The Design of Inverter Circuit of Pulse Laser Power Supply

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Abstract

This article designed the pulsation laser power supply-the design of inverter circuit. Single-phase bridge type inversion circuit as an example of a detailed description of the basic principles of inverter circuits, in-depth analysis of the circuit and the whole inverter half-bridge circuits operating principles, and basic composition and character. Produced a type of half-bridge inversion circuit: the voltage circuit , it rely on the pulsation laser power supply-the design of inverter circuit.

Keywords

Converter; IGBT; Laser; Series resonance.

1. Introduction

This paper is mainly used IGBT as the switching device to design series resonant inverter circuit and full-bridge series resonant inverter circuit ,and it's storage capacitor capacity can reach to 25000μF, the charging voltage is 0- 700V, the stability of adjustable voltage is ±0.8%, the ripple is less than ±1V.

2. The basic working principle of the inverter circuit

In this paper, we proposed single-phase bridge inverter circuit as an example to explain the inverter circuit works. The circuit structure shown in Figure 1.

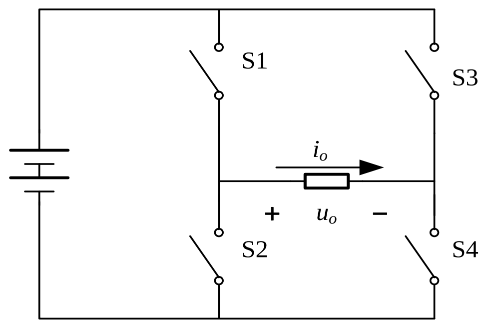

Figure 1 Single-phase bridge inverter circuit diagram

S1-S4 are four arms of the bridge circuit, They consist of electronic devices and auxiliary circuits. When the switch S1 S4 connected, S2 S3 disconnected, load voltage u_0 is in a positive level, otherwise, When the switch S1, S4 broken, S2, S3 linked, load voltage is negative. The waveform shown in Figure 2.

So, the DC has been changed into AC, change the switching frequency through two sets of switches , you can change the output frequency of alternating current. This is the basic principle of the inverter circuit. When the burden is resistance, The waveform shape of the load current is as same as the voltage, phase is also in this case.

When the burden is inductance, the phase of i_0 is later than u_0, Both the shape of the waveform is different , the wave shown in figure 2 is the inductive case. Suppose S1, S2 conducted before t_1, u_0 and i_0 are both positive. At time t_1, we cut off S1,S4, Connected S2, S3 at the same time, then u_0 immediately becomes the negative polarity. However, since the load inductance, the current polarity cannot be changed immediately while maintaining the original direction. Then the load current flows from the negative electrode, through S2, the load and S3 back into the lower pole. Stored energy in load inductance feedback to the DC power supply. The load current decreases, and gradually increase until zero at the time t_2. The case S2 S3 disconnected, S1 S4 connected is similar to previous result. The analysis above is built on ideal switch, the actual operation of the circuit may be complicated.

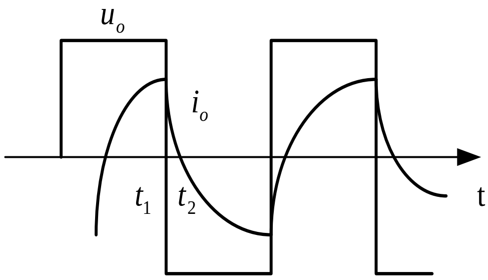

Figure 2 Inverter circuit waveform

3. Design of the inverter circuit

We describes the design of inverter circuit in these programs.

(1) SCR series connection half-bridge inverter circuit

We choose fast SCR as the power switching devices in this circuit. Maximum inverter frequency can reach up to 20KHz. Figure 3 for the main circuit topology, belonging to the half-bridge series connection resonant inverter SCR structure.

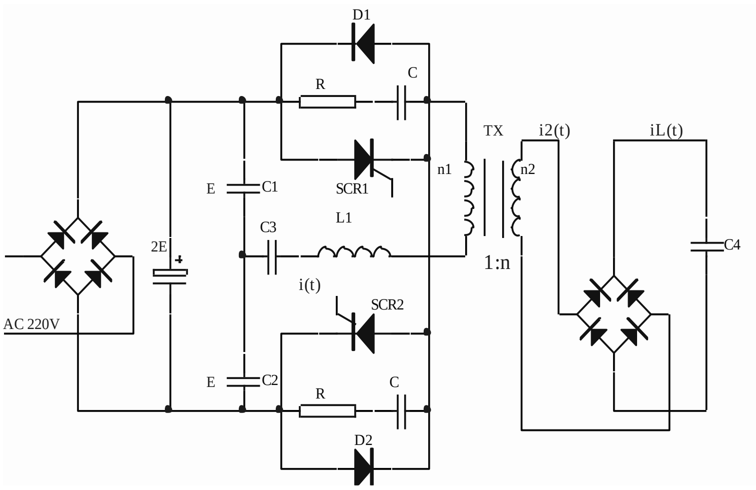

Figure 3 SCR series connection resonant half-bridge inverter charging circuit

Where 2E is the supply voltage, $C_1 = C_2$, when the circuit is static(SCR_1 and SCR_2 are cut-off) the power supply is divided into two equal parts E, each thyristor anti-parallel a high-speed diode d1, d2 making freewheeling effect, in addition, RC snubber circuit paralleled with the thyristor is used to limit the rate of voltage rise thyristor element. L_1 is a loop resonant inductor, restricting the flow through the thyristor current rise rate as the same time, resonant capacitor C_3 in series with a high-frequency transformer, after the full-bridge rectifier, Transformer secondary output charge the energy storage capacitor C_4.Note that $C_1, C_2 >> C_3$, $C_4 >> C_3$.

(2) VMOS full-bridge resonant inverter charging circuit.

SCR resonant inverter charging circuit has been more widely used, but it also has a lot of deficiencies. Due to the working mechanism of the device, the frequency of SCR can not be made very high, Working frequency of this inverter circuit is generally hard to reach 20KHz. This makes charging speed, charging accuracy is greatly limited, so that the transformer is also relatively bulky. When the operating frequency is lower into the audio range, the user will hear the annoying whistling. In addition, SCR conduction required gate trigger signal voltage amplitude is low, and some just 1.5V to satisfy the conduction conditions, Causing the gate jamming ability, easy to make false triggering SCR conduction cause inverter failure.

Compared with SCR, VMOS can achieve self-turn-off, high frequency, strong anti-jamming ability, easy to drive. Because of its control circuit is simple, easy to design, its reliability has been further improved, it is now widely used in small and medium power devices. Specific circuit topology shown in Figure 4, it belongs to the full-bridge series resonant inverter VMOS structure. The current waveform during work shown in figure 4.

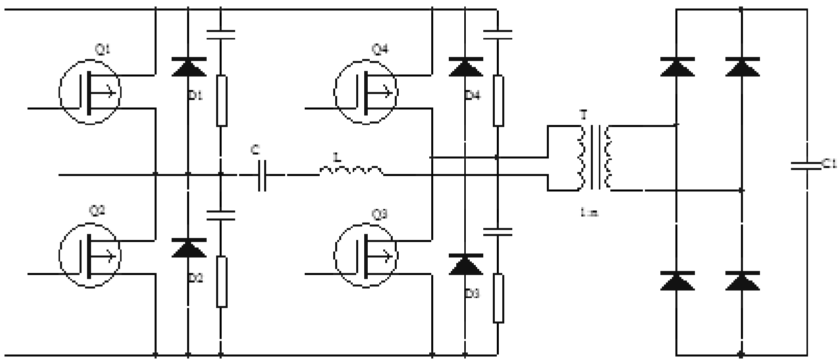

Figure4 VMOS series resonant full bridge inverter circuit

Circuit 220V rectifier filter is applied directly to the bridge on the bridge, Q1 ~ Q4 using high-power VMOS tube, D1 ~ D4 as internal parasitic reverse freewheeling diode, each tube connected RC snubber network. in the middle of L and C ,do current sampling coil, used for inverter over-current protection.

(3) IGBT series resonant half-bridge inverter circuit

Taking into account the advantages of IGBT VMOS and GTR, with high input impedance, the control circuit is simple, fast switching speed, good thermal stability. To improve the reliability of power supply, in order to reduce the volume and weight of the power supply, IGBT inverter has a strong competitive edge, especially IGBT series resonant inverter technology developed very rapidly.

As shown in Figure series resonant half-bridge IGBT inverter specific circuit structure 5.

Where in the rectified voltage is 220V AC 2 E, $C_1 = C_2$, when the circuit is static (ie IGBT1 and IGBT2 are closing) D_1, D_2 which the power is divided into two equal portions E, each on each IGBT a high-speed anti-parallel diode, from the freewheeling role, in addition, in parallel with the IGBT RC snubber circuit is used to limit the rate of voltage rise of the switching element. L_1 is a circuit resonant inductance inductance, while limiting the flow through the thyristor current rise rate, the resonant capacitor C_3 and high-frequency transformer T_1 series with primary transformer secondary output after the full-bridge rectifier to charge the energy storage capacitor C_4. Among them $C_1, C_2 >> C_3 ; C_4 >> C_3$.

4. Inverter control circuit design

It is necessary to control the signal power to coordinate the work of the various parts for the normal operation of the laser power supply,and these signals are generated by the control circuit.

(1) The internal structure and working principle of EXB841

EXB841's internal structure diagram and its wiring diagram shown in Figure 6 can be seen that EXB841 consists of amplifying section, overcurrent protection section and 5V reference voltage parts.

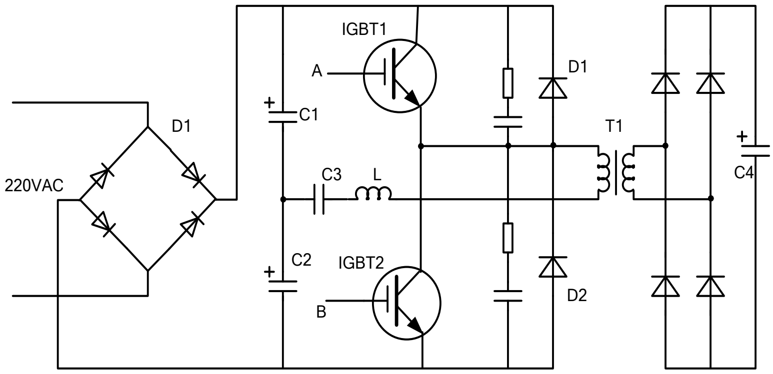

Figure 5 IGBT half-bridge series resonant charging circuit

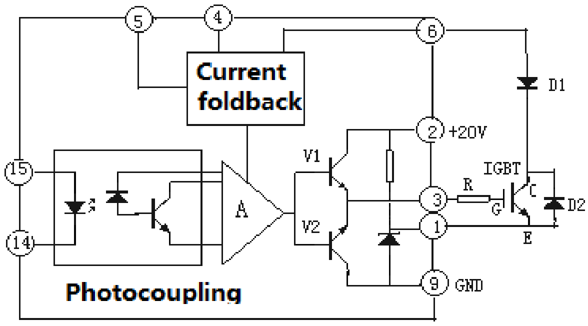

Figure 6 EXB841 internal block diagram and wiring diagram

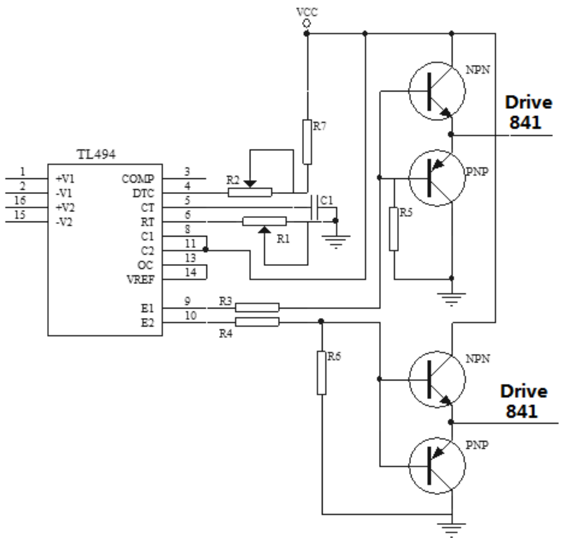

Figure 7 Generation circuit consists of two pulse signals constituted TL494

Its working principle is that in the normal opening process, when the control circuit EXB841 inputs pins 14 and 15 have 10mA of current flows optocoupler conduction, Part A amplified output 20V, push-pull circuit is turned on,and EXB841 provide a current IGBT by gate resistance R so that rapid conduction.In the normal shutdown process, the control circuit so that the output pins 14 and 15 EXB841 no current flows through the optocoupler nowhere, an enlarged portion of the output low, V2 conduction, EXB841 pin 3 potential drop rapidly to 0V (relative to pin 1 EXB841 low 5V), it is applied to the gate voltage of the IGBT -5V, it will give reliable IGBT turn-off.When detecting an overcurrent or short circuit, IGBT withstand large current exit saturation, VCE rise a lot, the diode D1 off, EXB841 6 feet vacant, so that the potential of 3 feet EXB841 gradually decline, slowly turn off IGBT, until the control signal to the optical coupler EXB841 off, the output signal amplification part a is 0V, thereby completely turned off, fully turned on, IGBT gate bias 0V suffered from slow turn-off to a rapid decline -5V, IGBT completely off. After EXB841 fully restored to normal state, normal drive.

(2) The design uses a driving circuit that TL494 component signal generating circuitand IGBT dedicated driver chip EXB841 constituted.TL494 pulse width modulation control integrated chip generates two adjustable phase difference of 180 °for the adjustable frequency width of the pulse signal. Concrete realization of the circuit as shown in Figure 7.

5. Conclusions

Papers have been more in-depth study of the half-bridge, full-bridge series resonant inverter circuit, designed IGBT half-bridge series resonant inverter circuit as a high-power pulsed laser power inverter circuit, through experimental and theoretical proof compliant. And TL494 dual pulse signal generated can not be directly driven IGBT, by EXB841 to control switching devices, generating the trigger signal inverter circuit as a control circuit, but also safe and reliable. But there are still unresolved problems in practice. In the mid-charging current waveform best, and at the end of the charging current of the significant current state occurs intermittently. This is a result of the frequency change in the charging process, but in theory needs further study, including research on in-depth research and output power IGBT transient protection is greater than 10KW power circuit.

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