The right solution for every cooling concept

Before starting the development of a mechanical enclosure for a new electronic or electrical system, there are a number of important steps that should be taken. The mechanical dimensions will have probably been set by the project or programme manager with market feedback from the sales and marketing team members. In the Engineering feasibility study stage, 3D modelling is frequently used to determine if all the required parts and assemblies will actually fit. In this article, TDK-Lambda explores the right solution for every cooling concept.

References
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The right solution for every cooling concept

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How the system will be cooled will normally be stated. A medical device in close proximity to the patient will most likely demand that audible noise is minimised. This will restrict or exclude the use of fan cooling. Even in an office or light industrial environment, there could be restrictions placed on the amount of cooling vents allowed, their size and location. Dust and other contaminants present in particularly dirty locations may contain materials that are conductive, conductive when wet or potentially flammable.

Equipment that is destined for rack mounting, like test, telecom or datacom equipment, will most certainly have an airflow direction stated. If accessible by an operator or technician, cool air will be drawn in from the front, rather than the rear of the rack assembly. This avoids the user being continually subjected to heated air, which can be irritating and potentially lead to eye irritation issues.

Once the locations of the major parts and assemblies are decided upon, computerised thermal modelling should be performed. This will determine whether there are any areas where heat generating items are causing problematic temperature rises on components that are sensitive to heat, which could affect the performance of the system. Thermal modelling may determine the volume and/or speed of airflow from internal or external cooling fans.

If the system is to be powered by an AC mains supply, one, or more, AC-DC power supplies will most likely be required. Many companies rely on the Electrical and Mechanical Engineers to determine which type of power supply should be used.

For the purpose of this article, we will assume that a standard off-the-shelf power supply, rated at 250W, is required. Traditionally in this power range, there are a number of form factors available.

Open frame construction models will have a printed wiring board construction. They utilise push on or screw terminals for the AC input and DC output (depending on the current rating) and usually have four holes to secure the power supply to the chassis of the system, using threaded stand-offs and metal screws. See Figure 1.

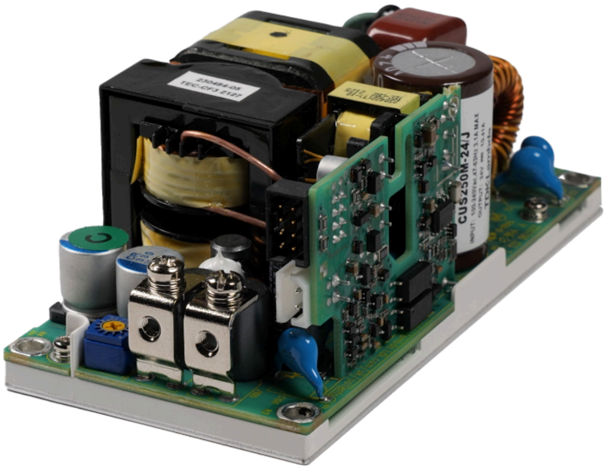

Figure 1: TDK-Lambda 250W open frame CUS250M power supply

An open frame construction that allows heat to radiate away more easily, is the lowest cost, but access by operators and service personnel to any live, high voltage components will have to be restricted. Additional metal shielding may be required to suppress radiated and conducted EMI (Electro Magnetic Interference).

Enclosed construction power supplies (Figure 2) are partially or fully enclosed in a metal case.

Figure 2: TDK-Lambda 250W enclosed CUS250M power supply

The cover on an enclosed power supply does restrict natural airflow slightly. One large advantage is that the heat generating power semiconductors, like the switching MOSFETs and output rectifiers (or FETs), can conduct heat into the power supply's chassis and into the system enclosure. If that material is aluminium, it can absorb more heat than steel.

The power supply cover, and to some extent the chassis, provide both suppression of unwanted EMI with protection for the operator or service technician against electric shock. Typically, due to the cost of the enclosure, the price will be higher than that of an open frame power supply.

Field reliability

The long-term reliability of an AC-DC power supply is very dependent upon the surrounding ambient temperature and the effectiveness of cooling the product. Power supplies use electrolytic capacitors for both energy storage and filtering, and their lifetime will be reduced in proportion to their temperature. A typical guideline is that for every 10ºC rise in temperature, their life is halved. A rise from 20ºC to 40ºC will result in the capacitor life being reduced by 75%.

To withstand short dips or loss of the AC source for a brief period of time, without a loss of the DC output, the high voltage "bulk" capacitor will enable the power supply to continue operating for a number of milliseconds. Low voltage capacitors are used in the output filter section to reduce high frequency ripple and noise output transients caused by sudden changes in load. Other electrolytic capacitors may be used in the control and "housekeeping" circuits. Degradation of these capacitors may severely compromise the power supply's performance and field life.

Cooling a power supply

There are several methods of cooling a power supply to ensure reliable operation. These are convection cooling, forced air and conduction cooling. These may be combined to lower the product's internal component temperatures. Until recently, most open frame power supplies would have to rely on convection or forced air cooling (usually from an external fan). Recently, power supply manufacturers have provided multiple case styles, options and designs to provide Engineers with more flexibility in managing their thermal challenges.

Convection cooling is where there is no external airflow present, but natural airflow must be allowed to circulate around the product (Figure 3). Restricting that airflow, just 0.3m/s, with external components or an enclosure will result in much higher component temperatures.

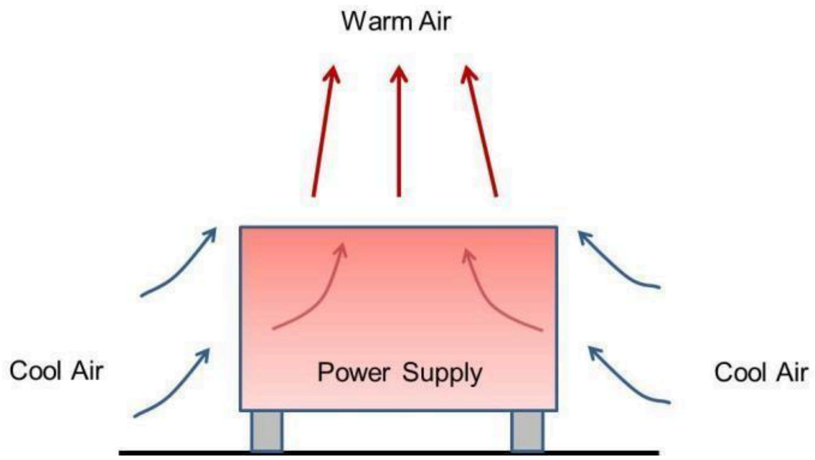

Figure 3: Natural airflow around a convection cooled power supply

Forced air cooling relies on an external fan to provide airflow across the power supply to cool the components. The direction of the airflow is as important as the amount of air being delivered. The manufacturer's data should indicate the preferred direction for airflow, the minimum speed of the air, or the suggested maximum temperatures of critical parts.

Referring to the open frame CUS250M supply shown in Figure 1, it can be noted that there are no power devices mounted to heatsinks. This is partly due to the product's high efficiency of up to 94%, but also that the power devices are surface mounted to the underside of the printed wiring board, giving a lower thermal resistance to the copper traces (Figure 4). This clean design enables air to freely flow though the unit with minimal obstruction.

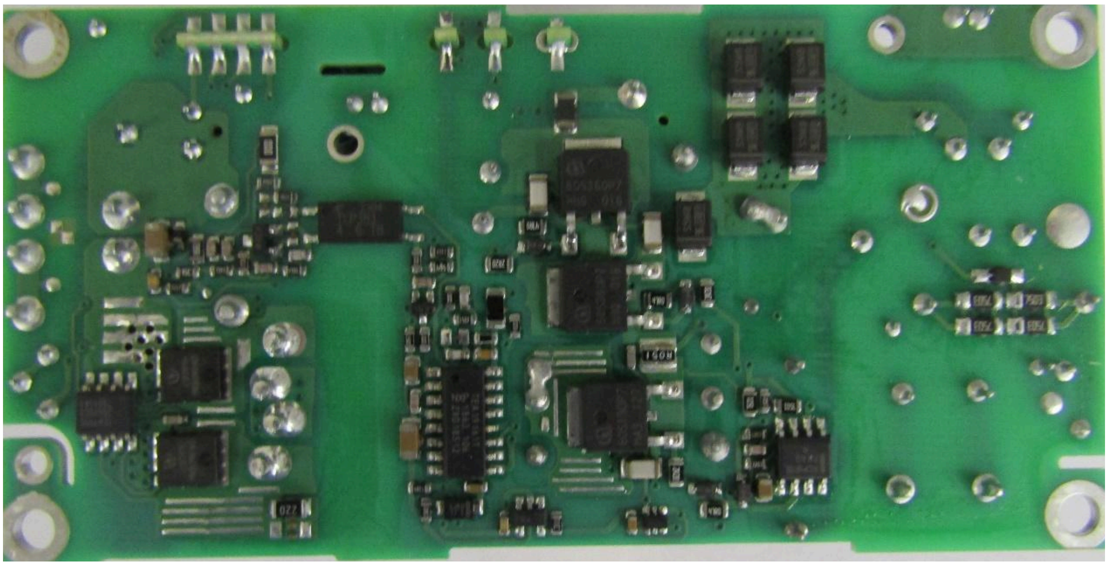

Figure 4: Surface mounted power devices on the underside of the CUS250M

If external airflow is not available, often the manufacturer will offer a unit with an integral fan. (Figure 5). Provided that there are no obstructions to either the incoming or outgoing air, the power supply will operate within specification. This simplifies the design of the system both from a mechanical and thermal perspective. The size of the fan used by the manufacturer will determine the audible noise level. For a given volume of air being delivered a large fan can be driven at a much lower speed than a smaller fan. Therefore a power supply with a larger fan will typically have lower audible noise. The compromise is that a larger integral fan will result in a larger power supply.

Figure 5: CUS250M/F with integral top mounted fan

Conduction cooling is ideal for applications where low, or zero audible noise can be tolerated, or there are no vents or fans allowed in the system. This may include medical devices, as certain noise frequencies from a fan can be irritating or tiring for a patient, hindering their recovery.

Also for outdoor or sealed enclosure applications, waste heat can be conducted away from the power supply to the exterior surfaces, which are often finned for better heat extraction. The conduction cooling method is also used with water and Peltier cooled systems.

As previously mentioned, the power semiconductors on products like the CUS250M are surface mounted and are attached to the underside of the printed wiring board. A number of companies manufacture flexible “gap fillers” with a high thermal conductivity and a low thermal resistance. When fitted between underside mounted heat generating components and a metal chassis, these will conduction cool the semiconductors (Figure 6).

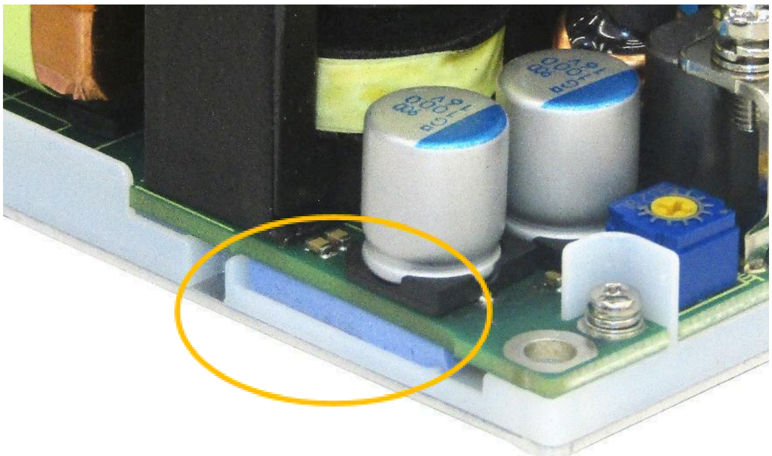

Figure 6: Gap filler between the printed circuit board and chassis

For conduction cooling, a metal baseplate or U-channel can be fitted to the power supply (Figure 7).

Figure 7: CUS250M/U with a U channel fitted

Regardless of which cooling method is chosen, the manufacturer's derating curves should be studied closely to ensure that the power supply is operating within its ratings. These will be found in the datasheet, installation manual or application notes.

Using the CUS250M again as an example, it can be noted from Figure 8a that just relying on convection cooling at 30°C ambient the power supply can provide 200W, or at 50°C ambient 160W.

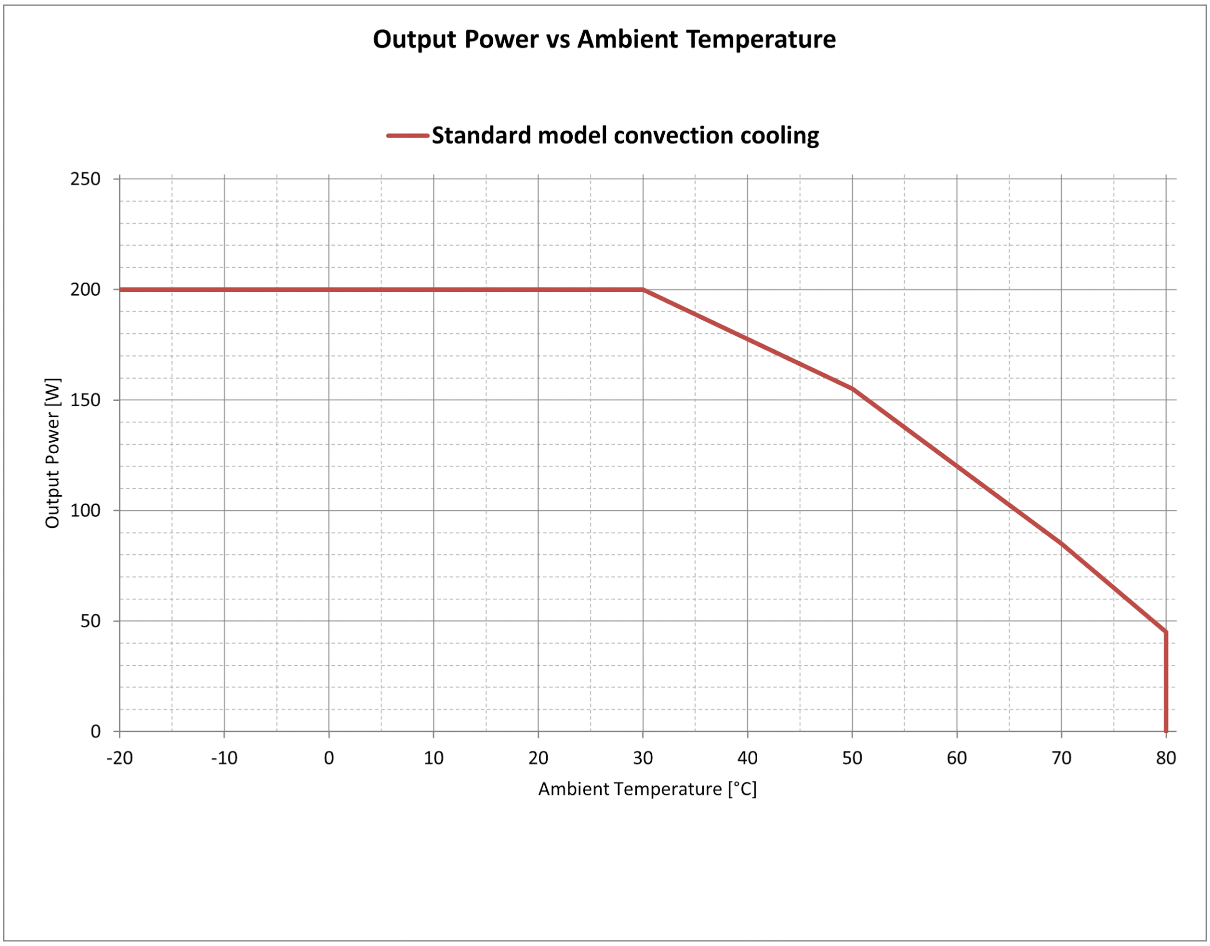

Figure 8a: Output power vs ambient temperature (Convection cooled)

Conduction cooling with the U-chassis option (Figure 8b orange line), the power supply can now deliver 250W at 30°C ambient. The semiconductors are conducting some heat into the metal chassis via the gap filler.

When the U chassis is mounted on to a cold plate or the system enclosure chassis (Figure 8b green line), the heat transfer is increased allowing the power supply to deliver the full 250W at 45°C ambient and 230W at 50°C.

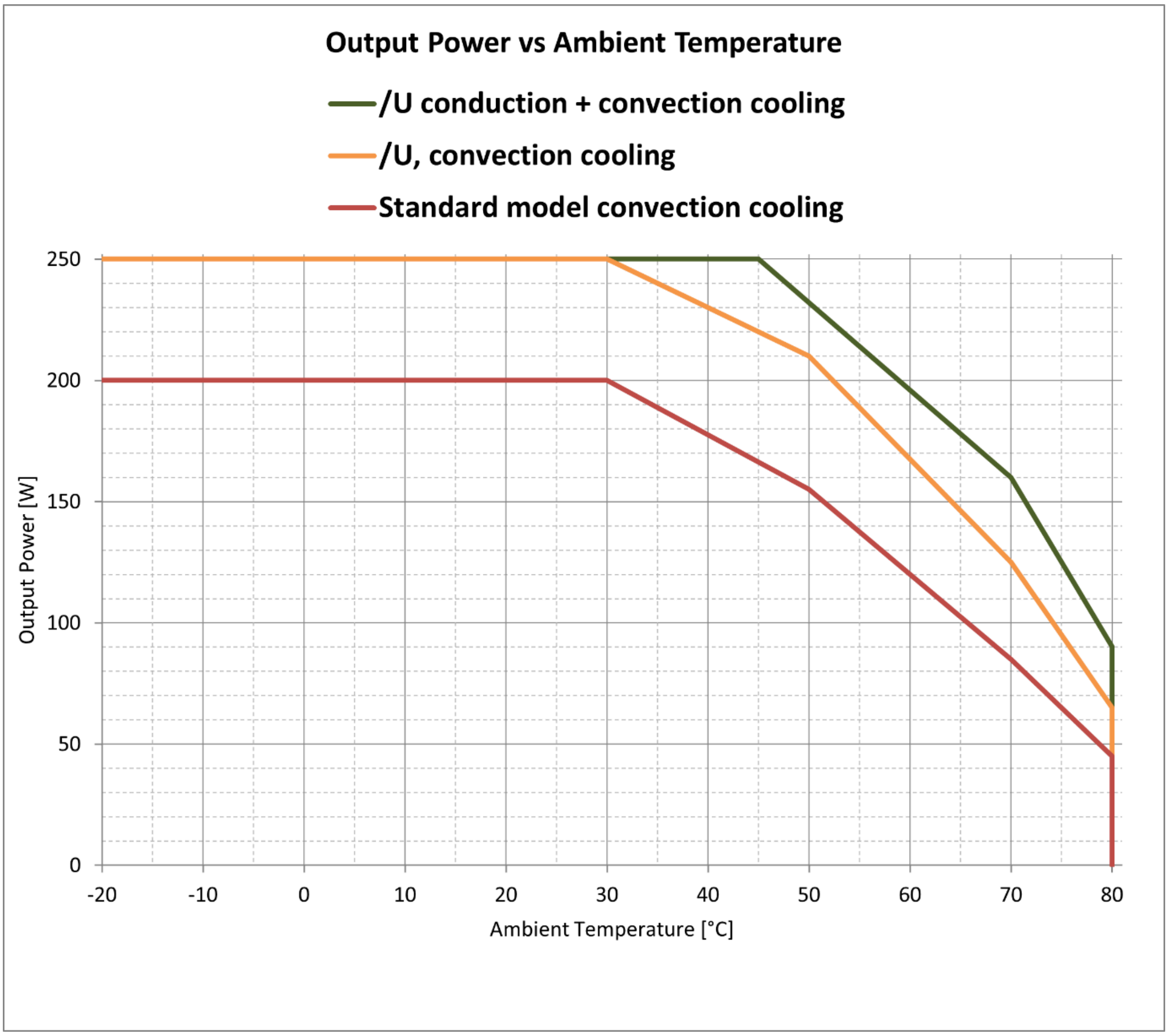

Figure 8b: Output power vs ambient temperature (Convection and cold plate cooling)

As a note, the power supply temperatures should be measured in the system enclosure.

Summary

Using a power supply series that has multiple cooling options may avoid compromising the system performance, or provide a method of offering a higher performance level for more challenging environments. The alternative solution of just using an open frame power supply, which relies only on convection cooling, may require use of a higher output power product. This would probably increase not only the space required, but also the cost and weight.

For more information about power supplies from TDK-Lambda, please visit:

www.emea.lambda.tdk.com/medical

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