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RESEARCH ARTICLE

A Single-Phase Z-Source Charger with Soft Switch Modulation for Electric Vehicle Application

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ABSTRACT

A modulation is suggested that can carry out numerous Zero-Voltage-Switching (ZVS) and Zero-Current-Switching (ZCS) transitions with no auxiliary circuit. Despite having two hard-switching turn-off transitions, they happen at low current levels. The quasi-Z-source network may be switched on using ZCS. The quasi-Z-source network uses BCM or DCM operation to enable all free-wheeling diodes to switch off automatically. In addition, the current and voltage stress on all switches is the same as hard-switching. Thus, it is concluded that the new modulation makes the qZSC system much more efficient. Operational concepts for this soft-switching qZSC are explored.

Keywords : ZVS, ZCS, BCM, DCM, qZSC

INTRODUCTION

A recent wave of work has been focused on EV battery charger development with regards to on-board charging types. Using this usual charger for EVs results in more weight and more space. For these issues, academics have given attention to integrated chargers. This integrated charger shares DC/DC converter and control circuits with the EV system. to ensure the correct functioning of the integrated EV charger system, a bidirectional dc/dc converter is required. Direct Current/Direct Current Converters (DC/DC) Single-phase half-bridge, single-phase full-bridge, or three-phase full-bridge[1-5]. Concerning the Z-source network, it is possible to use bidirectional power flow, as discovered by F.Z. Peng in [6]. This inverter has recently been utilised in EV traction systems [7-8]. This article introduces a single-phase integrated EV charger called a quasi-Z-source network from [9] and incorporates it into AC

Propulsion Inc.'s vehicle industry. Fig. 1 depicts the architecture of this single-phase quasi-Z-source integrated charger. Another topology is given in [10]. In traction mode, the mechanism uses Sw. When the system is charging, Sw is switched off. The quasi-Z-source network acts as a buck converter in charge mode. With regard to the system total losses, it is essential to minimise this loss in order to improve overall system efficiency. Using soft-switching technology for the qZSC is critical.

Some methods to resolve the hard-switching issue are suggested. In [11], all devices, including switches and diodes, use ZCS to turn on and off. While this technique requires a connected inductor, capacitor, and diode. So as a result, enhance size and weight. [12] proposes another paired-inductor soft-switching quasi-Z-source inverter. The system only achieves bidirectional energy flow with one more diode added. The bidirectional soft-switched quasi-Z-source inverter [13-15] is suggested. For gentle turn-on or turn-off, two bidirectional switches are required. The primary switch achieves quasi-ZVS. All switches are switched on and off using ZVS. It has an auxiliary circuit that comprises an IGBT switch and two diodes. The topology is too complicated. In a soft-switching quasi-Z-source inverter, just one auxiliary switch is required. all switches including the auxiliary switch are zero-voltage switched on [16-17] suggests a resonant circuit for use in Z-source. Only the ZCS switches may be turned off. Two snubber capacitors provide soft-switching capability utilising separated quasi-Z-source converters. It has a low propagation loss. a gentle modulation for three-phase Z-source rectifier [18] ZVS enables the switches to be turned off using the diodes. It cannot do complete soft-switching. The suggested modulation, which doesn't require any auxiliary circuit, is called ZSVM3. And all major switches and diodes may be controlled remotely. In comparison to BCM and DCM, the ripple current is large. None of these approaches will result in a fully soft-switched design. This won't work with the integrated EV charging system. Fig. 4 illustrates a novel soft-switched modulation scheme for single-phase qZSC. This qZSC comparable architecture is illustrated in Fig. 2. There is no extra circuit, just a Z-source inverter/charger architecture. All primary switches have the ZCS and ZVS criteria applied. S7 is on with ZCS, and all free-wheeling diodes may be switched off. There is no voltage and current stress on all switches. Integrated EV charging system—so the suggested modulation is appropriate.

OPERATION PRINCIPLE AND ANALYSIS OF THE NOVEL MODULATION

Proposed modulation for single-phase qZSC

It has been suggested that the Z-source/quasi-Z-source network exists, which has motivated the authors to offer various modulation schemes for the qZSC/ZSC and quasi-Z-source inverter (qZSI)/ZSI. This range of space vector modulations for Z-source/quasi-Z-source networks includes ZSVM2 [20-22], ZSVM3 [19], ZSVM4 [23] and ZSVM6 [24]. However, single-phase qZSC should not use these modulations. A new modulation has been suggested for single-phase qZSC. This modulation is unipolar asymmetrical double-frequency modulation [25]. Fig. 3 shows a typical asymmetrical unipolar double-frequency modulation. The modulation index for phase an is μ and for phase b is μ.

SIMULATION RESULTS

This portion verifies the soft-switching technology modulations in a 1.3 kW PLECS setting. The 25% load model also works with the soft-switching technology. Simulation data are used to test all hypotheses. Parameters of qZSC in simulation model and prototype are same. Table I lists the prototype's parameters.

CONCLUSION

qZSC modulation with soft switching No auxiliary circuit is required. Using a new modulation, the inductor current is soft-switched to DCM or BCM. ZCS and ZVS can control all the switches in the Hbridge. 2S is switched off soft. Besides, all free-wheeling diodes are shut off in ZCS situation. The Z-source switch 7S is activated under ZCS conditions. In short, system efficiency improves as a result of decreased switching losses. The voltage stress and current stress on all switches are on the same level. The soft-switching qZSC and unique modulation are appropriate for EV charging systems, making it more efficient.

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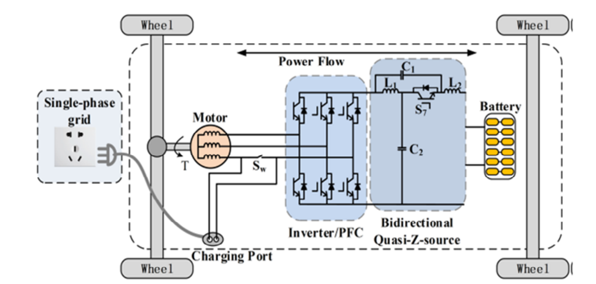

Fig. 1. The topology of single-phase integrated EV charger system

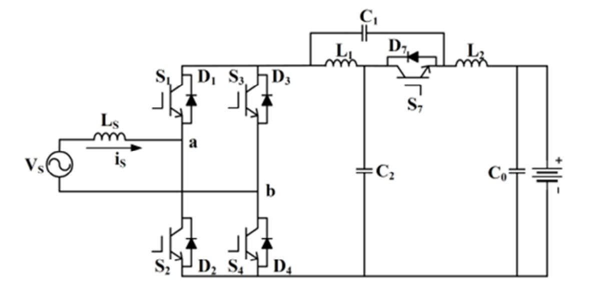

Fig. 2. The topology of single-phase qZSC

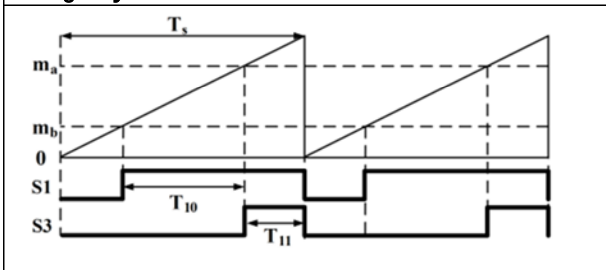

Fig. 3. Traditional asymmetrical module

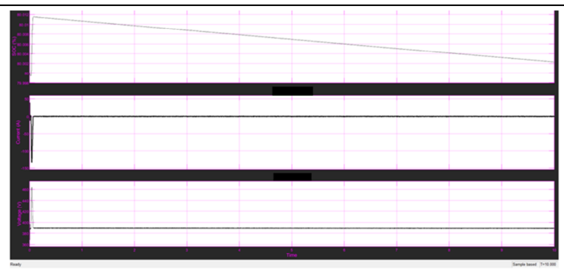

Fig. 4: Battery SOC, Current and voltage

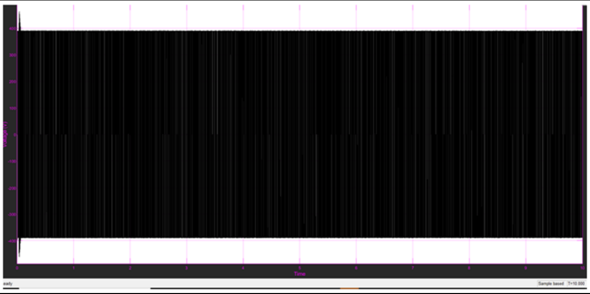

Fig. 5: Inverter output voltage

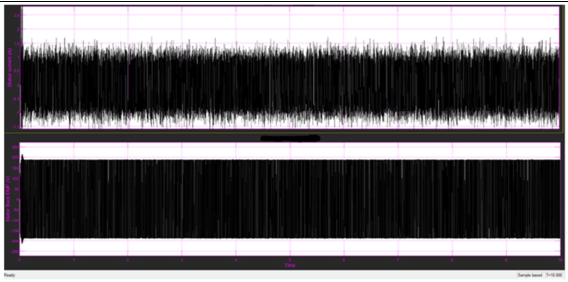

Fig. 6: Motor stator current and back EMF

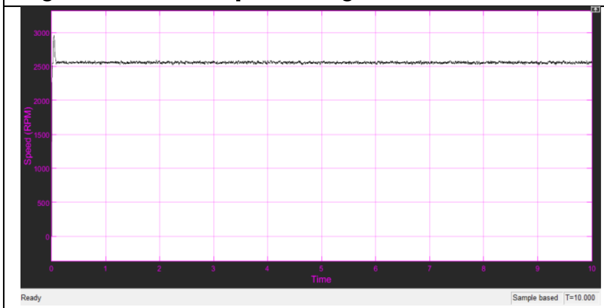

Fig. 7: Speed of the machine

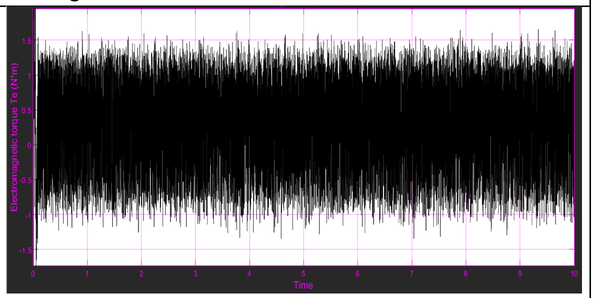

Fig. 8: Torque waveform the machine