International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 12, Issue 01, January 2023)

An Improved Power Factor Landsman Converter based Battery Charger for Electric Vehicle

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***Abstract*— Nowadays, for the sustainable development of the modern transportation sector, battery powered electric vehicles (BEVs) are dominating over the conventional gasoline powered vehicles. The transportation electrification is the most feasible way to establish a clean energy based vehicle market since the power source used to charge these batteries, is obtained from the electricity. For recharging of batteries of these vehicles, number of charging stations will also increase in future. These electric vehicle charging stations have great impact on power grid parameters like current, voltage and power factor. The non coordinated charging conditions, resulting in increased power load and increased voltage deviation due to this the grid network losses will also increase. This paper proposed design and analysis of modified battery charger for electric vehicle with improved power factor.**

***Keywords*—EV, Battery, Current, Voltage, Power, Flyback, AC-DC, DC-DC converter, power factor correction**

I. INTRODUCTION

Electric vehicles are the pollution free option of transportation which would reduce pollution levels, because EV involves battery technologies and battery charging systems. Many problems associated with the charging of batteries of electric vehicles when charging stations are integrated with power grid. The charging protocol relies upon the estimate and sort of the battery being charged. Some battery types have high tolerance for overcharging (i.e., kept charging after the battery has been completely energized) and can be revived by association with a constant voltage source or a constant current source, contingent upon battery type. Basic chargers of this sort must be physically disengaged toward the finish of the charge cycle, and some battery types totally require, or may utilize a clock, to cut off charging current at some fixed time, roughly when charging is finished. Other battery types can't withstand over-charging, being harmed (diminished limit, decreased lifetime), over warming or in any event, detonating. The charger may have temperature or voltage detecting circuits and a microchip controller to securely change the charging current and voltage, decide the cut off toward the finish of charge.

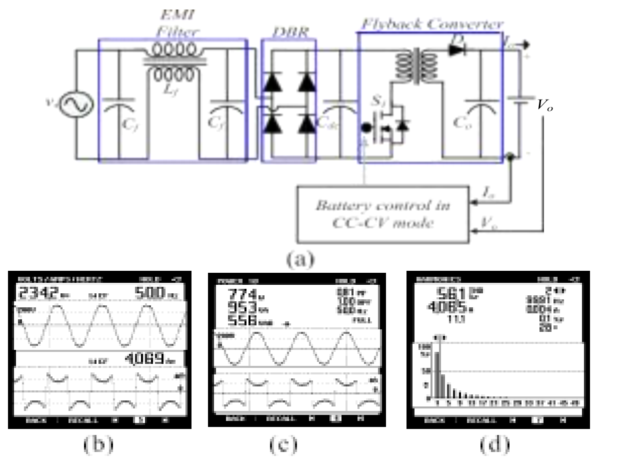

Figure 1: (a) Conventional charger and (b) circuit PQ performance at rated 230 V: observed distorted mains current with mains voltage. (c) Charger power profile with low input . (d) Mains current THD.

To obtain high efficiency and reliability during charging, the power factor correction (PFC) has become an important part of the modern EV chargers. The conventional charger without PF correction causes rich harmonic content in mains current and deteriorates the input power quality (PQ). The value of true PF lies in the range 0 to 1. To overcome the above PQ issues, the conventional converters are incorporated. The proposed PFC converter is a modified version of DC-DC converter. The design of modified converter is selected to operate in discontinuous mode (DCM). The operation of the modified converter in discontinuous mode considerably reduces the control complexity due to reduced sensors.

II. PROPOSED MODEL AND WORKING

Figure 3 is showing proposed design model battery charger for electric vehicle application. The entire block name is mentioned in the proposed model.

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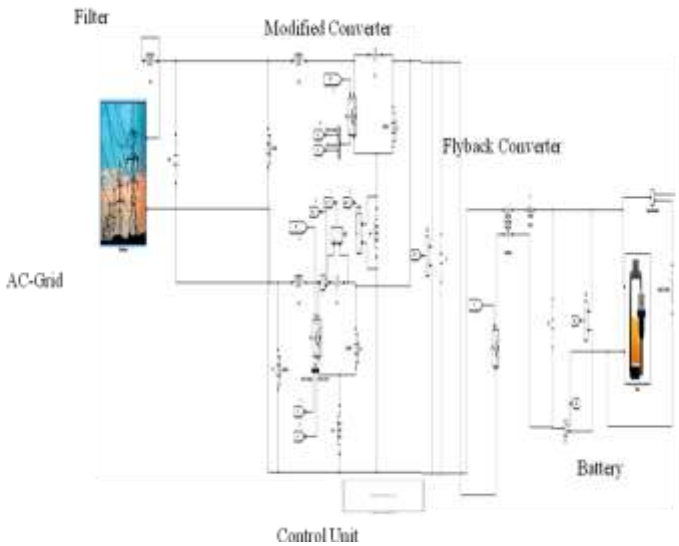

Figure 3: Proposed model

The operation of proposed modified converter over complete switching cycle and during the respective half of the mains voltage is proposed. The operating principle during positive half cycle is explained as follows.

Mode P-I (t0-t1): During positive half cycle of mains voltage, the converter operation begins with mode P-I. The switch *SP*, connected in upper line, is in ON condition and the inductor *Lop* starts charging. During this instant, intermediate DC link capacitor, *Co* discharges through the isolated converter connected at the load side. However, the high frequency diode, *D1* has no conducting path during this period, due to the stored charge in the inductor and hence, contains a reverse bias voltage across it.

Mode P-II (t1-t2): The high frequency diode, *D1* operates in mode P-II, when the gate pulse to the switch is prevented. The inductor, *Lop* finds a path, to discharge through it. The DC link capacitor, *Co* starts charging and the flyback converter at the output, is supplied for each switching cycle.

Mode P-III (t2-t3): In mode P-III operation, the stored charge in inductor *Lop* is depleted completely at the end of switching cycle. The inductor current becomes discontinuous for the rest of the switching cycle. During this time, the output power is delivered by the intermediate DC link capacitor, discharging through the path.

The proposed modified converter follows the same switching sequence for the lower switch *Sn*, inductor, *Lon* and diode, *D2* in negative half cycle of mains voltage, the switching sequence for the components operating in different modes during complete input voltage cycle and switching cycle of proposed converter.

III. PROPOSED MODEL METHODOLOGY

The methodology of proposed work is based on the following sub-module-

- AC grid
- Modified Converter
- Control Unit
- Battery

The proposed bridgeless converter is shown with topologies. As compared to the other (bridgeless) BL converters based on buck–boost configuration, the proposed converter has the significant advantage of comparable number of total components. The proposed converter has reduced number of conducting components in the current path thereby reducing the system cost and losses. Besides, its PF correction capability is seen to be more improved than the previously developed (bridgeless) BL buck boost and DBR fed converter. Moreover, the main drawback of BL buck-boost converter is the excessive EMI noise emission, which is achieved by proposed converter.

Therefore, the proposed improved bridgeless converter is considered as a better alternative for PFC solution of proposed EV charger. The performance of proposed BL converter based charger is also compared with

1) Conventional converter based EV charger, which is having a bridge rectifier for PFC at its front end.

2) Conventional EV charger, which comprises of only DBR and Flyback converter.

Modified Converter

This work proposes a grid interface converter to be applied in Vitality Control-Center (ECC) so as to interface dc factors, for example, battery vitality storage framework and AC regular utility grid. Such power electronics arrangement ensures:

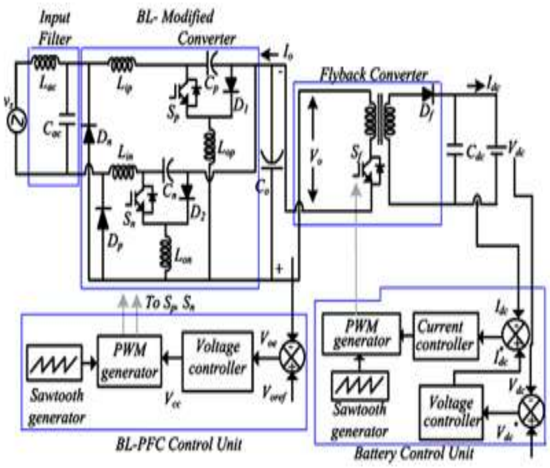

Figure 4: Modified converter

1. Power stream among DC and AC converter sides,
2. Autonomous control in the two sides,
3. Significant level of incorporation, and
4. Execution of two capacities utilizing a one of a kind power transformation organize.

This work manages the structure and execution of another charger for a battery-worked electric vehicle (EV) with power factor improvement at the front end. In the proposed arrangement, the traditional diode converter at the source end of existing EV battery charger is disposed of with the adjusted power factor correction (PFC) converter. The PFC converter is followed by a flyback secluded converter, which yields the EV battery control to charge it, first in constant current mode at that point switching to constant voltage mode. The proposed PFC converter is controlled utilizing single detected substance to accomplish the vigorous guideline of dc-interface voltage just as to guarantee the solidarity power factor activity. The proposed topology offers improved power quality, low gadget stress, and low info and yield current wave with low information current harmonics when contrasted with the regular one. In addition, to show the congruity of the proposed charger to an IEC 61000-3-2 standard, a prototype is fabricated and tested to charge a 48 V EV battery of 100 Ah limit, under homeless people in input voltage.

IV. Simulation And Results

The implementation of the proposed algorithm is done over MATLAB 9.4.0.813654. The control signal processing toolbox helps us to use the functions available in MATLAB Library for various methods.

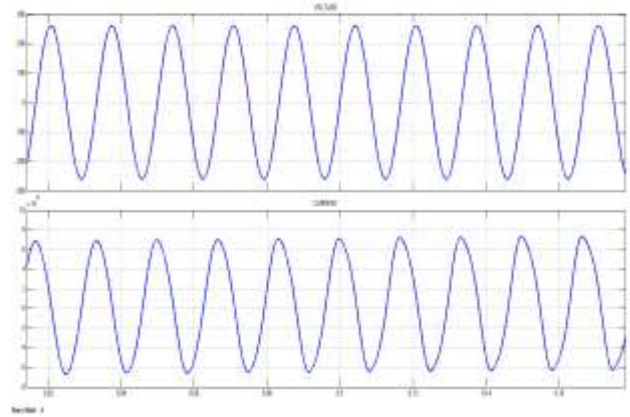

Figure 5: Output of Ac source voltage and current

Figure 5 presents output of source voltage is 260V and 10A current.

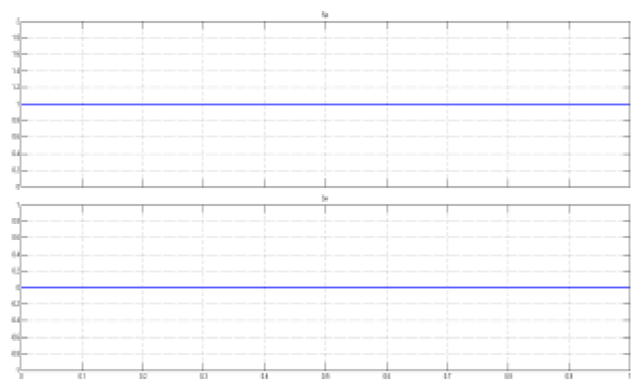

Figure 6: Switching pulses of BL-PFC control unit

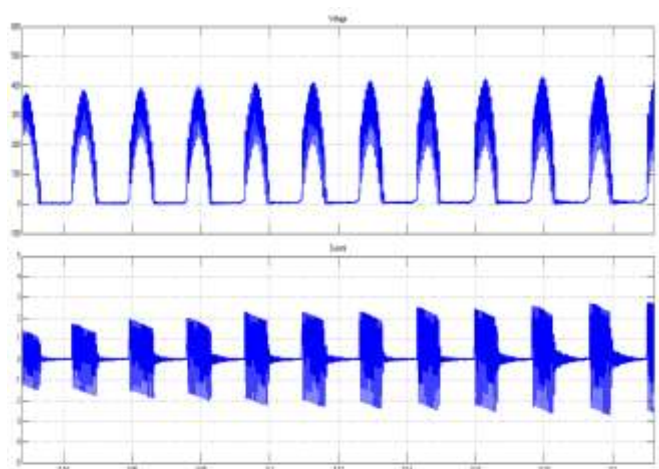

Figure 7: Voltage and current of capacitor Cn

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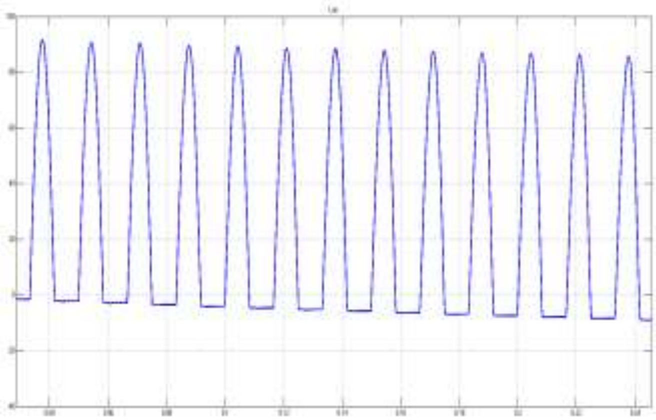

Figure 8: Voltage of Lop

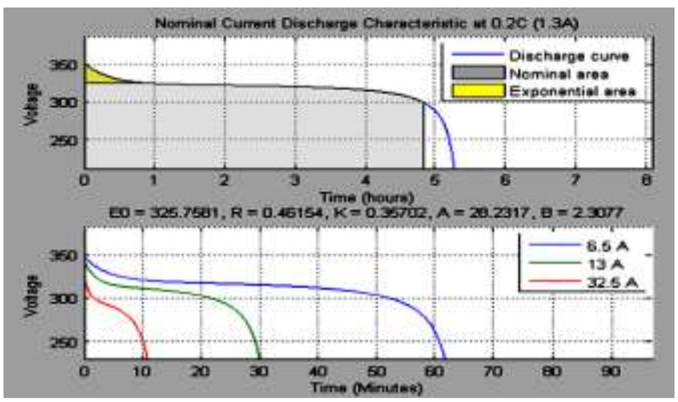

Figure 9: Battery discharge characteristic

Figure 9 shows nominal current discharge characteristic graph between voltage and time. It is clear that battery discharge at 5.30 Hours.

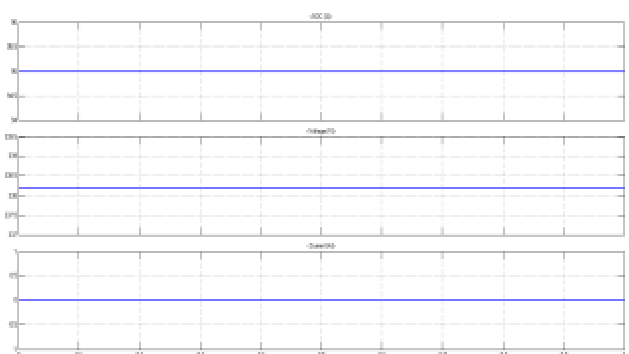

Figure 10: Performance of Battery

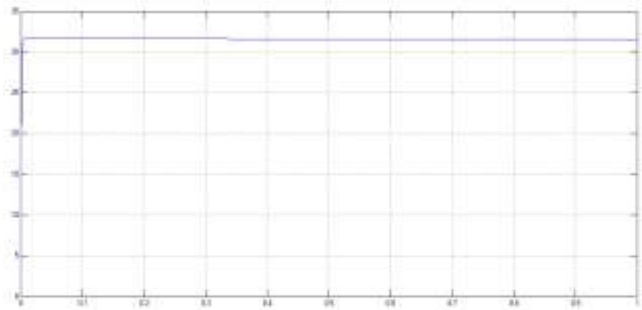

Figure 11: Battery output current

Figure 10 and 11 is showing output performance of battery. Here it can be seen that state of charge of battery is 95% and voltage is 338.25V and current is 33A.

Table 1:
Simulation Parameter

Sr. No.	Parameter	Value
1	Peak Voltage amplitude (AC Grid)	260V
2	Frequency	60Hz
Battery Parameter		
3	Nominal voltage	330 V
4	Capacity	6.5Ah
5	State of charge	95%
6	Battery type	Nickel- metal- Hydride

Table 2:
Result Comparison

Sr No.	Parameter	Previous Model	Proposed Model
1	Number of components	More	Less
2	Control (with PFC)	Voltage Follower	Voltage Follower
3	Control(Battery)	Simple (dual PI)	Simple (dual PI)
4	Power factor	0.88	0.92

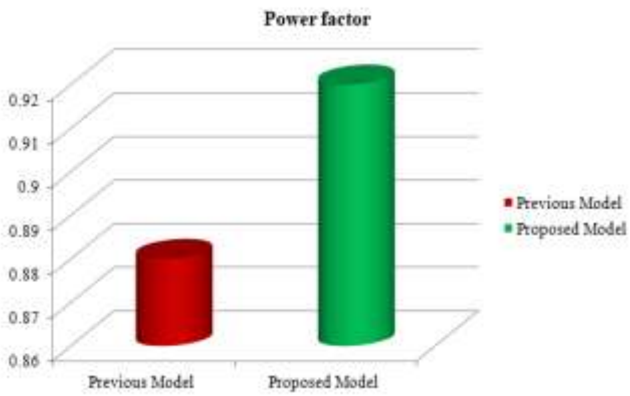

Figure 10: Result Comparison

Figure 10 is presenting the graphical representation of the result comparison.

V. Conclusion

A modified battery charger with improved power factor followed by a flyback converter has been proposed, analyzed, and validated. The peak load efficiency of 95% is achieved with this modified charger. The design and control of the proposed EV charger in DCM mode have offered the advantage of reduced number of sensors at the output. Moreover, the proposed converter has reduced the input and output current ripples due to inductors both in input and output of the converter. The power factor achieves the significant improvement rather than the previous work. Therefore the proposed modified battery chargers are more reliable.

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