A NEW ZVCS RESONANT PUSH-PULL DC/DC CONVERTER TOPOLOGY

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Abstract:- **A new ZVCS resonant dc/dc converter is presented in which the resonant circuit is located at the secondary side of the transformer and using the secondary leakage inductance as the resonant inductor. The proposed converter topology is suitable for unregulated low-voltage to high-voltage power conversion, as in battery-powered systems. The MOSFET primary switches and the output rectifiers turn-on and turn-off operate under zero-voltage and zero-current switching conditions. The measured efficiency is moreover than 94.5% from 20% loaded to full loaded.**

Index Terms—ZVCS, resonant converter, push-pull converter, step up converter.

I. INTRODUCTION

A new ZVCS quasi-resonant dc/dc converter topology suitable for unregulated low-voltage to high-voltage conversion is presented. The converter acts as a dc-transformer in system where power from low-voltage source, typically batteries, albeit stiff, higher intermediate voltage for use by a subsequent converter stage [1].

The LCL-resonant dc/dc converter push-pull topology [1] operate under zero-voltage switching condition where the input currents can exceed input voltage by an order of magnitude with high-efficiency.

Since the output load of the LCL topology is series connected with the output resonant inductor, so the output current will swing corresponding to the resonant current, and it is difficult to decrease or control the ripple output voltage.

In this paper, we proposed the ZVCS resonant push-pull dc/dc converter with low ripple output voltage.

II. CIRCUIT DESCRIPTION

The proposed dc/dc converter is based on push-pull dc/dc converter and it consists of MOSFET primary switches (S_1,S_2), series resonant circuit (L-C), output rectifier (D_1-D_4), output capacitor (C_O) and output load (R_L). The shunt capacitors (C_{S1},C_{S2}) are the inherent drain-source capacitance of the MOSFET switches, and the series inductor (L) is the leakage-inductance of the secondary side of the high-frequency transformer. The resonant circuit (L-C) resonates at the switching frequency of S_1 and S_2.

III. CIRCUIT OPERATION

The primary switches (S_1,S_2) are driven by the fixed frequency pulses at duty ratio below 50%; out of phase. The circuit operation modes are shown in fig.2 and the idealized operating waveforms are shown in fig.3. The quality factor of the resonant circuit (L-C) have to low enough to keep the resonant current (i_r) is discontinuous.

Mode 1: S1 is driven by v_{g1} to conduct the transformer primary current i_1 at the zero-voltage condition, and S_1 is turned-off at zero current due by the resonant circuit (L-C) at the secondary side.

Mode 2: Both switches are turned-off and the shunt capacitor C_{S1} will be charged until its voltage reached to $2V_{in}$ by the remain transformer magnetizing current, in the same time C_{S2} will be discharged from $2V_{in}$ to zero volt.

Mode 3: S_2 is driven by v_{g2} to conduct the transformer primary current i_2 at the zero-voltage condition, and S_2 is turned-off at zero current due by the resonant circuit (L-C) at the secondary side.

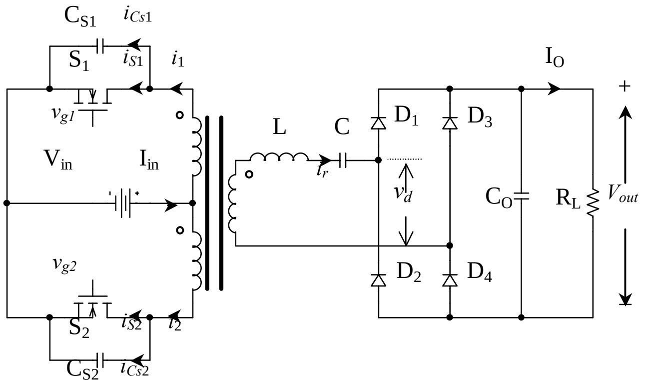

Fig.1 The proposed push-pull dc/dc converter

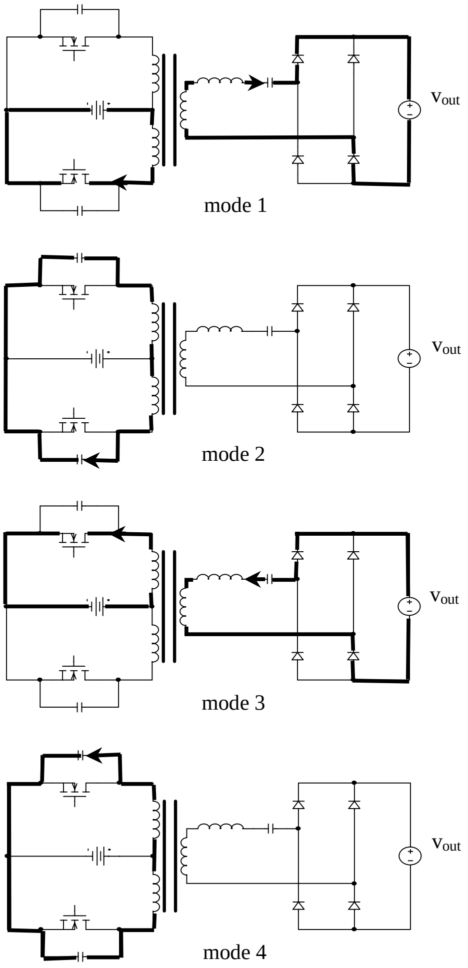

Fig. 2. Converter operations

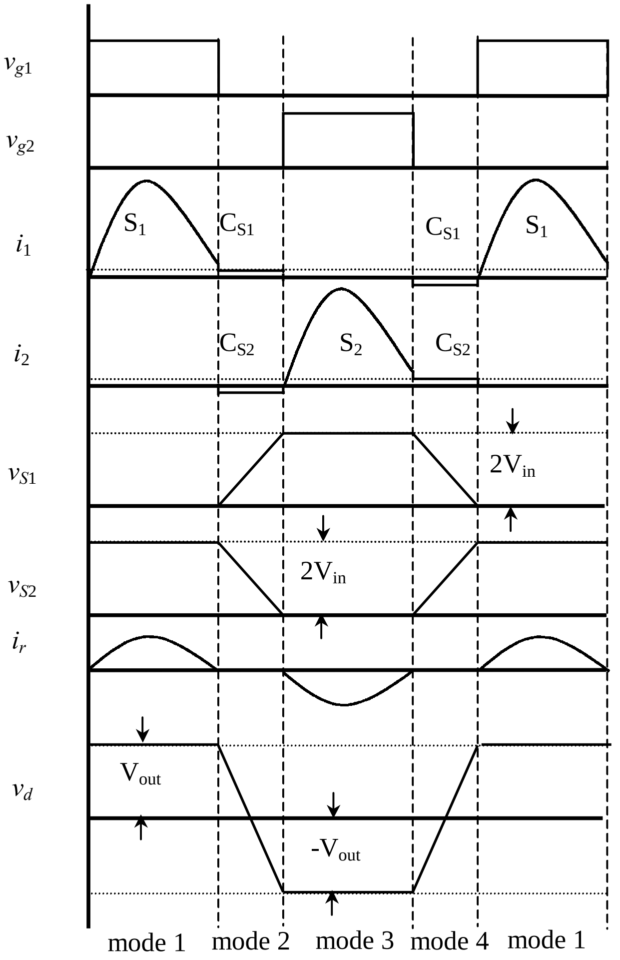

Fig. 3. Idealized operating waveforms

Mode 4: Both switches are turned-off and the shunt capacitor C_{S2} will be charged until its voltage reached to $2V_{in}$ by the remain transformer magnetizing current, in the same time C_{S1} will be discharged from $2V_{in}$ to zero volt.

The time duration of mode 2 and 4 are depended on the inherent drain-source capacitances of the switches and the transformer magnetizing current of the transformer.

IV. EXPERIMENTAL RESULTS

In experimentation, a 12V input 130W prototype converter shown in fig. 4 was built and tested. The ferrite core TDK PQ3220-PC44 with primary windings Np1=Np2=2 turns (0.6mm*3 lines) and secondary winding Ns=36 turns (0.6mm*2 lines) was used as the transformer, the secondary lumped model is shown in fig. 5. We use the MOSFET IRL2505S (R_{ds} on=0.008Ω) as the primary switches, rectifier diodes RPG10B*4 as the output rectifier, 221.67nF as the resonant capacitor (C) and 3.3uF as the output capacitor.The converter switching frequency was calculated from the resonant frequency of L-C circuit. From fig.5, the measured secondary leakage inductance of the transformer L=58.11uH, so the resonant frequency is equal 44.34kHz. Figure 6 shows the experimental converter voltages and current waveforms when loaded by 250Ω resistor at V_{out}=188.3V. The switching frequency (f_S) was fixed at 44kHz and both of v_{g1} and v_{g2} duty ratios are equal to 48.5%. Figure 6(b) shows the zero-voltage-zero-current (ZVCS) turn-on and turn-off switching of the primary switches, and shows the time durations of mode2 and 4. Figure 7 shows the conversion efficiency versus output power. The conversion efficiency can be maintained over 94.5% when supply load 22.2 to 138.5 watt. Figure 8 shows the output voltage loading effect when the output current is increased from 0.11A to 0.74A.

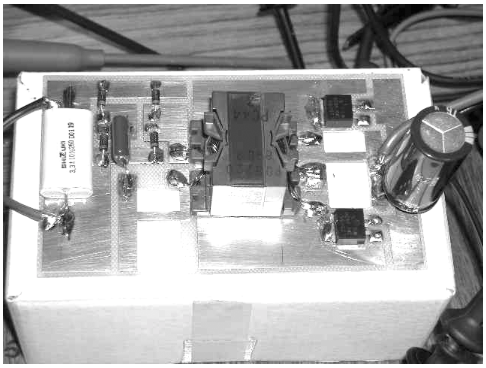

Fig. 4. Laboratory prototype

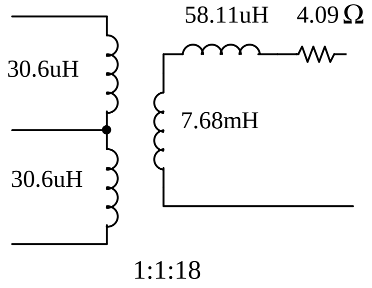

Fig. 5. Transformer lumped secondary model

Figure 9 shows the relation of output voltage and the conversion efficiency when the switching frequency was varied and output load was fixed at 250 Ω.

V. CONCLUSION

A new ZVCS quasi-resonant dc/dc converter topology can operates at high-conversion efficiency and very low switching noise [2] with simple operation and low cost. It is ideally suited for unregulated dc/dc conversion from low-voltage high-current source.

Since it uses the secondary leakage inductance as the resonant element and the converter needs no high Q resonant circuit, so the discrete resonant inductor is not required. Moreover, it easily to control the output ripple voltage because most of resonant current flow through the output capacitor.

REFERENCE

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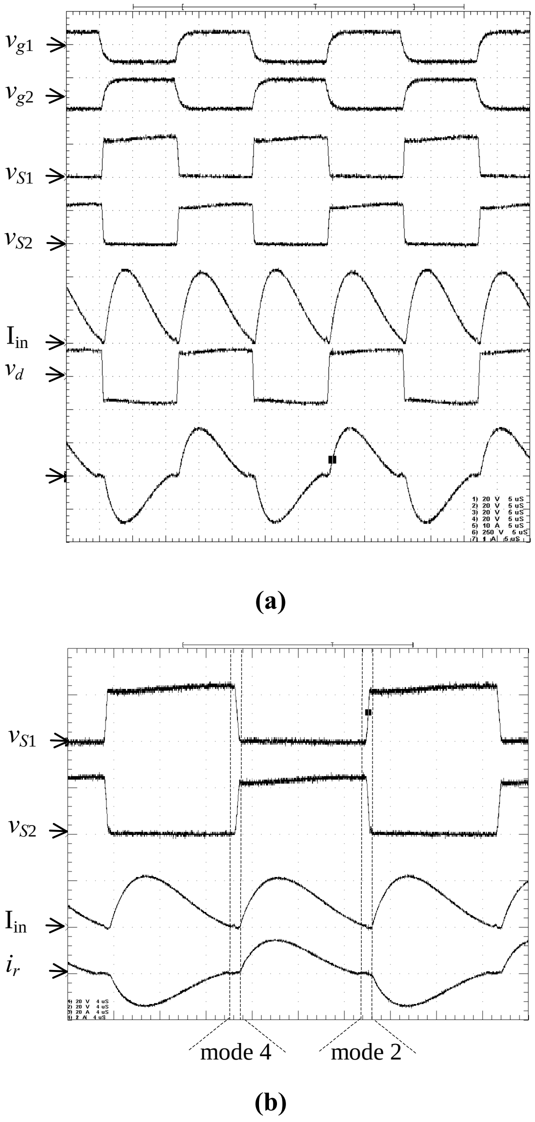

(vertical v_{g1},v_{g2}, v_{S1},v_{S2}: 20V/div; I_{in}: 20A/div; v_d: 250V/div; i_r:1A/div, horizontal 5uS/div)

Fig. 6. Experimental converter voltages and currents waveforms at full load (P_{out}=138.5W, V_{in}=12V, V_{out}=188.3V and f_S=44kHz)

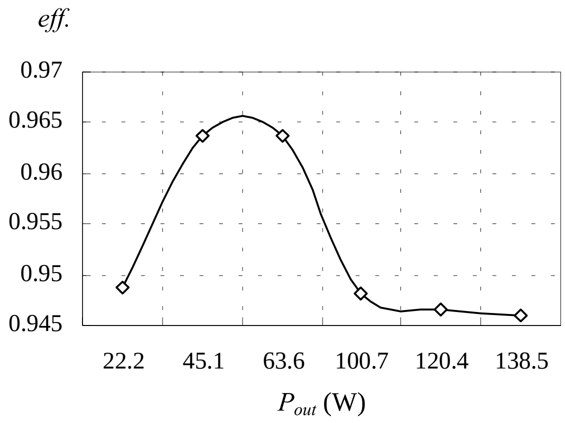

Fig. 7. Conversion efficiency versus output power

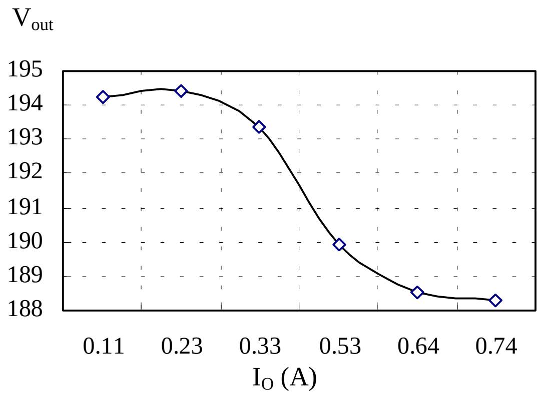

Fig. 8. Output voltage versus output current

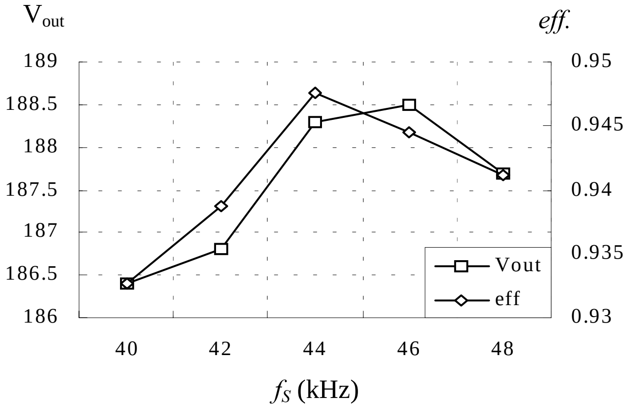

Fig. 9. Output voltage versus output current