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An Application of Soft Switching for Efficiency Improvement in ZVT-PWM Converters

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Abstract: **An energetic snubber cell is proposed to control zero voltage- transition (ZVT) pulse width-modulated (ZVT-PWM) converters. Exclusive for the auxiliary switch, all active and passive semiconductor devices in a ZVT-PWM converter operate at zero-voltage-switching (ZVS) turn on and turn off. The auxiliary switch operates at ZVS turn off and near zero-current-switching (ZCS) turn on. An logical study on a boost ZVT-PWM converter with the proposed active snubber cell is presented in detail. Six basic ZVT-PWM converters can be simply formed by attaching the proposed active snubber cells to Conventional PWM converters.**

Keywords: **Converters, pulse width modulation, switching circuits.**

1. INTRODUCTION

PULSEWIDTH-modulated (PWM) converters have been Widely used in the industry. The PWM method is admire for its high-power capacity and simplicity of control. Higher power solidity and closer transient response of PWM Converters can be achieved by raising the switching frequency. However, as the switching frequency increases, so do the switching wounded and electromagnetic interference (EMI) noises. High-switching losses decrease the power-handling capacity, and serious EMI noises interfere with the control of PWM converters. Switching losses and EMI noises of PWM converters are mostly generate during turn-on and turn-off switching transients. According to [1], there are three different no ideal commutation phenomenon when MOSFET's are used as power switch.

1) A rush current runs through the MOSFET reason by means of the reverse-recovery current of the freewheeling diode during turn-on process. This is the leading part of Switching losses and the EMI noise source.

2) Release of the parasitic drain–source capacitance of the MOSFET during turn-on process. This method can be eliminated only by resonant converter techniques or active snubbers.

3) Quick rise of the drain–source voltage during turnoff Process. This is the supply of EMI noise and turn-off loss.

Resonant converters [2]–[4] commutate with either zero voltage- switching (ZVS) or zero-current-switching (ZCS) to decrease switching losses and EMI noise.

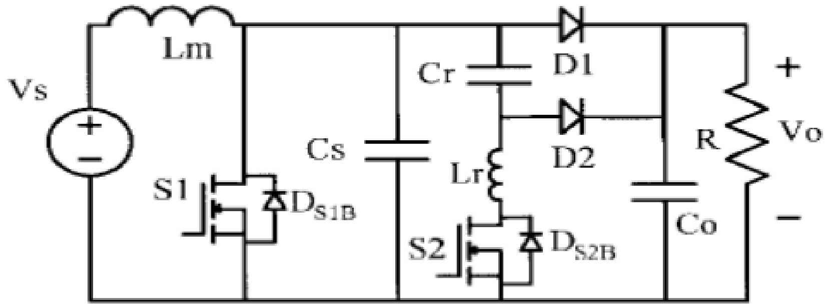

Fig. 1. The proposed synchronous buck converter

A small number of zero-voltage-transition (ZVT)-PWM and ZCT-PWM technique were anticipated in recent years to merge attractive features of both the conventional PWM converters and resonant converters [5]. They are usually implemented by addition active snubbers, which utilize resonant technique, to the conventional PWM converters. Switching losses and EMI noises minimized since the converters function at either ZVS or ZCS. However, hard switching still applies to auxiliary semiconductor devices in some active snubbers. Hard switching of these auxiliary components still generates considerable switching losses and EMI noises. By utilizing the body diode of the auxiliary switch, a series of ZVT-PWM converters are projected to turn off the auxiliary switch under ZVS . Soft switching can apply to semiconductor devices in not only the novel converters, but as well in the snubber cells. By using similar resonant topologies, the active snubber cell presented in this paper can be seen as a alteration of this series of converters. As an example, a study of a boost ZVT-PWM converter ready with the projected snubber cell is investigated in depth. Steady-state operation examination and relevant equations are presented in detail. Following the design procedures presented, 750-W 80-kHz 200-V dc-input and 400- V dc-output prototypes can be build to confirm the analysis

2. THE ZVT-PWM BOOST CONVERTER

2.1Circuit Analysis:

Revealed in Fig. 1 is the ZVT-PWM boost converter. It is the Mixture of the conventional PWM boost converter and the projected active snubber cell. The snubber cell consists of a resonant inductor, a resonant capacitor, a snubber Capacitor, an supplementary switch , and an secondary diode are also utilized in this converter.

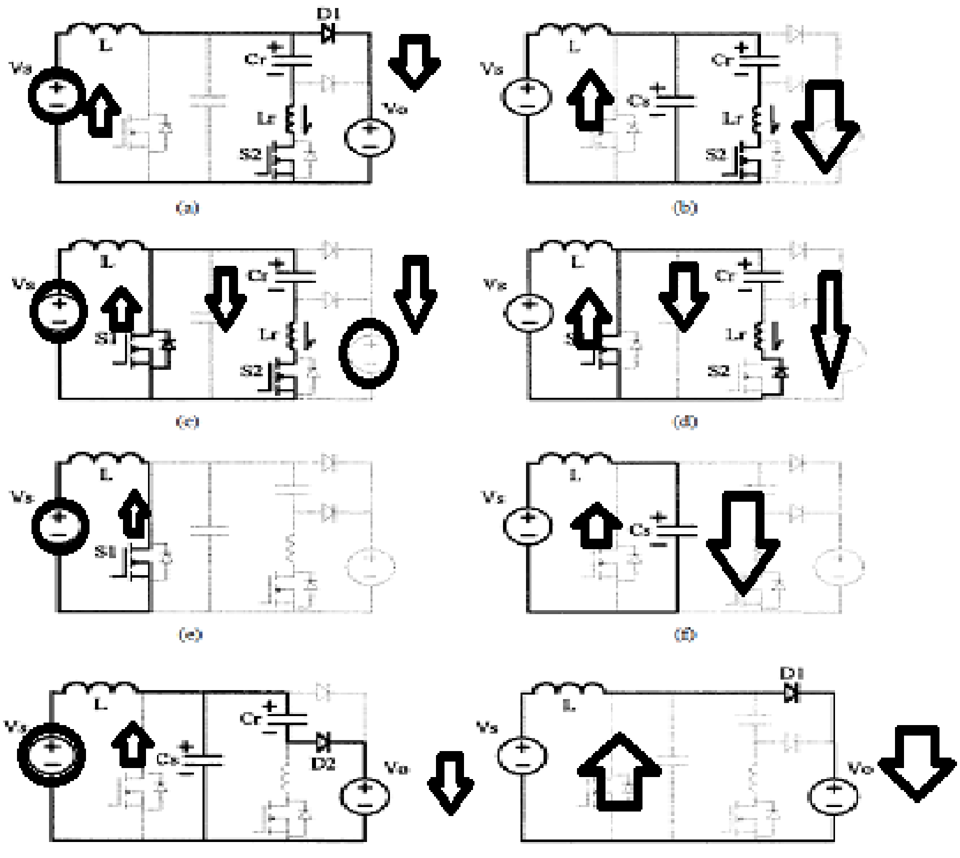

Fig 2: Working Principle

To examine the steady-state operation of the circuit revealed in Fig. 1, the subsequent assumptions are made during one Switching cycle.

1) The output capacitor is large enough to suppose that the output voltage is constant and ripple free.

2) Input voltage is invariable.

3) Main inductor is much superior than resonant inductor

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4) The voltage of the resonant capacitor and the current Of the resonant inductor are both zero before the supplementary switch turns on.

5) Earlier than, switches S1 and S2 are both off and D1 diode is on, and it is the same to the normal turn-off process of a boost circuit.

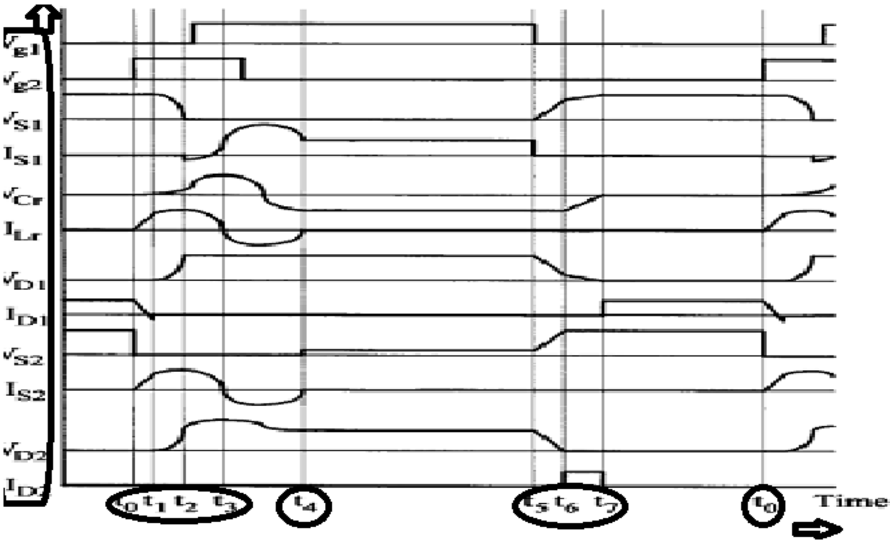


Fig 3: Waveforms

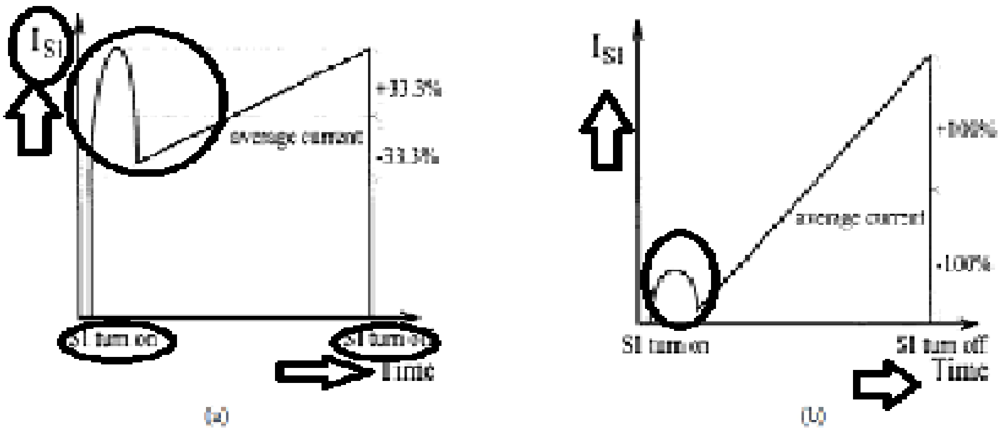


Fig 4: Boundary Condition

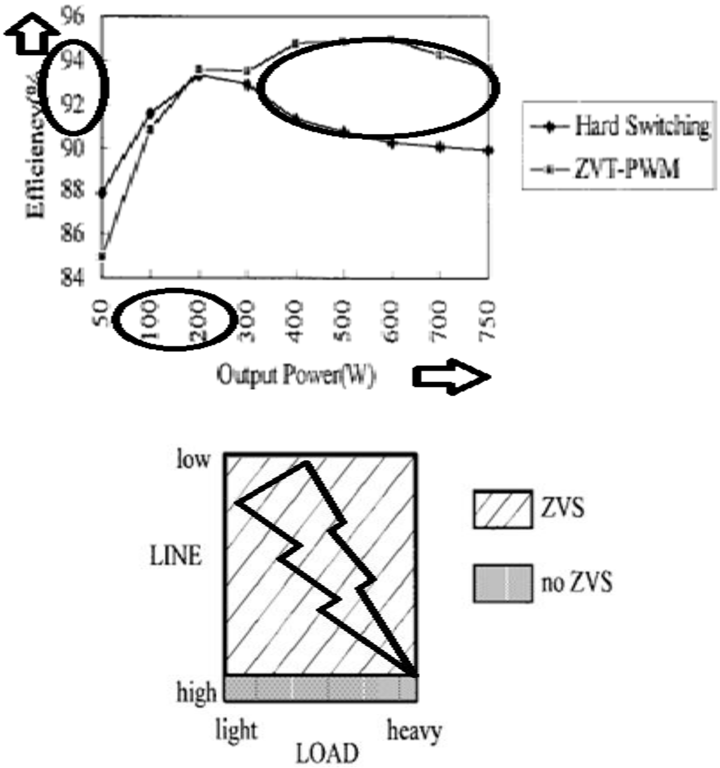
2.2 Basic Features of the Converter:

1)Soft Switching for All Semiconductor Devices: In a few of the ZVT-PWM converters, soft switching only applies to unique semiconductor devices. The auxiliary transistors and diodes still generate significant switching losses and EMI noise. To rise above this disadvantage, a sequence of ZVTPWM converters, including the proposed one, attempt to turn off the auxiliary switch under ZVS by utilize the body diode of the auxiliary switch . In the future ZVTPWM converter, except that suffers from the release of the parasitic drain–source capacitor during turn on, all semiconductor devices function in either ZVS or ZCS during both turn on and turn off. compare with the hard-switching counterpart, the turn-on loss of is also reduced because a smaller MOSFET with a smaller parasitic drain–source capacitance can be use to lever lower rms current.Switching losses and EMI noises are minimize by the active snubber cell.

2)Turn-On Current point and Current Stress of the MainSwitch:The auxiliary switch in the projected ZVT-PWM converter turns off under ZVS since its body diode is already conduct. The penalty is the turn-on current spike of the main switch . The turn-on current point is just about twice of the main inductor current during turn on. However, since the main inductor current is lesser throughout turn on and superior during turn off, current stress is not invariably doubled by the current point. For example, if the main inductor current ripple is 33.3% it means that the core inductor current during turn off is twice as that during turn on. In other words, the scale of the turn-on current spikeis the same as the current throughout turn off. Actually, current stress of is not influenced by the turn-on current point if the main inductor current ripple is more than 33.3%, such as in the discontinuous conduction form.

2)intrinsically a PWM Converter: Since the proposed snubber is activate only during short turn-on and turn-off ZVT transitory, the ZVT-PWM converter is identical to a common PWM converter during most of the time. ordinary PWM control strategy can be in a straight line apply to the ZVT-PWM converters. The design of an EMI filter is also simply to be optimized due to constant-switching frequency.

3)Robustness for Wide Line and Load Ranges: One drawback of resonant converter technique is that soft-switching condition is strongly reliant on the load current and the input voltage. At light load, ZVS is generally difficult to maintain as the energy stored in the resonant inductor is not enough to totally discharge the resonant capacitor prior to turn on of the active switch. ZVS is also hard to achieve at high line, since it wants more energy to release the resonant capacitor. even though losing ZVS at light load or high line does not cause serious thermal problems, the resulting EMI noises may be unbearable in a practical circuit.



ZVS region as functions of line voltage and load current.

Fig 5: Region Of Operation

3. SIMULATION RESULTS

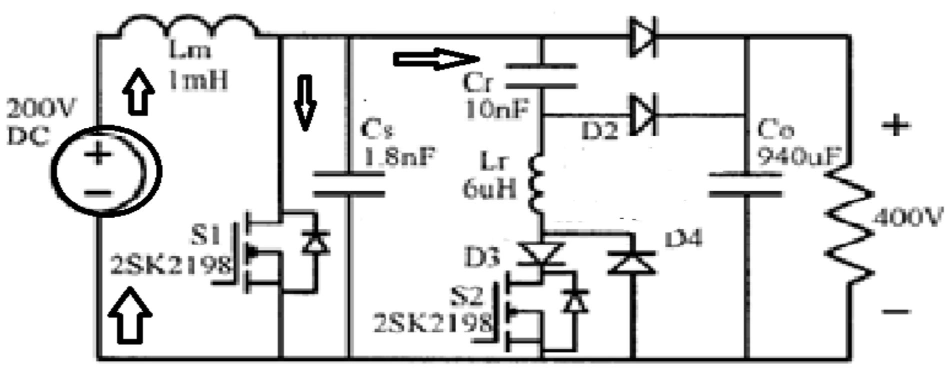


Fig 6: Simulation Circuit

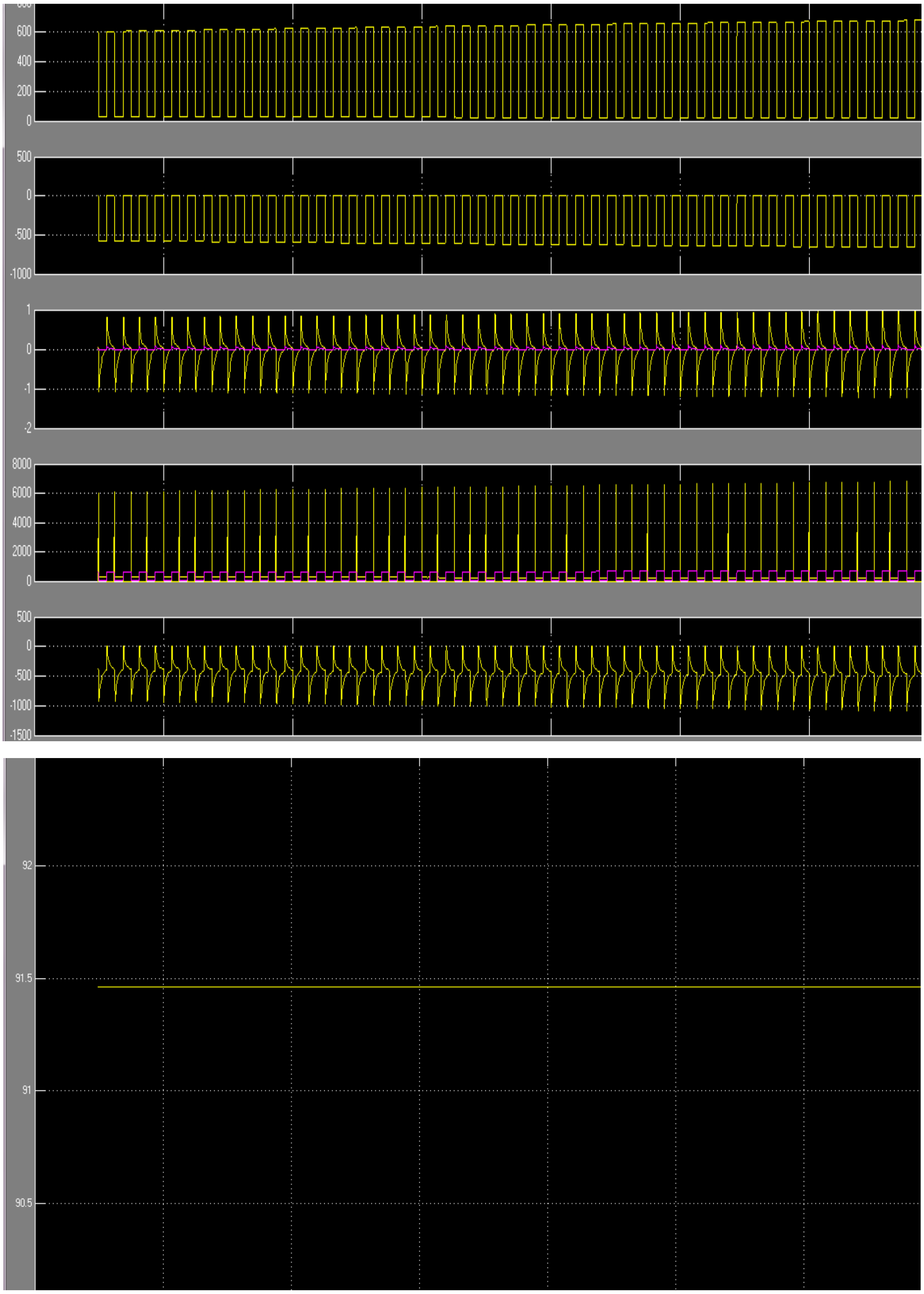


Fig 7: Output Waveforms Of the Circuit

4. CONCLUSION

In this document, a general active snubber cell is implemented to control new ZVT-PWM converters. To in detail reduce switching losses and EMI noises, soft switching is applied to all semiconductor devices in the ZVT-PWM converters. In an ideal world, apart from that suffer on or after discharge of parasitic drain–source capacitance during turn on, no switching loss is generate. Constant-switching frequency eases the design minimization of EMI filters and control circuits.

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