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Simulation and Analysis of Isolated Converter for on board charger

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Abstract:

This research paper introduces an isolated converter with power factor correction mainly designed for electric vehicles (EVs). EVs, which utilize rechargeable batteries instead of internal combustion engines, offer a greener alternative to traditional fossil fuel-based vehicles. The proposed isolated converter (IC) provides continuous output current and ensures isolation from input to output. By grasping the low on-state resistance of the main switch, this converter effectively minimizes switch losses. Additionally, the converter achieves a high voltage gain at the output, resulting in improved efficiency compared to a standard converter. Moreover, electric vehicles offer the advantages of reduced greenhouse emissions and lower overall costs. This study contributes to the development of efficient and cost-effective power conversion systems for electric vehicles, promoting sustainable transportation and mitigating environmental impact.

Index Term: Converter, Isolation, controller, Electric Vehicle (EV).

1. Introduction:

As technology is continuously advanced, the range and charging times of EVs are improving, and their cost is decreasing, making them a more attractive option for consumers. Due to the unpredictable unstable voltage source of the fuel cell and photovoltaic cell, the need of high voltage gain converter is required [1][2]. Before this, in general, in boost converters, all stress was on the main switch due to the conduction loss taking place [3]. In switched-capacitor inverters capacitors are linked in series to supply voltage to load by this source voltage can be increased [4]. Leakage inductance is a cause of increased stress on the main switch in inverter circuits. Also, for high voltage gain we need to add more supercapacitors in circuits which increase the complexity of the circuit [5][6][7][8] [9]. In the paper, dc-dc converter is proposed with less voltage stress, so losses are less [10]. Isolated converters are simple and flexible [14]. A buck-boost converter is used with high voltage gain as triple of a classic buck-boost converter [11]. In our proposed converter a high frequency transformer is used for design a converter, the main supply is AC which is higher than output voltage than after rectification DC-DC converter come into existence and performed well. This converter has one main switch, so the operation is simple.

2. MATLAB Schematic of Proposed Converter:

In this proposed converter we are using a diode D, One switch SW, Three capacitors Cf, C1, and C0, and two inductors Lf, Lo. In this circuit we are using two modes of operation. We can use this converter in continuous conduction mode (CCM) and discontinuous conduction mode (DCM).

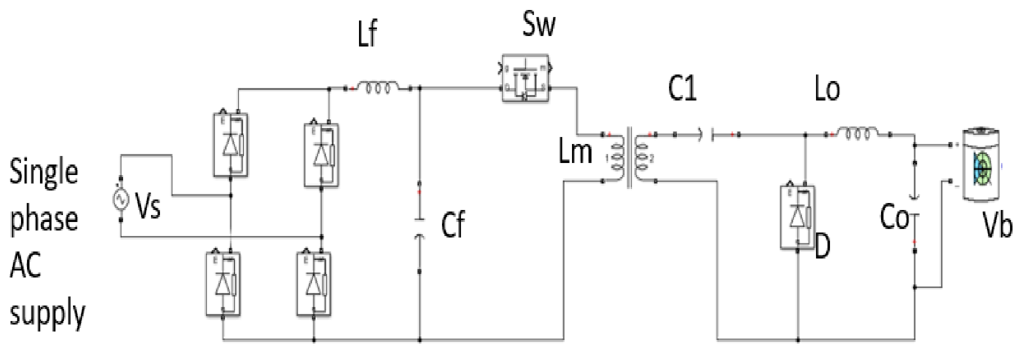

Fig. 1 Equivalent Circuit of the Proposed Converter.

2.1 Mode of Operation for proposed Isolated Converter

Mode 1: In this mode, the power transfer process initiates with the conversion of input power to direct current (DC) power. This conversion is achieved using a pair of diodes in the rectifier circuit. In this specific mode, a gate pulse is applied to switch Sw, enabling the build-up of magnetizing current in the inductance Lm. As the current accumulates, it linearly stores the energy obtained from the power source.

Simultaneously, the voltage across the energy transfer capacitor C1 starts to decrease. This reduction occurs as the current finds an alternative path through the output inductor Lo located at the secondary side of the circuit. It's worth noting that during this interval, the output diode D remains nonconducting, allowing the current to flow through the output inductor.

Mode 2: In this mode, the activation of switch Sw to the OFF position initiates a specific sequence of events. The conduction of diode D is triggered, allowing the discharge of the magnetizing inductance Lm. The stored energy is then directed towards both the output diode D and the secondary winding of the transformer. Simultaneously, the charging process of the output dc-link capacitor commences, facilitated by the inductance Lo, thereby enabling the flow of battery current.

Isolated converters play a crucial role in providing insulation between input and output voltages. To achieve this, a high-frequency transformer capable of withstanding significant voltage levels is required. Additionally, inductors are employed for energy storage purposes. Despite their advantageous features, it is important to acknowledge that isolated converter topologies possess inherent complexity, necessitating careful design and implementation.

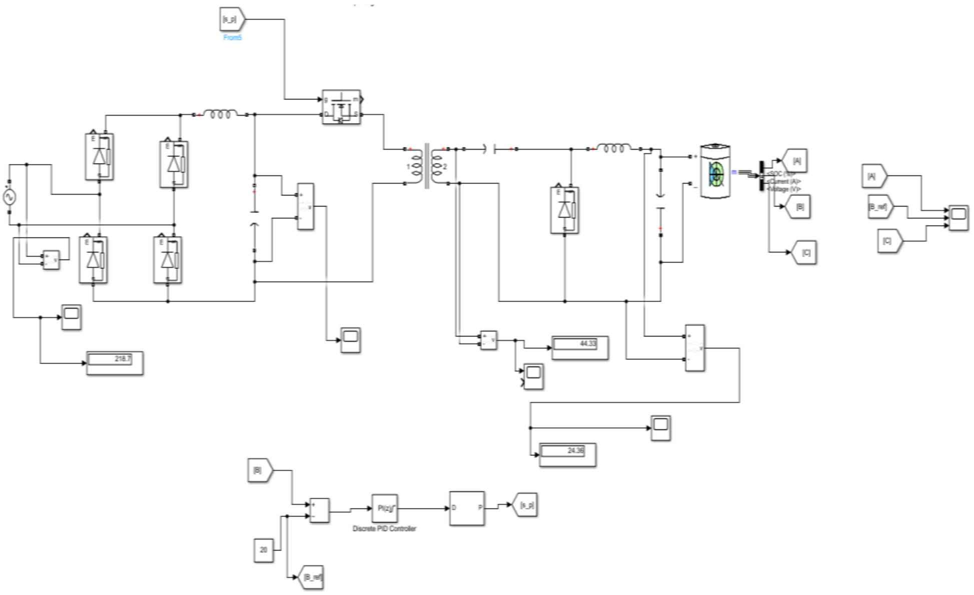

Fig 2. MATLAB Simulink Isolated converter with PI Converter

3. Performance Analysis:

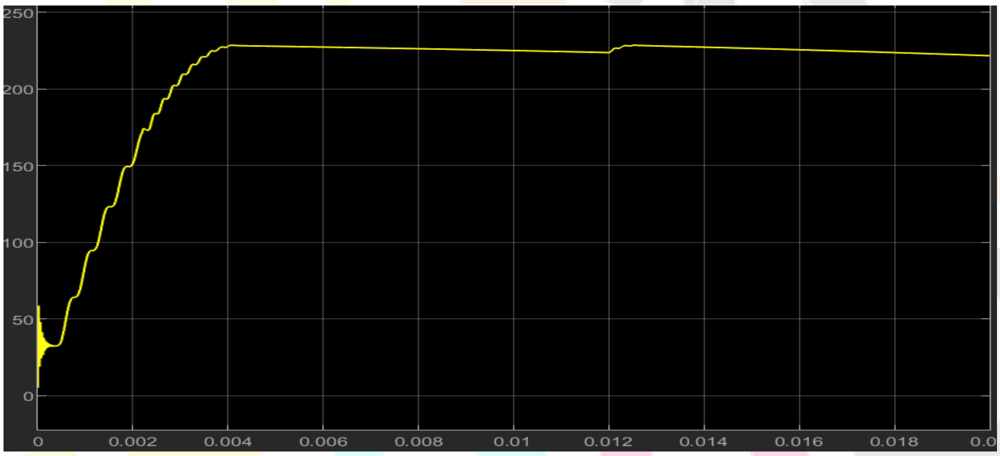

Fig 3. Rectified Voltage AC to DC Converter

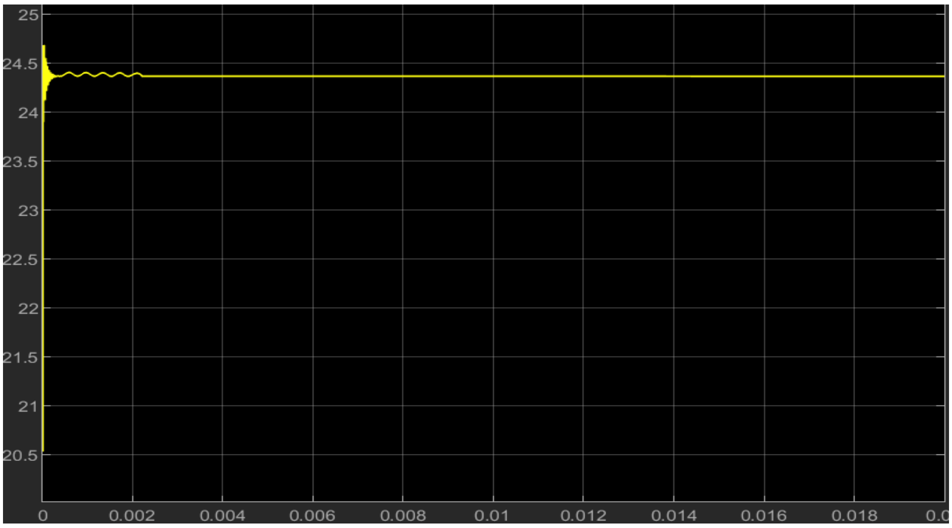

Fig 4. Output Voltage of the Converter

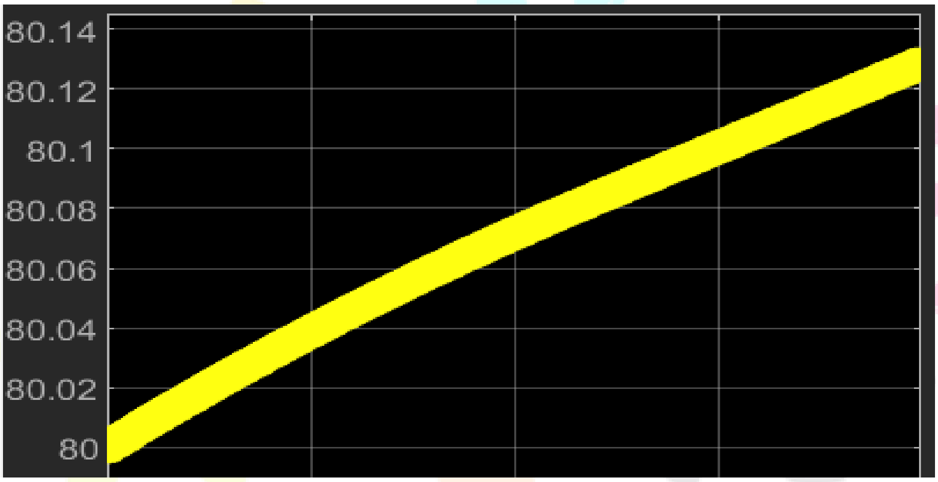

Fig 6. Soc 80% State of Charge

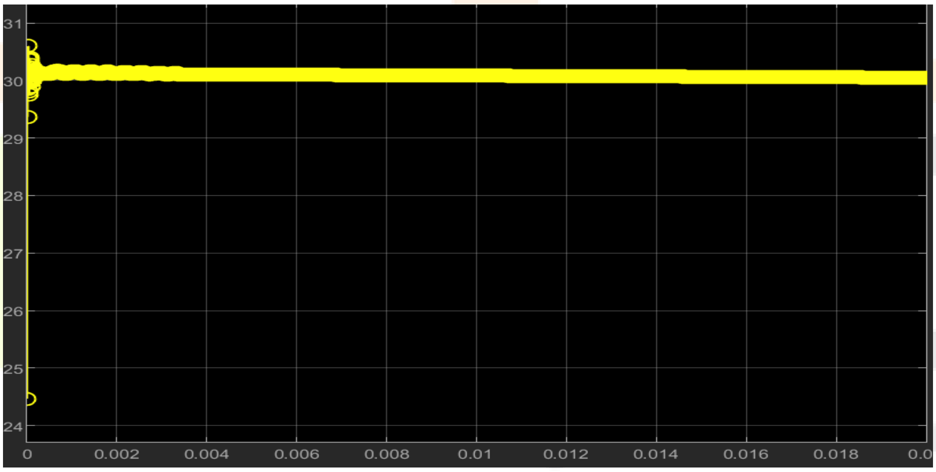

Fig 5. Output Voltage of Isolated Converter

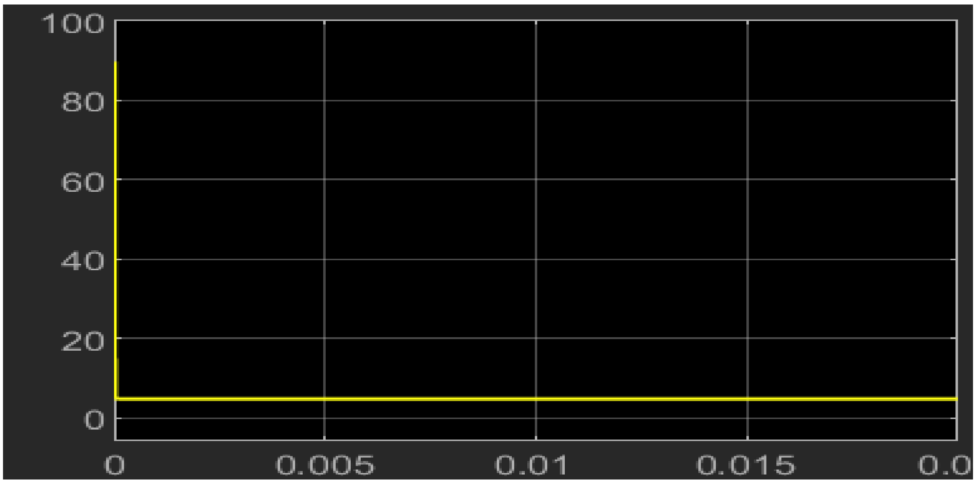

Fig 6. Output Current of Isolated Converter

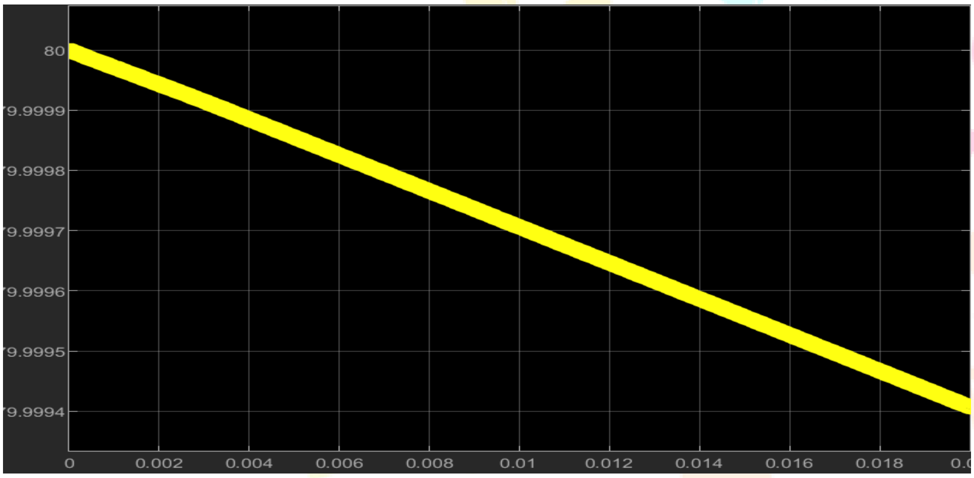

Fig 7. Battery Depth of Discharge

4. Simulation Result:

The proposed battery control system based on the isolated converter (IC) has been designed using the MATLAB/SIMULINK software. The developed model, as depicted in Figure 2, shows the implementation of the proposed PFC (Power Factor Correction) converter topology, employing a voltage control scheme integrated with a Proportional Integral (PI) controller.

To ensure stability and consistent performance, a fixed switching frequency of 50 KHz is maintained for PWM (Pulse Width Modulation) generation, regardless of any variations in the AC source voltage. The IC configuration effectively regulates the output voltage to maintain a steady state.

The controller's effectiveness is assessed by analysing the response to reference load voltage variations. Specifically, when subjected to a load variation of 25V, the controller successfully regulates the output voltage, output current, and state of charge.

The input voltage, derived from the grid, is 230V AC. Through the implementation of the IC, the output voltage is achieved at 24V DC. To further attain the desired 30V DC output voltage, a PI controller is employed.

Conclusion:

This paper introduces the application of an Isolated Converter (IC) for charging of electric vehicles. The proposed system utilizes a PI controller, which has been found to deliver satisfactory results compared to other types of controllers commonly used in similar applications.

To control the operation of the IC, unipolar Pulse Width Modulation (PWM) switching is employed as the control signal. This choice of control signal offers several advantages, including reduced losses and a lower harmonic content in the output voltage waveform. These characteristics contribute to improved efficiency and better overall performance of the converter.

The output current waveform, as demonstrated in Figure 7, exhibits a desirable profile that facilitates efficient charging of the battery. The PI controller's output current waveform ensures a smooth and controlled charging process, optimizing the battery's charging efficiency.

Conflict of interest:

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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