



Technical Bulletin

Heat Flow Calculation for 3M™ Thermally Conductive Tapes 9882, 9885, 9890

July, 2001

General Information

The function of thermally conductive tape is to mechanically bond the hot component to the heat sink and provide a thermal path from the chip or case of the package to the cooling air in the box. The important number in this calculation is the operating temperature of the chip or case when in use. The system must provide sufficient thermal outflow to keep the chip or case below its maximum rated temperature. The examples and worksheet provided are supplied to help the user determine the applicability of 3M tapes to their heat sink attachment application.

The chip manufacturer can provide either the maximum operating temperature of the chip or the maximum temperature allowed at the package case surface. The chip or case temperature $T_{\text{chip/case}}$ is calculated knowing the T_{air} , temperature of the air in the box, the power dissipation of the chip, P , and all the thermal resistance between the chip and the air, R_{total}

$$\text{(Eq. 1.)} \quad T_{\text{chip/case}} (^{\circ}\text{C}) = T_{\text{air}} + (P \cdot R_{\text{total}})$$

The total resistance is the thermal resistance from the chip to the air and it is the sum of the thermal resistance of the various components that make up the assembly:

$$\text{(Eq. 2.)} \quad R_{\text{total}} (^{\circ}\text{C/W}) = R_{\text{chip-case}} + R_{\text{case-sink}} + R_{\text{sink-air}}$$

$R_{\text{chip-case}}$ is the thermal resistance of the package holding the chip, $R_{\text{sink-air}}$ is the thermal resistance of the heat sink to air interface. The $R_{\text{case-sink}}$ is equal to the thermal resistance of the 3M Thermally Conductive Adhesive Transfer Tape which bonds the package case to the heat sink, R_{adhesive} :

$$\text{(Eq. 3.)} \quad R_{\text{adhesive}} (^{\circ}\text{C/W}) = \frac{\text{thermal impedance } (^{\circ}\text{C in}^2/\text{W})}{\text{contact area (in}^2\text{)}}$$

As noted in equation 3, the resistance of the adhesive will be controlled by the inherent thermal impedance of the material divided by the area of the tape. Theoretically, the contact area equals the physical area of the tape utilized in making the bond; in practice one never gets 100% contact between the tape and the substrates, so some loss in thermal performance is expected relative to the theoretical maximum. Wet-out (percent contact) is optimized by using very flat substrates and applying the tape in the prescribed manner. In these examples we have arbitrarily chosen a percent wet-out. This wet-out percent should be estimated for each combination of substrates in each application.

Technical Bulletin

Heat Flow Calculation for 3M™ Thermally Conductive Tapes 9882, 9885, 9890

Example 1

Example 1 shows a typical calculation where the user knows the maximum operating temperature of the chip. In this example we have chosen a piece of 10 mil 3M™ Tape 9890, which has relatively high thermal impedance.

Known quantities:

$$T_{\text{air}} = 50^{\circ}\text{C}$$

$$R_{\text{chip-case}} = 1.75^{\circ}\text{C/W}$$

$$R_{\text{sink-air}} = 1.5^{\circ}\text{C/W}$$

Thermal impedance of 3M Tape = $0.9^{\circ}\text{C in}^2/\text{W}$, tape area is 0.75 in^2

Power dissipation of chip = 5W

Chip maximum operating temperature = 90°C

Calculations:

From equation 3, $R_{\text{adhesive}} = 0.9^{\circ}\text{C in}^2/\text{W} / 0.75 \text{ in}^2 = 1.2^{\circ}\text{C/W}$. Recall that one does not get 100% wet-out between the adhesive and the substrates, so let us bump this value up to 2.0°C/W (approximately 60% wet-out assumed).

$$\text{From equation 2, } R_{\text{total}} = R_{\text{chip-air}} = 1.75 + 2.0 + 1.5 = 5.25^{\circ}\text{C/W}$$

So we can now calculate the chip operating temperature from equation 1.

$$T_{\text{chip}} = 50^{\circ}\text{C} + (5\text{W} \cdot 5.25^{\circ}\text{C/W}) = 50^{\circ}\text{C} + 26.25^{\circ}\text{C} = 76.25^{\circ}\text{C}$$

We can see that the calculated temperature of the chip surface (76.25°C) is less than the recommended operating temperature of the chip (90°C). If, on the other hand, the power dissipation for this chip were 10 W, our calculation would be:

$$T_{\text{chip}} = 50^{\circ}\text{C} + (10\text{W} \cdot 5.25^{\circ}\text{C/W}) = 50^{\circ}\text{C} + 52.5^{\circ}\text{C} = 102.5^{\circ}\text{C}$$

i.e. and this chip would run too hot in this design.

Technical Bulletin

Heat Flow Calculation for 3M™ Thermally Conductive Tapes 9882, 9885, 9890

Example 2

Example 2 shows a typical calculation where the user has been provided the maximum operating temperature of the case by the manufacturer. In this example we have chosen a piece of 2 mil 3M™ Tape 9882, which has relatively low thermal impedance. In this example there is no $R_{\text{chip-case}}$ in the calculation. The power dissipation of this chip is 10 W.

Now equation 1 can be written as: $T_{\text{case}} = T_{\text{air}} + (P \cdot R_{\text{total}})$

And equation 2 is given as: $R_{\text{total}} = R_{\text{case-sink}} + R_{\text{sink-air}}$

As before the $R_{\text{case-sink}}$ is equal to R_{adhesive} given in equation 3 above.

Known quantities:

$$T_{\text{air}} = 50^{\circ}\text{C}$$

$$R_{\text{sink-air}} = 1.5^{\circ}\text{C/W}$$

Thermal impedance of tape = $0.2^{\circ}\text{C in}^2/\text{W}$, tape area is 0.75 in^2

Power dissipation of chip = 10W

Maximum case temperature = 80°C

Calculations:

From equation 3, $R_{\text{adhesive}} = 0.2^{\circ}\text{C in}^2/\text{W} / 0.75 \text{ in}^2 = 0.27^{\circ}\text{C/W}$. Recall that one does not get 100% wet-out between the adhesive and the substrates, so let us bump this value up to 0.6°C/W (approximately 50% wet-out assumed; the thinner the tape, the more difficult it is to obtain complete wet out of the substrate.).

$$\text{From modified equation 2, } R_{\text{total}} = R_{\text{case-air}} = 0.6 + 1.5 = 2.1^{\circ}\text{C/W}$$

So we can now calculate the chip operating temperature from equation 1.

$$T_{\text{case}} = 50^{\circ}\text{C} + (10\text{W} \cdot 2.1^{\circ}\text{C/W}) = 50^{\circ}\text{C} + 21^{\circ}\text{C} = 71^{\circ}\text{C}$$

We see in example 2 with the thin tape 9882 the case temperature is below the specified maximum.

Technical Bulletin

Heat Flow Calculation for 3M™ Thermally Conductive Tapes 9882, 9885, 9890

Customer Worksheet:

Information Required (units):

| | |
|---|--|
| T _{air} - typical expected air temperature in the device (°C) | |
| Information from Material Suppliers: | |
| R _{chip-case} (if needed) (°C/W) | |
| R _{sink-air} (°C/W) | |
| P, power dissipation of chip (W) | |
| Chip maximum operating temperature (°C) or | |
| Maximum case temperature (°C) | |
| Thermal impedance of 3M™ Tapes (see product data page for most up-to-date values) | |
| Tape 9882 = 0.2°C in ² /W | |
| Tape 9885 = 0.5°C in ² /W | |
| Tape 9890 = 0.9°C in ² /W | |

1. Calculate R_{adhesive}:

$$R_{\text{adhesive}} = (\text{Thermal impedance of 3M tape/area of tape}) / \text{wet out \% estimate}$$

$$\text{_____ (°C/W)} = (\text{_____} / \text{_____}) / \text{_____}$$

2. Calculate R_{total} from equation 2:

$$R_{\text{total}} = R_{\text{chip-case}} (\text{if applicable}) + R_{\text{adhesive}} + R_{\text{sink-air}}$$

$$\text{_____ (°C/W)} = \text{_____} + \text{_____} + \text{_____}$$

3. Calculate the chip or case temperature:

$$T_{\text{chip or case}} = T_{\text{air}} + (P \cdot R_{\text{total}})$$

$$\text{_____ (°C)} = \text{_____} + (\text{_____} \times \text{_____})$$

4. Compare this calculated chip/case temperature with the chip manufacturer's recommendations.

Technical Bulletin

Heat Flow Calculation for 3M™ Thermally Conductive Tapes 9882, 9885, 9890

For Additional Information

To request additional product information or to arrange for sales assistance, call toll free 1-800-362-3550 or visit www.3M.com/conductives. Address correspondence to: 3M Engineered Adhesives Division, 3M Center, Building 220-7E-01, St. Paul, MN 55144-1000. Our fax number is 651-733-9175. In Canada, phone: 1-800-364-3577. In Puerto Rico, phone: 1-787-750-3000. In Mexico, phone: 52-70-04-00.

Important Notice

3M MAKES NO WARRANTIES, EXPRESS OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. User is responsible for determining whether the 3M product is fit for a particular purpose and suitable for user's method of application. Please remember that many factors can affect the use and performance of a 3M product in a particular application. The materials to be bonded with the product, the surface preparation of those materials, the product selected for use, the conditions in which the product is used, and the time and environmental conditions in which the product is expected to perform are among the many factors that can affect the use and performance of a 3M product. Given the variety of factors that can affect the use and performance of a 3M product, some of which are uniquely within the user's knowledge and control, it is essential that the user evaluate the 3M product to determine whether it is fit for a particular purpose and suitable for the user's method of application.

Limitation of Remedies and Liability

If the 3M product is proved to be defective, THE EXCLUSIVE REMEDY, AT 3M'S OPTION, SHALL BE TO REFUND THE PURCHASE PRICE OF OR TO REPAIR OR REPLACE THE DEFECTIVE 3M PRODUCT. 3M shall not otherwise be liable for loss or damages, whether direct, indirect, special, incidental, or consequential, regardless of the legal theory asserted, including, but not limited to, contract, negligence, warranty, or strict liability.

ISO 9002

This Engineered Adhesives Division product was manufactured under a 3M quality system registered to ISO 9002 standards.



Engineered Adhesives Division

3M Center, Building 220-7E-01
St. Paul, MN 55144-1000



Recycled Paper
40% pre-consumer
10% post-consumer

Printed in U.S.A.
©3M 2001 70-0709-3713-4 (7/01)

Mouser Electronics

Authorized Distributor

Click to View Pricing, Inventory, Delivery & Lifecycle Information:

3M:

9885 7000048857