HYBRID POWER MANAGEMENT ENERGY EFFICIENCY OF ELECTRIC VEHICLE (EV) CHARGING THROUGH PHOTOVOLTAIC (PV) AND MICRO GRID (MG)

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Abstract

This Paper proposes a novel integrated low-voltage DC–DC converter (LDC) and on-board charger (OBC) for electric vehicles (xEVs) that share heat sinks, terminals, sensing circuits and circuit components between both parts. The proposed OBC-LDC integrated power unit (OLPU) can be simplified by modifying the internal connections of the vehicle, thus eliminating the cost of high-power cables. In addition, the OLPU decreases the number of circuit components and increases the total power density by combining or sharing heat sinks, terminals, sensing circuits and circuit components. Further, the proposed circuit satisfies the performance characteristics of conventional OBCs and LDCs and can be operated as such. Moreover, a simultaneous charging method for both a high voltage battery and a low voltage battery is suggested through an additional operational mode that results from the integration. This paper also specifically describes the operating characteristics and the design method in each mode. Design considerations including possible problems with the integrated circuit structure are presented, and an additional compensation circuit is suggested to solve these problems. The prototype is built, and experiments are carried out to verify the performance and validity of the proposed power unit.

Keywords: DC–DC converter, OBC-LDC integrated power unit, cost of high-power cables, design method, power unit.

1. Introduction

Batteries are especially treated as the key elements in xEVs and thus have spurred a great demand for the technical improvement of onboard battery chargers (OBC) and low-voltage DC–DC converters (LDC), which directly affect the lifetime, charging, and discharging performance of batteries [1]-[9]. Typical OBCs use an AC grid as an input and charge high voltage batteries (HVB) that require a wide charging range through AC to DC conversion [1]-[5]. Currently, most xEV powertrains demand galvanic isolation between the grid and the battery [1]-[9]. Thus, DC–DC converters in OBCs are implemented by an isolated topology. In addition, LDCs with isolated transformers use HVBs as an input source and supply power to the electronic devices and low voltage battery (LVB) in the vehicle [1], [6]-[8].

2. OBC & LDC Performance

Because the OBC and LDC are directly involved in the charging performance of both batteries (HVB and LVB), they should be highly efficient and reliable. Moreover, high power density and light weight are desirable because OBCs and LDCs are implemented in vehicles. Various researches have investigated the mechanical or electrical integration of OBCs and LDCs with the powertrain elements of conventional xEVs to satisfy these requirements [1]-[14].

The proposed OLPU not only has standalone modes as an independent OBC or LDC but also an additional mode that can charge both the HVB and the LVB simultaneously. This work describes a proposed integrated main circuit, a structural explanation of a practical compensation circuit, an analysis of operating modes, and design considerations for key components. The validity of the proposed circuit is verified through simulation and experimental results under various conditions. The design of an onboard battery charger is not as simple as connecting the battery straight to the grid. The power charging the battery must be within certain specifications to prevent damage to the battery and overall system. In terms of PHEVs, the high- energy battery pack is to be charged with Power Factor Correction (PFC) from an AC outlet. The most common topology for the PHEV battery charger is the two-stage approach with cascaded PFC AC-DC and DC-DC converters. In the PFC stage, AC single phase is rectified and boosted with power factor correction. The output of the boost converter is connected to the DC bus, and a bidirectional converter for the battery charging or discharging is also connected to this DC bus.

3. SIMULATION RESULTS

Simulation has become a very powerful tool on the industry application as well as in academics, nowadays. It is now essential for an electrical engineer to understand the concept of simulation and learn its use in various applications. Simulation is one of the best ways to study the system or circuit behaviour without damaging it .The tools for doing the simulation in various fields are available in the market for engineering professionals. Many industries are spending a considerable amount of time and money in doing simulation before manufacturing their product. In most of the research and development (R&D) work, the simulation plays a very important role. Without simulation it is quiet impossible to proceed further. It should be noted that in power electronics, computer simulation and a proof of concept hardware prototype in the laboratory are complimentary to each other. However computer simulation must not be considered as a substitute for hardware prototype. The objective of this chapter is to describe simulation of impedance source inverter with R, R-L and RLE loads using MATLAB tool.

Typical uses includes

1. Math and computation
2. Algorithm development
3. Data acquisition
4. Modelling, simulation, and prototyping
5. Data analysis, exploration, and visualization
6. Scientific and engineering graphics
7. Application development,

Including graphical user interface building, integrated full bridge dc-dc converter for C Filter is appeared in Fig 3.2. The input voltage is shown in Fig 3.3. The input value is 15 V. The Output voltage of interleaved boost converter is shown in Fig 3.4 and its value is 31 V. Switching pulses for inverter (M1, M3) are appeared in Fig 3.5 and its value is 1 V. The

Transformer primary voltage is shown in Fig 3.6 and its peak value is 40 V. The Transformer secondary voltage (HVS) is shown in Fig 3.7 and its value is 125 V. The Output voltage is shown in Fig 3.8 and its value is 125 V. The Output voltage ripple (zoom out) is shown in Fig 3.9 and its value is 125.5 N-m. The output current is shown in Fig 3.10 and its value is 1.25 A. The output power is shown in Fig 3.11 and its value is 150 watts. The Transformer secondary voltage (LVS) is appeared in Fig 3.12 and its value is 28 V. The output voltage is shown in Fig 3.13 and its value is 30 v. The Output voltage of ripple (zoom out) is shown in Fig 3.14 and its value is 29 N-m. The output current is shown in Fig and its value is 1.3 A. The output power is shown in Fig 3.16 and its value is 34 watts.

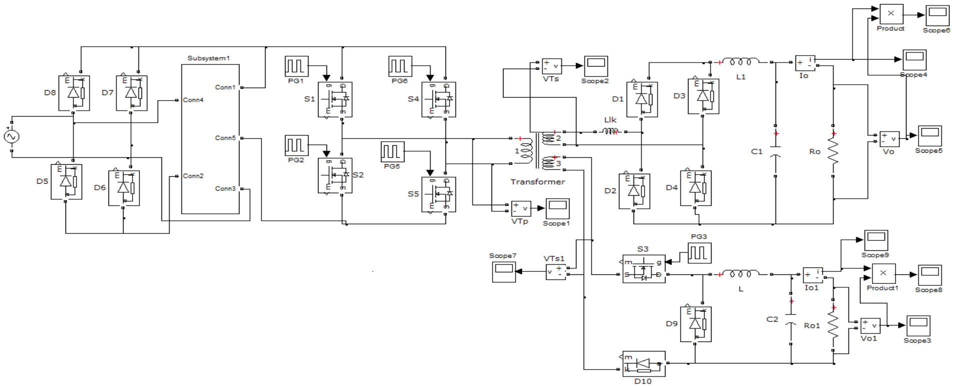

Figure 2. Integrated full bridge dc-dc converter for C Filter

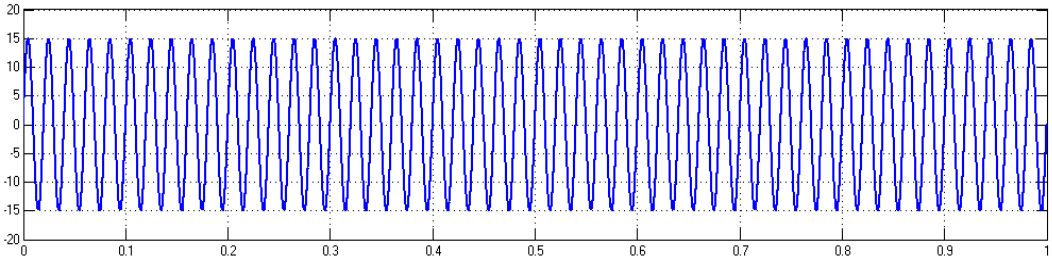

Figure 3.Input voltage

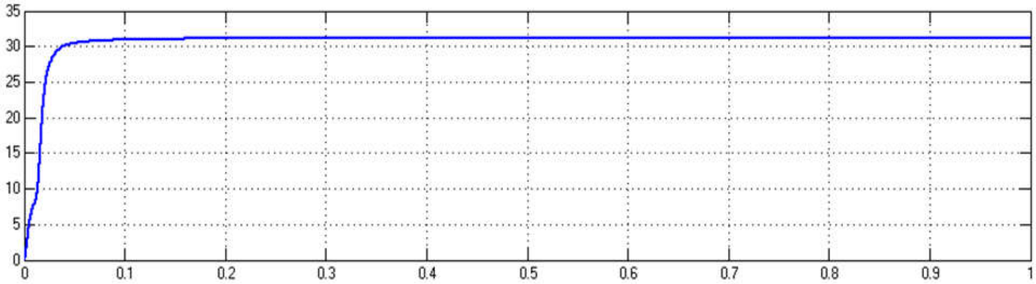

Figure 4.Output voltage of interleaved boost converter

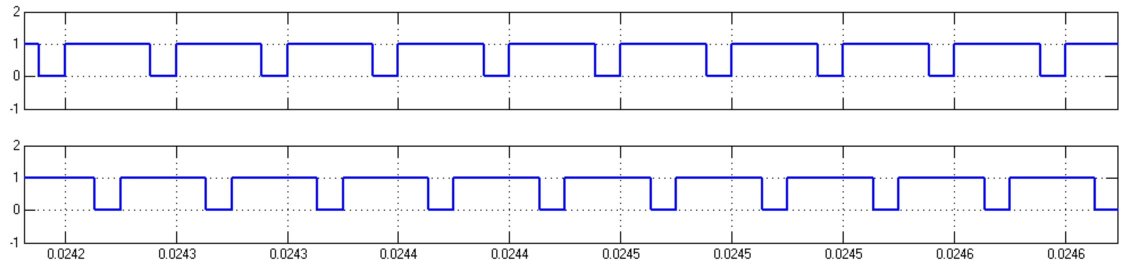

Figure 5.Switching pulse for inverter (M1, M3)

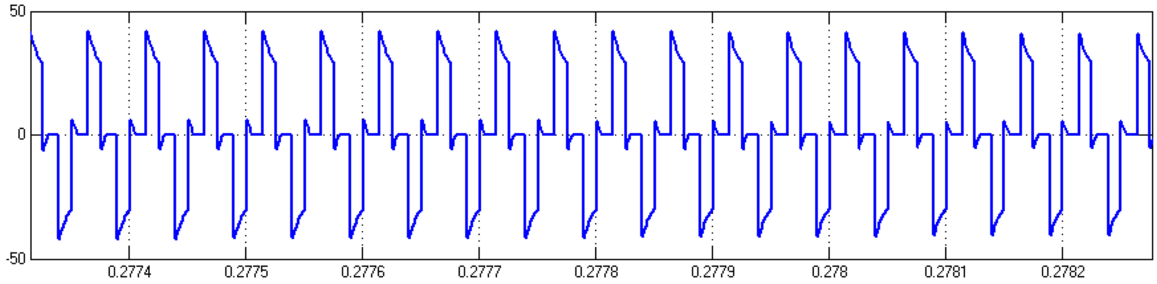

Figure 6.Transformer primary voltage

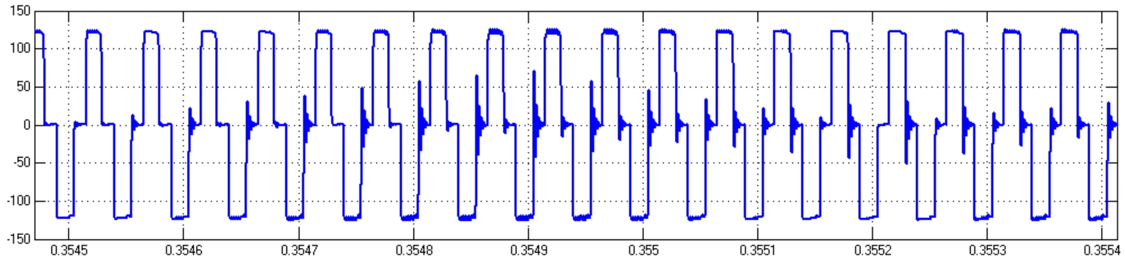

Figure 7.Transformer secondary voltage (HVS)

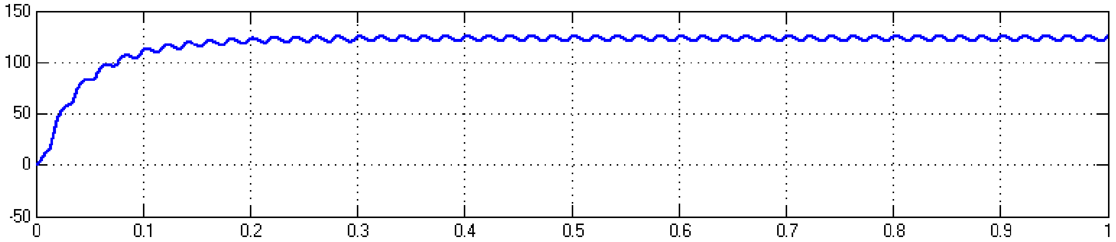

Figure 8.Output voltage

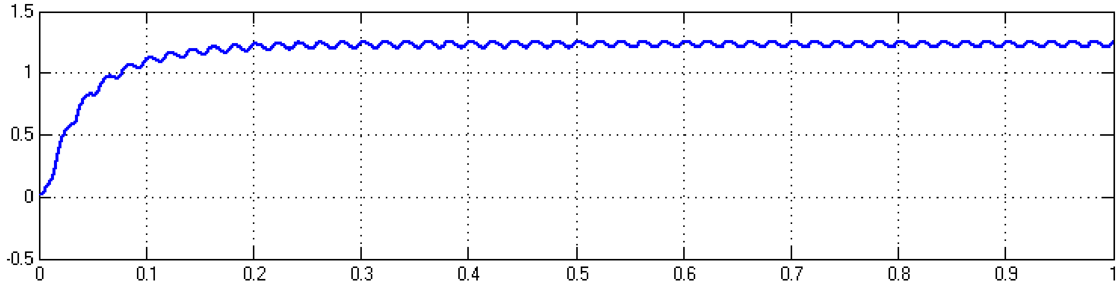

Figure 9.Output current

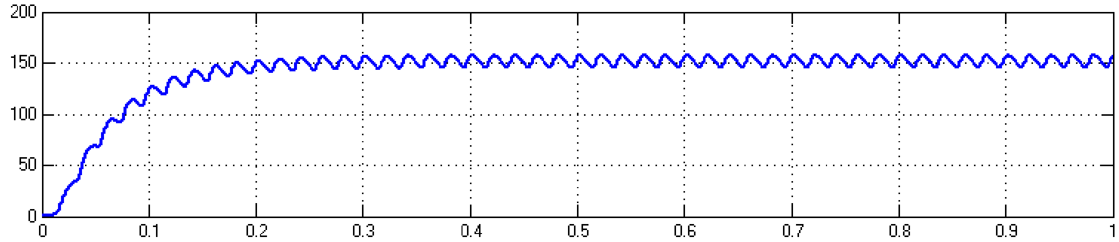

Figure 10.Output power

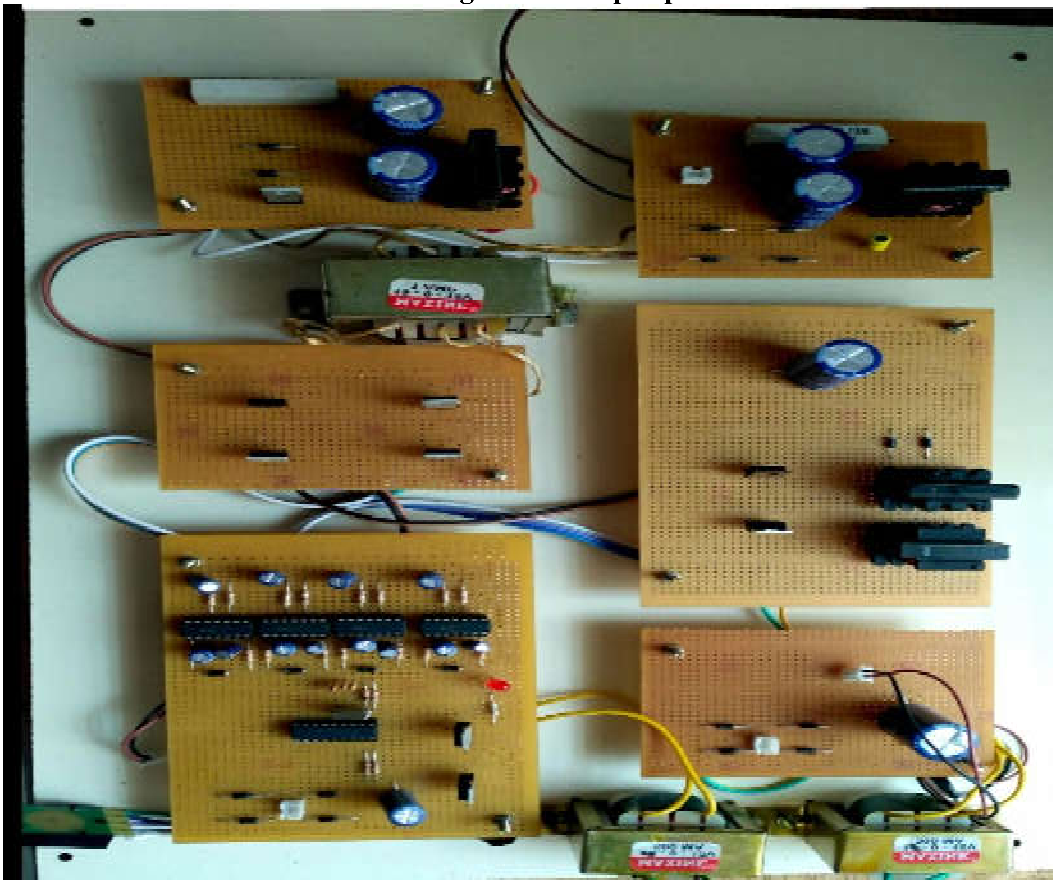

Figure 11. Hardware implementation of open loop system

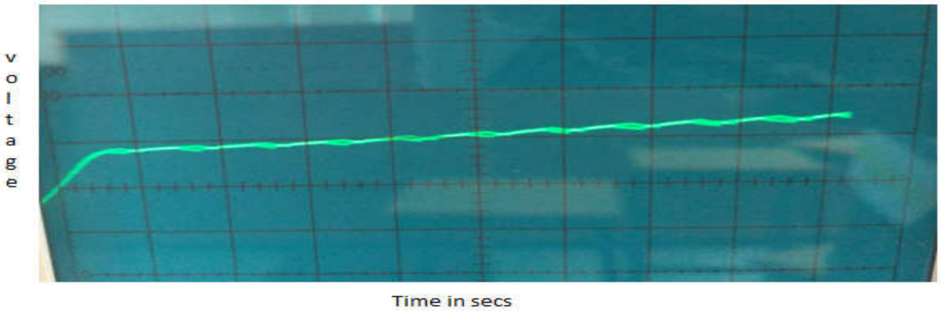

Figure 12.Amplitude=10, y-axis=1.2,voltage =10*1.2=12v

4. CONCLUSION

The overall efficiency of the OBC is 93.5%, and the overall efficiency of the LDC is more than 93% with high regulation performance. Furthermore, the induced voltage problems caused by the integrating structure in terms of the charging stability were addressed. From this empirical evaluation, the structures and the performance of the proposed OLPU are suitable for adoption in a vehicle.

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