# DESIGN AND SIMULATION OF PFC BASED CUK-SEPIC CONVERTER FOR ELECTRIC VEHICLES BATTERY CHARGER

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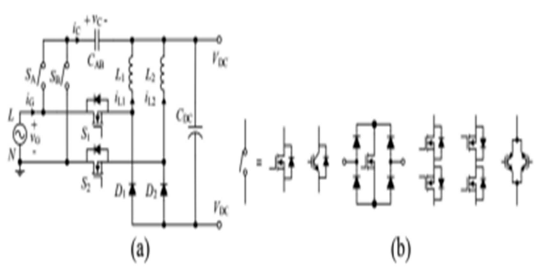
**Abstract:** Using a Cuk-single-ended primary inductor converter (SEPIC) that is isolated bridgeless (BL), this article creates a one-stage charger for electric car batteries. When connected to the AC mains, the charger should make advantage of intrinsic power factor correction (PFC) while running in discontinuous conduction mode. In both positive and negative cycles, the suggested design beats the BL Cuk converter architecture, although using fewer components. This is because, in the midpoint of each cycle, SEPIC and Cuk converters are combined. The output is different from the SEPIC converter that was utilized in both cycles. inductor is included into the Cuk converter side, which aids in reducing the ripple in the output current. Our novel BL isolated PFC converter was tested with a single-phase PQ analyzer under a 48 V/100 Ah electric vehicle battery load, and it was found to work with good power quality (PQ). We build and test the suggested charger to show that it works well with two different charging profiles. Every possible scenario, from steady-state to extreme-load and line, has its corresponding modeling results shown. Several performance indicators are documented, including ac mains PF, displacement PF, and mains current distortion.

**Keywords:**Charger for batteries, bridgeless single-ended primary-inductor converters (SEPICs), discontinuous mode (DCM), electric vehicles (EVs), and power quality (PQ).

## I.INTRODUCTION

Electric vehicles (EVs) have quickly become the norm in the current automotive industry due to their many benefits, including minimal environmental impact and excellent fuel economy [1, 2]. The efficiency of various grid-connected electrical appliances and the battery life of electric vehicles are significantly impacted by the charging method [3, 4]. Additionally, IEC 61000-3-2 specifies that Superior battery chargers with sinusoidal line current and low mains current distortion (THD) are essential for small-scale cars.

normative [5]. When using conventional battery chargers with diode bridge rectifiers (DBRs), nonlinear behavior occurs, making it challenging to get accurate indices. In Table I, you can see the E-rickshaw's specs and battery rating. One way to improve the quality of utility electricity is to connect the rectifier's output to a conventional front-end power factor correction (PFC) converter. However, conventional chargers need an additional converter, which increases the overall number of components. This has a detrimental impact on the charger's efficiency and cost. Implementing two-stage systems with large dc-link capacitors is another approach to reduce the charger's weight, efficiency, and reliability when dealing with high-power applications [6]. Isolated ac-dc converters with input diode bridges are becoming more common for use in electric vehicle chargers for power factor correction (PFC) [7], [8]. The literature has described many kinds of on-board PF correction converters for electric vehicles [9]. The tiny charging footprint of on-board solutions is making them more attractive as a means to achieve significant power efficiency. A detailed description of the construction of an interleaved (IL) PFC converter for high-power applications was provided by Musavi et al. [10]. Power factor correction (PFC) chargers that cover a broad power spectrumrely heavily on soft switching [11], [12]. Working with IL has many advantages, such as reduced input/output ripple, circuit inductance, and electromagnetic interference (EMI) filtering. Running the switches in parallel cuts the current across them in half compared to an IL-free converter. Despite this, the devices' heat dissipation is unchanged from rectifier-fed chargers, which limits the size decrease. To harness the benefits of low switching device losses and low line side electromagnetic interference (EMI), Li et al. [13] introduced a charger that employs a single-stage resonant converter. Despite their ability to handle substantial line voltage changes, component selection becomes more challenging in full bridge (FB) LLC converters due to the presence of four switches and circuitry. The circuit described in [14] is more sophisticated and uses more components due to the addition of a boost-FBLLC converter to an alternative design for a battery charger. The device's four gate drivers need a complex control architecture to be developed. The goals of low design complexity and high power density may be achieved by several efficient unidirectional EV charging solutions that do not rely on the vehicle's on-board components, as mentioned in [15], [16]. In terms of built-in PFCs, the conventional boost rectifier is the undisputed king among unidirectional chargers. Due to their restricted duty cycle ranges at varied line voltages and inability to correctly shape the current, traditional buck [17] and boost [18] converters aren't suitable for high power applications. As an alternative, a buck-boost converter can handle unexpected changes in the mains voltage thanks to its fully adjustable duty cycle.




Figire.1: the Manitoba rectifier-BL buck-boost PFC component count [19]. Chapter one: The electrical system. (b) Two different types of bidirectional switches, one for supply and one for demand, are to be used.

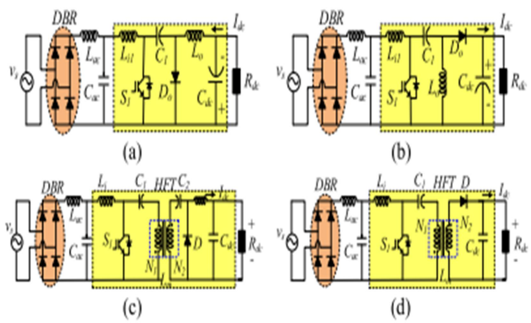


Figure 2: Isolated PFC converter layouts (c) and (d) and traditional PFC converter layouts (a) Cuk and (b) SEPIC, respectively.

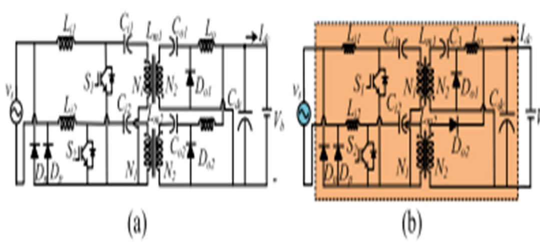


Figure 3: (a) A comparison of the proposed the BL-SEPIC converter, which uses Cuk converters for both the line cycle and the prior BL isolated converter, and (b) comparing the two

Using bridgeless (BL) technology will not fix the isolation problem in the buck-boost converter mentioned in [19]. An extra isolated stage is required at the battery end because the nonisolated design and limited voltage step-down capabilities of the buck-boost converter—which was previously mentioned—make it unsuitable for single-stage charging. Due to the short duty cycle required to produce 48 V at the battery end, a single-stage charging design converter has poor efficiency and dynamic performance. The results of reducing the excessive CM noise generated by the buck-boost converter using a reconfigurable filter with two bidirectional switches are shown in Figures 2(a) and 2(b).

This causes a deluge of devices due to the unique nature of bidirectional switches. Singh et al. has discussed in detail the many buck-boost designs utilized in single-phase PFCs, such as zeta converters, flyback converters, SEPIC converters, and Cuk converters. There are too many gaps between the input and output currents of SEPIC converters and single-stage isolated zeta converters for them to be useful as battery charger inputs. Not only does this shorten the battery life, but it also makes the line filter cumbersome by linking the input ripple to the output. This restriction is irrelevant due to the minimization of ripples in the Cuk converter's input and output. You may make the SEPIC converter's output current constant by coupling it with an architecture that ensures a constant output current, such a

Cuk converter.

TABLE I

DETAILS OF THE E-RICKWAW BEING EVALUATED

| Parameter | Specification |
|---|---|
| Speed | 0-25 kmph |
| Battery Rating | 4*12V (48V) of 100Ah Capacity |
| Motor Rating | 48V, 850W BLDCM |
| Charger Specifications | Charger output voltage:63-65V<br>Line voltage range:160-260V<br>Output charging current:10-12A |

TABLE II

IMPORTANT TOPOLOGIES FOR BUCK-BOOST CONVERTERS FOR THE REALIZATION OF THE SUGGESTED TOPOLOGY

| Configuration / Attributes | BL Buck-Boost [19] | SEPIC [23] | CSC[20] | Luo[20] | Zeta[24] | Traditional Cuk [22] | Proposed BL Cuk-SEPIC Converter |
|---|---|---|---|---|---|---|---|
| Input Rectifier required | No | Yes | Yes | Yes | No | Yes | No |
| High Frequency Transformer | No | Yes | Yes | Yes | No | Yes | Yes |
| Conducting component count in one switching cycle | 1S+2D | 1S+1D | 1S+1D | 1S+1D | 1S+2D | 1S+1D | 1S+2D |
| Superfast Diode | 2 | 2 | 1 | 1 | 2 | 1 | 2 |
| No. of Magnetics | 2 | 4 | 1 | 2 | 4 | 2 | 3 |
| Intermediate capacitor | No | Yes | Yes | Yes | Yes | Yes | Yes |
| DC-link Capacitor | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Number of IGBT switches | 2 | 2 | 1 | 1 | 2 | 1 | 2 |
| Device current rating | High | High | Average | High | High | High | Low |
| Device Loss | Average | High | Average | Low | Average | Low | Low |
| Voltage ripple | High | High | High | Low | Low | Low | Low |
| Current ripple | High | Low | Low | High | High | Low | Low |
| Output voltage type | -ve | +ve | -ve | -ve/+ve | +ve | -ve | +ve |
| Power Density (Analytical study) | 95W/inch$^3$ | 75W/inch$^3$ | 80W/inch$^3$ | 70W/inch$^3$ | 70W/inch$^3$ | 85W/inch$^3$ | 140W/inch$^3$ |

Hence, it seems that the two topologies working together will significantly enhance PQ. Table II provides a summary of important buck-boost converter topologies, including and excluding diode-bridge, with the aim of creating novel combination topologies. Due to its increased requirements for side gate drivers, output ripple, and electromagnetic interference (EMI), the BL isolated version would be unfeasible to implement most of these combinations. Table II provides the rationale for choosing the suggested converter combination based on the hardware implementation feasibility, taking into consideration the various characteristics of the converters mentioned previously. Figure 1.2(a)-(d) shows that An updated version of the classic Cuk-SEPIC converter, the BL Cuk-SEPIC converter takes design cues from its predecessor. The charger efficiency has been the center of attention for a number of well-known isolated BL PFC converter topologies. An integrated Cuk-SEPIC configuration BL isolated converter based EV charger was constructed and tested, as seen in Figure 3 of the aforementioned study [25]. A 48 V, 100 Ah battery is used to monitor the charging process, and a cascaded PI (proportional-integral) controller is also employed. is being charged in CC-CV mode [26]. When compared to other BL isolated designs—

like the Luo, zeta, CSC, and mostly Cuk configurations—that use two identical converters, this topology provides a reduced number of components. The recommended charger has the following features and advantages: 1) A new topology is proposed for the BL buck-boost converter that is isolated, which uses fewer components overall than the BL Cuk topologies that are isolated. 2) During two line cycles, the Cuk and SEPIC procedures share a single output inductor, as shown in Figure 2(a)-(b). in order to attain high power density.

The third advantage over BL standalone Cuk converters is the efficiency, which is greatly sought after, because to the decreased number of components.

Since transitioning to discontinuous mode (DCM) operation necessitates very tiny magnetizing inductances, resulting in even less magnetic weight, the desired cost reduction is accomplished. Incorporating low-side switches, line didoes, and basic control makes the suggested design simply implementable. Because of its improved grounding arrangement, the suggested converter had superior EMI performance than the ones that were later exhibited ([29], [30] and [32]-[36]). Because of this, constructing the circuit becomes much easier. Even when the mains voltage varies, our 780 W BL isolated converter-fed charger prototype guarantees seamless EV charging in both phases. High PQ indices are indicative of chargers that function well in steady state and over a broad variety of line voltages and loads.

## II. LITERATUR SURVEY

"Power electronics challenges in electric vehicles," in Proceedings of the IEEE International Electrotechnical Conference 1993, pages 701–706, written by C. Chan and K. Chau.

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Along with the fast advancements in electric vehicle technology, there has been a noticeable uptick in efforts to decrease energy use and safeguard the environment. The long-awaited arrival of affordable, practical electric automobiles is something that many are hoped will happen in the 1990s. With a focus on the outcomes of the lightning-fast advancements in electric motors and power electronics, this article offers a brief summary of the current and future of electric vehicle propulsion systems. In this piece, we'll examine the power electronics issues plaguing electric vehicle (EV) components including electric brakes and battery chargers. The essay delves into the anticipated growth of the electric vehicle sector in the next years and the potential consequences of EVs [1].

*B.* Paper presented at IEEE MWSCAS'16 by Tar and A. Fayed titled "An overview of the fundamentals of battery chargers"

.Included in this study's evaluation of the domain are topics such as charging algorithms, circuit implementation of switching and linear battery chargers, and related disciplines. Starting with the most fundamental aspects, we will go over how a battery works when charged, discharged, and in an open circuit. What follows is a high-level review of the pulse charging method, as well as an explanation of the Constant-Current Constant-Voltage (CCCV) scheme and its operation. Along with general charging problems, we will also go over issues specific to Lithium Ion (Li-Ion) batteries. We next build the CCCV charging mechanism using switching and linear circuits. Methods for balancing cells, multi-cell chargers, and fuel measurement circuits for batteries are discussed in the next section [2]. According to an article published in May 2013 by M. Yilmaz and P. T. Krein in the IEEE Transactions on Power Electronics, "Review of battery charger topologies, charging power levels, and infrastructure for plug-in electric and hybrid vehicles," the subject matter is "battery chargers."

. Check out this post for a rundown of where things stand in terms of charging capacity, battery chargers, and hybrid and plug-in electric car infrastructure. There are on-board and off-board charger systems, and the power flow direction may be either bidirectional or unidirectional. Unidirectional charging is an excellent choice as it simplifies communication concerns while reducing hardware demands. It is possible to charge batteries in both directions and then feed that energy back into the grid. Space, weight, and cost are the primary reasons why most on-board chargers have limited power capabilities. One solution is to include them into the electric powertrain. The availability of charging infrastructure decreases the need for, and the expense of, on-board energy storage. When on the go, you may choose between conductive and inductive charging methods. Because its design is not constrained by physical constraints, an off-board charger allows for a faster charging rate. Levels 1, 2, and 3 of fast power, main power, and convenience are covered, in that order. Things like roadbed charges and other future-oriented subjects are covered. Research, comparison, and assessment of different power level chargers and infrastructure configurations are based on a number of criteria, such as equipment, equipment cost, charging time and location, and power [3].

S. S. Williamson, A. K. Rathore, and F. Musavi published an article in May 2015 in the IEEE Transactions Industrial Electronics, volume 62, number 5, pages — Presenting the current state-of-the-art in electric transportation industrial electronics and future obstacles 3021-3032.

.This article looks at the present and future of industrial electronics research in the context of the inevitable electrification of transportation. The primary emphasis is on the drivetrain components of plug-in hybrid electric vehicles (PHEVs). The article delves into topics such as power electronics, energy storage, traction motor drives, and charging as they pertain to electric vehicles (EVs). In order to increase the service life of series-connected lithium-ion (Li-ion) batteries, it is possible to balance the voltages of the individual cells. Also included is a detailed synopsis of all the paperwork, specs, and regulations that pertain to electric vehicle and plug-in hybrid battery chargers. We take a look at the front ends of traditional PHEV and EV ac/dc charger converters, as well as DC/DC topologies that are isolated. As part of its conclusion, the research examines the topologies and designs of electric vehicle propulsion systems as well as efficient bidirectional DC/DC converters. Additional advantages include their innovative methods for controlling DC/AC inverters in electric vehicles. Battery voltage, capacity, and range are the three primary criteria around which the designs are built [4].

"Evaluation and Efficiency Comparison of Front End AC-DC Plug-in Hybrid Charger Topologies," published in March 2012 by IEEE Transactions Smart Grid, was written by F. Musavi, M. Edington, W. Eberle, and W. G. Dunford.

.Every charging system for plug-in hybrid electric vehicles (PHEVs) must include a small and efficient front-end ac-dc converter. Several topologies for front-end ac-dc converters are compared and contrasted in our topology survey for PHEV battery chargers. Due to their low cost, high density, efficiency, and power factor, boost power factor adjustable converters are the focus of this topology research. Using a universal ac input voltage as a starting point, the article describes five prototype converters that can convert it to 400 V dc. The paper goes on to evaluate and explain the pertinent experimental results. When supplied with a 120 V and 1.44 kVA or 1.92 kVA power source, the phase-shifted semi-bridgeless PFC boost converter can work with level I home auto charging systems in North America. Potentially ideal for use in level II charging applications in homes throughout Europe and North America are bridgeless interleaved PFC boost converters that can draw power from a single 240 V supply and provide three distinct power outputs (3.3 kW, 5 kW, and 6.6 kW) [5].

Volume 28, number 6, pages 2629-2634 of the IEEE Transactions on Power Electronics published an article by H. Choi titled "Interleaved Boundary Conduction Mode (BCM) Buck Power Factor Correction (PFC) Converter" in June 2013.

Throughout the whole load and line range, our power-factor-correction buck converter demonstrates remarkable efficiency when paired with the boundary conduction mode. The adaptive master-slave interleaving technique keeps the operational phase inverted, even if it's just brief. One that isless bulky differential mode line filters may be made by connecting two buck converters in parallel; this will double the ripple frequency and halve the input current ripple. By examining line current harmonic distortion, one may ascertain the permissible range of output voltages in relation to harmonic standards. An 80 V output and a 300 W universal line experimental prototype verifies the circuit's functionality and performance. Across the whole universal line range, the claimed efficiencies remain above 96% even while operating at 20% of maximum load. It is still possible to achieve 94% efficiency even while running at 10% of full load. It has also been verified verified compliance with IEC61000-3-2 (class D) [6] for input current harmonics.

## III. EXISTING SYSTEM

In pictures 4 and 5, you can see the recommended electric car charger in action, both during setup and operation.2 During the positive half cycle, the Li1-S1-Do1-Lo1-Dp Cuk converter cell is active. Contrarily, the negative half line emerges during the active state of the second cell for Cuk conversion, Li2-S2-Do2-Lo2-Dn. In order for the two Cuk converter cells to function in CCM, the input inductors Li1 and Li2 must be selected. Due to the arrangement of the output inductors Lo1 and Lo2, the converter may enter DCM in a single switching cycle, even if the output diode current, iD, decreases to zero. C1 and C2 are selected as intermediate capacitors based on their voltage, which remains constant during the switching time. For the sake of simplicity and economy, we'll be using a single pulse width modulation (PWM) signal to operate switches S1 and S2.

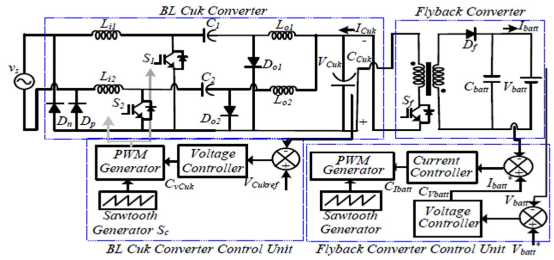



Fig.4Existing BL Cuk Converter based EV Charger Configuration

This innovation uses a single voltage sensor operating under single loop voltage feedback to regulate the PFC Cuk converter's output voltage, significantly lowering charger costs. The efficiency with which the flyback converter runs the CC and CV charging stages is dependent on its DCM operation with a cascaded PI controller, which manages the battery charging instructions.

## IV. PROPOSED SYSTEM

As demonstrated in Figure 5, the BL isolated Cuk-SEPIC converter has the ability to enhance PQ-based battery chargers. The proposed BL Cuk-SEPIC converter maintains unity power factor operation while operating at steady state over a broad range of voltages and loads by operating in DCM. A two-phase half-cycle battery charger for Cuk and one for SEPIC were combined to create the suggested configuration. The Cuk converter normally conducts the following voltages and currents: S1, an intermediate capacitor C1, an output diode Do1, a transformer's magnetizing inductance Lm1, and the positive half line. Nevertheless, with the help of the following components—a semiconductor switch S2, an intermediate capacitor C2, and a transformer magnetizing inductance Lm2—the SEPIC converter may function on the negative half line.

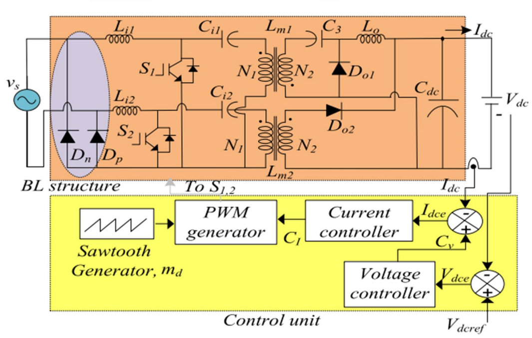



Fig. 5 Proposed isolated BL Cuk–SEPIC converter based EV charger circuit

Here we provide the theoretical analysis of the suggested BL isolated converter operating at steady state.

### a) Operation of BL Isolated Converter:

Every switching cycle ends with a voltage drop across the transformer's magnetizing inductance, Lm1,2, due to the design of the suggested BL isolated converter in DCM. The isolated converter, three different modes of operation, and the key operations that go along with them are shown in Figures 6 and 7. During the positive half of a cycle, the Cuk mode is used., whereas the SEPIC mode is employed during the negative half. On the level-I interval [0, 1], you'll find switch S1, which must be activated to enter this mode. An exponential rise in current is seen when the input inductance Li1 starts to charge from the source. The decrease in the intermediate capacitance voltage, vC1, when the magnetizing inductor is increased is seen in Figure 6(a)., Lm1, begins to store the energy it receives. Intentionally biased in the opposite direction over this whole time is the output diode Do1. The energy transfer capacitor (C3) may discharge thanks to the output inductance (Lo), which also charges the battery. Lo, Li1, and Lm1 are the currents that are

$$i_{L_{i1}}(t) = I_{Li1}(t_0) + \frac{V_{\text{in}}}{L_{i1}}(t - t_0) \text{ for } t_0 \le t \le DT_s \quad (1)$$

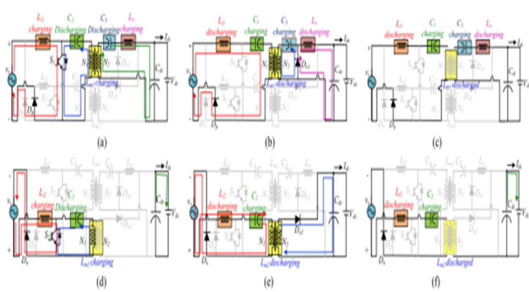


Figure 6: Three modes of operation for the new BL isolated converter: The first three intervals in the Cuk configuration (+ve cycle) are (a) to (c), whereas the second three intervals in the SEPIC configuration (−ve cycle) are (d) to (f).

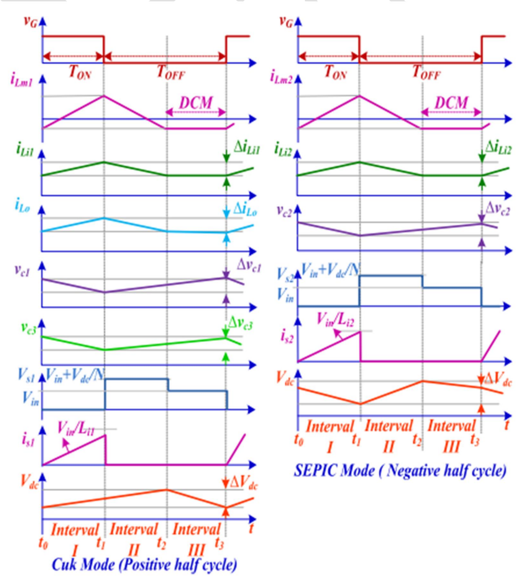



Figure 7 shows the waveforms of Cuk and SEPIC converters operating in various modes during a single switching cycle.

$$i_{L_{m1}}(t) = I_{L_{m1}}(t_0) + \frac{V_{C1}}{L_{m1}}(t - t_0) = I_{L_{m1}}(t_0) + \frac{V_{in}}{L_{m1}}(t - t_0) \quad (2)$$

$$i_{L_o}(t) = I_{L_o}(t_0) + \frac{nV_{C1} + V_{C3} - V_{dc}}{L_o}(t - t_0)$$
$$= I_{L_o}(t_0) + \frac{nV_{in}}{L_o}(t - t_0). \quad (3)$$

In order to get the switch current iS1 (t), we use (1)-(3) as

$$\begin{aligned} i_{s1}(t) &= i_{Li1}(t) + i_{Lm1}(t) + ni_{Lo}(t) \\ &= I_{Li1}(t_0) + I_{Lm1}(t_0) + nI_{L_o}(t_0) \\ &\quad + \frac{V_{in}}{(L_{i1} + L_{m1}) \parallel (L_o/n^2)}(t - t_0) \\ &= I_{Li1}(t_0) + I_{Lm1}(t_0) + nI_{L_o}(t_0) \\ &\quad + \frac{V_{in}}{(L_{i1} + L_{m1}) \parallel (L_o/n^2)} DT_s \end{aligned} \quad (4)$$

$$i_{Do1} = 0 \quad (5)$$

where D is the Cuk-SEPIC converter's turn-on ratio that, when set to n, ensures a 65 V output voltage regardless of the transformer's turn-on ratio (N2/N1 = n). Ts stands for a whole switching time, Vin for iLo, which stands for the current flowing through Lo, and the rated peak grid voltage.

**b) Control of Proposed Converter**

The two semiconductor switches that make up this proposed BL isolated converter-based charger work in tandem for a single switching cycle. Both PFC switches are guaranteed to receive identical pulses by use of a cascaded PI controller. A voltage PI controller is used to charge the battery to its full state of charge (SOC), whichallows for lower current charging and the maintenance of CC via the battery. While running the CC profile, the cascaded current controller (PI) receives an error signal Idce after comparing the current Idc measured from the battery to the reference current (Idcref). The error signal, Idce, may be mathematically described at any time k:

$$I_{dc_e}(k) = I_{dcref}(k) - I_{dc}(k). \quad (5)$$

Whenin CC mode, the voltage PI controller is used to generate the battery current reference, Idcref. The present-day PI controller furthermore generates a second control signal, CI. Looking at this data at a certain sample point k reveals the control signal, CI, as

$$\begin{aligned} C_I(k) &= C_I(k-1) + K_{pI}\{I_{dce}(k) - I_{dce}(k-1)\} \\ &\quad + K_{iI} I_{dce}(k) \end{aligned} \quad (6)$$

where KpI and KiI are the current controller's PI gain constants. While in CC mode, the battery will maintain a steady current demand from the mains until its state of charge (SOC) reaches 80%. At 80% SOC, the voltage PI controller takes over and the battery control goes into CV mode. There is a decrease in grid current when a battery reaches its full charge since the battery can only carry so much current. Measuring and comparing Vdc, the voltage at the battery, to Vdcref, the voltage at the reference dc voltage, is necessary for control operation in CV profile. Specifically, at the kth sampling instant, the comparator generates Vdce,where V is the voltage error, as

$$V_{dce}(k) = V_{dcref}(k) - V_{dc}(k). \quad (7)$$

At every given instant k, the voltage error (Vdce) is sent into the voltage controller, and the voltage control signal (Cv) is produced as an output.

$$C_v(k) = C_v(k-1) + K_{p_v}\{V_{dc_e}(k) - V_{dc_e}(k-1)\} + K_{iv}V_{dc_e}(k) \quad (8)$$

where Kpv and Kiv are the values of the tuned PI constants used by the current controller. In order to generate the PFC switch gate signals, the control signal CI is compared to a sawtooth wave (md) utilizing examples like as

$$\begin{aligned} For\, v_s \geq 0; & \begin{Bmatrix} if m_d \leq C_I then PWM_{S1} =' ON' \\ if m_d \geq C_I then PWM_{S1} =' OFF' \end{Bmatrix} \\ For\, v_s \leq 0; & \begin{Bmatrix} if m_d \leq C_I then PWM_{S2} =' ON' \\ if m_d \geq C_I then PWM_{S2} =' OFF' \end{Bmatrix} \end{aligned} \quad (9)$$

To implement intrinsic PF correction in the vicinity of abrupt line voltages, the switches need pulses PWMS1 and PWMS2. The suggested converter's DCM-based architecture also gives it an inherent UPF operation. Compared to an IL converter, the proposed BL isolated converter has significantly easier control since the two switches are physically separated yet still utilize the same pulses. During the positive half of the cycle, one set of switches is active, and during the negative half, another set is engaged. Perhaps the understanding could be enhanced if the writers could provide more details regarding the independent operation of a single cell in either the positive or negative half cycle, the impact of connecting the line diodes Dp and Dn on the other cell's operation, and the consequences of simultaneously pulsing two switches in a BL converter (free of phase delay). A more detailed description of the present trajectory may be seen in Figure 8(a) and (b).

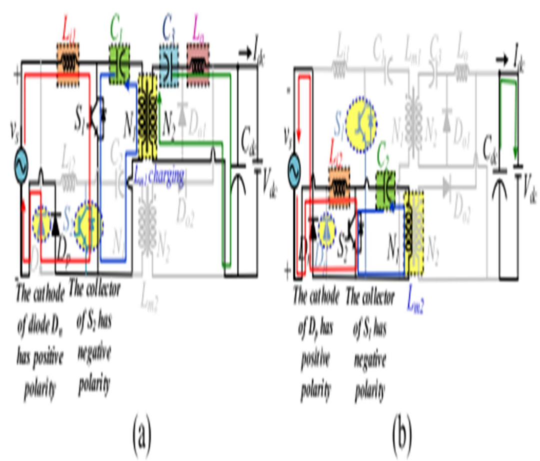



Figure 8. (a) The process is being started in positive half mode, also known as Cuk mode, with the inductor set to output. (b) In the negative half operation, when the diode is used as the output (SEPIC mode).

**V.SIMULATION RESULTS**

**1)EXISTING RESULTS**

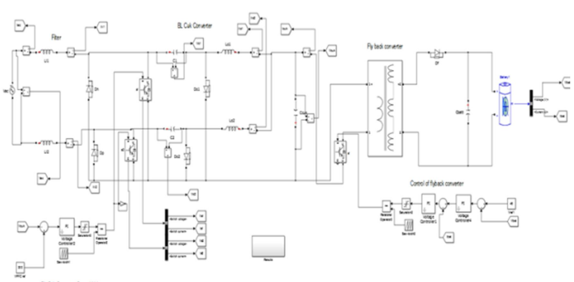


Fig.9 A schematic of the proposed BL Cuk Converter-based EV charger setup in MATLAB/SIMULINK

**Case 1:Enhanced AC Mains Power Quality Parameters**

**A)Improved Power Quality at nominal source voltage**

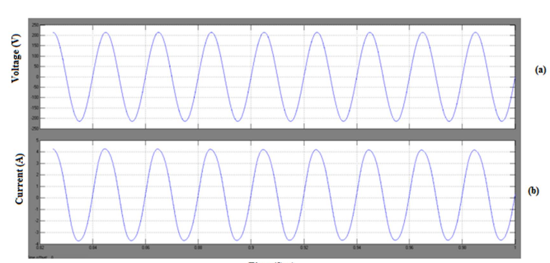



Fig.10(a)Mains voltage (b)Mains current

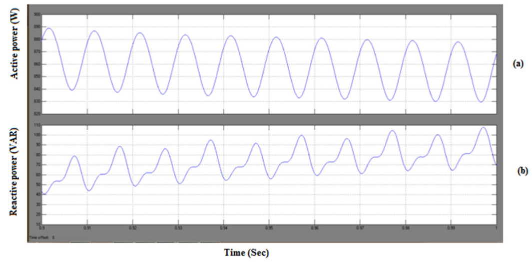



Fig.11 (a)Active power (b)Reactive power

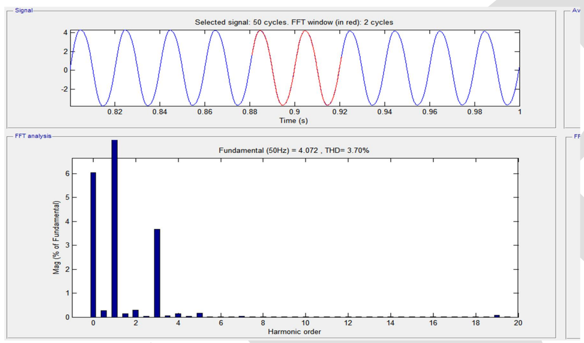



Fig.12 THD of source voltage = 3.70%

**B) Power Quality Improvements for Unexpected Decreases in Source Voltage**

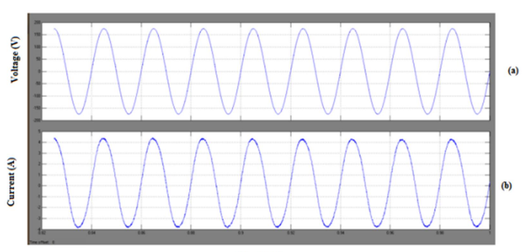



Fig.13 (a)Mains voltage (b)Mains current

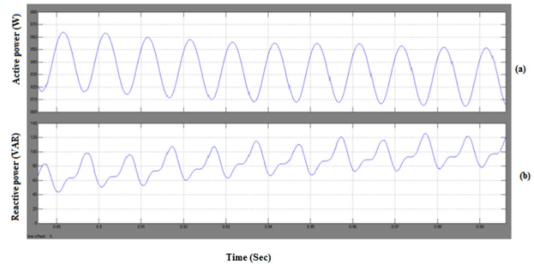



Fig.14(a)Active power (b)Reactive power

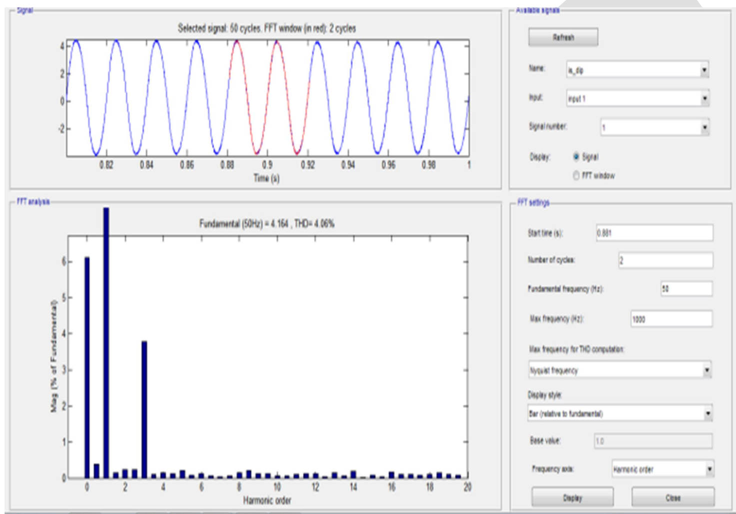



Fig.15 THD of source voltage ( sudden dip in source voltage) = 4.06%

**C) Improved Power Quality for sudden rise in source voltage**

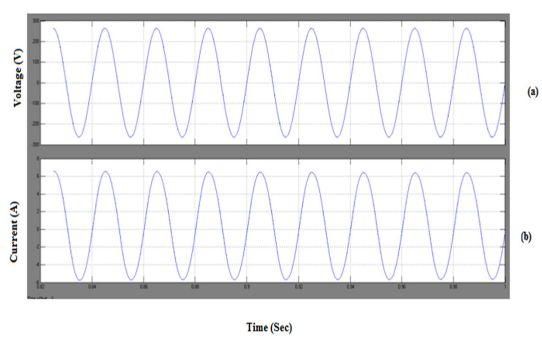



Fig.16(a)Mains voltage (b)Mains current

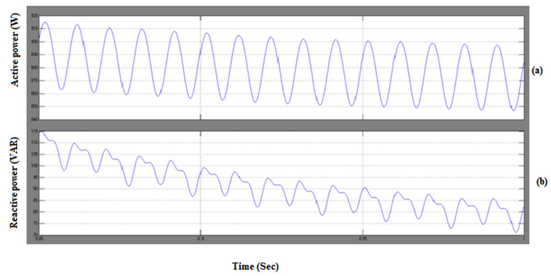



Fig.17(a)Active power (b)Reactive power

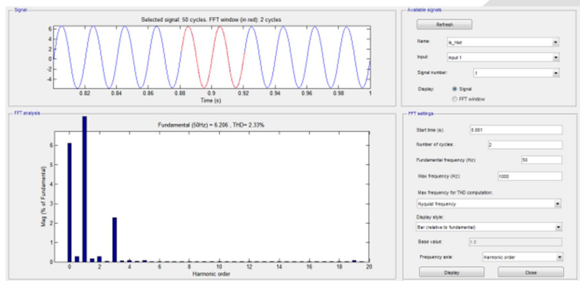


Fig.18 THD of source voltage (sudden rise in source voltage)= 2.33%

**2) EXTENSION RESULTS**

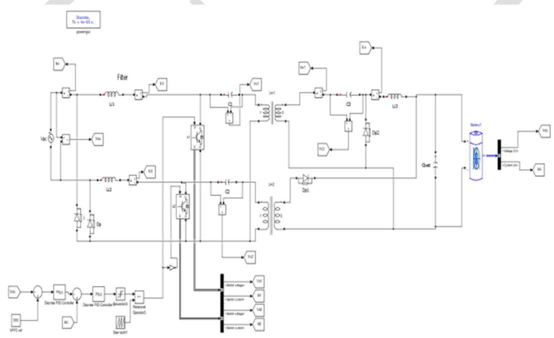
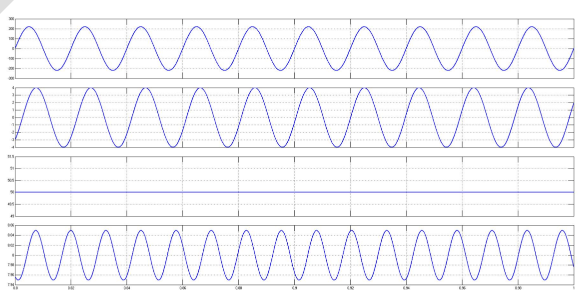
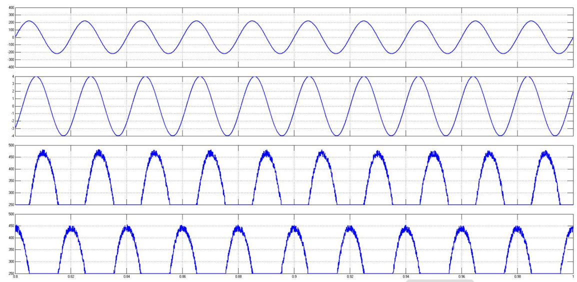


Fig. 19. Electric vehicle charging circuit based on a proposed isolated BL Cuk-SEPIC converter, as shown in MATLAB/SIMULINK

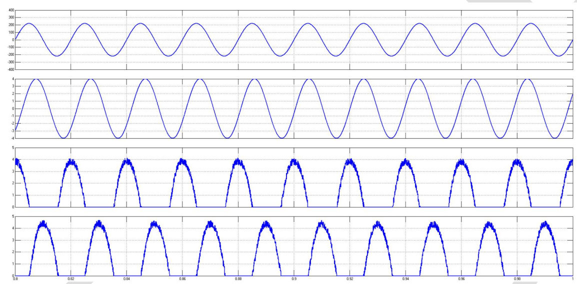


(a)

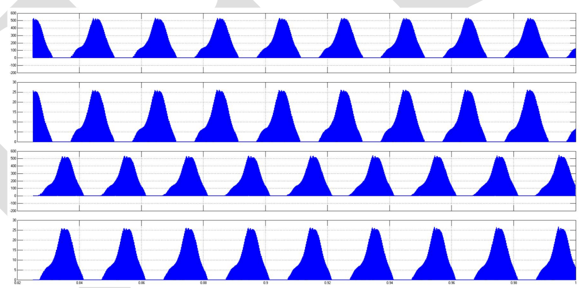
At the rated grid voltage, the isolated BL Cuk-SEPIC converter operates as shown in Figure 20. performance of unity PF



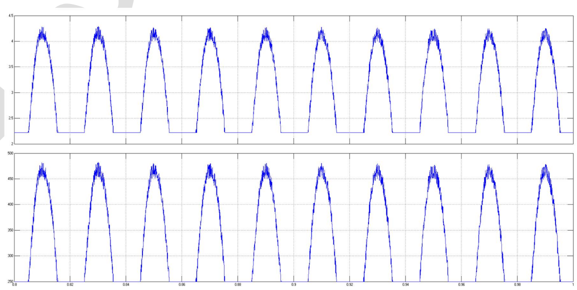
(a)



(b)



(c)



(d)

At steady state, the following variables are measured in Fig.21: (a) voltages on the input side of the intermediate capacitors, (b) currents through the input inductor, (c) voltages through the output inductor and capacitor C3, and (d) stress on the PFC switch and voltages.

ISSN 2277-2685

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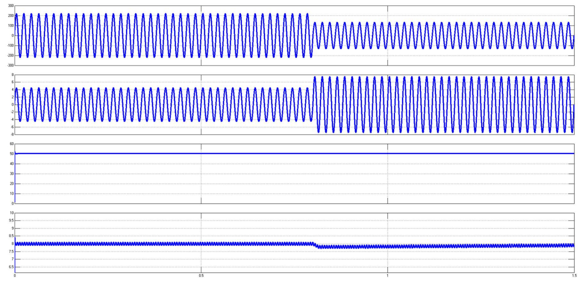
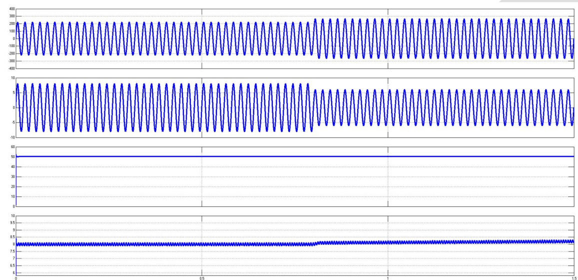
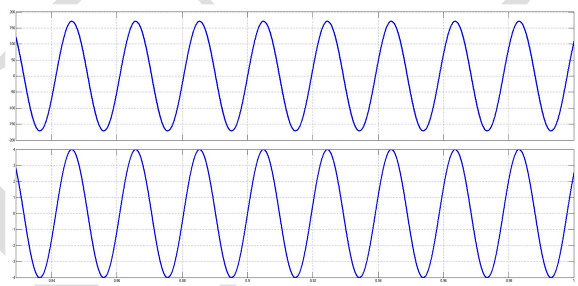


(a)

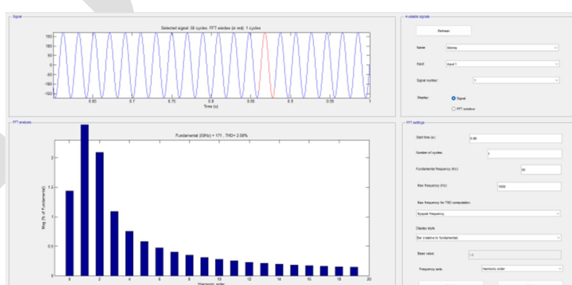


(b)

Figure 22: Power factor correction (PFC) functioning of the proposed EV charger during the following voltage transitions: (a) from 220 to 160 V and (b) from 220 to 260 V

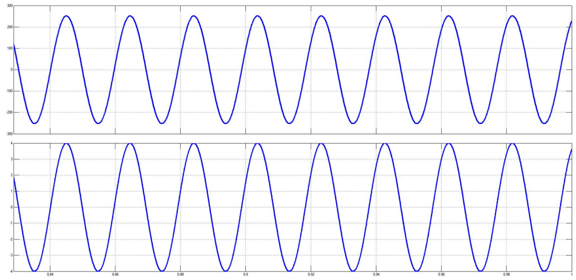


(a)

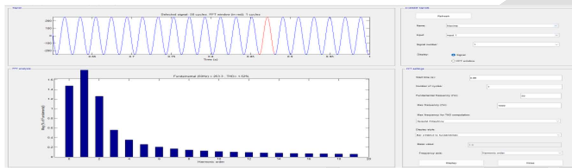


(b)

Fig.23 (a)–(b) Proposed charger at sudden dip of grid voltage.

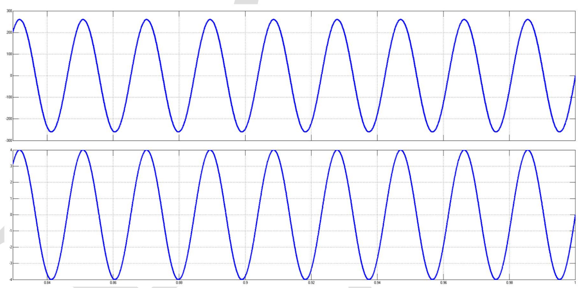


(a)

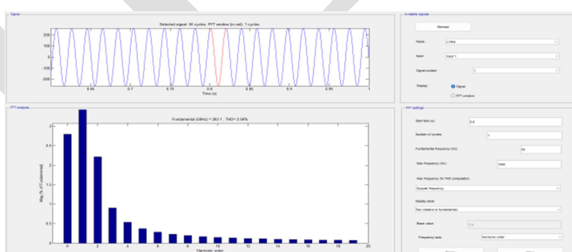


(b)

Fig.24 (a)–(b)proposed charger at rise of grid voltage



(a)



(b)

Fig.25 (a)–(d) Proposed charger at reduced load and normal source voltage (during CV profile).

**COMPARISION TABLE**

| | **Existing system** | **Extension system** |
|---|---|---|
| **THD of Source voltage at normal condition** | **3.70%** | **2.66%** |
| **THD of Source voltage at sudden dip of grid voltage** | **4.06%** | **2.80%** |
| **THD of Source voltage at sudden** | **2.33%** | **1.52%** |

| | | |
|---|---|---|
| **rise of grid voltage** | | |

**CONCLUSION**

An improved electric vehicle battery charger was created and tested using a PQ-based BL isolated Cuk-SEPIC converter in DCM. By incorporating Cuk and SEPIC converters into each half cycle of the singlestage converter, this design reduces the number of components while increasing efficiency. The result is a smaller and cheaper charger. Also, the output current is more consistently maintained when the Cuk side of the output inductor is used for both cycles rather than the SEPIC converter. Since the two devices get identical pulses, operating and controlling the gate are both made simple when the UPF is running. In particular, IEC 61000-3-2 regulations lend credence to the suggested charger's functionality across the board in terms of line and load working range. We measure the line side PF as one for every change in the input voltage, and we record the line current in phase with the line voltage. Grid current distortion in the CC profile is 4.1%, 3.4%, and 4.3%, but in the CV profile it is 6.3%. Therefore, the preferred enhanced PF based BL isolated converter is the best and most economical option for electric car chargers that are not integrated with the vehicle.

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