IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Impact Factor: 4.819
Volume 7, Issue 2, July 2021

Solar Charging Station for Electric Vehicles

Bugatha Ram Vara Prasad[1], T. Deepthi[2], N. Satyavathi[3], V. Satish Varma[4], R. Hema Kumar[5]
Assistant Professor, Department of Electrical Engineering[1]
U. G. Students, Department of Electrical Engineering[2,3,4,5]
Lendi Institute of Engineering and Technology, Vizianagaram, Andhra Pradesh, India

Abstract: *This paper describes design of solar powered charging station for charging of electric vehicle that solves the key downside of fuel and pollution. While EV charging has traditionally been grid-based, use of solar powered chargers has emerged as an interesting opportunity. As worlds resources are diminishing, government agencies and non-government organization are pushing greener solution through the use of renewable energy sources. In order to reduce the pollution through the motor vehicles, there is a large scope of increase in electric vehicles all over the world. To run the electric vehicle the fuel required is the electricity which can be storable through the use of solar energy. Electric vehicles that run on the Electric vehicle smart charging station which is the promising alternative and environmentally sustainable solution to meet up the energy crisis. This paper investigates the possibility of charging the battery of electric vehicles at a various working place like offices, colleges, hospitals, universities etc in India using solar energy. In this paper, the charging station successfully developed as desired features for electric vehicle from renewable energy resources with solar panel, solar charge controller, batteries storage and DC-DC converter. A laboratory-scale experimental prototype was also developed, and the performance of the proposed charging station was investigated.*

Keywords: Batteries; DC/DC converter; Electric Vehicle; Photovoltaic; Solar Charge Controller.

I. Introduction

An electric vehicle (EV) is one that operates on an electric motor, instead of an internal-combustion engine that generates power by burning a mix of fuel and gases[1]. Therefore, such as vehicle is seen as a possible replacement for current-generation automobile, in order to address the issue of rising pollution, global warming, depleting natural resources, etc. Though the concept of electric vehicles has been around for a long time, it has drawn a considerable amount of interest in the past decade amid a rising carbon footprint and other environmental impacts of fuel-based vehicles[2].

Emergence of battery electric vehicles (EV) as the future mode of transport. Firstly, the use of renewable energy sources such as solar energy is accessible to a wider audience because of the falling cost of PV panels. Industrial sites and office buildings has a great potential for photovoltaic (PV) panels with their large surface on flat roofs[3]. Examples include warehouses, industrial buildings, universities, factories, etc. This potential is largely unexploited today. Secondly, EVs provide a clean, energy efficient and noise-free means for commuting when compared with gasoline vehicles.

Figure 1: Design of solar powered EV charging station.

II. Charging Station

A charging station, also called electric vehicle charging station, electric recharging point, charging point, charge point, electronic charging station (ECS),and electric vehicle supply equipment (EVSE), is a machine that supplies electric energy to charge plug-in electric vehicles—including cars, neighbourhood electric vehicles, trucks, buses and others. Some electric vehicles have on-board converters that plug into a standard electrical outlet or a higher voltage outlet[4]. Others use custom charging stations. Charging stations provide connectors that conform to a variety of standards. Charging an electric vehicle is possible in a variety of locations and at a variety of speeds. The cost for charging is set by the charging service provider and can even be free. Charging types can be divided into three broad categories:

Figure 2: Charging station

- **Private Charging**: Private charging points are not available to everyone. Home chargers and reserved spaces are examples of private charging.
- **Semi-Private Charging**: Office charging or guest parking are examples of semi-private charging stations.
- **Public Charging**: Public chargers are charging stations which are available to all drivers, e.g. at destinations (restaurants, shopping centers, etc) or roadside (highways, city parking, etc).

III. Solar Powered EV Charging System

Electric vehicle (EV) charging from SPV offers a sustainable way for recharging the car batteries. Workplaces such as factories, office buildings, and industrial areas are perfect places to enable solar EV charging where the area under the building's rooftops and car parks can be utilized to install photovoltaic panels[5]. The generated power is utilized directly for EV charging in an EV-PV charger, without the need for the storage system. Due to the variability in the nature of PV generation, a grid connection is essential to guarantee the reliable electricity supply for charging the vehicles. Generally, employee's vehicles remain there for 6–9 h at the parking area and the long charging period results in less EV charging requirements and also paves the way for grid support through vehicle-to-grid (V2G) technology[6]. While in the off-grid system, vehicle-to-home (V2H) technology is possible. The literature on solar energy for charging the EVs is much advanced and diverse. This is because the electricity produced by solar PV provides more integration with the existing grid. Among the various strategies, one is to charge the EV directly using the principle of 'charging-while-parking' to supplement the more common practice i.e. 'charging-by-stopping.' Subsequently, the EV can be getting charged by means of the integrated PV-grid system whereas at the same time EV owner involves in other activities. P. J. Tulpule et al. have listed several advantages of the PV powered charging station. As the charging is being done during the hours of daylight, when the demand and tariff are on their peak, the substantial cost savings is accomplished. On top of that, the roofed parking facility provides free housings from the sunlight and raindrops, the scheme is very much favorable in hot climate regions. Owing to these benefits, the on-grid PV system is more favored one than other renewable-based generations

3.1 Solar Powered DC Fast Charging System

A bi-directional DC-DC electric vehicle (EV) charger is positioned between the high-voltage DC bus of a PV system and the EV battery. In addition, to charging the EV battery from the PV or the grid at a faster rate, the fast changes in

PV power output to the battery can be diverted by the charger itself. Hence, the rate of change of inverter output power reduces to a level below the existing grid resource ramp rate. The EVs have inbuilt direct DC fast charging port and consequently, no inverter is needed between PV and EV. But in the on-grid system, the inverter is needed between PV and power grid[7].

3.2 Charging Modes

A. CC Mode of Charging

Until the SOC of battery reaches 95% of its total charge, CC mode of charging is done. After it reaches 95% SOC, CV charging mode is done. In CC mode as shown in Fig.2, load current is constantly compared with reference current and the difference (error) is given to a PID controller. The output signal from PID is compared with a saw tooth wave by a comparator and the duty cycle of output wave varies accordingly. This output from comparator is used to drive the buck converter.

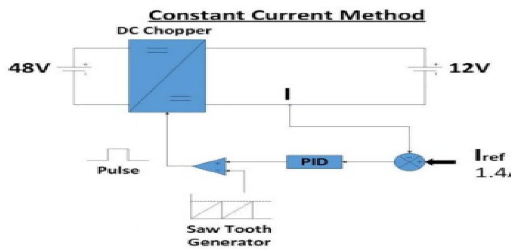

Figure 3: CC Charging mode

B. CV Mode of Charging

In CV mode of charging, the voltage across battery is constantly compared with a reference value of 12V. The difference in the error is used to calculate the reference current and this current is compared with the load current. The difference is fed to a PID controller and the output from PID is compared with saw tooth wave and the duty cycle of output wave varies accordingly. When the SOC of battery reaches 95%, a relational operator and a switch toggles from CC mode to CV mode of charging.

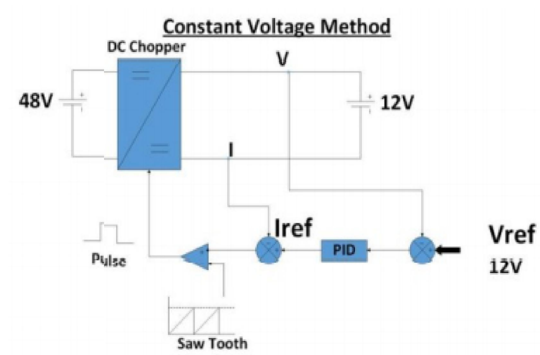

Figure4: CV Charging mode

IV. Boost Converter

Working Range: DC 8.5V to 50V input voltage, 10V to 60V continuously adjustable output voltage, 15A maximum input current, 12A maximum output current. High Conversion: 96% maximum conversion efficiency, stable and reliable performance[8]. Easy to Connect and Disconnect: Input and output are designed with screw terminals, you can connect or disconnect the wire conveniently[9]. Faster Dissipation: Designed with two heat sinks, better dissipation performance. Widely Applications: Suitable for electric equipment, digital products, laptop, etc. Type: Non-isolated boost module. Input Voltage: DC 8.5V to 50V. Output Voltage: DC 10V to 60V (continuously adjustable, default 19V). Max. Input Current: 15A (please enhance heat dissipation if more than 8A). Max. Output Current: 12A (related to the input and output voltage difference, the greater voltage difference is, the smaller output current will be. please enhance heat dissipation when current is over 7A).

Figure 5: Boost Converter

Quiescent Current: 10mA(will increase when convert 12V to 20V). Constant Current Range: 0.2A to 12A. Output Power = Input Voltage*Current. Operating Temperature: -40℃ to 85℃(if temperature is too high, please enhance heat dissipation). Frequency: 150KHz. Max. Conversion Efficiency: 96% (Efficiency is related to input/output voltage, current and voltage difference). Over Current Protection: Yes (if input current is more than 15A, it will automatic reduce output voltage [10].

4.1 Block Diagram of Solar Charging Station

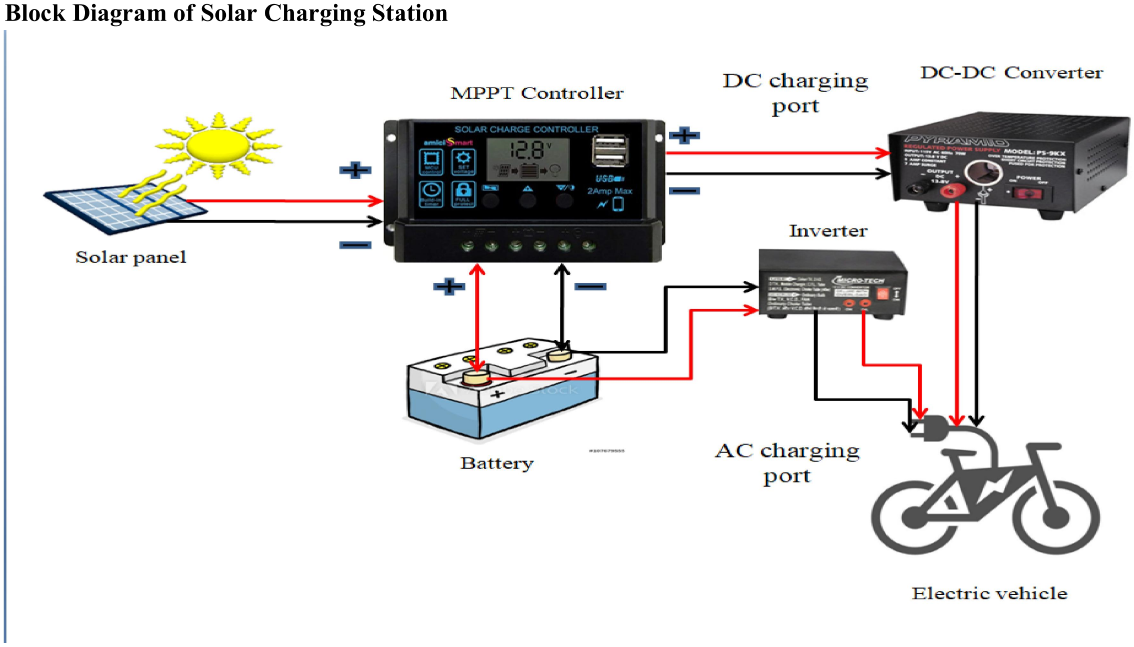

Figure 6: Block diagram of solar charging station

V. Results and Discussion

Open circuit voltage is a common term in solar cell applications. V_{OC} is the open circuit voltage, which is the maximum voltage that is available for drawing out from a solar cell, and occurs at zero current[11]. The open circuit voltage resembles the forward bias amount on the solar cell as a result of the bias of the solar cell junction with light generated current. Connect the positive lead of the multimeter to the positive wire (or terminal) of the solar panel, and

IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

Volume 7, Issue 2, July 2021

Impact Factor: 4.819

the negative lead of the multimeter to the negative wire (or terminal) of the solar panel. The multimeter will now show the open circuit voltage of the solar panel.

5.1 Open Circuit Voltage Test of Solar Panel when the Sun Radiation is Low

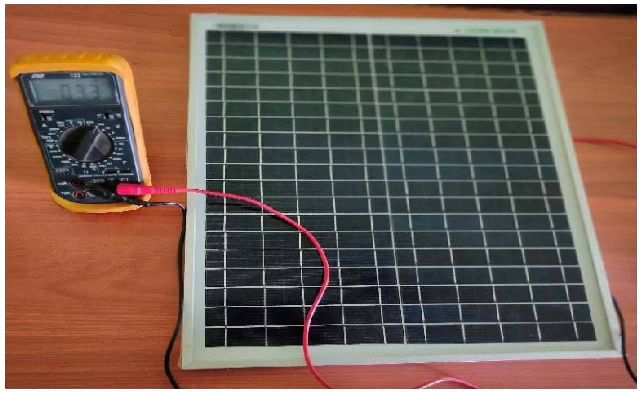

Figure 7: Open circuit voltage test of solar panel with multimeter

Results (typical)

- 12V nominal panel: 18 to 28V.
- 24V nominal panel: 34 to 56V

5.2 Output Voltage Test of Battery with Solar Charge Controller

Output voltage is the voltage which was exhibited by the battery under normal conditions. The battery that used in this project is a lead acid battery which was shown above. Output voltage test of battery is as follows:

Connect the positive lead of the solar charge controller to the positive wire (or terminal) of the battery, and the negative lead of the solar charge controller to the negative wire (or terminal) of the battery. The solar charge controller will now show the output voltage of the battery[12].

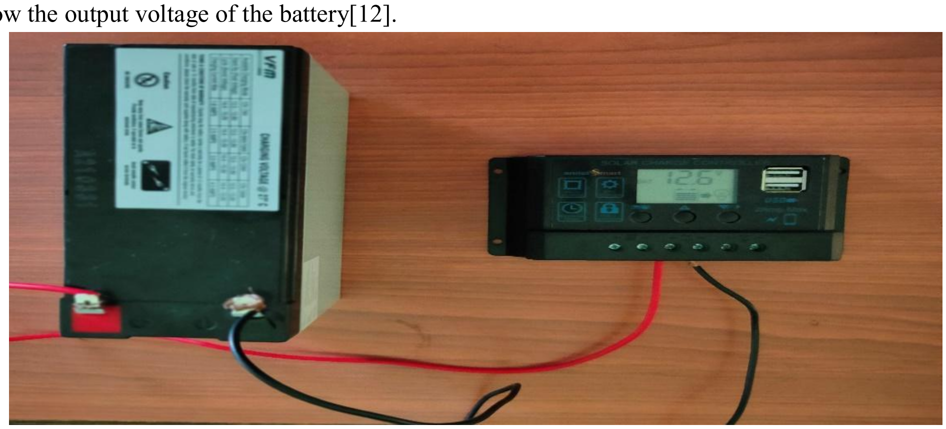

Figure 8: Output voltage test of battery with solar charge controller

Result

- 12V DC under normal conditions

5.3 Input Voltage Test of DC-DC Boost Converter

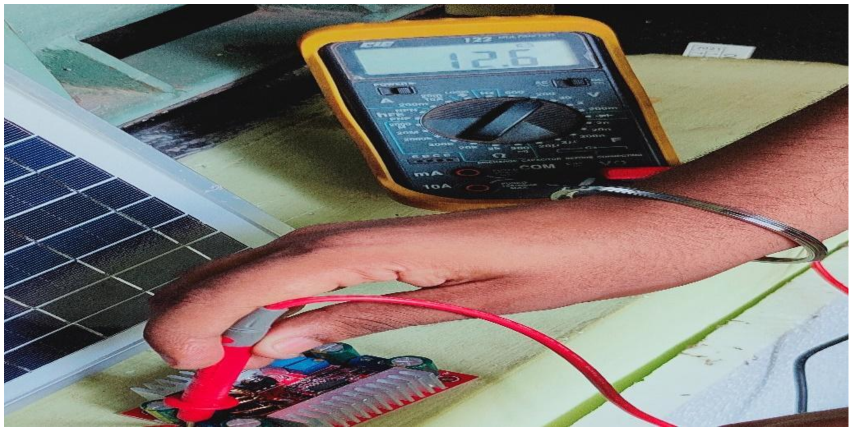

Figure 9: Input Voltage Test of DC-DC Boost Converter with Multimeter

Input voltage is the voltage which was accepted by the boost converter under normal conditions. Input voltage test of DC-DC converter is as follows:

Connect the positive lead of the multimeter to the positive wire (or terminal) of the boost converter, and the negative lead of the multimeter to the negative wire (or terminal) of the boost converter. The multimeter will now show the input voltage of the boost converter.

Result

- 12V under normal conditions

5.4 Output Voltage Test of Boost Converter(28V)

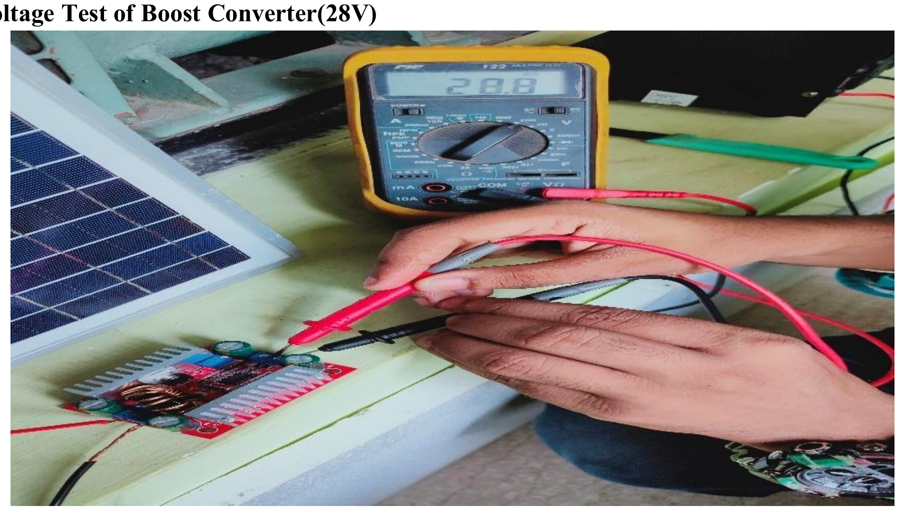

Figure 10: Output voltage test of DC-DC boost converter with multimeter

Output voltage is the voltage which was exhibited by the boost converter under normal conditions. Ouput voltage test of DC-DC boost converter is as follows:

Connect the positive lead of the multimeter to the positive wire (or terminal) of the boost converter, and the negative lead of the multimeter to the negative wire (or terminal) of the boost converter. The multimeter will now show the output voltage of the boost converter.

Result

- 28V under normal conditions.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Impact Factor: 4.819
Volume 7, Issue 2, July 2021

5.5 Output Voltage Test of Boost Converter(36V):

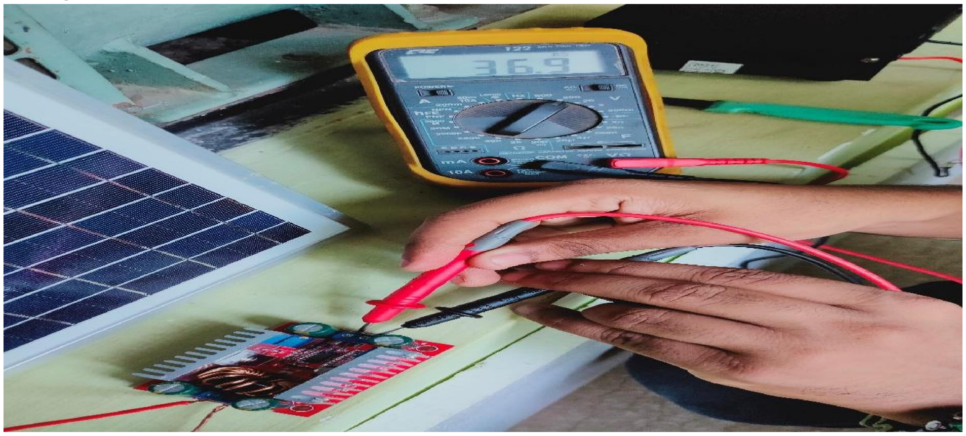

Figure 11: Output voltage test of DC-DC boost converter with multimeter

Output voltage is the voltage which was exhibited by the boost converter under normal conditions. The above picture depicts that the output voltage of boost converter can be boost up to certain values till its maximum range. Output voltage test of DC-DC boost converter is as follows:

Connect the positive lead of the multimeter to the positive wire (or terminal) of the boost converter, and the negative lead of the multimeter to the negative wire (or terminal) of the boost converter. The multimeter will now show the output voltage of the boost converter[13].

Result

- 36.9V under abnormal conditions.

5.6 Complete Circuit for AC charging

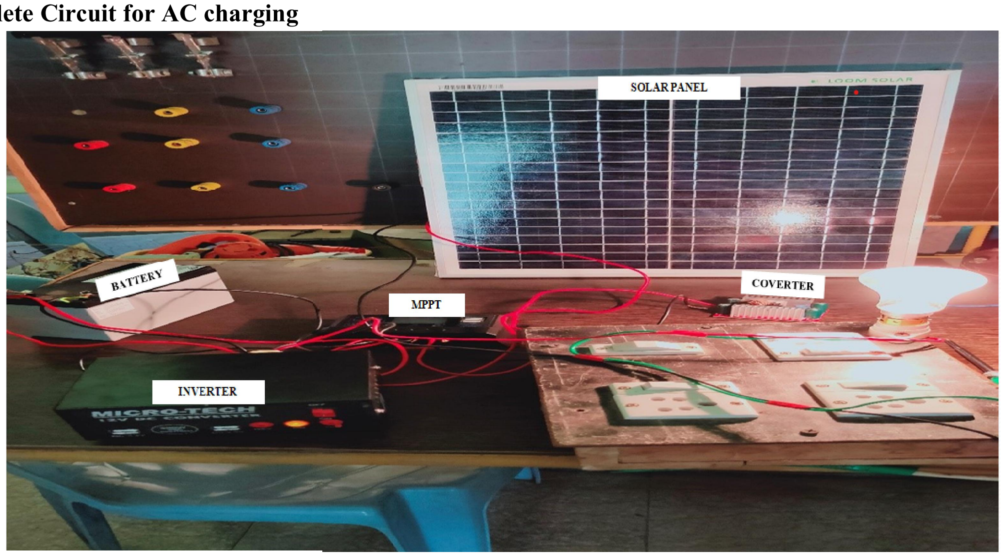

Figure 12: Testing for AC charging

By connecting all the required components together with perfect connections then we can get the required output. When the inverter connected across the battery then it converts the battery output voltage i.e DC to AC .That AC is used for the purpose of AC charging. So the above picture is the result of testing an AC bulb by connecting its terminals to inverter terminals to the bulb.

5.7 Complete Circuit for DC Charging:

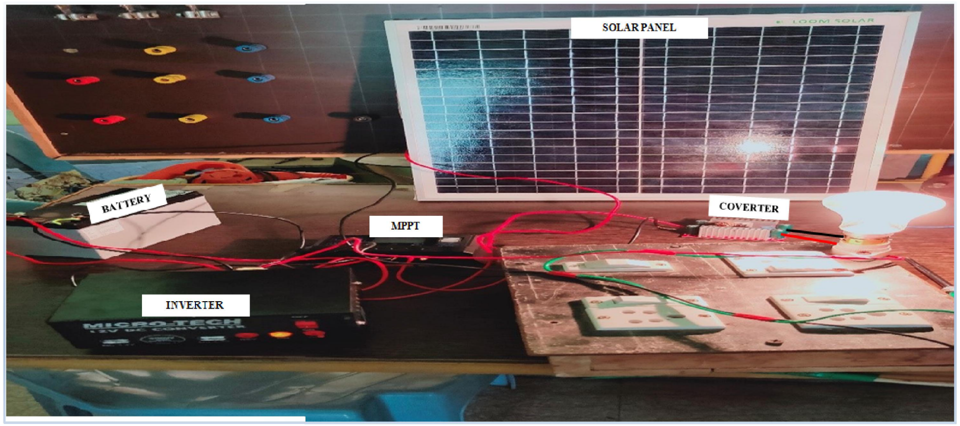

Figure 13: Testing for DC Charging

By connecting all the required components together with perfect connections then we can get the required ouput. When the boost converter connected across the battery then it converts the battery ouput voltage i.e DC to DC .That boosted voltage is used for the purpose of DC charging. So the above picture is the result of testing an AC bulb by connecting its terminals to converter terminals to the bulb.

5.8 Chassis of the Project

Figure 14: Chassis of the project

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 7, Issue 2, July 2021
Impact Factor: 4.819

Figure 15: Final output

VI. Conclusion

This paper is to make every individual to feel comfortable as it was movable and portable. As today's world is fully covered with a huge amount of pollution that is being caused by the automobiles, electric vehicles are the best replacement for the future generation. So, in order to feed the electric vehicles this paper that is charging station helps a lot to the public in the way of economic and also helps in instant charging where one can't be able to find the electric grid. The final conclusion of this paper is to use renewable energy resources to the maximum extent and to promote the electric vehicles as they are eco-friendly so that there may be a chance of reduction in pollution in future. In order to run the electric vehicles, there is a requirement of fuel that is electricity. So,this paper provides that electricity which is required by the vehicles to be get charged. As our designed charging station is movable and portable, each individual can use it even in the absence of grid.

References

[1]. F. Mwasilu, J. J. Justo, E. K. Kim, T. D. Do, and J. W. Jung, "Electric vehicles and smart grid interaction: A review on vehicle to grid and renewable energy sources integration," Renew. Sustain. Energy Rev., vol. 34, pp. 501–516, 2014, doi: 10.1016/j.rser.2014.03.031.

[2]. B. Battke, T. S. Schmidt, D. Grosspietsch, and V. H. Hoffmann, "A review and probabilistic model of lifecycle costs of stationary batteries in multiple applications," Renew. Sustain. Energy Rev., vol. 25, pp. 240–250, 2013, doi: 10.1016/j.rser.2013.04.023.

[3]. Bugatha Ram Vara prasad, "Solar Powered BLDC Motor with HCC Fed Water Pumping System for Irrigation," Int. J. Res. Appl. Sci. Eng. Technol., vol. 7, no. 3, pp. 788–796, 2019, doi: 10.22214/ijraset.2019.3137.

[4]. Bugatha Ram Vara Prasad, C. Prasanthi, G. Jyothika Santhoshini, K. J. S. V. Kranti Kumar, and K. Yernaidu, “Smart Electrical Vehicle,” i-manager’s J. Digit. Signal Process., vol. 8, no. 1, p. 7, 2020, doi: 10.26634 /jdp.8.1.17347.

[5]. Bugatha Ram Vara prasad, D. V. S. J. Poojitha, and K. Suneetha, “Closed-Loop Control of BLDC Motor Driven Solar PV Array Using Zeta Converter Fed Water Pumping System,” vol. 04, no. 17, pp. 2795–2803, 2017.

[6]. P. Goli and W. Shireen, “PV integrated smart charging of PHEVs based on DC Link voltage sensing,” IEEE Trans. Smart Grid, vol. 5, no. 3, pp. 1421–1428, 2014, doi: 10.1109/TSG.2013.2286745.

[7]. A. Shukla, K. Verma, and R. Kumar, “Impact of EV fast charging station on distribution system embedded with wind generation,” J. Eng., vol. 2019, no. 18, pp. 4692–4697, 2019, doi: 10.1049/joe.2018.9322.

[8]. R. A. Dolly and Bugatha Ram Vara prasad, “Enhancement of PFC and Torque Ripple Reduction using BL Buck- Boost Converter fed HCC BLDC Drive,” vol. 02, no. 11, pp. 895–901, 2015.

[9]. Bugatha Ram Vara prasad, K. M. Babu, K. Sreekanth, K. Naveen, and C. V. Kumar, “Minimization of Torque Ripple of Brushless DC Motor Using HCC with DC-DC Converter,” vol. 05, no. 12, pp. 110–117, 2018.

[10]. Bugatha Ram Vara prasad, “Highway Monitoring System and Power Saving,” vol. 8, no. 4, pp. 2270–2274, 2020.

[11]. Bugatha Ram Vara prasad, T. S. Babu, K. A. Jose, and M. Satish, “A Novel Performance Evaluation of Power Quality Features Using Hybrid FACTS Device with Induction Motor,” vol. 04, no. 17, pp. 3281–3287, 2017.

[12]. H. S. Das, M. M. Rahman, S. Li, and C. W. Tan, “Electric vehicles standards, charging infrastructure, and impact on grid integration: A technological review,” Renew. Sustain. Energy Rev., vol. 120, no. November, 2020, doi: 10.1016/j.rser.2019.109618.

[13]. J. N. Ingole, “Pic Based Solar Charging,” vol. 4, no. 02, pp. 384–390, 2012.

AUTHOR PROFILE

Bugatha Ram Vara Prasad received UG degree in Electrical and Electronics Engineering from JNTU-Kakinada. He received PG degree in the stream of Power & industrial drives (PID) from JNTU-Kakinada. His area of interest includes Electric vehicles, Power electronic converters and Renewable energy, IOT. He is currently working as Assistant Professor in department of electrical and electronics engineering at Lendi institute of engineering and technology, Vizianagaram and has more than 5 years of teaching experience. He had published papers in international conferences and journals and having one patent.