SMD Resistor Thermal Analysis

The ability of a surface mount resistor to dissipate a given amount of power is ultimately limited by the temperature of the active resistor film. Assuming that the effects of convection and radiation are negligible, this film temperature is determined by the accumulation of increases in temperature due to conduction through each thermal impedance between the film and the ultimate "perfect heatsink." This relationship is shown in the block diagram titled "Figure 1." A typical example of this relationship applied to a surface mount resistor is shown in "Figure 2." A detailed analysis of this example and some comments on the extension of the model to the generic problem follow.

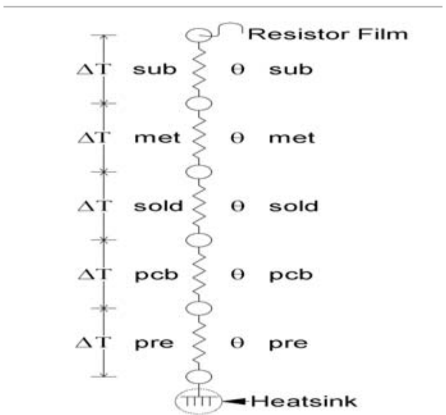

Figure 1

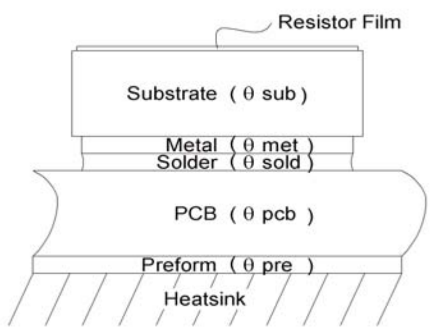

Figure 2

Figure 2 depicts a typical mounting design for a surface mount resistor. The resistor is soldered to a PC board using Sn62 solder. The PC board has copper traces and a land area for the ground terminal of the resistor that is populated with an array of filled vias. The density of this array is designed at the maximum permitted by the design rules, for the associated PC board manufacturing process, to minimize the thermal impedance of the area under the resistor. Finally, the PC board is mounted to a heat sink using a thermally conducting preform. Often the preform is replaced by a solder joint, but the issues are the same. The heatsink in this example is assumed to be ideal (i.e. an infinite quantity of thermal flux can be absorbed without an increase in temperature).
In an actual heat sink there will be a thermal gradient around the area of flux entrance, but here this effect is assumed negligible due to the fact that the thermal resistance of the PC board is typically a minimum of an order of magnitude higher than that of the heatsink.

Since only thermal conduction is considered, the thermal impedance from the film to the heatsink is the linear combination of the thermal impedance of each layer of the composite structure. This can be represented as:

$$\theta tot := \theta sub + \theta met + \theta sold + \theta pcb + \theta pre$$

Because the resistor is typically supplied as a component to the manufacturer of the circuit it is convenient to separate the calculation at the solder to chip interface. The merit of this approach will be readily apparent in what follows.

The thermal impedance of the resistor can then be represented by:

$$\theta res := \theta sub + \theta met$$

For this example we will assume that the resistor substrate and metal thermal impedances are:

$$\theta met \equiv .2 \qquad \theta sub \equiv 1.2$$

DERATING CURVE:

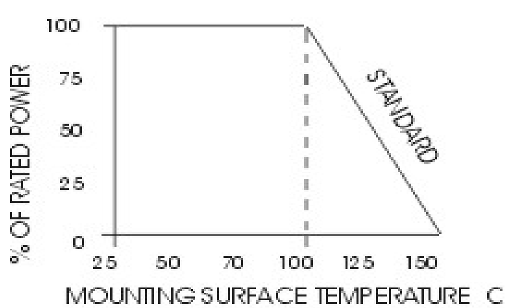

FIGURE 3

Assume in this case that the maximum desired film temperature is 250°C and that the manufacturer specifies a derating curve as shown in "Figure 3." Using the 100°C 100% maximum operating temperature point as the reference at the plane of the solder joint, we can calculate the maximum power dissipated as:

$$Pres\_max := \frac{250 - 100}{\theta res}$$

$$Pres\_max = 107.1$$

Using similar logic the maximum power that can be conducted through the PC board can be calculated. Continuing the example of "Figure 2;" assuming a thermal conductivity of the PC board, heatsink attachment layer and solder layer as follows:

$$\theta pcb \equiv 2 \qquad \theta pre \equiv .2 \qquad \theta sold \equiv .1$$

And fixing the solder temperature at 100°C as before with the heatsink constrained to a temperature of 65°C the maximum power conducted is:

$$Ppc\_max \equiv \frac{100 - 65}{\theta pcb + \theta pre + \theta sold} \qquad Ppc\_max = 15.2$$

Using the solder joint temperature as a reference clearly separates the problem into two manageable parts. The power handling capability of the combined assembly is, of course, the lower of the two calculated values. Therefore, in this example the maximum power that can be dissipated is 15 watts.