# How to Determine Thermal Resistance for a Power Semiconductor Heat Sink in an SMPS

FAIRCHILD SEMICONDUCTOR®

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A practical method for determining the thermal resistance of a heat sink in a power supply is provided. The basic principles are straightforward. The implementation is unique to each system and heat sink arrangement.

The basic principle is to operate the power supply under a known set of conditions. Monitor the case temperature of the power switch in question along with the heat sink and ambient temperature. Then disconnect the power dissipating components from the rest of the circuit. Connect the power dissipating components to a DC power supply. Set the system up such that any fans are operating as they normally would. Apply constant power to the power dissipating components. Allow the system to stabilize at the case and heat sink temperature of the previous operation. The effective thermal resistance is determined from $R_\theta sa = \Delta T/power$.

The following example demonstrates how this approach is used to determine the thermal resistance for a heat sink with two IGBTs mounted on the same heat sink in a two switch forward converter.

Initially, the power supply is operated at full load with $50^oC$ ambient intake air temperature. The case temperatures of Q1, Q2 and the heat sink along with the fan voltage are recorded. The fan voltage is used to ensure that the same cooling effort is exerted when the IGBTs are operated in a standalone mode. A representation of the physical setup is provided in Figure 1.

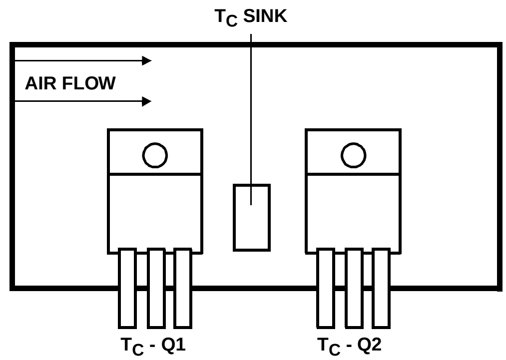

FIGURE 1. PHYSICAL SETUP

To determine the thermal resistance for a heat sink ($R_\theta sa$), the IGBTs are removed from the circuit and the gate is shorted to the collector for each IGBT. The fan is disconnected and operated at the same voltage as recorded earlier by a standalone power supply. Each IGBT is operated in the linear mode until the steady state case and heat sink temperatures match those from the normal operation. Since the IGBTs are in a linear mode, the total power dissipated is $V_{CE} \times I_C$. The table below summarizes the results.

This method works best if all the major power dissipating components in a power supply are measured at the same time.

| POWER DISSIPATED (W) | AMBIENT TEMPERATURE ($^oC$) | HEAT SINK ($^oC$) | $T_C$-Q1 ($^oC$) | $T_C$-Q2 ($^oC$) | $R_\theta sa$ ($^oC/W$) |
|---|---|---|---|---|---|
| 22.69 | 50 | 77 | 75 | 78 | 1.19 |

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