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High Efficiency AC-DC Power Converter using a ModifiedFull-Bridge Circuit

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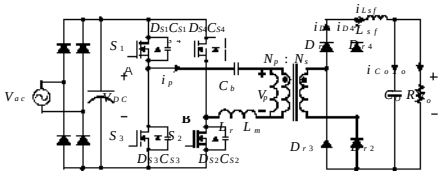
Abstract. This paper presents a high efficiency AC-DC power converter using a modified full-bridge circuit. The proposed converter resolves a drawback of the conventional power converter using a modified full-bridge circuit by inserting the DC blocking capacitor in the converter primary. Thus, the proposed converter can improve total efficiency and its performance.

Keywords: Resonant, DC-DC converter,ZVS, Phase-shift PWM

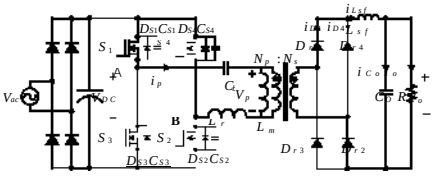
1 Introduction

Because the conventional full-bridge AC-DC power converter using the phase-shift PWM technique has advantages that the switching loss decreases by zero voltage switching (ZVS) of the primary main switches, the converter has been widely used in industry. However, the conventional converter has adrawback that the load range is dependent on the resonant inductance to maintain its ZVS[1-3].
Therefore, in this paper, a high efficiency AC-DCpower converter using a modified full-bridge circuit is proposed. The proposed converter overcomes the drawback of the conventional converter and improves the performance by inserting a blocking capacitor in the converter primary.Thus,as the proposed converter can reduce its freewheeling interval [4], itstotal efficiencycan be improved.

2 The operation principle of the proposed converter



(a)Mode 1(t_0~t_1)



(b)Mode 2(t_1~t_2)

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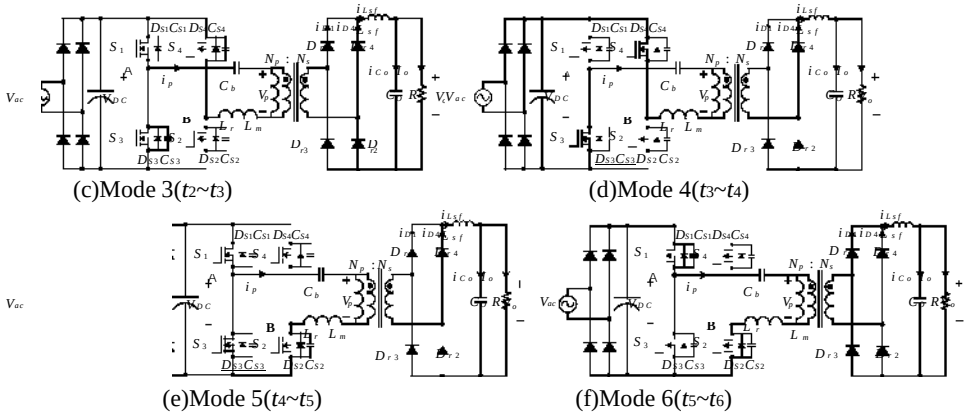

Fig. 1. The operation modes of the proposed converter

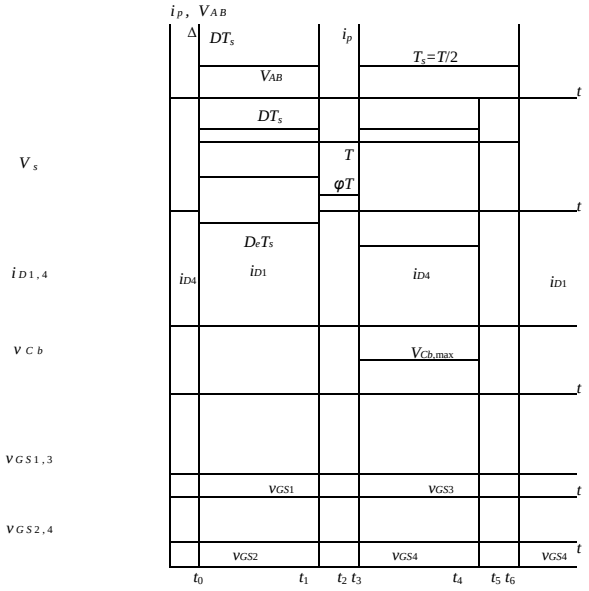

Fig. 2. The theoretical key part waveforms of the proposed converter

Figure 1 shows the operation modes of the proposed converter, and figure 2 shows the theoretical key part waveforms of the proposed converter, respectively. For easy mode analysis, it is assumed that the following conditions:

- The transformer has the magnetizing inductanceL_m and the leakage inductance L_r that can be ignored, because it is very small compared with L_m. And the turn ratio of transformer is n ($=N_s/N_p$).
- Each switch is an ideal component except its internal diodeand output capacitor.

- The output voltage is constant.

Mode 1 (t_0~t_1): Mode 1 starts at time $t=t_0$. The power is transferred from the primary to the secondary through the switch S_1 and S_2. The secondary diodesD_{r1} and $D_{r2}$are turned on, andthe secondary diodesD_{r3} and $D_{r4}$are turned off at this mode. The primary current i_p and the blocking capacitor voltagev_{Cb} are given as follows:

$$() = -/-() (-0) + (0) \quad (1)$$

$$() = 1 \int () \quad (2)$$

When the switch S_2 is turned off at time$t=t_1$,this mode ends

Mode2(t_1~t_2): Mode 2 starts at time $t=t_1$. The internaldiode $_{Ds4of}$ the switch S_4turns on when the switch S_2 turns off. The power charged in the leakage inductance L_r is discharged through the secondarydiodesD_{r1} and $_{Dr2.}$ The primary current $i_p$is given as follow:

$$() = - \_/ + () \quad (-1) + (1) \quad (3)$$

This mode ends, when the switch S_1 turns off at time $t=t_2$.

Mode3 (t_2~t_3): Mode 3 starts at time $t=t_2$. The output capacitor$C_{s3}$of the switch S_3starts discharging power. Then,the internal diode $_{Ds3of}$ the switch S_3turns on and the primary current $i_p$flows to the source. At this time, the voltage across the leakage inductance $_{Lr}$becomes$VDC+vCb,$ and all the secondarydiodesturn on.The primary current $i_p$and the blocking capacitor voltage $v_{Cb}$are given as follows:

$$() = - + () \quad (-2) + (2) \quad (4)$$

$$() \cong _{,max} \quad (5)$$

If the primary current changes its direction during the mode 3 and flowsreverselyduringthe next second half switching period, the modes 4~6, the secondary diodesD_{r3} and $_{Dr4}$ turn on and the secondary diodesD_{r1} and $_{Dr2}$ turn off. At this period, the secondary current is rectified by the secondary diodes $_{Dr3}$ and $D_{r4}$and then the secondary current flows into the output filter inductorL_{sf}. The primary current changes its direction during the mode 6. Therefore, the mode operations of the converter during the second half switching periodare same as the modes 1~3 except the current direction and the conducting components.

3 Experimental results

Table 1. The design example of a prototype converter

Input AC voltage(V_{ac})	180~265V
Output DC voltage(V_o)	24V
Maximum power($P_{o,max}$)	650W
Switching frequency(f_s)	100kHz
Nominal duty ratio of phase-shift(D_e)	0.5

Table1 shows the design specifications of a prototype converter. The prototype converter was designed according to the table 1 for verifying the performance of the proposed converter.

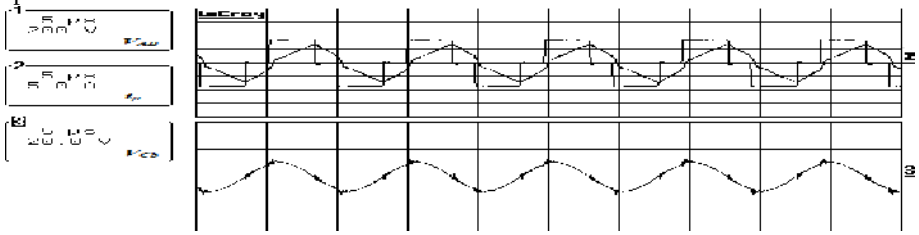

Fig. 3. The experimental waveforms of the voltage $_{VAB,}$ the currenti_p, and the blocking capacitor voltage $_{vCb}$in the primary

Figure 3 shows the experimental waveforms of the voltage $_{VAB,}$ the current i_p, and the blocking capacitor voltage $_{vCb}$in the primary.

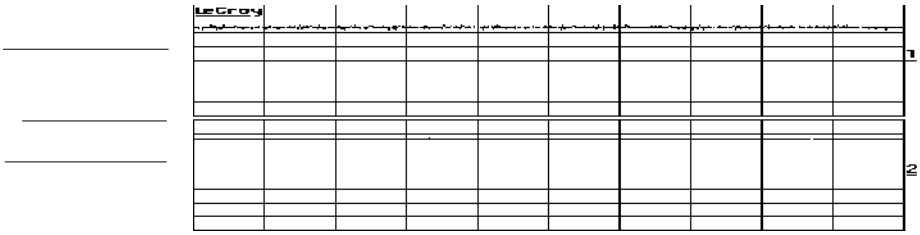

Fig. 4. The experimental waveforms of the output voltage V_o and output current I_o

Figure 4 shows the experimental waveforms of the output voltage V_o and output current $_{Io.}$ These waveforms show that the proposed converter has good performance.

4 Conclusion

This paper presents a high efficiency AC-DC power converter using a modified full-bridge circuit. The proposed converter can improve efficiency and overcome the drawback of the conventional converter by using the resonant circuit and phase-shift. The proposed converter shows goodcharacteristics through the experimental results.

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