Design and Performance Enhancement of Bridgeless Landsman Converter for Electric Vehicle Battery Charger

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Abstract: An electric vehicle can charge by charging point at home or work, some electric vehicles have converters on board that can plug into a standard electrical outlet or a high-capacity appliance outlet. Others either require or can use a charging station that provides electrical conversion, monitoring, or safety functionality. The research is going on various type of advance battery charger. In this paper the design and performance enhancement of bridgeless Landsman Converter for electric vehicle battery charger is proposed. Discharging time, Power factor, etc are essential parameters of this design. MATLAB 8.3 software is used for simulation of proposed work.

***IndexTerms* -** Bridgeless, Battery charger, Power, Landsman, Electric vehicle (EV).

I. INTRODUCTION

The charging protocol (how much voltage or current for how long, and what to do when charging is complete, for instance) depends on the size and type of the battery being charged. Some battery types have high tolerance for overcharging (i.e., continued charging after the battery has been fully charged) and can be recharged by connection to a constant voltage source or a constant current source, depending on battery type. Simple chargers of this type must be manually disconnected at the end of the charge cycle, and some battery types absolutely require, or may use a timer, to cut off charging current at some fixed time, approximately when charging is complete. [1] Other battery types cannot withstand over-charging, being damaged (reduced capacity, reduced lifetime), over heating or even exploding. The charger may have temperature or voltage sensing circuits and a microprocessor controller to safely adjust the charging current and voltage, determine the cut off at the end of charge.

S. Gupta presents microgrid system consists of a wind turbine, solar PV array AC grid and DC loads. The wind turbine & AC grid is interfaced to the microgrid with a rectifier and a buck converter which are controlled to maintain a constant DC bus voltage. While the PV array is connected via a boost converter which extracts maximum power from the circuit. The microgrid system also consists of a Energy Storage System (ESS) which is connected via a bidirectional buck-boost converter [2]. A trickle charger provides a relatively small amount of current, only enough to counteract self-discharge of a battery that is idle for a long time. Some battery types cannot tolerate trickle charging of any kind; attempts to do so may result in damage. Lithium ion battery cells use a chemistry system which does not permit indefinite trickle charging. [3]

Slow battery chargers may take several hours to complete a charge. High-rate chargers may restore most capacity much faster, but high rate chargers can be more than some battery types can tolerate. Such batteries require active monitoring of the battery to protect it from overcharging. Electric vehicles ideally need high-rate chargers. For public access, installation of such chargers and the distribution support for them is an issue in the proposed adoption of electric cars.[4] A good battery charger provides the base for batteries that are durable and perform well. In a price-sensitive market, chargers often receive low priority and get the “after-thought” status. Battery and charger must go together like a horse and carriage. Prudent planning gives the power source top priority by placing it at the beginning of the project rather than after the hardware is completed, as is a common practice. Engineers are often unaware of the complexity involving the power source, especially when charging under adverse conditions.[5]

There are three main types of electric vehicles (EVs), classed by the degree that electricity is used as their energy source. BEVs, or battery electric vehicles, PHEVs of plug-in hybrid electric vehicles, and HEVs, or hybrid electric vehicles. Only BEVs are capable of charging on a level 3, DC fast charge.

Battery Electric Vehicles (BEV)

Battery Electric Vehicles, also called BEVs, and more frequently called EVs, are fully-electric vehicles with rechargeable batteries and no gasoline engine. Battery electric vehicles store electricity onboard with high-capacity battery packs. Their battery power is used to run the electric motor and all onboard electronics. BEVs do not emit any harmful emissions and hazards caused by traditional gasoline-powered vehicles. BEVs are charged by electricity from an external source. Electric Vehicle (EV) chargers are classified according to the speed with which they recharge an EVs battery.

The classifications are Level 1, Level 2, and Level 3 or DC fast charging. Level 1 EV charging uses a standard household (120v) outlet to plug into the electric vehicle and takes over 8 hours to charge an EV for approximately 75-80 miles. Level one charging is typically done at home or at your workplace. Level 1 charger have the capability to charge most EVs on the market.

Level 2 charging requires a specialized station which provides power at 240v. Level 2 chargers are typically found at workplaces and public charging stations and will take about 4 hours to charge a battery to 75-80 miles of range.

Level 3 charging, DC fast charging, or simply fast charging is currently the fastest charging solution in the EV market. DC fast chargers are found at dedicated EV charging stations and charge a battery up to 90 miles range in approximately 30 minutes.

Plug-in Hybrid Electric Vehicle (PHEV)

Plug-in Hybrid Electric Vehicles or PHEVs can recharge the battery through both regenerative braking and “plugging in” to an external source of electrical power. While “standard” hybrids can (at low speed) go about 1-2 miles before the gasoline engine turns on, PHEV models can go anywhere from 10-40 miles before their gas engines provide assistance.

Hybrid Electric Vehicles (HEV)

HEVs are powered by both gasoline and electricity. The electric energy is generated by the car’s own braking system to recharge the battery. This is called ‘regenerative braking’, a process where the electric motor helps to slow the vehicle and uses some of the energy normally converted to heat by the brakes. HEVs start off using the electric motor, then the gasoline engine cuts in as load or speed rises. The two motors are controlled by an internal computer, which ensures the best economy for the driving conditions.

II. PROPOSED MODEL

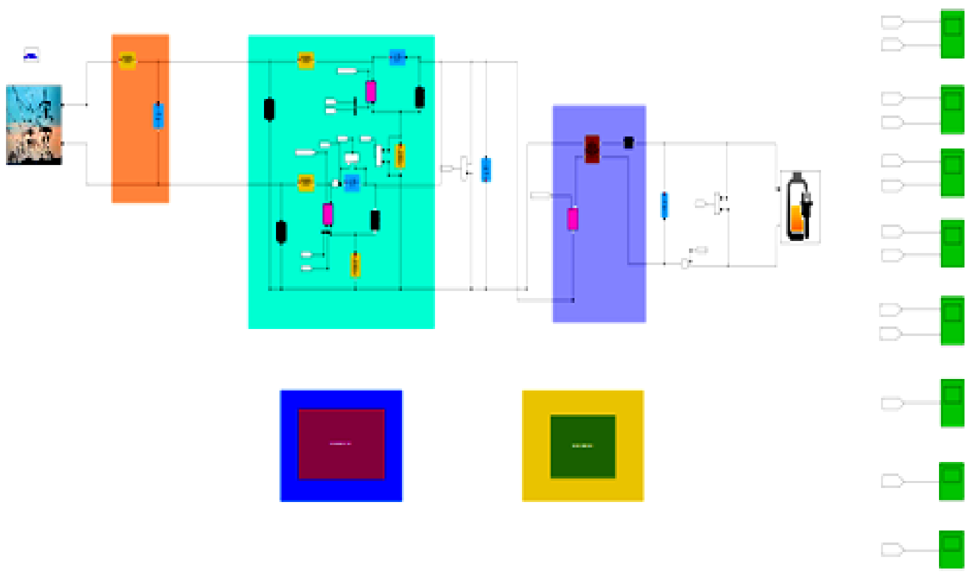

Figure 1: Proposed Model

Figure 1 showing proposed design model of modified bridgeless landsman converter for electric vehicle battery charger. The proposed model is divided into following sub modules-

- AC grid
- BL- Modified Landsman Converter
- Flyback Converter
- PWM
- BL-PFC Control Unit

MODIFIED BRIDGELESS LANDSMAN CONVERTER

This work deals with power factor correction (PFC) in high-brightness (HB) light emitting diode (LED) module using a bridgeless canonical switching cell (BL-CSC) converter. This application is designed for large area LED projection application with full brightness control of HB red-green-blue LED module. A PWM technique is used for brightness control of LED driver. This BL-CSC PFC converter is used to feed dual flyback DC-DC converter which supplies power to the cooling unit and the LED module with galvanic isolation. Synchronous buck converters are used for brightness control using PWM dimming technique of the multiple LED strings. The BL-CSC PFC converter is designed for discontinuous inductor current mode operation to provide natural PFC at AC mains. A working prototype of the proposed LED driver is developed for experimental verifications. The performance parameters of the proposed HB LED driver is evaluated for a full brightness control capability with high power factor at universal input AC (90–265 V). The improved power quality parameters observed at AC mains are found within the acceptable limits of international power quality standard IEC 61000-3-2.

When switch (Sw) is on, an energy from the supply and stored energy in the intermediate capacitor (C1) are transferred to input inductor (Li). The output inductor (Lo) starts discharging and the voltage of intermediate capacitor (vC1) starts reducing while DC-link voltage (Vdc) starts increasing. The value of intermediate capacitor is large enough to store required energy such that the voltage across the capacitor does not become discontinuous. Mode-2 In this mode of converter operation, switch is turned-off. An intermediate capacitor (C1) and DClink side inductor (Lo) are charging through the supply current while output inductor (Li) starts discharging. Hence, vC1 starts increasing in this mode. Moreover, the voltage across the DC capacitor (Vdc) decreases. Mode-3. This is the DCM for converter operation as the input inductor (Li) is discharged completely and current iLi becomes zero. The current of DC bus side inductor (iLo) starts increasing and the voltage of intermediary capacitor (vC1) continues to decrease in this mode.

III. SIMULATION RESULTS

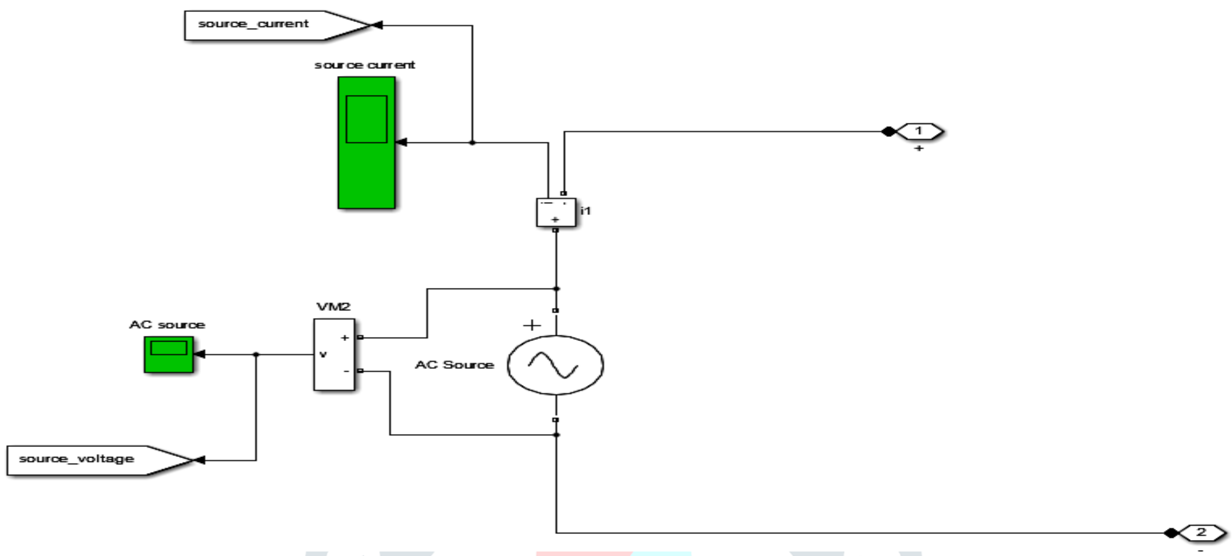

Figure 2: AC Source or Grid

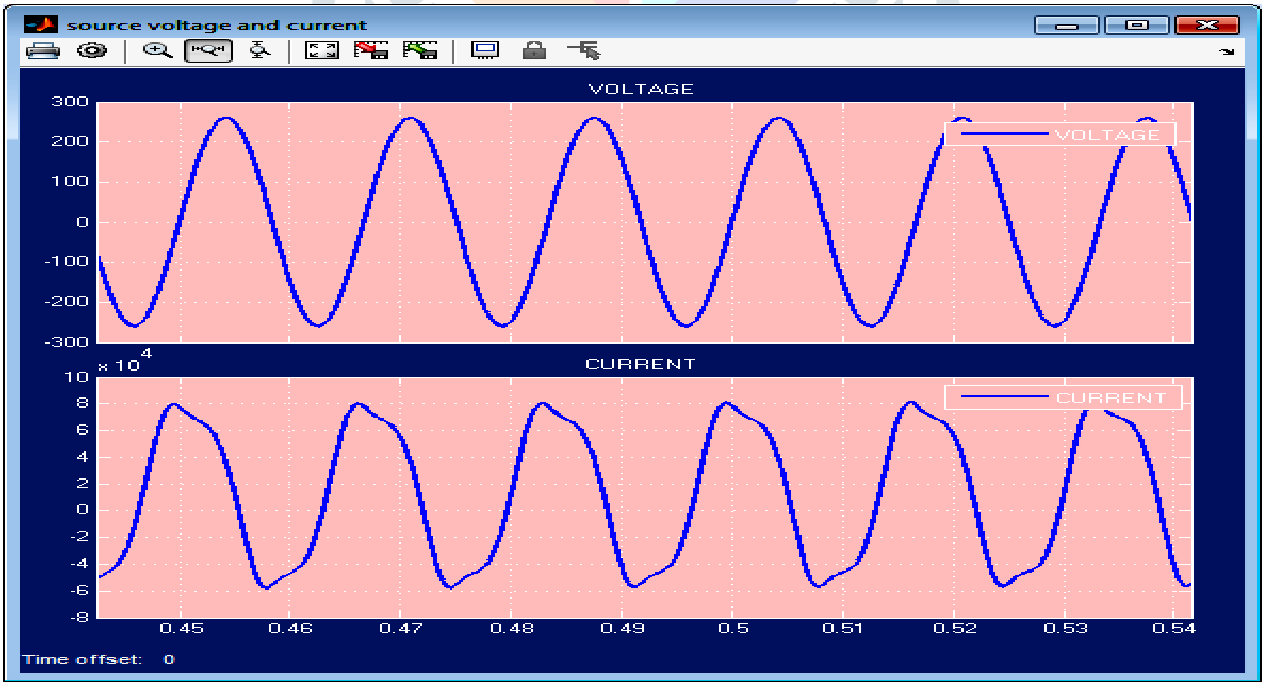

Figure 3: Output of AC source voltage and current

Figure 3 presents output of source voltage is 260V and 10A current.

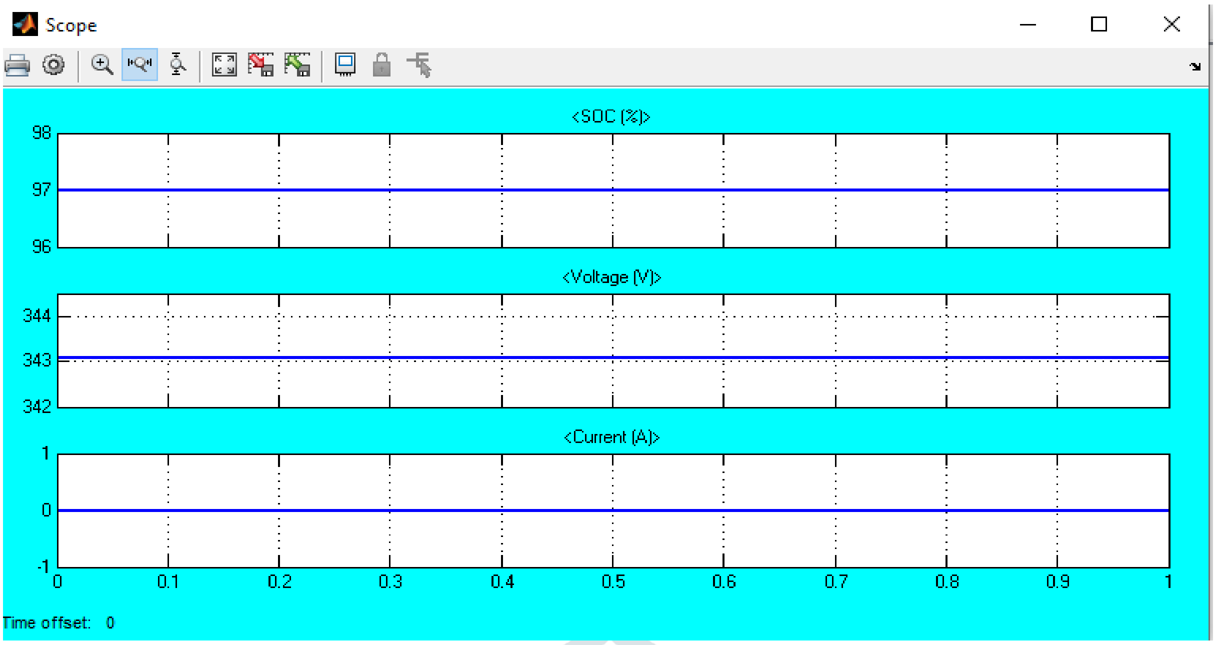

Figure 4: Performance of Battery

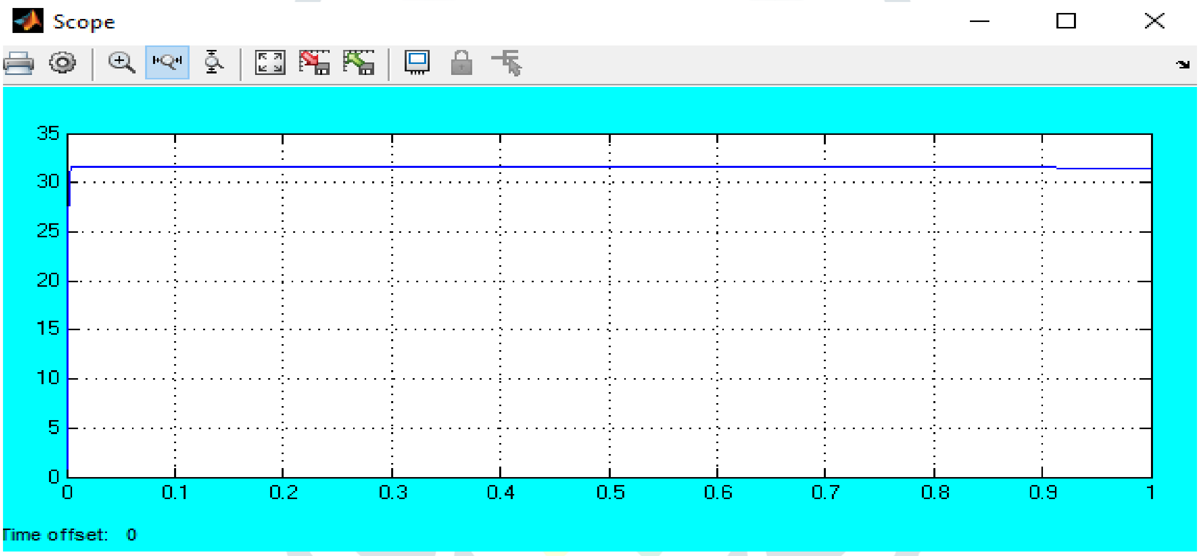

Figure 5: Battery output current

Figure 4 and 5 is showing output performance of battery. Here it can be seen that state of charge of battery is 95% and voltage is 343V and current is 33A.

Table 1: Comparison of proposed design result with previous design result

Sr No.	Parameter	Values
1	AC voltage	230V
2	AC Current	10A
3	Battery Voltage	50V to 343 V
4	Battery Current	33A
5	State of charge	97%

Table 1 is showing the parameter values of considered in proposed model system. The voltage and current of AC source and battery performance values is presented.

Table 2: Comparison of proposed design result with previous design result

Sr No.	Parameter	Previous Model	Proposed Model
1	Number of components	Increased	Constant
2	Control (with PFC)	Voltage Follower	Voltage Follower
3	Power density	0.369kW/kg	0.32W/kg
4	Power factor	0.88	0.90
5	Efficiency	91%	97%

Table 2 showing comparison of proposed model results with previous design model results in terms of output voltage, rated power, efficiency, power factor etc. Therefore above result shows, proposed model give significant improved result rather than then the existing model.

IV. CONCLUSION

The electric vehicle battery charger is very important to maintain pperformance enhancement. This paper focused on bridgeless landsman converter for electric vehicle battery charger. Proposed model have sub modules also to control system. Therefore the state of charge is 97% and it can be say that proposed model is giving significant improved result than previous model in terms of simulated values. The parameters can be varying as per simulation results.

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