MOTOROLA
Semiconductor Products Inc.

AN930
Application Note

HIGH VOLTAGE, HIGH CURRENT, NON-DESTRUCTIVE FBSOA TESTING

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This Application Note provides specifications for a test instrument which can be used to perform non-destructive testing of the Second Breakdown (S.B.) limits of the Forward Bias Safe Operating Area (FBSOA) curve. In addition, this note illustrates typical S.B. portions of the FBSOA and temperature derating curves for various technologies.

INTRODUCTION

A prime concern to both users and suppliers of power transistors is verification of the second breakdown capability of the devices. Second breakdown energy limitation can manifest itself under two operating conditions: active-region safe operating area, commonly referred to as Forward Bias Safe Operating Area (FBSOA); and Reverse Bias Safe Operating Area (RBSOA).

FBSOA is defined for turn-on conditions where the base is forward biased and forward base current, I_{B1}, flows, or when the base is open circuited. RBSOA, on the other hand, occurs when reverse base current, I_{B2}, flows during device turn-off. For either condition, second breakdown (S.B.) is the result of current crowding in the emitter finger due to direction of the lateral field in the base. The field causes current crowding at the periphery of the emitter during forward bias and at the center of the emitter during reverse bias. This greater current density produces a hot spot which eventually causes the transistor to go into second breakdown. If the energy is not quickly removed, the device will be destroyed.

NOTE: The mechanism and theory of S.B. has been under investigation since as early as 1958. Rather than to briefly try to review the complex phenomena, the reader may refer to the references listed at the end of this paper.

This paper will address the non-destruct testing of FBSOA. Since conventional methods of measuring the S.B. limits of the FBSOA curve (Figure 1) invariably result in device failures, the generation of a complete family of curves through destructive testing is costly and time consuming. Generally, the transistor under test (TUT) is measured for S.B. capability in a common base configuration (Figure 2), allowing for easily adjustable and repeatable collector current, collector-emitter voltage and pulse width measurements. To determine the S.B. capability of the transistor, either the voltage or current for a particular pulse width is increased until the device fails. Several transistors are tested in this manner and the failed points recorded. The number of devices tested at each condition is dictated by the degree of clustering of failed parts; it is not unusual for as many as five to ten devices to be tested at each point on an S.B. curve to determine a guaranteed energy level. (The specification $I_{S/B}$ is often listed on the transistor data sheet which defines the one guaranteed point on the FBSOA curve.) For a single pulse width S.B. limitation curve, perhaps four different power levels are tested. A complete family of curves could thus require destructive testing of as many as 100 transistors.

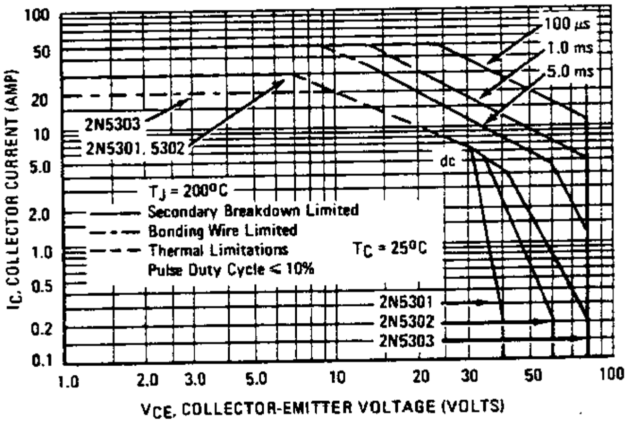

FIGURE 1 – Typical FBSOA Curve

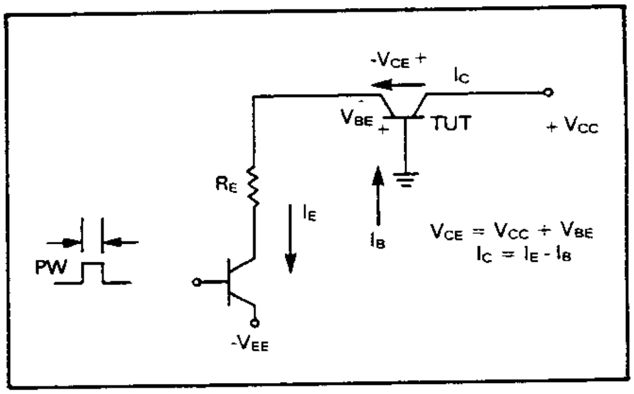

FIGURE 2 – Simplified Common-Base Test Circuit for Measuring FBSOA Second Breakdown