October 2008 Ref.: MPS319A

Murata Power Solutions
www.murata-ps.com

Thermal Testing of Board Mounted Power Units

Author: Don Gerstle, VP Design Quality, Murata Power Solutions

Introduction: Thermal Derating and Thermal Management of BMP Units

This article discusses some of the key issues in dealing with thermal derating and thermal management of board mounted power units (BMPs).

There is an insatiable demand in the marketplace for higher power density BMP units. Satisfying this demand means more watts have to be extracted from the same, if not smaller, volumes. This results in higher levels of heat generated within a given package size that must somehow be dissipated. There is also a push for higher mean time to failure (MTTF) numbers for these units. MTTF is inversely proportional to the operating temperature of electronic components, so thermal management in terms of airflow required to keep temperatures within specified ranges has become increasingly more important.

Use of higher efficiency topologies, better materials, optimized layout, and low loss components is critical to achieving increased power density while also achieving increased reliability levels. After all of this has been done, thermal management in terms of airflow is important. This allows optimum use in the end application, to achieve the maximum power output while achieving high MTTF/reliability levels.

Thermal performance of BMP modules should be evaluated in an environment where ambient temperatures and airflow rates can be accurately controlled. Normally this is done in a “closed loop wind tunnel” with the means to heat and control the air temperature within the tunnel. The test section of a wind tunnel is shown in Figure 1. Only after collecting and analyzing the data can the BMP unit’s thermal performance be determined. In many respects, the wind tunnel environment mimics the equipment found in networking, telecom, wireless, and advanced computer systems, in that it utilizes a vertically mounted PCB (test card), with fixed spacing to an adjacent surface/PCB, similar to those found in industry standard cabinets and racks.

The BMP unit to be tested is soldered to a test PCB, which is then positioned vertically inside the wind tunnel. The spacing between the test PCB and the side wall of the tunnel is fixed at a distance of one inch, which is typical of board spacing in “card racks.” The unit under test (UUT) has four possible orientations within the airflow. There may be significant differences in thermal performance relative to orientation. The best orientation needs to be determined and used to generate the derating data.

Preparation for Thermal Airflow Testing

First it has to be determined whether the UUT to be tested is fully functional and is truly representative of a typical unit that would come through “normal” production. Prior to commencing the actual thermal airflow testing, the UUT should be examined with thermal imaging equipment to ensure that no unexpected hot spots exist. If they do, the cause of the hot spot should be eliminated before proceeding. While simulation could be used to determine hot spots, the results would only be as accurate as the data entered and should always be confirmed with imaging equipment. A sample IR image of a BMP unit is shown below.

Before conducting thermal airflow tests, one should verify that the unit is fully functional and achieves target efficiency and power dissipation levels.

Critical components are those components that limit the thermal performance of the unit. They include, but are not limited to, components such as power MOSFETs, diodes, control ICs, optocoupler ICs, the PCB itself, and magnetic cores. The maximum temperature of these components should not exceed those defined in the Derating Guidelines being used, which are usually based on internal supplier requirements, customer requirements, or market standard requirements.

The critical components may vary depending on the operating conditions. The critical components may change as line and load are varied.

Temperature Measurement

The UUT temperature in the wind tunnel should be monitored with an IR camera that views the critical components through an IR window on the wind tunnel. It should be noted that the IR camera identifies the highest temperature within a target whose size and shape can be changed to encompass an entire component if desired (versus thermocouples that may not be on the hottest spot). Use of thermocouples would be a less preferred measurement method, but certainly is an available option. The thermocouple endpoint, where the thermocouple wires are welded together, is mounted with thermally conductive adhesive with a minimum amount applied between the thermocouple and the hidden component to minimize the thermal drop between the thermocouple and the hidden component. It is important to have a good understanding of how to make and attach thermocouples for accurate temperature measurement.

Unit Mounting in Airflow Chamber

The unit should be mounted on a PCB that is representative of one that it may see in an end application, in terms of the PCB dimensions, number of layers, and copper weight. The unit should be mounted at the centre of the PCB. The tests should be conducted with the unit mounted in one transverse direction, and then in the other transverse direction. The tests should also be conducted with the unit mounted in one longitudinal direction and then in the other longitudinal direction. The optimal orientation should be shown in the application notes, with the corresponding derating chart. All test data should be saved for future reference should it be necessary. Test boards with mounted tested units should be dated and saved for future reference.

Products that will be used at higher altitudes will require additional testing or evaluation, which is a separate topic of discussion.

Thermal Test Data and Airflow Derating Test Conditions

Test data should be taken at the unit’s nominal input voltage and at multiple input voltages for units with a wide input operating range. The tests should be repeated at incrementally increasing airflow levels, starting at natural convection, up to 600 LFM for high-power units.

The wind tunnel ambient temperature should be increased in uniform increments across a temperature range from normal ambient to 100ºC. At each airflow rate to be tested, the wind tunnel temperature is increased from ambient room temperature in incremental steps until a critical temperature is reached on some component. At that point, the load is reduced such that the critical temperature is maintained but not exceeded on any component. These steps are repeated until the maximum ambient temperature is reached. This cycle continues until the UUT has been tested at all airflow rates. At each measurement point the temperature should be allowed to stabilize before a load current data point is recorded. This means that there should be an iterative measurement to ensure that the maximum temperature of the critical component at the respective LFM and ambient temperature has been reached.

There may be various configurations of the unit being tested. For example, it may be available with a base plate or heat sink, in which case thermal testing should be repeated in those configurations.

Test Set-up for Thermal Derating of BMP Units

The thermal performance data of the product is based upon measurements obtained from a wind tunnel test such as the one shown in Figure 1. It is the responsibility of the end user to ensure that their application has adequate airflow to properly cool the product in the environment in which it is being used. It is important for the end user to conduct tests at all of the end application temperature extremes and not assume that there is a linear extrapolation to other thermal measurements. The

BMP’s thermal performance will be affected by end application factors such as airflow direction, PCB thickness and size, and adjacent components in terms of their temperature and effect on the airflow.

The power module is soldered on the center of a printed circuit board in the wind tunnel. The cross section of the airflow passage is rectangular. The power module’s orientation with respect to the airflow direction can have a significant impact on the module’s thermal performance. An airflow collimator (sometimes called contractor) should be used upstream of the UUT if there is substantial turbulence in the airflow, to make the airflow uniform and minimize turbulence. The product application notes should indicate the optimal orientation and provide thermal derating data for that orientation. Test data for other orientations should be stored for data to provide customers where required.

Conclusion

Thermal testing of BMP units using the proper techniques is key to providing good thermal airflow derating information for optimal utilisation in the end application.

Ends

About Murata Power Solutions

Murata Power Solutions (www.murata-ps.com) is headquartered in Mansfield, Massachusetts, with over 1,300 employees, and locations in the USA, Canada, England, France, Germany, Singapore, Japan and China. Murata Power Solutions designs, manufactures and distributes DC/DC Converters, AC/DC Power Supplies, Magnetics, Data Acquisition devices and Panel Meters, and offers these products in custom, standard and modified-standard variations. These products, which are built to exacting requirements in ISO9000:2000-approved facilities, are typically used worldwide within telecommunications, computing, industrial and other high-tech applications.

About Murata

Based in Kyoto Japan, Murata Manufacturing Company Ltd is one of the world's leading providers of ceramic based components, sensors, and AC/DC and DC/DC power solutions. Founded in 1950, the company has over 34,000 employees worldwide, and over $6.3 billion US in consolidated annual sales (as of March 31, 2008). Everywhere in the world, wherever you can reach, Murata's electronic components are always at work.

Contact:
John Sutherby, Marketing Communications Department
Telephone: +1-508-339-3000 x 117

Issued by/more information from:
Simon Krelle, Pinnacle Marketing Communications Ltd
Tel: +44 (0) 7973 821036 Fax: +44 (0) 20 868 4373.
E-mail: simonk@pinnaclemarcom.com
Web: www.pinnacle-marketing.com

October 2008 Ref. MPS319/A