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Article Title: PI Controller Based Bridgeless Isolated Cuk Converter for Electric Vehicle Battery

PI Controller Based Bridgeless Isolated Cuk Converter for Electric Vehicle Battery

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ABSTRACT

This work proposes a cruise control idea based on a proportionate and integral (PI) direct torque control applied to an electric vehicle's (EV) propulsion system. This study designs and develops a bridgeless isolated Cuk converter-based electric vehicle (EV) battery charger with a high power factor and enhanced efficiency. The study also goes into simulation, control design, and simulation, which results in a numerically emulator made up of detailed models of the key parts: transmission structure, inductive motor, electricity systems, system of control, and car dynamics. The simulation was created in MATLAB/Simulink and will enable for the assessment of an EV's energy usage in various configurations. The simulation results demonstrate the effectiveness of the planned control.

Keywords: EV- Electric Vehicle, PWM - Pulse Width Modulation, PI - Proportional and Integral, AC- Alternating Current, HCC – Hysteresis Current Control.

1 Introduction

The direct ignition of petroleum and coal in automobile combustion engines faces rising economic and ecological risks. Green electric car demand has risen dramatically in recent years. The first generation of EVs mostly employ basic add charging techniques, causing safety concerns due to exposed connectors and broken wires. Wireless solutions for charging were extensively researched in order to remove connectors and cords. Both the primary and secondary ends of a charger that is wireless can be entirely isolated with no physical touch. As a result, it is adaptable in humid and hazardous climates. The entire payment procedure may be automated, secure, and user friendly [1]. Starting, Lightning and Ignition batteries are not the same as electric vehicle batteries, which are generally lithium-ion batteries with a high ratio of weight to power and a high density of energy. Smaller, lighter batteries are preferred as they lower vehicle weight and hence increase speed. The battery accounts for a substantial percentage of an electric vehicle's price and ecological impact [2]. A lithium-ion battery is probably the most prevalent form of electric car battery. This is owing to their high

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effectiveness, substantial specific energy (Wh/kg), and long lifespans. The power source is composed of two electrodes immersed in a fluid called electrolyte. [3, 4]. EVs do not utilize one battery like phones, but rather a pack made up of many separate Li-ion cells that operate together [5]. The significance of possible renewable energy sources in comparison to traditional fossil fuels is discussed. Yet, the resonant converter's complicated calculation renders it inappropriate for EV charging across a large input voltage spectrum. A full-bridge PFC converter appears to be the most promising option for EV chargers, but building separate gate drivers for four silicon switches increases its dimensions and intricacy. As a result, several unidirectional PFC off-board EV chargers were proposed in order to give ease of deployment while keeping the benefits of high density of energy and reliability [6].

Because they may buck and boost the input voltage, buck-boost converters are the most appealing alternative for PFC in EV chargers. In, the various buck-boost configurations-based converters, including Cuk and SEPIC converters, are outlined and examined. Despite the fact that the Zeta, Cuk, and SEPIC PFC converters have minimal current input fluctuation and a large duty cycle fluctuation range, the SEPIC converter has an interrupted current output, unlike the Cuk converter. As a result of the minimal ripple in the battery current, the Cuk converter gives more practicable recharging properties to the battery [7, 8]. Cuk converters are perfect for use in electric vehicle battery management systems and renewable energy integrating, including systems with sunlight on the supply side and mixed solar-wind systems, as well as solar energy uses that allow oversight and functioning at the maximum power point, and sunlight uses to facilitate regulation and functioning at the maximum power point [9]. PI Controller is a loop of feedback control that calculates an error signal by subtracting the system's results, that in this instance is the power obtained from the battery from the initial value. Furthermore, the flexible and imprecise PI controller settings are optimized using the evolutionary algorithm optimizing toolkit. [10].The contribution of the paper using Bridgeless isolated Cuk converter for boosting the AC supply voltage, the EV battery is used for improving and storing the power also the PI controller is apply for maintain the power in the same level of value.

2 Proposed System Explanation

This work focuses mainly on improving the performance of an EV traction system through the use of a PI controller for speed regulation and suitably tweaking its gains. To demonstrate the usefulness of a PI controller in EV applications by increasing power utilizing a bridgeless isolated Cuk converter. The processing of this method is exposed in the Figure 1.

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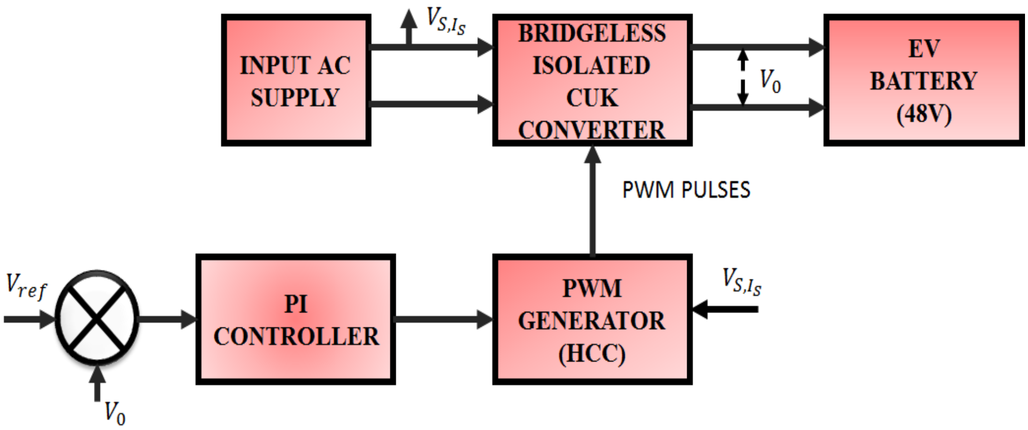

Figure 1: *Proposed Diagram*

From this process the power of the Input AC supply to the Bridgeless Isolated Cuk converter. This converter occupies the AC voltage and current, it improves the incoming power by this converter. The reference voltage is transferred to the PI controller. The output voltage of this controller passes to the PWM generator of Hysteresis current control also it gathers the source voltage and current, the current controlled and generated PWM pulses connected to the proposed converter. The overall output voltage is passes to the EV battery for storing as well as processing the power.

3 Proposed System Modelling

3.1 Input AC supply

An alternating current power supply is a kind of electrical supply that is used to deliver AC electricity to a load. The source of power may be either AC or DC. The power provided by wall outlets mains supply and different power storage gadgets is frequently inconsistent with the load's electrical needs. To overcome this issue, AC power supplies convert and fine-tune alternating current power from an electrical source to the frequency, voltage, and current required by the device. It's done by stepping up or stepping up the voltages and then filtering. As a result, electrical power is delivered to the gadget in a safe and controlled manner. AC power supply also adjust the voltage provided to the load and/or get the load's discharge to safe limits. Our electrical equipment are compatible with the provided AC energy from the mains supply thanks to AC power supplies in the form of converters and transformers. Using an incompatible kind of electricity (i.e., the incorrect frequencies or voltage) might cause the linked equipment to break or fail. It is critical to check the AC power supply's input current rating to ensure that it will function with the electrical power supply in your area. Otherwise, it may cause harm to the alternating current power supply and the electrical equipment linked to it.

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3.2 Bridgeless Isolated Cuk Converter

This research presents a converter architecture for EV battery chargers based on the bridgeless isolated Cuk converter, as shown in Figure 2. When compared to other traditional topologies, the Cuk converter has various advantages in PFC applications, including reduced EMI in DCM, intrinsic current limiting during transients and overloading conditions, easy isolating execution, small size, and strong dynamic responsiveness. This converter operates symmetrically in the two half periods of the input signal. As a result, conventional functioning is described for one changing period in the voltage that was input's negative half line cycle.

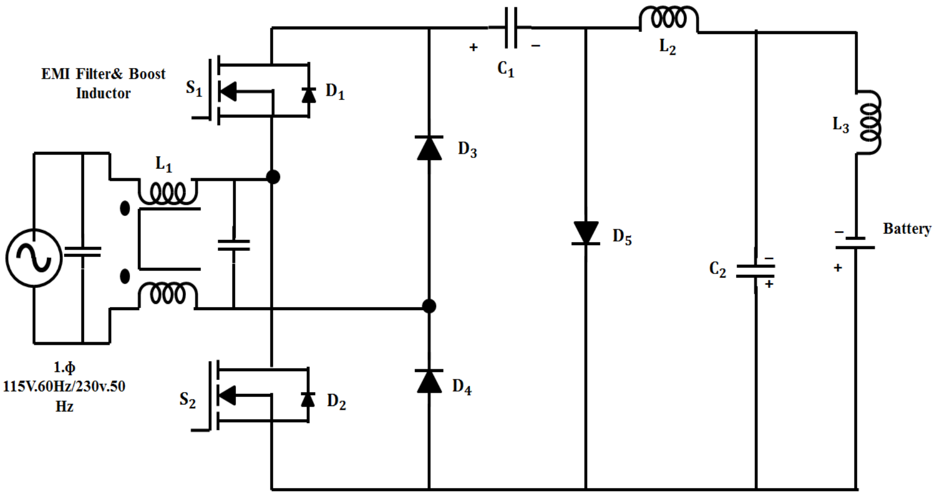
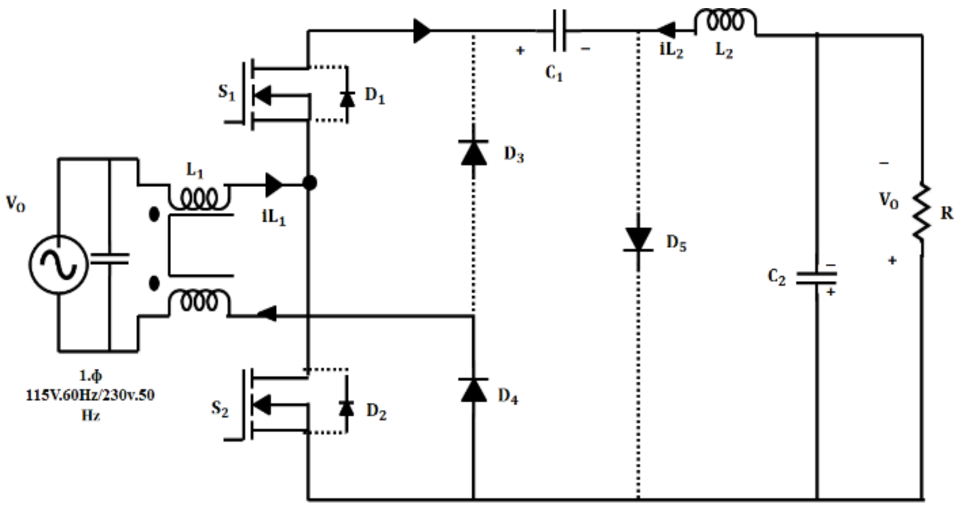


Figure 2: *Bridgeless isolated converter (a) Circuit Topology*



(b) Stage 1 Operation

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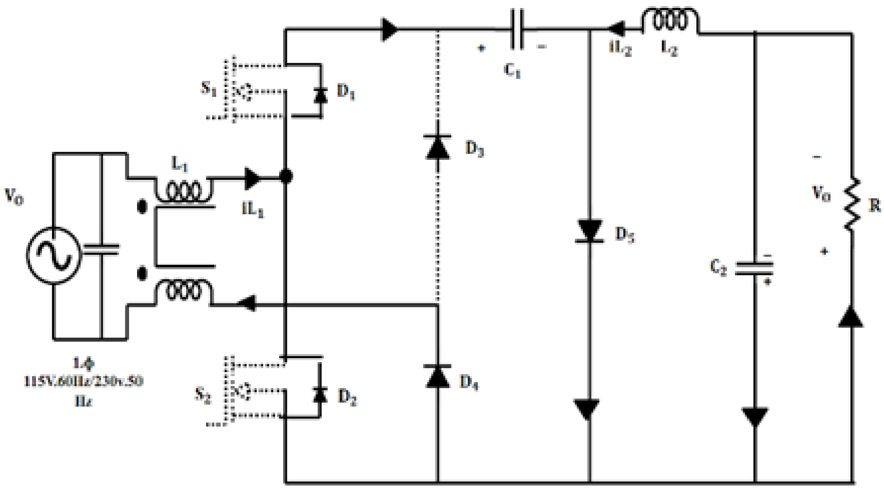

(c) Stage 2 Operation

Stage 1: The functioning of a circuit is clarified using distinct circuits in every mode of operation in Figure 3. During the opposite half-line cycle, the switchesS_1, S_2 and D_4 are turned on, and the inductor stores energy and capacitor C1 retains the diode D5 so that the opposite current begins to flow via L_1 S_2 D_4 and S_1 S_2 C_2 L_2 C_1

$$i_{L1}(t) = i_3 + \frac{vg^t}{L_1} \tag{1}$$

$$i_{L1}(t) = i_3 + \frac{(V_{C1-V_0})t}{L_2} \tag{2}$$

Stage 2: During OFF mode, S_1 and S_2 are turned off, D_5 and D_4 are turned on, and current flows through L_1 D_5 C_2 and $L_1 D_1 C_1$ D_5 D_4 L_1 and back to the supply. S_1, S_2 andD_3 are turned on throughout the opposite half-line cycle, and the inductor accumulates power. The diode D_5 is kept reverse biased by the capacitor C_1 ,

$$i_{L1}(t) = i_{L1}(t_1) + \frac{\left(V_{C1-V_g}\right)t}{L_1} \tag{3}$$

$$i_{L2}(t) = i_{L2}(t_1) + \frac{vo^t}{L_2} \tag{4}$$

3.3 PWM (Hysteresis Current Control)

A research of advancing the use of a hysteresis current-controlled PWM generator for robotic applications is done in this work. The gating signals for a three-phase hysteresis PWM generator with isolated neutral are raucous, and every of their switch may not freely change switching modes over a certain during the current instruction. Thus, rather of conducting switching frequency feedback control by sensing the switch restricting signal in the proposed

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hysteresis current-controlled PWM system, an effective harmonic spectrum shaping approach is created to allow the output current harmonic frequency to remain constant. If the current-controlled PWM inverter has a very tight current instruction control of tracking traits, the mechanical motion of the placement stage may be appropriately described as shown in Figure 3.

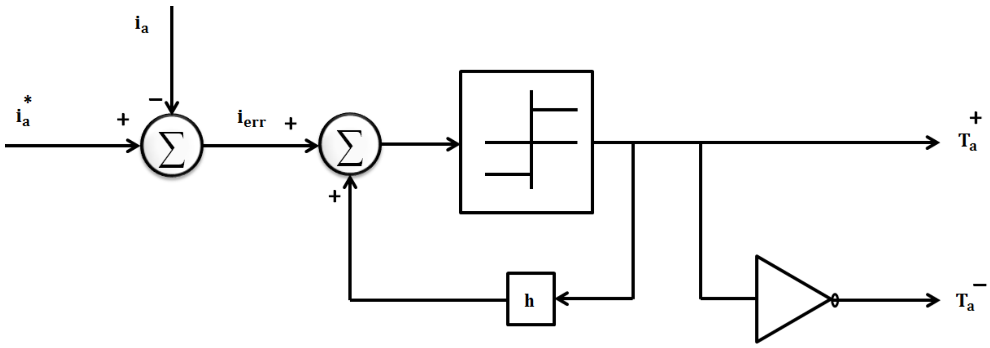

Figure 3: *HCC-PWM Generator*

An inverse modelling is used to extract a harmonic frequency error signal, and a compensation signal is created to adjust the current request for hysteresis switching control. The switched characteristic of a hysteresis current-controlled PWM inverter is highly sensitive on supply and load fluctuations. The hysteresis current-controlled PWM generator's periodic phase current instructions are created from an external control loop, with its argument maintained in sync with the measured movement component position.

4 Result and Discussions

The following outcomes are attained as a result of implementing the planned work in MATLAB simulation. The parameters specification of the respective converter is given below in the Table 1

Table 1: *Bridgeless Isolated Cuk converter parameters value*

SL. NO	Parameters	Values
1.	L_1	$1.5mH$
2.	L_2	$1.5\ mH$
3.	L_3	$1.5mH$
4.	C_1	23.6μF
5.	C_2	23.6μF
6.	C_3	2200μF

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Figure 4 and 5 shows the AC input voltage and current wave variations, The AC voltage has the value occupies between the -200V to 200V and current flows and maintains the constant power as 0 to 8A

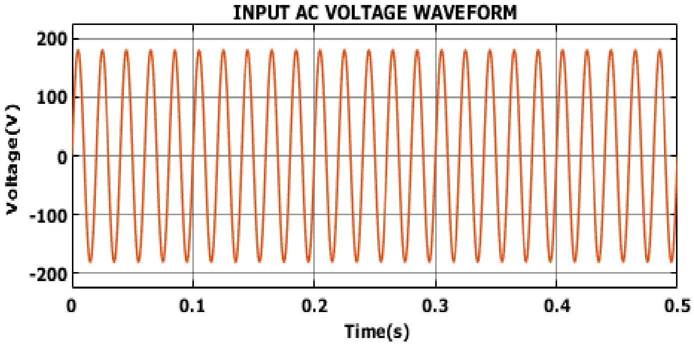

Figure 4: *AC Input voltage waveform*

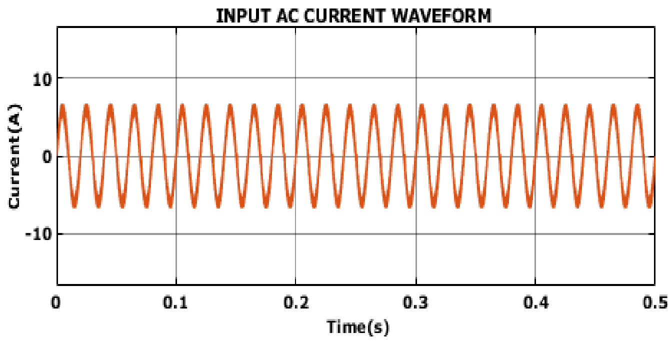

Figure 5: *AC Input Current waveform*

Figure 6 depicts the Input AC voltage and current inphase wave speed it has the voltage leave appears between the value as -200V to 200V and the current as 0A. Figure 7, shows the power factor wave form has the constant value as 1p-u

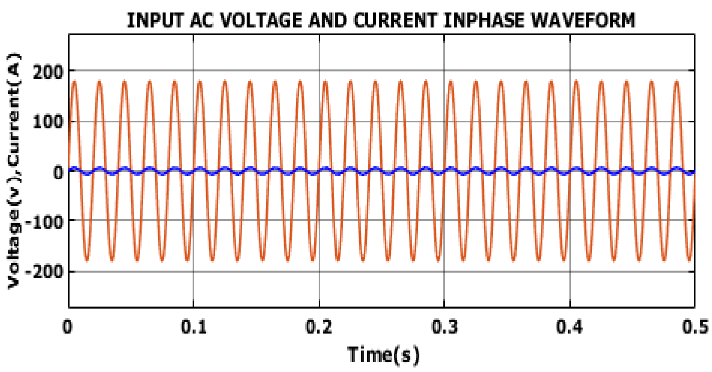

Figure 6: *Input AC voltage and current inphase waveform*

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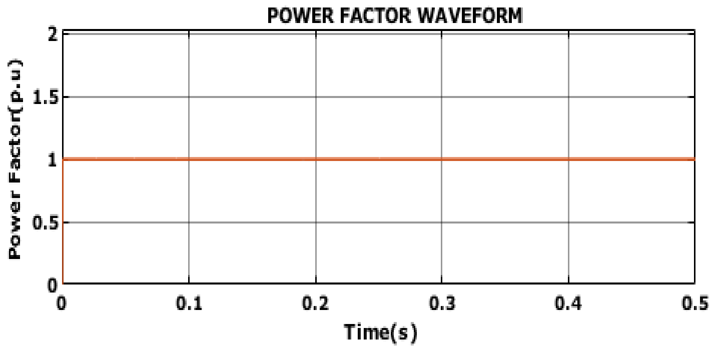

Figure 7: *Power factor wave form*

Figure 8, depicts the converter output voltage wave form is maintain the constant value of the voltage for all seconds as 42V , and Figure 9 has the converter output current waveform it has the value of 0A for the complete cycle.

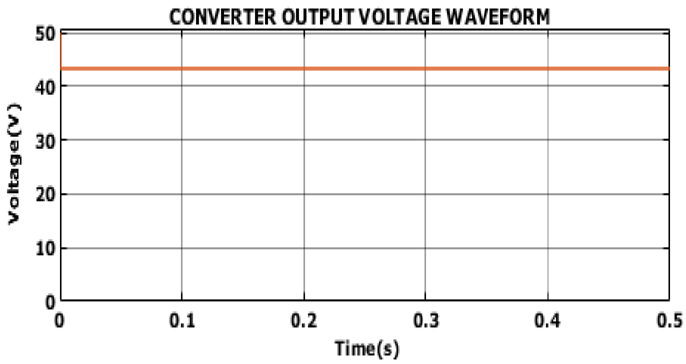

Figure 8: *Converter output voltage wave speed*

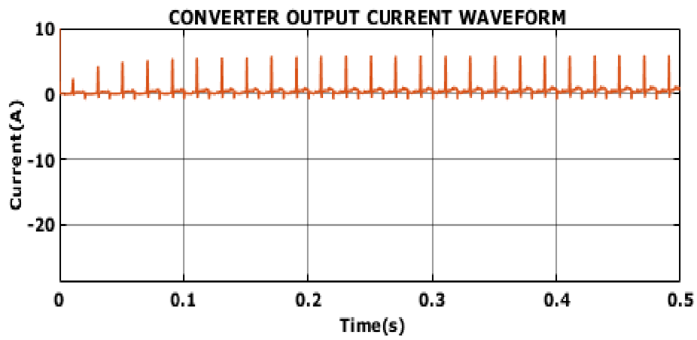

Figure 9: *Converter output current waveform*

Figure 10, depicts the Battery Voltage waveform maintains the constant voltage leave as 40V for all seconds. Figure 11 shows the Battery current wave speed it has maintain the constant value as 0A.

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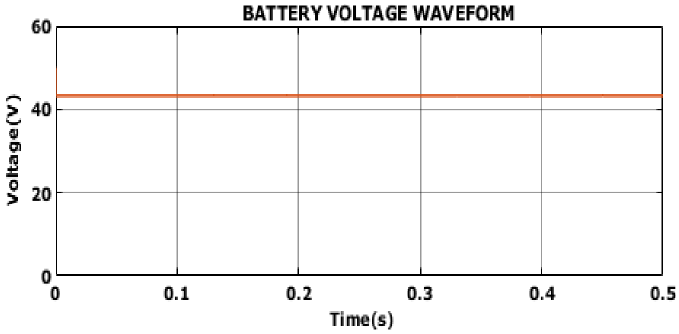

Figure 10: *PWM rectifier voltage waveform*

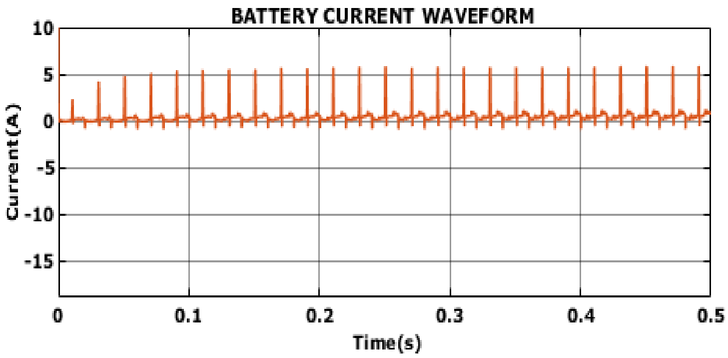

Figure 11: *Battery SOC waveform*

Figure 12, shows the Battery SOC waveform it has the endless value as 90% for the complete time period

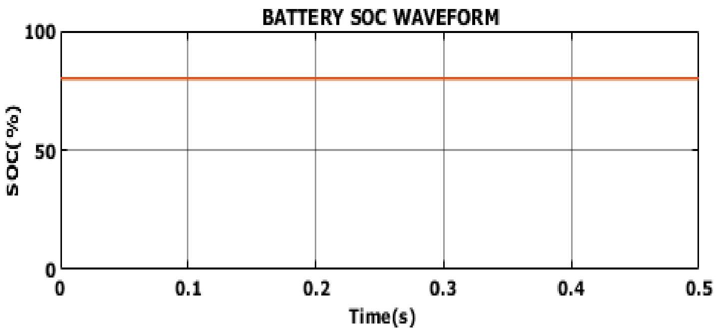

Figure 12: *Battery SOC waveform*

The valuation of the Efficiency Assessment between the converters are registered in Figure 13, in which they are scheduled as 89.7%, 90.8% and 92.7% as Boost, Bridgeless Isolated Boost and Bridgeless Isolated Cuk Converters individually.

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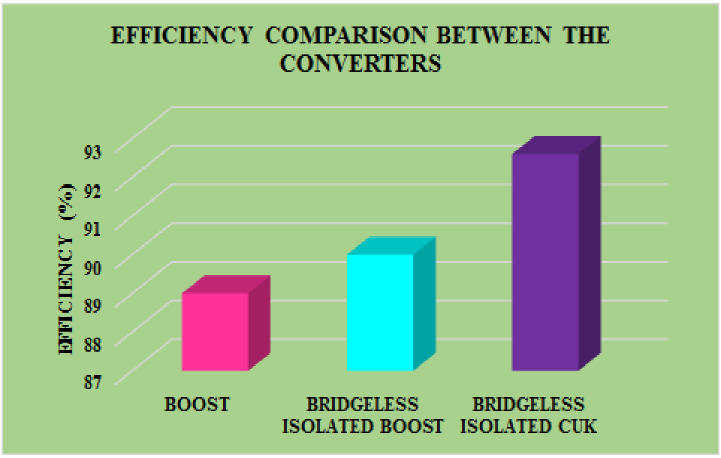

Figure 13: *Efficiency Comparison*

Figure 14 shows the voltage gain comparison between the converter has the value as individually Boost (1.5V), Bridgeless Isolated Boost (4V) and Bridgeless Isolated Cuk (8V).

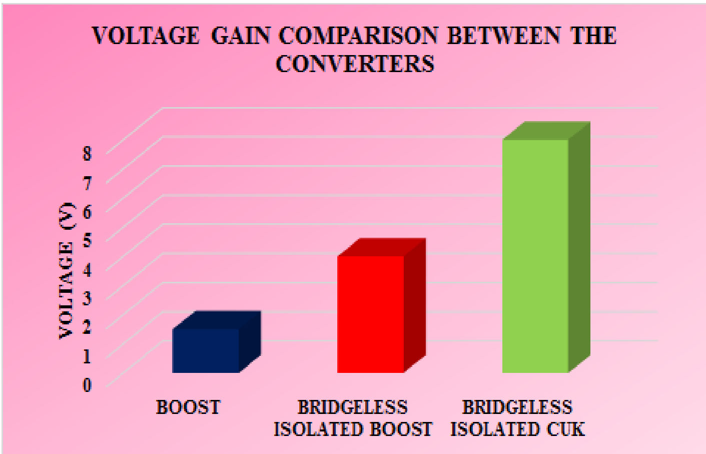

Figure 14: *Voltage gain comparison*

5 Conclusion

A bridgeless isolated Cuk converter with fewer conducting components over a single switching cycle is proposed for an EV charger. The proposed converter has outstanding features and reduces the size of the charger by adopting a single voltage feedback control. The recommended topology also eliminates the undesired capacitive coupling loop in addition to the undesired conduct through the body diode of the active switching in the earlier proposed Bridgeless isolated Cuk converter. This enhances the charger's efficiency greatly. The converters and controller traction system's design approach, control design, and simulation were all described. The results demonstrate that a PI Controller improves system performance. A real-time implementation is envisaged in the future.

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