AN-300 HTRB Reliability Testing

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Abstract

High Temperature Reverse Bias (HTRB) testing is often used to verify the reliability of power semiconductor rectifiers. This application note describes the requirements of a valid HTRB test for power semiconductor rectifiers. It also proposes an effective strategy for performing an HTRB test that requires minimal supervision while assuring that no parts are inadvertently destroyed by unintentional overheating.

Introduction

HTRB testing is an accelerated life-test for power semiconductor rectifiers that is often used to verify the robustness of the devices themselves and the reliability of their assembly and packaging. It artificially ages the devices under test (DUTs) by making them block a voltage that is close to their maximum rated reverse breakdown voltage (V_{RRM}) while close to their maximum rated junction temperature (T_{JMAX}). As the maximum junction temperature of any power semiconductor is approached, adequate removal of heat from the device package is critically important to prevent thermal runaway from occurring and driving the devices into self-destruction. This is particularly true when there is very little difference between the ambient temperature (T_A) and the junction temperature (T_J) of the device. The most significant factor of any HTRB test strategy involves affixing a heatsink to each device that is put on test. Heatsinking the DUTs achieves three objectives. 1) For a properly designed test, it eliminates the need to measure DUT case temperatures to ensure that an acceptable junction temperature is being maintained throughout the duration of the test. 2) It ensures a fairly consistent junction temperature for all of the DUTs in the test environment. 3) It minimizes the likelihood of accidental device destruction due to thermal runaway driven overheating. The appendix suggests a potential heatsink vendor and the part number of a heatsink that should be adequate for the HTRB testing of rectifiers mounted in TO-220 packages.

Valid HTRB Test Conditions

JEDEC specification JESD22-A108C, section 4.2.1 [1] addresses HTRB testing of power devices and defines the acceptable test condition as one where the ambient temperature keeps the junction temperatures of the DUTs at or above 125 °C. A108C also declares that the T_J of the DUTs should not exceed the T_{JMAX} specified in the manufacturer's data sheet (typically 150 °C, for Silicon devices).

The closer the T_A of a power semiconductor is to the T_{JMAX} of the device, the more difficult it becomes to effectively remove heat from the die, and less internally dissipated heat is required to maintain an elevated T_J. That is why reverse bias (leakage) current (I_R) is used to accelerate the aging of power rectifiers. The small amount of internally dissipated heat that results when I_R flows at a high reverse voltage can very effectively keep the T_J of the device close to its maximum rated value when the T_A is held at or slightly above 125 °C. Reliability Engineering is typically responsible for ensuring that the T_J of the DUTs stay within the proscribed 125 to 150 °C window. Any combination of heatsinks and T_A set points that result in device case temperatures between 125 and 140 °C should qualify as an acceptable HTRB test setup.

Why Thermal Runaway During HTRB Testing is Probable and Problematic

The I_R of power rectifiers has a positive temperature coefficient, and therefore, an increase in T_J causes I_R to increase, which further increases the T_J. This makes thermal runaway inevitable, if the dissipated heat is not adequately conducted away from the die.

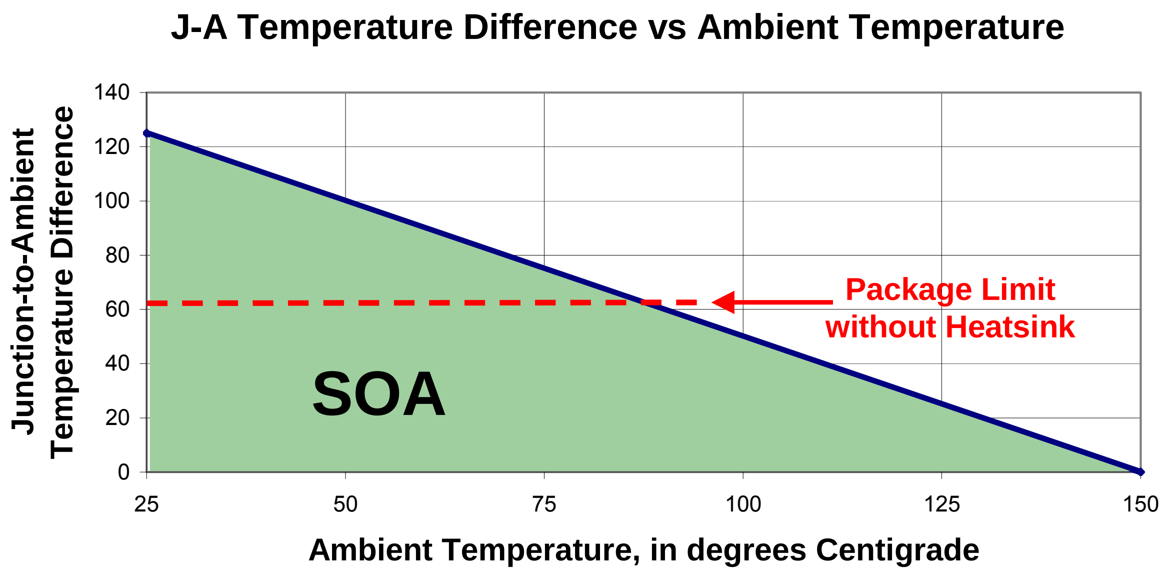

Figure 1: To keep the T_J of power semiconductor rectifiers encapsulated in TO-220 packages below their T_{JMAX}, heatsinks are used to reduce junction-to-ambient thermal resistance ($R_{\theta J\text{-}A}$) and temperature difference.

When the ambient temperature is high (≥ 85 °C) and the difference between the T_J and the T_A of a device is small, a heatsink is the only practical way to remove enough heat from the device package to prevent the junction from overheating and the device from being driven into thermal runaway. Figure 1 is a graph of the junction-to-ambient temperature difference that must not be exceeded, for power rectifiers encapsulated in TO-220 packages.

Due to the relatively high junction-to-ambient thermal resistance ($R_{\theta J\text{-}A}$) of a typical TO-220 package–especially when the die is isolated from the lead frame (≈62 °C/W)–small fluctuations in device power dissipation can cause large swings in T_J. As can be seen from the graph, the difference between T_J and T_A must be linearly reduced as the ambient temperature increases, and especially as it approaches the maximum junction temperature of the DUTs. This is accomplished by reducing the case-to-ambient thermal resistance ($R_{\theta C\text{-}A}$) with a heatsink. The heatsink significantly lowers $R_{\theta C\text{-}A}$, which helps to maintain tight control of DUT junction temperatures. With the heatsink shown in Figure 2 (specified in the Appendix), $R_{\theta J\text{-}A}$ for the DUT is reduced to about 7 °C/W.

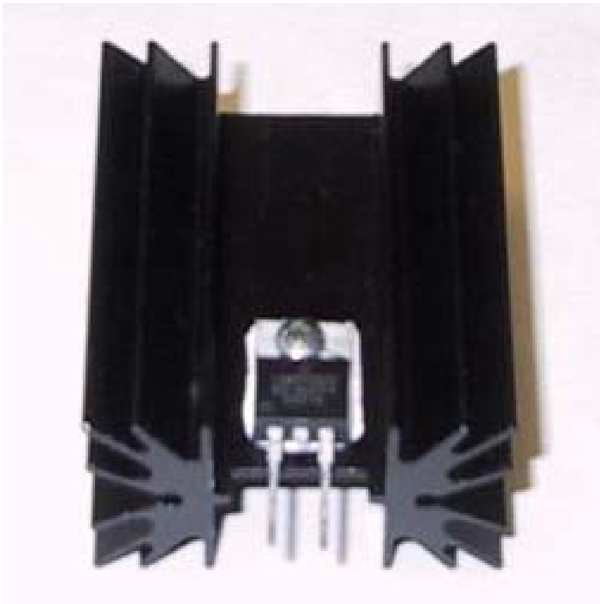

Figure 2: A heatsink that can be affixed to DUTs that are to be put into HTRB testing. Typical thermal resistance for the heatsink alone is approximately 4.5 °C/W (see appendix).

Summary

In order to avoid accidentally destroying DUTs during HTRB reliability testing, a heatsink should be affixed to each device to be tested. In a properly designed test, an adequate heatsink eliminates the need to measure DUT case temperatures to ensure that an acceptable T_J is being maintained throughout the test period, ensures a fairly consistent T_J for all DUTs in the test environment, and minimizes the likelihood of driving them into thermal runaway. The appendix suggests a potential heatsink vendor and the part number of a heatsink that should be adequate for the HTRB testing of rectifiers mounted in TO-220 packages.

References

[1] JEDEC specification JESD22-A108C http://www.jedec.org/download/search/22a108c.pdf

Appendix

Specifications of a heatsink for power semiconductor rectifiers in TO-220 packages. Aavid p/n 529902B00000 mechanical drawing and thermal characteristics: