Powering Communications in harsh environments

The reliability of communications equipment depends primarily upon the reliability of the power supply. The most cost-effective approach to power system design is to employ power supplies designed for the application. Power supplies that dissipate heat from the sensitive electronics via large, flat baseplates to heatsinks mounted outside of the enclosure are suited to this application, not just because of their delivery of a constant power level but because they perform consistently despite external temperatures that can vary from –30 ºC to 40 ºC.

To develop the desired power supply the project engineer must consider several design and environmental factors to meet the requirements of supplying such communications units.

As well as delivering the required voltage and current, power supplies also have a role in protecting system electronics from problems caused by variations in mains voltage, transients, surges and drop-outs.

Electronic systems in remote locations are often sealed against the elements which makes the removal of unwanted heat difficult. The most common solution adopted by system designers is to use a standard power supply and change the overall system's mechanical design to remove heat from the sealed system. A more practical approach is to select, or design, a power supply specifically for sealed enclosure applications.

Design considerations

There are three main design considerations: temperature management; protection of the device from contamination (ingress prevention); and protection of the device from input power variations.

Temperature

Besides the extremes of ambient temperature encountered in such locations from Scandinavia to the Middle East, it is commonplace for the temperature within the supply's enclosure to rise some 15-20ºC above the external temperature. The positioning of the power supply within the enclosure can minimise the ambient temperature in which it operates and this can have a significant effect on system reliability. Typically, the mean time between failures (MTBF) halves with every 10ºC rise in temperature. Power supplies therefore need to be able to operate from -40ºC to 65ºC as a minimum specification.

Ingress prevention

System enclosures are typically sealed to IP65 or IP66 standards to prevent dust or water causing damage. But how does one then remove heat effectively from power supplies in a situation with negligible airflow?
From the power system perspective, the most effective solution is to remove the heat using a heatsink external to the enclosure. However, most standard power supplies cannot provide an adequate thermal path between the heat-dissipating components within the unit and the external environment.

Power quality

The power supply must deliver the required output across its full input (90 to 264Vac) and load range. In Europe and the US, we have reliable mains supplies but the same situation does not apply in many developing countries where low mains voltage, flat-topped waveforms, brown outs and transient surges can be an everyday issue.

Hardware considerations

Conventional power supplies dissipate heat into small on-board heatsinks or onto a U-section chassis. The basic construction is shown in Figure 1.

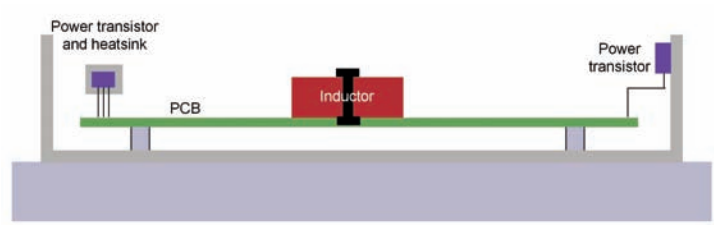

Figure 1: Construction of typical industrial AC/DC power supply

Most of the dissipated heat goes into the enclosure in which the power supply is used. Such power supplies typically have to be derated at temperatures above 50ºC, only delivering 50% of their full-rated power at 70ºC. This derating model is a general guide based on not exceeding the maximum operating temperature of individual components within the power supply.

In situations where there is a combination of a power supply unit rated above 200W with power factor correction (PFC) to EN610000-3-2 the power supply usually has to be derated by 25% if the input voltage drops below 110Vac.

Effective cooling

The components that generate the most heat in a power supply include the power FET used in an active PFC circuit, the PFC inductor, rectifier ICs, and baseplate-cooled DC/DC converters (where used). Heat can be removed from these components by mounting them directly onto a substantial baseplate that in turn can be affixed to an external heatsink.

The BCC series power supply from XP is a good example of a power supply designed in this way. Reliability is enhanced by ensuring that electrolytic capacitors operate from -40ºC to 105ºC and DC/DC converters with failure rates of less than 50ppm are selected.

Figure 2 shows the basic construction with all of the major heat-generating components fixed directly to the baseplate. With the appropriate heatsink, removal of heat is so effective that there is no need to de-rate the unit until the ambient temperature reaches 70ºC. This eliminates the need to over-engineer the power supply for the application.

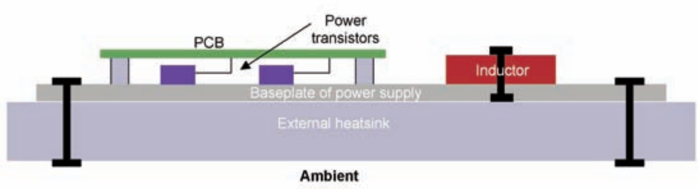

Figure 2: Construction of BCC Series power supply for harsh environment applications

The aluminium baseplate of the BCC power supply bolts to a heatsink surface. Three basic mechanisms then contribute to heat dissipation: conduction, radiation and convection, the last being the main process. Effective conduction between the baseplate and heatsink demands very flat surfaces in order to achieve low thermal resistance. Heat transfer can be maximised by the use of a thermal compound that fills any irregularities on the surfaces. System designers should aim to keep thermal resistance between baseplate and heatsink to below 0.1ºC/W. This is the performance offered by most commonly used bonding pastes.

Radiation accounts for less than 10% of heat dissipation and precise calculations are complex. In any case, it is good practice to consider this 10% to be a safety margin.

Heatsink selection process

1.Calculate the power dissipated as waste heat from the power supply. The efficiency and worst-case load figures are used to determine this using the formula:

Waste Heat = [1-(Eff%)/(Eff%)] x P(out)

Waste Heat = [1/(Eff%)–1] x P(out)

2. Estimate the impedance of the thermal interface impedance between the power supply baseplate and the heatsink. This is typically 0.1ºC/W with a thermal compound and this figure can be used as a rule-of-thumb.
3. Calculate the maximum available temperature rise on the baseplate. In the example of the BCC product, the maximum allowable baseplate temperature TB is 85ºC. The available temperature rise is simply: TB-TA where TA is the maximum ambient temperature outside of the cabinet.

4. The required heatsink is firstly defined in terms of its thermal impedance using the formula:

Ø(H) = TB – TA/(waste heat) – Ø(TII)

Where Ø(H) is the thermal impedance of the Heatsink, and Ø(TII) is the thermal impedance of the baseplate to heatsink interface

5. The final choice is then made based on the best physical design of heatsink for the application to deliver the required thermal impedance. The system's construction will determine the maximum available area for contact with the baseplate of the power supply and the available space outside of the enclosure will then determine the size, number and arrangement of cooling fins on the heatsink to meet the dissipation requirement.

Conclusion

The reliability of remotely sited communications equipment is dependent upon power supply reliability. The most cost-effective power system uses power supplies designed for the application that conduct heat via large, flat baseplates to heatsinks mounted outside the enclosure.

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