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High Power DC-DC Converterusingthe PD PWM Technique and Resonant Circuit

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Abstract. This paper proposes ahigh power DC-DC converter using thephase-displacement(PD) pulse-width modulation (PWM) technique and resonant circuit. The proposed converter realizes the unipolar PWM switching using the PDPWM technique and thus achieves high efficiency withthe resonant circuit. In this paper,the operation principle of the proposed converter is described,briefly, andan experimental result of a prototype is shown to verify the feasibility of the proposed converter.

Keywords: DC-DC converter, PDPWM technique, Resonant circuit

1 Introduction

Recently, as increase of power capacity of electric/electronic devices,many high power DC-DC converters have been proposed. Among these converters, the conventional ZVS (Zero Voltage Switching)PD PWM full-bridgeDC-DC converter isa popular topology for medium/high power applications, which has desirable features such as the ZVS operation and high efficiency.In this paper, a high power DC-DC converter using the PD PWM technique and resonant circuit is presented.A DC clamp capacitor and a resonant inductance are used as a resonant circuitfor the soft-switching of the converter primary with the PD PWM technique. Thus, the proposed converter achieves high efficiency.

2 Operational principles

Fig. 1 shows the first half operation modes of the proposed converter circuit, and Fig. 2 shows the theoreticalkey part waveformsof the proposed converter, respectively. The operation of the proposed converter is divided into six modes. However, one switching cycle of the proposed converter is divided into two half cycles:modes 1~3 and modes 4~6. Since the operation principles of two half cycles are symmetric, in this paper, only the first half cycle is explained, conveniently.

Mode 1(t_0~t_1): The power is delivered from the primary to the secondary in this mode. This mode is the powering mode. The secondary diodes$D_{r1}$and D_{r2} areturned

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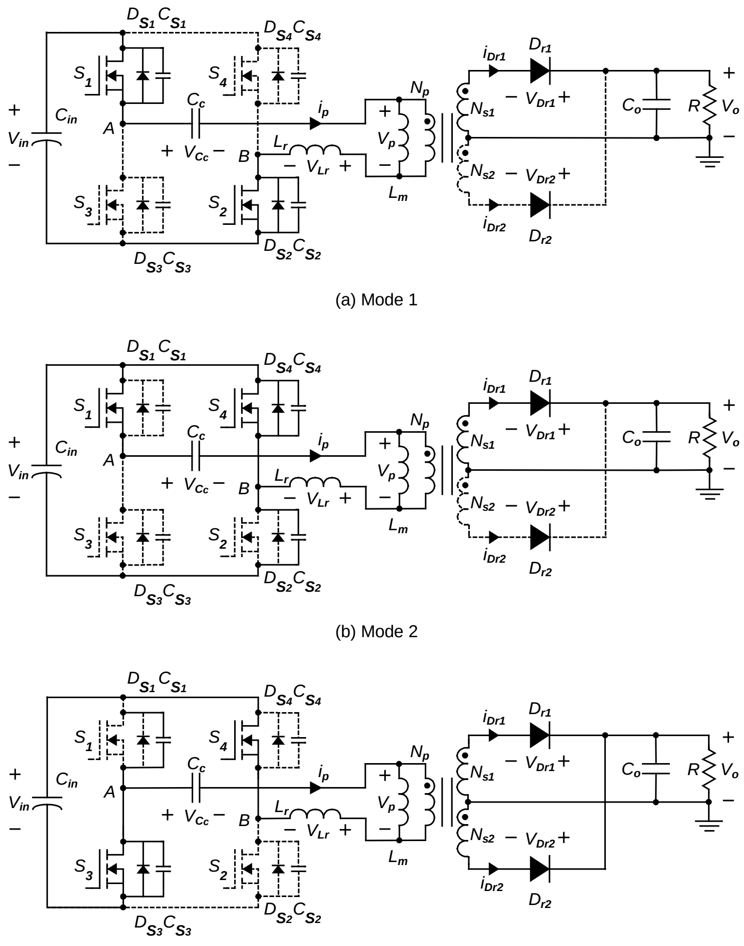
on and off, respectively. At this time, the primary current $i_p$increases almost linearly as follows:

$$i_p = \frac{V_{in} - \frac{N_p \cdot V_o}{N_{S1}} - v_{Cc}}{L_r}(t - t_0) + i_p(t_0) \quad (1)$$

$$v_{Cc} = \frac{1}{C_c}\int i_p dt \quad (2)$$

Mode 2(t_1~t_2): When the switchS_2 is turned off at time $t = t_1$, mode 2begins. This mode is the freewheeling mode.The primary current$i_p$startsto charge and discharge the parasitic capacitors of the switchesS_2andS_4, respectively. At this time, the primary current $i_p$can be expressed as follows:

$$i_p = -\frac{\frac{N_p \cdot V_o}{N_{S1}} + v_{Cc}}{L_r}(t - t_1) + i_p(t_1) \quad (3)$$



(a) Mode 1

(b) Mode 2

(c) Mode 3

Fig. 1. The first half operationmodes of the proposed converter

The anti-parallel diode D_{S4} of the switch S_4 conducts in the primary side, and thus the ZVS of S_4 is achieved.

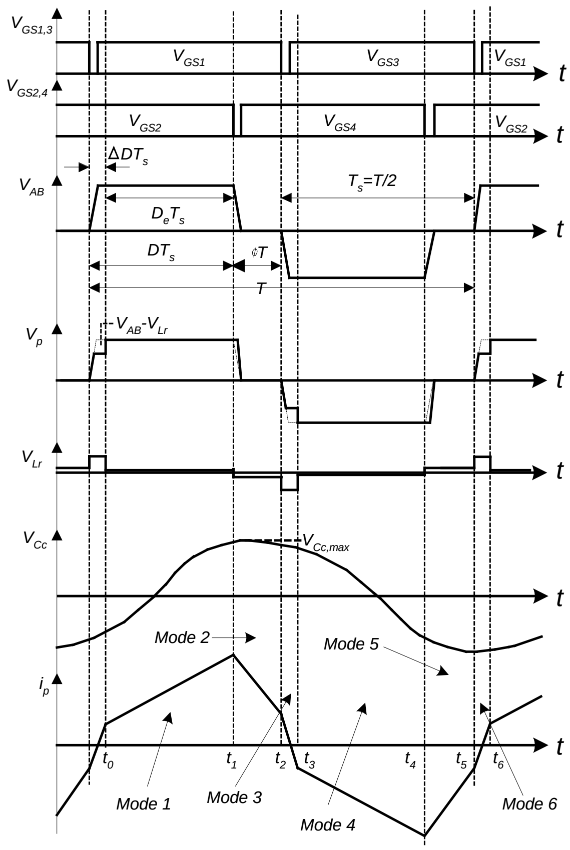


Fig. 2. The theoretical key part waveforms of the proposed converter

Mode 3(t_2~t_3): When the switch S_1 is turned off at time $t = t_2$, mode 3 begins. During mode 3, the direction of primary current i_p is changed, which is different from modes 1 and 2. The primary current i_p is expressed by the following equation:

$$i_p = -\frac{V_{in}+v_{Cc}}{L_r}(t - t_2) + i_p(t_2) \qquad (4)$$

3 Experimental result

Fig. 3 shows experimental waveforms of proposed converter. The waveforms coincide with the theoretical waveforms in Fig. 1(b).

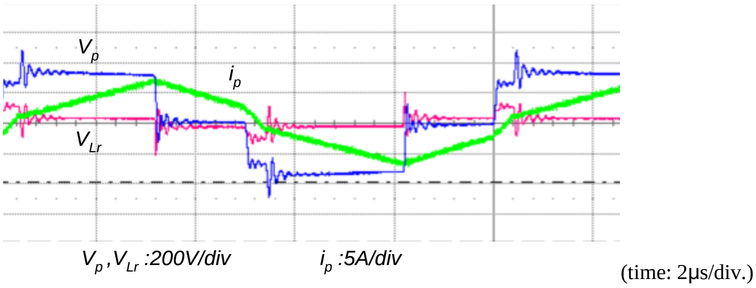


Fig. 3. Experimental waveforms of the key parts of the proposed converter

4 Concluding remarks

In this paper,a high power DC-DC converter using the PD PWM technique and resonant circuit has been proposed, and the operational principle and the experimental result have been described and shown to verify the feasibility of the proposed converter, respectively.

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