A Lossless auxiliary circuit for Interleaved Boost Converters

Bin-xin Zhu¹, Senior Member, IEEE, Yu-jin Yang¹, Xiao-li She¹ and Lei Liu²
1. School of Electrical Engineering and Renewable Energy, China Three Gorges University, Yichang 443002, Hubei Province, China
2. Science and Engineering Faculty, Queensland University of Technology, Brisbane, Queensland, Australia

ABSTRACT

Abstract—This paper proposes a novel lossless auxiliary circuit for interleaved boost converter which provides zero voltage switching condition (ZVS) for switches at turn off instant, and the auxiliary circuit uses no magnetic components or active switches, so that high efficiency and high-power density can be achieved.

I. INTRODUCTION

Hybrid electric vehicles (HEVs), battery electric vehicles (BEVs), and plug in hybrid electric vehicles (PHEVs) are becoming more popular solutions to tackle climate change and energy shortage [1-2]. High power dc/dc converters are a crucial component in these new kinds of vehicles. Interleaving technique and some soft-switching circuits have been proposed to achieve high efficiency and higher power density dc/dc converter [3-4]. A few auxiliary circuits also have been proposed to reduce the switching losses [5-6]. This paper proposes an intuitive lossless auxiliary circuit which is designed for interleaved boost converters. This new auxiliary circuit contains a diode and a small capacitor only, without additional controllers or extra heavy inductors.

II. OPERATION PRINCIPLE

The topology of two-phase interleaved boost converter with the proposed auxiliary circuit is shown in Fig.1.

![Fig.1 The two-phase interleaved boost converter with the proposed auxiliary circuit](image)

The driving signals of S₁ and S₂, denoted as D₁ and D₂, are interleaved with 180° phase shift. The main theoretical waveforms of the proposed converter are shown in Fig.2. Distinctly, all switches have achieved zero voltage turn off and the equivalent circuit for each operating interval is shown in Fig.3. Before the first interval, it is assumed that switch S₁ is off, switch S₂ is conducting, diode D₁ and D₀ are conducting, diode D₂ is off and the voltage of Cᵢ is zero.

![Fig.2 The main waveforms in one switching period when D>0.5](image)

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III. EXPERIMENTAL VERIFICATION

In order to perform a potent comparison between the proposed interleaved boost converter and the hard-switched interleaved boost converter in efficiency, two 400W boost converters, i.e. one with and the other without the auxiliary circuit, were designed, built, and tested.

Figs.4(a) and 4(b) show the voltage across and the current through the main switch in the hard switched and the proposed converters, respectively, during turn off of S1. Figs.5(a) and 5(b) show the voltage across and the current through the main switch in the hard switched and the proposed converters, respectively, during turn off of S2. Fig.4 and 5 shows that the auxiliary circuit reduces the turn off losses by reducing the rate of voltage rise across the switch.

![Fig.3 The equivalent circuits of six intervals](image)

![Fig.4 The experimental waveforms of switch S1](image)

(a) The turn off waveforms of switch S1 in the basic converter
(b) The turn off waveforms of switch S1 in the proposed converter

![Fig.5 The experimental waveforms of switch S2](image)

(a) The turn off waveforms of switch S2 in the basic converter
(b) The turn off waveforms of switch S2 in the proposed converter

Shown in Fig.6, the efficiency values of the proposed converter are relatively higher when compared to the hard switching converter. The overall measured efficiency of the proposed converter is about 94.2% at the nominal output power.

![Fig.6 Comparison of the efficiency of the proposed converter with the efficiency of the basic converter prototype](image)

IV. CONCLUSION

In this paper, a new auxiliary cell for interleaved boost converter is presented. The operation principle and the experimental results are given, which show the following potential advantages of the proposed driver: (1) the proposed auxiliary cell is implemented by adding only one diode and one capacitor without significant increase in cost or complexity; (2) the auxiliary circuit will not use additional active switches and it is relatively easy to design control circuits; (3) switching loss reduction allows the switch to be operated at higher switching frequency, resulting in significant reduction in the mass of inductor, and input and output low pass filter inductors. Based on these above, the proposed circuit is well suitable for many potential applications such as fuel cell, hybrid electric, battery electric vehicles and photovoltaic arrays.

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