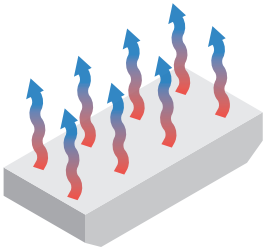
About the problem of choosing a power supply: cooling

Dear Colleagues! We often hear at the conferences and exhibitions some questions about purposiveness of power converters manufactured by KW Systems or a third-patry too. Also from the point of view of a cooling method. For which applications are these or those series of power supplies are optimal, and for which ones may their use can be redundant?

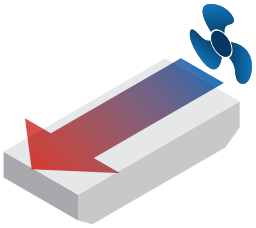
We bring to your attention a small article that can «shed light» on this issue. We hope that after reading of this article you will be able to define which type of power supply cooling will be optimal for your project.

To begin let us share some theory. It is well known that heat can be transferred with several ways: within thermal conduction, convection and heat radiation. Therefore, convection can be natural and forced-air.

Natural convection is a heat transfer between hot surface of solid body (for example power supply) and an ambient fluid (air or coolant) that is forced by natural circulation of hot air caused by different density and temperature.



Forced convection occurs when flow of warm air is formed with additional devices (usually fans).



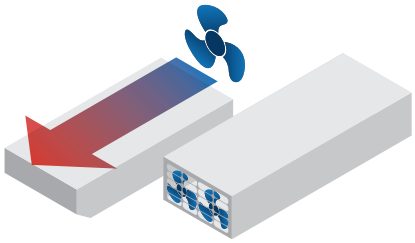
All these types of heat transfer are present at power supplies but usually dominates only one. According to above certain types of cooling are:

Convection cooled power supplies

This type is divided on 2 subcategories:

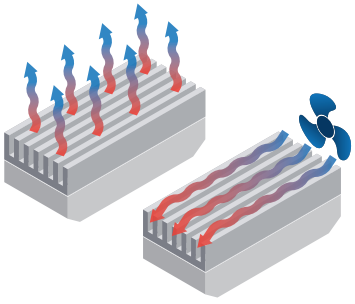
1) Power supply for cooling of which it is necessary of *natural convection* without any additional devices. It have to be pointed here that necessary condition in such cases is availability of enough free space around power supply for efficient mixing of air layers. Without enough free space having dense packaging moreover at enclosed space, air will be heated up till limiting operating temperature that will cause triggering of overheat protection that will shut down power supply. Power supplies with such type of cooling named *convection cooled power supplies*.

2) Power supplies that require direct forced airflow are called *forced-air cooled*. As a rule, such air flow is created using fans – as built-in (*fan cooled*) as external (*forced air cooled*).



Conductive cooled power supplies

At such power supplies heat is transferred to the heatsink (because of thermal conductance). Heatsink further can be cooled with different ways.



Material for the heatsink can be chosen either an ordinary metal (less often ceramic) plate (including the wall of the case or cabinet), and what is meant by the word "radiator" is usually a plate with a ribbed or needle-shaped surface. Its task is to increase the contact area with the cooling agent, which can be both any gas (air, hydrogen, helium) and liquid (water, glycol, oil).

With other words with conductive method of cooling heat is distributed through a "interagent". This type of cooling is known as *baseplate-cooling* (heat removing to a baseplate) or a *conduction cooling*.

And now let's look at the details of different types of cooling, in relation to the power supply and the purpose of the final product.

So, in order:

1. Convection cooling

1.1. Natural convection.

If the project has a lot of relatively free space, there is no need for tightness, but reliability, ease of mounting, service and replacement of the power supply are important, then this type of cooling is your choice!

An indicator of operation temperature range of power supply here is the *ambient temperature*, since the module is cooled by the same environment.

Advantages:

– ease of use – no calculations required, no additional devices needed;

– low cost of implementation – the reasons are similar to the previous point;

– absence of fans gives both improved reliability and decreased noise, that are important for habitable inner space.

Limitations:

– as a rule, the dimensions of convection cooled modules are larger than those of other types of cooling due to the low heat transfer coefficient (~10 W/m/K), which in case of difficult convection can significantly be decreased;

– for high power – high cost of power supplies;

– considering that convection is possible only from the bottom upwards,

the possibilities for the arrangement of modules in space are limited, otherwise their effective operation is impossible;

– modules cannot operate in a rarefied atmosphere and in zero gravity conditions.

Thus, it is optimal to implement convection cooled power supplies there, where reliability and simplicity of implementation are required. Hence main areas of application are:

• Industrial automation, for example DIN rail solutions;

• Security systems – DIN-rail solutions;

BTS – cellular Base Transceiver Stations.

Examples of convection-cooled power supplies produced by KW Systems are all modules of the DIN-rail KAN-D series, as well as KWant20/30, KWant30/75 - SG(SD).

1.2. Forced air cooling.

This type of cooling is most common, using built-in or external fan. It will be correct in case of *low-cost solution* where price is more important than reliability or at *hi-power solutions, wide functionality and a high power density* (but not at the golden age where liquid cooling has long been implemented). An important nuance is the lack of tightness in such power supplies, with rare exceptions.

As for cooling with natural convection an indicator of operation range will be *ambient temperature* range.

Advantages:

– Compact dimensions due to high heat transfer coefficients (~100 W/m/K);

– high reliability of built-in electrolytic capacitors since these capacitors have operation temperature close to an ambient temperature. At modern power supplies electrolytic capacitors often limit reliability of an entire device;

– ready-made solution that require for correct cooling only availability of free space for intake and blow-out of the air;

– in contrast to convection cooling, the possibilities for the location of the power supply in the system are wider;

– low cost of both power supply itself and the work on its mounting/engineering in the product;

– within external fan – opportunity to limit implementation with only one fan for entire device.

Disadvantages are similar to convection cooling, plus:

– relatively low reliability due to implementation of fans – both from the point of view of their design either from the point of view of external subjects entering into power supplies (sand, dust, moisture, insects);

– in case of fan failure – troubles with its replace (in case of built-in fan);

– fan noise;

– high cost and few choices of reliable fans.

Examples of KW System's AC-DCs are KWadr and KWasar series, hi-power systems with forced air cooling where reliable fans are implemented coupled with smart fan speed control.

2. Conductive cooling

And our article ends with a description of a power supply with a conductive type of cooling. Experience shows that not all developers often know it, and even then superficially. Meanwhile, such converters often allow to solve problems that are beyond the power supplies with other types of cooling. When either product tightness or peak energy density is required, and in both cases with maximum reliability and/or with rare service - in this case power supply with conductive type of cooling remain the only choice.

Parameter of the operating temperature range of such power supply is the maximum case temperature. As a result, an additional task appears at the developer, when designing his product – to use such a combination of power supply + radiator + coolant + load, where the temperature of the power supply case does not have to exceed the specified value.

Advantages:

– high flexibility of solution – depending on the task it is possible to make cooling of power supply with two ways:

1) with a smaller heatsink with forced convection (this gives a compactness of power supply system);

2) with larger heatsink with natural convection (gives high reliability, decreasing of noise level, possibility of making of hermetic systems (protected from dust, moisture, insects).

– possibility of implementation systems with maximal energy density (using liquid cooing);

– minimum of limitation in placement of power supplies.

Limitations:

– Having the same schematics, power of power supplies with conductive cooling is 2-2,5 times less comparing to power supplies with built-in fans. Complexity of developing and high cost of thermal interfaces such as power supply. And a dear price as a result;

– poor assortment of power supplies for power less than 60W;

– increased requirements for the qualifications of the developer of the final product – experience in performing thermal calculations is required;

– the relative complexity of mounting of power supply with a heatsink.

Power supplies with such type of cooling are most wanted in spheres that require reliability, ambient factors resistance, compactness (high energy density).

• calculating modules with liquid cooling;

• military electronics (radars, telecom, mobile systems);

• nuclear energetics;

• mining industry;

• aviation, navy – both as civil and not very.

Examples of power supplies with conductive type of cooling are all power supplies of KWant/MAA series.

The choice is definitely yours, dear readers. There are no truly one-stop solutions – for some projects it can often be difficult (and sometimes almost impossible) to find power supply with an optimal ratio of parameters. Therefore, we wish you good luck in solving such a difficult task!

P.S. And if you wish you can connect our technical support and we will help you how we can!