Design of Single-phase Sine Wave Variable Frequency Power Supply Based on STM32

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Abstract: The power supply uses isolation transformer to step down and uses full-bridge inverter to converse. The inverter part adopts the driver chip IR2110 for full-bridge inverter, and the latter output adopts current transformer for sampling feedback, forming a double feedback link and increasing the stability of the power supply. In terms of protection, it has the functions of output overload protection, short-circuit protection, over-current protection, etc., which enhances the reliability and safety of the power supply, the output AC voltage is converted by the STM32's own AD, and then controlled by the STM32F407 microcontroller. The mode conversion finally shows the voltage value on the OLED, forming a good human-machine interface. The power supply has completed all the indicators well, the input power is 46.9W, the output power is 43.6W, the efficiency is up to 93%, and the standard 50Hz sine wave is output.

Keywords: *Frequency Conversion; Sinusoidal Pulse Width Modulation; Single Phase Sine Wave; Full Bridge Inverter; STM32*

I. INTRODUCTION

The variable frequency power supply converts the AC power in the mains through AC→DC→AC conversion. The output frequency is stable, the voltage is stable, the internal resistance is equal to zero, the voltage waveform is pure sine wave (no distortion), and the output frequency and voltage can be adjusted within a certain range. Today's international advanced frequency conversion power supply is adoptedIGBT inverter output technology, high-performance precision power supply designed with advanced microprocessor control, it has over-current, short-circuit, over-voltage, under-voltage, overload and other protection and alarm fault display functions to ensure power equipment and variable frequency power supply Safety. It has the characteristics of strong load adaptability, good output waveform quality, good man-machine interface, simple operation, small size and light weight. This design adopts STM32F407 single-chip microcomputer as the main control chip, adopts full-bridge inverter two-stage conversion, and obtains an ideal sinusoidal power supply, and has various protection functions. The external keyboard and liquid crystal display of the system have good human-computer interaction.

II. SYSTEM DESIGN

The 220V, 50Hz AC power supply is stepped down by the transformer, and is converted into DC power by rectification and filtering, and the AC to DC conversion is completed, and then converted into an AC power source whose frequency is adjustable through the inverter. The overall circuit design is shown in Figure 1.

The general circuit diagram is shown in Figure 1. The 220V, 50Hz AC power is rectified by D3 full-bridge, and the filter is converted into DC power. The DC voltage is converted by the inverter into an alternating voltage whose frequency is consistent with the resonant frequency of the load (or transducer). The system hardware circuit is composed of a main circuit, a control drive circuit, a protection circuit and a keyboard display circuit. The inverter is a power electronic device used to implement DC-AC conversion. Its function is to convert DC power into AC power through the opening and closing action of the semiconductor power switching device, so it is a power conversion device. The rectifier circuit of the circuit adopts a rectifier bridge block, has a simple structure and high reliability; the inverter circuit uses IGBT as a switch tube to form a bridge inverter circuit; the output of the output filter circuit full-bridge inverter circuit is a series of high-frequency pulses, in order to obtain The standard sine wave must filter out its high frequency components. The function of the LC filter circuit is to filter out the high frequency. The parameters are determined by the resonant frequency and characteristic impedance of the LC filter.

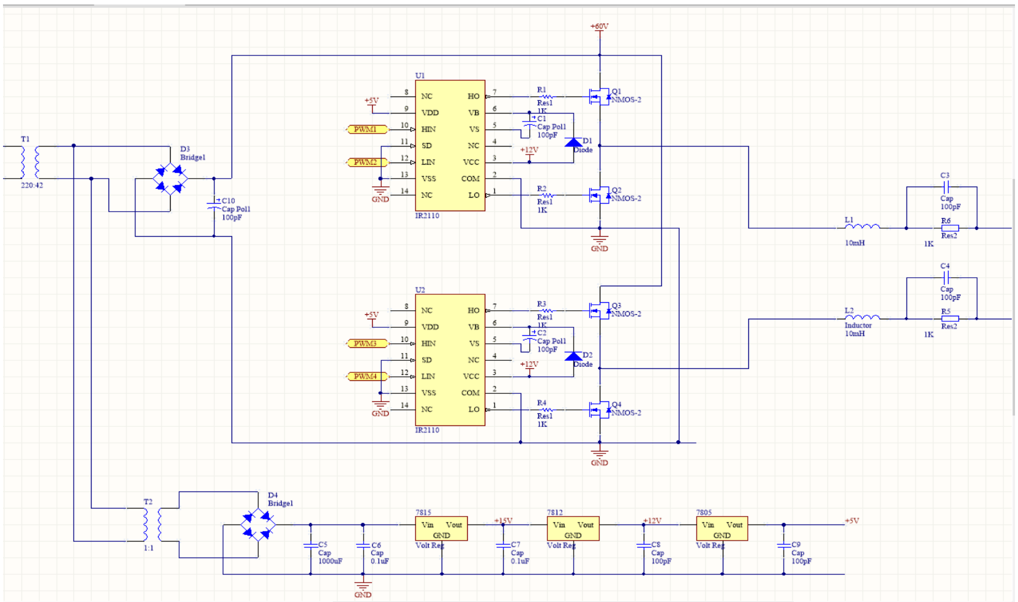

Figure 1: Total Circuit Diagram Block

A. Rectifier Circuit

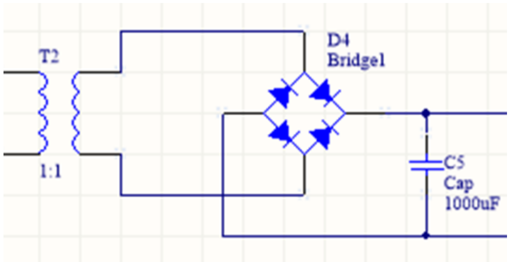

Figure 2: Rectifier Circuit

The rectifier circuit is shown in Figure 2. It is rectified with a single-phase bridge. Using the unidirectional conductivity of the diode, the 220 V AC voltage is converted to DC, which provides the DC bus voltage to the inverter. D4 is a rectifier bridge, and the output voltage is pulsating in the rectifier circuit. In addition, the pulsating current and load changes generated in the inverter part also cause the DC voltage to pulsate. In order to filter out the AC component as much as possible to make it smooth DC, it is necessary to add a low voltage. Pass filter circuit. Here, a common capacitor filter circuit is used, and a large capacitor C5 is incorporated at the rectified output end. The rectified output DC voltage contains many even harmonics. The higher the frequency, the smaller the capacitive reactance, the larger the shunting effect, and the harmonics are filtered out. The more the output voltage, the larger the average value.

B. Inverter Circuit

The full bridge inverter circuit is shown in Figure 3. The circuit adopts two half-bridge driving chips IR2110, which respectively drive the two-side FET IRF4668 of the full bridge, and alternately conducts according to the driving signal SPWM wave, and outputs the power-amplified SPWM wave.

The inverter circuit adopts a voltage type full-bridge inverter circuit, which has four bridge arms, and it can be seen that the two half-bridge circuits are combined. The bridge arms 1 and 4 are paired, the bridge arms 2 and 3 are used as the other pair, and the pair of two bridge arms are simultaneously turned on, and the two pairs are alternately turned on by180^{o}. Output voltage U_o Waveform and waveform of a half-bridge circuit $U_{o.}$ The shape is the same, it is also a rectangular wave, but its amplitude is doubled. Output current in the case of the same DC voltage and load I_{0}.The waveform is of course also with the half bridge circuit $I_{0.}$The shape is the same, only the amplitude is doubled. In comparison, the full-bridge inverter's output capacity is doubled for high-power circuits.

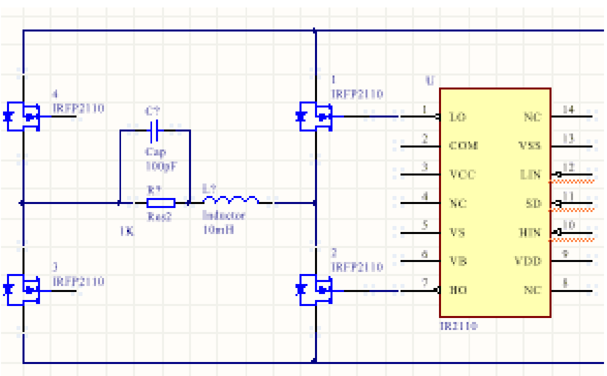

Figure 3: Inverter Circuit

C. Display Circuit Analysis

The sampling voltage value is selected from OLED display. It has small volume, high resolution, long life, low power consumption, clear output image and clear data, and can realize real-time dynamic display of curves quickly.

D. Dead Time Setting

The deadband voltage is set using the STM32 advanced timer to implement the deadband. The advanced control timer TIM1 is capable of outputting two complementary signals at 2.3 and is capable of managing the instantaneous turn-off and turn-on of the output. This period of time is often referred to as the dead zone and the dead time should be adjusted based on the devices connected to the output and their characteristics.

III .SYSTEM SOFTWARE DESIGN

Due to the development of microcomputer technology, it is easier to generate SPWM waveforms by software. The software generation method uses software to implement the modulation method. The rule sampling method generally uses a triangular wave as a carrier. The principle is to use a triangular wave to sample the sine wave to obtain a staircase wave, and then control the on/off of the switching device at the intersection of the staircase wave and the triangular wave, thereby realizing SPWM.

The software part of the flow chart shown in Figure 4, the system defaults to set the voltage 20V, frequency 50Hz, and wait for the interrupt. After entering the interrupt, the interrupt type is determined. If it is a serial port interrupt, the output parameter set by the single chip microcomputer is received, and the SPWM output is changed to realize the output voltage and frequency setting. If it is CPUtimer interrupt, measure the output voltage value, change the SPWM output after calculation by the PID module, and realize the PID voltage regulation control of the output voltage.

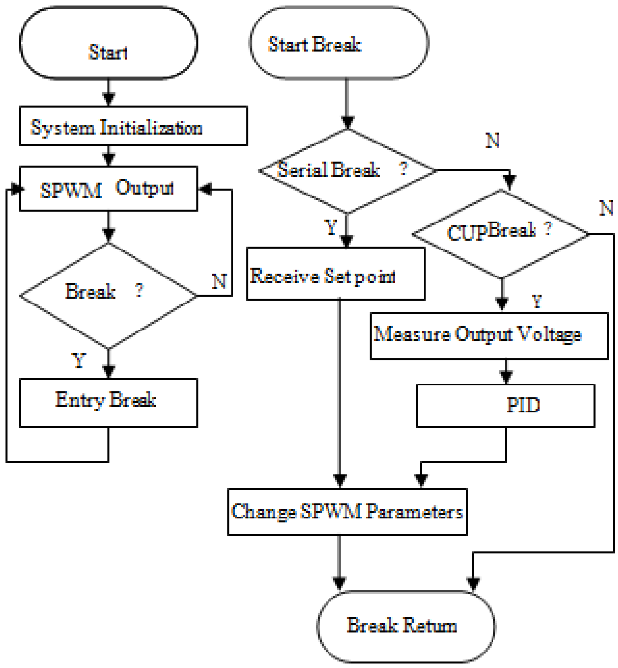

Figure 4: Software Flow Chart

IV. TEST PLAN AND TEST RESULTS

In order to clearly observe the output waveform, the method of measuring the output waveform is to use the DP3014 digital oscilloscope to more intuitively observe the output waveform effect. The waveform of the test output is a stable sine wave. The waveform quality is very good, the error is small, the harmonics are few, the sinusoidal waveform is perfect, and the ideal waveform is required. The output waveform is shown in Figure.5.

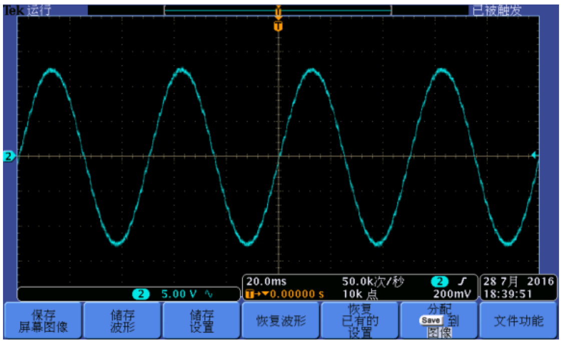

Figure 5: Sine Wave Output Waveform

CONCLUSION

The variable frequency power supply of this paper mainly adopts the method of intersection and intersection, first converts the power frequency AC power supply into a DC power source through a rectifier, and then converts the DC power source into an AC power source whose frequency and voltage can be controlled. The circuit of the variable frequency power supply is composed of a main circuit and a control circuit. The main circuit is composed of a rectification and filtering circuit, an inverter circuit and an output filter circuit, and the control circuit mainly generates PWM to control the IGBT. The power supply has completed all the indicators well, the input power is 46.9W, the output power is 43.6W, the efficiency is up to 93%, and the standard 50Hz sine wave is output.

References

[1] Hu Lianghong, Gan Yongjin et al. Design of single-phase sine wave variable frequency power supply[J].Journal of Yulin Teachers College 2017,38 (2):29-36

[2] Zhang Jianjun, Zhang Jiatian, Du Hanjun. A digital single-phase sine wave variable frequency power supply based on MSP430F2002[J]. Power Technology Application, 2009,5(5) : 58 - 61.

[3] Bandung,Ba Fengli. Principles and Application Technology of Single Chip Microcomputer [M]. Tsinghua University Press, 2010.

[4] Wang Zhaoan, Huang Jun. Power Electronics Technology [M]. Beijing: Mechanical Industry Press, 2008.