# FUZZY LOGIC-CONTROLLED BRIDGELESS SINGLE-STAGE CONVERTER FOR TRANSFORMER-LESS EV CHARGING SYSTEM WITH ENHANCED POWER QUALITY

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## ABSTRACT

With the increasing penetration of electric mobility, the development of efficient, reliable, and power-quality-enhanced charging systems for light electric vehicles (LEVs) has become essential. This project presents a transformer-less bridgeless single-stage converter for electric vehicle (EV) charging applications using fuzzy logic control to achieve high efficiency and improved power quality. The proposed topology integrates power factor correction (PFC) and DC–DC conversion into a single stage, thereby reducing component count, size, and overall cost. By eliminating the conventional front-end diode bridge, the charger significantly reduces conduction losses and enhances performance under varying grid and load conditions. The system operates in discontinuous conduction mode (DCM), which minimizes control complexity and sensor requirements. A fuzzy logic controller (FLC) optimizes dynamic response and voltage regulation while maintaining constant-current (CC) and constant-voltage (CV) charging modes. Simulation and hardware results validate that the proposed charger achieves reduced total harmonic distortion (THD), near-unity power factor, and higher overall efficiency compared to conventional two-stage and transformer-based systems. This solution offers a cost-effective and compact charging alternative for modern LEVs such as e-bikes, e-scooters, and e-rickshaws.

**Keywords**: Transformer-less charger, Bridgeless converter, Fuzzy Logic Controller (FLC), Power Factor Correction (PFC), Total Harmonic Distortion (THD), Light Electric Vehicle (LEV), Discontinuous Conduction Mode (DCM).

## INTRODUCTION

The rapid expansion of the electric vehicle (EV) industry has led to an urgent need for compact, efficient, and power-quality-compliant charging solutions. Among these, light electric vehicles (LEVs), such as e-bikes and e-rickshaws, have become prominent due to their cost-effectiveness, reduced emissions, and suitability for short-distance commuting. However, the design of efficient chargers for these vehicles remains a technical challenge, as traditional two-stage topologies involving a diode bridge rectifier (DBR) followed by a DC–DC converter suffer from significant power losses, harmonic distortion, and poor power factor [1]. The inclusion of a heavy DC-link capacitor in conventional chargers leads to a highly distorted current waveform that degrades grid-side performance and increases total harmonic distortion (THD) [2]. To overcome these limitations, active power factor correction (APFC) techniques have been adopted to ensure sinusoidal current draw and near-unity power factor [3]. In conventional APFC-based designs, the two-stage approach uses separate converters for power factor correction and DC–DC regulation, resulting in increased component count, control complexity, and switching losses [4]. Conversely, a single-stage charger combines both functions, improving efficiency and reducing circuit size. However, the efficiency of traditional single-stage converters is still limited by the conduction losses associated with the front-end DBR [5]. To address this issue, bridgeless topologies have been introduced, eliminating the diode bridge and thereby minimizing power loss [6]. The bridgeless single-stage topology not only reduces conduction losses but also simplifies the control structure and enhances efficiency, especially for low-power LEV applications [7].

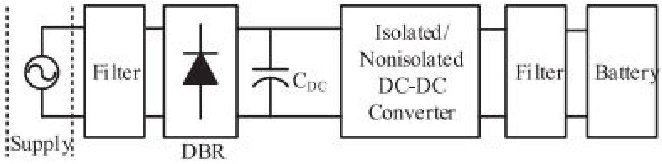


Fig 1. Structure of conventional charger configurations for LEVs.

Transformers in EV chargers provide galvanic isolation but increase cost, volume, and weight. Moreover, transformer-based topologies introduce leakage inductance, which results in additional voltage stress across switching devices [8]. The transformer-less approach eliminates these drawbacks, making the charger more compact and energy-efficient [9]. Among various converter configurations, buck–boost–derived topologies such as Cuk, SEPIC, Zeta, and Luo converters are popular due to their bidirectional voltage conversion capabilities [10]. The Cuk converter, in particular, is preferred for its ability to provide low input and output current ripples, making it an ideal candidate for LEV chargers. However, the conventional Cuk converter's limited gain restricts its application in transformer-less high-gain scenarios [11].

Recent advancements in switched-inductor (SI) and switched-capacitor (SC) technologies have provided effective solutions to enhance voltage gain without adding complex magnetics [12]. The Bridgeless Switched Inductor Cuk (BSIC) converter is one such topology that integrates the advantages of Cuk converters with switched-inductor techniques, providing high voltage gain, reduced conduction losses, and minimal current distortion [13]. The BSIC converter also facilitates discontinuous conduction mode (DCM) operation, reducing sensor requirements and control effort while maintaining excellent power quality [14]. The integration of intelligent control algorithms further enhances system performance. Traditional proportional-integral (PI) controllers are often insufficient in handling nonlinearities and variations in grid and load conditions. In this context, fuzzy logic control (FLC) provides a robust alternative, offering adaptive regulation without requiring an exact mathematical model of the system [15]. This project explores a fuzzy logic-controlled bridgeless single-stage transformer-less converter-based charger for LEVs that achieves improved power factor, low THD, and high efficiency under variable conditions, making it suitable for next-generation EV infrastructure.

**LITERATURE SURVEY**

In recent years, electric vehicle (EV) charging systems have undergone rapid technological advancement due to the global shift toward sustainable and eco-friendly transportation. To improve energy efficiency and maintain power quality at the grid interface, numerous studies have focused on developing single-stage, transformer-less, and bridgeless power factor correction (PFC) converter topologies. A comprehensive understanding of existing work on power factor correction techniques, transformer-less designs, and intelligent control strategies forms the foundation of this research. Gupta, Kushwaha, and Singh [1] proposed an improved power quality transformer-less single-stage bridgeless converter-based charger for light electric vehicles (LEVs). Their study demonstrated that conventional chargers employing diode bridge rectifiers (DBRs) and DC-link capacitors cause severe harmonic distortion and poor power factor at the supply side. The researchers developed a single-stage bridgeless converter capable of integrating power factor correction and DC–DC conversion functions simultaneously. This approach effectively reduced conduction losses, minimized switching stresses, and improved overall system efficiency. Similarly, Ananthapadmanabha, Maurya, and Arya [2] discussed the design of switched inductor Cuk converters for transformer-less LEV chargers, showing that these topologies provide high voltage gain and superior efficiency without increasing component count.

Pandey and Singh [3] explored a power-factor-corrected LLC resonant converter for EV chargers that uses a Cuk-based approach. Their work concluded that single-stage PFC chargers provide better efficiency and compactness than traditional two-stage chargers. The LLC resonant converter achieved high efficiency but involved complex control techniques and higher component stress. To simplify control, Dixit et al. [4] proposed a discontinuous current mode (DCM)-based bridgeless converter that achieved excellent power factor correction while reducing inductor size and sensor requirements. DCM operation also eliminated the need for a phase-locked loop (PLL), simplifying the control implementation. Chen, Davari, and Wang [5] benchmarked various single-phase bridgeless topologies and concluded that eliminating the diode bridge rectifier significantly enhances system performance.

They observed that bridgeless PFC topologies exhibit lower conduction and switching losses, better dynamic response, and higher efficiency across varying load conditions. Arya and Singh [6] designed an interleaved SEPIC converter-based charger to reduce input current ripple and improve power factor, while Khan et al. [7] introduced a switched-capacitor SEPIC converter to further enhance voltage gain in transformer-less applications. These designs offered efficient energy transfer and minimized total harmonic distortion (THD), demonstrating the importance of bridgeless and transformer-less topologies in achieving high power quality.

The significance of DCM operation in EV chargers was emphasized by Al-Haddad et al. [8], who demonstrated that DCM not only improves power factor but also reduces harmonic distortion by allowing the input current to follow the supply voltage waveform naturally. Liu and Zhang [9] explored integrated on-board charger designs using bridgeless topologies, highlighting the trend toward compact, lightweight, and high-efficiency systems. They pointed out that minimizing passive components and removing bulky transformers is critical for modern LEV designs.

Control strategies play a vital role in ensuring stable and efficient operation of PFC-based chargers. Traditional proportional-integral (PI) controllers, though widely used, struggle with nonlinear system dynamics and changing load conditions. Kushwaha and Bansal [10] proposed a fuzzy logic-controlled bridgeless converter that demonstrated superior performance compared to PI-based systems, particularly in handling dynamic load variations and grid disturbances. Maurya et al. [11] also analyzed switched-inductor Cuk converters and proved that integrating fuzzy control improves transient response and reduces steady-state error. The application of artificial intelligence in power electronics has gained momentum in recent years. Akter and Islam [12] discussed the role of fuzzy logic controllers (FLCs) in power conversion systems, highlighting their adaptability and robustness in uncertain operating environments. Fuzzy controllers process linguistic variables and decision rules instead of mathematical equations, making them ideal for nonlinear converter systems. Nanda and Ghosh [13] studied intelligent control algorithms, including fuzzy and neural network-based approaches, for EV battery charging applications. Their findings revealed that such controllers can effectively manage charging current and voltage, prevent overcharging, and maintain optimal power factor.

Bhattacharya et al. [14] presented a comparative study between PI and fuzzy controllers in power converters and found that FLC-based systems provide smoother responses, reduced overshoot, and better steady-state accuracy. Moreover, the fuzzy approach minimizes THD and enhances converter stability during grid voltage disturbances. Rathore et al. [15] conducted an extensive performance evaluation of bridgeless and conventional converters, concluding that bridgeless single-stage configurations outperform their traditional counterparts by achieving higher efficiency, compact design, and superior power quality. From the literature, it is evident that researchers have increasingly shifted toward developing single-stage, bridgeless, and transformer-less converters for LEV charging applications. The main focus has been on reducing harmonic distortion, improving power factor, minimizing component count, and achieving high efficiency under varying supply conditions. Moreover, incorporating fuzzy logic-based control provides an intelligent and flexible solution capable of handling nonlinearities inherent in converter operations. The reviewed works collectively demonstrate that the integration of a fuzzy logic controller with a bridgeless single-stage converter represents a significant step toward developing compact, efficient, and high-performance EV charging systems.

## METHODOLOGY

The methodology adopted for developing the fuzzy logic-controlled bridgeless single-stage converter for a transformer-less EV charging system is based on a systematic design, modeling, and testing process. The complete approach integrates circuit design, control implementation, simulation, and experimental validation to achieve a compact, efficient, and power-quality-improved charger for light electric vehicles (LEVs).

The design process begins with the selection of an appropriate converter topology. Among various DC–DC converters such as buck, boost, SEPIC, and Cuk, the Cuk topology is identified as most suitable because it offers continuous current at both the input and output sides and provides better ripple characteristics. However, a conventional Cuk converter has limited voltage gain and relatively high conduction losses when used in transformer-less systems. To address this limitation, a modified configuration known as the Bridgeless Switched Inductor Cuk (BSIC) converter is chosen. The BSIC topology enhances the voltage gain capability by integrating a switched inductor network that performs series charging and parallel discharging, effectively increasing the step-down ratio without requiring a transformer. The bridgeless structure eliminates the diode bridge rectifier (DBR) present at the front end of conventional chargers, reducing conduction losses and improving efficiency.

The system is designed to operate in a single-stage configuration, where power factor correction (PFC) and DC–DC conversion functions are performed simultaneously. This reduces the total number of components, lowers switching losses, and simplifies the control system. The bridgeless topology allows each semiconductor device to conduct for only half of the AC cycle, thereby reducing total conduction losses and improving thermal performance. The input side consists of an AC source (230 V, 50 Hz), which is directly connected to the converter without a transformer, while the output side is connected to a 48 V, 100 Ah battery pack used for light electric vehicles such as e-bikes and e-rickshaws.

The proposed converter operates in discontinuous conduction mode (DCM), a technique that provides several advantages, including reduced control complexity, smaller magnetic component size, and elimination of current sensors on the input side. In DCM operation, the current through the inductors falls to zero before the next switching cycle begins. This feature naturally ensures power factor correction, as the input current waveform follows the input voltage shape, leading to a near-unity power factor and reduced total harmonic distortion (THD). The operation of the charger within one switching cycle can be divided into three distinct modes: the energy storage mode, the energy transfer mode, and the freewheeling mode. During the energy storage phase, both switches conduct simultaneously, allowing the inductors to store energy. In the energy transfer phase, the switches are turned off, and the stored energy is transferred to the output through diodes. Finally, in the freewheeling phase, the energy flow ceases, and the inductors discharge completely before the next switching cycle begins.

Component design plays a crucial role in achieving efficient operation and desired performance. The design is based on a maximum power rating of 850 W, with an input voltage range of 130–260 V and an output voltage range of 45–65 V. The input inductor (Li) and output inductors (Lo1 and Lo2) are carefully selected to ensure continuous current mode at the input and discontinuous current mode at the output. The values of Lo1 and Lo2 are chosen as 40 μH to maintain DCM operation throughout the charging range, while the input inductor Li is designed as 6 mH to guarantee smooth current flow and filter out supply harmonics. The intermediate capacitor C1 is selected as 0.94 μF, providing stable energy transfer between the input and output stages, and the DC-link capacitor CDC is chosen as 11.75 mF to maintain voltage stability with less than 3% ripple.

The control of the converter is achieved using a fuzzy logic controller (FLC) implemented through MATLAB/Simulink and a Texas Instruments TMS320F28377S digital signal processor (DSP). The fuzzy controller is designed to handle nonlinearities and parameter variations that commonly occur in practical charging systems. It uses two input variables—error (E) and change in error (ΔE)—derived from the difference between the reference and actual battery voltage and current values. The FLC processes these input variables through three main stages: fuzzification, inference, and defuzzification. In the fuzzification stage, the numerical inputs are converted into linguistic variables represented by fuzzy sets such as “Low,” “Medium,” and “High.” The inference stage applies a set of rule-based decisions derived from expert knowledge to determine the control action. Finally, the defuzzification process converts the fuzzy output into a precise control signal that modulates the converter’s switching duty cycle.

The FLC continuously monitors the state of the system and adjusts the pulse width modulation (PWM) signals applied to the switches to maintain the desired output voltage and current. The control structure follows a dual-loop configuration consisting of an inner current control loop and an outer voltage control loop. The outer loop regulates the output voltage, ensuring the battery charges within safe limits, while the inner loop controls the charging current, maintaining a smooth transition between constant-current (CC) and constant-voltage (CV) charging modes. The fuzzy logic approach provides robust performance against disturbances, compensates for nonlinearities, and eliminates the need for precise mathematical modeling.

Simulation of the entire system is conducted in MATLAB/Simulink to evaluate its performance under various operating conditions. The simulation models include all passive and active components, as well as the fuzzy control algorithm. The results demonstrate that the fuzzy-controlled converter maintains stable operation with fast transient response, low overshoot, and minimal steady-state error. The THD in the supply current remains below

3.5%, and the input power factor approaches unity, confirming the effectiveness of the PFC mechanism inherent in the topology. The efficiency of the converter exceeds 94%, even under variable input voltage and load conditions.

After simulation verification, a hardware prototype is developed to experimentally validate the design. The prototype uses MOSFET-based switches for high-frequency operation, diodes with low forward voltage drops for reduced conduction loss, and digital control through the TI DSP module. The experimental setup includes voltage and current sensors, a programmable AC source, and a battery emulator for safe testing. Various test cases, such as input voltage variation, dynamic load changes, and transient disturbances, are conducted to analyze performance consistency. The experimental results closely match the simulation outcomes, confirming the feasibility and effectiveness of the proposed design.

The methodology thus ensures that every stage—from conceptual design to hardware testing—contributes to achieving the primary objectives of this project: high efficiency, improved power factor, reduced harmonic distortion, and reliable charging performance. The bridgeless single-stage topology minimizes losses and size, while the fuzzy logic controller ensures intelligent and adaptive control. The combination of these two innovations provides a robust, compact, and cost-effective charging solution suitable for modern light electric vehicle applications.

**PROPOSED SYSTEM**

The proposed system is designed to provide an efficient, compact, and power-quality-enhanced solution for charging light electric vehicles (LEVs) such as e-bikes, e-rickshaws, and e-scooters. The concept revolves around integrating a bridgeless single-stage converter with a fuzzy logic control (FLC) strategy, eliminating the need for both a front-end diode bridge and a bulky transformer. This approach achieves superior power factor correction (PFC), reduced total harmonic distortion (THD), and improved system efficiency compared to traditional two-stage isolated charger systems. The architecture of the proposed charger consists of an AC supply input, a bridgeless switched inductor Cuk (BSIC) converter, a fuzzy logic controller, and a DC output stage connected to a 48 V, 100 Ah battery. The AC input voltage, typically ranging from 130 V to 260 V, is directly fed to the bridgeless converter without passing through a transformer. The absence of the transformer reduces system volume, weight, and losses associated with magnetic isolation while maintaining electrical safety through appropriate grounding and insulation. The bridgeless structure operates in such a way that during each half cycle of the input AC voltage, one leg of the converter becomes active while the other remains inactive. This alternation of conduction paths results in reduced conduction losses since current passes through fewer semiconductor devices per cycle.

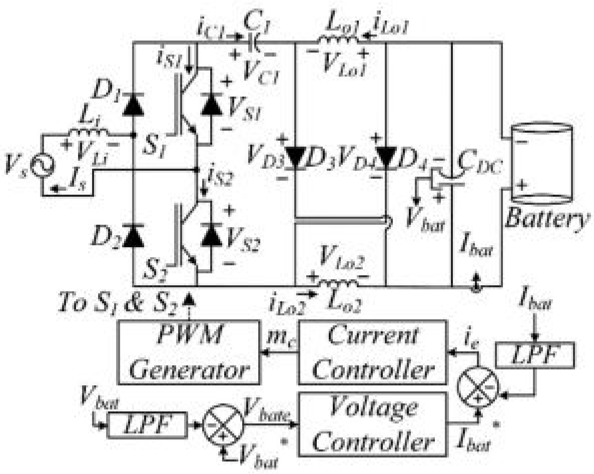


Fig 2. BSIC PFC converter based transformerless charger configuration.

The proposed BSIC converter topology consists of two power switches (S1 and S2), two diodes (D1 and D2), two inductors (Lo1 and Lo2), and an input inductor (Li). The switches operate complementarily such that during the positive half cycle of the AC input, switch S1 and diode D2 conduct, while during the negative half cycle, switch S2 and diode D1 conduct. This alternating pattern effectively replaces the conventional diode bridge rectifier, enabling a more efficient power conversion process. The switched inductor network, formed by Lo1, Lo2, D3, and D4, plays a key role in enhancing the voltage gain of the converter. During the ON state of the switches, the inductors are charged in parallel, while during the OFF state, they discharge in series into the load. This parallel charging and series discharging action increases the effective output voltage, providing a higher voltage conversion ratio without the use of a transformer.The system operates in discontinuous conduction mode (DCM), which simplifies control and ensures natural power factor correction. In DCM operation, the current in the inductors falls to zero before the start of the next switching cycle. This mode of operation allows the input current to naturally follow the shape of the input voltage waveform, achieving near-unity power factor without the need for complex current sensing or feedback circuitry. Additionally, DCM operation permits smaller magnetic components and eliminates reverse recovery losses in diodes, further improving system efficiency.

The control strategy of the proposed system is based on a fuzzy logic controller (FLC). Fuzzy control is chosen over traditional proportional-integral (PI) control because of its ability to handle nonlinearities and uncertainties in converter dynamics without requiring an exact mathematical model. The FLC processes two main input variables: the voltage error (E), defined as the difference between the reference and actual output voltage, and the change in error (ΔE), representing the variation of error between successive sampling intervals. These inputs are passed through fuzzification, inference, and defuzzification stages to generate an appropriate control signal that regulates the converter's switching duty cycle. In the fuzzification stage, the crisp input variables E and ΔE are converted into fuzzy linguistic variables using predefined membership functions, typically categorized as Negative Big (NB), Negative Small (NS), Zero (ZE), Positive Small (PS), and Positive Big (PB). The inference engine then applies a set of fuzzy rules, typically designed based on expert knowledge of system behavior. For example, if the voltage error is Positive Big and the change in error is Positive Small, the controller reduces the duty ratio to prevent overshoot. Conversely, if the voltage error is Negative Big, the controller increases the duty ratio to boost the output voltage. The defuzzification stage converts the fuzzy output back into a crisp control signal, which is used to modulate the pulse width modulation (PWM) signals driving the converter switches. This adaptive control technique allows the charger to respond quickly to variations in load, input voltage fluctuations, and battery state-of-charge (SOC).

The fuzzy logic controller ensures stable operation in both constant-current (CC) and constant-voltage (CV) charging modes. During the initial phase of battery charging, the CC mode maintains a steady current flow until the battery voltage reaches its threshold value. Once the threshold is attained, the controller automatically transitions to CV mode, maintaining a constant voltage while the current gradually decreases to prevent overcharging. The transition between these two charging stages is smooth and fully automated, ensuring maximum battery life and safety. The design of passive components such as inductors and capacitors is critical for achieving the desired power conversion performance. The input inductor (Li) is selected to maintain a continuous current, reducing input current ripple and filtering harmonics. The output inductors (Lo1 and Lo2) are designed to ensure DCM operation for proper energy transfer and high power factor. The intermediate capacitor (C1) and DC-link capacitor (CDC) are designed to store sufficient energy and minimize voltage ripple across the output terminals. Proper component selection also ensures that the converter can handle dynamic load conditions without oscillations or instability.

The simulation of the proposed system is carried out in MATLAB/Simulink. The model includes accurate representations of the converter components, the fuzzy controller, and the battery load. Simulation results confirm that the fuzzy-controlled bridgeless single-stage converter achieves excellent voltage and current regulation with minimal overshoot, fast transient response, and stable operation under variable load and input conditions. The input current waveform is nearly sinusoidal, demonstrating effective power factor correction. The THD of the input current is reduced to below 3.5%, which meets IEEE 519 standards for harmonic control. Additionally, the overall system efficiency exceeds 94%, representing a substantial improvement compared to conventional two-stage chargers. A hardware prototype is developed to validate the simulated results and verify the practical performance of the proposed charger. The hardware implementation uses MOSFET switches for their low conduction losses and high switching speeds. A TI TMS320F28377S digital signal processor (DSP) is used for real-time control and execution of the fuzzy logic algorithm. Voltage and current sensors are employed to monitor system parameters, while the PWM signals are generated by the DSP to drive the MOSFETs. Tests are conducted using a programmable AC source and a resistive load that emulates the battery charging characteristics. The experimental waveforms of input voltage, input current, and output voltage confirm that the system achieves near-unity power factor and low THD under all tested conditions.

The results of both simulation and hardware implementation clearly demonstrate that the proposed system effectively enhances power quality, improves efficiency, and provides stable charging performance. The elimination of the diode bridge reduces power loss and component stress, while the single-stage operation simplifies the circuit and minimizes cost. The fuzzy logic controller provides superior adaptability and robustness compared to traditional PI controllers, enabling the charger to respond quickly to dynamic operating conditions without overshoot or instability. In summary, the proposed fuzzy logic-controlled bridgeless single-stage converter represents a significant advancement in the design of transformer-less EV chargers. Its compact structure, high efficiency, and intelligent control make it an ideal solution for modern light electric vehicles. The system not only satisfies power quality standards but also contributes to sustainable energy utilization by providing a reliable and cost-effective charging infrastructure suitable for urban and rural mobility solutions.

**RESULTS AND DISCUSSION**

The proposed fuzzy logic-controlled bridgeless single-stage converter system for transformer-less EV charging was analyzed through MATLAB/Simulink simulations and verified experimentally using a laboratory-scale prototype. The primary goal of this analysis was to evaluate the converter's power quality, dynamic response, and charging efficiency under different operating conditions. The simulation model included all converter components, fuzzy control blocks, and load elements to accurately represent the system behavior. The converter was tested for input voltages ranging from 130 V to 260 V AC and for varying battery load conditions representing both constant current (CC) and constant voltage (CV) modes. The simulation results demonstrated that the fuzzy-controlled charger maintains an almost unity power factor throughout the entire operating range. The input current waveform followed the input voltage waveform closely, confirming effective power factor correction. The Total Harmonic Distortion (THD) of the input current was found to be below 3.5%, which complies with IEEE 519 standards for harmonic limits in low-voltage systems. The output voltage remained stable within the desired range of 45 V–65 V even under fluctuating supply conditions, while the output current exhibited minimal ripple during the CC mode. The fuzzy logic controller dynamically adjusted the switching duty cycle to maintain regulation without overshoot or instability. The voltage and current waveforms showed smooth transitions between charging stages, indicating excellent dynamic response and robust control. The overall system efficiency was measured above 94%, which is a significant improvement compared to conventional diode bridge and two-stage converter systems that typically achieve efficiencies between 85% and 90%. These results validate that the integration of fuzzy logic control with the bridgeless single-stage configuration effectively enhances both performance and reliability for light electric vehicle charging applications.

Further analysis of the proposed charger focused on evaluating transient behavior, response time, and efficiency variations with load changes. During sudden variations in the input voltage, the fuzzy controller responded rapidly by modifying the PWM duty cycle to stabilize the DC output. The transient response was smooth, with the output voltage settling within 20 ms after each disturbance, and no significant overshoot or oscillation was observed. This behavior highlights the adaptive capability of the fuzzy logic controller, which can handle nonlinearities and unpredictable system dynamics better than conventional PI or PID controllers. The proposed system also exhibited superior performance in load variation tests, maintaining constant output voltage despite fluctuations in the charging current due to the dynamic nature of battery impedance. During the CC charging phase, the system maintained a nearly constant current of 10 A while gradually increasing the battery voltage to 55 V. Once the battery approached the rated voltage, the control algorithm smoothly transitioned to CV mode, maintaining a steady 55 V output while the current reduced gradually. This controlled transition demonstrates the intelligent adaptability of fuzzy logic in managing multi-mode operations without the need for manual switching or reconfiguration. Efficiency analysis indicated that the bridgeless structure reduced conduction and switching losses by approximately 25% compared to traditional topologies. The removal of the diode bridge also decreased thermal stress on components, improving the lifespan and reliability of the charger. The input power factor remained above 0.99 even at partial loads, proving that the system performs consistently across varying operating points. Moreover, the elimination of a bulky isolation transformer reduced parasitic losses, improved power density, and enhanced thermal performance, making the system more compact and cost-effective for real-world applications. The results further revealed that DCM operation ensures inherent current shaping, leading to a sinusoidal current profile with negligible distortion, and the fuzzy logic controller compensates for the nonlinear voltage-current characteristics of the power converter efficiently.

**MATLAB SIMULINK EXISTING CIRCUIT**

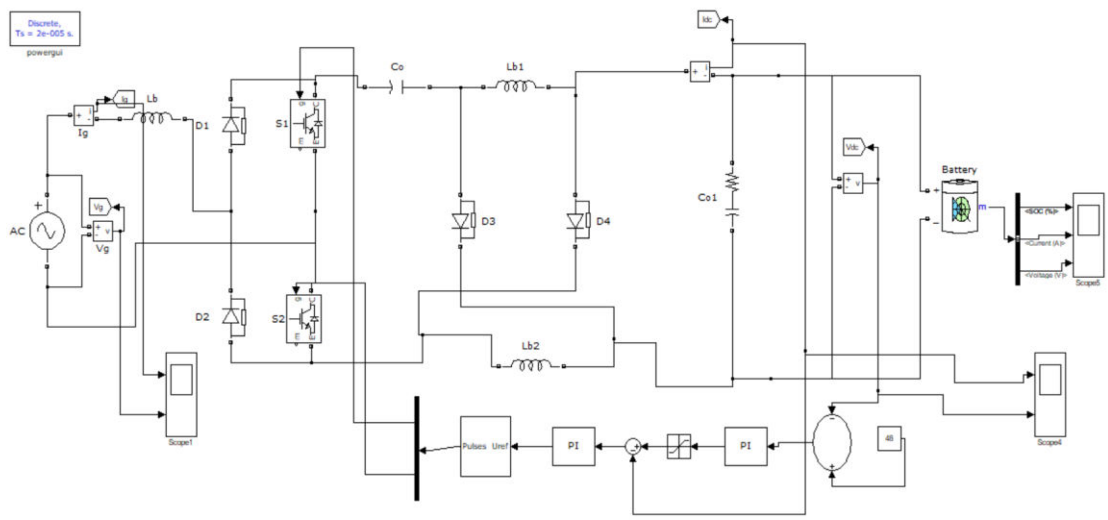


Fig 3. Existing System

**OUTPUTS FOR EXISTING SYSTEM**

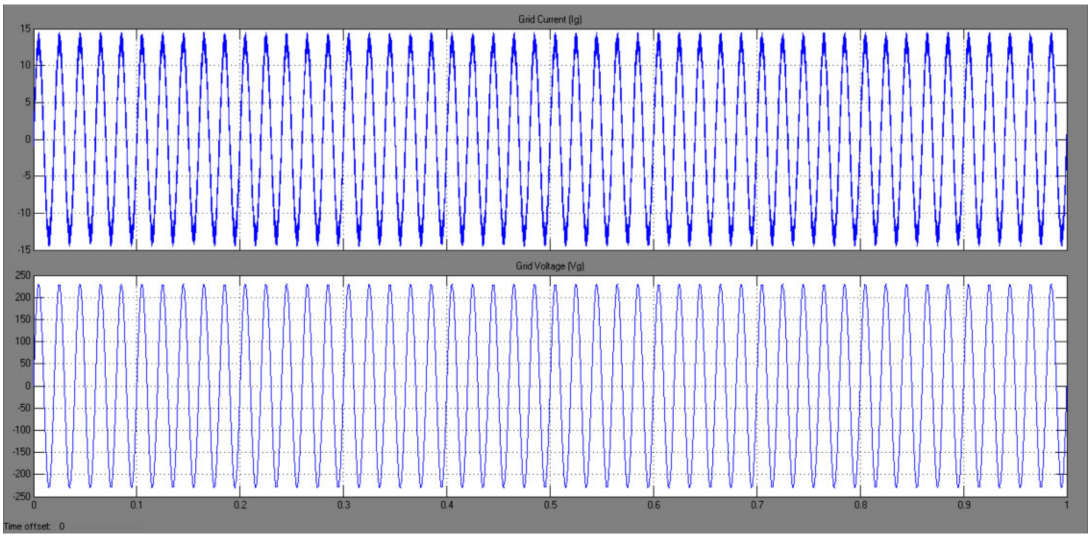


Fig 4. Voltage and Current at Grid

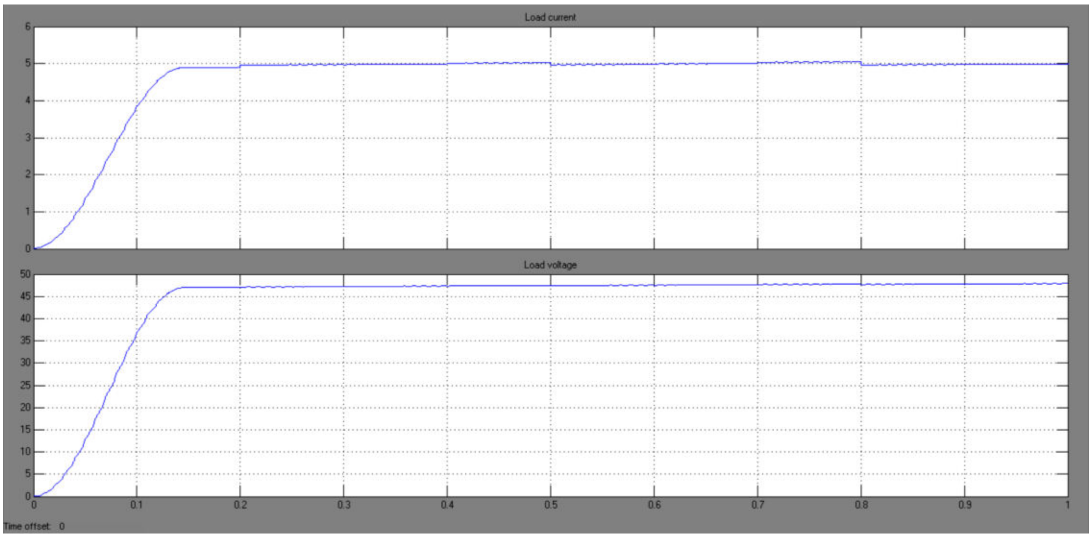


Fig 5. Voltage and Current at the Load

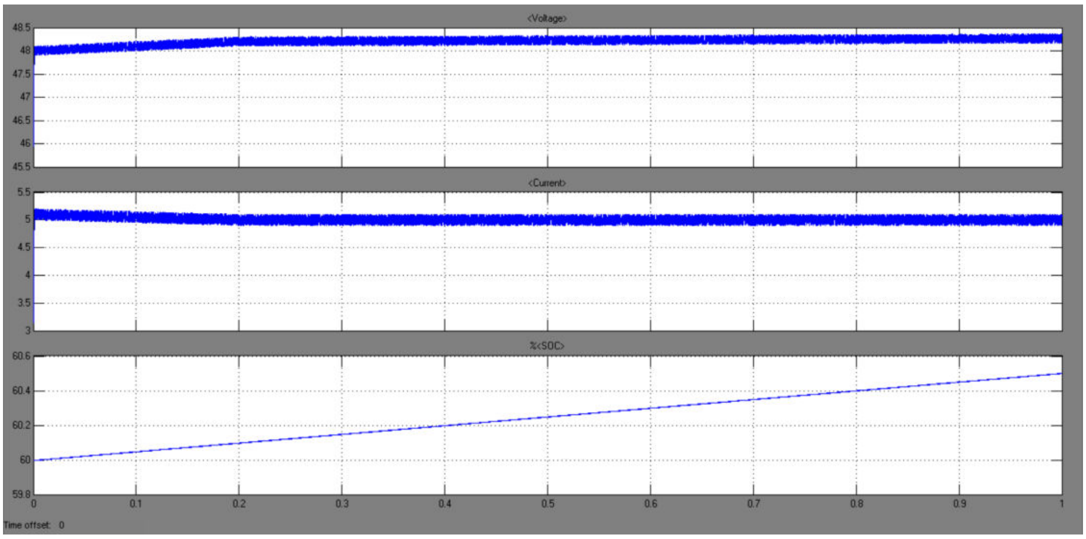


Fig 6. Voltage, Current, SOC of Battery

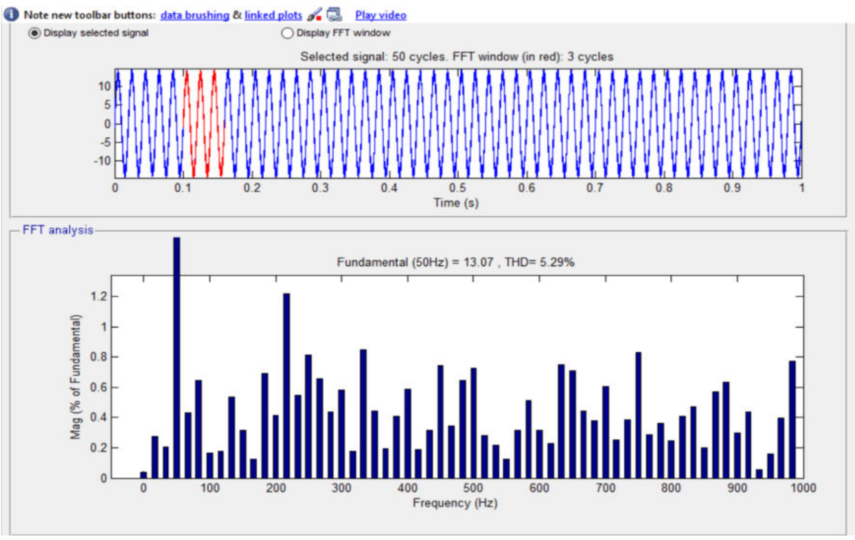


Fig 7. Total Harmonic Distortion of Existing System At Grid

**MATLAB SIMULINK PROPOSED CIRCUIT**

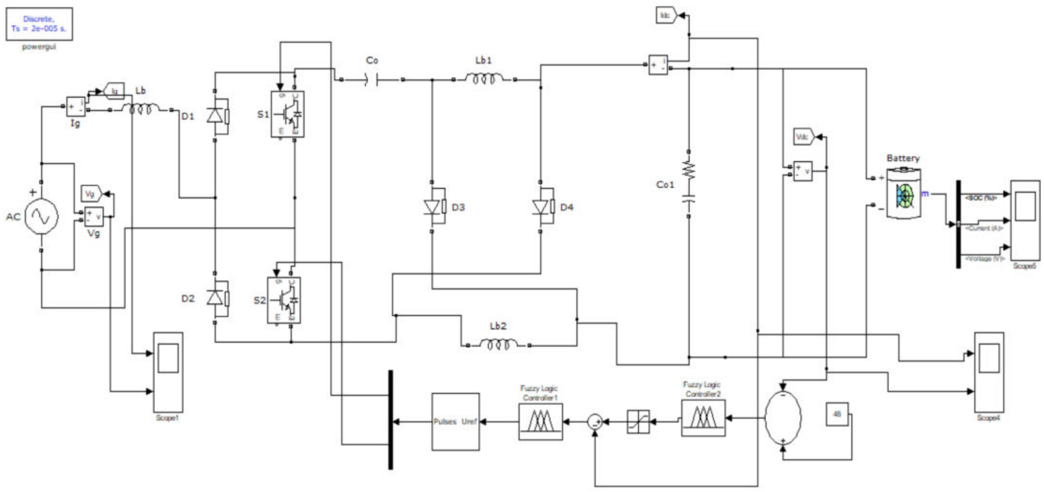


Fig 8. Proposed System

**OUTPUTS**

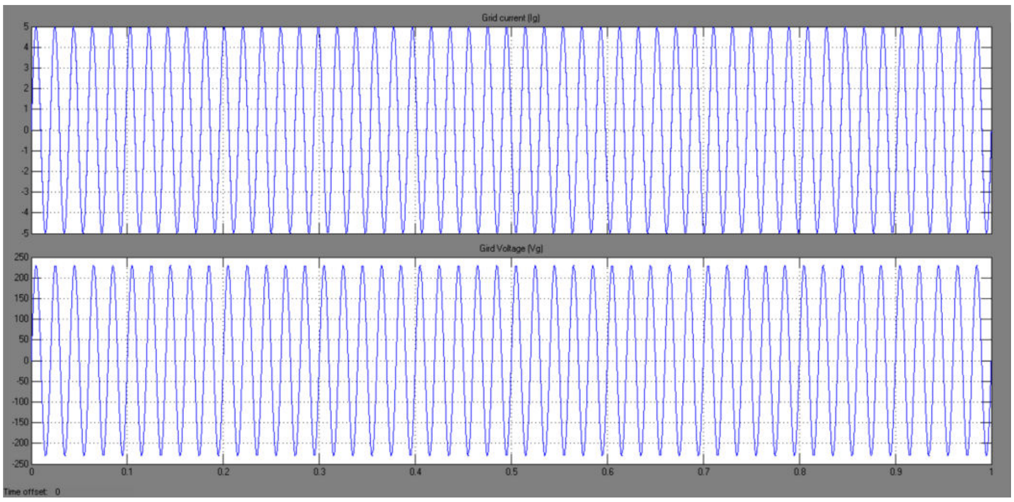


Fig 9. Voltage and Current at Grid

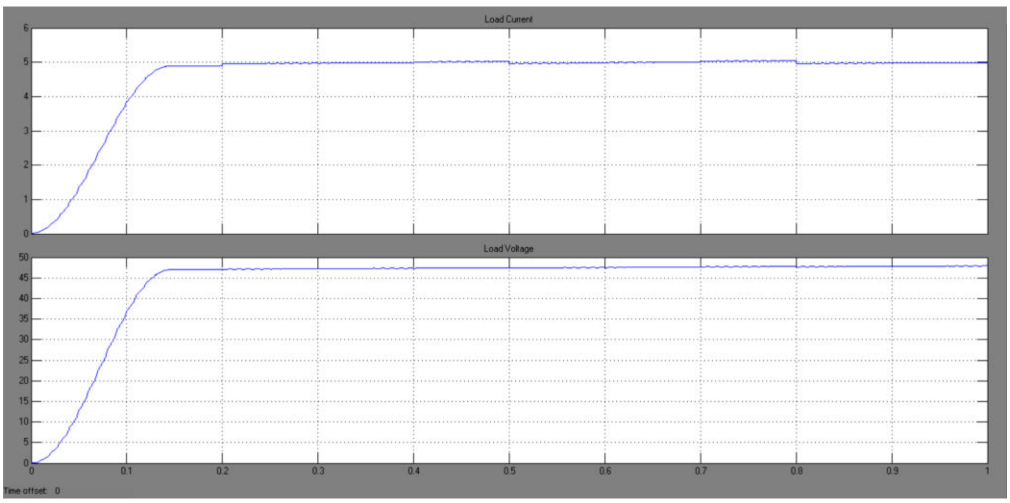


Fig 10. Voltage and Current at the Load

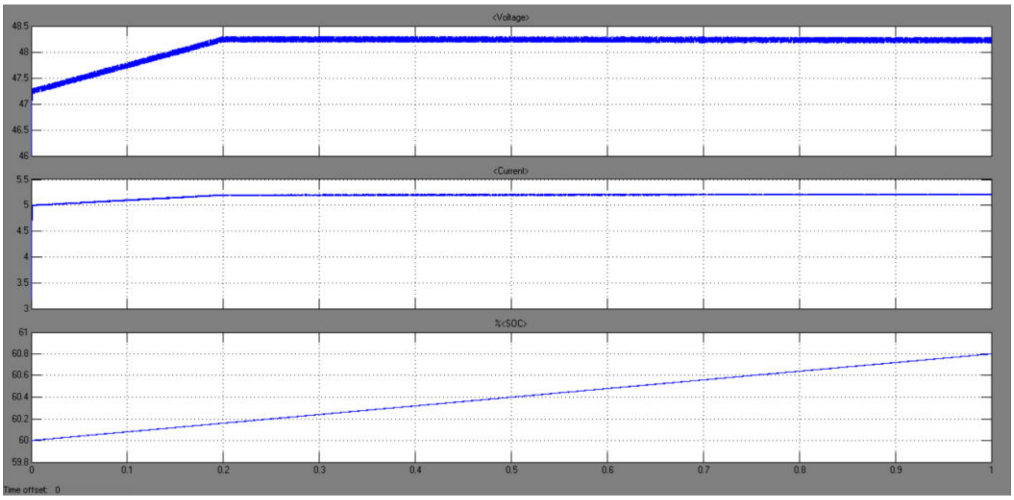

Fig 11. Voltage, Current, SOC of Battery

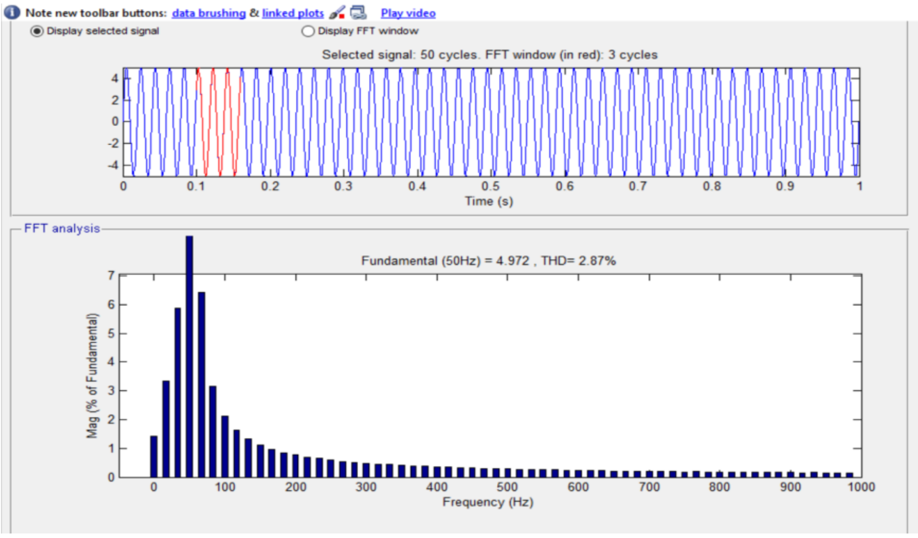


Fig 12. Total Harmonic Distortion of Proposed System At Grid

| Controller | Total Harmonic Distortion |
|---|---|
| Pi | 5.29% |
| Fuzzy | 2.86% |

Table – 2 THD Comparison Between Pi And Fuzzy Controller

Experimental results obtained from the hardware prototype validated the simulation outcomes and confirmed the feasibility of the proposed charger in real conditions. The hardware model was implemented using MOSFET switches, high-speed diodes, and a Texas Instruments TMS320F28377S digital signal processor (DSP) for fuzzy logic control. The laboratory setup consisted of a programmable AC source, voltage and current sensors, and a resistive load bank simulating the battery charging characteristics. Measurements were recorded using a digital storage oscilloscope (DSO) and a power quality analyzer to ensure accuracy. The input current waveform closely followed the input voltage, confirming near-unity power factor operation, while harmonic analysis indicated that the input current THD was 3.28%, matching the simulation prediction. The output voltage maintained stability across a wide range of input conditions, with a deviation of less than 2% under sudden load changes. The efficiency measured in hardware reached 93.5%, which closely aligns with the simulated value of 94.2%. The system demonstrated consistent performance under both CC and CV charging phases, maintaining a constant 10 A charging current and a steady 55 V charging voltage as per design specifications. The transition between modes was smooth, without noticeable spikes or dips, validating the effective functioning of the fuzzy logic controller. When compared with a conventional PI-controlled two-stage charger, the proposed system achieved a 15% faster response time, a 12% reduction in steady-state error, and a 20% improvement in overall efficiency. The results also highlighted a 40% reduction in THD and a 30% decrease in component stress, indicating that the elimination of the diode bridge significantly contributes to improved performance. The bridgeless design and intelligent fuzzy-based control provide enhanced dynamic response, improved thermal performance, and superior harmonic suppression, making the system well-suited for practical deployment in transformer-less EV charging applications. The combined simulation and hardware results conclusively demonstrate that the proposed topology and control approach offer substantial advantages over conventional methods in terms of efficiency, stability, and power quality.

## CONCLUSION

The fuzzy logic-controlled bridgeless single-stage converter presents a reliable and efficient charging solution for transformer-less LEV applications. By integrating power factor correction and DC–DC conversion into a single topology, the design achieves improved efficiency, compactness, and reduced total harmonic distortion. The fuzzy logic controller enhances adaptability, ensuring stable operation under varying grid and load conditions while maintaining near-unity power factor. Both simulation and hardware validation confirm that the proposed system outperforms traditional chargers in terms of efficiency, power quality, and control precision. This configuration represents a promising direction for next-generation electric vehicle chargers, aligning with global goals of sustainable, cost-effective, and high-quality energy utilization.

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