

High Efficiency AC-DC Power Converter using a Modified Full-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.

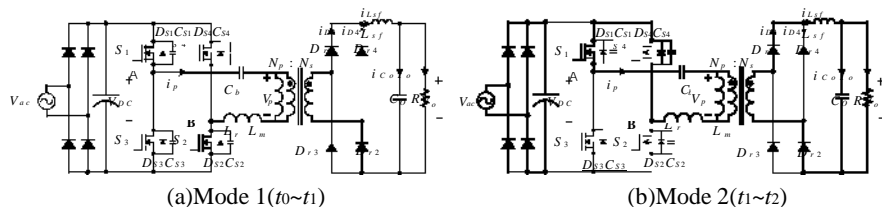
Keywords: Resonant, DC-DC converter, ZVS, Phase-shift PWM

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 a drawback that the load range is dependent on the resonant inductance to maintain its ZVS [1-3].

Therefore, in this paper, a high efficiency AC-DC power 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], its total efficiency can be improved.

2 The operation principle of the proposed converter



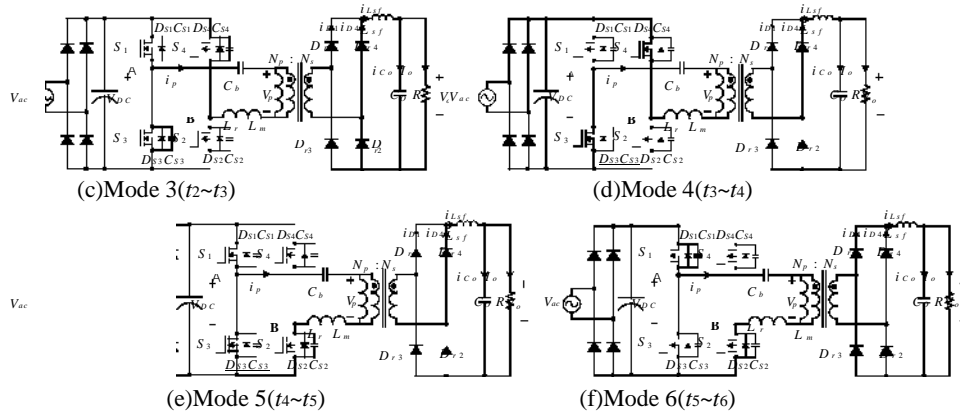


Fig. 1. The operation modes of the proposed converter

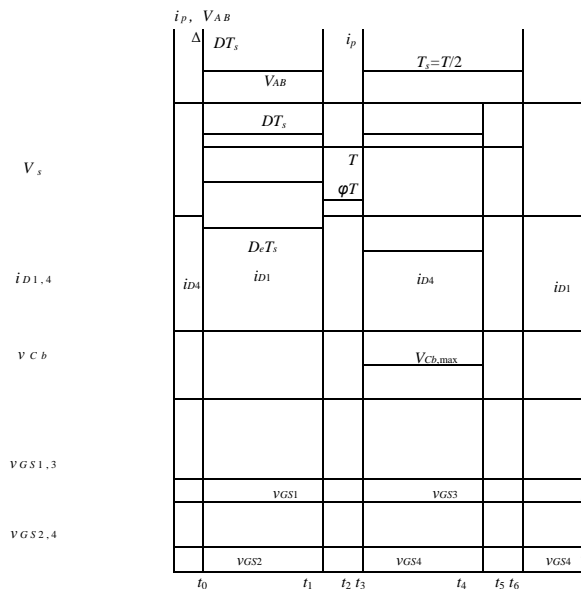


Fig. 2. The theoretical key part waveforms of the proposed converter

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 inductance L_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 diode and output capacitor.

- The output voltage is constant.

Mode 1 (t₀~t₁): Mode 1 starts at time t=t₀. The power is transferred from the primary to the secondary through the switch S₁ and S₂. The secondary diodes D_{r1} and D_{r2} are turned on, and the secondary diodes D_{r3} and D_{r4} are turned off at this mode. The primary current i_p and the blocking capacitor voltage v_{cb} are given as follows:

$$i_p = -i_o(t_0) + (0) \quad (1)$$

$$i_p = -\int i_o \quad (2)$$

When the switch S₂ is turned off at time t=t₁, this mode ends

Mode 2 (t₁~t₂): Mode 2 starts at time t=t₁. The internal diode D_{s4} of the switch S₄ turns on when the switch S₂ turns off. The power charged in the leakage inductance L_r is discharged through the secondary diodes D_{r1} and D_{r2}. The primary current i_p is given as follows:

$$i_p = -i_o(t_1) + (0) \quad (3)$$

This mode ends, when the switch S₁ turns off at time t=t₂.

Mode 3 (t₂~t₃): Mode 3 starts at time t=t₂. The output capacitor C_{s3} of the switch S₃ starts discharging power. Then, the internal diode D_{s3} of the switch S₃ turns on and the primary current i_p flows to the source. At this time, the voltage across the leakage inductance L_r becomes V_{DC}+v_{cb}, and all the secondary diodes turn on. The primary current i_p and the blocking capacitor voltage v_{cb} are given as follows:

$$i_p = -i_o(t_2) + (0) \quad (4)$$

$$i_p \cong i_{p,max} \quad (5)$$

If the primary current changes its direction during the mode 3 and flows reversely during the next second half switching period, the modes 4~6, the secondary diodes D_{r3} and D_{r4} turn on and the secondary diodes D_{r1} and D_{r2} turn off. At this period, the secondary current is rectified by the secondary diodes D_{r3} and D_{r4} and then the secondary current flows into the output filter inductor L_s. The primary current changes its direction during the mode 6. Therefore, the mode operations of the converter during the second half switching period are 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

Table 1 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.

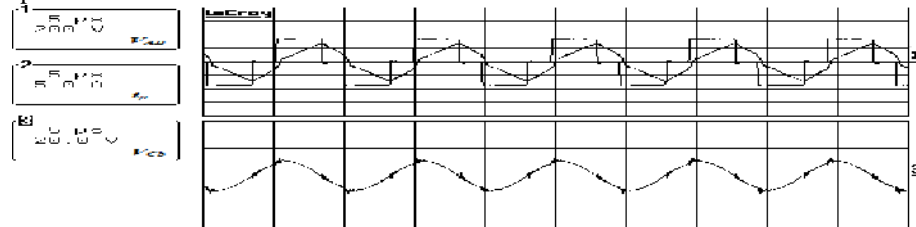


Fig. 3. The experimental waveforms of the voltage V_{AB} , the current i_p , and the blocking capacitor voltage v_{Cbin} the primary

Figure 3 shows the experimental waveforms of the voltage V_{AB} , the current i_p , and the blocking capacitor voltage v_{Cbin} the primary.

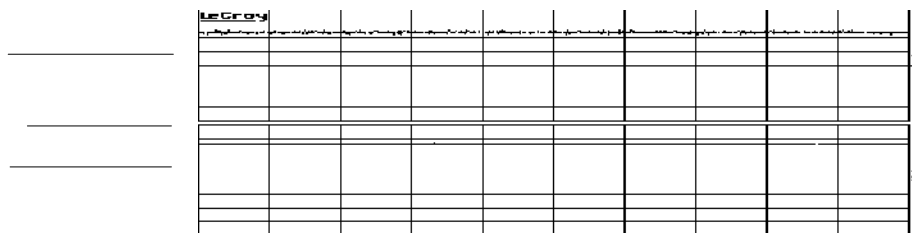


Fig. 4. The experimental waveforms of the output voltage V_o and output current I_o

Figure 4 shows the experimental waveforms of the output voltage V_o and output current I_o . 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 good characteristics through the experimental results.

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