Research and design of gasoline generator inverter

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ABSTRACT: The paper introduces the design of gasoline generator inverter. First of all, I made a simple introduction to the gasoline generator, and a detailed description of the inverter circuit respectively. Then the hardware and software design process of the system are described in detail. In the process of hardware design, I designed the whole circuit and each module, and made a printed circuit board. During the software design process, MFC (Microsoft Foundation Classes) is used to design an monitoring software of inverter. The software communicates with the main chip through a serial port to obtain and display the status of the inverter and set the parameters of the inverter. Finally, the test of the whole system is completed. The design has the advantages of good output waveform, comprehensive protection measures, low power consumption and low cost.

1. Introduction

Human beings have entered the era of industrial economy and are entering the period of rapid development of high-tech industries. With the rapid development of China's economy, the demand for industrial and agricultural electricity has increased sharply. As a mobile power supply and standby power supply, the market demand of gasoline generator is also increasing. The latest development trend of gasoline generator is the combination of gasoline generator and power electronic converter, that is, the original voltage output by the generator is processed by power electronic converter and then output to the load. When the load and input voltage fluctuate, the voltage processed by the power electronic converter can be adjusted in time to keep the output voltage unchanged. At the same time, the power electronic converter generally has a protection circuit, which can block the output under the conditions of overcurrent, overvoltage and undervoltage to avoid damaging the load. The voltage of the power electronic converter is sinusoidal wave with little distortion, which can adapt to all kinds of loads, especially some loads which have strict requirements on the power supply parameters.

Technology of Inverter is an important part of power electronics technology. Inverter is a kind of power conversion device which adopts switching mode, It converts DC into AC. When the AC side is connected to the power grid, It's called active inverter. When the AC side is connected to the load directly, It's called passive inverter. Without explanation, Inverter circuit generally refers to passive inverter. Gasoline generators generally provide power to the user's load directly. Therefore, the gasoline generator inverter is a passive inverter circuit.
Take single-phase bridge inverter circuit as an example to illustrate the basic working principle of inverter circuit

Figure 1 shows the basic structure of a typical single-phase bridge inverter circuit. S1~S4 are the four arms of bridge circuit, which is composed of power electronic devices and auxiliary circuits. When S1, S4, closed, S2, S3 disconnected at this time, the load voltage \(u_o\) is positive\(^{[1]}\). When S1, S4, disconnected, S2, S3 closed at this time, \(u_o\) is negative. Therefore, the alternating conduction of the four switching tubes changes DC into AC. Frequency of output AC could be changed by adjusting the switching frequency of two sets of switches. This is the most basic working principle of inverter circuit\(^{[2]}\).

3. Determination of the general design scheme of inverter

3.1. Choice of inverter circuit

The topological structure of inverter has many kinds: select the full bridge inverter circuit. In the inverter, the control method is the core technology. This design adopts the control circuit with EG8010 as the main control chip. I chose IR2110 driver produced by IR Company in the United States to choose other circuits. Besides inverter circuit, drive circuit and control circuit, there are also power circuit and display circuit in the hardware circuit\(^{[2-4]}\). The display circuit can be integrated into the control circuit. The design of the drive circuit selected IR2110, the power circuit is very simple only need one drive power supply and one logic power supply. Power circuit I use the three-terminal voltage regulator integrated circuit LM7805 to convert the 12V power supply to 5V, so only one 12V power supply is needed to power the system. The composition of inverter system is shown in Figure 2.
3.2. Design of hardware circuit

After the DC bus voltage is introduced, a large capacitance filter is first used to eliminate the voltage pulsation on the DC side, and then added to the bridge inverter circuit composed of MOSFET. This DC high voltage is inverted by the inverter circuit into the high-frequency pulse wave that the pulse width changes according to the sine wave rule. Then the high frequency harmonic is filtered out by the output filter, and the sine wave is provided to the load. The SPWM pulse wave is generated by the main control circuit and the width of the pulse wave is changed according to the output feedback voltage and current, so as to ensure the stability of the output voltage. The main switching power element is n-type MOSFET produced by Toshiba company in Japan. The drain-source voltage is 500V, the on-off resistance is only 0.35 ohms, the continuous drain current is 15A, and the pulse current is 60A. Because of the body diode in MOSFET, four continuation diodes can be omitted. To ensure reliable shut-off of the MOSFET, a resistance of 10 kw is connected between the gate and source of each MOSFET. The high speed switch 1N4148 is designed to provide the MOSFET with a fast discharge path of capacitance voltage between gate sources at the moment of turn-off. VBF is the voltage feedback signal, IFB is the current feedback signal, a 0.1ohm sampling resistance is connected between the source pole of the two lower bridge arms and the ground, magnetic ring inductance and CBB capacitance are used to filter the SPWM waveform. IR2110 drive circuit is shown in Figure 3.
3.3. Design of software
The hardware circuit USES EG8010 chip, which has serial communication function. Using this function, I designed an inverter monitoring software based on MFC with Microsoft Visual Studio 2010. The software can display the output voltage, output current and output frequency of real-time monitoring through the graphical interface, and can also set the working mode, output voltage and output frequency of the inverter. The inverter monitoring software is connected to the inverter control chip through serial port communication. After the inverter monitoring software is started, set the serial port number and open the serial port, click some Settings or monitoring buttons on the interface of the software, then the corresponding message response function can be triggered and different instructions can be executed. To automatically monitor the operation of the inverter parameter, for example, click the "read automatically parameters" button, the software will start a timer, every one second software will send inverter, 0x4100 software read into 4 bytes after the return value, will be shown in four bytes of data of voltage, current, temperature and frequency data through a graphical interface display.

3.4. System debugging
(1) Hardware circuit test of inverter
After the inverter PCB is made, the power circuit is welded. After passing the test, other module circuits are welded one by one. After each module circuit is debugged and passed, the overall circuit is tested.

During the test, to ensure personal safety, only DC stabilized voltage power supply was used for simulation. Assuming sinusoidal alternating current with an average value of 11V, a maximum value of 15.5V, and a peaking value of 31.1V, then the DC bus voltage to the inverter cannot be less than 15.5V. During the test, the DC bus voltage to the inverter is 17.5V to 30V[5]. The load in the test was a 100 ohm slide-line rheostat. The parameter design method of LC filter is based on the important technical analysis of inverter. The basic parameters that need to be known before design include: effective value of rated output voltage U0, output frequency F0, switching frequency FS, minimum inductive power factor cos, load rated power P, variation range of amplitude of filter input PWM amplitude E_min ~ E_max. The parameters of L and C are determined based on four design indexes:

The output voltage harmonic content index is determined by the user's requirements for the single harmonic content of the output voltage;

The fundamental wave voltage gain index of the filter makes the inverter voltage in the case of the lowest input voltage, the heaviest load, inductive load and the lowest power factor, the output voltage
can still reach the rated value, without over-modulation;

The filter's no-load input fundamental wave current index, so that the no-load loss will not be too large;

Adaptability index. On the premise of meeting the first three basic indexes, the inverter has the best adaptability to nonlinear loads. The specific improvement needs to be realized for specific applications. This circuit is only an analog demonstration circuit, so there is no further design of LC filter. It can be calculated from the test results that the output voltage is also biased. As the EG8010 chip uses unipolar modulation mode, the voltage feedback processing of the EG8010 chip is to measure the output AC voltage of the inverter through pin (13)VFB, measure the peak voltage of the feedback and internal reference sine wave peak voltage 3V for error calculation, and adjust the output voltage value accordingly.

Software debugging

During software debugging, only the monitoring software is used to communicate with other serial ports of the computer, check whether the format of each instruction is correct, and then connect with the main control chip of the inverter through the serial port line. After the system is powered on, according to the following instructions operation monitoring software: check the computer's device manager - port (COM and LPT), according to the serial port hardware select the correct COM port; Select the correct baud rate according to the communication baud rate of hardware; Press the "Open Serial Port" button to open the serial port, and press the same button again to close the serial port; Three radio buttons can choose whether to send in hexadecimal, whether to display in hexadecimal and whether to automatically clear; Press the "Clear received Data" button to clear the received data; Press the "Send" button to send the data of the edit box above the button; When the serial communication is normal, press the "get Running status" button to display the working status of the inverter at the pressed time in the four combo boxes on the left of the software. A serial port communication normal "read automatically parameters" button, the software read every 1 seconds inverter parameters, in 4, according to the chart and tips below have been monitoring time, press the "stop automatically read" button, you can stop automatically read, read operation parameters, if received 10 consecutive 0x00, software will pop-up prompts and alarm sound; Press the "set working mode" or "set output voltage" or "set output frequency" button, the sending would be prompted words on the edit box, according to the prompt for the correct data, press the "Ok" button to send the command to chip, press the "Again" button will just send the command Again, when after confirm the order has been successfully received at the receiving zone can stop sending; The number of bytes received and sent by the serial port is displayed in the top right two edit boxes; 11. Press the "exit" button to exit the software(6).

After the test, the equipment runs well, and the functions of the inverter monitoring software can be basically realized

4. The development prospect of gasoline generator inverter

With the development of technology, the requirement of gasoline generator inverter is getting higher and higher, which is mainly concentrated in the following aspects.

4.1. High frequency

By increasing the switching frequency of the power supply, the volume and weight of the power supply can be reduced, and the audio noise of transformer and inductor can be eliminated, and the dynamic response of output voltage can be improved.

4.2. Miniaturization

There are two ways to miniaturize the gasoline generator inverter:

1) to increase the switching frequency and miniaturize the filter;

2) Adopt the new PWM control mode, optimize the frequency spectrum of PWM wave output by the inverter bridge, and miniaturize the filter.
4.3. Digitization
Gasoline generator inverter digitization is not simple to point to in the application of the digital device in the system, such as MCU and FPGA, it refers to the control of the whole system of digital devices are used to calculate capacity and discrete control method to finish, with the development of hardware technology, the processor computing speed enhancement, necessarily promote inverter to digital direction.

5. Conclusion
The design is a simple gasoline generator inverter using special SPWM chip, low cost, small size, powerful function. In this system, the output voltage is basically unchanged when the DC bus voltage changes in a wide range, and there is no obvious change in the output voltage when the load changes. The output frequency is very stable, and the frequency response is very fast when the frequency is adjusted. This system also has the functions of overvoltage, undervoltage, overcurrent and overheat protection. In case of these faults, the output SPWM signal can be blocked out in time, and the flashing LED warning can remind the user of the faults. The system also designed a computer monitoring software, using RS232 serial communication can remotely read the working status of the inverter and set the output parameters of the inverter. Due to its low cost, small size and powerful function, the system can be used in gasoline power generation system or other equipment using inverter (such as uninterrupted power supply), which has a very wide application prospect.

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