

Design of Modified Luo Converter for Electric Vehicle Battery Charger

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Abstract

Higher energy and battery efficiency are now major concerns for Electric Vehicle (EV) manufacturers and consumers. The main component of the two-stage EV on-board charger is the DC-DC converter. The phase displacement of full-bridge to operate the switch at either zero voltage or zero current in a power switch DC-DC converter, currently has issues such as voltage variation on the consequent side, which is secondary of the transformer, and it implies poor performances. Power Factor Correction (PFC) converters used in modern EV chargers achieve high performance and adequacy throughout charging. A modified Luo converter is designed to achieve high efficiency in EV charging.

A Luo converter is a type of PFC that is commonly used as a converter of DC to DC with improved voltage regulation in the presence of rapidly changing line voltages. In this aimed work, a reformed separate Luo converter-based electric vehicle charger is developed. To suppress voltage oscillations, two devices which means switches and two clipping diodes are connected at the elementary side in the detachment of High Frequency Transformer (HFT). The Luo converter handles Discontinuous Conduction Mode (DCM) of operation, decreases control complexity, and keeps converter's output constant. In the feedback system, the Constant Current and Constant Voltage (CC-CV) mode technique is used in conjunction with the PI controller to improve competence and reduce transmission leakage. The proposed system's performance is evaluated by applying in MATLAB/SIMULINK software, and the outcomes are promising.

Keywords: Power Factor Correction, Discontinuous Conduction Mode, and High Frequency Transformer

1. Introduction

Higher Power and fuel yielding features greater stake for makers and Electric Vehicle (EV) consumers, fueling demand of proper battery chargers for Electric Vehicles (EVs) are important. The converter used for correction of power factor become an essential component for the present - day EV chargers in order to achieve high performance and adequacy throughout charging. The use of a conventional charger without PF correction results in a high harmonic content in the mains current as well as poor input power quality. The selection of a PFC converter that is appropriate for a specific application. An EV charger must provide a dependable outcome by limiting extreme power quality occurrence, like overvoltage, network erosion and balancing issues. An enhanced power quality-based EV charger delivers minimum upsurge establishment EV exciting to the battery and extending aliveness of battery for an extensive period. The lot of individual level correction of power factor based from Alternating Current to the Direct Current conversion analyzed in order to overcome the power quality occurrences in present day EV battery chargers and to yield inclusive characteristics of power factor correction.

Zeta, Cuk, SEPIC (Single Ended Primary Inductance), and Luo converters are examples Buck-Boost of single-phase eminent oftenness desolated PF correction converters. When using Zeta converters, the input current ripple increases, and the output ripple increases, both of which have a negative effect on the life of battery. Cuk converter thought preferable outcome integral PFC in EV chargers because rectifies above drawback steady currents both inlet, outlet, but it has a lower efficiency as a result. A CLCL converter used to avoid simultaneous high current and high voltage in a power switch for half bridge converter increases the bulkiness of the converter as well as the devices which means switch stresses and high ripple. The Luo converter is commonly found in voltage super-lift, Re-lift, and ultra-lift applications.

A Luo converter commonly exploited Direct Current to Direct Current converter due to enhancement voltage variation upon the rapid changing in line voltages and more suitable moderate load performance, as well as its competency for intensified voltage transformation ratio, low output surge, and input surge. The Luo converter exhibits the excellent performance with low input and low output ripple and high voltage transfer gain. The converter enables affordable cost and considerable energy density EV charging. The

drawbacks of Bridgeless Luo Converters include the superior device voltage constraint that endure in these converters, which reduces converter efficiency.

In the proposed system, diode bridge rectifier is utilized for Alternating Current to Direct Current conversion process, and a high frequency transformer is used for isolation.

2. Modified Isolated Luo Converter

For power factor correction, the modified isolated luo converter has two switches and diodes such as S1, S2 and D1, D2. According to the proposed system, high frequency transformer on primary side the modifications done and diode bridge rectifier, filters also connected. The block diagram for the modified isolated luo converter for closed loop system is shown below.

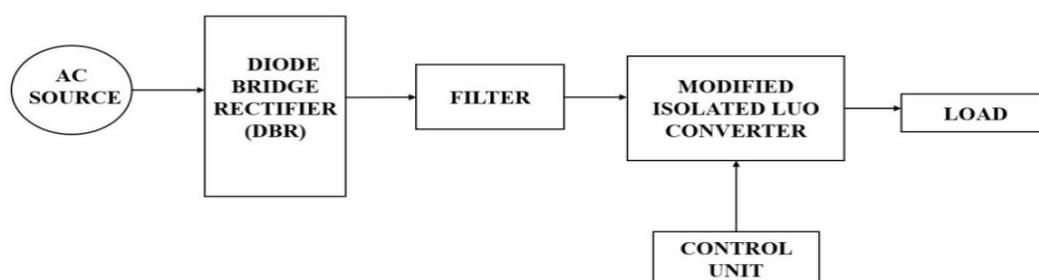


Figure 1. Block Diagram of the proposed Modified Isolated Luo Converter

2.1 Construction

Figure 1 depicts the block diagram of a modified isolated luo converter for the proposed system. The components that are used in the block diagram namely, AC voltage source give the input supply voltage, secondly Diode Bridge Rectifier (DBR) consist of four Diodes such as D1, D2, D3 and D4 used as full bridge rectifier for the conversion process from AC to DC, thirdly the filter components are the combination of capacitor (Cf) and inductor (Lf), Modified Isolated Luo Converter having high frequency transformer namely magnetizing inductance (Lm) having primary and secondary side. On the transformer's primary side linked to the source side and consist of two switches and diodes such as S1, S2 and D1, D2. The consequent side of the transformer, which attached in load side, is made up of an output diode (Do), an intermediate capacitor (C1), an output inductor (Lo), and a capacitor (Co), finally the load and control unit are connected and it consist of load as resistive load and control unit as PI controller. From the load the actual voltage given to the

controller and it tunes the actual to desired value of voltage then controller of output side is connected to the switches as S1, S2 of modified isolated luo converter. So, these are the construction for proposed system of modified isolated luo converter.

2.2 Working of Modified Isolated Luo Converter

The modified isolated luo converter set work for the Discontinuous Conduction Mode (DCM). The advantage of discontinuous conduction mode is that it reduces control complexity and improves the robustness of the modified converter's performance. Over the course of a single switching cycle, the current flowing through the high frequency transformer becomes discontinuous. An enhanced minimum upsurge-based charging is yielded constant current - constant voltage (CC-CV) mode, it reduces emanation decline and step up the effectiveness of the aimed charger. The price of the device such as switch significantly decreased due to minimum of voltage and current constraint, making this as dependable and economical outcome for battery chargers.

The output inductor is chosen to be large enough to make sure proper manipulation in CCM mode especially, maintaining battery current sequence. Similarly, the sustained capacitor voltage V_{C1} over the full transition period depicts an performance of vitality transfer capacitance in CCM mode.

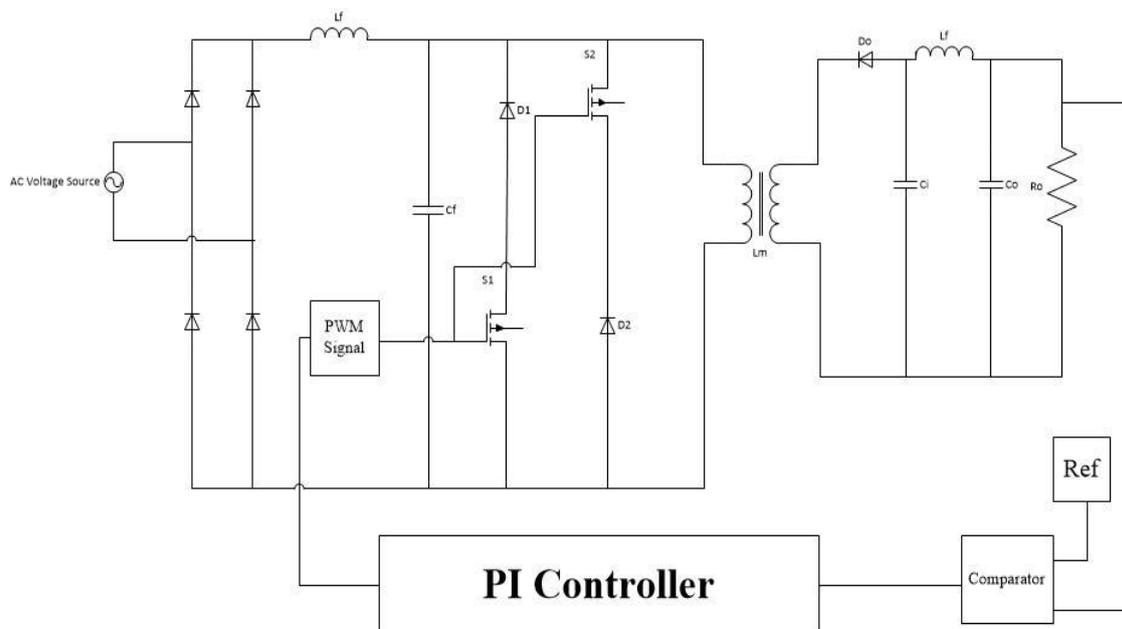


Figure 2. Circuit Diagram for the proposed Modified Isolated Luo Converter

As a result, this work designs and implements a reformed detached Luo converter fed individual level EV charger Discontinuous Conduction Mode to charge a 48V, 100Ah EV battery in constant current and constant voltage (CC-CV) mode. Another prominent intervention of the planned performance is the significantly decrease voltage constraint through correction for power factor devices that is switches, attained by modifying the basis of detached Luo arrangement system. In outlined, Luo converter is a reformed aspect of the fundamental detached Luo converter that includes an extra device as switch and two attachment diodes.

Table 1. Tabulation for Modes of Operations

Modes Of Operations	Switches	Diodes	Output
First Mode	S1 - ON S2 - ON	D1 - OFF D2 - OFF	L - Charging C – Charging
Second Mode	S1 - OFF S2 - OFF	D1 - ON D2 - ON	L - Charging C - Charging
Third Mode	S1 - OFF S2 - OFF	D1 - OFF D2 - OFF	L – Charging C - Discharging

3. Simulation Results and Discussion

The Luo DC-DC converter's design topology was implemented in the MATLAB-Simulink software. This chapter discusses the simulation results. MATLAB is a comprehensive technical computing environment. MathWorks Inc.'s Simulink (Simulation Link) is a MATLAB extension. It collaborates with MATLAB to provide dynamical system modelling, simulation, and analysis through a GUI. The interpretation of a pattern is aided by mouse snap-and-pull performances. Simulink incorporates a large directory toolbox block for equally narrow and parametric analyses. The modelling of multilevel, allowing equally high-low and low-high addressed. Because Simulink is an essential element of MATLAB, just simple to swap between the two throughout scrutiny technique, allowing the usage to draw entire vantage of the attributes available in equally circumstances. Simulation is one of the best ways to study the behavior of a system or circuit without causing damage to it. For engineering professionals, simulation tools in a variety of fields are available on the market.

Many industries invest a significant amount of time and money in simulation before manufacturing their product. Simulation is essential in the majority of research and development (R&D) projects. It is nearly impossible to proceed without simulation.

This guideline recommends a maximum ripple in battery current of 5A for a 100Ah battery. The charging performance of a 48V, 100Ah battery using the isolated Luo converter proposed.

3.1 Closed Loop Modified Luo Converter

The proposed simulation circuit diagram in Figure 3 it depicts a modified isolated luo converter. According to proposed system, it consists of AC source, Diode Bridge Rectifier, filter, High Frequency Transformer, and for the modification purpose, two switches and diodes are used.

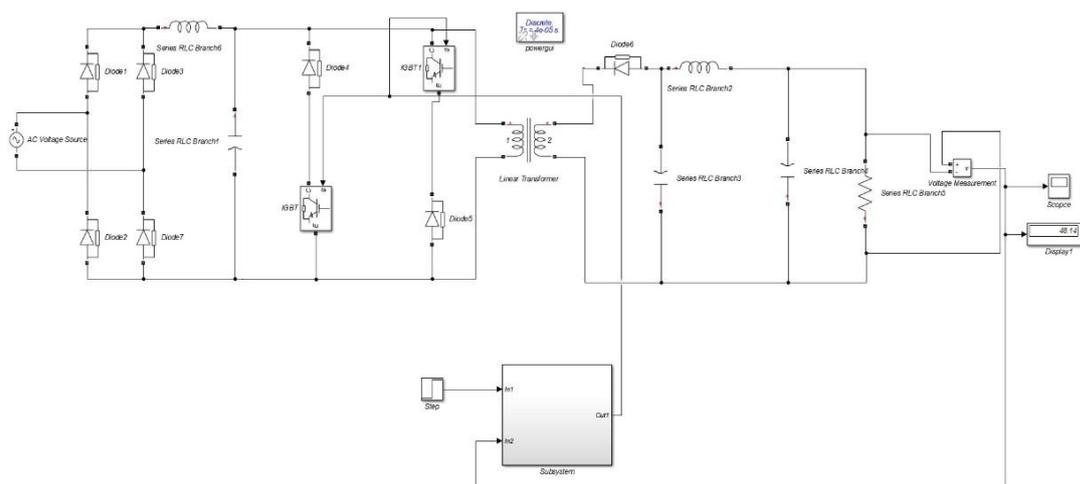


Figure 3. Closed loop for Modified Isolated Luo Converter

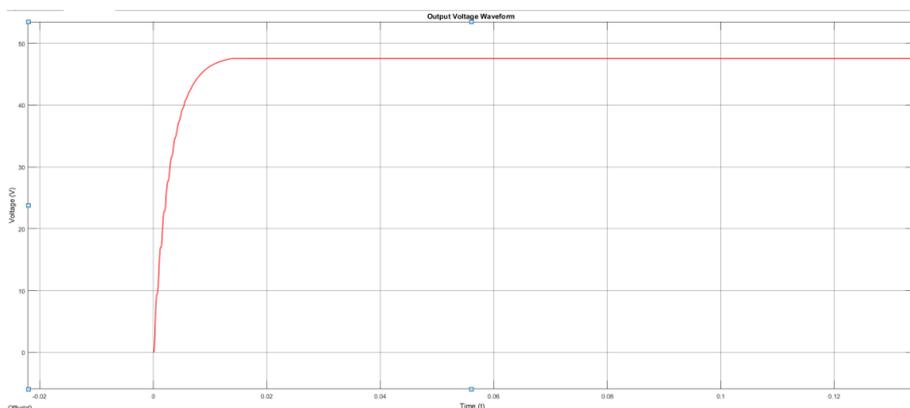


Figure 4. Output Voltage Waveform for the closed loop system

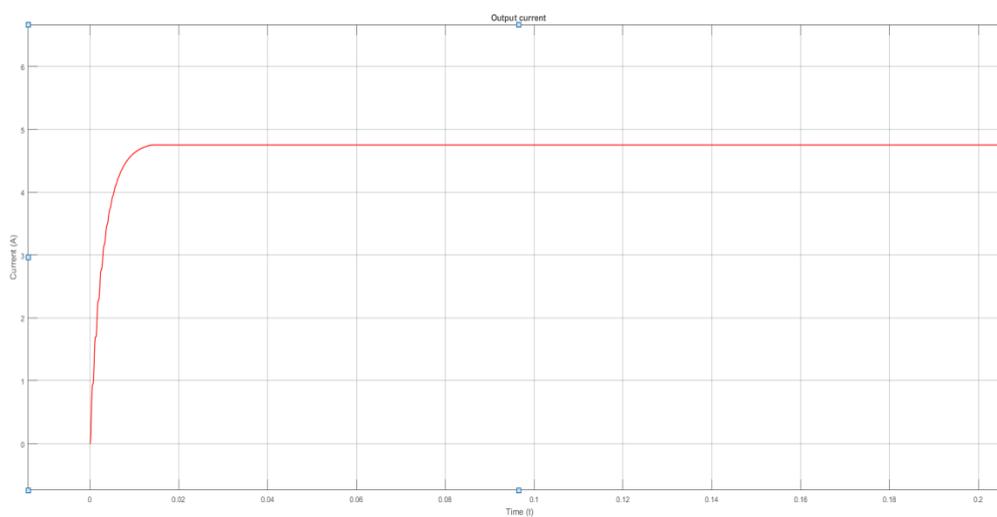


Figure 5. Output Current Waveform for the closed loop system

Figures 4 and 5 show the simulation fulfilment of the outlined feedback system based on the simulation results. The figure 4 exhibit that the output voltage waveform of 48V of the proposed battery specifications and figure 5 shows that the output current waveform of 4.8A nearer to five ampere which is shown in the figure 4 and 5 respectively.

4. Conclusion

Luo Converters are new generation of DC-DC increased transformation electrical structure. Luo-Converters have unique characteristics such as elevated yielding, considerable energy density, a low-cost layout with a elementary system, nearer to zero outcome voltage and current upsurges. With a high output voltage, converters can be used in computer outermost structure, hospital machinery, and industrial utilization. The modified Luo Converter closed loop system proposed with PI controller has been simulated using MATLAB Simulink. The proposed system has a 48V output voltage. The proposed system has a 5A output current. The proposed converter's performance will be efficient due to low ripples in both the inlet and outlet positions of voltage and current. With the proposed converter, the application will have a long life.

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