# Electric Vehicle On-Board Fast Charging Through Converter Maximum Switch Utilization

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***Abstract***. This work deals with a single-phase on-board fast charger for electric vehicles (EVs). One of the key parameters to restrict the on-board fast charging is the converter power density. Almost all the existing single-stage and two-stage converter topologies in discontinuous conduction mode are limited to slow charging due to high current stress. Further, these converters, regardless of conduction modes, experience high voltage stress across semiconductor switches due to the interaction between filter and circuit inductances that limit their EV charging rate. To overcome these challenges, in this article, a new concept of utilizing the converter semiconductor switch capacity to facilitate fast charging is proposed. It is demonstrated that by using the converter switch rating at its maximum capacity, the range of power drawn from the input can be extended. To achieve the aforementioned objective ,a two-stage configuration based on bridgeless switched inductor (BLSI) Cuk converter is proposed to achieve EV fast charging. The performance of the proposed concept is validated through MATLAB/ Simulink-based simulation study and proof-of-concept with a scaled-down laboratory prototype. It is shown that the proposed concept along with the BLSI Cuk converter can charge EV battery upto three times faster than conventional buck–boost converter-based single-stage and two-stage chargers.

**Index Terms**—Bridgeless switched inductor (BLSI) Cuk converter, discontinuous conduction mode (DCM), electric vehicle (EV), fast chargers, power factor correction (PFC).

## 1.INTRODUCTION:

This section briefly discusses the commonly used EV chargers based on single-stage and two-stage topologies. It is worth mentioning that the proposed concept of fast charging is valid for all the single-phase on-board EV chargers regardless of the converter conduction mode. However, for the analysis and verification of the proposed concept, DCM operated LEVs are considered in this article. The problem of high switch voltage and current stresses in the DCM operation is also analyzed and highlighted in figure 1

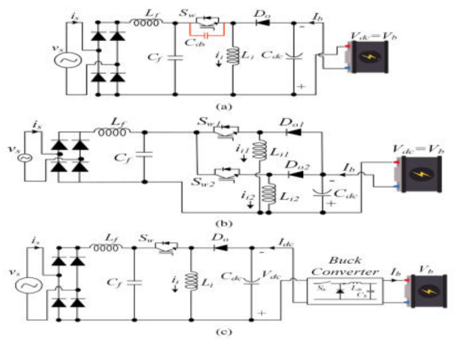


**Figure.1:** Conventional with Configuration of EV Chargers with conventional buck–boost converters.(a) Single-stage. (b) Single-stage with interleaving. (c) Two-stage charger. interface.

## 2. OVERVIEW OF CONVENTIONAL SLOW CHARGING TOPOLOGIES

## INTRODUCTION

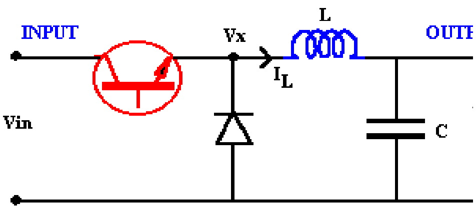
In this chapter we have discused about Overview of Conventional Slow Charging Topologies, types of DC-DC Converter ,buck,boost,buck-boost and there voltage and current ratios, Transition between Continuous and Discontinuous, Stress analysis of switches.

## TYPES OF CONVERTER

1 Buck Converter

2 Boost Converter Circuit

3 Buck-Boost Converter




Fig(2.1) Buck Converter

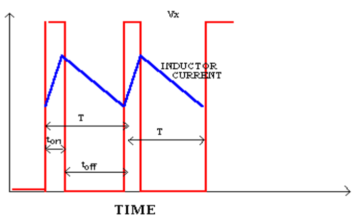
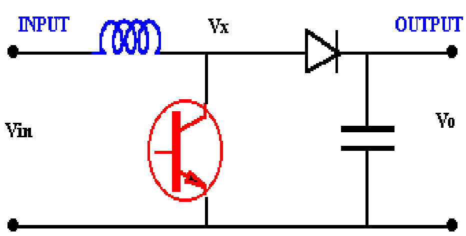
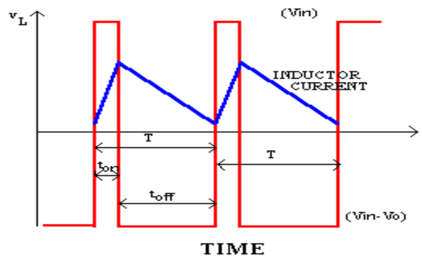


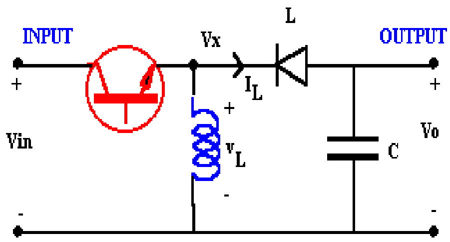

Fig (2.1.1) Voltage and current change




Fig(2.2) Boost Converter Circuit




Fig(2.2.1) Voltage and current waveforms (Boost Converter)




Fig(2.3) Schematic for Buck-Boost Converter

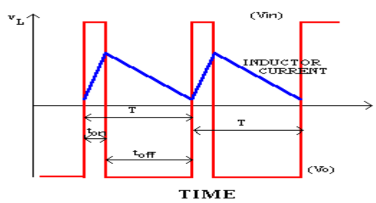



Fig (2.3.1) Waveforms for buck-boost converter

## 3. ON -BOARD EV FAST CHARGING

In This chapter we have discussed about introduction to on board charging and its fast charging configuration with an analytical example to illustrate the proposed fast charging concept and an application of proposed fast charging concept in Figure 3.1

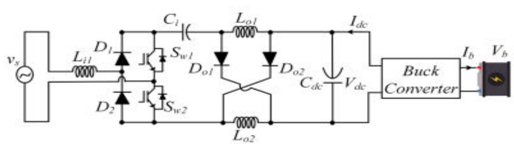


FIG 3.1Proposed BL switch inductor Cuk converter-based fast EV charger configuration.

## 4. STEADY STATE ANALYSIS, DESIGN, AND CONTROL

Steady- state analysis and design of the proposed BLSI(Boosted Load switchingInductor)converters,as well as the bucket converter, involves examining their operating conditions and optimizing their components for efficiency and performance. This includes analyzing the Steady- state behavior of the converters under different load conditions, designing the control loops and feedback mechanism to regulate voltage and current, selecting appropriate semiconductor devices and passive components, and optimizing the converter topology for specific application requirements such as voltage regulation, efficiency, and transient response.

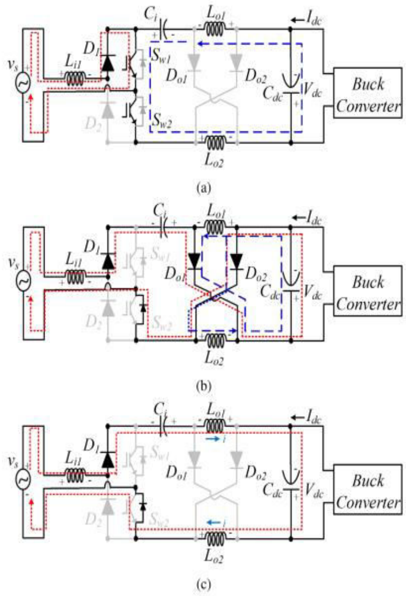


**Fig. 4**.1 Operation of the proposed BLSI Cuk converter over one switching cycle (during +ve half cycle).

## CONTROL SCHEME

The control circuit for the proposed BLSI converter appears in Fig. 4.3(a). To accomplish the charge rate three times higher than the ordinary charger, the dc-link voltage of the BLSI converter is controlled at 200 V, which bolsters the buck converter at the battery conclusion. This dc-link voltage is chosen to utilize the switch voltage to its greatest voltage rating of 800 V, as per the edge accessible in customary buck-boost converter-based charger (examined in Area III-D). The controller is created to meet the taking after two targets.

1) To direct the DC-link voltage of the BLSI converter.

2) To give UPF operation at the ac supply side.

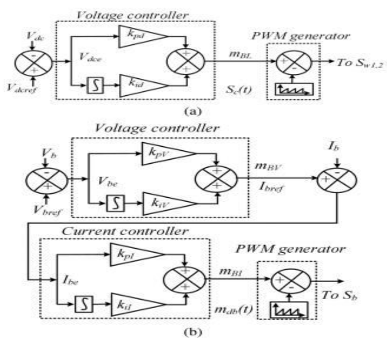



**Fig. 4.2** Overall control scheme of the

proposed charger: (a) control unit of BL PFC converter in DCM operation and (b) CC/CV control implementation through dual PI control, i.e., buck converter control.

**TABLE 1 CHARGER SPECIFICATION AND COMPONENTS RATINGS**

| Parameter | Specifica |
|---|---|
| Input Voltage ($v_s$) | 220 V, Single- |
| Battery Rating | 48 V, 100Ah |
| Switching/resonance frequencies ($f_s$, $f_{sb}$, $f_r$) | 20 kHz, 50 k |
| Maximum switch stress ($V_{sw}$, $I_{sw}$) | 800 V, |
| Compnents | Selected v |
| Input Inductor ($L_i$) - CCM | 5 mH (20% cu |
| Output Inductors ($L_{o1,2}$) - DCM | 70$\mu$H |
| Intermediate transfer Capacitor ($C_i$) - CCM | 1 $\mu$F (20% vol |
| Buck Inductor ($L_b$)-DCM | 50 $\mu$ |
| DC-link Capacitor ($C_{dc}$) | 4700 $\mu$F, 400 V |
| Output Capacitor ($C_b$) | 3*1000 $\mu$F |

## 5. SIMULATION RESULTS

### INTRODUCTION

The performance of the proposed EV fast charger is validated through simulation and experimental studies. The circuit specifications and components usedfor simulation as well as the developed scaled test setup are given in Table I. The simulated and experimental results under different operating conditions are discussed in the following sections. loop system is implemented in MATLAB SIMULINK. As per the converter, the three simulations are considered. The three types of the CUK converter are analyzed through the waveforms at the input and load side. Simulated results are plotted.

### 5.1 OPEN LOOP SYSTEM

The open loop result is, shown in Fig. 5(a). For the buck stage, the magnitude and phase plots of the uncompensated and compensated inner current loop are shown for the current compensator's proportional and integral gains as 0.0008 and 0.074, respectively. The compensated loop has positive gain and PM of 34.8 dB and 95.7◦, respectively, which ensure the good stability of the compensated loop.
Output voltage and input side wave forms are shown in fig 5.1 and 5.2

**Fig.5(a) Simulation of the open loop system of the converter in MATLAB**

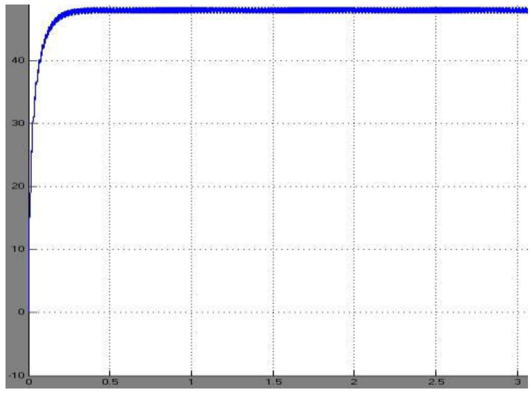



**Fig.5.1 Output voltage waveform**

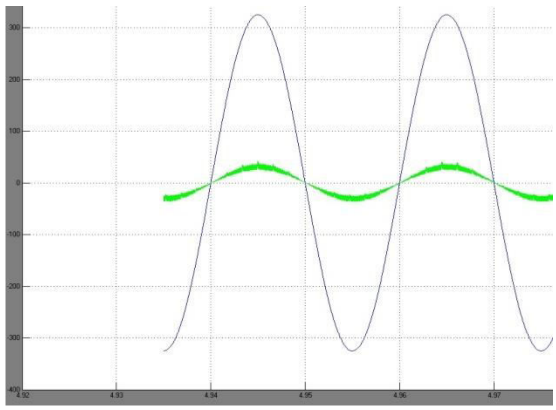


**Fig.5.2 Effect at the input side**

## 5.2 SIMULATION DESIGN

The Ćuk converter (verbalized Chook, a few of the time incorrectly spelled Cuk, Čuk or Cúk) is a sort of DC-DC converter that has an abdicate voltage significance that is either more conspicuous than or less than the input voltage measure. The non-isolated Ćuk converter can as it were have converse limit between input and surrender. It livelihoods a capacitor as its essential energy-storage component, not at all like most other sorts of converters which utilize an inductor. It is named after Slobodan Ćuk of the California Set up of Advancement, who to start with shown the design

**Fig.5(b) Simulation of the open loop system of the converter in MATLAB**

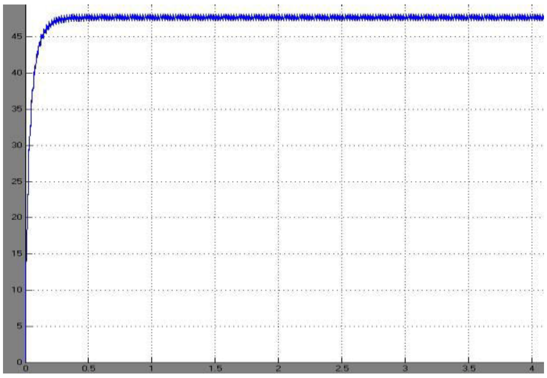



**Fig 5.3 Output voltage waveform**

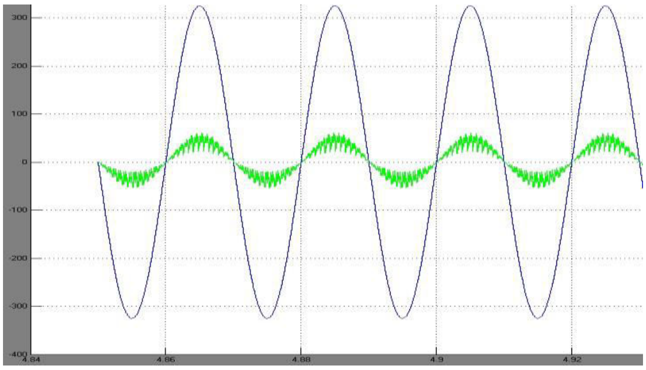



**Fig 5.4 Effect at the input side**

## 5.3 CLOSED LOOP SYSTEM

The closed loop system is implemented in MATLAB SIMULINK. For closed loop simulation using PI controller, the type-1 system of the proposed CUK converteris considered. Simulated results are presented.

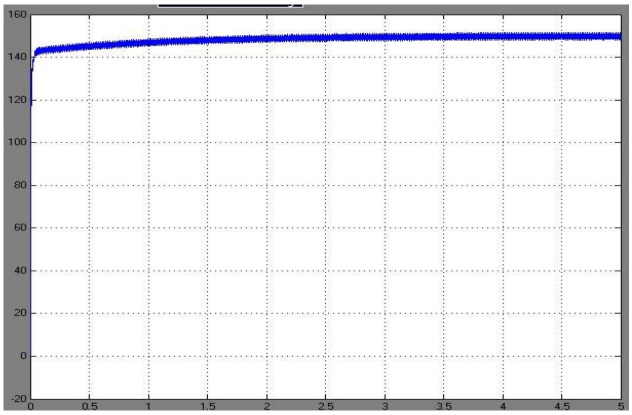



**Fig 5.5 Output voltage waveform**

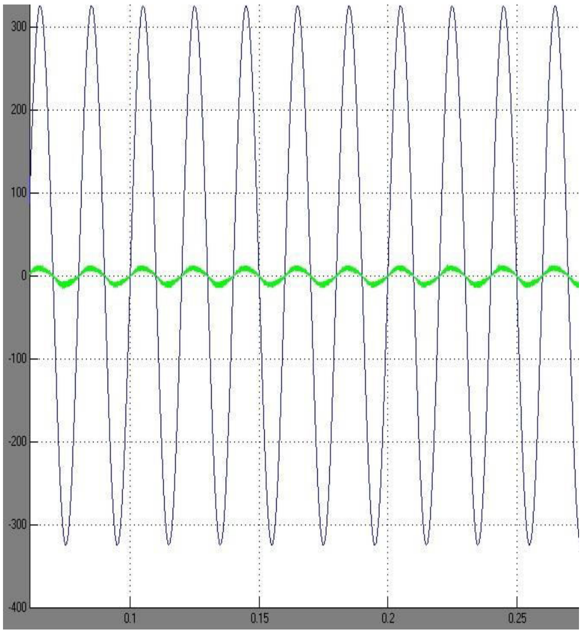


**Fig.5.6Effect at the input side**

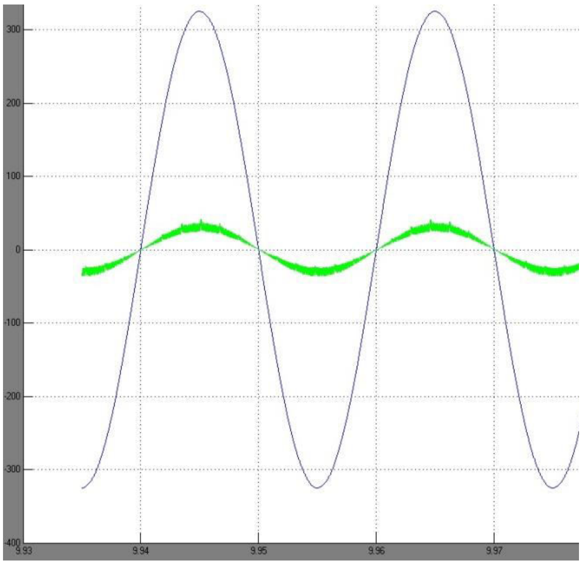


**Fig.5.7 Effect at the input side**

# CHAPTER 6

## CONCLUSION

In this project, an unused concept of utilizing the converter semiconductor switch capacity to encourage EV quick charging has been proposed. The existing single-stage and two-stage on-board EV chargers are constrained to moderate charging due to tall switch voltage and current stresses. The fundamental reasoning of the proposed work is to
utilize the same semiconductor gadgets in the ordinary buck-boost converter-based charger, in any case, to their evaluated capacities by expanding the middle of the road dc-link voltage level such that a higher rate of vitality exchange is accomplished. To fulfill this objective, a modern tall step-down pick up Cuk converter-based two-stage charger with BLSI is too created. The proposed work can either increment the charging speed or diminish the impression of on-board EV chargers. The other points of interest of the proposed converter are tall voltage pick up, moved forward energetic execution, end of EMI channel, and no spillage current. The plan of both stages has been carried out in DCM to accomplish characteristic PFC capability at mains, minimize invert recuperation misfortunes in the diodes, and decrease the number of sensors required. Encourage, due to the utilization of BL structure at input and exchanged inductor at yield, lower conduction, and switching losses are accomplished.

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