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# Design and Analysis of Modified Battery Charger for Electric Vehicle

[1] Shruti Rani, [2] Prof. Barkha Khambra
[1]Research Scholar Master of Technology Department of Power Electronics, NIIST, Bhopal
[2]Assistant Professor & Head Department of Electrical Engineering, NIIST, Bhopal
shrutigwp@gmail.com

***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. To facilitate the battery charging, an AC-DC converter based on board or off board charger is the significant supporting equipment of the electric vehicle (EV). Battery charging for EV, is performed in constant current (CC) and constant voltage (CV) regimes using a fly back DC-DC converter. This paper presents design and analysis of improved battery charger for electric vehicle with high power factor.***

**Keywords: EV, Battery, Current, Voltage, Power, Fly back, AC-DC.**

## 1. Introduction:

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. A stream charger gives a moderately limited quantity of current, sufficiently just to check self-release of a battery that is inactive for quite a while. Some battery types can't tolerate stream charging of any sort; endeavors to do so may bring about harm. Lithium particle battery cells utilize a science framework which doesn't allow uncertain stream charging.

**Slow battery chargers may take a few hours to finish a charge. High-rate chargers may restore most limit a lot faster, yet high rate chargers can be more than some battery types can tolerate. Such batteries require dynamic monitoring of the battery to shield it from overcharging. Electric vehicles in a perfect world need high-rate chargers. For community, establishment of such chargers and the appropriation support for them is an issue in the proposed reception of electric autos.**

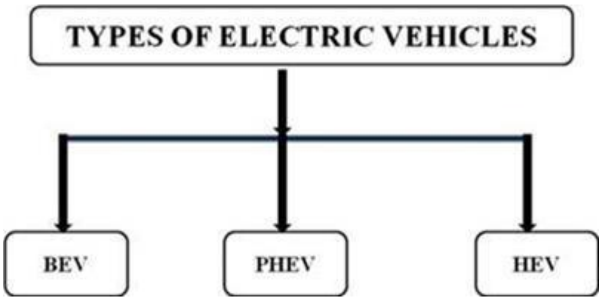


Figure 1: Types of electric vehicles

A decent battery charger gives the base to batteries that are sturdy and perform well. In a value delicate market, chargers frequently get low need and get the "after-thought" status. Battery and charger must go together like a steed and carriage. Judicious arranging gives the power source top need by setting it toward the start of the undertaking as opposed to after the equipment is finished, just like a typical practice. Architects are regularly unconscious of the intricacy including the power source, particularly while charging under unfavorable conditions.

There are three fundamental kinds of electric vehicles (EVs), classed by the degree that electricity is utilized as their vitality source. The BEVs, or battery electric vehicles PHEVs of plug-in hybrid electric vehicles, and HEVs, or hybrid electric vehicles. Just BEVs are fit for charging on a level 3, DC fast charge

Chargers give a DC charging voltage from an air conditioner source whether from a typical attachment outlet or all the more as of late from a reason manufactured DC charging station. Most significant are the techniques for controlling the charge and shielding the battery from over-voltage, over-current and over-temperature. These charger capacities are coordinated with and extraordinary to the battery.

## 2. Proposed Model And Working:

Figure 2 is showing proposed design model battery charger for electric vehicle application. The entire block name is mentioned in the present model

The operations of proposed modified converter over complete switching cycle and during the respective half of the mains voltage are given. 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.

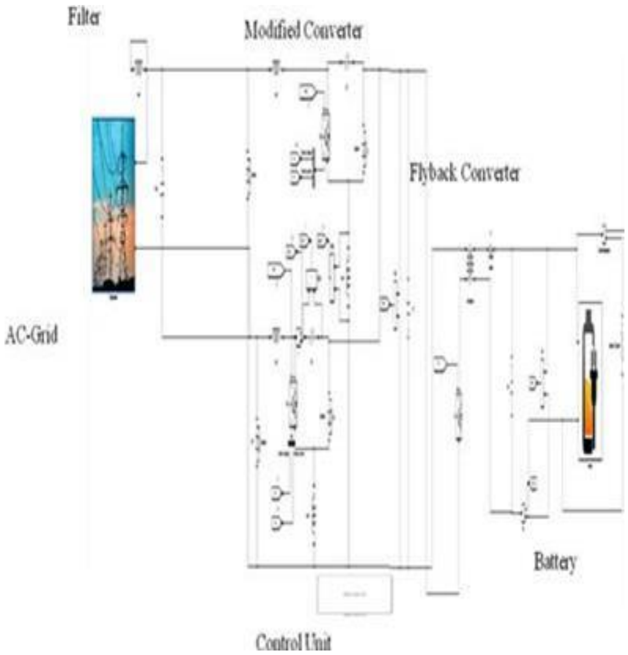


Figure 2: Present model

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.

**3, 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 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 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 Fly back converter

**AC Grid:**

An electrical grid is an interconnected system for conveying electricity from makers to shoppers. It comprises of creating stations that produce electrical power, high voltage transmission lines that convey power from far off sources to request focuses, and dissemination lines that interface singular customers.

**Modified Converter**

This work proposes a bidirectional 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:

(I) Power stream among DC and AC converter sides, Fly back Converter
(II) Autonomous control in the two sides,
(III) Significant level of incorporation, and
(IV) Execution of two capacities utilizing a one of

A fly back converter with a yield voltage of 65V, is intended to give the segregation to the battery just as to control the charging current in two charging modes. The determination of ideal switch rating and the charging inductance L mag, are the critical criteria for the fly back converter. For the required venturing down of the info voltage to 65V, an obligation proportion (Dif) of 0.394 is chosen to give the essential charging voltage to the battery. In this manner, the turns proportion (Nsec/Npri) is determined during on calculated

$$V_{dc} = \frac{N_{sec}}{N_{pri}} \frac{D_{if}}{1-D_{if}} V_o \quad (1)$$

$$\frac{N_{sec}}{N_{pri}} = \left(\frac{1-D_{if}}{D_{if}}\right)\frac{V_{dc}}{V_o} = \frac{1-0.394}{0.394} * \frac{65}{300} = 0.333 \quad (2)$$

During ON time of switch Sf, the current in the magnetizing inductance of the transformer, starts increasing as described in mode-I of the fly back converter operation. The inductor current ILmagf is expressed as;

$$I_{Lmagf} = \frac{2*P_i}{V_{dc}*D_{if}} = \frac{2*850}{300*0.394} = 14.38A \quad (3)$$

Where, $V_{dc}$ is the output DC voltage of the PFC bridgeless converter that powers up the fly back converter.

$I_{Lmag}$ f denotes the current in the primary of the flyback transformer during ON state of switch Sf. Moreover, the size of the transformer is minimized using 50 kHz switching frequency, $f_{sf}$ for flyback converter.

**Pulse Width Modulation (PWM)**

Pulse Width Modulation technique is a fixed dc input voltage is given to the inverters and a controlled AC yield voltage is gotten by modifying the on and off times of the inverter segments. This is the most prominent technique for controlling the yield voltage and in this strategy is known as pulse width modulation.

**Control Unit**

A correlation investigation of proposed converter encouraged charger and traditional DBR nourished charger with and without PFC, is given.

In this unique situation, various bridgeless converter dependent on double lift setups, are talked about. Regardless of offering the upside of high effectiveness at high power level and improved warm pressure, BL support topology experiences the confinement of high electromagnetic interference clamor and complex control.

Also, the lift converter has the obligation cycle variety point of confinement to control the middle of the road DC-connect voltage at lower supply voltage. Along these lines, a group of bridgeless front-end buck-support converters is given their application to give wide scope of variety in input voltage

**4. Simulations 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.

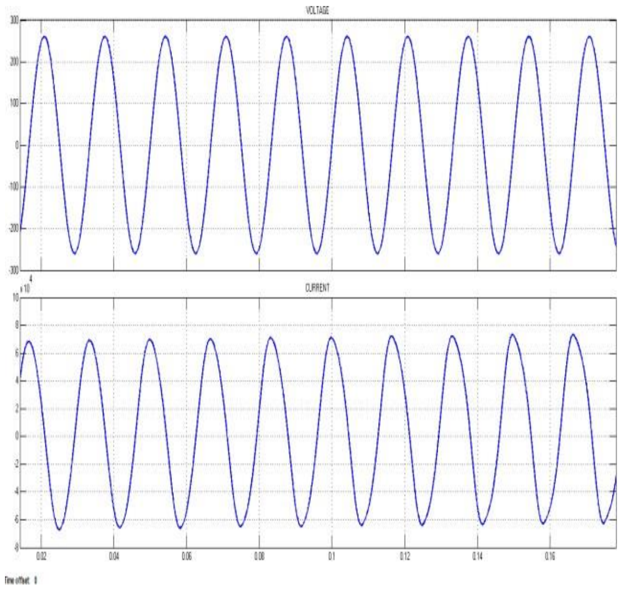


Figure 3: Output of Ac source voltage and current

The Figure 3 have presented the output of source voltage is 260V and 10Acurrent.

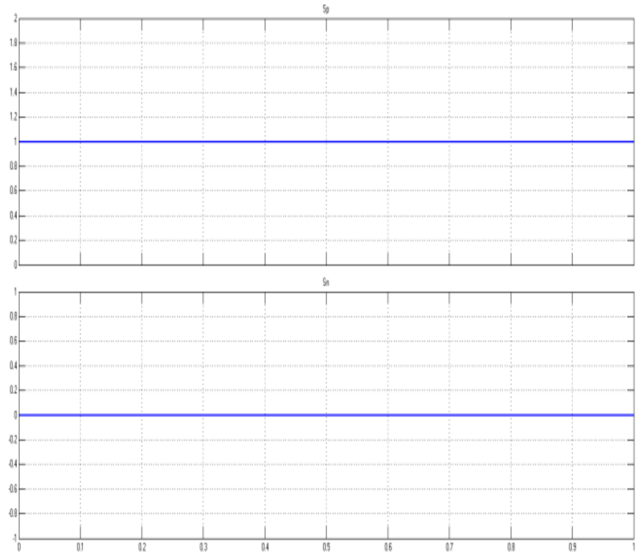

Figure 4: Switching pulses of BL-PFC control unit

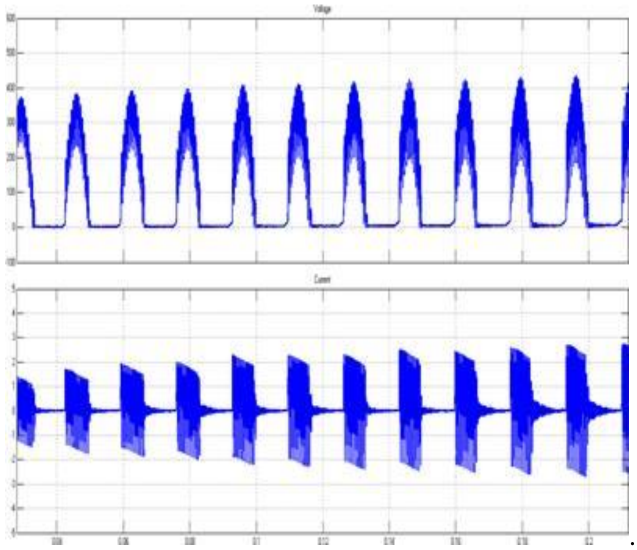

Figure 5: Voltage and current of capacitor Cn

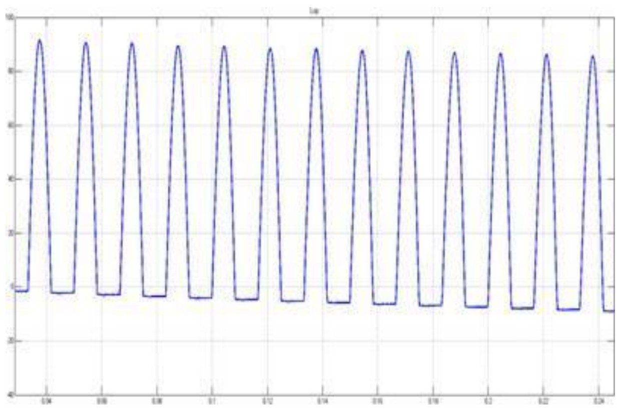

Figure 6: Voltage of Lop

Figure 7 shows the nominal current discharge characteristic graph between voltage and time. It is clear that battery discharge at 5.30 Hours.

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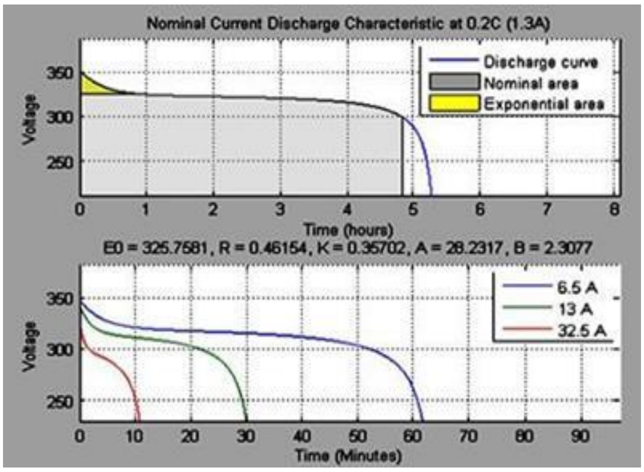


Figure 7: Battery discharge characteristic

Figure 8 and 9 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.

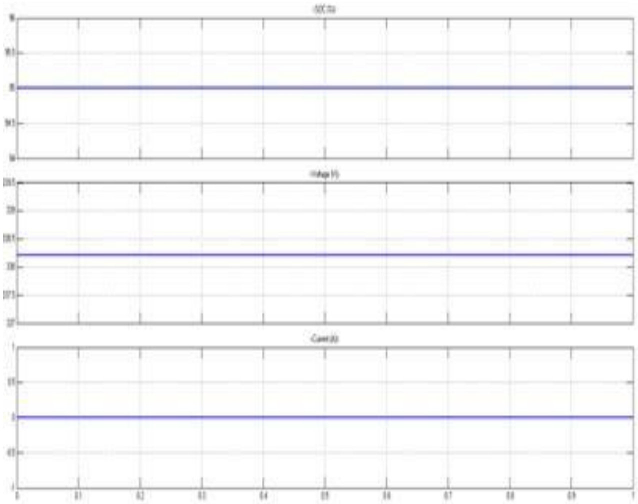

Figure 8: Performance of Battery

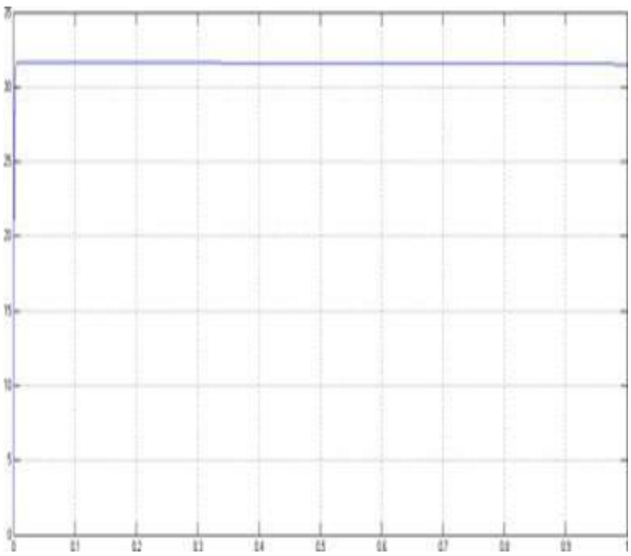

Figure 9: Battery output current

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

| S No. | Parameter | Previous Model | Proposed Model |
|---|---|---|---|
| 1 | Output voltage | 300 V | 338 V |
| 2 | Output Current | 10.83 A | 33A |
| 3 | Power factor | 0.88 | 0.92 |

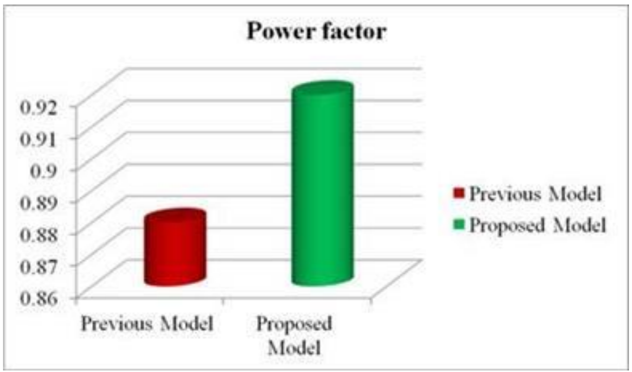


Figure 10: Result Comparison

Figure 10 is presenting the graphical representation of the result comparison

**5, Conclusions:**

An modified battery charger with improved power factor followed by a flyback converter has been proposed, analyzed, and validated. 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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