper, shows the capability of the rapid battery charging technology with bidirectional power flow for HEV. It is used rectangular phase shift method with PWM (RPPWM) for zero voltage switching based on the dual active bridge.

It controls the capability of power flow in both directions and reduces the complexity. Here Boost converter is used to regulate the constant DC output voltage which, also improve the power factor. Here boost converter plays another important role, it provides the bidirectional power flow.

Real-time Power Hardware-in-the-Loop Emulation of a Parallel Hybrid Electric Vehicle(2017)[4]. In this paper, shows the control and coordination of several sources of the hybrid electric vehicle. This paper put light on a real-time emulator for parallel hybrid electric vehicle. Here every system is modeled and controlled to balance the performance and control as per torque and speed.
Energy Management And Strategies For Hybrid Electric Vehicle Using Photovoltaic, Ultra-capacitor, And Battery (2017)[5]. In this paper, three sources are using PV, battery, an ultra capacitor. During daytime when solar panel provides maximum voltage then at that point of the time PV run the motor as well as it also charges the battery and capacitor. When the power output of the PV get reduce then battery and an ultra capacitor provides power to the motor.
Here regenerative braking technology is also applied which is very useful for hybrid electric vehicles. In this method, when the brakes applied then at that point of time motor act as a generator and start feeding supply to the battery and an ultra capacitor. As compare to others this type of electric vehicle provides high performance and battery backup will be improved. But this is not a permanent solution. If the vehicle is running in the night then the solar panel will be unable to provide power then after sometime battery will be low which is the major disadvantage of the electric vehicle.
Smart Hybrid Electric Vehicle (2017)[6]. In this paper, more than one input sources are using to drive an electric vehicle. The sources are internal combustion engine (ICE) and electric motors. But both the sources are separately connected to the motor. When Battery get discharge ICE start providing supply to the motor.
The pollution from the vehicles is one of the main cause of air pollution. Day by day the graph of pollution in traffic area is increasing very sharply. To prevent this, the electric car must run in the city. So that the maximum pollution will be reduced. The amount Greenhouse gases as well as the global warming will be decreased.

2. WORKING OF PROPOSED RECHARGING SYSTEM

To increase the overall performance of the hybrid electric vehicle it is necessary to increase the battery performance or it's backup. According to this charging system this hybrid vehicle using two battery so the charging of one battery and discharging of second battery which is connected to load occurs at the same time. This controller has recharging unit which is divided into two phases. In phase1, two input sources like solar panel and Brushless DC generator are connected. Both sources are again connected to relay via voltage sensor and this voltage sensor is connected to the microcontroller, as shown in Fig. 1.

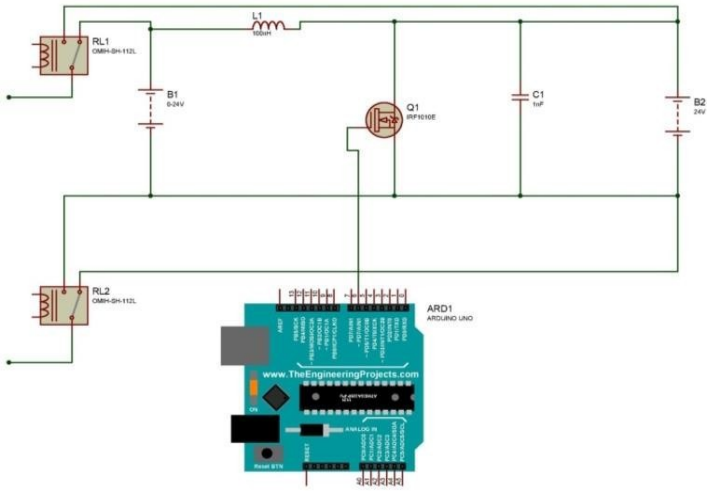


Fig.1 Circuit diagram of phase 1

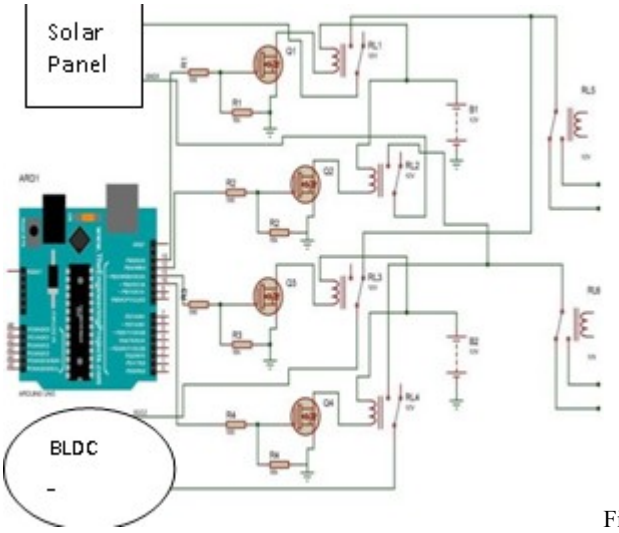


Fig. 2 Circuit diagram of phase 2

As shown in Fig. 2 Another microcontroller is used in phase 2 with a voltage sensor, relay and boost converter. The coming voltage is directly connected to relay via voltage sensor. If the coming voltage is less than or equal to 23 volts then microcontroller feed the voltage to boost converter via a relay. If the voltage is 24 volt or more then microcontroller bypass the boost converter and directly feed to the battery.

The ATMEL 8-bit microcontroller contains 32 kb flash memory with the capability of read-while-write. 1 kb of EEPROM, 2 kb of SRAM, 23 general purposes I/O lines. The device operates between 1.9 to 5.5 volts. The programming is written inside the microcontroller in such a way that, which input sources provide the higher voltage the microcontroller will proceed that voltage source to next level via a relay. If, both the incoming sources provide the same amount of voltage then at that point of time microcontroller will proceed the voltage of BLDC generator because the preference is given to the BLDC generator in the programming. Here BLDC generator and Solar Panel both deliver voltage which is shown in Fig. 3. The value of the voltage of both sources continuously varies according to time. Here the microcontroller compares both voltages and selects the higher voltage with the help of relays.

3. Response of controller with different conditions

Condition 1(If the vehicle is running in day time then output from sources)

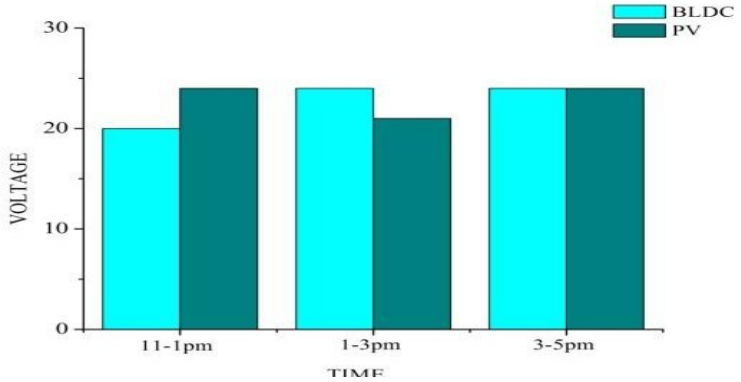


Fig. 3 Different output from BLDC and Solar Panel during running conditions in day)

Here BLDC generator and Solar Panel both deliver voltage which is shown in Fig.3. The value of the voltage of both sources continuously varies according to time. Here the microcontroller compares both voltages and selects the higher voltage with the help of relays.

Condition 2(If the vehicle is stationary in day time then output from sources)

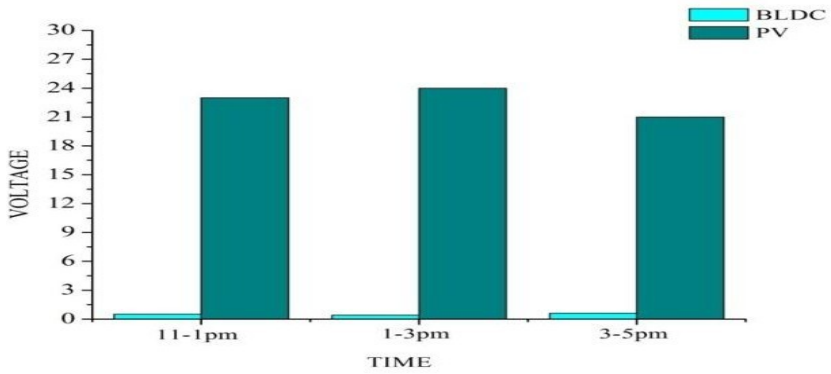


Fig. 4 Different output values during a traffic jam or in parking conditions

As shown in Fig. 4 Solar Panel delivers supply and output of BLDC generator is almost zero. The supplied value of BLDC generator is less than solar panel so, the microcontroller selects only higher supply value.

There are two pairs of the relay are connected with solar panel and BLDC generator and these relays are controlled by the microcontroller as per programming is installed in it. Here V1 stands for the supply of BLDC generator and V2 stands for solar panel's supply. Relay 1 & 2 are connected with BLDC generator and Relay 3 & 4 is connected to the solar panel. If the conditions (V1>V2 and V1=V2) as shown in Table 1. then relay 1&2 will on and relay 3 & 4 will be off and vice-versa.

Table 1.
Switching Mode of the relay according to the supply voltage

CONDITION	Relay 1	Relay 2	Relay 3	Relay 4
V1 >V2	ON	ON	OFF	OFF
V1=V2	ON	ON	OFF	OFF
V1<V2	OFF	OFF	ON	ON

Condition 3 (If the vehicle is running in night time then output from sources)

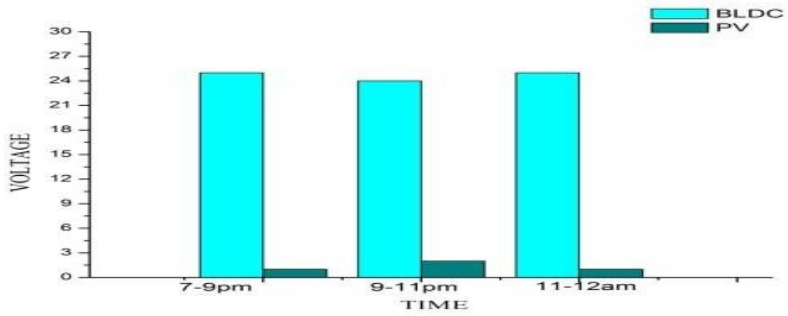


Fig. 5 Different output values during running in Night

In this condition, only BLDC generator provides supply and the output of the solar panel is almost zero as shown in Fig. 5

4. BATTERY'S CONNECTION SWAPPING SYSTEM

This technology is useful for HEV which increase the battery backup, range, and the performance. Here one battery, which is connected to the charging system and another battery which is connected to a load, both are also connected to the microcontroller via voltage sensor. The voltage sensor measures the voltage level of the batteries and sends the information to the microcontroller. Here the microcontroller will decide that which battery is going to connect the load and which will connect to the recharging system via a relay. The circuit diagram of battery swap technology is given in fig. 6.

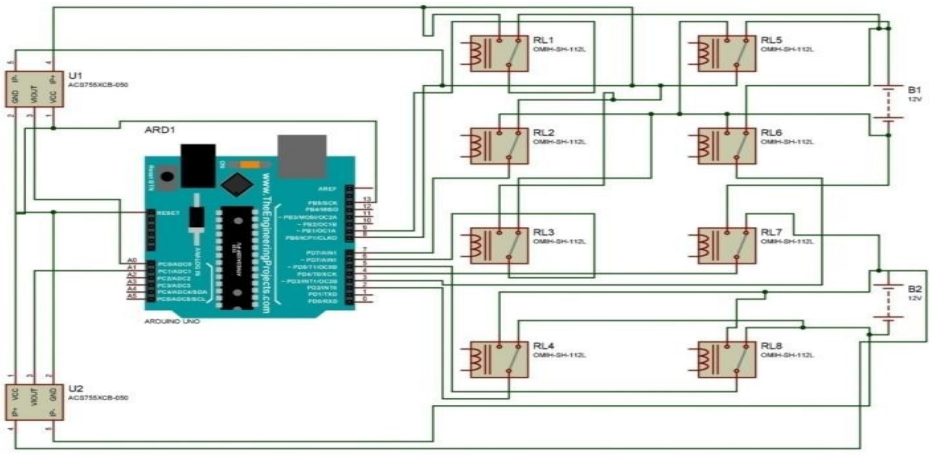


Fig. 6 Circuit diagram of batteries swap system

Table 2.

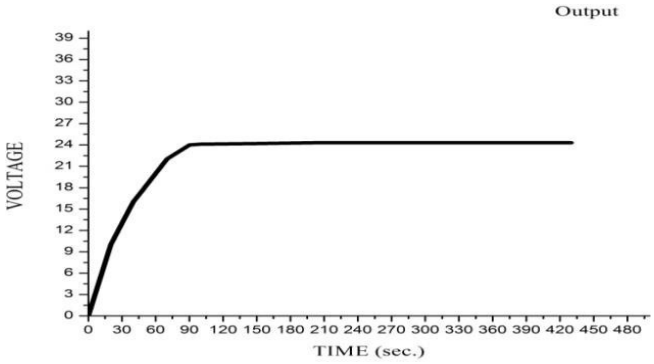
Switching Mode of the relay with respect to the voltage level of batteries

CONDITION	R1	R2	R3	R4	R5	R6	R7	R8
V1 >V2	OFF	ON	ON	OFF	OFF	ON	ON	OFF
V1=V2	OFF	ON	ON	OFF	OFF	ON	ON	OFF
V1<V2	ON	OFF	OFF	ON	ON	OFF	OFF	ON

switching mode of the relay of battery swap circuit is controlled by the microcontroller as shown in Table 2.

5. RESULTS AND DISCUSSION

The output of recharging system with respect to variable input source for the battery is 24 volt which is shown in Fig. 7 The image of a hardware implementation of Battery Swap System shown in Fig 8. The image of a hardware implementation of Battery Swap System shown in Fig. 9. This system is controlled by Arduino



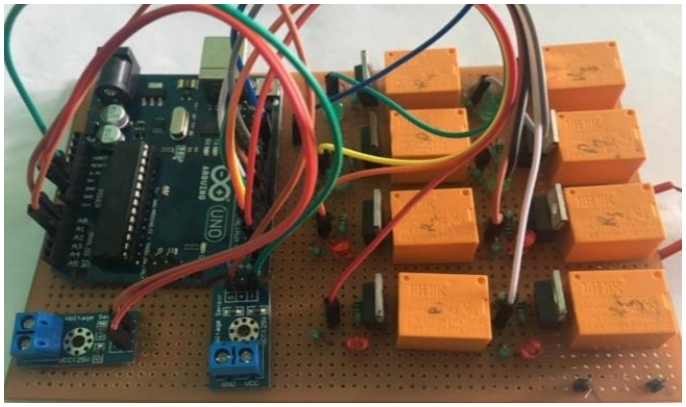


Fig. 7. The output of recharging system to feed battery.

Fig.8 Image of batteries connection swap system.

- Recharging system and Battery connection swap method increase the performance and efficiency of the HEV.
- The recharging system provides constant output to the battery as shown in fig. 9.
- It increases the range of HEV.

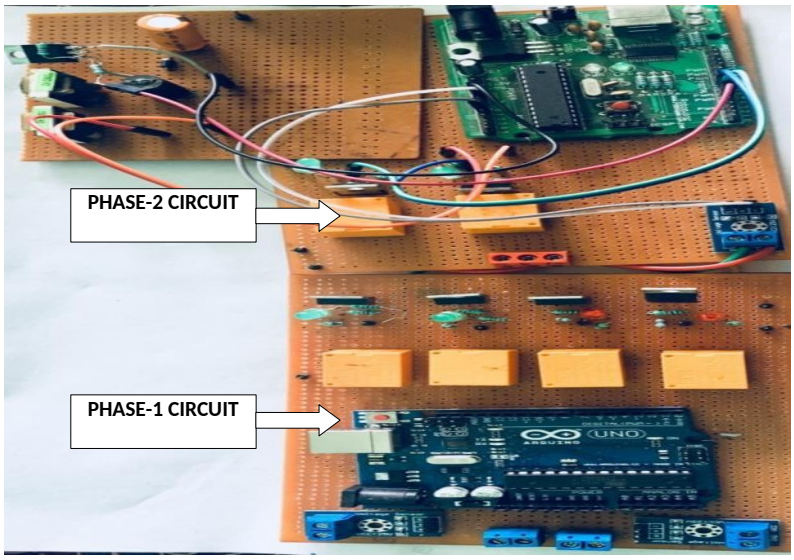


Fig. 9 Image of recharging system.

6. CONCLUSION

The main source of pollution is the Internal Combustion based vehicles is the main cause of air pollution. The traffic area is more polluted. So it is prevented by electric vehicle. So, the level of pollution will be low. Both Greenhouse gases, as well as global warming, will decrease and it also improves the quality of the environment. Due to addition of recharging system with battery, the overall range of the vehicle will increase. The solar panel is used as a source in this system. As recharging system provides the sufficient amount of power to the battery in small period of time, it also improves the positive characteristics as well as driving range of the whole system. Hence, with this phenomenon, a large amount of energy saving is possible. The cost-effectiveness of this system is increased due to large number of components used but the cost impact of recharging system will increase fuel economy and decrease harmful emissions. It also save the overall cost because of long life cycle.

REFERENCES

[1] Kaleeswari M, Madheswaran M, Vijayakumar K. “Investigation on PV Fed Hybrid Electric Vehicles with Various Power Electronic Circuits Kaleeswari”, IEEE International Conference On Advances In Electrical Technology For Green Energy, PP. 49-55, 2017.

[2] Sabah Saib, Zahir, KhoudirMarouani, “Energy Management in a Fuel Cell Hybrid Electric Vehicle using a Fuzzy Logic Approach”, The 5th International Conference on Electrical Engineering, 2017.

[3] Maloth Naresh1, V. Sravanthi Bai2, Ajay Kumar Pandey. “A Rapid Charging System with Bi-directional Power Flow for Plug-in Hybrid Electric Vehicle”, International Conference on Innovations in Power and

Advanced Computing Technologies, PP. 01-05, 2017.

[4] R. SudharshanKaarthik, Pillay. P. “Real-time Power Hardware-in-the- Loop Emulation of a Parallel Hybrid Electric Vehicle Drive Train”, IEEE Transportation Electrification Conference, 2017.

[5] Mingchun Liu, Juhua Huang, Ming Cao. “Handling Stability Improvement for a Four-Axle Hybrid Electric Ground Vehicle Driven by InWheel Motors”. IEEE Access, 2017.

[6] GargiPancholi, D.K. Yadav, LokeshChaturvedi. “Energy Management Strategies For Hybrid Electrical Vehicle Using PV, Ultra capacitor, And Battery”, IEEE Transportation Electrification Conference, 2017.

[7] Senthilnathan A, Manohar R, Mohanavel J, OmeshHeman Kumar A, Saravana Kumar R, “Smart Hybrid Electric Vehicle”, IEEE international conference on Innovations in Green Energy and Healthcare Technologies, PP. 01-06, 2017.

[8] M.Z. Shaikh, Dr. S.F. Kodad, Dr. B.C. Jinaga, “Performance Analysis of Piezoresistive Mems For Pressure Measurement”, Journal of Theoretical and Applied Information Technology, PP. 227-231, 2008.

[9] Jingyu YAN1, Chongguo L, Guoqing XU2,1, Yangsheng XU1, “A Novel On- line Self-learning State-of-charge Estimation of Battery Management System for Hybrid Electric Vehicle”, IEEE Transportation Electrification Conference, PP. 1161-1166, 2017.

[10] http://www.circuitstoday.com/working-of-electric-cars.

[11] https://www.arduino.cc/

[12] https://www.wikipedia.org/