

Effect of polarity on control based power supply

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Abstract: In order to ensure the weld seam more beautiful in welding process, a variable polarity power supply is designed based on 80C196KC control technology. The main circuit of the power supply contains the first inverter circuit and the second inverter circuit. The first inverter circuit uses the soft-switching control technique and realizes the inverted closed-loop constant current control; the second inverter circuit realizes the output waveform control and the variable polarity control.

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1. Introduction

As a new type of power supply for aluminum and aluminum alloy welding technology, the Variable Polarity Power Supply (VPPS) can replace the sine wave alternating current power and the square wave alternating current power. VPPS uses the 80C196KC microcontroller as the core, and realizes the real-time control for the variable polarity power. VPPS outputs the square wave alternating current power, whose power frequency, current amplitude of the plus-minus half-wave and the duty ratio can be adjusted independently. VPPS can implement waveform control easily by applying microcontroller. Because of using the new power electronic devices and the soft-switching inverter technology, VPPS performs better than the frequency power, and can be applied in manual or automatic welding system, which is mainly used for argon-arc welding or plasma welding currently.

2. Block diagram

In this design, we apply the 80C196KC microcontroller system, and utilize two inverter circuits to realize the variable polarity power output. Firstly, 80C196KC achieves the inverted closed-loop constant current control by using PI real-time control for the first inverter circuit according to the current limit and the current feedback value of the system. Secondly, we implement the output waveform control and realize the variable polarity control for the second inverter according to the frequency, current amplitude of the plus-minus half-wave and the duty ratio. The microcontroller can achieve dual-inverter collaboration at the same time.

The main circuit consists of the first inverter circuit and the second inverter circuit. The first inverter circuit applies the full-bridge PWM circuit to greatly reduce the switching cost of power transistor, enhance the first inversion frequency, and function as the soft

switcher in wide load range. The second inverter circuit applies push-pull converter (also known as PFM), composed of power transformer with center tap, to be consistent with the working condition of heavy current and low switching frequency. Both inverter circuits apply IGBT module as the main control switch. Intermediate frequency transformer applies nanocrystalline. Switching control circuit applies specific integrate circuit UC3875. The driver for IGBT module applies EXB841 circuit. Figure 1 shows the electrical configuration.

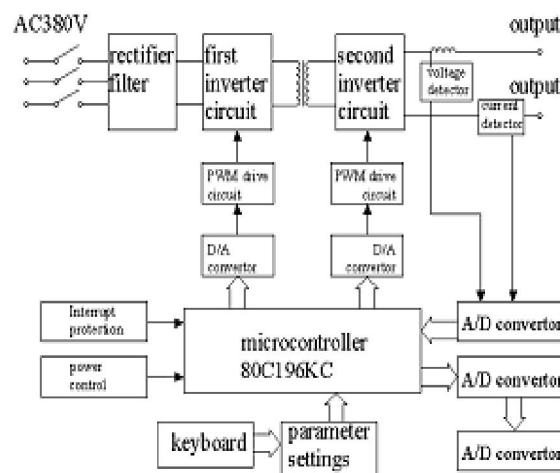


Figure 1. Electrical block diagram

3. Hardware System

A. Micro controller- Based Minimal Control System

The core component of the control system is microcontroller 80C196KC, whose minimal control system consists of power circuit, external program memory, data memory and keyboards etc.

B. The First Inverter Circuit

The first inverter circuit is designed to be a closed-loop constant current control system having

high dynamic response characteristics, with the purpose of supplying the power of the second inverter bridge. Figure 2 shows the electrical configuration.

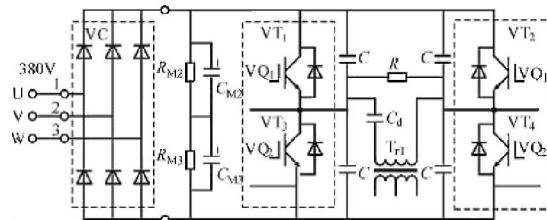


Figure 2. First inverter circuit

The circuit shown in Figure 2 applies phase-shifting zero voltage zero current full-bridge inverter. It can utilize soft switch technique to make the transformer's two bridge-arm switches workable below zero voltage or zero current. Rectifier VC outputs 540V direct current. IGBT module, capability and saturable reactor etc. compose soft switch DC/AC switching part. Direct current can then be transformed into alternating current with 17kHz and adjustable pulse width. At last, intermediate frequency transformer passes the energy to the second inverter circuit.

Microcontroller is required to process the input signal and feedback signal efficiently and execute output control in time to meet the control system's requirement of real-time control on output voltage and current. Output signal (current and voltage) is detected by Hall sensor, and is passed to microcontroller through A/D transformer. Microcontroller 80C196KC processes the signal and sends control signal to PWM phase-shifting controller UC3875. Through EXB841 driver circuit's control on IGBT module's turn-on and cut-off, the first inverter circuit's closed-loop constant current control is implemented.

C. The Second Inverter Circuit

The characteristics of the second inverter circuit are low voltage, heavy current and low switching frequency of switch transistor. The circuit design adopts push-pull power supply circuit. Figure 3 shows the electrical configuration. The low voltage alternating current pulse signal is obtained through intermediate frequency transformer Tr3, and is rectified into direct current square wave signal. Under the control of the secondary PWM signal, IGBT parallel bridge-arm transformer takes the square wave signal and transforms it into low frequency square wave alternating current with adjustable plus-minus half-wave width and frequency. Microcontroller 80C196KC controls the output wave form, making the first inverter and the second inverter working concurrently. The current amplitude of the low frequency square wave

current DCEP and DCEN will be adjustable then (Xuejun, 2005).

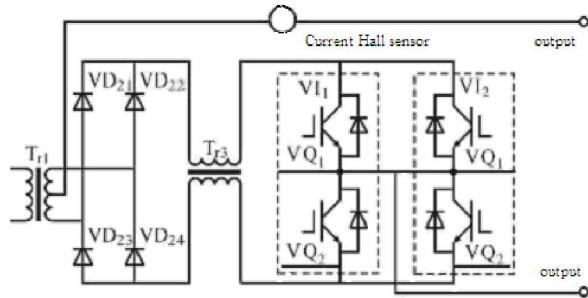


Figure 3. Second inverter circuit

D. Full-Bridge PWM Control Circuit

The circuit adopts the integrated PWM UC3875, which is under the control of phase-shifting full-bridge soft switch. Four signal channels of A, B, C and D are outputted. A and B are complementation signals and dead time is left between them. They are corresponding to the control signal for the two above and below switches of the lagging leg. Similarly, C and D are corresponding to those of the leading leg. B's phase is lagging behind C, A's phase is lagging behind D. The lagging angle is ϕ , which is controlled by PWM comparator. The control signal of phase-shifting PWM is obtained by transforming 80C196KC's output signal through D/A converter.

4. Experimental result

We applied the design on the pilot production of WSE- 300 inverter power supply. The parameters of the main circuit are: the input voltage is alternating current 380V? 0%, rated output current $I_o=300A$, the first inverter frequency $f_1=17kHz$, the second inverter frequency $f_2=5\sim100Hz$, resonant capacity $C_d=25\mu F$, intermediate transformer Tr1's transformation ratio $N_p:N_s=30:5$. Figure 4a shows the first inverter circuit's experimental waveforms: the driver voltage $ugVT1\sim ugVT4$ of switch transistors VT1~VT4 and the inverter output voltage $uo1$. The dead time between the leading leg and lagging leg is adjustable. It is about 5 μs , which ensures that bridge arms are in the working condition of ZVS or ZCS, and one inversion is fulfilled. Figure 4 shows the second inverter circuit's experimental waveforms: the driver voltage $ugVI1$, $ugVI2$ of switch transistors VI1, VI2 and the inverter output voltage $uo2$. The second inverter control system can work stably. Therefore, the variable polarity power supply based on microcontroller functions well and stably, attains the standards and requirements of the pilot production. Figure 5 shows the time dependence of the discharge (electrode) impedance calculated from the voltage and current waveforms.

Figure 6 shows the dependences of the average velocity of the streamer heads on the time after the pulsed voltage application for all discharge conditions. The average velocity of the streamer heads is given by the following equation:

$$V_{\text{streamer}} = \frac{L}{t_{\text{delay}}} \quad (1)$$

where L and t_{delay} are the distance between the surface of the inner electrode and the tip of streamer head and the delay time after the pulsed voltage application, respectively. It is observed from Figure 3 that the velocity of the streamer heads increased with increasing time for all discharge conditions.

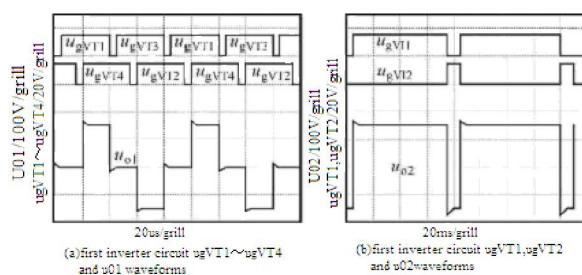


Figure 4. Primary and secondary experimental output waveforms

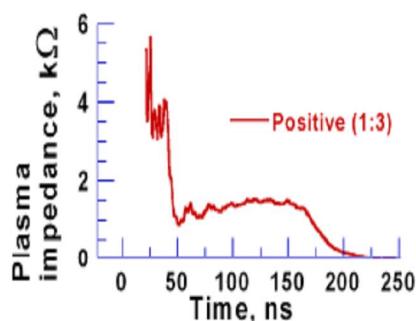


Figure 5. Time dependence of discharge impedance

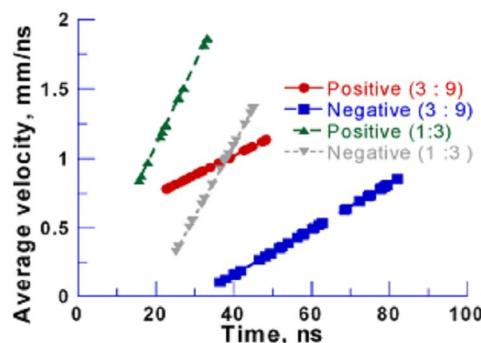


Figure 6. Time dependences of average velocities for all discharge conditions.

5. Conclusion

In the design of the variable polarity power supply, phase-shifting zero voltage and zero current full-bridge inverter circuit can apply soft switch technique to make the first inverter circuit stable. Microcontroller 80C196KC control system can fulfill various kinds of protection and enhance the system's control performance. The current waveform collaboration between variable polarity and low frequency modulation can improve welding arc's stability and weld seam performance. The power circuit applied in this paper can also be designed as a double power supply circuit which supports direct or alternating current square wave power supply.

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