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Main Circuit Parameters Design of DC operating Power Supply

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Abstract. The phase-shifted full bridge zero voltage soft switch (ZVS) topology of 2.2KW electric operation power supply is analyzed in brief. According to the actual characteristics of electric power supply, the power MOSFET and the second rectifier-diode are chosen. By waveform analysis, temperature and power efficiency test, the experimental results confirm the reasonableness of the design.

Keywords: Electric operation, Power supply, Main circuit, ZVS

1 Introduction

With the development of power electronics technology, phase-shifted full-bridge soft switching control technology has been widely used in the power supply operation, which not only can reduce the switching losses, electromagnetic interference power, but also to improve the output characteristics of the circuit to improve the efficiency of the circuit, stability and reliability. In soft-switching full-bridge phase-shift Electric Power study, involving a lot of aspects, such as the parameter selection and design of the main circuit, control circuit design, anti-electromagnetic interference design and parameters of influence and so on, this paper analyzes only Electric Power main circuit parameters.

2 Electric power works

The principle of the power module block diagram shown in Figure 1. Three-phase AC input power via the input phase rectifier, filter is converted into direct current, full-bridge DC converter circuit and then converted into a high-frequency alternating current, and then by the high-frequency transformer isolation transformer, rectified by the rectifier filter is converted into a stable DC output; the main circuit switching power phase-shifted full bridge soft switching converter circuit, each one arm using two power transistors in parallel, one can ensure that the pipe will not be burned , on the other hand to prepare for the potential of the power, which the topology shown in Figure 2.

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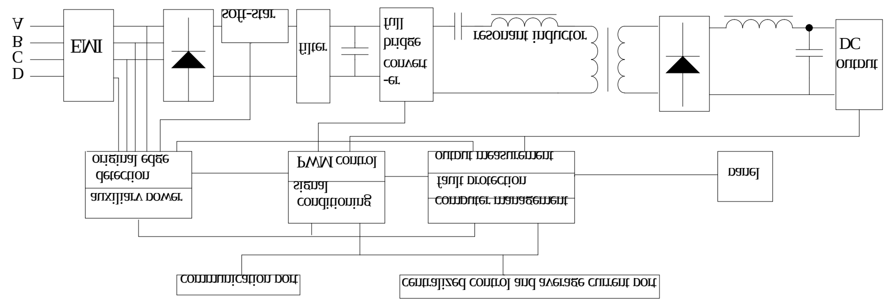

Fig.1. Block Diagram of the Electric Power Modules

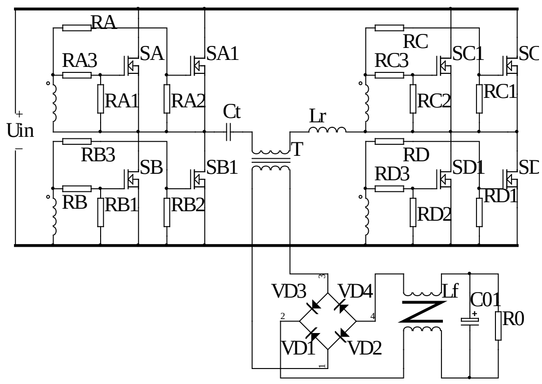

Fig.2. Full-bridge Soft-switching converter Topologies

The converter in a transformation period, a total of 12 kinds of working conditions, four switch turns conducting achieve zero voltage turn-on and turn-off, reducing power consumption. The converter also uses the isolation capacitors to suppress the DC component, and uses the saturation inductance to reduce duty cycle loss.

3 Design parameters of the main circuit

The input Three-phase 380V AC power becomes into pulsating DC voltage after the bridge rectifier. A filter capacitor C_{in} is added before the converter to further smooth and reduce the voltage ripple, and the noise can be greatly reduced.

RMS phase voltage: $380^{+15\%}_{-20\%} = 304V \sim 437V$

In order to ensure that the filtered rectified DC voltage minimum value $V_{in\ (min)}$ to meet the requirements, the energy per cycle C_{in} provided is about:

$$W_{in} = \frac{P_{in}}{3\times f_{\min}} = \frac{P_{out}/\eta}{3\times f_{\min}} = \frac{2200/0.85}{3\times 45} = 19J$$

(1)

After further calculations, we can get the input capacitance as:

$$C_{in} = 676\mu F$$

Resonant inductor design, in order to achieve the lagging leg of zero voltage switching, must satisfy the following formula:

$$\frac{1}{2}L_r I^2 = \frac{4}{3}C_{MOS}V_{in}^2 \tag{2}$$

Which, L_r is the resonant inductor, I was the primary current when lagging switch off, C_{MOS} is the MOSFET drain-source capacitance, Vin is a DC voltage rectified and filtered.

In the actual design, taking into account the lagging achieve zero-voltage switching when more than 1/3 full, V_{in} should take the maximum. while the load current is 1A, the filter inductor current I_{Lf} critical continuous, that is, the amount of its pulsation Δi_{Lf} is 2A. In The case of the 1/3 load, the following formula:

$$I = \frac{I_0/3 + \Delta i_{Lf}/2}{K} = \frac{10/3 + 2/2}{1} = 4.44 \tag{3}$$

IXFX2780Q switch drain-source capacitance C_{MOS} = 750pF, $V_{in\,(max)}$ = 618V, L_r = 39 μH. The resonant inductor core selected Siemens G42 models pot core, take the gap δ = 2mm, then according to the formula:

$$L = \frac{\mu_0 N^2 A_e}{\delta} \tag{4}$$

Where: μ_0 is the magnetic permeability, the size of $4\pi \times 10^{-7}$H / cm. A_e is the cross-sectional area of the magnetic core, the size of 388mm2. The μ0, A_e and δ into the formula, we get: winding turns N=4, with 6 wire wounding a diameter of 0.62mm.

4 Experimental results and analysis

In order to investigate whether the selected parameters to achieve the design requirements, the waveform of the transformer primary and secondary voltage , current waveforms and secondary rectifier output voltage was collected by an oscilloscope, and the power temperature and efficiency was tested.

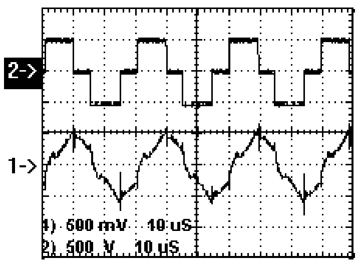

Fig.3. Current and Voltage Waveform of Primary

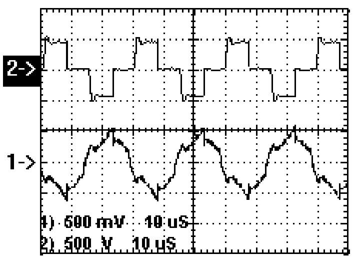

Fig.4. Current and Voltage of Secondary

Figure 3 shows the waveforms of transformer primary voltage and current when the input AC voltage is 380V and the output is 220V/6.5A. As can be seen from the figure, the primary transformer voltage waveform is very clean. Primary current only when the current commutation, due to the transformer leakage inductance and current oscillations affect exists small spikes. Can also be seen from figure 3, the primary current slope during overshoot or undershoot is large, nearly equal to 1, so that the current rises rapidly to the load current. This shows that the resonant inductor is almost at saturation point, resulting in a greatly duty cycle loss decreases.

Figure 4 shows the waveforms of transformer secondary voltage and current when the input AC voltage is 380V and the output is 220V/6.5A. As can be seen from the figure, the secondary current waveform is very clean, and at the time of the commutation, spike smaller than the primary current. Can also be seen from the figure, there is little secondary voltage oscillation, which is caused by the leakage inductance of transformer secondary side and reverse recovery of the output rectifier.

Table 1 shows that when the input and output voltages are constant (U_i = 380V, U_0 = 220V), the power efficiency of different output current. As can be seen from the table, the overall efficiency of the power supply in the whole load range is up to more than 90%.

Table 1. Supply Efficiency under Different Output Current

Input Current(A)	Output Power(W)	active power(W)	Efficiency(η%)
1	220	196.9	89.5
2	440	395.56	89.9
3	660	595.32	90.2
4	880	797.28	90.6
5	1100	1004.52	91.32
6	1320	1210.31	91.69
7	1540	1404.48	91.2
8	1760	1598.08	90.8
9	1980	1787.94	90.3
10	2200	1962.4	89.2

5 Conclusion

According to the selected parameters, designed the power supply operation main circuit. The practical application shows better stability and reliability of the power supply, energy-saving effect, and higher efficiency

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