International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347 - 6435 (Online) Volume 13, Issue 4, April 2023)

Converter-Fed Electric Vehicle Battery Charger: A Review

Sunil Kumar Shahu[1], Balram Yadav[2], Anjana Tripathi[3]
[1]Research Scholar, Dept. of Electrical and Electronics Engineering, SCOPE College of Engineering, Bhopal, India
[2]Associate Professor & HOD, Dept. of Electrical and Electronics Engineering, SCOPE College of Engineering, Bhopal, India
[3]Assistant Professor, Dept. of Electrical and Electronics Engineering, SCOPE College of Engineering, Bhopal, India

***Abstract*— Electric Vehicles (EVs) become a more prominent solution to replace all fossil fuel-based combustion vehicles. As the growth of battery powered electric vehicles is increasing, a high boost in the DC voltage is essential before interfacing the high gain converter to the grid through an inverter. Solar or PV cell based energy has been the most well-known wellsprings of sustainable power source for private and business applications. Variances of sunlight based vitality reaped because of barometrical conditions can be moderated through vitality stockpiling frameworks. Sun oriented vitality can likewise be utilized to charge the batteries of electric vehicle (EV) to diminish the reliance on the AC network. This paper review of different converter based battery charger for electric vehicle.**

***Keywords*— Converter, Photovoltaic, Grid. Electric Vehicles, DC-DC.**

I. INTRODUCTION

With the evolution of Electric Vehicles (EVs) in the modern world, the need for development of charging infrastructure for EVs has become paramount. The Plug-in electric vehicles (PEVs) widely utilize three-phase off-board DC fast chargers for their propulsion systems. An off-board charger topology typically includes an AC-DC power factor correction (PFC) converter, an isolated or nonisolated DC-DC converter, and in some cases PV systems [1]. During a battery charging mode by the grid or solar cells, the converter works as an isolated zeta converter. In the propulsion and regenerative operations, the developed converter has buck/boost conversion capability to adjust the dc bus voltage according to driving conditions for the BLDC motor drive to use a cost-effective motor controller and inverter switches. As a result, the overall system is compact, efficient, and cost-effective to make it a suitable solution for an on-board charging system [2].

MPPT is implemented to improve the efficiency of the solar converter and enables the converter to extract maximum power from the solar panels for charging the battery. Suitable charging modes like Constant Voltage (CV) and Constant Current (CC) modes are required to prevent overcharging of the battery. The designed converter would prove to be an efficient solution for the charging of EVs and help the expansion of EVs in the world [3].

Figure 1: EV charging station

Introduce a high step-up DC-DC converter for the integration of the photovoltaic (PV) energy into the electric vehicle (EV) DC fast charging systems. The proposed converter has an interleaved structure using the integration of coupled inductor (CI), built-in transformer (BIT), and switched-capacitor concepts to achieve high-voltage gain, low current and voltage stresses on the power switches and diodes, and high efficiency [4]. A voltage source converter (VSC) is used to connect the charger. Moreover, a buck-boost converter is used to regulate the power flow in/from the BES in a charging station. The design of high frequency transformer for DAB, is required to consider the selection of leakage inductance. A bidirectional charger of a 1.1 kW power transfer capability is designed. An improved phase shift control of second stage converter is used to regulate the output during disturbances from the source side and a pulse width modulation (PWM) control is used to regulate the DC link voltage [6]. Adaptive neuro fuzzy inference system (ANFIS) is used in control unit which improves the performance of the converters. MPPT (maximum power point tracking) technique is used to get the appropriate pulses for DC/DC converter to extract the maximum output power from PVS at different conditions. The proposed system is simulated in MATLAB/SIMULINK environment and results are discussed to validate the system [10]. By using constant power control, a hybrid generation system including wind, solar and lithium batteries is proposed in this paper to overcome the uncertainty in the output power of new energy. Perturbation and observation method is employed to track the maximum power point of photovoltaic (PV) array and wind turbine, electric vehicle (EV) energy storage system with bi-directional DC-DC control logic is conducted to constantly adjust the unbalanced power [11].

II. LITERATURE SURVEY

B. Singh et al.,[1] presents the change conduction misfortune because of decreased gadget current pressure and accordingly, the charger effectiveness is moved along. The interleaved Luo converter consolidates low information and result current wave because of wave crossing out. This charger works in consistent current mode up to specific battery condition of charge (SOC). In any case, for higher SOC range, it keeps up with steady voltage charging utilizing a flyback converter at the following stage. Two converters are planned in DCM to give inbuilt zero current exchanging and circuit diodes show great converse recuperation. An inborn PF preregulation is gotten at input mains over an extensive variety of supply voltages as well as dc-connect voltage.

A. K. Mishra et al.,[2] presented an efficient configuration for light plug-in electric vehicles (PEVs) with a cost-effective and compact charging system. An integrated isolated DC-DC converter has been investigated for a light PEV that employs a brushless DC (BLDC) machine as a traction motor to lower the motor drive component cost. The proposed isolated DC-DC converter has the capacity to work efficiently under all working conditions for an electric vehicle including charging, propulsion, and regenerative operations with two energy sources such as utility grid and solar PV.

J. Dalal et al.,[3] provides, the implementation of a universal solar charger using a DC-DC converter has been discussed. The universal solar charger is needed for charging the EVs using solar panels and reduces the energy demand from the power grid. A buck-boost converter has been implemented using the MSP430G2553 microcontroller which charges the battery using Maximum Power Point Tracking (MPPT) technique.

R. Rahimi et al.,[4] The reverse-recovery problem of all diodes is solved due to the presence of the leakage inductances of CI and BIT. Operation modes and steady-state analysis of the proposed converter in the continuous conduction mode (CCM) are presented. To verify the merits of the proposed converter, a comparison between the proposed converter and other related converters is performed. Furthermore, an 800 W converter with the input voltage of 40 V and the output voltage of 800 V is simulated in PLECS Blockset to validate the theoretical analyses.

S. P. Sunddararaj et al.,[5] discusses the circuit model and performance of a bidirectional chopper with coupled inductor for electric vehicle applications. The coupled inductor operates as the filter inductor for non-isolated part of the converter and as a transformer for the isolated converter topology. The reduction of switching voltage stress across the power semiconductor devices is achieved by series connection of two switch bridges. This converter is further tested with a nine level inverter. The bidirectional converter designed for electric vehicles is further interfaced with a multilevel inverter (nine level). The implementation of the converter design is simulated using MATLAB/SIMULINK.

U. Sharma et al.,[6] presents voltage source converter (VSC) is utilized to interface the charger. Besides, a buck-help converter is utilized to manage the power stream in/from the BES in a charging station. The plan of high recurrence transformer for Spot, is expected to think about the determination of spillage inductance. A bidirectional charger of a 1.1 kW power move capacity is planned. A superior stage shift control of second stage converter is utilized to manage the result during unsettling influences from the source side and a heartbeat width tweak (PWM) control is utilized to direct the DC connect voltage.

S. D. Kadam et al.,[7] presents the converter used for PV cell based applications is to have a minimum number of changes organizes and give segregation. Impedance (Z) -source inverter topology can evacuate numerous stages and accomplish voltage lift and DC-AC power converter in a solitary stage. The utilization of uninvolved parts likewise displays a chance to incorporate vitality stockpiling frameworks (ESS) into them. This suggested paper presents displaying, plan and activity of an adjusted Modified Z-source inverter incorporated with a split essential confined battery charger for charging of electric vehicles (EV).

G. Guru et al.,[8] During the parking of EVs, power produced by solar photovoltaic (PV) present in the PV powered EVs is underutilized when the capacity of the EV battery is full. Also, a converter is devoted in the conventional EVs to perform the vehicle to grid (V2G) or vehicle to vehicle (V2V) operation. To utilize PV and to perform V2G operation, a novel non-isolated dual-input single output DC-DC converter (DISOC) is proposed. The DISOC structure can be reconfigured to perform six types of operation based on the status of power availability with PV, battery and also the running status of the EV. Simultaneous power transfer from both the input sources, charging the battery from solar PV, V2G and G2V operations are the key features of the proposed converter. The converter operation, component design, effect of parasitic elements on the converter performance, small-signal model, etc., have been reported. The hardware prototype of the converter is fabricated for 500 W, and the experimental results are presented.

S. Atanalian et al.,[9] presents a bidirectional power electronics converter assisted by Photovoltaic Panels for Electric Vehicle battery charging application is presented. The charger is composed of two conversion stages: an AC/DC converter represented by an active-rectifier, and a DC/DC converter illustrated by a Dual Active Bridge. The solar renewable energy is considered an alternative DC source assisting in charging the battery. The charger is tested using MATLAB/SIMULINK under different charging and discharging scenarios. An Electric Vehicle equipped with a bidirectional battery charging system has the ability to act as source or a load.

K. K. Jaladi et al.,[10] provides an insight of electric vehicle charging station which is supplied by three sources grid, photovoltaic system (PVS) and battery energy system (BES), and this system works in both conditions like shore and offshore. Power grid, equipped with an AC/DC converter supplies a continuous and constant power to EV charging station through a DC/DC converter. BES used as a buffer by storing excessive energy at light load conditions and supplying it when needed. Control unit enables the bi-directional DC/DC converter for charging and discharging.

Z. Xin et al.,[11] Large-scale grid-connected new energy will cause great fluctuation of power system and even endanger the stability of it. Energy storage technology with reasonable control logic can balance the fluctuating power and enhance the stability of power system. Voltage source converter (VSC) with d-q decoupling control is used to maintain the DC bus voltage. The simulation results of Simulink verify the feasibility and effectiveness of the proposed system.

R. A. da Câmara et al.,[12] presents an application of the multi-port bidirectional three-phase AC-DC converter as interface between a microgrid composed by several power sources and an electric vehicle charging station (EVCS). The main advantage of using this converter is that it can integrate multiple power sources and loads into a single power conversion stage and thus control the power flow between them reducing the number of power conversion stages and / or devices as well as weight and volume of the entire system and the control architecture does not require communication strucure as main current solutions in this field present.

III. CHALLENGES AND ADVANTAGES

1.) Range anxiety - Range anxiety is one of the crucial challenges ahead of the growth path for electric vehicles in India. The EV customers are often worried about the vehicles capability to reach point B from point A before the battery runs out. This issue is closely connected to the scarce charging infrastructure in India. The Ev charging infrastructure in India too low compared to the petrol pumps. Also, the available Ev charging stations are concentrated in urban areas only.

2.) Consumer perception - The consumer perception about electric vehicles in India is still weak compared to ICE vehicles. The range anxiety, lack of charging infrastructure, a wide gap between EV and ICE vehicle prices, lack of assurance about satisfactory resale value play key roles in that. Despite the Indian consumers are becoming more open about adopting e-mobility than before the negative perception about EVs is still there.

3.) High price - There is no price parity between electric vehicles and ICE vehicles in India. Electric vehicles are way more expensive than their conventional fuel-powered counterparts. For example, the Tata Nexon price starts from ₹7.19 lakh, while the Tata Nexon EV price starts from ₹13.99 lakh. This huge price difference discourages many interested EV buyers to shy away from making the final decision to buy a BEV.

4.) Scarce battery technology - The lithium-ion battery is the most popular and widely used energy source for EVs. India doesn't produce lithium. The country doesn't produce li-ion batteries either. India relies on import for EV batteries resulting in the sky-high price for these important components and eventually the EVs as well.

Advantages:

1.) Low cost of ownership - It is a proven fact by many researches that EVs offer way lower cost of ownership in their lifecycle compared to fossil fuel powered vehicles. At times, the cost of ownership for an EV is as lower as 27% than a fossil fuel vehicle. The incessant rise of petrol and diesel costs are increasing the cost of ownership further for the conventional vehicles.

2.) Easier to maintenance - An internal combustion engine usually contains more than 2,000 moving parts. An electric motor onboard an EV on the other hand contain around 20 moving parts. The only major components in an EV are the battery and the electric motor. This makes the EVs much easier for maintenance, reducing the cost of ownership significantly.

3.) State EV policies - Several state governments across India have already announced their respective EV policies. Some of them promote the supply side, while some promote the demand side. There are EV policies that promote both the supply and demand side through incentives, discounts and other benefits. Delhi Ev policy for example is one such state EV policy. These policies are driving the growth of the electric vehicles in India, in a slow but steady manner.

4.) Cleaner environment - The direct and obvious advantage of adopting electric mobility is the cleaner environment. Electric vehicles don't emit pollutants into the air like their ICE counterparts. The EVs are silent as well unlike their ICE counterparts. This means EVs ensure a cleaner and quieter environment.

IV. CONCLUSION

Electric vehicles (EVs) can be charged with renewable photovoltaic (PV) solar power, and contribute to the integration of solar power in the electricity network via vehicle-to-grid systems. In such systems the role of consumers becomes crucial as they both generate and store energy. Fast charging for electric vehicles is a decisive green light to the prevailing acceptance of EVs. It could be a solution to consumers' range anxiety and the assurance of electric vehicles. This paper reviews of different converter based battery charger for electric vehicle. There is many of the DC-DC converter based charger available and research is still going on to enhance the performance of this charger.

REFERENCES

1. B. Singh and R. Kushwaha, "Power Factor Preregulation in Interleaved Luo Converter-Fed Electric Vehicle Battery Charger," in IEEE Transactions on Industry Applications, vol. 57, no. 3, pp. 2870-2882, May-June 2021, doi: 10.1109/TIA.2021.3061964.
2. A. K. Mishra and T. Kim, "A BLDC Motor-Driven Light Plug-in Electric Vehicle (LPEV) with Cost-Effective On-Board Single-Stage Battery Charging System," 2021 IEEE Transportation Electrification Conference & Expo (ITEC), 2021, pp. 452-456, doi: 10.1109/ITEC51675.2021.9490066.
3. J. Dalal, H. Chandwani, T. Bhagwat, M. Karvande and M. S. Shaikh, "Implementation of Universal Solar Charger for EV applications using a Cascaded Buck-Boost Converter," 2021 6th International Conference for Convergence in Technology (I2CT), 2021, pp. 1-6, doi: 10.1109/I2CT51068.2021.9418156.
4. R. Rahimi, S. Habibi, P. Shamsi and M. Ferdowsi, "An Interleaved High Step-Up DC-DC Converter Based on Combination of Coupled Inductor and Built-in Transformer for Photovoltaic-Grid Electric Vehicle DC Fast Charging Systems," 2021 IEEE Texas Power and Energy Conference (TPEC), 2021, pp. 1-6, doi: 10.1109/TPEC51183.2021.9384943.

International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347 - 6435 (Online) Volume 13, Issue 4, April 2023)

5. S. P. Sunddararaj, S. S. Rangarajan, U. Subramaniam, E. R. Collins and T. Senjyu, "A new topology of DC-DC Converter with Bidirectional Power Flow Capability Coupled with a Nine Multilevel Inverter for EV Applications," 2021 7th International Conference on Electrical Energy Systems (ICEES), 2021, pp. 177-182, doi: 10.1109/ICEES51510.2021.9383766.
6. R. Kushwaha and B. Singh, "An Improved Power Factor Luo Converter based Battery Charger for Electric Vehicle," 2020 IEEE Transportation Electrification Conference & Expo (ITEC), 2020, pp. 723-728, doi: 10.1109/ITEC48692.2020.9161736.
7. S. D. Kadam and V. M. Panchade, "Designing of Photovoltaic Cell Based Modified Impedance (Z)-Source Integrated Electric Vehicle DC Charger/ Inverter," 2020 9th International Conference System Modeling and Advancement in Research Trends (SMART), 2020, pp. 406-410, doi: 10.1109/SMART50582.2020.9337091.
8. G. Guru Kumar and S. Kumaravel, "Dual-Input Non-isolated DC-DC Converter with Vehicle to Grid Feature," in IEEE Journal of Emerging and Selected Topics in Power Electronics, doi: 10.1109/JESTPE.2020.3042967.
9. S. Atanalian, K. Al-Haddad, R. Zgheib and H. Y. Kanaan, "Bidirectional Electric Vehicle Battery Charger Assisted by Photovoltaic Panels," IECON 2020 The 46th Annual Conference of the IEEE Industrial Electronics Society, 2020, pp. 2327-2332, doi: 10.1109/IECON43393.2020.9255292.
10. K. K. Jaladi, S. Kumar and L. M. Saini, "ANFIS Controlled Grid Connected Electric Vehicle Charging Station Using PV Source," 2020 First IEEE International Conference on Measurement, Instrumentation, Control and Automation (ICMICA), 2020, pp. 1-5, doi: 10.1109/ICMICA48462.2020.9242717.
11. Z. Xin, X. Dong and X. Xie, "Multi-energy hybrid power generation system based on constant power control," 2019 IEEE 8th International Conference on Advanced Power System Automation and Protection (APAP), 2019, pp. 745-749, doi: 10.1109/APAP47170.2019.9225178.
12. R. A. da Câmara, L. M. Fernández-Ramírez, P. P. Praça, D. de S. Oliveira, P. García-Triviño and R. Sarrias-Mena, "An Application of the Multi-Port Bidirectional Three-Phase AC-DC Converter in Electric Vehicle Charging Station Microgrid," 2019 IEEE 15th Brazilian Power Electronics Conference and 5th IEEE Southern Power Electronics Conference (COBEP/SPEC), 2019, pp. 1-6.