An Efficient Design of Modified Bridgeless Landsman Converter for Electric Vehicle Battery Charger

Anchal Raghuwanshi[1], Amol Barve[2], Nand kishore[3]
M.Tech Scholar, Electrical & Electronics Engineering. LNCT, Bhopal[1]
Associate Professor, Electrical & Electronics Engineering. LNCT, Bhopal[2]
Assistant Professor, Electrical & Electronics Engineering. LNCT, Bhopal[3]

Abstract : This paper deals with the design and implementation of a new charger for battery operated electric vehicle (BEV) with power factor improvement at the frontend. In the proposed configuration, the conventional diode converter at the source end of existing electric vehicle (EV) battery charger is eliminated with modified Landsman power factor correction (PFC) converter. This work deals with the design and implementation of a new charger for battery operated electric vehicle (BEV) with power factor improvement at the frontend. 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.

IndexTerms - Electric vehicle (EV), battery charger, Power, Capacity, Landsman.

I. INTRODUCTION

The charging protocol relies upon the estimate and sort of the battery being charged. Some battery types have high tolerance for overcharging (i.e., kept charging after the battery has been completely energized) and can be revived by association with a constant voltage source or a constant current source, contingent upon battery type. Basic chargers of this sort must be physically disengaged toward the finish of the charge cycle, and some battery types totally require, or may utilize a clock, to cut off charging current at some fixed time, roughly when charging is finished. Other battery types can't withstand over-charging, being harmed (diminished limit, decreased lifetime), over warming or in any event, detonating. The charger may have temperature or voltage detecting circuits and a microchip controller to securely change the charging current and voltage, decide the cut off toward the finish of charge.

A stream charger gives a moderately limited quantity of current, sufficiently just to check self-release of a battery that is inactive for quite a while. Some battery types can't tolerate stream charging of any sort; endeavors to do so may bring about harm. Lithium particle battery cells utilize a science framework which doesn't allow uncertain stream charging.

Slow battery chargers may take a few hours to finish a charge. High-rate chargers may restore most limit a lot faster, yet high rate chargers can be more than some battery types can tolerate. Such batteries require dynamic monitoring of the battery to shield it from overcharging. Electric vehicles in a perfect world need high-rate chargers. For community, establishment of such chargers and the appropriation support for them is an issue in the proposed reception of electric autos.

A decent battery charger gives the base to batteries that are sturdy and perform well. In a value delicate market, chargers frequently get low need and get the "after-thought" status. Battery and charger must go together like a steed and carriage. Judicious arranging gives the power source top need by setting it toward the start of the undertaking as opposed to after the equipment is finished, just like a typical practice. Architects are regularly unconscious of the intricacy including the power source, particularly while charging under unfavorable conditions.

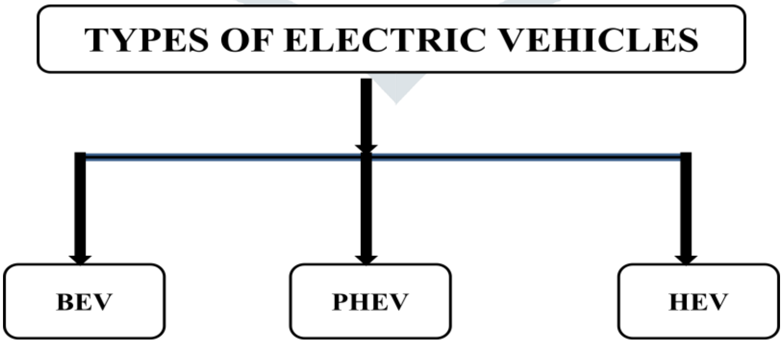

Figure 1: Types of electric vehicles

There are three fundamental kinds of electric vehicles (EVs), classed by the degree that electricity is utilized as their vitality source. BEVs, or battery electric vehicles, PHEVs of plug-in hybrid electric vehicles, and HEVs, or hybrid electric vehicles. Just BEVs are fit for charging on a level 3, DC fast charge.

Chargers give a DC charging voltage from an air conditioner source whether from a typical attachment outlet or all the more as of late from a reason manufactured DC charging station. Most significant are the techniques for controlling the charge and shielding the battery from over-voltage, over-current and over-temperature. These charger capacities are coordinated with and extraordinary to the battery.

Chargers for electric bicycles are generally minimal effort, separate units. To spare weight they are not generally mounted on the bicycle and charging happens at home. Their power dealing with limit is adequate for charging the generally low power bicycle batteries and altogether unacceptable for traveler vehicle applications.
Chargers for traveler autos are ordinarily mounted inside the vehicle. This is on the grounds that the vehicle might be utilized far from home, more distant than the range conceivable from a solitary battery charge. Consequently they need to convey the charger with them on board the vehicle. Charging can be done at home from a standard household electricity attachment outlet yet the accessible power is exceptionally low and charging takes quite a while, potentially ten hours or all the more relying upon the size of the battery. Since charging is generally done medium-term this isn't really an issue, yet it could be if the vehicle is away from its command post. Such low power charging is ordinarily utilized in a crisis and most vehicles are fitted with a higher power charging choice which can be utilized in business areas or with a more powerful household establishment. In numerous nations this more powerful office is executed by methods for a three stage electricity supply.

II. LITERATURE OVERVIEW

R. Kushwaha et al., [1] This work deals with the design and implementation of a new charger for a battery-operated electric vehicle (EV) with power factor improvement at the front end. 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 capacities, under transients in input voltage. The performance of the charger is found satisfactory for all the cases.

M. Gjelaj et al., [2] 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. The proposed solution is shown to reduce not only the installation costs, but also the charging time and it facilitates the integration of fast chargers in existing low-voltage grids. A cost-benefit analysis is performed to evaluate the financial feasibility of BES within the DCFCSs by considering the installation costs, grid connection costs and battery life cycle costs.

A. Taylor et al., [3] As two exemplary candidates of wide-bandgap devices, SiC MOSFET s and GaN HEMT s are regarded as successors of Si devices in medium-to-high-voltage (>1200 V) and low-voltage (<650 V) domains, respectively, thanks to their excellent switching performance and thermal capability. With the introduction of 650 V SiC MOSFETs and GaN HEMTs, the two technologies are in direct competition in <650 V domains, such as Level 2 battery chargers for electric vehicles (EVs). This study applies 650 V SiC and GaN to two 240 VAC/7.2 kW EV battery chargers, respectively, aiming to provide a head-to-head comparison of these two devices in terms of overall efficiency, power density, thermal performance, and cost. The charger essentially is an indirect matrix converter with a dual-active-bridge stage handling the power factor correction and power delivery simultaneously. These two chargers utilise the same control strategy, varying the phase-shift and switching frequency to cover the wide input range (80–260 VAC) and wide output range (200 V–450 VDC). Experimental results indicated that at the same efficiency level, the GaN charger is smaller, more efficient and cheaper, while the SiC charger has a better thermal performance.

M. Truntič et al., [4] This study discusses a converter structure appropriate for charging the batteries of an electric vehicle (EV). The structure is obtained by a transformation of a conventional three-phase inverter, which is already present in an EV's power-train system. Since the motor inverter's semiconductor components and the electric motor's windings form the battery charger's circuit, a reduction in the power-train system's size and weight is achievable. The proposed fully integrated battery charger operates alternately in two modes, buck and boost, while providing power factor (PF) correction capability continuously. This study also proposes an input current control strategy that ensures smooth operating mode transitions, which occur during the operation of a battery charger. The control is entirely implemented within a microcontroller and ensures operation with a high PF and low total harmonic distortion of the input current. The performance of the discussed converter using the proposed control scheme was verified experimentally.

S. Faddel et al., [5] The penetration of electric vehicles (EVs) is expected to increase in the future. With more EVs on the road, more loads will be added to power systems, which will impact the system voltage and loading. This work studies the impact of the EVs on the distribution system and provides an automated controller that satisfies the customer requirements and mitigates the negative impacts of the charging of EVs on the system. The controller takes into consideration the system voltage, the customer requirements, and the state of charge of the battery. The controller is tested using a large-scale distribution system in MATLAB Simulink. It is also validated using a small-scale four-bus experimental system. To show the interaction between local distributed generations (DGs) with the EV charging, the controller is tested in the presence of DG units. The results showed the superior performance of the controller in charging the EVs smoothly and mitigating the negative impacts of the grid.

III. PROPOSED MODEL

- The proposed modified Landsman converter fed battery charger consists of two stages, a modified BL converter for improved input wave-shaping and an isolated converter for the charging of EV battery during constant current (CC) constant voltage (CV) conditions.
- The operation of the modified converter is selected in DCM or CCM mode based on the application requirement of low cost or low device stress, respectively.
- BL converter fed EV battery charger with regulated DC link voltage at an intermediate stage. The input side of the proposed charger is fed by a single phase AC source.

The input DBR is eliminated by two Landsman converters, which operates in parallel during the positive half line and negative half line, separately. Therefore, the conduction losses are reduced to half due to reduced number of components conducting in one switching cycle. For improved performance based switching, two converters, in synchronization

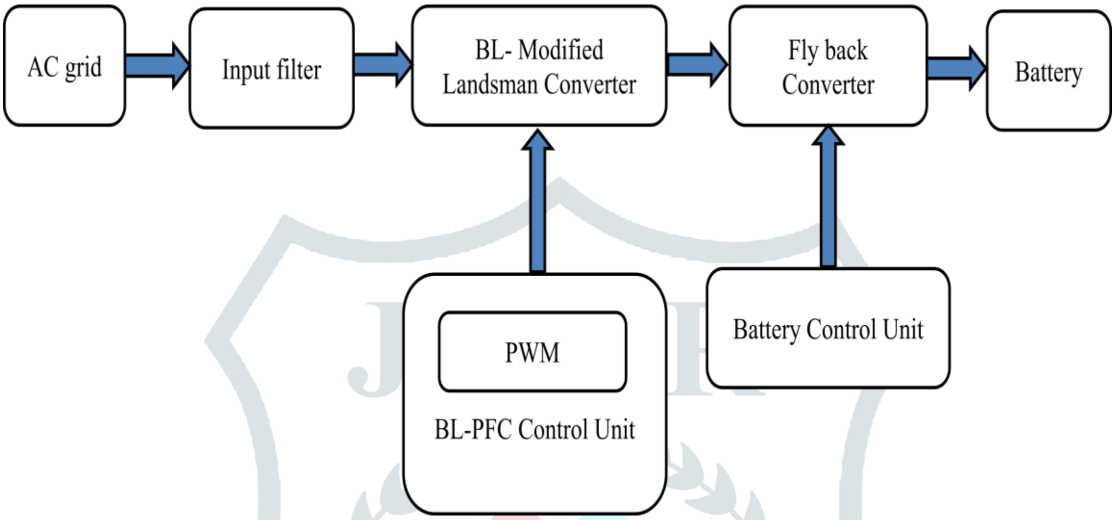

Figure 2: Flow Chart

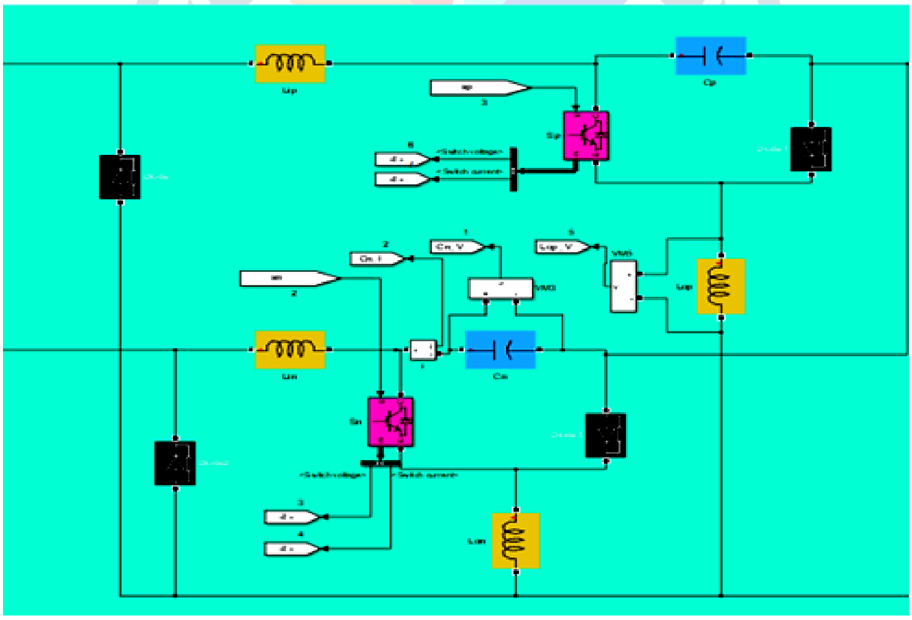

Figure 3: New Landsman Converter

Figure 3 is showing landsman converter circuit. Where Implements a diode in parallel with a series RC snubber circuit. In on-state the Diode model has an internal resistance (Ron) and inductance (Lon).

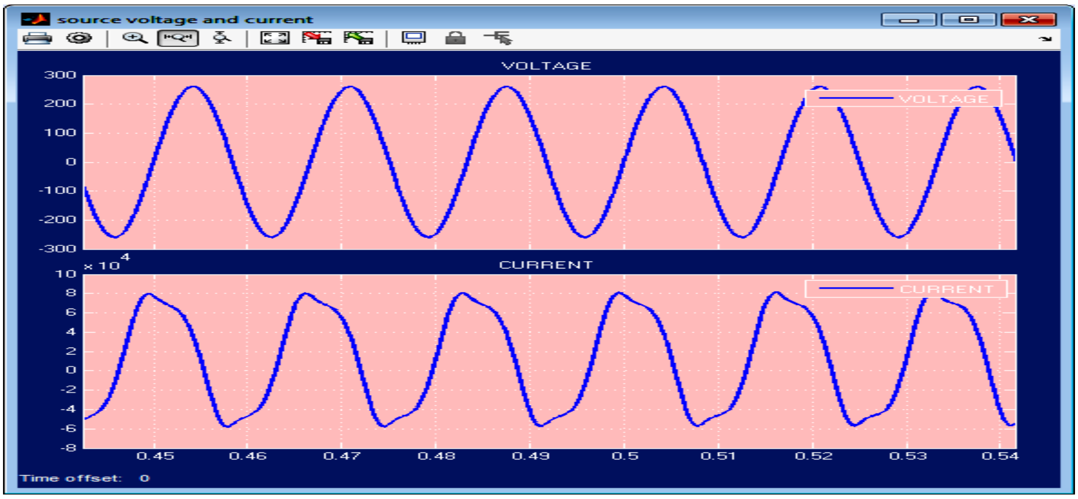

Figure 4: Output of Ac source voltage and current

Figure 4 presents output of source voltage is 260V and 10A current.

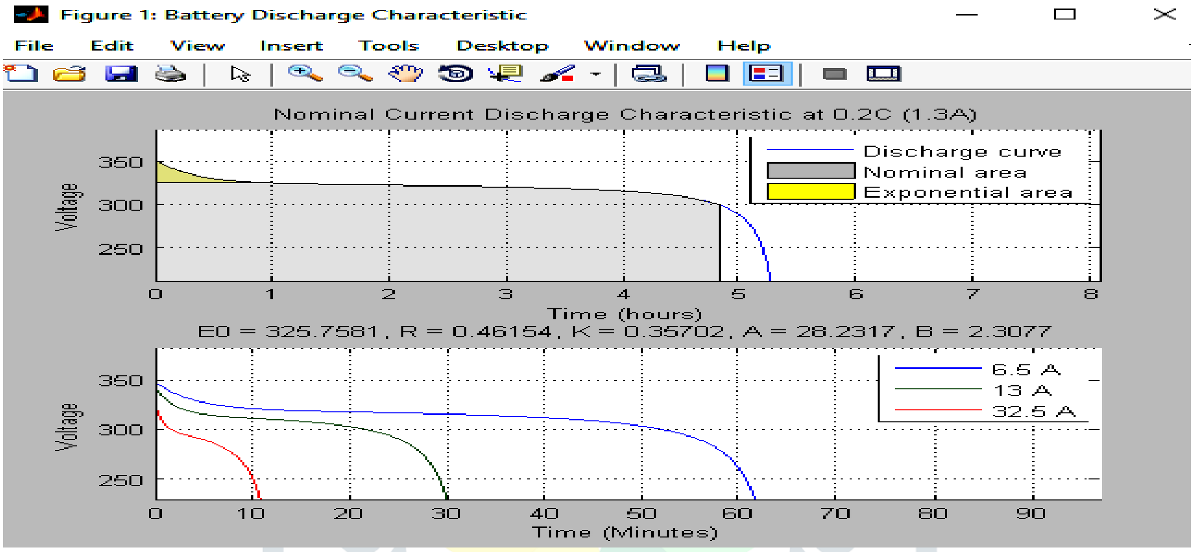

Figure 5: Battery discharge characteristic

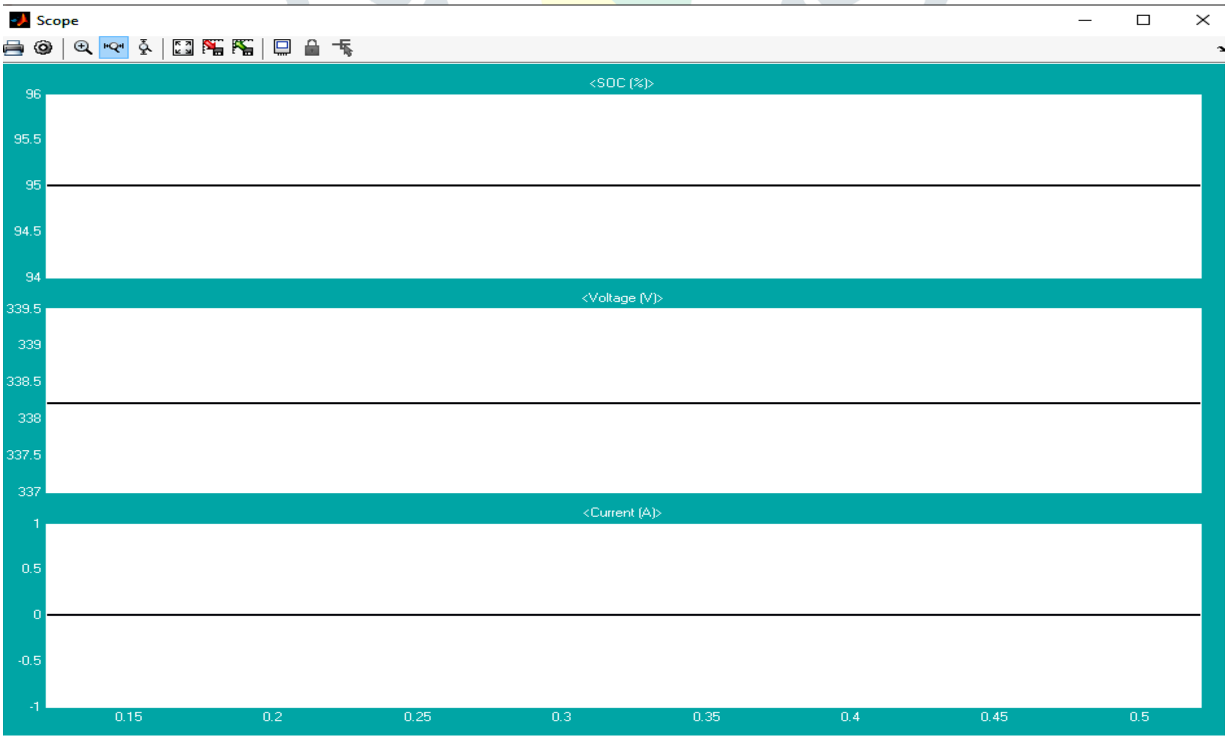

Figure 6: Performance of Battery

Above figure 5 shows nominal current discharge characteristic graph between voltage and time. It is clear that battery discharge at 5.30 Hours. Figure 6 is showing output performance of battery. Here it can be seen that state of charge of battery is 95% and voltage is 338.25V.

Table 1: Comparison of proposed design result with previous design result

Sr No.	Parameter	Previous Model	Proposed Model
1	Number of components	Increased	Constant
2	Control (with PFC)	Voltage Follower	Voltage Follower
3	Control(Battery)	Simple (dual PI)	Simple (dual PI)
4	Losses (with DBR and PFC)	5.88% of total power	5.2% of total power
5	Power density	0.369kW/kg	0.32W/kg
6	Power factor	0.88	0.92
7	Efficiency	91%	95%

Table 1 showing comparison of proposed model results with previous design model results in terms of output voltage, rated power, efficiency, power factor etc. Therefore above result shows, proposed model give significant improved result rather than then the existing model.

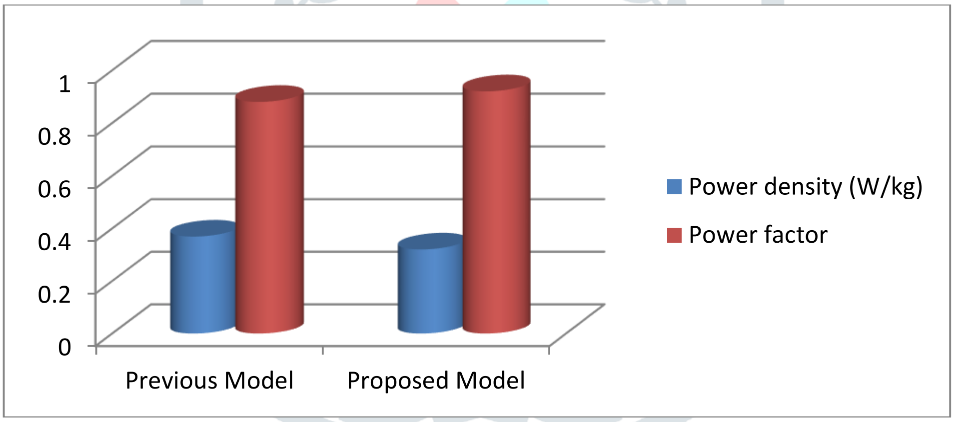

Figure 7: Comparison graph-I

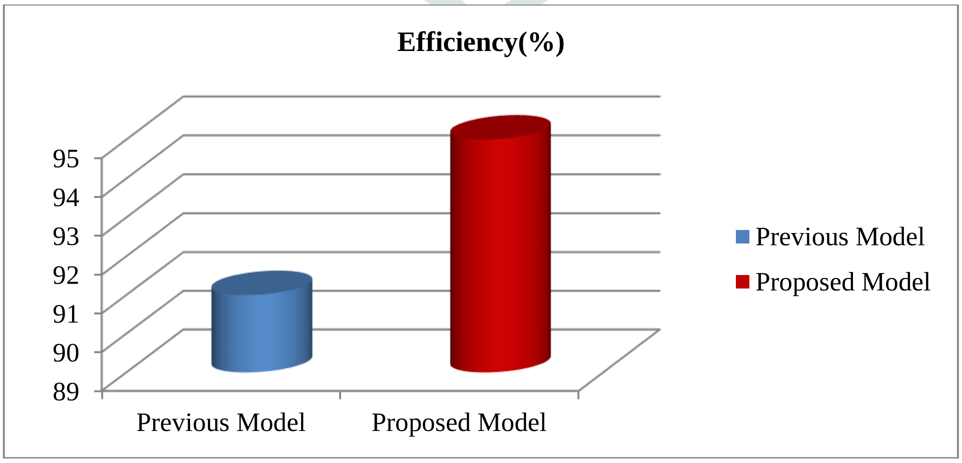

Figure 8: Comparison graph-II

Figure 7 and 8 are showing comparative result graph of efficiency, power density and power factor.

IV. CONCLUSION

An improved EV charger with modified BL Landsman converter followed by a flyback converter has been proposed, analyzed, and validated in this work to charge an EV battery with inherent PF Correction. The design and control of the proposed EV charger in DCM mode have offered the advantage of reduced number of sensors at the output. Moreover, the proposed BL converter has reduced the input and output current ripples due to inductors both in input and output of the converter.

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. M. Gjelaj, 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.
3. A. Taylor, J. Lu, L. Zhu, K. (. Bai, M. McAmmond and A. Brown, "Comparison of SiC MOSFET-based and GaN HEMT-based high-efficiency high-power-density 7.2 kW EV battery chargers," in *IET Power Electronics*, vol. 11, no. 11, pp. 1849-1857, 18 9 2018.
4. M. Truntič, T. Konjedic, M. Milanovič, P. Šlibar and M. Rodič, "Control of integrated single-phase PFC charger for EVs," in *IET Power Electronics*, vol. 11, no. 11, pp. 1804-1812, 18 9 2018.
5. S. Faddel, T. Youssef, A. T. Elsayed and O. A. Mohammed, "An Automated Charger for Large-Scale Adoption of Electric Vehicles," in *IEEE Transactions on Transportation Electrification*, vol. 4, no. 4, pp. 971-984, Dec. 2018.
6. G. Hilton, M. Kiaee, T. Bryden, B. Dimitrov, A. Cruden and A. Mortimer, "A Stochastic Method for Prediction of the Power Demand at High Rate EV Chargers," in *IEEE Transactions on Transportation Electrification*, vol. 4, no. 3, pp. 744-756, Sept. 2018.
7. 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
8. J. Lu *et al.*, "Applying Variable-Switching-Frequency Variable-Phase-Shift Control and E-Mode GaN HEMTs to an Indirect Matrix Converter-Based EV Battery Charger," in *IEEE Transactions on Transportation Electrification*, vol. 3, no. 3, pp. 554-564, Sept. 2017.
9. B. Lee, J. Kim, S. Kim and J. Lee, "An Isolated/Bidirectional PWM Resonant Converter for V2G(H) EV On-Board Charger," in *IEEE Transactions on Vehicular Technology*, vol. 66, no. 9, pp. 7741-7750, Sept. 2017
10. N. Bodo, E. Levi, I. Subotic, J. Espina, L. Empringham and C. M. Johnson, "Efficiency Evaluation of Fully Integrated On-Board EV Battery Chargers With Nine-Phase Machines," in *IEEE Transactions on Energy Conversion*, vol. 32, no. 1, pp. 257-266, March 2017.
11. M. A. Awadallah, B. N. Singh and B. Venkatesh, "Impact of EV Charger Load on Distribution Network Capacity: A Case Study in Toronto," in *Canadian Journal of Electrical and Computer Engineering*, vol. 39, no. 4, pp. 268-273, Fall 2016
12. 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.