

# Review of Various Battery Chargers and Charging Level for Electric Vehicle

Ravi Kishore Prasad<sup>1</sup>, Prof. Mithlesh Gautam<sup>2</sup>, Prof. Meha Shrivastava<sup>3</sup>

M.Tech Scholar, Department of Electrical and Electronics Engineering, Truba College of Science and Technology,  
Bhopal, India<sup>1</sup>

Assistant Professor, Department of Electrical and Electronics Engineering, Truba College of Science and Technology,  
Bhopal, India<sup>2</sup>

Associate Professor & HOD, Department of Electrical and Electronics Engineering, Truba Institute of Engineering &  
Information Technology, Bhopal, India<sup>3</sup>

**ABSTRACT:** Electric vehicles are a new and upcoming technology in the transportation and power sector that have many benefits in terms of economic and environmental. An electric vehicle (EV) is a vehicle that uses one or more electric motors or traction motors for propulsion. An electric vehicle may be powered through a collector system by electricity from off-vehicle sources, or may be self-contained with a battery, solar panels, fuel cells or an electric generator to convert fuel to electricity. This study presents a literature review of electric vehicles battery charger performance and charging station. A comparison is made on the commercial and prototype electric vehicles in terms of electric range, battery size, charger power and charging time.

**KEYWORDS:** Electric vehicle (EV), battery charger, Power, Capacity.

## I. INTRODUCTION

Today, began to consider battery-powered EVs as a potentially major strategy to reduce vehicle emissions and improve air quality, it did so with the view that the broadest market would be served by electric vehicles with advanced batteries several important EV-battery programs were discontinued during the last few years, in good part because their sponsors were losing confidence that a market would develop for EV batteries with the currently projected performance and cost characteristics.

Electric mobility becomes trending issue than ever in transportation sector. The essential part of electric mobility is the use of electric vehicles. Electric Vehicle (EV) is type of vehicle which primarily powered by an electric motor drawing power from a rechargeable energy storage device. EV receives electricity by plugging into the grid and store it in batteries. EV Charger is an electrical device that converts alternating current energy to regulated direct current for replenishing the energy of an energy storage device (i.e. battery) and may also provide energy for operating other vehicle electrical systems. The energy storage device namely battery is heart of an electric vehicle. Therefore, battery charger plays a very important role in the electric vehicle technology. Electric vehicle battery chargers divided into two types: on-board type (in electric vehicle) and off-board type (at a fixed location). In this paper, the charging technologies in commercial vehicles, related standards, charging levels and charging modes are described. Also, EV charging sockets are explained clearly. The whole issues about chargers are presented for commercial EV manufacturers. The experience of the past decade makes it clear that the development of batteries for electric vehicles is facing major technical and cost barriers, and that only those organizations willing to take substantial financial risks and capable of providing extensive resources over a number of years have a realistic chance of overcoming these barriers.

Over the past five years, battery developers and automobile manufacturers devoted large efforts to the continued advancement of EV-battery technology and the development of a new generation of electric vehicles. Under the MoA between the six leading automobile manufacturers and the California Air Resources Board, a substantial number of these vehicles has been deployed. Nevertheless, since they are produced in limited volume only, the vehicles—including their batteries—are expensive, and vehicle leases had to be subsidized heavily to attract early users.



Figure 1: Electrical vehicle charging

Today's automobile safety requirements are very stringent, and the assurance of a very high level of safety will be a critical requirement for electric vehicles deployed as a broadly available new automotive product. As a high-energy system, the battery is the main safety challenge associated with electric vehicles. However, no statistically valid experience base exists for defining and quantifying adequate safety for the advanced batteries used in EV propulsion. Moreover, the safety issues differ substantially from one type of battery to another, and even within a battery type from one design to another.

## II. RELATED WORK

R. Kushwaha et al., [1] In the proposed configuration, the conventional diode converter at the source end of existing EV battery charger is eliminated with the modified Landsman power factor correction (PFC) converter. The PFC converter is cascaded to a flyback isolated converter, which yields the EV battery control to charge it, first in constant current mode then switching to constant voltage mode. The proposed PFC converter is controlled using single sensed entity to achieve the robust regulation of dc-link voltage as well as to ensure the unity power factor operation. The proposed topology offers improved power quality, low device stress, and low input and output current ripple with low input current harmonics when compared to the conventional one. Moreover, to demonstrate the conformity of the proposed charger to an IEC 61000-3-2 standard, a prototype is built and tested to charge a 48 V EV battery of 100 Ah capacity, under transients in input voltage. The performance of the charger is found satisfactory for all the cases.

S. Bharati et al., [2] presents the traction systems for electric vehicles have advanced considerably over recent years, with the application of different topologies of power converters for the control of various types of electric induction motors and permanent magnet. Furthermore, the evolution of power semiconductor elements of Si to SiC wideband have opened up lines of research and development in this area.

M. Gjelaj et al., [3] Widespread use of electric vehicles (EVs) requires investigating impacts of vehicles' charging on power systems. This study focuses on the design of a new DC fast-charging station (DCFCS) for EVs combined with local battery energy storages (BESs). Owing to the BESs, the DCFCS is able to decouple the peak load demand caused by multiple EVs and decrease the installation costs as well as the connection fees. The charging system is equipped with a bidirectional alternating current/direct current (DC) converter, two lithium-ion batteries and a DC/DC converter. The introduction of BES within the DCFCSs is investigated with regard to operational costs of the CSs as well as the ability of a BES to mitigate negative impacts on the power grid during congestion hours.

J. Lu et al., [4] This work presents a method for efficiency estimation of boost-derived continuous conduction mode power factor correction (CCM-PFC) converters for electric vehicle (EV) onboard chargers. The proposed methodology incorporates converter nonidealities, especially caused by magnetic components. The value of magnetizing inductance in an inductor or transformer core does not remain constant over variable current levels, which causes non uniform power losses at different current levels. The method proposed in this work considers a time-variant inductance over various current levels and accordingly establishes a dynamic model of loss estimation. As a proof-of-concept verification, the approach is applied to three different PFC topologies for EV applications and the estimated conversion

efficiencies exhibit good agreement with experimentally obtained efficiency values over a wide range of load power from 400 W to 4.6 kW. The deviation of the efficiency predicted from the experimental data is considerably.

X. Wang, C et al., [5] It is expected that wide-band gap devices like silicon-carbide MOSFETs and gallium-nitride HEMTs could replace Si devices in power electronics converters to reach higher system efficiency. This work adopts the conventional half-bridge LLC topology to realize a 10-kW all-SiC bidirectional charger used in electric vehicles. Though it is a well-known topology for the unidirectional charger, it has not been comprehensively explored for the bidirectional energy flow yet. A double-pulse-test (DPT) platform is utilized to provide accurate power losses. A state-space model is built to obtain accurate switching current waveforms, which is eventually combined with the DPT results to accurately predict the system efficiency. Based on this model, to further enhance the system efficiency, the dc-bus voltage is varied with LLC dc/dc converter running at the resonant frequency through the whole power range. Experimental results validated that the proposed approach could realize the bidirectional power flow. By varying the dc-bus voltage, the V2G and G2V modes reach ~96 % wall-to-battery efficiency.

J. Deng, S. Li et al., [6] In this work, an inductor-inductor-capacitor (LLC) resonant dc-dc converter design procedure for an onboard lithium-ion battery charger of a plug-in hybrid electric vehicle (PHEV) is presented. Unlike traditional resistive load applications, the characteristic of a battery load is nonlinear and highly related to the charging profiles. Based on the features of an LLC converter and the characteristics of the charging profiles, the design considerations are studied thoroughly. The worst-case conditions for primary-side zero-voltage switching (ZVS) operation are analytically identified based on fundamental harmonic approximation when a constant maximum power (CMP) charging profile is implemented. Then, the worst-case operating point is used as the design targeted point to ensure soft-switching operation globally.

Table 1: Summary of Literature Survey

Sr No.	Author Name	Publish Detail	Proposed Work	Outcome
1	R. Kushwaha	IEEE, April 2019	Modified Landsman power factor correction converter.	Charge a 48 V EV battery of 100 Ah capacity
2	M. Gjelaj	IEEE, Nov 2018	New DC fast-charging station	Cost-benefit analysis is performed
3	J. Lu	IEEE, Sept. 2017	Boost-derived continuous conduction mode power factor correction	Load power from 400 W to 4.6 kW.
4	X. Wang	IEEE, Sept. 2016	Double-pulse-test (DPT) platform	V2G and G2V modes reach ~96 % wall-to-battery efficiency
5	J. Deng	IEEE, May 2014	Inductor-inductor-capacitor (LLC) resonant dc-dc converter design	3.3 kW with a peak efficiency of 98.2%.

### III. BARRIERS AND STRATEGIES FOR EV-BATTERY COMMERCIALIZATION

- EV market size as function of performance and cost
- Possible strategies for overcoming commercialization barriers
- Role of and prospects for formation of alliances between automobile manufacturers and developers/suppliers of EV batteries.

All charging systems take AC power from the grid and convert it to DC power at a suitable voltage for charging the battery. In EV applications, except for bicycles, Level 1 and Level 2 chargers are completely contained within the vehicle. In Level 3 charging systems however the charging functions are split between the charging station and the vehicles on board charger.

#### A. Level 1 and Level 2 Chargers

In low power, Level 1 and level 2, applications the power conditioning which includes the AC to DC conversion, the power control unit which delivers a variable DC voltage to the battery, and various filtering functions are all carried out

within the charger and can be implemented at a relatively low cost. The Battery Management System (BMS) is tightly integrated with the battery. It monitors the key battery operating parameters of voltage, current and temperature and controls the charging rate to provide the required constant current / constant voltage (CC/CV) charging profile and it triggers the protection circuits if the battery's operating limits are exceeded, isolating the battery if needed. See more details about BMS functionality on the battery management systems page. The charger will also most likely incorporate CAN Bus functionality to integrate with other vehicle systems but not necessarily with the charging station.

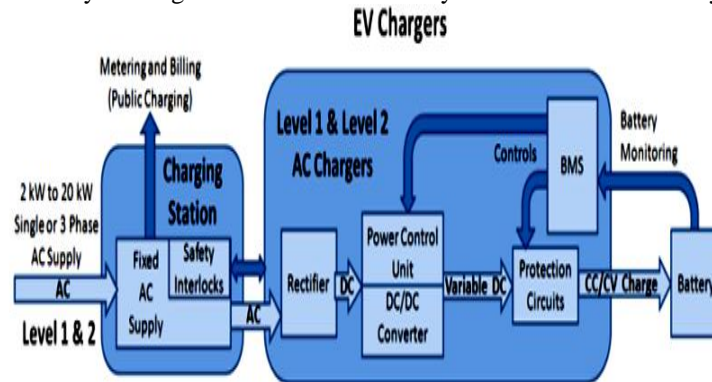


Figure 2: Charging level 1&2

Safety measures in the relatively low power Level 1 charging station are fairly simple and may be limited to a ground fault sensing device and a circuit interrupting device (CID) or "circuit breaker", however the charger itself will usually incorporate more comprehensive safety measures in addition to the standard BMS functions including safety interlocks and isolators to prevent power being connected if there is a fault in the battery or the charger, as well as measures to prevent misuse, electric shocks and inadvertently driving away with the power cord still plugged in.

Level 1 charging works from a single phase AC power outlet and is suitable for private, domestic installations and these do not need authentication and billing.

If the charger is designed to work with public charging stations, as many Level 2 installations will be, it will most likely need to incorporate further intelligence to communicate with the charging station to verify that the user is authorized to draw power from that particular source and to allow it to bill the customer for the energy transferred unless charging is installed at home or as a free service in the workplace or shopping mall.

Level 2 charging stations may use either single phase or three phase AC power from the grid.

### B. Level 3 Chargers

Level 3 chargers have the same functionality as the Level 1 and 2 chargers but with the very high power levels used, the AC/DC conversion and the power conditioning and control circuits become very large and very expensive requiring heavy duty components. It makes sense to carry out these functions in the charging station rather than the charger so that the equipment can be shared by many users. This allows major cost and weight savings in the vehicles on board charger and with a bigger budget for the charging station, more efficient designs may be possible. In this case the BMS must communicate with the charging station to control the voltage and current delivered to the battery since power control is not implemented within the battery. The charging station however does not control how the batteries on the vehicle are charged. That is the function of the charger on the vehicle itself, and its battery management system. The charger provides this control by means of the CAN Bus which communicates its demands to the charging station. Safety functions for isolating the battery and protecting the vehicle's occupants are also managed by the charger and the BMS.

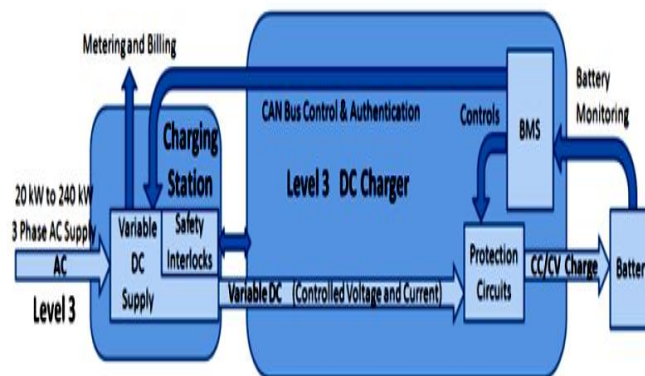


Figure 3: Charging level 3

While putting some of the traditional charger functions into the charging station permits cost savings in the vehicle, the charging station will be correspondingly more expensive. Level 3 charging stations currently cost between \$20,000 and \$50,000. On top of this there is the cost of providing access to the grid. Because of the high power requirements of up to 240 kWatts per station, they can't just be connected to the grid anywhere.

### Characteristics of Electric Vehicle

- Weights (without payload; with representative payload)
- Performance (acceleration, top speed, hill climbing capability)
- Efficiency (kWh consumption for representative driving cycles, with and without space conditioning equipment operating)
- Battery Specifications
- Battery type and weight
- kWh capacity, module capacity, cell size
- Performance (specific energy and energy density at different rates; specific power as function of depth of discharge)
- Charging characteristics (typical kWh consumption for full charge; normal charging rate and efficiency; maximum charging rate; efficiency at maximum rate)
- Thermal characteristics (battery temperature limits for charging and for discharge; cooling and heating requirements and implications for battery weight, volume and cost)
- Control and safety systems
- Reliability and abuse tolerance
- Calendar and cycle life

### IV. CONCLUSION

In this paper studied various level of battery charging concept. This charging level also discuss improve power quality, cost and performance. Lithium-ion EV batteries give good performance and, up to now, high reliability and complete safety in a limited number of EVs. Lithium-metal polymer EV batteries are being developed in two programs aimed at technologies that might cost \$200/kWh or less in volume production. However, these technologies have not yet reached key technical targets, including most notably cycle life, and they are in the pre-prototype cell stage of development. Modified Bridgeless Landsman Converter is also good approach to improve performance. Therefore in future designed and implement efficient converter Fed Electric Vehicle Battery Charger..

#### REFERENCES

- [1] R. Kushwaha and B. Singh, "Power Factor Improvement in Modified Bridgeless Landsman Converter Fed EV Battery Charger," in *IEEE Transactions on Vehicular Technology*, vol. 68, no. 4, pp. 3325-3336, April 2019.
- [2] S. Bharati and M. M. Upadhyay, "Review on Electric Traction Systems Driving Induction Motor and Associated Power Quality Issues", *IJOSCIENCE*, vol. 6, no. 3, pp. 23-26, Mar. 2020. <https://doi.org/10.24113/ijoscience.v6i3.278>
- [3] M. Gjelij, S. Hashemi, C. Traeholt and P. B. Andersen, "Grid integration of DC fast-charging stations for EVs by using modular li-ion batteries," in *IET Generation, Transmission & Distribution*, vol. 12, no. 20, pp. 4368-4376, 13, 11 2018.
- [4] J. Lu, A. Mallik and A. Khaligh, "Dynamic Strategy for Efficiency Estimation in a CCM-Operated Front-End PFC Converter for Electric Vehicle Onboard Charger," in *IEEE Transactions on Transportation Electrification*, vol. 3, no. 3, pp. 545-553, Sept. 2017
- [5] X. Wang, C. Jiang, B. Lei, H. Teng, H. K. Bai and J. L. Kirtley, "Power-Loss Analysis and Efficiency Maximization of a Silicon-Carbide MOSFET-Based Three-Phase 10-kW Bidirectional EV Charger Using Variable-DC-Bus Control," in *IEEE Journal of Emerging and Selected Topics in Power Electronics*, vol. 4, no. 3, pp. 880-892, Sept. 2016.
- [6] J. Deng, S. Li, S. Hu, C. C. Mi and R. Ma, "Design Methodology of LLC Resonant Converters for Electric Vehicle Battery Chargers," in *IEEE Transactions on Vehicular Technology*, vol. 63, no. 4, pp. 1581-1592, May 2014.
- [7] J. Park, M. Kim and S. Choi, "Zero-current switching series loaded resonant converter insensitive to resonant component tolerance for battery charger," in *IET Power Electronics*, vol. 7, no. 10, pp. 2517-2524, 10 2014.
- [8] T. Mishima, K. Akamatsu and M. Nakaoka, "A High Frequency-Link Secondary-Side Phase-Shifted Full-Range Soft-Switching PWM DC-DC Converter With ZCS Active Rectifier for EV Battery Chargers," in *IEEE Transactions on Power Electronics*, vol. 28, no. 12, pp. 5758-5773, Dec. 2013.
- [9] A. Kuperman, U. Levy, J. Goren, A. Zafransky and A. Savernin, "Battery Charger for Electric Vehicle Traction Battery Switch Station," in *IEEE Transactions on Industrial Electronics*, vol. 60, no. 12, pp. 5391-5399, Dec. 2013.
- [10] H. H. Wu, A. Gilchrist, K. D. Sealy and D. Bronson, "A High Efficiency 5 kW Inductive Charger for EVs Using Dual Side Control," in *IEEE Transactions on Industrial Informatics*, vol. 8, no. 3, pp. 585-595, Aug. 2012.
- [11] J. C. Gomez and M. M. Morcos, "Impact of EV battery chargers on the power quality of distribution systems," in *IEEE Transactions on Power Delivery*, vol. 18, no. 3, pp. 975-981, July 2003.
- [12] I. Subotic, N. Bodo and E. Levi, "Single-Phase On-Board Integrated Battery Chargers for EVs Based on Multiphase Machines," in *IEEE Transactions on Power Electronics*, vol. 31, no. 9, pp. 6511-6523, Sept. 2001.