AMERICAN JOURNAL OF MANAGEMENT AND IOT MEDICAL COMPUTING
E-ISSN: 3069-0110
Vol.3, No. 1(2024)
www.ajmimc.com

BRIDGELESS BOOST CONVERTER FOR ENHANCED POWER FACTOR IN EV BATTERY CHARGERS

SATHULURI RAMARAO
Department of Electronics and Communication Engineering (ECE)
Chalapati Institute of Technology,AR Nagar, Mothadaka, Andhra Pradesh, India- 522016
Email-id: ramarao409@gmail.com.

ABSTRACT

This study focuses on the design and implementation of a novel topology to enhance the input power factor of electric vehicle (EV) battery chargers. The proposed approach employs a bridgeless power factor correction (PFC) converter instead of a conventional diode-bridge rectifier, reducing losses and improving efficiency. A DC–DC converter follows the PFC stage to control battery charging in both constant voltage (CV) and constant current (CC) modes. With only a single sensing element, the system achieves near-unity input power factor while maintaining a stable DC output voltage, making it cost-effective and simpler to implement. Unlike traditional PFC designs, the proposed topology meets critical PFC requirements without using an inner control loop or phase-locked loop. Key advantages include extended battery life, reduced component stress, improved power quality, lower harmonic distortion in the input current, and reduced current ripple at both input and output.

Index-terms: Bridgeless Boost Converter, Power Factor Correction (PFC), Electric Vehicle Charging, DC–DC Converter, Harmonic Reduction.

1.INTRODUCTION

Power supply networks have experienced disturbances since the late 1800s, with early regulations such as the British Lighting Clauses Act of 1899 addressing flickering caused by uncontrolled arc lamps. The rapid proliferation of electronic devices in the 1970s further highlighted the need to monitor their impact on supply systems. In modern electronics, AC-to-DC rectification circuits are widely used, contributing significantly to harmonic distortion in power systems. While individual devices, such as a television, have low reactive power demand, large numbers of appliances connected to the same phase can generate substantial reactive currents and harmonics.Advances in power electronic converters have made them more compact, lightweight, and efficient, enabling widespread use in residential, commercial, and industrial settings. However, conventional electricity meters often do not measure reactive current, causing discrepancies between billed and actual power. Phase imbalances in three-phase systems can induce neutral currents, leading to conductor heating and potential damage. Additionally, reactive currents distort supply voltage waveforms, creating electromagnetic compatibility (EMC) issues for sensitive equipment.

With increasing demand from high-power, compact devices such as computers, telecom equipment, biomedical instruments, and UPS systems, the industry requires power sources that are smaller, cost-effective, and high in power density. Distributed Power Systems (DPS) have emerged as a solution, evolving from traditional isolated DC–DC architectures to intermediate bus configurations employing non-isolated converters.

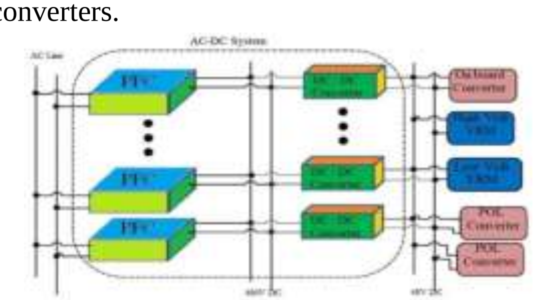

Fig. 1.1: Block Diagram of Basic Distributed Power System

Received: 02-02-2024 | Accepted: 17-03-2024 | Published: 24-03-2024 |

1.1 OBJECTIVE

Electric vehicles (EVs) offer a sustainable solution to reduce environmental pollution, decrease dependence on fossil fuels, and promote green mobility. In recent years, EV adoption has grown significantly due to support from governments, manufacturers, and consumers. Despite their advantages, EVs face challenges that hinder widespread adoption, such as limited battery capacity, which restricts driving range, and insufficient charging infrastructure. Efficient, reliable, and scalable charging systems are critical to accommodate the increasing number of EVs. Addressing these challenges requires advancements in battery charging technologies and power electronics. Among emerging solutions, the Dual Active Bridge (DAB) converter has gained attention in EV charging applications due to its bidirectional operation capability, enabling efficient energy transfer for both charging and vehicle-to-grid scenarios. Continuous research and innovation in such power electronic technologies are essential to enhance EV performance, improve user convenience, and support sustainable transportation systems.

1.2 POWER ELECTRONICS

Power electronics is the field of study focused on using solid-state electronic devices to convert, control, and manage electric power efficiently. Unlike traditional electronics, which primarily handle signal processing and communication, power electronics deals with the rapid, nonlinear, and time-varying control of large amounts of electrical energy.

The evolution of power electronics began with mercury arc valves, followed by the invention of semiconductor switching devices such as transistors and diodes in the 1950s by R.D. Middlebrook and others. These devices remain fundamental in modern power conversion systems. Power electronics components are widely used in consumer electronics, including battery chargers, laptops, and televisions, typically handling power levels from a few watts to several hundred watts. In industrial applications, variable speed drives (VSDs) control induction motors, with output power ranging from a few hundred watts to tens of megawatts. The field combines design, computation, control, and integration of electronic systems to achieve efficient, reliable, and precise energy management across various applications.

2.LITERATURE SURVEY

Bhati et al. (2024) proposed a Y-Cell Modified Boost (YCMB) converter for EV battery chargers with integrated power factor correction (PFC). By transforming the boost network into a Y-cell topology, the design reduces conduction paths and diode losses typical of full-bridge rectifiers. The control strategy maintains sinusoidal input current in phase with the grid voltage, achieving near-unity power factor (PF) across varying loads. Hardware experiments and small-signal modeling demonstrated lower input current ripple, enabling smaller input filters without EMI issues. The YCMB design provides high PF and low total harmonic distortion (THD), making it suitable for compact, high-efficiency onboard EV chargers.

Ramya et al. (2022) introduced a single-stage, bridgeless EV battery charger that combines PFC and DC-link regulation in one boost AC–DC stage. Removing the input diode bridge reduces conduction losses, while enhanced switching strategies improve light-load efficiency and thermal management. Experimental results show improved PF, lower THD, and reduced heat stress on components, making the design ideal for space-constrained vehicle chargers.

Shukla et al. (2023) presented a bridgeless buck-boost–Ćuk hybrid charger with a power-factor-profile-improved front end. The hybrid configuration ensures sinusoidal input current under varying battery and grid conditions, lowering THD without large EMI filters.

Hardware validation confirmed high PF, low harmonic content, and stable efficiency, making it suitable for residential EV charging.

Tseng et al. (2021) proposed an interleaved bridgeless boost converter for PFC. Interleaving reduces input/output current ripple, allows smaller magnetics, and improves thermal management. Experiments demonstrated superior PF, reduced THD, and higher efficiency compared to conventional single-phase bridged topologies, highlighting its effectiveness for high-power onboard chargers.

Lee et al. (2023) developed a digital control algorithm for bridgeless totem-pole PFC (TPPFC) for high-efficiency EV onboard chargers. Using a grid-phase-based approach without complex current loops, the method simplifies implementation on low-cost MCUs/DSPs while maintaining high PF, low THD, and robust dynamic response. The study emphasizes practical considerations such as sensor placement, delay compensation, and digital sampling effects, facilitating reliable, high-density chargers with SiC/GaN devices.

3.PROBLEM STATEMENT

Electric vehicles (EVs) are rapidly gaining popularity due to their environmental and economic benefits. However, the performance and reliability of EVs are heavily dependent on the efficiency and quality of their battery charging systems. Conventional battery chargers typically employ diode-bridge rectifiers, which introduce conduction losses, reactive power, and harmonic distortion in the input current, leading to poor power factor (PF) and reduced energy efficiency. Additionally, maintaining constant voltage (CV) and constant current (CC) charging often requires complex control schemes, increasing system cost and design complexity. These limitations can reduce battery life, increase stress on components, and compromise the overall reliability of EV charging infrastructure. Therefore, there is a need for a simpler, cost-effective, and efficient charging topology that improves power factor, reduces harmonic distortion, and ensures stable and reliable battery charging.

4.PROPOSED MODEL

The proposed model utilizes a bridgeless power factor correction (PFC) converter at the input stage, replacing the conventional diode-bridge rectifier to reduce conduction losses and enhance overall efficiency while maintaining a near-unity input power factor. The PFC stage is followed by a DC–DC converter, which manages battery charging in both constant voltage (CV) and constant current (CC) modes. By employing a single sensing element, the design simplifies control and ensures a stable DC output voltage without requiring an inner control loop or phase-locked loop. This topology offers several advantages, including improved power quality, reduced harmonic distortion in the input current, and minimized current ripple at both input and output. Additionally, it prolongs battery life, reduces stress on components, lowers system cost, and simplifies implementation. Overall, the proposed model provides a compact, efficient, and robust solution for EV battery charging, suitable for both residential and onboard applications.

5.IMPLEMENTATION:

Electric vehicle (EV) battery charging systems require high efficiency and compliance with power quality standards, particularly regarding input current harmonics and power factor. Conventional boost converters often suffer from high voltage stress and limited flexibility in regulating output voltage while maintaining a high power factor. This project presents a SEPIC (Single-Ended Primary Inductor Converter) based bridgeless converter topology for EV battery charging applications, aimed at improving input power factor and reducing conduction losses. The proposed SEPIC converter combines the advantages of continuous input current, reduced voltage stress, and the ability to step up or step down the input

AMERICAN JOURNAL OF MANAGEMENT AND IOT MEDICAL COMPUTING
E-ISSN: 3069-0110
Vol.3, No. 1(2024)
www.ajmimc.com

voltage, making it suitable for varying grid conditions. Simulation and experimental results demonstrate that the bridgeless SEPIC converter achieves high efficiency, low total harmonic distortion (THD), and improved power factor, while maintaining stable and controllable battery charging characteristics. This work provides a practical and efficient solution for modern EV chargers, meeting both energy efficiency and regulatory requirements.

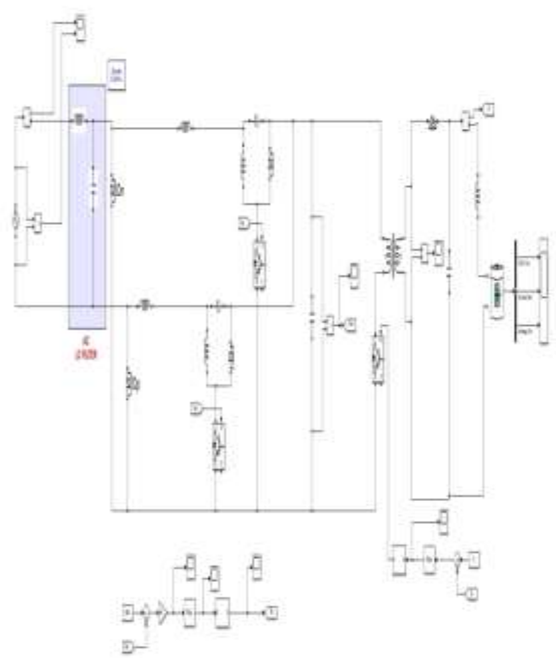

Fig .1 Simulation circuit

6.SIMULATION RESULTS AND DISCUSSION

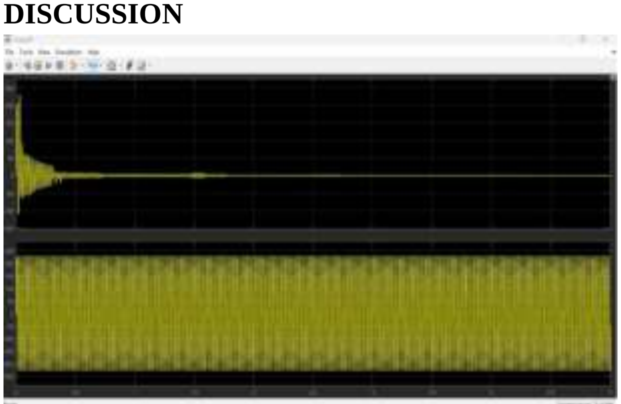

Fig.2. Input voltage and current values

Fig.3. DC link output voltage.

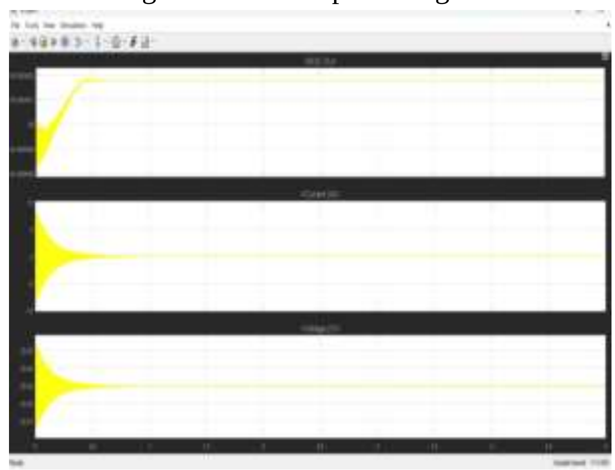

Fig.4. EV battery ratings along with tile.

7.CONCLUSION

This study presented, analyzed, and validated an enhanced power factor correction (PFC) topology for electric vehicle (EV) chargers, aimed at improving battery charging efficiency and overall system performance. The proposed bridgeless (BL) modified PFC charger operates in discontinuous conduction mode (DCM), resulting in a compact design with reduced complexity, lower current ripple, and minimal sensor requirements. Input-side inductors effectively smooth current, enabling fast battery charging while maintaining unity power factor (UPF) and low-frequency operation with negligible distortion. The total harmonic distortion (THD) of the input current was measured at 2.53%, well below the IEC 61000-3-2 standard and lower than comparable BL modified buck–boost topologies. Component values were carefully selected to ensure stable PFC operation across a wide range of input voltages, providing reliable performance under

Received: 02-02-2024 | Accepted: 17-03-2024 | Published: 24-03-2024 |

varying conditions. Overall, the proposed topology demonstrates a practical, efficient, and robust solution for EV battery charging, combining improved power quality, reduced harmonic distortion, and reliable operation for both residential and onboard applications.

8.FUTURE SCOPE

The proposed bridgeless (BL) modified PFC charger provides a robust foundation for further advancements in EV charging technology. Future work can focus on integration with renewable energy sources, such as solar or wind, enabling eco-friendly and grid-independent charging solutions. Bidirectional operation can be implemented to support vehicle-to-grid (V2G) applications, allowing EVs to feed energy back to the grid during peak demand. Advanced control techniques, including artificial intelligence (AI) or adaptive digital controllers, can enhance dynamic response, optimize efficiency under varying load conditions, and further reduce harmonic distortion. Miniaturization of components and the use of wide-bandgap semiconductors like SiC or GaN can improve power density and thermal performance. Additionally, multi-output or modular architectures can enable simultaneous charging of multiple batteries or integration into smart microgrid systems. These developments would make EV charging faster, more efficient, scalable, and compatible with future sustainable energy infrastructures.

9.REFERENCES

[1] K. V. Suhaskrishnan, V. Sruthy, and P. K. Preetha, “Smart grid compatible universal electric vehicle charging outlet to boost India’s EV penetration rate,” in Proc. IEEE 19th India Council Int. Conf., 2022, pp. 1–6.

[2] Limits for Harmonics Current Emissions (Equipment Current 16 A Per Phase), IEC Standard IEC 61000-3-2, 2000.

[3] IEEE Standard for Harmonic Control in Electric Power Systems, IEEE Standard 519-2022 (Revision of IEEE Standard 519-2014), Aug. 2022.

[4] D. Patil and V. Agarwal, “Compact onboard single-phase EV battery charger with novel low-frequency ripple compensator and optimum filter design,” IEEE Trans. Veh. Technol., vol. 65, no. 4, pp. 1948–1956, Apr. 2016.

[5] J.-H. Kim, C.-E. Kim, J.-K. Kim, J.-B. Lee, and G.-W. Moon, “Analysis on load-adaptive phase-shift control for high-efficiency full-bridge LLC resonant converter under light-load conditions,” IEEE Trans. Power Electron., vol. 31, no. 7, pp. 4942–4955, Jul. 2016.

[6] S. Sun, J. Fu, and L. Wei, “Optimization of high-efficiency half-bridge LLC resonant converter,” in Proc. 40th Chin. Control Conf., 2021, pp. 5922–5926.

[7] C. Shi, H. Wang, S. Dusmez, and A. Khaligh, “A SiC-based high efficiency isolated onboard PEV charger with ultrawide DC-link voltage range,” IEEE Trans. Ind. Appl., vol. 53, no. 1, pp. 501–511, Jan./Feb. 2017.

[8] C. Shi, Y. Tang, and A. Khaligh, “A single-phase integrated onboard battery charger using propulsion system for plug-in electric vehicles,” IEEE Trans. Veh. Technol., vol. 66, no. 12, pp. 10899–10910, Dec. 2017.

[9] T. P. Pandhi, A. S. Jain, and T. N. Dote, “An approach for power factor correction of single-phase single-stage three-level AC-DC converter with phase shift modulation,” in Proc. Int. Conf. Adv. Commun. Comput. Technol., 2018, pp. 487–491.

[10] S. Maneesh Kumar Prodduturi, “Leveraging Big Data And Business Intelligence To Revolutionise Corporate Strategy,” International Journal for Research Trends and Innovation, vol. 8, no. 7, 2023, doi: 10.56975/ijrti.v8i7.207667.

[11] K. S. B. Muhammad and D. D. C. Lu, “ZCS bridgeless boost PFC rectifier using only two active switches,” IEEE Trans. Ind. Electron., vol. 62, no. 5, pp. 2795–2806, May 2015.

[12] M. Alanz, W. Eberle, S. G. Deepak, C. Botting, N. Dehancier, and F. Musavi, “A hybrid

resonant pulse-width modulation bridgeless AC-DC power factor correction converter," IEEE Trans. Ind. Appl., vol. 53, no. 2, pp. 1406–1415, Mar./Apr. 2017.

[13] S. Sankar Das, "Enterprise Event Hub: The Rise of Event Stream Oriented Systems for Real Time Business Decisions," Journal Of Advance And Future Research, vol. 1, no. 10, Dec. 2023, doi: 10.56975/jaafr.v1i10.500878.

[14] A. Molshitzky, F. Albuquerque, E. Agostini, and B. N. Claudinor, "Single-stage integrated bridgeless-boost resonant half-bridge converter for led driver applications," IEEE Trans. Ind. Electron., vol. 65, no. 5, pp. 3866–3878, May 2018.

[15] H. Wu, T. Mu, H. Ge, and Y. Xing, "Full-range soft-switching-isolated buck-boost converters with integrated interleaved boost converter and phase-shifted control," IEEE Trans. Power Electron., vol. 31, no. 2, pp. 987–999, Feb. 2016.

[16] N. Naga Charan, "Predictive Sql Injection Detection And Prevention Using Machine Learning Across Aws, Azure, And Google Cloud Platforms," International Journal of Engineering Science and Advanced Technology, vol. 22, no. 8, pp. 68–74, Aug. 2022, doi: 10.64771/ijesat.2022.v22.i08.pp68-74.

[17] B. Singh and V. Bist, "A BL-CSC converter-fed BLDC motor drive with power factor correction," IEEE Trans. Ind. Electron., vol. 62, no. 1, pp. 172–183, Jan. 2015.

[18] H.-T. Yang, H.-W. Chiang, and C.-Y. Chen, "Implementation of bridgeless Cuk power factor corrector with positive output voltage," IEEE Trans. Ind. Electron., vol. 31, no. 4, pp. 3325–3333, Aug. 2015.

[19] J. P. R. Balestero, F. L. Tofoli, R. C. Fernandes, G. V. Torrico-Bascope, and J. Mendez de Seixas, "Power factor correction boost converter based on the three-state switching cell," IEEE Trans. Ind. Electron., vol. 59, no. 3, pp. 1565–1577, Mar. 2012.

[20] P. J. S. Costa, T. B. Lazzarin, and C. H. I. Font, "Hybrid bridgeless DCM SEPIC rectifier integrated with a modified switched capacitor cell," in Proc. IEEE Appl. Power Electron. Conf. Expo., 2016, pp. 2376–2381, doi: 10.1109/APEC.2016.7463158.

Received: 02-02-2024 | Accepted: 17-03-2024 | Published: 24-03-2024 |