Design And Development of Solar Electric Charging Station For Green Vehicle

Geeta Thakur[1], Anju Bala[2], Abhay Mahajan[3], Shekhar Sharma[4]
[1, 2, 3, 4] Assistant Professor Dept of Electrical Engineering
[1, 3, 4] Green Hills Engineering College, Solan, India
[2]TR Abhilashi Memorial Instt. of Engg. & Tech., Mandi, India

Abstract- *This paper presented a model of charging station by using battery and solar PV as source of energy is designed to reduce the toxic emissions and improve fuel economy. The three current methods of charging an electric vehicle include 120 volt, 240 volt and 480 volt systems. In this, 240V charging method (Level 2) is used which can easily charge a typical EV battery overnight. Batteries are charged through charging level 2 (230V AC supply) and through solar panel (DC supply) by using an auto electro switching technique. This paper represents a method of charging and discharging the battery by using electronic control circuit based on the minimum and maximum voltage battery level.*

Keywords- Photovoltaic cell, solar electric charging station, charging levels, lead acid batteries.

I. INTRODUCTION

It is estimated that current global petroleum resources could be used up within 50 years if they are consumed at present consumption rates. There has been an in-creasing penetration of Plug-in Hybrid and pure Electric Vehicles (PHEV/EV) over the last few years due to developments in battery technology that have dramatically increased their range advances in charging technologies that have reduced charging times, incentives that have lowered the acquisition and operation costs, and an overall desire to lower emission. Battery be-comes a must choice because it can provide immediate power when needed. Among the battery family, lead-acid battery become a popular choice because it came in variety of output voltage and can be recharge. Al-though the lead-acid can be recharge, problems still occur when recharging the battery. The battery tends to undergo overcharge if there is no control mechanism to stop the charging. As a renewable and clean energy, photovoltaic (PV) energy can be produced anywhere, including the urban areas for EV applications. Thus, the direct integration of PV with EV charging infrastructure is a possible way to effectively improve the emission reduction of EVs and reduce the dependence on the power grid. On one hand, the intermittency of PV generation can be relieved by the integration of the energy storage system and EVs. On the other hand, PV generation could help EVs reduce the dependence on the power grid.

II. CHARGING LEVELS

Table.1 shows the different charging levels (or chargers) for charging the batteries of electric vehicles.

Table.1 EVs Charging Levels

Level	Voltage (V)	Ampere (A)	Charging Time (Hour)
Level I Charger	120	15	10-15
Level II Charger	208/240	30	6-8
Level III Charger	208/600, 3 phase	400	15 minutes

III. LEAD ACID BATTERY

In this paper solar electric charging station is used for charging the eight lead acid batteries for green vehicle. Single battery capacity is 12V, 100AH and these eight batteries are connected in series and in parallel then it gives 48V, 200AH as output which is shown in Fig.1.

Fig.1 Lead Acid Batteries

After selection of battery type, calculations for battery bank specifications were performed. For calculating battery bank specifications following parameters maximum speed of vehicle, distance to cover in one charge was required.

Distance to cover in one charge was taken from specified design parameters.

Rated Motor voltage = 48 V
Rated current of motor = 42 A
Maximum speed of vehicle = 27.7 km/h
Distance to cover per charge = 80 km
Running time = 80/27.7
= 2.88 hours = 3 hours approximate
Amperage required for 3 hours run = 42 × 3
= 126 *A*h
Maximum efficiency of Lead Acid battery = 60%
Required amperage of battery bank = 126×100÷60
= 210 Ah

From study it was found that batteries were available with following specifications as shown in Table.2. It is very much clear that the 12V, 100Ah battery best fit into the required specifications. A battery bank of 8 batteries with same specifications was developed in order to make 48V, 200Ah. So, from these specification solar electric charging station is designed.

Table.2 Technical Specifications of Lead Acid Battery

Battery Type	Capacity (AH)	Charging Current (A)
12ER100L	100	7.0

IV. SOLAR ELECTRIC CHARGING STATION SYSTEM WORKING PRINCIPLE

The main objective is to design and development of 50V and 20A solar electric charging station using Level II charger (AC supply) and solar PV as source of energy to reduce the toxic emissions and improve fuel economy. Significant improvement for charging the batteries is achieved by minimizing the human efforts and errors by using an auto electro switching. The hardware developed for the proposed system consists of the following modules and circuitry

- Step down transformer
- Bridge rectifier
- Solar charging module
- Auto electro switching module
- Battery level indicator module

Fig.2 shows the block diagram representation of the proposed hardware model.

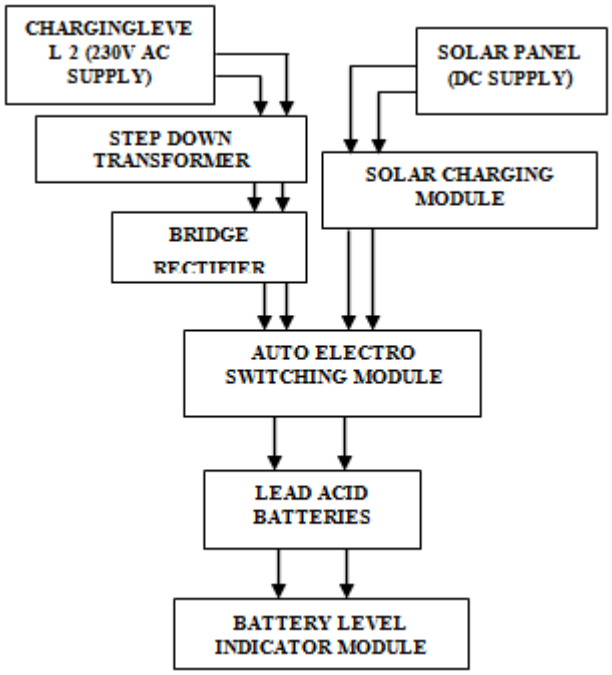

Fig.2 Block Diagram of the Charging Station Model.

A. Step down transformer

A step down transformer of 50V and 20A is used. Level 2 charging is used in which 230V is applied to primary winding of transformer and 50V is obtained at the output of transformer. This output of transformer is applied to bridge rectifier.

B. Bridge rectifier module

In this module, sixteen diodes of 6A and 1000V are connected to negative terminal of other eight diodes. And used in bridge form. Negative terminals of eight diodes are connected to each other and positive terminal is con positive terminal of other eight diodes are connected to each other and it is given to the relay, as per the connection diagram shown in Fig.3.

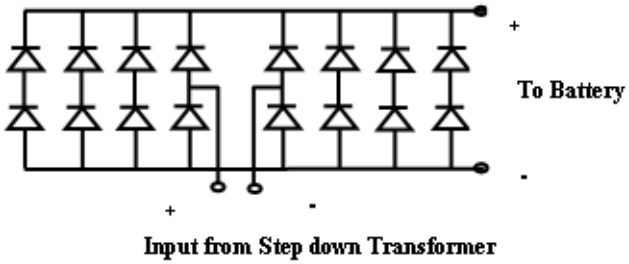

Fig.3 Bridge Rectifier

C. *Solar panel*

In this paper one solar panel of 10W is used to receive the sunlight. Solar panel gives dc supply to solar charging module. The rated voltage of solar panel is 18V, rated current is 0.6A and open circuit voltage is 21V.Solar panel rating is low so it cannot charge the vehicle. So, it is used as a prototype in this paper.

D. Solar charging module

In this module, two capacitors of 50V and 4700 µf are used. These capacitors are connected in parallel and two diodes of 6A are used i.e. one diode is used for blocking the voltage flowing back to solar panel and other diode for blocking the voltage which comes from batteries back to solar panel. Then output of solar charging circuit is given to relay section as per the connection diagram is shown in Fig.4.

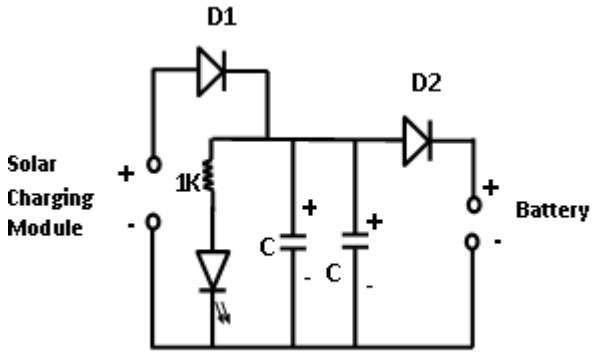

Fig.4 Connection Diagram of Solar Charging Module

E. Auto electro switching module (Relay driver using optocoupler)

Fig.5 shows the auto electro switching module. The coil of the relay passes a relatively large current, typically 30mA for a 12V relay, but it can be as much as 100mA for relays designed to operate from lower voltages.

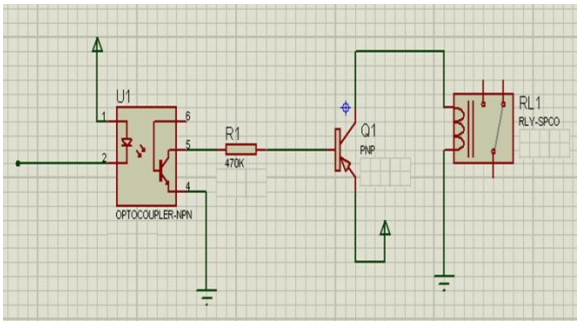

Fig.5 Auto Electro Switching Module

Most ICs (chips) cannot provide this current and a transistor is usually used to amplify the small IC current to the larger value required for the relay coil. Optocoupler 4N35 has one IR LED and a photo- transistor. One pin of the LED is connected to the MCU to get a signal (0 or 1) and the other pin is connected to ground. When the signal from the MCU is 0, then LED emits light. This light will turn ON the NPN transistor. Emitter of the NPN transistor is grounded and collector is connected to the PNP transistor (BC369) whose emitter is connected to V_{cc} and collector to the relay.

V. WORKING OF THE HARDWARE MODEL

The entire circuit is designed in five major parts. First section is the main power supply (230V AC, Level 2 charging) is given to the primary winding of 50V step down transformer. This transformer steps down the voltage from 230V to 50V at the secondary winding and this voltage is given to the bridge rectifier. The bridge rectifier converts AC supply into DC supply and is given to the auto electro switching circuit for charging the lead acid batteries. In the second section regulated power supply is used for microcontroller unit and for auto electro switching circuit. In this supply, a 12V step down transformer is used to step down the 230V into 12V AC supply which is applied to bridge rectifier which consist of four 1N4007 diodes. This bridge rectifier is then converted ac supply into dc supply. And in this section, 7812 LM is used to supply 12 V dc supply to relay section. 7805 LM is used to provide 5V dc supply to microcontroller section. In the third section, solar panel receives the solar power as DC source and this DC output is used for charging the batteries through a solar charging module and an auto electro switching module (relay section). Solar charging module consist of two capacitors which are used for storing the DC power. This DC supply is fed to the relay section for charging the batteries. In the fourth section, an auto electro switching circuit or relay section is used in which output of regulated power supply is given to switch on the relay by using an optocoupler and transistor. In this circuit the MCU is connected to transistor through optocoupler, means there is an optical connection between microcontroller and transistor not any physical connection, so the spike generated by the transistor wouldn't be reach controller. In this section both the outputs of first section i.e. level 2 charging as main supply is given to the relay NC terminal and output of third section i.e. solar panel as DC supply is given to the relay NO terminal. In MCU programming, condition is given that if the threshold value is less than 10V then batteries are charged through mains supply otherwise through solar power as DC source by using relay. So, relay will automatically charge the batteries through these two sources. And in the last section, battery level indicator module which is used to indicate the battery status that the battery is fully charged or it is empty.

VI. HARDWARE MODEL OF CHARGING STATION

Fig.6shows the complete hardware model and this model is fabricated and tested in the laboratory with solarpanel as DC source as well as with AC supply (230V).

Fig.6 Hardware Model of Charging Station

VII. COMPLETE ASSEMBLY OF THE SYSTEM

Complete system assembly of charging station is shown in Fig.7. In this model charging station is connected to the batteries which are placed in the vehicle.

Fig.7 Original Picture of Complete Assembly of Charging Station.

Then lead acid batteries are charged through AC supply and through solar panel by using an auto electro switching circuit depends on the condition which is given in the programming of MCU. Then battery level indicator circuit is connected to the output terminals of batteries. And battery level indicator module is used to indicate the battery status.

VIII. RESULTS AND DISCUSSION

The design, development and implementations of the solar electric charging station for charging the batteries through charging level 2 and through solar power has been successfully carried out. Two hardware test are done. (i) The vehicle is charged through charging level 2 as AC source or through solar panel as DC source by using the auto electro switching circuit. The result will be shown on the 16✕2LCD. (ii) The status of the lead acid batteries by using battery level indicator circuit.

IX. OUTCOME OF AUTO ELECTRO SWITCHING CIRCUIT

In the hardware test, there is a condition which is given in the MCU programming that if the threshold value is less than 10 then batteries will be charged through charging level 2 or 230V AC supply, otherwise through DC source (solar panel).Threshold value is entered on the LCD by using push buttons which is shown in Fig.8.

Fig.8 Switch Pad

Case I

First button is used to increment the data, second to decrement the data and third to enter or set the data. The reset button is pressed and then increment button is pressed to enter 1 on the LCD. Then the threshold value 1 is displayed on the LCD as shown in Fig.9.

Fig.9 Threshold Value 1 is entered in Case I

After that set button is pressed and command will be sent to the MCU. The relay (auto electro switching circuit) will operate and the batteries are charged through AC supply. This is because of the condition that if the threshold value is less than 10, or the solar generation is less than 10V then the batteries will be charged from the 230V AC supply. This display is shown in Fig.10.

Fig.10 Charging from AC in Case I

Case II

To show that enough solar generation is available, when the threshold value is set to greater or equal to 10 and then the batteries will be charging from solar. Fig.11shows the display of threshold value and Fig.12 shows the display charging status from solar.

This has been done by the auto electro switching circuit.

Fig.11 Threshold Value 10 is entered in Case II

Fig.12Charging from Solar in Case II

X. OUTCOME OF BATTERY LEVEL INDICATOR

The battery level indicator circuit is connected at the output terminals of batteries and is used to indicate the status of the lead acid batteries. As the battery is placed within the vehicle, there are five LEDs of different colors which indicate the battery charging status as listed in Table.3.

Table.3 Battery Status

Yellow LED	Power Connected (0%) (essentially always on)
Red LED	Greater than 43V (25%)
Orange LED	Greater than 45V (50%)
Green LED	Greater than 47V (75%)
Blue LED	Greater than 50V (100%) (full charge is about 51to 52V)

Fig.13 shows all LEDs are ON (i.e. glow) and this indicate that the batteries are fully charged.

Fig.13 All LEDs are ON (Battery Status)

Fig.14 shows only three LEDs are ON. This means that only 50% of battery charge is left.

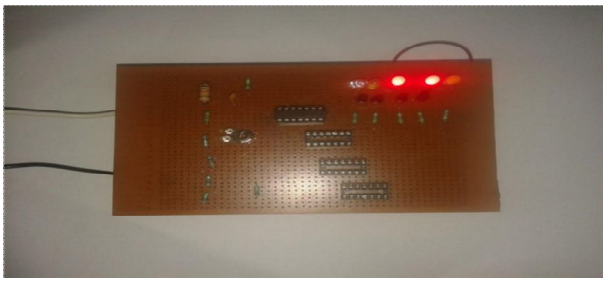

Fig.14 Three LEDs are ON (Battery Status)

Fig.15 shows only two LEDs are ON (i.e. glow). This means that only 25% of battery charge is left.

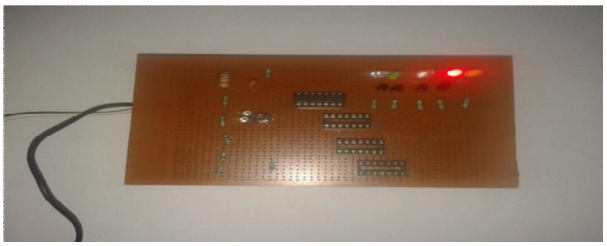

Fig.15 Two LEDs are ON (Battery Status)

XI. CONCLUSION AND FUTURE SCOPE

This paper has presented a model of a charging station to charge the lead acid batteries as storage device through level 2 charging (AC supply) and through solar power. Automated switching system is used to eliminate human efforts and errors while switching from the solar power to backup power and vice versa. It will also ensure that excess current is not drawn from the backup power while there is enough irradiance from the solar panel producing sufficient current to charge the batteries. Since it hasadvantages: charging and discharging times in the order of few hours, and environmentally friendly. The experimental results of the hardware model are presented and analyzed. This paper indicated a benefit to the college campus for such a structure. As well, rapidly advancing solar innovations and designs could lend themselves to creating a more efficient charging station.

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