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DESIGN AND PERFORMANCE OF ZCS-ZVS COMBINED SNUBBER NETWORK IN A DC-DC APPLICATION

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ABSTRACT
In this paper, a combined zero-current switching and zero-voltage switching (ZCS-ZVS) snubber network is proposed for a DC-DC boost converter. This technique can reduce the ringing and spiking on drain-source voltage (V_{DS}) during switching. Thus, it will reduce the EMI radiation and the voltage and current stress encountered by switches. A boost converter with 60 V input voltage, 80 V output voltage and 100 kHz switching frequency adopting this technique is presented as an example, to illustrate the circuit operation principles and derive the design procedures. Simulation and hardware implementation of a combined snubber boost converter has been made to validate the operation and the efficiency. Experimental result shows an improvement in output power efficiency of 94%. This is an increment of 20% compared to the conventional boost converter.

KEY WORDS
Pulse-Width Modulation, Soft Switching, Snubber Network and DC-DC Converter.

1 Introduction

Many DC-DC applications demand high power density power converters. This leads to the research of converters that can provide high efficiency and high power operation, which is a great concern due to the switching stresses and losses in semiconductor devices during the power conversion stages. Reducing these losses without increasing device voltage and current stress will be the main factor in producing efficient soft-switching scheme [1]. Several circuit topologies have been proposed in recent years to achieve this target and most of them commutate in the range of line voltage or load current during a small resonant transient and operate in constant-frequency pulse width modulation (PWM) with minimum voltage and current stresses [2,3].

In order to propose better topology, zero-voltage-switching (ZVS) converter can be applied. It contains an active snubber circuit to achieve soft switching [4, 5]. The snubber circuit normally consists of several auxiliary components that can be connected across the switch or at any parts in the circuit. This component layout configuration will generate soft switching and hence reduce switching stress and also losses [6].

On the other hand, hard switching will lead to an increase of switching loss during the turn-off of the switch and during its turn-on, the switch requires an elaborate cross-zero detection circuit otherwise the switch may suffer from high current stresses [7]. A zero-current-switching (ZCS) converter can be used to solve this problem however it will then again suffer from increased voltage stress [8, 9].

Using ZVS circuit system alone in the design is not desirable to achieve high power efficiency especially at light load and large duty cycles [10]. Moreover when the current stresses during turn-on are increased, the designs become relatively complicated. The soft switching cannot be achieved easily once the output voltage exceeds twice the input voltage [11] which makes boost converter topology as the preferred test circuit. Duty cycle selection range for the boost converter design is also limited by the soft-switching resonant commutation [12].

A new soft-switching method is proposed in this paper using a passive dissipative snubber to achieve zero-current turn-on and zero-voltage turn-off for the active switches, as well as soft switching for the passive switches, without increasing their voltage and current stresses. Its operation principle is analysed and the design issues are discussed. The performance of this soft-switching method is demonstrated and verified with the experimental results.

2 Operation of the boost converter

To demonstrate the viability of the ZCS-ZVS combined snubber network in a DC-DC application, boost converter topology is chosen to be the test circuit due to its requirement in achieving soft switching whenever its output voltage is at least twice or more than the input. The conventional boost converter circuit is shown in Figure 1.

During the time the switch is closed, energy is transferred to the inductor while the diode prevents the capacitor to discharge through the switch. When the switch opens, current, which initially has been charged, will discharge through the inductor. This current continues to flow in the same direction as during the