Selection of Radiators in Power Electronics and Analysis of Heat Dissipation

Liuning Zhu and Chuanwu Liu*
Maanshan Technical College, Maanshan 243000, Anhui China

*Corresponding author e-mail: liu2364287@sina.com

Abstract. People have attached increasing importance to the heat generated by power in power electronics during the production process in the field of industrial production at home as China's science and technology rapidly makes progress in recent years. The operation of power electronic devices, due to the effects of resistance and voltage in the circuit, generates a certain amount of heat that will have a certain impact on the operation process of the entire power system. This essay, first and foremost, analyzes the heat circuit and heat group that cause power electronic devices to generate heat, and then the heat dissipation design of power electronic devices. Finally, detailed analysis on the current cooling methods and cooling effects commonly used in power electronic devices are made in accordance with the real conditions.

Keywords: Power Electronic Devices, Radiator, Radiating Effect, Radiating Analysis

Introduction
Under the condition of the power electronic device being powered on, the internal circuit of the device will consume considerable power in the course of the power conversion which will be transferred into a certain amount of heat and lead to the power electronic device to generate heat. It will drive the partial temperature of devices to rise quickly if with excessively heating devices, disturbing the normal operation. Therefore, in the middle of the operation, it is necessary to radiate the power electronic devices through the external environment and auxiliary facilities. This is how we can guarantee the devices free of excessive losses caused by high temperatures and avoid the functional failure.

1. The Major Causes of Power Electronic Devices Radiating In the Operation
The heat generation is mainly brought by heat circuit and thermal resistance of power electronic devices. Specifically, power electronic devices at both ends of the circuit produce a certain temperature difference and the heat generated by the circuit will flow from high temperature to low temperature. Typically, the heating parts inside the power electronic device are hided inside the semiconductor chip that will transfers the heat from shell to the chip's external environment[1]. On condition of device operation, the heat generated by the power consumed by the chip equate to the heat transmitted by itself. If the chip temperature arrives to stability, it will not rise again. Consequently, there concludes a correspondent schematic diagram according to the heat transfer power electronic devices. Quite similar to our common circuit diagrams, the heat circuit diagram during the
power electronic devices radiation can be considered: taking the temperature difference as the voltage in the circuit diagram and the power consumed by the devices in a unit time as the current in the circuit diagram [2]. The thermal resistance in the devices resembles to the resistance in the circuit diagram this is why we can calculate the device power through dividing the temperature difference by the thermal resistance. The thermal difference in power electronic devices mainly comes from the D-value between the junction temperature and the ambient temperature. At the same time, the radiation of power electronic devices flows from the high temperature area to the low temperature area and the general trend of temperature is junction temperature > shell temperature > radiator temperature > ambient temperature.

![Diagram of heat dissipation process of power electronic devices](image.png)

**Figure 1** Schematic diagram of heat dissipation process of power electronic devices

2. The Transient Heat Circuit and Transient Thermal Resistance of Power Electronic Device Circuit

The operation of a power electronic device, a steady-state circuit at a constant average power secure the device to generate a steady-state thermal effect under a constant average power. However, if the power electronic device operates under a switching mode, it will generate a transient heat circuit and a transient thermal resistance, mainly attributed to the short duration of the current pulse and the small capability. As a result, the peak junction temperature of power electronic devices stays much higher than the average junction temperature of the device under normal power. The transient thermal resistance of power electronic device reflects the thermal inertia of the heat transfer body in the electronic device [3]. Once the power electronic device has a constant radiation during operation through the circuit with a certain thermal capacity, leading to the increase in the device external temperature and internal temperature. When cutting off the constant radiation, a decrease in the internal and external temperature will take place. The temperature rise and drop, namely a transient process, can be simulated by the DC circuit in the circuit diagram. The change in transient thermal resistance in the operation of power electronic devices owes to the length of energized time. The
transient thermal resistance, also called the thermal impedance curve, is a function pertaining to energized time and the capability of the load power [4].

3. Frequently Used Radiating Methods and Radiation Effect Analysis of Power Electronic Devices

(1) Power Electronic Devices Radiation Through Air Cooling Fans and Its Effects

Air-cooled fins can be used to dissipate heat in the middle of the operation of power electronic devices, mainly composed of a fin radiator and a fan. The former one, directly linking with the heating source that can induce the power electronic device in a timely manner. At the same time, the radiator in the device can also be given a forced convection cooling to reduce the temperature. The air-cooled fins are utilized to cool down can create a high-efficiency working environment for devices. The effect of radiator is mainly closely related to its own structure. At present, during the power electronic devices radiation, research on air-cooled heat sinks stays focused on the structure and materials of the radiation [5]. However, the fans used in air-cooled heat sinks also pose impacts on the radiation effect of power electronic devices. The higher wind speed, coupled with the greater the generated wind power, contributes to a better effect. However, the disadvantage brought by the high fan speed concentrates on the excessively large flow resistance in the power electronic device. Neither can we improve the radiation effect of the air-cooled radiator, nor reduce a large amount of power loss inside the radiator. At present, the cooling method of air-cooled fin radiators used has been widely applied in the radiation of power electronic devices [6]. This radiator technology, relatively mature with a simple structure, performs well in safe and reliable use. However, the shortcoming lies in the air-cooled fin radiator has a general radiation effect during the operation. The temperature in the power electronic device cannot be lowered below room temperature. At the same time, the fan, rotating at high speed, will also generate large noises that disturb people, bringing a extremely limited use in work and daily life [7].

![Figure 2](image)

**Figure 2** Power Electronic Devices through Liquid Cooling Radiation and Its Effects

The radiation of power electronic devices through liquid cooling can better solve the difficulty of high heat flow density. The use of liquid cooling radiators are mainly composed of corresponding
water channel devices through radiators, water pipes and pumps and reasonably arranging these channels inside the power electronic devices. This is will be conducive to allow these channels fully link to the radiator source of the devices; then a large quantity of cold water will be poured through the water inlet. The water flow will take away the heat emitted by the radiator source in a way which can maintain the normal temperature inside the device. Research statistics shows that the forced convective heat transfer coefficient generated by water cooling is more than a hundred times the forced convective heat transfer coefficient of gas, as a result, so the effect of liquid cooling radiation performs better than air-cooled radiators. However, the liquid cooling radiators are usually expensive and costly. At the same time, the radiator spread all over the water channel makes the internal water flow in the water channels always sealed in the operation. Therefore, the phenomenon of deterioration and scaling will occur after a long time, and will inevitably bring an adverse impact on radiation effect of the water-cooled radiator.

(2) Power Electronic Devices Radiation Through Microchannel and Its Effects

The radiation of power electronic devices through microchannel cooling mainly by designing a large number of microchannels on a material featuring high thermal conductivity. The diameter of these microchannels can be specially designed to the micron size, and then the bottom surface is directly linked with the radiation source in the power electronic device, and the heat generated by the radiation source inside conducted by the microchannels wall flow into the channel. At this moment, a forced fluid in the channel can be used to take out the heat. The dense quantity and fully changed the fluid and the radiator is attributed to generally micron-sized diameter of the microchannel, moreover, the fluid in the microchannel will present highly unstable during the flow-in which will greatly enhance the radiation capacity of the microchannel. In line with the research, it concludes that the radiation effect of the microchannel radiation technology depends entirely on the area of the microchannel cross section. If in a too small area, the fluid will rapidly heat up through the channel after the internal wall of the microchannel is heated. Quickly, there will generate corresponding thermal stress which will impose influences on the stability of power electronic devices.

(3) Power Electronic Devices Radiation Through Semiconductor Cooling and Its Effects

Nowadays, the use of semiconductor cooling radiation in power electronic device is a relatively advanced method. In the middle of the intelligent semiconductor radiation, it mainly finished by closed circuits composed of different metal wires. And then these circuits are connected to the power supply so that the heat at the intelligent end can be transferred to the hot end and the opposite side will drop rapidly. This way enables the semiconductor cooling radiation device can absorb heat at one end and release heat at the other end, in order to achieve the effect of radiation for the power electronic devices.

4. Conclusion

Higher and stricter requirements on the radiation equipment and radiation effects will be asked to help power electronic devices safe and sound, as the power electronic devices meet increasingly miniaturized and centralized application in the future at home.

Acknowledgments

This work was financially supported by Support Plan for Outstanding Young Talents in University of Anhui fund. Serial number: gxyq2017245

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