AN23

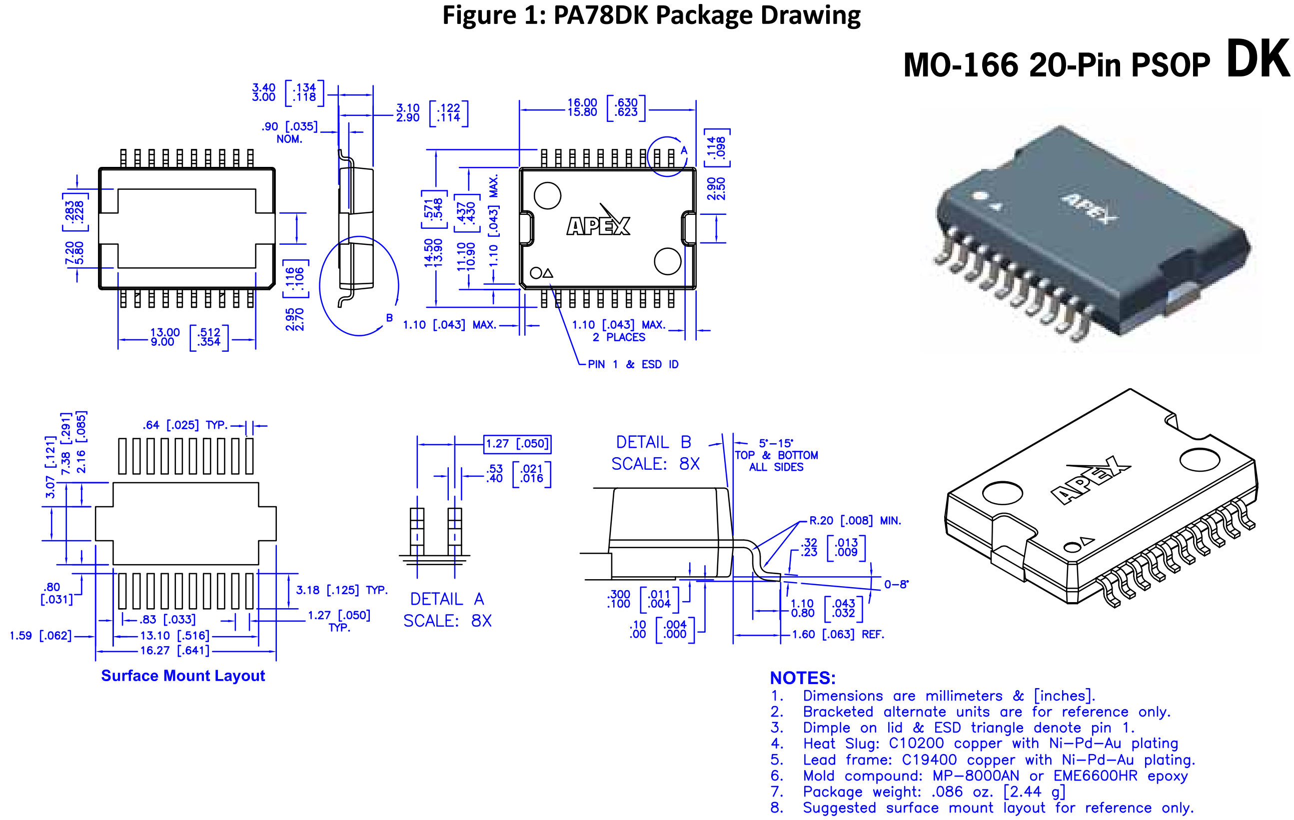
Heat Sinking Options and Techniques for Thermally Enhanced SMT Packges

SUMMARY

With the migration of certain Apex Microtechnology power amplifier and PWM amplifier products from the EU and CX pin-through-hole packages to the surface mount DK package, customers may find the heat sinking requirements to be more challenging. For example, the use of just any heatsink with a flat surface is no longer suitable, as well as simply picking different sizes for different thermal conductivity.

This application note is intended to illustrate that by using different thermal techniques, the same heat sinking results can be achieved, even with the DK and other surface mount packages. For this exercise, the PA78DK power amplifier will be used. The PA78DK package drawing is shown in Figure 1. Computer simulated thermal resistance data is provided by using different thermal techniques.

Figure 1: PA78DK Package Drawing



USING PC BOARD AS A HEATSINK

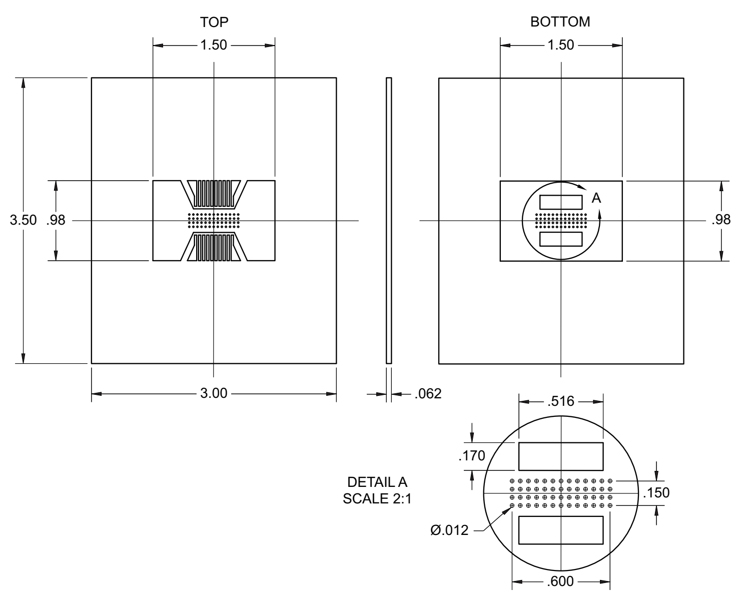
All Apex Microtechnology thermally enhanced SMT packages that feature Apex Microtechnology® technology have a heat slug on which the power chip is attached. The power chip is the heat source from which the heat is transferred to the heat slug. This heat must be transferred from the heat slug to the surrounding air.

In principle, if the heat slug is soldered onto the PC board so that the contact area's copper is made very large and very thick, it essentially serves as a heatsink. In practicality, a user has only limited PC board space to allow for such a heat sinking technique. With a one square inch copper area on a 1 oz. copper PC board, it will allow a junction-to-air thermal resistance of 27 °C/W with an air flow of 600 lfpm (linear foot per minute). With no air flow, the thermal resistance goes up to 60 °C/W, junction-to-air.

ADD THERMAL VIAS

Thermal vias can be added underneath the heat slug to provide an additional path to carry the heat away from the top side PC board's copper to the bottom side's copper. With a 4 x13 pattern of thermal vias, as shown in Figure 2, and about the same one square inch copper area at the bottom, the junction-to-air thermal resistance can be further reduced down to 24 °C/W at 600 lfpm air flow, or to 56 °C/W at still air. Multi-layer coppers can also be used, such as ground planes and power supply planes, to reduce thermal resistance even more.

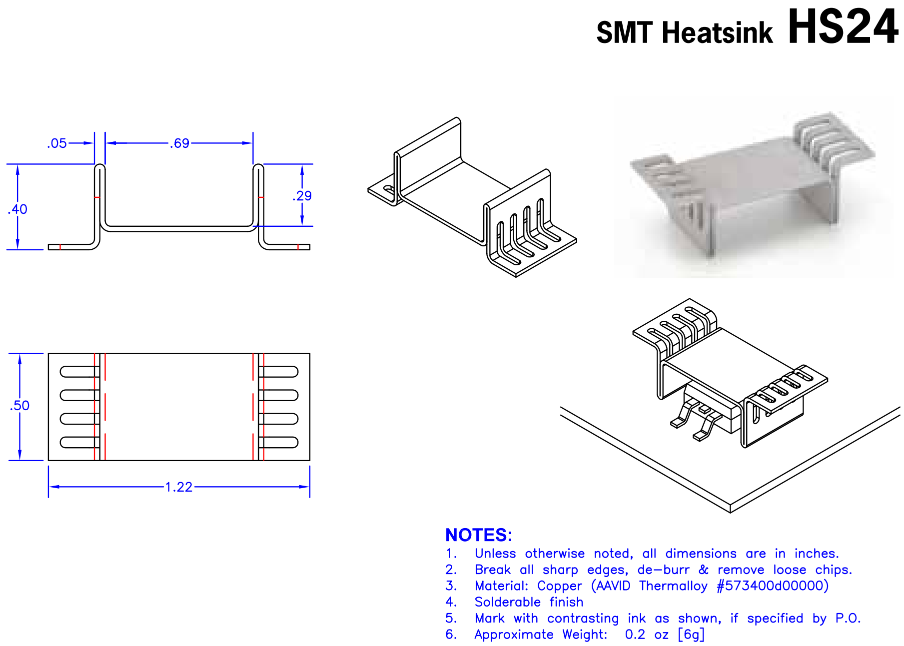
Figure 2: Thermal Vias



USE A BRIDGE HEATSINK

A more powerful way to reduce the thermal resistance than adding thermal vias is to use a bridge heatsink. The 0.2 oz. heatsink, measuring 0.5" x 1.22" x 0.4", shown in Figure 3, will reduce the thermal resistance down to 16 °C/W and 50 °C/W respectively at 600 lfpm and still air. This option does not require the drilling of holes for thermal vias or the addition of a bottom side copper for improved thermal conductivity. Just solder this bridge heatsink on the top side of the PC board's copper so that it sits over the PA78DK, as shown in Figure 3.

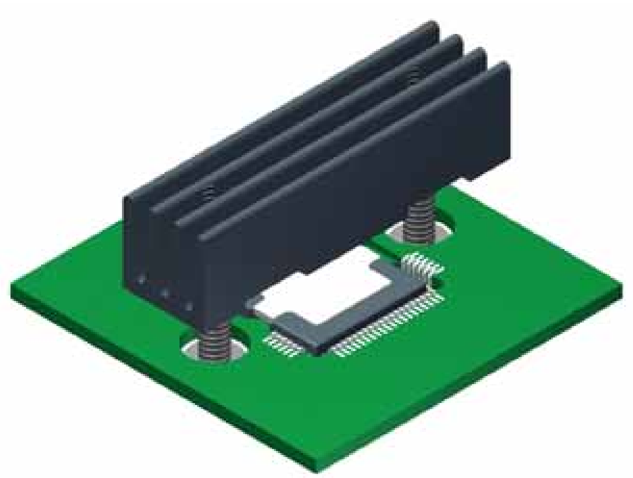
Figure 3: SMT Bridge Heatsink



CUT A SQUARE HOLE IN THE PC BOARD

To get the most power out of a surface mount package, the package's heat slug must be in direct contact with the heatsink. Since the heat slugs of such enhanced SMT packages are on the bottom side of the packages, the only way to create contact is by cutting a square hole in the PC board. The SMT package can then be soldered onto the other side of the PC board, as illustrated in Figure 4. A small custom designed heatsink, similar to the HS33, which measures 0.4" x 0.4" x 1.50", will reduce a PA78DK's junction-to-air thermal resistance to 14 °C/W with an air flow of 600 lfpm.

Figure 4: Heat Sink Technique By Direct Surface Contact To SMT Package's Heat Slug



This direct contact technique allows the use of much larger heatsinks, and the conventional way of selecting the proper heat sink can be employed for a specified junction-to-air thermal resistance or a specified internal power dissipation for the amplifier under consideration. Use the following thermo-electric formula:

$$Tj = Pd(Rjc + Rcs + Rsa) + Ta$$

Where:

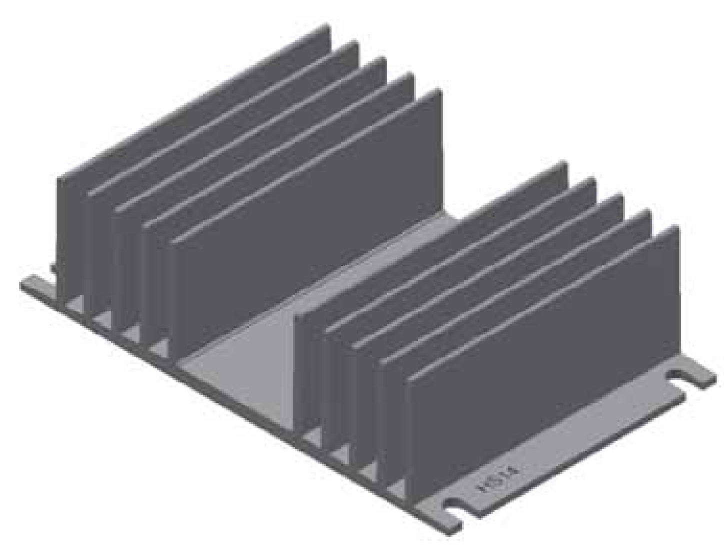
Tj: is the amplifier's junction temperature, which is specified in the PA78DK data sheet as 150 °C maximum. The recommended temperature of 125 °C allows for safety margin and for better mean-time-to-failure.
Pd: is the amplifier's internal power dissipation, determined by the user.
Rjc: is the amplifier's junction-to-case thermal resistance, specified in the PA78DK data sheet as 8.3 °C/W
Rcs: is the thermal washer or thermal grease's case-to-heat sink thermal resistance, which is ~1 °C/W
Rsa: is the heatsink-to-air thermal resistance to be determined
Ta: is the ambient temperature, specified by the user

For example, specifying Pd = 9W and Ta = 30 °C, then:

$$125°C = 9W\left(8.3\frac{°C}{W} + 1\frac{°C}{W} + Rsa\right) + 30°C$$

Calculate for Rsa and the result is Rsa = 1.26 °C/W. Looking through the accessories section of the Apex Microtechnology V15 Data Book, the HS14 heatsink that is shown in Figure 5 is rated 1.04 °C/W with an air flow of 200 lfpm.

Figure 5: HS14, 3" x 4.8" x 1.3", 1.04 °C/W with 200 lfpm air flow



GRAPHICAL REPRESENTATIONS

As shown in Figure 6, computerized thermal simulations are used to plot the PA78DK's power versus thermal resistance-to-air for the four cases described above; and plotted in Figure 7, the PA78DK's power versus air flow.

Figure 6: Stimulated PA78DK Power vs. Thermal Resistance to Air for Four Cases

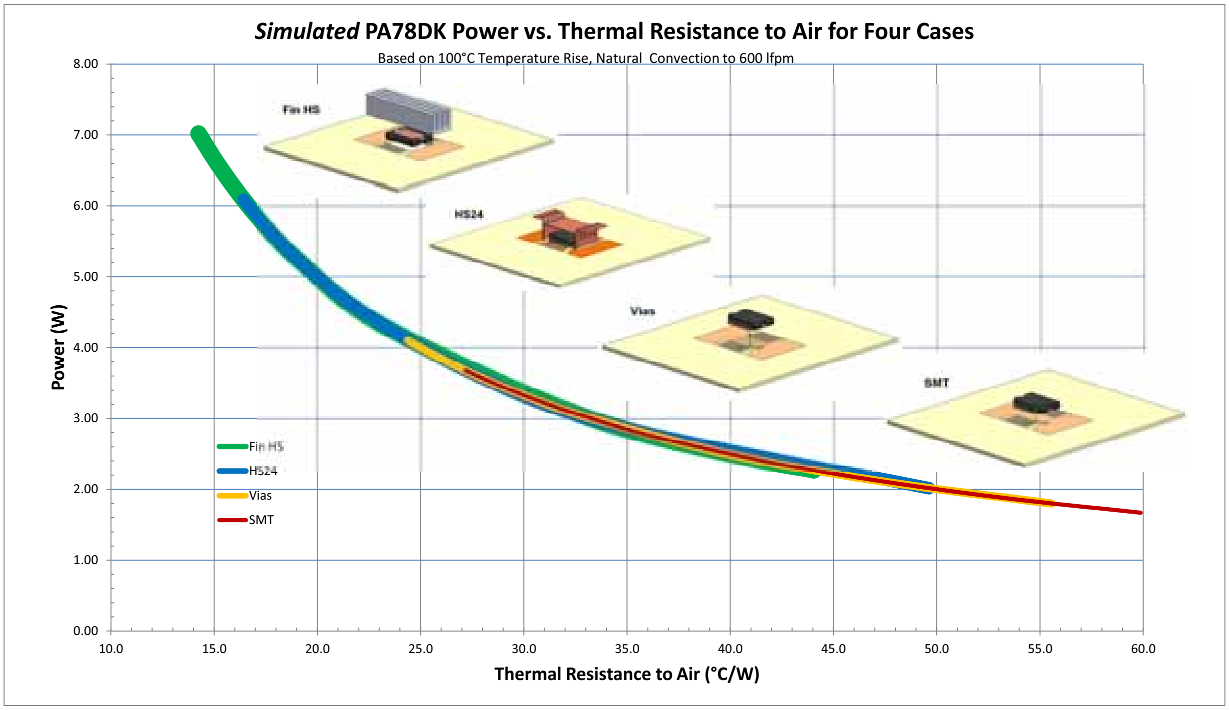
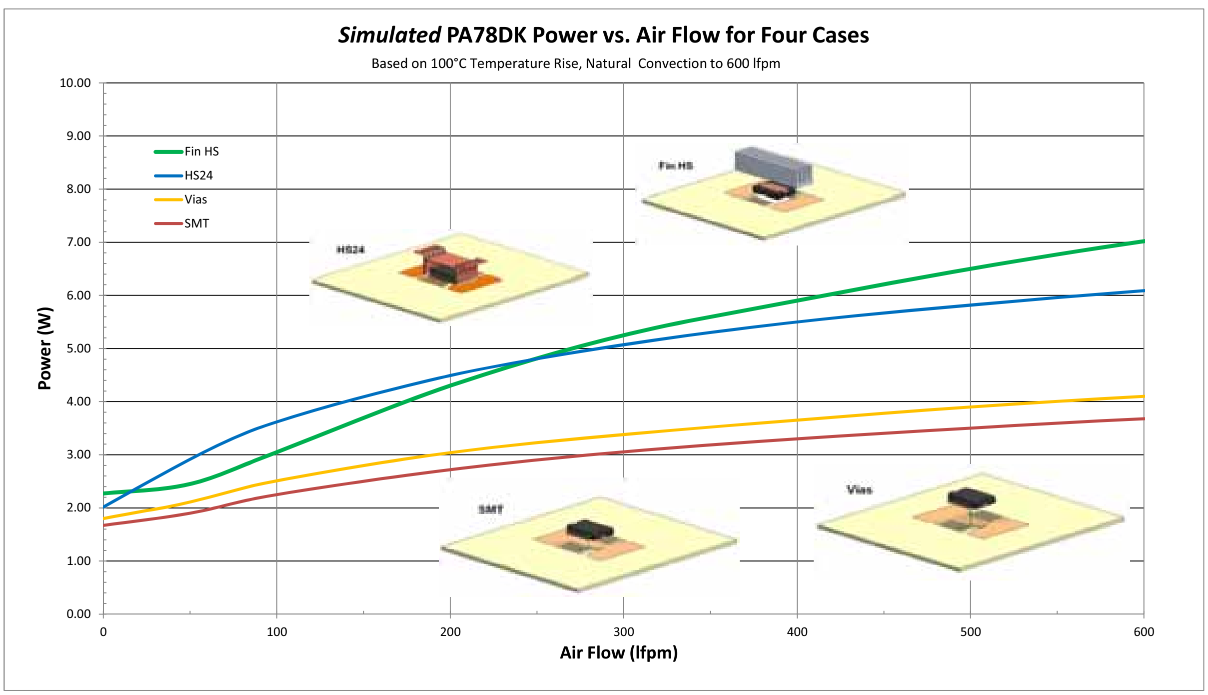


Figure 7: Stimulated PA78DK Power vs. Air Flow for Four Cases



COMPRESSIBLE THERMAL WASHERS

It has long been recommended not to use compressible thermal washers for power products that utilize hybrid technologies where a beryllia (BeO) substrate is employed. These are silicon rubber based pads such as Silpad. The amount of compressibility in a washer over 2 mil thick can lead to header flexing, which can crack the BeO substrate.

However, all Apex Microtechnology power products in thermally enhanced SMT packages are single chip ICs with no BeO substrates. Because these IC's are soldered onto a PC board, where the heatsink is mechanically mounted onto the board, it is very difficult to keep the IC's heat slug, the PC board, and the heatsink - all parallel to one another for a perfect match. Compressible thermal washers are actually recommended in such conditions because it has the capability to fill micro gaps to achieve better thermal conductivity.

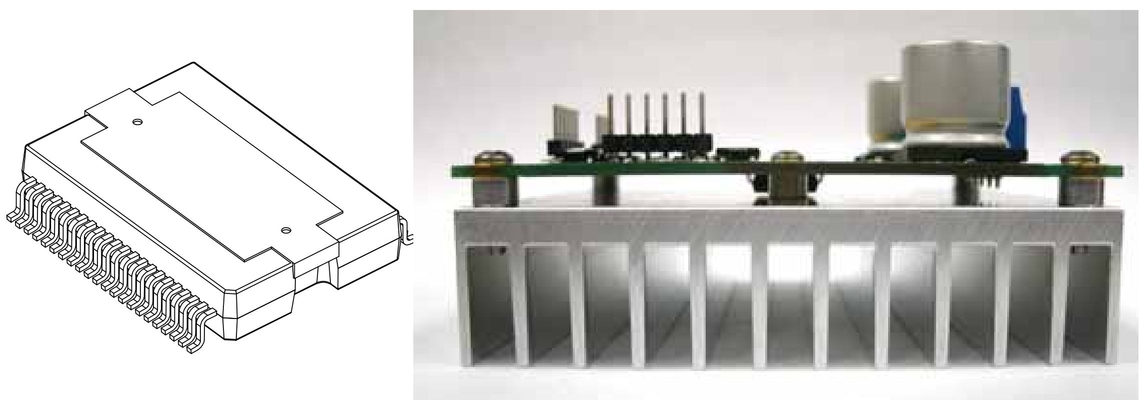
To locate proper compressible thermal washers, there are a number of manufacturers. One such company is Bergquist at http://www.bergquistcompany.com/.

MOVE A SMT PACKAGE'S HEAT SLUG TO THE TOP SURFACE

If an application requires medium power dissipation and the PC board is good enough to serve as heatsink, or even with the addition of a bridge heatsink, it is preferable to have a SMT's heat slug on the bottom so the package can be soldered directly onto the PC board, just like all other SMT components on the same PC board. But if an external heatsink is being used for high power applications, most users prefer the heat slug on the SMT package's top surface so a hole does not need to be cut through the PC board as discussed earlier.

There are no technical limitations to moving a SMT's heat slug to the top surface. All it takes is to form the I/O pins differently. Figure 8 shows such a SMT package with an external heat sink mounted.

Figure 8: Heat slug at top of SMT package



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