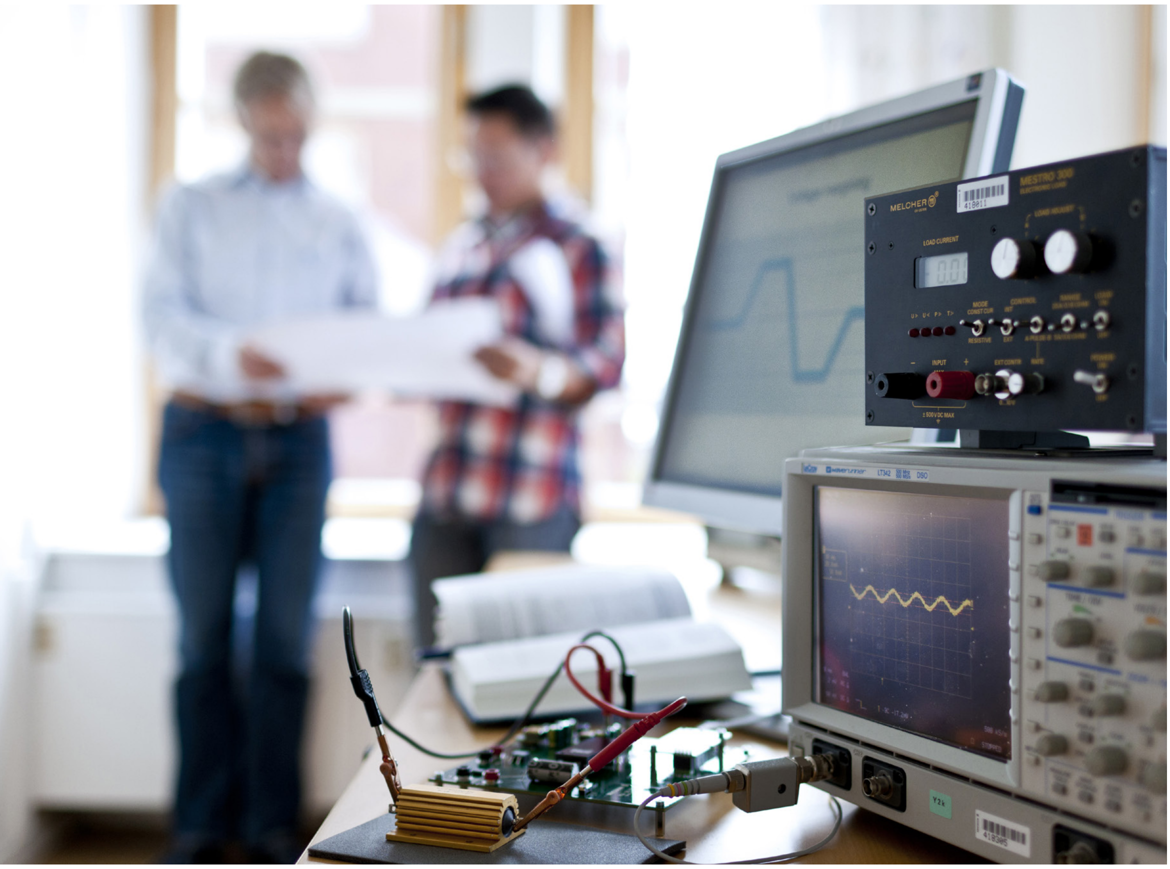
Thermal Characterization of Board Mounted Power Supplies in Sealed Box Applications



Design Note 028

Flex Power Modules

Abstract

This design note describes the thermal performance of board mounted power supplies when used in applications with no or limited convection cooling. In these condition, often referred to as 'sealed box' applications, the main part of the power losses is dissipated by conduction through the power supply's baseplate coupled to a large thermal mass (cold wall).

Application conditions

Classic thermal current derating or thermal resistance characteristics are not enough to describe the thermal properties of board mounted power supplies, BMPS, used in sealed box applications.

Sealed box cooling conditions are often encountered in applications such as radio communication equipment e.g. RFPA (Radio Frequency Power Amplifiers).

Cooling in a sealed box application is achieved mainly by conduction from the BMPS baseplate to the enclosure which functions as a heatsink or "cold wall", often not only for the BMPS but also for other heat dissipating devices like radio frequency (RF) transistors. Figure 1 presents a typical example of sealed box applications.

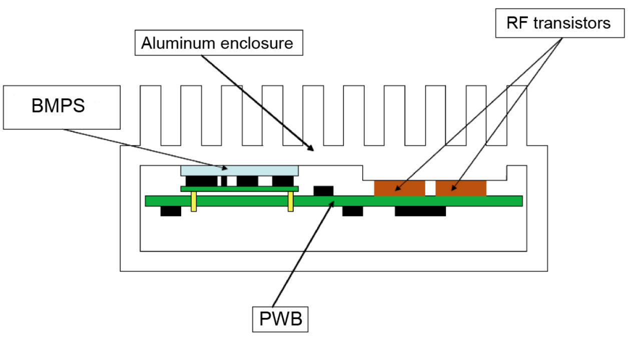


Figure 1 - Sealed box application example

Designers of systems with equipment in sealed boxes usually have two thermal constraints: the maximum air temperature inside the sealed box and the maximum temperature of the enclosure. An accurate measurement method for these conditions is presented below.

Test method

In sealed box applications a large part of the heat dissipated in the BMPS is conducted via the baseplate to the enclosure wall. The heatsink temperature can be significantly different than the temperature of the ambient air inside the box. Also, thermal radiation could play a more significant role in the heat transfer since air convection cooling becomes relatively small resulting in higher temperature differences for the components in the BMPS. For the majority of sealed box applications, the enclosure wall temperature is lower than the ambient air temperature. However, in applications such as RFPA, the enclosure's wall temperature can be higher than the ambient air temperature inside since the heat dissipating BMPS and RF transistors are usually mounted together on one part of the enclosure. This part will then become warmer than other parts of the enclosure and warmer the air temperature inside the box.

Considering the above factors, it is crucial that the thermal performance of BMPS used in sealed box applications should be verified in an environment where both ambient air, enclosure wall and baseplate temperatures correspond to the actual operating conditions. In order to achieve that the test equipment must be able to control the baseplate and the ambient temperature independently. The equipment used by Flex Power Modules for thermal verification of BMPS in sealed box is presented in Figure 2.

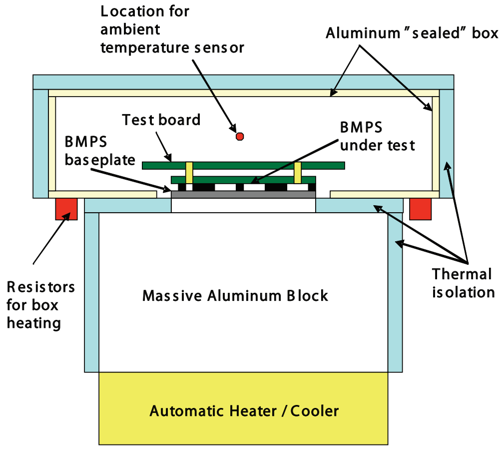


Figure 2 - Cross-section of the test equipment

The baseplate of the BMPS under test is placed on the top of a massive aluminum block. The BMPS is also attached to a small two layers PWB which provides all necessary electrical connections.

A box with a removable lid is mounted on the top of the aluminum block. The box (built from aluminum plate) is thermally isolated and can be heated by resistors mounted underneath.
The measurements are performed as follows: First, thermally critical components of the BMPS are identified. Thermocouple temperature sensors are placed on the top of the critical components as well as on the baseplate. The ambient temperature sensor is also put inside the box. The desired baseplate temperature (which is very close to the aluminum block temperature) is automatically regulated. The desired ambient temperature (air temperature inside the box) is regulated manually either by the box heating resistors or by partially removing the box's thermal isolation. The air temperature inside the test box varies as it does in real sealed box applications.
The ambient temperature sensor is placed 12.7 mm (0.5 in) above the center point of the test board as proposed by Bellcore TR-332 standard. The location proposed by EIA/JEDEC 51-2 standard (1 inch aside and 1 inch below the test board) is less suitable for typical sealed box applications. Several measurements for different ambient and different baseplate temperatures are performed in order to characterize thermal performance of the BMPS under test.

Example

Thermal derating characteristics of the PKY2616PI (DC/DC converter, 18-36 V input, 28 V / 21.5 A output) in sealed box applications are presented in Figure 3. The maximum available output current vs. baseplate temperature at two different ambient temperatures (+70ºC and +85ºC) are presented.
The presented characteristics show that the PKY2616 can provide the maximum rated output current at +70ºC ambient (sealed box air) temperature up to +100ºC baseplate temperature.
The characteristics also show that the baseplate temperature must be kept below +90ºC if the product is loaded with the maximum rated current at + 85ºC ambient temperature.
Note that the above characteristics are totally different than the "classic" thermal derating curve for natural convewction cooling. The difference is that "classic" thermal derating curves are obtained in a measuring setup where the BMPS baseplate is not thermally connected to a large heatsink (cold wall), i.e. the product is cooled only through the application board and ambient air.

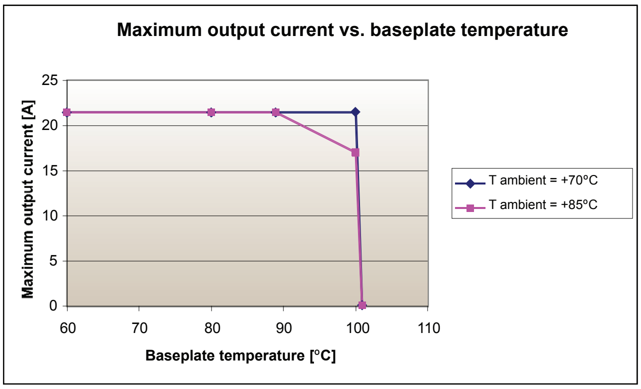


Figure 3 - PKY2616PI Available output current vs. baseplate temperature at V_{in}=27 V

Conclusion

Classic thermal characteristics, i.e. thermal current deratings obtained in wind tunnels are not suitable for describing thermal properties of BMPS used in sealed box applications. In order to obtain correct thermal data in sealed box applications a test method that simulate actual operating conditions must be used. The test method presented in this design note can control both ambient air and BMPS base plate temperature independently and is thereby able to create thermal conditions similar to the actual operating conditions and provide accurate test data that can be used by the system design engineer.

Formed in the late seventies, Flex Power Modules is a division of Flex that primarily designs and manufactures isolated DC/DC converters and non-isolated voltage regulators such as point-of-load units ranging in output power from 1 W to 700 W. The products are
aimed at (but not limited to) the new generation of ICT (information and communication technology) equipment where systems' architects are designing boards for optimized control and reduced power consumption.

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