High Efficiency Bridge-Less Battery Charger for Light Electric Vehicles

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Abstract – *High efficiency chargers are required by the batteries of light electric vehicles. An isolated step-up AC-DC converter with a series-resonance circuit is composed in the bridge-less single power conversion battery charger, so that this charger is able to meet this need. The conduction losses associated with the input diodes in the chargers which contains bridge rectifiers can be reduced by the bridge-less configuration, and the reverse recovery losses of the output diodes can be reduced by providing zero current switching which is done by the series-resonance circuit. In addition, allowing high power capability by the bidirectional core excitation which is done by the transformer enabled by the direct and series-resonance current injection. A high-frequency transformer is used to ensure galvanic isolation for user safety. The current fed parallel resonant converter is suitable for step-up power conversions with its inherent high boost characteristics and hence less turns-ratio requirement for the transformer. Instead of LC for the output filters single capacitor is applied, so the circulating energy with in the circuit is minimized by the clamping of the maximum voltage of the resonance capacitor to the output voltage and ZCS can be offered to the rectifying diodes. 150W prototype was used to verify the performance of the proposed converter. The 92.02% efficiency was achieved by running the prototype at 255 kHz with 12 V input and 50 V output, which is peak efficiency.*

Key Words: Bridge diode, series resonance

1. INTRODUCTION

The current fed parallel resonant converter is suitable for step-up power conversions with its inherent high boost characteristics and hence less turns-ratio requirement for the transformer. In the past years, most of the efforts for the current fed parallel resonant converter were focused on achieving the zero-voltage switching (ZVS) operation of the primary switches no matter the active switches were controlled with dead time or over lapping. However, in low-voltage, high-current input applications, ZVS is not that much important while ZCS is critical for the switching losses elimination. And some efforts were spent on reducing the input current ripple so that the bulk input ripple current filter could be eliminated. Nevertheless, the existing leakage inductance of the transformer still causes high voltage spikes across the switches. The current fed multi-resonant converters utilize the leakage inductance to create ZCS condition for all primary switches. Whereas, in order to achieve full load range ZCS operation of the primary switches, the leakage inductance is manipulated according to the heavy load condition which results in large redundant circulating current flowing through the anti-parallel diodes of the switches and the greatly reduced efficiency in light load condition. Large circulating energy within the resonant tank also induces high conduction losses and blocks the efficiency improvement of the current fed parallel resonant converter. Energy feedback was proposed to reduce the circulating energy. However, the additional transformer and its impact on the quality factor make this concept unacceptable for a design with high density and voltage regulation requirements. Besides, the reverse recovery issue of the rectifying diodes still exists and results in high voltage spikes on the rectifying diodes which limit the application of ultra-fast recovery diodes with lower forward voltage drop.

2. LITERATURE REVIEW

Alireza Khaligh, Serkan Dusmez..,has outlined comprehensive overview of conductive and inductive charging solutions for PEVs. Inductive charging techniques use primary (receiver) coils for transferring power using the principle of magnetic induction to provide electricity. Conductive charging eliminates wire between the charger and charging device. Inductive chargers appear attractive due to their ability of contactless power transfer. The absence of wired connections between the PEVs and the charger in case of inductive charging would make it a safe and robust technology for high power (excess of 50 KW) charging applications [1]. D. S. Gautam, F. Musavi.., In a plug-in hybrid electric vehicle (PHEV) battery back charging is done by an on-board charger. Two stage battery charger architecture with an interleaved PFC and isolated full-bridge DC-DC converter. The interleaved boost converter reduces ripple current, conduction losses. The efficiency of the charger is 93.6 [2]. N.Q. Trong, H. J. Chiu.., proposes a new isolated current fed full-bridge power factor correction converter having efficiency improvement, good common mode, noise perform. High-voltage splits on MOSFET is the major drawbacks of full bridge power factor correction converters which is of conventional current fed converters. Non-dissipative clamping structure is used for the effective elimination of voltages spikes which results in the consumption of no-loss and low voltage MOSFETs are used here [3]. Kwang-Min Yoo, Kyung-Dong Kim.., suggests a new on-board charger for plug-in hybrid electric vehicle. Is having a constant switching frequency and also having a cascade structure of a high frequency resonant converter for electrical isolation and discontinuous -conduction-mode buck-boost converter for charge control and harmonics regulation of input current under universal line input. Single-phase and three-phase prototypes have been used for verifying the feasibility of the proposed charger [4].

3. EXISTING SYSTEM

Bridge rectifier consists four diodes. The diodes D_a, D_d conduct in forward direction during positive half cycle. diode D_b, D_c conduct in reverse biased direction during negative half cycle. Each diode can consume 0.7V which leads to conduction losses. Conduction losses can be reduced by employing switches in the conventional method.

3.1 CIRCUIT DIAGRAM

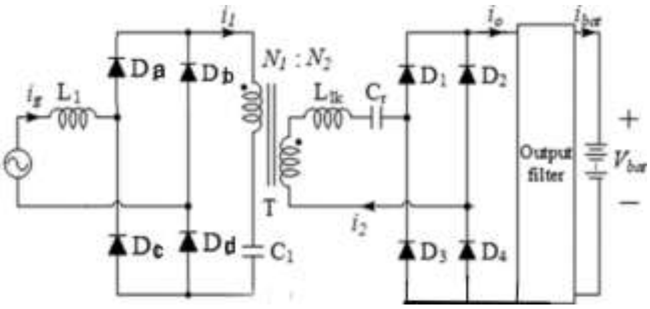

Fig- 1: Circuit diagram for existing system

4. PROPOSED SYSTEM

In the proposed methodology of our project, we have included four MOSFETs as switching devices instead of using diodes in bridge rectifier. In existing chargers, the structure of charger contains bridge rectifiers, which leads to more power losses. The bridge rectifiers consist of four diodes and two of the diodes conducts in each half cycle, and this is the main disadvantages of bridge rectifiers. Due to the voltage drops in the diodes, losses are increased and efficiency of rectification is reduced. By using MOSFET switches instead of bridge rectifier diodes, the efficiency can be increased in this proposed charger.

4.1 CIRCUIT DIAGRAM

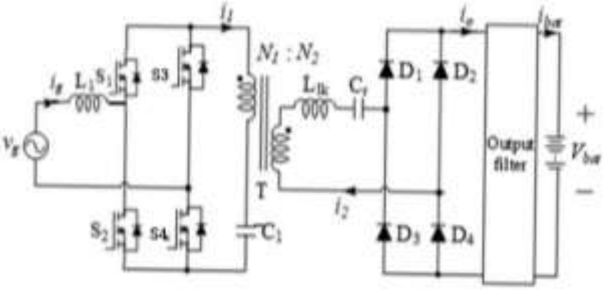

Fig -2: Circuit diagram of proposed system

4.2 CIRCIUT EXPLANATION

The proposed charger has four switches on the primary side of the transformer T. The switches (MOSFET) S1 and S2 conduct alternately during each half-cycle of grid period Tg; S1(S2) is turned on during the positive(negative) half-cycle of the grid voltage vg. The switch S3(S4) is driven at high frequency and switch S4(S3) is always on during the positive(negative) half-cycle. Thus, only one switch operates at high frequency, while the other switch is always turned on. Therefore, switching losses are incurred by only one switch. The secondary side consists of output diodes and a series-resonance circuit composed of a leakage inductance Llk and a resonant capacitor Cr. The series resonance reduces the reverse-recovery problem of the output diodes by providing ZCS.

5. COMPONENTS DESCRIPTION

5.1. Power supply

All electronic devices need power supply. The power that we get from the wall outlet is 230V, 50 Hz. Low voltage DC power supply is required for electronic circuitry inside such devices. So, a need arises to convert high voltage AC supply into low voltage DC.

5.2. Step down transformer

Step down transformer converts the high voltage (HV) and low current from the primary side in the low voltage and high current value to the secondary side. The low voltage range which is required by electronic components is provided by step-down transformer.

5.3.Microcontroller

Microcontroller is device which is used to generate and provide pulses for MOSFET switches. The microcontroller is supplied by 5V power supply. The microcontroller and the switch cuircuit is seperated by isolator circuit.

5.4. Isolator and driver circuit

An isolator is a device used for isolating a circuit or equipment from a source of power. An isolator, when at the open condition, it isolates the input and output of the device. That’s why it is called as a mechanical switching device. An isolator isolates the supply source from the power circuit and controller circuit.

5.5. High frequency transformer

It is operate using the same basic working principles as the standard transformers. The primary difference is that, as their name implies, they operate at much higher frequencies. The frequency range of high frequency transformers is from

20KHz to over 1MHz, while normal voltage transformers have frequency range of 50Hz or 60Hz.

6. EXPERIMENTAL PROTOTYPE FOR BRIDGELESS CONVERTER

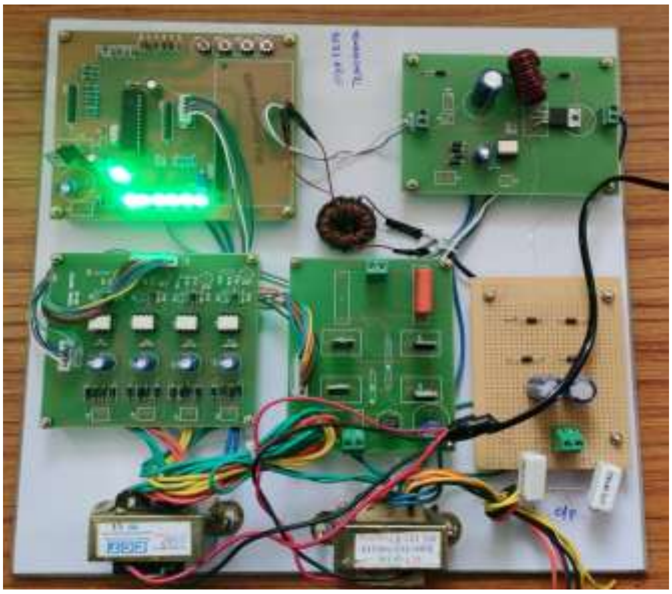

Fig-3: Experimental prototype for bridge less converter

7. OUTPUT

7.1. AC input for power circuit (12V AC)

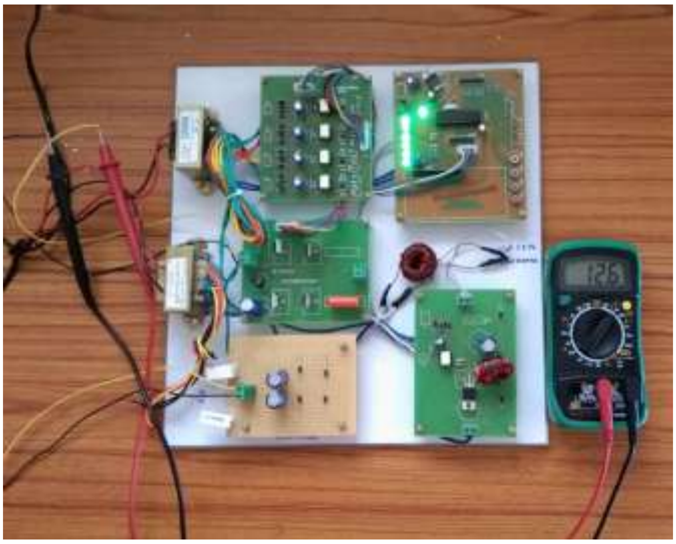

Fig-4: Ac input for power circuit

7.2. DC output of the charger (50V DC)

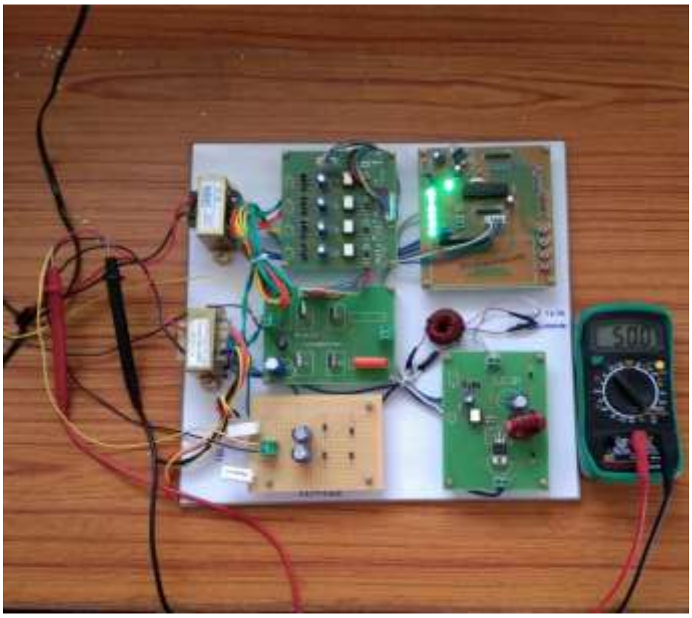

Fig-5: Dc output of the charger

8. CONCLUSION

This paper proposes a high-efficiency bridge-less battery charger for light EVs and analyses its performance experimentally. The presence of bridge-less configuration and series-resonance circuit reduces conduction losses and reverse recovery loses by providing zero current switching. Since, the proposed charger offers high efficiency. The proposed charger is an effective solution for EVs, which require high charging efficiency.

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