Power Factor Improvement Of Ev Charger Using Landsman Converter

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Abstract

The design and employment of a novel battery-operated electric vehicle (BEV) charger with front-end power factor increase are the topics of this article. The suggested configuration replaces the present electric vehicle (EV) battery charger's traditional diode converter at the source side with a modified Landsman power factor correction (PFC) converter. The flyback isolated converter, which connects the PFC converter in series, controls how the electric car battery is charged, initially in constant current mode and then switching to constant voltage mode. The proposed PFC converter is governed by a single sensed entity to achieve the strong regulation of DC-link voltage and to ensure the operation of unity power factor. Comparing the suggested architecture to the standard one reveals that it delivers higher power quality, reduced device stress, low input and output current ripple, and low input current harmonics.

Keywords: Landsman converter, Power Factor Improvement, E vehicle.

I. INTRODUCTION

Electric mobility contributes significantly to the creation of a sustainable and effective alternative in the transportation industry, which is important given the severe regulations on emissions, fuel efficiency, global warming challenges, and limited energy resources. In this regard, a survey based on the current situation and potential technologies for electric vehicle (EV) propulsion is offered. Comparing electric mobility to traditional petrol- and diesel-powered vehicles, there are a number of benefits. However, if the researcher wants to completely embrace transportation electrification, they must pay particular attention [1]. It is necessary to develop appropriate, efficient control mechanisms in order to integrate them with the current distribution system. Some of the strategies listed above have to do with the poor power quality issues that EV chargers have when charging battery packs.

The electric vehicles are powered by the rechargeable batteries, which also provide the necessary traction force. These batteries are usually recharged using an EV charger, commonly referred to as an AC-DC converter. A boost converter up front and an isolated converter later make up the most typical design for an electric vehicle battery charger. Because the output voltage and current are controlled, the DC-DC converter's performance alone determines how well this sort of charger performs **[2] - [5].** Numerous interleaved and zero voltage switching (ZVS) PFC (Power Factor Correction) converter-based battery chargers have been developed to reduce the inductor size and output current ripple. The PFC converter interleaving, however, has a large current stress cost in switches. With benefits including high power density and high efficiency, the full-bridge topology is the most popular for PFC-based EV chargers; nevertheless, the configuration of four switches makes the charger operation difficult. An LLC (Inductor-Inductor-Capacitor) resonant converter presents an attractive alternative because to its high efficiency, minimum electromagnetic interference noise, and high power density across a wide input range. Due to the growing complexity of the design and analysis of LLC converters, unidirectional or bidirectional AC-DC converters are replacing this type of topology in integrated on-board or off-board configurations **[6].**

II. DIODE BRIDGE RECTIFIER

In an existing system that considers AC-DC conversion as the distinguishing feature of EV battery chargers, numerous DBR (Diode Bridge Rectifier) fed unidirectional isolated single stage or two-stage converters without isolation are recognized. In this regard, the current block diagram shows the setup of a conventional single phase DBR fed unidirectional E-rickshaw battery charger. **[7] –[9].** However, the conventional charger's performance does not adhere to the required power quality (PQ) standard, IEC 61000-3-2. Full-wave diode bridges at the charger's input cause a significant level of harmonic distortion (55.3%) in the input current drawn during battery charging. The result is a low source power factor. The difference between source voltage and current is also getting wider since the input current is no longer sinusoidal. Therefore, an efficient power factor correction (PFC) technique that also mitigates the negative effects of input DBR is needed for the front-end of the conventional DBR fed charger..

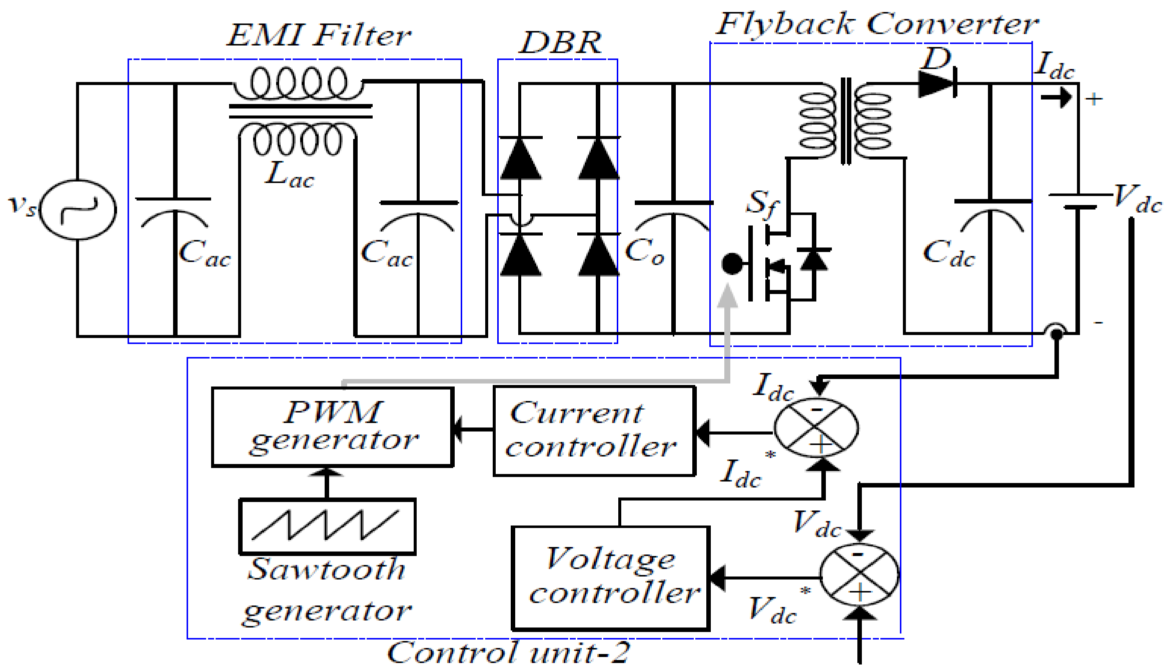

Fig 1. Diode Bridge Rectifier Configuration

III. LANDSMAN CONVERTER

By reordering the input and output side inductors, the first stage of the proposed Landsman converter differs slightly from the existing system. Due to continuous conduction (CCM) of the input inductors, the suggested change delivers the benefit of low input current ripple as well as the benefit of low output current ripple with the standard Landsman topology being maintained. To raise the power factor to unity, two parallel converters run in synchronization and in discontinuous region (DCM mode) during the respective mains voltage half cycles. Due to the employment of a single sensor at the output stage, the DCM operation has the inherent advantages of being inexpensive and simple in the circuit. The charger's intermediate DC link voltage is successfully controlled using a proportional and integral (PI) controller based on a voltage follower [17]. However, a dual loop PI controller is used to operate the flyback converter in the second stage. During the conditions of constant current and constant voltage mode charging, the battery current is regulated to correspond to 60% state of charge (SOC) to 100% SOC with the help of a straightforward PI control. As a result, the suggested EV battery charger provides the EV battery with an enhanced power quality-based charging profile. Additionally, the charger's input power quality indices were found to be within the acceptable limits of the IEC 61000-3-2 standard [20]. Due to the fact that DBR conduction losses are cut in half for each cycle, the efficiency is increased as compared to the traditional DBR fed charger.

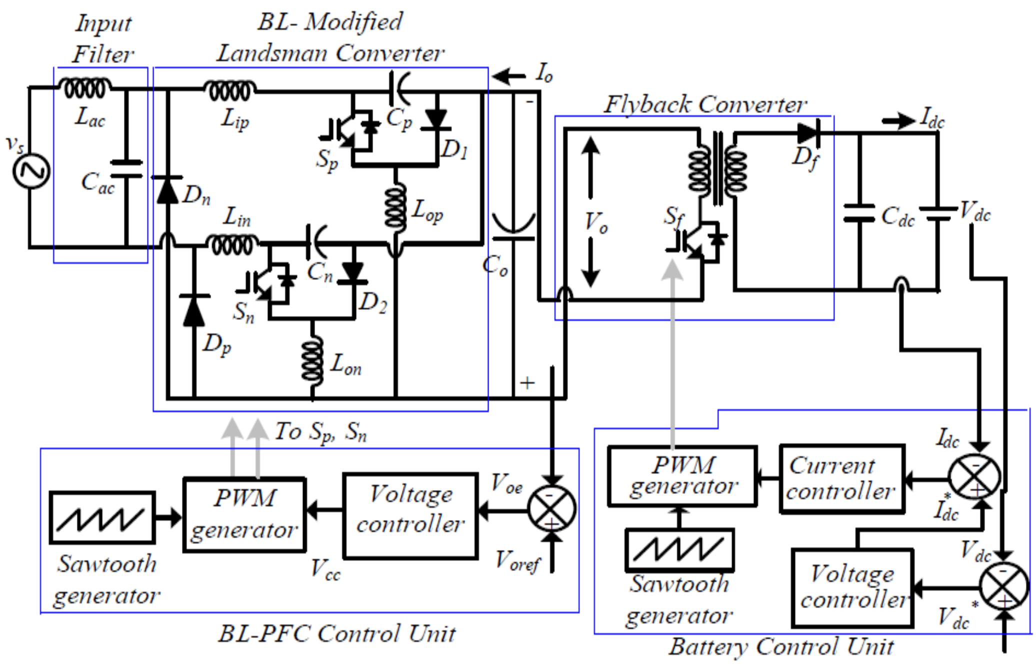

Fig 2. Landsman Converter Configuration

IV. MODES OF OPERATION

Figs. 3 (a) –3 (c) Show the switching cycle and the corresponding half of the mains voltage operation of the proposed redesigned BL converter (f). The operational principle during the positive half cycle is explained in the following..

Mode P-I (t0-t1): The converter's operation starts in mode P-I during the positive half cycle of the mains voltage [10,11]. The inductor Lop begins charging through the path depicted in Fig. when the switch SP, connected in the upper line, is in the ON position. 3 (a). At this moment, the isolated converter linked to the load side causes the intermediate DC link capacitor, Co, to discharge. Due to the inductor's stored charge, the high frequency diode D1 does not have a conducting route at this time, and as a result, a reverse bias voltage is present across it.**[12] – [14]**

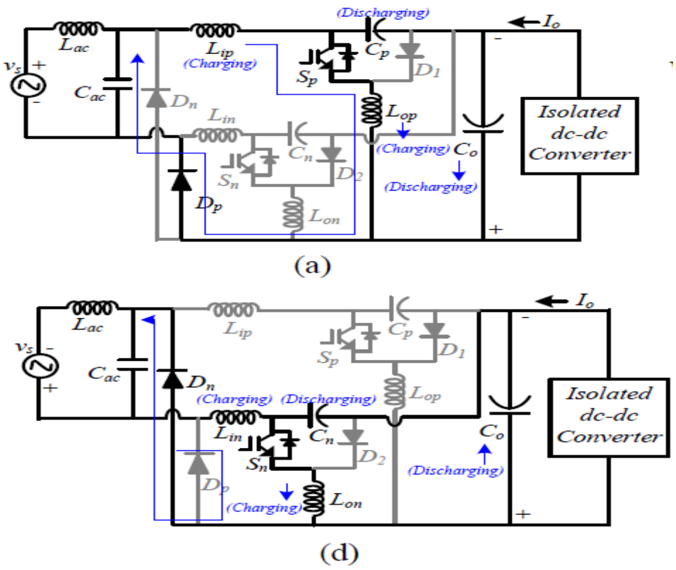

Fig: 3 (a) & (d) Mode of Operation – I

Mode P-II (t1-t2): When the gate pulse to the switch is suppressed, the high frequency diode D1 works in mode P-II. The inductor, Lop, follows the route shown in Fig. To discharge through it, use 3(b) [15, 16]. For each switching cycle, power is delivered to the flyback converter at the output and the DC link capacitor, which Co starts charging.

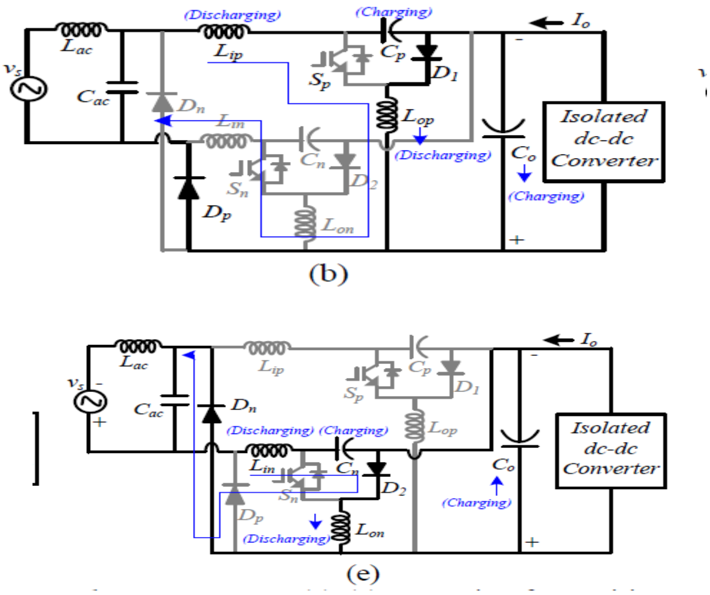

Fig: 3 (b) & (e) Mode of Operation II

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Mode P-III (t2-t3): At the conclusion of the switching cycle in mode P-III operation, the stored charge in inductor Lop is totally exhausted. For the rest of the switching cycle, the inductor current discontinues [18, 19]. The intermediate DC link capacitor is responsible for supplying the output power during this time, discharging through the channel shown in Fig. 3. (c). The revised BL converter proposed switches the lower switch Sn, inductor Lon, and diode D2 in the same order throughout the negative half cycle of the mains voltage, as shown in Figs. 3(d)-(e) (f) [21, 22]. Show both the switching cycle of the suggested bridgeless Landsman converter and the switching order for the components operating in the various modes during the whole input voltage cycle

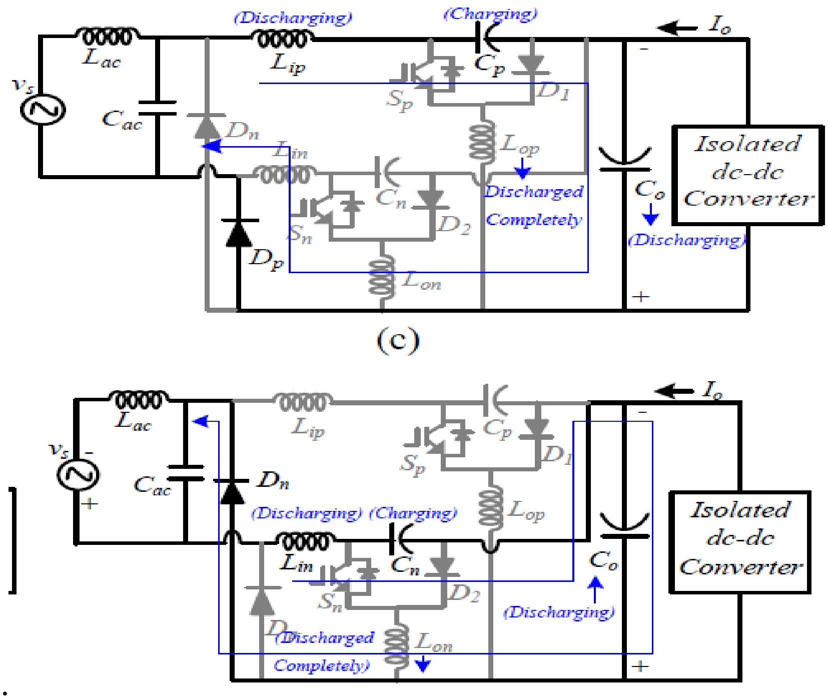

Fig: 3 (c) & (f) Mode of Operation - III

V. Hardware & Simulation Diagram

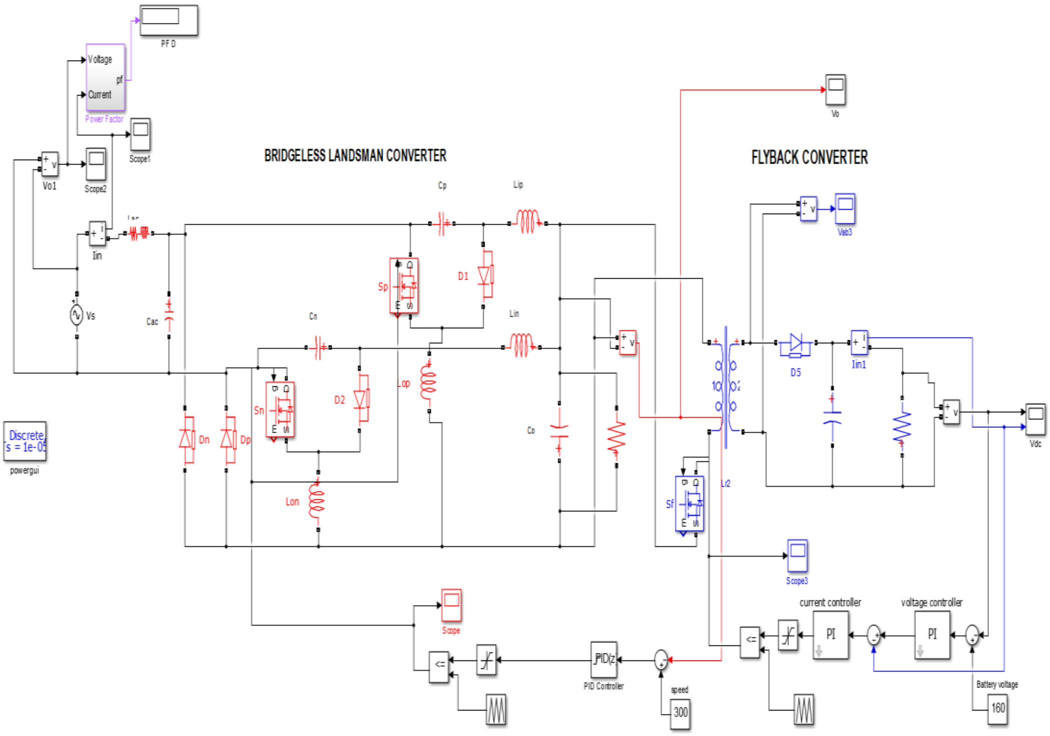

Fig 4. Simulation Diagram

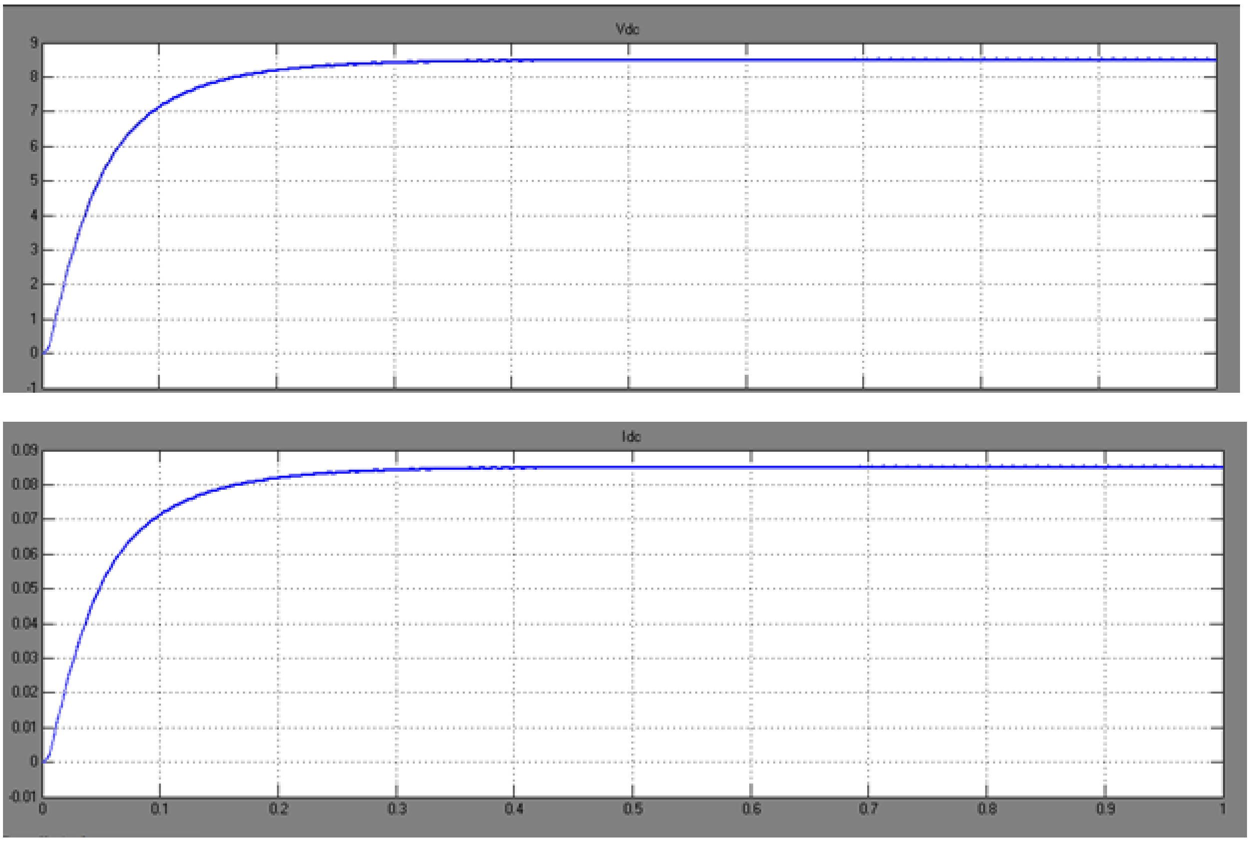

Fig 5. Output voltage and current

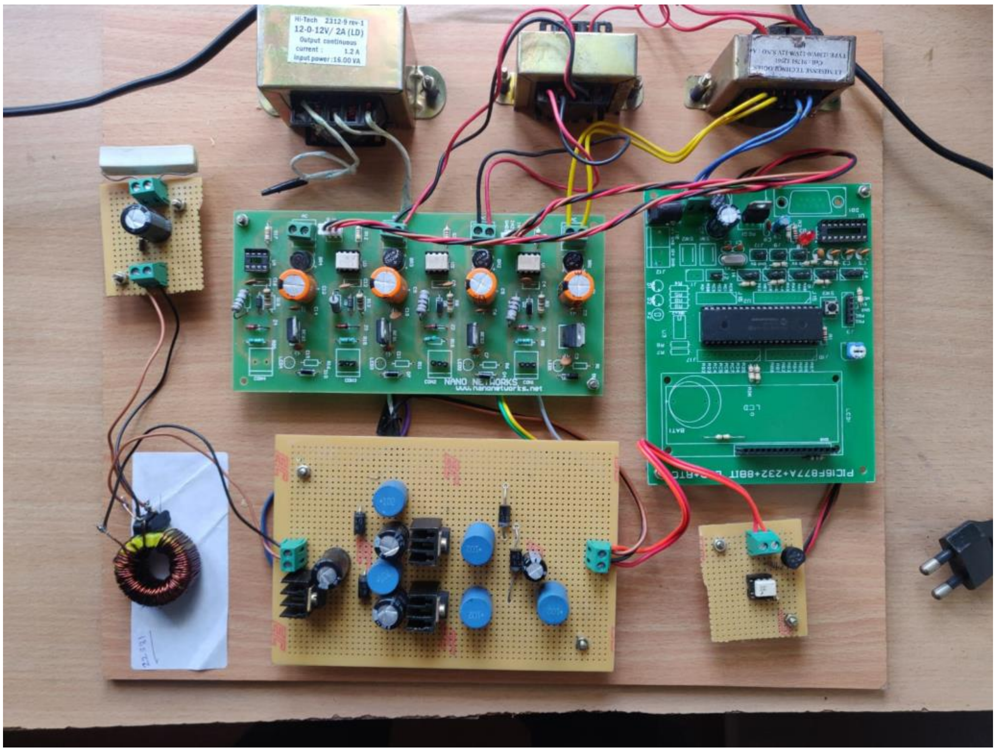

Fig 6. Hardware Set up

Due to the fact that DBR conduction losses are cut in half for each cycle, the efficiency is increased as compared to the traditional DBR fed charger [23]. Due to the continuous conduction (CCM) of the input inductors, the proposed change has the benefit of reduced input current ripple.

VI. CONCLUSION

In order to charge an EV battery with inherent PF Correction, an improved EV charger with a modified BL Landsman converter followed by a flyback converter has been designed, examined, and confirmed. The suggested EV charger's design and control in DCM mode has the benefit of using fewer sensors at the output. Additionally, the suggested BL converter has lessened the converter's input and output current ripples caused by inductors. The operation of the charger has been confirmed by experimental findings under steady state and abrupt variations in input voltage after the development of a prototype. The outcomes of the hardware validation demonstrate that the performance of the suggested charger for enhanced power quality-based charging of EV batteries is deemed satisfactory. Additionally, to comply with the advised IEC 61000-3-2 standard criteria for power quality, the input current THD is decreased to as low as 4.3%. As a result, the suggested BL converter fed charger seeks to be a more affordable, acceptable, and dependable alternative to the traditional lossy and inefficient EV battery charger.

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