

# DESIGN AND SIMULATION OF BRIDGELESS CUK CONVERTER FOR EV CHARGER TO INCREASE THE POWER QUALITY

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## ABSTRACT:

A Cuk converter based EV (Electric vehicle) battery charger is designed and developed in this work. It supplies affordable as well as high-power density-based billing service for EV. This charger includes much less variety of tools running over one switching cycle, which minimizes the additional transmission loss incurred by a diode bridge rectifier of conventional battery charger and hence, enhances the charger effectiveness. Throughout constant present and also consistent voltage regions, the commands for battery charging are synchronized by a flyback converter. The included benefit of recommended geography is that the undesirable capacitive combining loophole is eliminated, as well as unwanted conduction via the body diode of non-active button in formerly created BL Cuk converter is prevented. This substantially boosts the charger effectiveness. For the consistent present and also continuous voltage (Curriculum Vitae) charging, the commands are synchronized by a flyback converter. The suggested charger is examined to demonstrate the improved power quality. Test results validate the better performance of the recommended battery charger.

**Keywords:** *Electrical vehicle, cuk converter, CC, flyback converter, battery charging.*

## 1. INTRODUCTION

Recently, a number of vast towns within the world develops safety and additionally encourages promoting a surroundings-friendly truck, commonly Electric Vehicles (EVs) in conjunction with Plug-In Crossbreed EVs (PHEVs). In order to boost up its employer putting in place within the market, it is required to get a excessive-performance battery and its charger development, that's the important thing stamina supply of the cars. Among of severa batteries, Nickel Steel Hydride (Ni-MH), Lithium-Ion (Li-Ion) and also Li-Polymer batteries are usually getting used to have an awful good deal better electricity thickness, overall overall performance, safety and protection in conjunction with rate, in addition to

also the batteries efficiencies are boosting. There are 2 styles of battery chargers for EV application. One is a standalone kind which might be contrasted to an oil terminal targeted at fast fee. The various different is an onboard kind which can be appropriate for gradual-transferring fee from a residence electricity electrical outlet all through night time, while name for of electric power is decreased. Slow charge over night is really treasured for an electric energy distribution device. Especially, an on-board battery charger wishes to be little similarly to mild with an goal to make high-quality use energy effectiveness and the space blanketed consistent with charging. For that purpose, a high frequency converting method is wanted to

reduce length of easy additives, and additionally to reduce reworking losses delivered on with the aid of manner of the excessive frequency switching. The battery billing algorithm attitude, many researches are completed to have a high-quality deal far higher battery charging additives, as a circumstances, Consistent Voltage (Curriculum Vitae), Constant Existing (CC), CC-CV, stamina manage as well as pulse shot strategy and so forth, considering lifecycle, defense in addition to safety and security and further performance of the batteries. The broadly speaking all of On-board battery chargers is diode bridge rectifier abided by PFC circuit in an initiative to enhance energy detail of enter cutting-edge and output voltage regulation. Decreased strength thing and additionally harmonics have a harmful outcome on power top class derogatory trendy gadget performance in energy systems. To conquer these scarcities, AC/DC circuits with lively longevity detail correction (PFC) have clearly been hooked up. This PFC circuit's utilization a bridge adhered to.

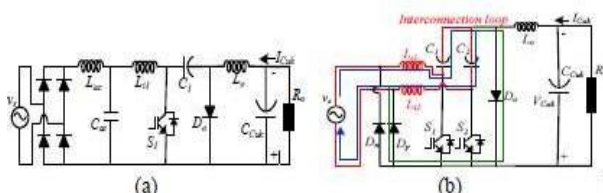


Fig.1.1. Different BL Cuk Converters.

## 2 LITERATURE SERVEY

C. Chan and K. Chau, "Power digital devices challenges in electrical vehicles," in Proc. IEEE IECON 'ninety three., pp. 701-- 706. In a globe wherein energy conservation as well as environmental control is increasing issues, the development of electrical vehicle cutting-edge era has truly taken a speeded up pace. The 1990s

are possibly to the years in which the lengthy-sought sensible, within your means electrical Heavy vehicle will actually begin to be recognized. The paper offers an overview of existing condition and additionally future fads in electrical vehicle propulsion structures, with attention at the effect of speedy development of electric cars and also electricity electronics. The problems of energy digital devices in other components including battery chargers, electrical brakes as well as different critical programs of electrical vehicle are looked at. The market size of electrical vehicle inside the coming years and additionally the possible electric powered car affects are discussed [1].

B. Tar as well as A. Fayed, "A summary of the ideas of battery chargers," IEEE MWSCAS' sixteen, pp. In this paper gives an introduction of the fundamentals of battery chargers, inclusive of charging formulation as well as circuit execution of linear and also converting battery chargers. Initially, the standard process of batteries is described beneath open circuit, discharging, and also charging situations. Next off, a creation of the heart beat billing scheme and its execution exists, complied with by a précis of the Constant-Current Constant-Voltage (CCCV) charging plan in addition to the unique considerations concerning charging Lithium Ion (Li-Ion) batteries. Linear and additionally converting circuit realizations of the CCCV billing scheme are after that furnished, adhered to by using an creation of battery gasoline-gauging circuits, multi cellular battery chargers, and also cellular-balancing strategies [2]

M. Yilmaz and additionally P. T. Krein, "Evaluation of battery charger topologies, billing power levels, as well as centers for plug-in electric and additionally hybrid automobiles,"

IEEE Purchases Power Electronic devices, vol. 28, no. 5, pp. 2151-- 2169, May 2013. In this paper evaluation the existing standing and also execution of battery chargers, billing electricity degrees, and also framework for plug-in electric vehicles as well as hybrids. Charger systems are classified into off-board and on-board types with unidirectional or bidirectional power drift. Unidirectional billing limits device needs and streamlines affiliation concerns. Bidirectional charging supports battery strength injection back to the grid. Common on-board chargers restriction strength due to weight, location, in addition to price constraints. They can be integrated with the electrical power to avoid these issues. The accessibility of billing framework reduces on-board power garage demands in addition to fees. On-board battery charger structures can be conductive or inductive. An off-board charger can be designed for high billing charges and is a great deal less constrained with the aid of measurement and weight. Degree 1 (ease), Level 2 (key), and additionally Degree 3 (speedy) power levels are reviewed. Future factors which include roadbed charging are provided. Various energy degree chargers and also infrastructure configurations are offered, in comparison, as well as assessed based totally upon amount of electricity, charging time in addition to location, price, devices, in addition to different aspects [3]

S. S. Williamson, A. K. Rathore, and additionally F. Musavi, "Industrial electronic gadgets for electrical delivery: Present reducing aspect and also destiny difficulties," IEEE Purchases Industrial Electronics, vol. 62, no. Five, pp. 3021-- 3032, May 2015. In this paper the cutting-edge study patterns and destiny issues for commercial digital gadgets related to transportation electrification. Specific

recognition is placed on electric in addition to plug-in crossbreed electric automobiles (EVs/PHEVs) and their crucial drivetrain additives. The paper manages marketplace associated EV electricity garage device troubles, EV charging troubles, in addition to power electronic gadgets as well as grip motor drives problems. The relevance of battery cell voltage equalization for series-related lithium-ion (Li-ion) batteries for prolonged life time is presented. Additionally, an in depth overview of EV/PHEV battery charger category, necessities, and wishes is presented. A variety of traditional EV/PHEV front-give up ac/dc battery charger converter geographies in addition to separated DC/DC geographies is assessed. Lastly, this paper evaluates numerous EV propulsion machine styles and green bidirectional DC/DC converter topologies. Novel DC/AC inverter inflection strategies for EVs are also provided. The styles are based at the battery voltage, capacity, and using variety.

### 3. OVER VIEW OF PROJECT

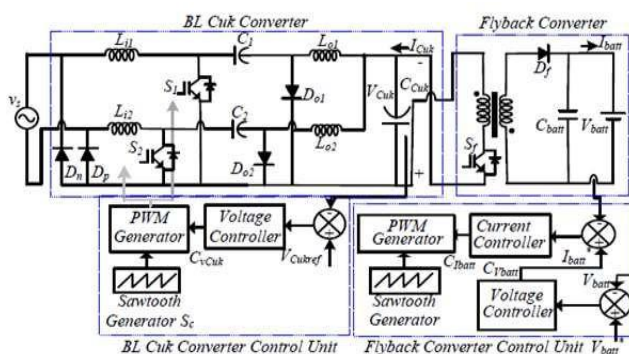
The extensive functions of suggested charger to decrease above worries are summarized as follows.

- The intermediate capacitors are performing individually, in both fifty percents; as a result, distributing losses are removed, which ends up into boosted performance of the battery charger.
- There isn't any return modern-day through the body diode of non-active buttons within the different 1/2 cycle because of used manipulate. For that reason, losses inside the button are reduced.

- The manipulate of the PFC converter is simple thanks to use of precise identical gateway force as well as control circuitry for every and every half of cycles. The result inductors of counselled Cuk converter are developed small sufficient to ensure converter operation in DCM (Discontinuous transmission placing), for that reason, the rate and additionally size of the converter, are decreased.

### 3.1 METHODOLOGY AND DESULTS EXPLANATION

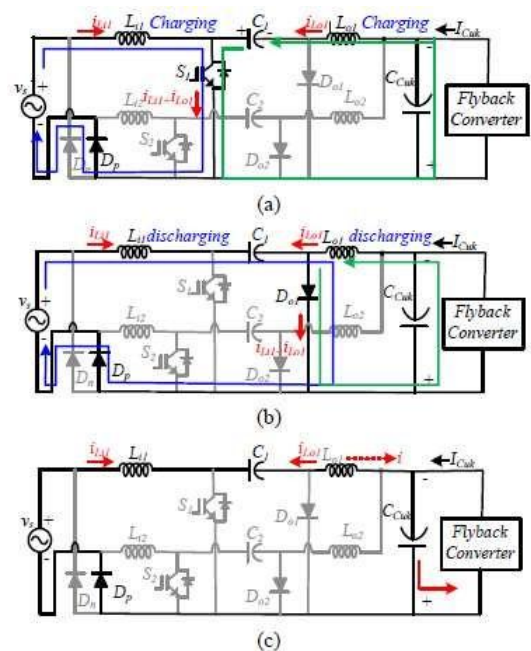
The manager of PFC converter is easy due to use equal gate pressure similarly to control wiring for each half cycles, i.e. Each the buttons S1 and S2 operate with equal vehicle purpose pressure signal, in twist of fate. Simply positioned, as a manner to lower the conduction loss through the frame diode of the non-energetic buttons, an appropriate identical driving force sign and interleaved chauffeur sign can be carried out to manipulate buttons S1 and also S2. As a stop result, losses within the body diode are decreased. The real operating modes are pretty distinct.



**Fig.3.1. Proposed model.**

The enter inductors  $L_{i1}$  and  $L_{i2}$  are selected to perform in CCM for both the Cuk converter cells. However, the layout of end result inductors

$L_{o1}$  in addition to  $L_{o2}$  is made superb which encompass the output diode cutting-edge,  $i_D$  finally ends up being no and moreover the converter enters DCM over one changing cycle. The intermediate capacitors  $C_1$  and additionally  $C_2$  are selected consisting of the voltage during capacitors, is still regular within the direction of the switching length. It deserves to issue out that both switches  $S_1$  and  $S_2$ , are driven making use of the very same PWM sign, which decreases the system expense and also circuit complexity.

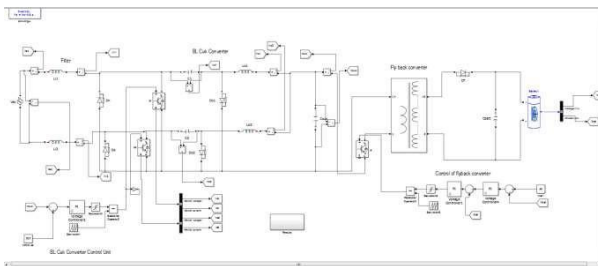


**Fig. 3.2. Circuit Operation of EV Charger with BL PFC Cuk Converter at some stage in favorable 1/2 cycle (a) Mode P-I (b) Mode P-II (c) Setting P-III.**

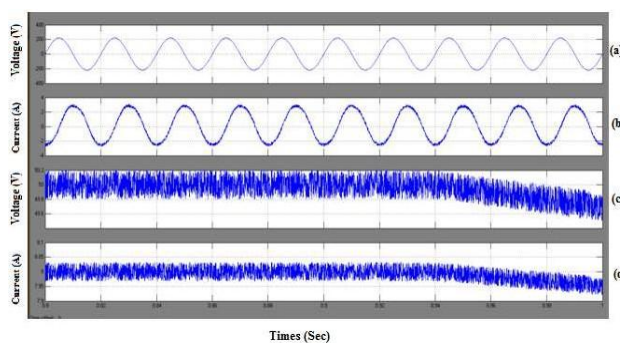
This implies that in +ve 1/2 of cycle operation, at the identical time as switch  $S_1$  gets on, the current-day blood circulations no extra fine with  $D_p$  however likewise part of this present returns through the shape diode of switch  $S_2$  in a comparable manner to inductor  $L_{i2}$ . Likewise, even as button  $S_1$  is block, the cutting-edge now not essentially activities via the road diode  $D_p$

via genuinely very last results diode Do1, but some existing similarly undertakes inductor Li2 the use of frame diode, Dp. Similar example takes place for the-- ve half cycle machine with transfer S2. This takes location because of the single PWM indicator being executed to fine one of the switches throughout one fifty percentage i.e S1 or S2 and furthermore high-quality switch is dispersed for different half of virtually. As a cease result, the circuit generally sustains some losses throughout the body diode of the non-lively button (S1 or S2) because of in thing move again cutting-edge-day flow thru it within the course of the respective fifty percent of cycle technique, that is sizeable.

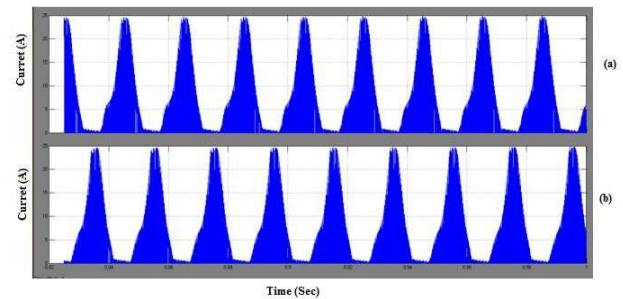
### 3.2 SIMULATION RESULTS:



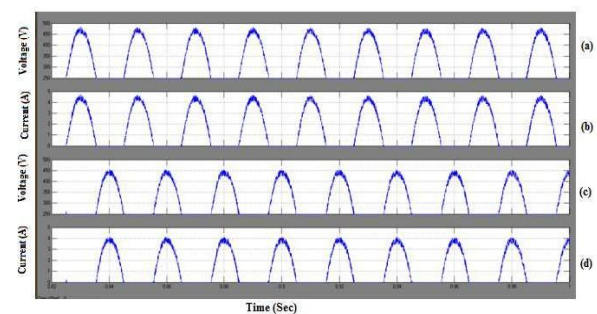
**Fig.3.3. Simulation circuit.**



**Fig.3.4. Source and Battery side quantities.**



**Fig.3.5. Output inductor current (a)ilo1=28A (b) ilo1=28A.**

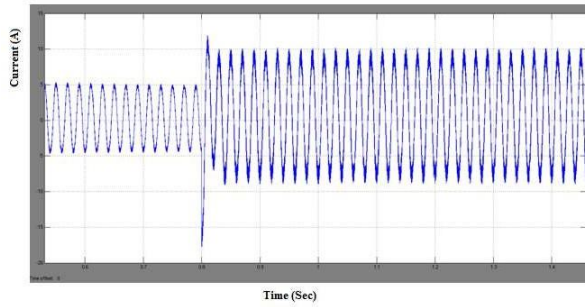


**Fig.3.6. charger Capacitor voltages in CCM (no return current through Li1 and Li2 in -ve and +ve half respectively).**

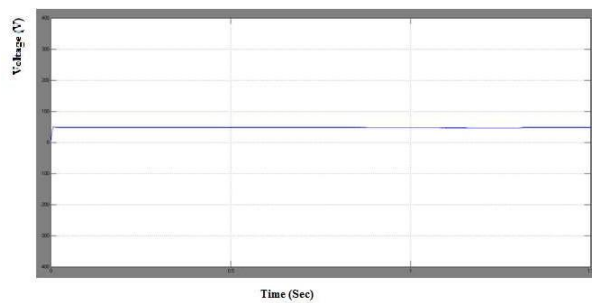
The voltage and current stress through the PFC switches  $S1$  and  $S2$  during the respective half cycle, with proposed BL Cuk converter and with BL converter topology-1 in fig. 3.3. to fig.3.5. It is clear from the recorded switch current waveforms that switch current  $is1$  and  $is2$  has no effect of circulating current flow during the +ve and -ve half cycle operation. Therefore, it is evident that proposed BL Cuk converter has no circulating current flowing through the input inductors  $Li1$  and  $Li2$  as there is no interconnection of intermediate capacitors to form circulating current loop, as mentioned earlier in the topological discussion in Fig.3.5.

### Performance of Charger at Wide Fluctuations in Input Voltage:



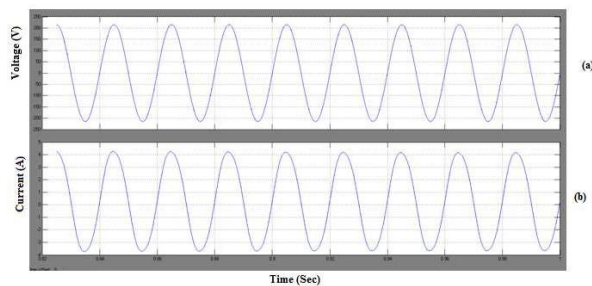


**Fig.3.7.** Mains current increased AC mains current (10A).

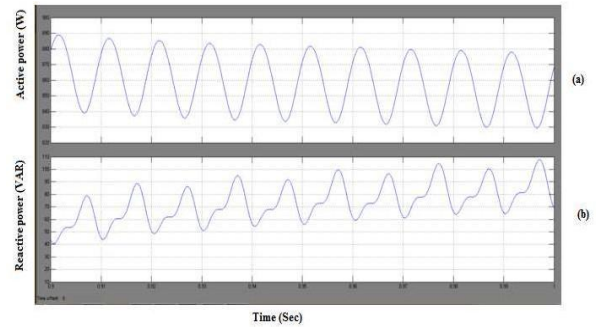


**Fig.3.8.** Battery voltage (50V).

### Improved Power Quality Parameters at AC Mains:

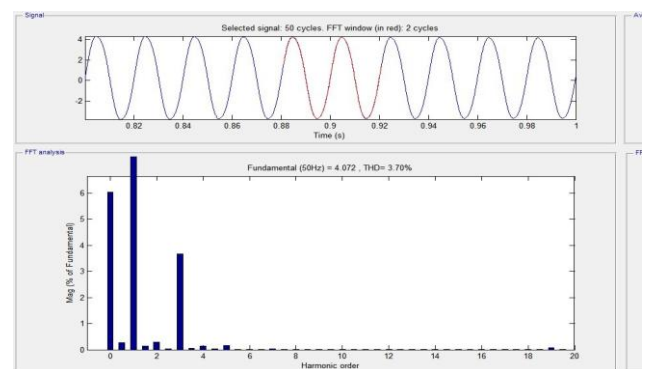


**Fig.3.9.** Main voltage and currents.

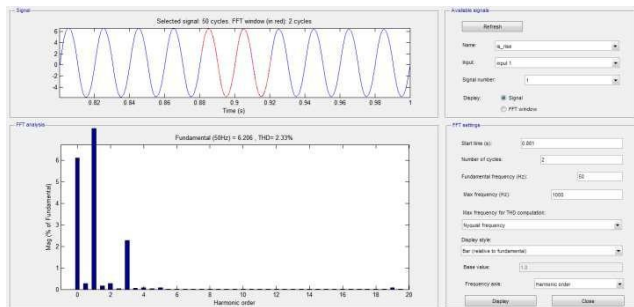


**Fig.3.10.** (a)Active power (b)Reactive power.

Similarly, there is no return current seen through *Li1* during -ve half cycle, unlike previous BL Cuk converter topology-3 with conventional control, as shown in Fig. 3.6. It is worth to note that BL Cuk converter with conventional control has small amount of current flowing through *Li2* during +ve half line, which is obtained due to the path provided by the body diode of inactive switch *S2* during +ve half. Similarly, *Li1* also shows small amount of current flowing through it during -ve half line as body diode of inactive switch *S1* is conducting during this instant. Therefore, the converter efficiency is seen to be low due to losses incurred by the body diode of inactive switch show in Fig.3.9 and fig.3.10.



**Fig.3.11.** THD of source voltage = 3.70%.



**Fig.3.12. THD of source voltage (sudden rise in source voltage)= 2.33%.**

Therefore, the converter rejects any transients in the mains voltage to maintain DC link voltage of PFC converter constant, to provide an uninterrupted charging to the battery. To maintain the, power flow of the charger during the perturbation period, sudden corresponding dip or rise in source current, is seen for 50% rise and dip in grid voltage, respectively. The mains current is seen to be sinusoidal with low current THD and a stable charging operation is observed throughout the mains voltage variation range.

#### 4. CONCLUSION

The progressed PQ based EV battery charger is proposed with BL Cuk converter being composed much less variety of engaging in additives over single changing cycle. The recommended PFC Cuk converter makes use of incredible PFC attributes in DCM mode using single voltage responses manipulate. As an end result, the dimensions of the battery charger are diminished. The added advantage of advocated geography is that the unwanted capacitive combining loophole is eliminated, as well as unwanted transmission through the body diode of non-active switch in formerly superior BL Cuk converter is prevented. This dramatically boosts the battery charger effectiveness. The proposed battery charger has virtually demonstrated adequate billing features in some

unspecified time in the future of regular nation and moreover over 50% version in grid voltage. However, the PQ assessment of endorsed battery charger is received in keeping with the IEC 61000-three-2 standards over big enter voltage array. Consequently, the counseled battery charger provides the feasible EV billing preference for stepped forward power high first-rate and additionally effectiveness.

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