The design of single-phase variable frequency power supply with APFC

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Abstract—**Around the above problem, the new power supply is designed. In the design, L6562 is used to control the APFC circuit, and EG8010 is used to control full-bridge inverter circuit. According to the design requirements, firstly, the parameter calculation and the device selection are completed. Then, Saber software is used to simulate the active power factor correction circuit and the inverter circuit. At the same time, the parameters of input power factor and output load regulation rate are calculated to validate the rationality of the calculated devices and the feasibility of the design circuit. At last, the hardware circuit is built and tested. In a word, the designed power supply is available and efficiency, because it can not only achieve the function of changing frequency, but also have the result of power factor correction.**

Keywords-APFC; variable frequency; parameter; saber

I. INTRODUCTION

The traditional single phase frequency conversion power consists of non-control rectifier and full bridge inverter circuit, its application field is very wide. However, because of the lower power factor of its input side, the system would have the big harmonic, and the energy utilization rate would be low. Around the above problem, this design is proposed. According to the low power factor faults of the input side of the traditional single phase frequency conversion power, combining with the active power factor correction technology, the boost chopper circuit is added between the non-control rectifier and the full bridge inverter circuit, which forms the active power factor correction circuit and full bridge inverter circuit combination as a new hand in rectangular variable frequency system main circuit. The design requires that level before input is 220 V, 50 Hz AC, boost output is 400 V DC, and level after output is 60 Hz AC, to ensure the realization of the variable frequency function at the same time to achieve power factor correction effect.

II. CIRCUIT DESIGN

A. Active Power Factor Correction Circuit Design

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Active power factor correction circuit consists of non-control rectifier and boost chopper circuit. The design need select the good performance of control chip to control the switch device of boost circuit, used for correcting the input side of the power factor. This design takes the peripheral circuit relatively simple L6562 chip to control, the whole circuit is as shown in figure 1.

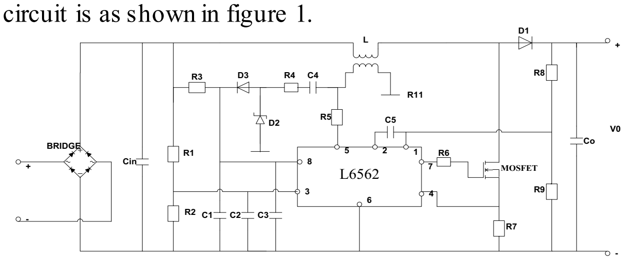

Figure 1. The integral structure of the active power factor correction circuit based on L6562

As shown in figure 1, the active power factor correction circuit based on L6562 includes input rectifier bridge, input filter capacitance C_{in}, boost inductance L, boost diode D_1, MOSFET, output filter capacitor C_0 and L6562 chip, among them, the peripheral circuit of L6562 chip, and the peripheral circuit consists of the multiple resistance, capacitance and diode composition. This design should be based on the input voltage, output voltage, output power and efficiency of the parameters such as the design requirements, combining L6562 chip work manual, on the above element to parameter calculation and selection devices. The main circuit of the device selection is shown in table Ⅰ.

TABLE I. THE MAIN CIRCUIT DEVICE SELECTION

Element	Size	Element	Size
input rectifier bridge	2W10	Boost D1	MUR460
C_{in}	0.47uF/400V	MOSFET	FQPF12N60C
Boost L	300uH	C_0	47uF/450V

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Among them, the input filter capacitance C_{in} is ordinary ceramic chip capacitor, the output filter capacitor C_0 is electrolytic capacitor.

The control circuit of the device selection is shown in table Ⅱ. The elements of table Ⅰ and table Ⅱ are taken to build circuit, which can satisfy the input side of the power factor correction, and ensure that boost output 400 V.

TABLE II. THE MAIN CIRCUIT CONTROL ELEMENTS SELECTION

Element	Size	Element	Size
R_8	1MΩ	C_2	10nF
R_9	6.3KΩ	R_7	0.5Ω/5W
C_5	1uF	R_3	360KΩ
R_1	1.39 MΩ	R_5	68KΩ
R_2	R2=10KΩ	C_4	10nF
R_4	100Ω	C_1	22uF/25V
D_3	IN4148	C_3	100nF
D_2	IN4746		

B. Inverter Circuit Design

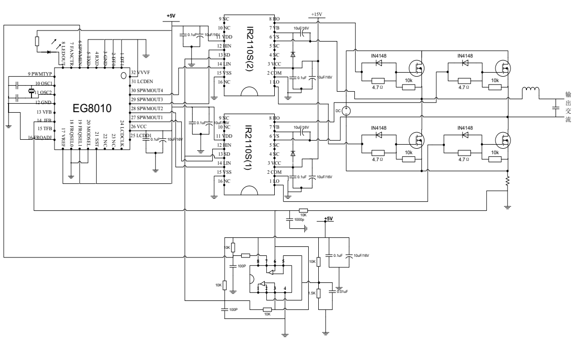


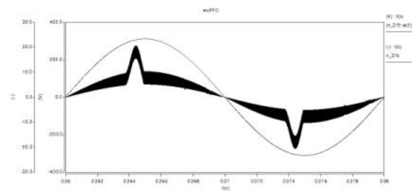
Figure 2. The integral structure of the full bridge inverter circuit based on EG8010

This design uses the SPWM control chip EG8010 to control the full bridge inverter circuit, but as a result of EG8010 is +5 V DC voltage power supply, its output control signal peak also only 5 V, this design inverter circuit switch tube for voltage driving type MOSFET, +5 V control signal is not enough to drive the switch pipe opened and shut off. Therefore, this design also uses two pieces of dedicated half bridge drive IR2110 chip to drive level after inverter circuit, in order to realize frequency conversion function, its circuit structure is as shown in figure 3. This design will also output current sampling, the use of LM393 voltage comparator made over current protection circuit, to ensure the safe operation of the circuit.

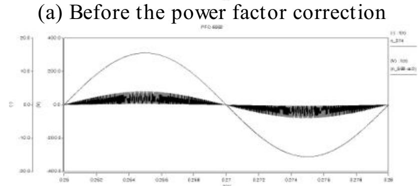
III. SIMULATION ANALYSIS AND HARDWARE CIRCUIT TEST

The simulation can not only verify the accuracy of the design scheme, but also can be used as the theory basis of building hardware circuit. The design uses Saber software, in accordance with the above the selection of circuit structure and the design of the element parameters on the circuit simulation, and analyzes the results.

A. The Simulation Analysis of APFC Circuit



(a) Before the power factor correction



(b) After the power factor correction

Figure 3. PFC before and after input voltage and current waveform comparison

Figure 3 shown as power factor correction and input voltage and current waveform contrast situation, as shown in figure 3(a), the input current in voltage peak appears near the peak, current waveform distortion is very serious, leading to the input side power factor lower; As shown in figure 3(b), the current waveform is sine wave, and fully follow the input voltage change, the power factor of the input side has been very good correction.

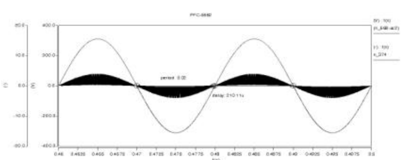


Figure 4. PFC after the input voltage, current period and delay map

Figure 4 is the situation of the input voltage, current cycle measurement conditions and time delays. From figure 4, it is known that the cycle of sine wave is 0.02s, frequency is 50Hz. Input current and voltage waveform, the time delay for 210.11us, and the cycle of 20000us compared, can think basically no delay, voltage and current with phase, the power factor is closed to be 1. After calculation, the input voltage and current in the angle is 3.782°, the power factor is 0.9978, which meet the requirements of the power factor more than 0.9.

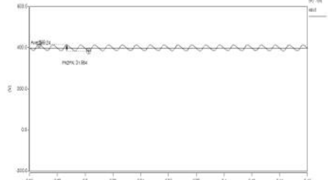


Figure 5. Boost output voltage test chart

Figure 5 is boost output voltage test chart. As shown in figure 5, when the circuit stability, the average of the output voltage is 399.24V, and voltage fluctuation is 31.954V, after calculation, the output power is 94.88 W, input power 100.02 W, the efficiency of the circuit is 94.86%, which meet the design requirements.

B. Inverter Circuit of the Simulation Analysis

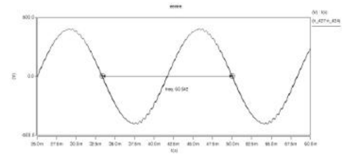


Figure 6. Inverter circuit output voltage

For the inverter circuit of the simulation analysis, this design using EG8010 chip control full bridge inverter circuit, in the Saber software will be high frequency triangular wave and sine wave comparison, with output SPWM wave on full bridge inverter circuit to control. As shown in figure 6, inverter circuit output voltage for sine wave, the measurement, output the frequency of the alternating current 60.042 HZ, which meets the inverter circuit output 60Hz requirements.

Section 3.1 and 3.2 are using Saber software respectively on active power factor correction circuit and full bridge inverter circuit analysis, in order to ensure the integrity of the design, this section will be two parts circuit together, active power factor correction circuit output as a full bridge inverter circuit of input, to the whole of the into rectangular variable frequency system to carry on the analysis.

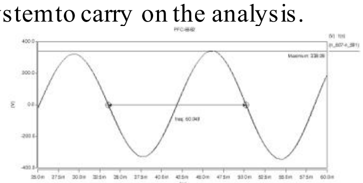


Figure 7. AC-DC-AC variable frequency system when there is no output voltage test chart

Figure 7 is the whole AC-DC-AC variable frequency system in no load cases output voltage measurement condition. As shown in figure 7, it is known that in light load, the output voltage of 60.049Hz, meets the inverter circuit output requirements and output voltage of 338.28V; Also, it is known that AC-DC-AC variable frequency system in rated load, the output voltage of 311.76V, after the calculation, the load adjustment rate is 8.53%, which meets the design requirements.

C. Hardware Circuit Test

Above of the simulation analysis show the correctness of the calculation parameters and the feasibility of the scheme selection, through constructing the debugging of hardware circuit for further plan feasibility is validated.

Figure 8 is the design of the active power factor correction circuit hardware structures and test. After the measurement, the actual output DC voltage is between 397V and 393V, which meets the boost output voltage 400V requirement, the lesser fluctuation and the circuit performance is good.

Figure 8. Hardware circuit test pattern

Also, figure 8 for the design of inverter circuit overall test chart. Considering the test security, this design not will boost output of 400 V supply full bridge inverter circuit, but choose the voltage level relatively safe 24V DC as input, the measurement, AC output is 17.6 V, waveform for sine wave, meeting the design requirements.

IV. CONCLUSION

The design of all the indexes has met the design requirement, from two aspects of hardware and simulation to prove the feasibility of the scheme, design achievement has certain actual application value. The only deficiency is in hardware circuit test phase, there is no will be two parts circuit together. But the shortage in the simulation analysis got up, simulation analysis has two parts circuit together, to the whole into rectangular variable frequency system efficiency and load regulation analysis, to ensure the integrity of the design. If the shortage of place was improved, the design can be a performance good into rectangular frequency conversion power and can be used in practical production.

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