Design of front-end push-pull sine wave inverter

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Abstract. This paper designs a sine wave inverter that converts 12V DC into 220V/50Hz AC. In the DC/DC converter circuit, the push-pull circuit is used for boosting. The pulse width modulator SG3525 control chip is selected. The MOS tube provides the drive signal modulation wave, first boosts the 12V DC voltage to 400V; then designs the full-bridge DC/AC converter circuit, selects the control circuit based on the SPWM dedicated chip EG8010 and the drive circuit based on the IR2110S driver chip. Finally, according to the hardware circuit and parameter design, the simulation of the design scheme is carried out, and the feasibility of the design scheme of the sine wave inverter is verified.

1. Introduction

The inverter is a converter device that converts DC power into AC power, and is widely used in power electronic devices such as AC motor speed control inverters, uninterruptible power supplies, induction heating power supplies, and DC power supplies. Its application field has reached an unprecedented scale, from milliwatt LCD backlight inverter circuit to 100 megawatt high voltage DC transmission station, from daily inverter air conditioner, inverter refrigerator to airborne equipment in aviation field. From thermal power generation equipment using conventional fossil energy to solar wind power generation equipment using renewable energy, inverter power is indispensable. There is no doubt that with the development of computer technology and various new power devices, inverter devices will also develop toward smaller size, higher efficiency, and superior performance indicators.

2. System design

Since the transformer and the weight of the high-frequency inverter are relatively small, the conversion and isolation performance are good, and the high-frequency switching conversion technology is mature and cheap, the design uses the circuit structure of the high-frequency inverter. Since the output requirement is 50Hz sinusoidal alternating current, the high frequency alternating current needs to be converted into 50Hz alternating current, so the high frequency inverter mainly includes two stages: the front stage is from the input to the high frequency rectification filter circuit, namely DC/DC converter; The stage is a high frequency rectification and filtering circuit to an output filter, that is, a DC/AC converter. The pre-stage DC/DC converter uses MOS tube, transformer and SG3525 chip to convert 12V DC to 400V DC. The latter stage uses SPWM dedicated EG8010 pure sinusoid inverter control chip to convert to 220V/50Hz AC, and then through LC filter circuit. The filter removes the high-frequency interference waveform and finally outputs the desired pure sine wave AC.

The actual circuit composition can be divided into four parts: DC/DC circuit, DC/AC circuit, protection circuit and control circuit. As shown in ‘figure 1’.
3. DC / DC circuit design

3.1 DC / DC main circuit scheme is determined

The driving circuit composed of SG3525 chip is used to control the large current MOS tube. Here, two high-current MOS tubes are used to complete the two sets of square wave inverter processes in parallel, and two sets of high-frequency and high-current square wave alternating currents are formed. The high frequency and high current square wave alternating current is converted into a high frequency square wave alternating current of about 400V by a high frequency step-up transformer. Finally, by rectification, a high-frequency square wave alternating current of about 400V is converted into 400V direct current. The SG3525 chip can be powered by a 12V power supply, receives signals from the step-up transformer and the high-current MOS tube, and processes and controls the state of the MOS to provide overheat protection and over-voltage protection.

Since the input voltage of the inverter is only 12V, the high frequency inverter circuit usually selects a push-pull inverter circuit, and the advantage is that the driving signals of all the switching tubes in the circuit are referenced to the input voltage negative terminal (GND). The potential is easily compatible with the control circuit, the drive signal does not require potential transfer, and can be driven directly to simplify the circuit. The schematic diagram of the DC/DC circuit is shown in ‘figure 2’[1].
3.2 DC / DC main circuit design

Considering that the input voltage is 12V and the output power is 1.5KW, this paper selects the push-pull converter circuit to complete the boost task from low voltage to high voltage. The circuit structure is shown in 'figure 3'.

The output voltage of the circuit is finally determined by the sine wave of the output, and the relationship between the output sine wave voltage $U_o$ and the DC high voltage $U_{DC}$ is satisfied.

$$U_o = MU_{DC} \sin \alpha t$$  \hspace{1cm} (1)

Where $M$ is the degree of modulation, defined as the ratio of the amplitude of the modulation wave $U_s$ to the amplitude of the carrier $U_c$

$$M = \frac{U_s}{U_c}$$  \hspace{1cm} (2)

It is known from equation (1) that the amplitude of the output sine wave is proportional to the DC high voltage, and the modulation degree $M$ is usually less than 1, so the value of the DC high voltage should be greater than the peak value of the output sinusoidal voltage to meet the output requirement [2]. Usually, this high voltage is set to about 400V, and the output voltage is adjusted by adjusting the modulation degree $M$.

3.3 Control circuit design

Since the switching MOS transistor of the push-pull circuit is under low voltage measurement, it can be directly driven by the pulse width modulator SG3525 chip. The SG3525 chip is a PWM output control pulse width modulation control chip designed according to the characteristics of the power switch tube. Therefore, the PWM control signals output on the 11th and 14th pins of the pulse width modulator SG3525 chip can be directly applied to the gate of the MOS transistor through voltage adjustment, and the source can be directly grounded. The control circuit of SG3525 is shown in ‘figure 4’.
An error amplifier is included inside the SG3525 chip, and the design is used to implement feedback control of the push-pull circuit. Inv.input (1-pin) is the inverting input of the error amplifier, connected to the feedback signal of the output voltage. Noninv.input (2-pin) is the non-inverting input of the error signal, and a stable voltage value is used as the comparison reference voltage. When the input operating voltage of the chip is 15V, VREF (16-pin) can output a high-precision 5.1V voltage value, and the input value of the 2-pin can be 1.5-5.2V, using the 16-pin output high-precision voltage. The voltage is divided into two voltages and connected to the reference voltage of the error amplifier. At the output end, the output DC voltage value is taken. After the voltage division, the reference value of the voltage feedback is set at a DC voltage of the output voltage of 400V[3]. The feedback circuit is as shown in ‘figure 5’.

4. DC / AC circuit design
The DC/AC circuit is composed of a high voltage MOS tube, an SPWM dedicated EG8010 pure sinusoidal inverter control chip, a driving circuit, and an LC filter circuit. SPWM dedicated EG8010 pure sinusoidal inverter control chip generates modulation wave for SPWM modulation control and is driven by IR2110S to drive MOS tube, so that 400V DC can modulate pure sine wave through MOS tube.

4.1 Full-bridge DC/AC circuit
The DC/AC converter circuit of this system uses a full-bridge inverter circuit structure. In order to reduce the weight and miniaturization of the whole inverter, the output transformer is not used to change the output voltage. The post-stage converter is selected to directly convert 400V DC into
220V/50Hz AC. The actual circuit shown in ‘figure 6’ is mainly composed of four switches. The tubes V1-V4 are composed, and the switching tubes V3 and V4 are turned on in turn, each conducting 180° electrical angle; the same is true for V1 and V4, but V2 and V3 are not simultaneously turned on, the former is turned on first, after an electrical angle, the latter leads Pass, the voltage obtained at the output is positive and negative alternate, according to the design requirements through the control circuit to properly set the on-time of the two pairs of switches, you can achieve the output 220V / 50Hz AC [4].

![Figure 6. Full bridge inverter circuit](image)

4.2 Control circuit design

According to the design requirements, the DC/AC link of the system uses the SPWM dedicated chip EG8010 as the control chip. With unipolar SPWM modulation, the carrier frequency is set to 25KHz and the dead time is set to 800ns. When the chip is working, the 5V reference voltage is supplied to the chip through the 17-pin. The sampling voltage and the sample current enter the feedback signal processing module inside the chip through pins 13 and 14, respectively, and the feedback signal is fed back to the SPWM generator together with the state controller to generate four. The path SPWM control signals respectively control the four switching tubes in the inverter circuit. Since unipolar modulation is selected, only one bridge arm is used for SPWM modulation output, and the other bridge arm is used for fundamental wave output. Therefore, the filter inductor in the circuit is connected to the output end of the SPWM modulation bridge arm, and the voltage sampling circuit only adopts the SPWM modulation bridge arm. The voltage across the inductor [5-6]. The EG8010 control circuit is shown in ‘figure 7’.

![Figure 7. EG8010 control circuit](image)
4.3 Drive circuit design
Because the signal power generated by the chip EG8010 cannot directly drive the switching transistor to turn on and off, it is necessary to add a driving circuit. In the actual development process, it is indispensable to ensure the isolation between the SPWM signal and the gate of the switching tube. The usual isolation measures are transformer isolation and optical isolation. In order to ensure that the signal can drive the switch tube smoothly and realize the isolation function, the design uses the more common IR2110S as the driver chip, and its output voltage can reach 15V, which has the advantages of electromagnetic isolation and optical isolation. Because the IR2110S is a half-bridge driver chip, and the post-design stage uses a full-bridge inverter circuit, two IR2110S chips are used in the circuit design to achieve the drive function [7-8].

4.4 Protection circuit
The EG8010 pure sinusoidal inverter control chip, SG3525 chip and IR2110S chip complete the over-voltage, under-voltage, over-current and overheat protection of the circuit.

5. Simulation
In this paper, according to the output power demand is 1.5KW, assuming that the load is a resistive load, and the value of the set resistor is 17.6Ω, the output AC voltage waveform is shown in ‘figure 8’.

![Figure 8. Main circuit simulation output voltage waveform diagram](image)
From the output waveform of the figure, the design frequency is stable, the load distortion is low, the amplitude is stable, and the design requirements are met.

6. Conclusions
In this paper, the push-pull circuit and the pure sine wave inverter power supply EG8010 chip are adopted, which makes the inverter circuit design simple, volume reduction, cost reduction and good conversion efficiency. The inverter also has the advantages of light weight, good stability, over voltage, under voltage, over current and over heat protection circuit, and has high practical value.
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