Evaluation of Environment on Heat Sink Performance

Introduction

Optimal Thermal Solutions BV used the 6SigmaET simulation software to investigate the effect that the environment has on the thermal performance of a LED heat sink. The performance of an LPF80A50 heat sink was examined in an open environment and UL6". The simulation results were compared with measured values, and the average difference between the test and simulation data was found to be 3.5%.

How Difficult Can LED Lighting Be?

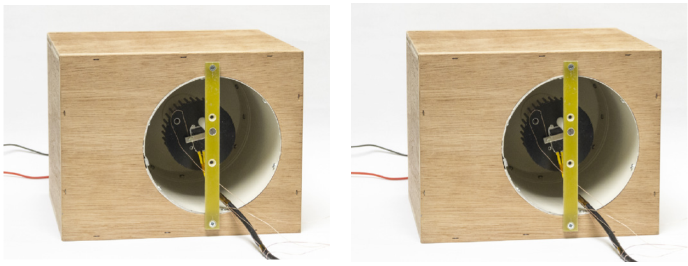
LED lighting can be an effective method to reduce the operating cost of a building. However, unlike traditional lighting solutions, LEDs have a maximum junction temperature of around 100 °C whilst incandescent lighting solutions will still operate at around 2,000 °C. This means that for LED lighting, there needs to be an effective heat transfer path to the ambient air; a thermal design challenge to say the least.

LED lamp application environments vary from client to client, and in most cases, the heat sinks for LED chip-on-board (COB) lamps are tested in a 'free' or open environment. When in use however, there is no guarantee that the lamp will be used in a free environment - for example downlight lamps operate in recessed ceilings. In this experiment, the heat sink thermal performance is assessed in both a free environment set-up and a defined environment.

Investigation

The heat sink used in this investigation is the MechaTronix LPF80A50 - an 80 mm diameter pin fin heat sink that is 50 mm high.

Experiments were conducted with known heat sink power dissipation in a power MOSFET. The MOSFET is mounted to the base plate of the heat sink, with Laird T-grease 1500 as the interface material. Thermocouples (K-type, 36 and 40 gauge) were placed on the base plate close the MOSFET, and on the MOSFET itself. Testing was stopped when the MOSFET temperatures exceeded 100°C.



Experiment set-up of the heat sink free air (left) and a UL6" environment (right)

The 'defined' environment is based on the UL 1993 6" format that is used to test incandescent light bulbs and LED based replacement bulbs.The heat sink was placed concentrically to the UL 6" aluminium tube in the test box. In both set-ups the heat sink is orientated with the base plate horizontal and the pins above the base plate.

The MOSFET is powered and allowed to stablize at 5 W, 10 W, 20 W and 30 W, and the maximum temperature difference between the heat sink and ambient is recorded for the 'free' and UL6" environments.

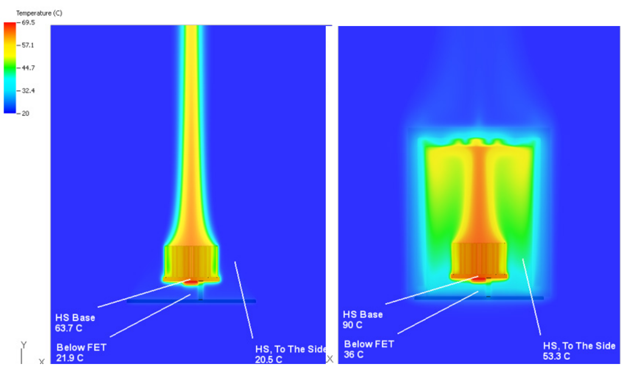
Optimal Thermal Solutions is a Dutch engineering firm specializing in thermal management of electronics. With over seventy years of combined experience, OTS has solved many problems for a large variety of customers. From chip- up to system level, OTS has been involved in the development and verification to get the most optimal solution possible.

The Results

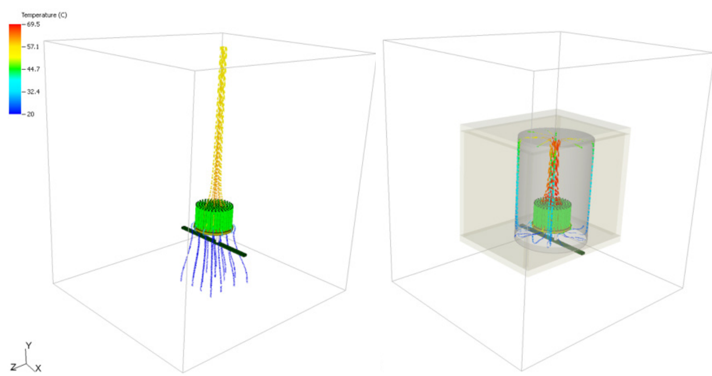
The results show that there is a significant increase in the heat sink to ambient temperature difference for the same power input when the heat sink is inside the UL6" test box as opposed to when it is in free air. The smallest increase is for 5 W dissipation which results in a 7 K increase in the base plate temperature. This is 45% higher than the value in free air. The largest difference is 31 K, which is 71% higher than in free air. The aforementioned is for 20 W. Above 25 W for the UL6" test, the MOSFET was switched off to prevent it from exceeding its maximum junction temperature.

CFD Simulation

A CAD model of the heat sink was imported into 6SigmaET, and the two environments were modelled. The CFD simulation results showed a significant increase in the heat sink base plate temperature when the heat sink is placed inside the test box.



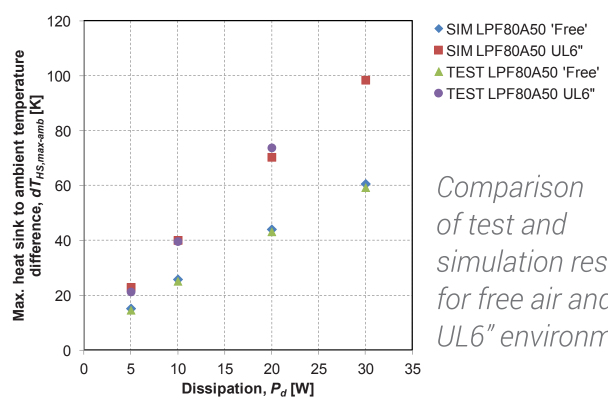
Temperature plots for free air (left) and a UL6" environment for 20 W dissipation (right)



Airflow patterns for free air (left) and a UL6" environment for 20 W dissipation (right)

The simulation also provides an explanation of this behavior - the plume rises in free air, and recirculates within the test box.

Comparing the simulated and measured results for the temperature differences shows an average percentage discrepancy of 3.5%, indicating that there is a good comparison between the simulation model and the test results.



Comparison of test and simulation results for free air and UL6" environment

6SigmaET, a computational fluid dynamics (CFD) simulation tool, brings new levels of productivity to electronics cooling design. Thanks to its ease-of-use, it overcomes many of the problems that have plagued analysis tools from the beginning. Boasting substantial automation and intelligence, 6SigmaET is already being used by a global community of design engineers.