Design of Overheating Protection Circuit in Power Integrated Circuit

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Abstract: Because the power dissipation of power integrated circuits is relatively large and the calorific value is also large, the overheat protection circuit is very important for power integrated circuits. The development of power electronic technology is closely related to the development of power electronic devices. The appearance of new devices will promote the development of new devices. When the chip has an overcurrent condition, the temperature of the chip will rise rapidly, thus causing the chip to fail due to overcurrent. Overheat protection circuits in integrated circuits generally use the temperature characteristics of diodes and triodes as sensors. When the chip temperature exceeds the allowable value, the protection circuit will automatically cut off the power path, until the temperature drops to the safe working area, the circuit can start to work again. Power integrated circuit is different from general chips in that it not only integrates low-voltage digital or analog circuits, but also integrates high-voltage power output circuits in the same chip. How to transform the temperature signal into the voltage signal is the key to design the overheat protection circuit.

1. Introduction

The development direction of modern power electronics technology is from traditional power electronics, which mainly deals with problems with low frequency technology. Change to the direction of modern power electronics, which focuses on high-frequency technology to deal with problems. The development of power electronic technology is closely related to the development of power electronic devices. The appearance of new devices will promote the development of new devices and open up new application fields [1]. In a power integrated circuit, the temperature of the chip is relatively high because the power dissipated by the circuit is relatively large. In order to make the chip work under some abnormal conditions without damage, overheat protection circuit must be set. In power integrated circuits, large driving capability is very important [2]. Excessive load or short circuit will cause permanent damage to the chip. Power integrated circuit is a chip with certain load capacity and higher voltage input and output, which is mainly used in electrical lighting equipment [3]. When the chip temperature exceeds the allowable value, the protection circuit will automatically cut off the power path until the temperature drops to a safe working area before the circuit can start working again. When the chip temperature exceeds the allowable value, the protection circuit will automatically cut off the power path until the temperature drops to a safe working area before the circuit can restart its operation [4]. In order to protect the chip from damage in this case, it is often necessary to integrate the overcurrent protection circuit and the overheat protection circuit inside the chip.

The development of power electronic devices has gone through several stages such as uncontrolled and semi-controlled devices, current fully controlled devices, voltage fully controlled devices and power integrated circuits. The power integrated circuit is different from the general chip in that not only low voltage digital or analog circuits but also high voltage power output circuits are integrated in the same chip [5]. How to convert temperature signal into voltage signal is the key to designing overheat protection circuit. Since the frequency converter will be used to drive loads that are very sensitive to specific harmonics, the output waveform and control methods have been studied. In the case of high-voltage power supply and the limited withstand voltage of power devices, the method of series connection of power devices can be used to solve [6]. According to the needs of industrial processes, power supplies usually need to be transformed into a variety of

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waveforms and power levels, and the needs in various fields are very different. Through the study of the relationship between the power supply current and the junction temperature in the case of overcurrent, it is found that when the chip has an overcurrent condition, the chip temperature will rise rapidly, resulting in chip failure due to overcurrent [7]. Every improvement and innovation in power electronics and power transmission technology can be immediately applied in practical industrial and civil applications. It plays an extremely important role in transforming traditional industries, developing high-tech and efficient use of energy. Due to the large power dissipation and high heat generation of power integrated circuits, overheating protection circuits are very important for power integrated circuits.

2. Method for Isolate Power Integrate Circuit

When the devices are used in series, static and dynamic voltage sharing problems exist because the dynamic resistance and polar capacitance of each device are different. For the design of analog control circuit, its reliability and practicability should be considered comprehensively. The power integrated circuit integrates the power semiconductor device and the driving circuit into one chip, i.e. the control part, the power part and the protection circuit with more functions are all combined into one device [8]. With power electronic devices as the core, different circuit structures and control modes are adopted to control and change the form of electric energy, which is the converter circuit. For the input signal, the transmission distance should be reduced as much as possible in the process of processing, so that it is not affected by external interference. Therefore, the thyristor of the inverter can realize natural commutation, and the capacity of the filter is basically equivalent to that of the inverter. In step wave modulation, the device is switched on and off at the fundamental frequency, with low loss and high efficiency [9]. As many components are integrated into the same chip, discrete components are no longer needed after the power integrated circuit is used, so that the reliability of the system is guaranteed, the stability is greatly improved, and the power consumption, volume, weight and cost of the system are reduced. Controllable reactive and active power flow, thus can be used for high voltage direct current transmission and variable frequency speed regulation. Different main circuit topologies are adopted, and the types and quantities of power devices used are different. As well as the use of transformers, filters, etc., will affect the efficiency of the system.

The voltage level and the number of units connected in series determine the output voltage of the medium voltage inverter, and the current rating of the units determines the output current of the inverter. Proper increase of stator voltage can enhance the load carrying capacity. As the frequency increases and the voltage remains constant, the air gap magnetic flux is bound to weaken, resulting in a decrease in torque. Frequency conversion speed regulation and stray loss, which are often neglected in classical vector control but have important influence on control performance, also change with slip frequency. Fig. 1 is the flow chart of the control system fault diagnosis algorithm.

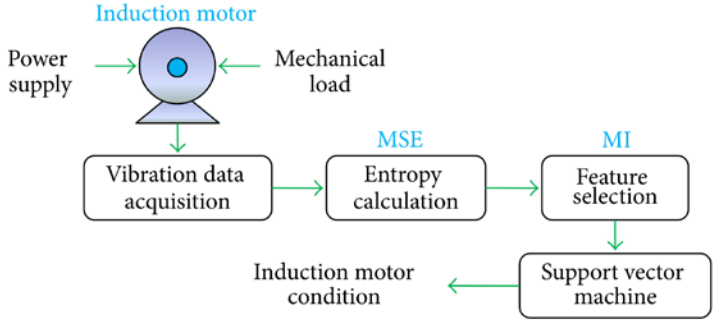

Fig.1 Control System Fault Diagnosis Algorithm Flow

As home appliances and office automation, DC power is the most used, so it is necessary to convert AC power to DC power. Power integrated devices and corresponding drive circuits are combined to achieve changes in electrical energy. They can transform high voltages and large

currents to the required voltage and current values. The requirement for the drive circuit is that it must be able to provide a sufficiently high voltage to the gate of the power device. Because the traditional device is not connected in series to achieve high voltage output, the entire power unit is connected in series. Therefore, there is no voltage equalization problem caused by the series connection of the devices. A large number of switch state combinations are redundant and can be used for voltage balance control. The main function of the control circuit in power electronics is to provide gate drive signals for the semiconductor power devices in the converter topology, to realize the input and load on and off, so as to obtain the required energy control and form conversion [10]. For the output calculation module of the current regulator and speed regulator of the system, each redundant computing unit can adopt different algorithms, and make the various algorithms as different as possible. In semiconductor integrated circuits, because doped silicon can conduct electricity, effective isolation methods must be used to avoid the formation of electrical paths between components. The output loop current signal can also be decomposed into a fundamental wave containing only a sine wave and other harmonics, and the higher harmonic current directly interferes with the load.

3. The Relationship between Thermal Resistance and Current

For the same output voltage, it can be obtained by combining different switch states. The optional switch state combination provides reliability and flexibility for voltage balance of flying capacitor. According to the given speed and feedback, the controller uses the corresponding control algorithm to control the turn off time sequence of the power devices in the inverter. The power electronic control mode is generally classified according to the relationship between the switch signal and the control signal of the device. According to the relationship between switching signal and control signal of semiconductor power device, power electronic control mode can be divided into phase control mode, frequency control mode and chopping control mode. Considering that the volt ampere characteristic of diode is sensitive to temperature, we can use diode as sensor. The interface function of intelligent power integrated circuit is realized by logic circuit. The chip can not only respond to the signals from the microprocessor, but also send out information about its working state, such as the information about overheat shutdown, no-load or short-circuit, and other information related to load monitoring.

The transient thermal resistance Z (t) is defined as: at the end of a certain time interval, the change of the difference between junction temperature T_j and reference point temperature T_r is the ratio of the step change dissipation power P at the initial time interval of the same time interval that causes the change of the temperature difference

$$T_j(t) = Z(t)P_d(t) + T_a(1) \quad (1)$$

Where $T_j(t)$ is junction temperature, $Z(t)$ is transient thermal impedance, $P_d(t)$ is power dissipation, T_a is ambient temperature. Because Z (t) increases with time, the high current at the charging time will not cause the junction temperature to be too high. The following is a practical calculation to show that the junction temperature at room temperature and short circuit can be calculated by providing thermal parameters. In steady state, $Z(t)_{\max} = 150℃/W$, $i_{sc} = 0.3A$, $u_{in} = 3V$, $T_j(t)$ = - 40 ~ 150 ℃, $P_d(t) = i_{sc}u_{in} = 0.3 \times 3 = 0.9W$, then:

$$T_j(t) = 150 \times 0.9 + 25 = 160℃ \quad (2)$$

When thermal resistance is given as an index, its dissipated power is the average power of DC power or sinusoidal half-wave current in one period. This definition is obtained under the condition of steady state heat balance. Another key of overheat protection circuit is that the circuit is only affected by temperature change and not by voltage change. The development of intelligent power integration technology is not only the need of economic development, but also becomes one of the important means of energy saving and emission reduction because the integration of information

processing and power processing improves the reliability of power integrated circuits, reduces the weight and volume of the whole machine and reduces the power consumption. The ideal situation that is completely unaffected by voltage changes is impossible, so we must find ways to make the circuit less affected by voltage changes. Although the inverter has an additional intermediate DC link, the frequency of the output AC power can be higher than that of the power grid. When necessary, the route from the source node to the destination node is found by using the known route to the destination node or by re-initiating the route discovery process.

4. Conclusion

The overheat protection circuit can better inhibit the overheat protection threshold drift caused by the power supply voltage, and its thermal hysteresis function can prevent the generation of thermal oscillation. For the design of analog control circuit, its reliability and practicability should be considered comprehensively. The rationality of the design is proved by the actual test of the data of the designed chip. According to the relation between switching signal and control signal of semiconductor power device, power electronic control mode can be divided into phase control mode, frequency control mode and chop control mode. As many components are integrated into the same chip, discrete components are no longer needed after power integrated circuits are used, thus the reliability of the system is guaranteed and the stability is greatly improved. Power integrated devices and corresponding driving circuits are combined to realize the change of electric energy. They can transform high voltage and large current to the required voltage and current value. The output circuit current signal can be decomposed into fundamental and other harmonics with only sine wave, while the higher harmonic current directly interferes with the load. The development of intelligent power integration technology is not only the need of economic development, but also the reliability of power integrated circuit is improved by integrating information processing and power processing.

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