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The Thermal Side of 64-Bit Processing

The newest workstations and servers, targeting computationally-intensive applications and large-scale database management, use 64-bit microprocessors and provide the next generation of computing power. Introductory level, 400 MHz 64-bit processors dissipate 30 watts of heat (only the latest Pentium II processor [the 400 MHz Xeon] generates as much), and a workstation may have as many as four processors. More than ever before, system reliability depends on keeping these microprocessors cool. To ensure system reliability, Digital Equipment's AlphaServer includes sensors for system temperature and fan failure, which shut the system down in case of malfunction. Silicon Graphics' Origin workstations include a redundant cooling system.

These workstations and servers use expensive, custom-engineered heat sinks and large, variable-speed fans for cooling. These leading-edge products easily absorb the higher cost of a custom thermal solution. Because servers and workstation computers are often remote from the user, the noise associated with the large fans is not a major problem. When 64-bit architecture gets into desktop applications produced at volumes approaching three million units per year, however, system designers will need to address both of these issues.

From Custom-Machined Heat Sinks to a Complete Heat Path

Today's 64-bit systems use heat sinks with very dense fin patterns to get the most out of the available airflow where the processor is located. To achieve tightly spaced fins, the heat sink frequently is made by machining the fins out of a solid block. This allows optimum fin thickness that often is too thin for extrusion processes. Further machining provides a precision surface to mount against the IC, ensuring good contact to the microprocessor's heat-transfer plate. This extensive machining increases the cost of the heat sinks by 30% or more.

To reduce costs in higher volume systems, an extruded heat sink placed in an area inside of the system that has greater air speed and that is directly above the microprocessor will meet the performance as less surface area is required. Using a heat pipe to transfer the heat to the extruded heat sink and a mounting block that connects the heat pipe to the microprocessor can reduce cost in some applications. The thermal interfaces between these sub-components are critical for meeting thermal requirements of the microprocessor. The heat-sink design must take into consideration the boundary conditions inside the system. Since extruded heat sinks lack the surface area of the more expensive machined heat sinks, they need a way to ensure good contact with the microprocessor's heat-transfer plate, minimizing the interface resistance. Phase-change interface materials may provide this function without adding significantly to the cost. In addition, heat sinks provide high-frequency shielding in current 64-bit designs. To maintain this critical function, the entire heat path should be made with non-anodized finishes.

Ease-of-assembly also becomes an issue with higher-volume, lower-priced applications. Current 64-bit systems use standard mechanical hardware to attach the heat sink to the microprocessor. As in current 32-bit desktop systems, 64-bit systems will most likely use application-specific clips that enable rapid assembly and provide robust attachment in adverse conditions.

Engineered Airflow and Acoustics

To minimize the size of the fan required (and the cost of the fan itself), 64-bit desktop designers will need to optimize component placement and the airflow path. One solution may be to put all the hot components together and then concentrate the airflow in that area. The heated air from this area can then be ducted out so it does not heat up other components in the system. Baffles and ducting to channel airflow where it is needed will become more common with the next generation of desktop systems.

The noise generated by the airflow needed to cool a device at 30 watts (or more) may be more than the typical desktop user is willing to put up with. The designer will need to add loudness to his design criteria. Acoustical solutions may include sound insulation and dampening.

IC Manufacturing Techniques May Play a Thermal Role

Silicon-on-insulator and copper-bonded-silicon technologies may offer some power efficiencies in later generations of 64-bit processors. Most likely, however, the IC manufacturers will take advantage of the benefits of this technology to increase the speed of the microprocessor, which will result in the same cooling requirements. These higher power chips need heat pipes embedded in the heat-sink base to help spread the heat throughout the heat sink. If a manufacturer chooses to reduce the overall power consumption at the same frequency with new silicon interconnect methods, the lower power chip will still need a conventional heat sink that is optimized on system boundary conditions.

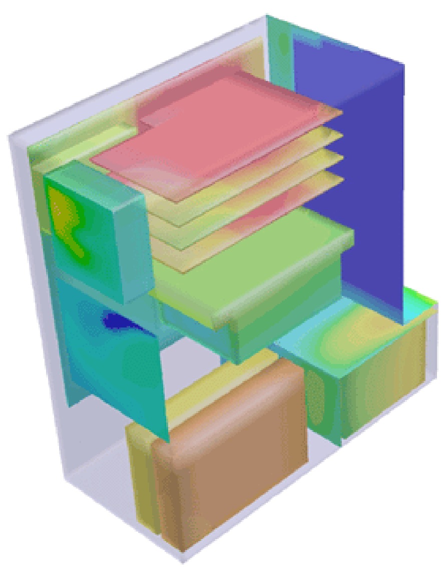
Where to Find Thermal Solutions

Developing the optimum thermal solution around a 64-bit system may seem like a daunting task. Tools exist today that allow the designer to optimize around current generation microprocessors as well as processors for years to come. Thermal modeling programs that use computational fluid dynamics help the designer optimize component placement and system airflow. Heat sink manufacturers, like Aavid Thermalloy, use thermal modeling to help design custom heat sinks for one or more hot components. Heat sink manufacturers will also design custom attachment systems and thermal interface mechanisms to optimize both heat transfer and assembly time. Fan manufacturers have developed variable-speed fans, which provide only the cooling required by the computing demand on the microprocessor. They may also be able to assist with acoustical engineering.

Conclusion

Often industrial applications expose the electronics to harsh environments. Dust, machining residue, or even corrosive fumes exist in many industrial environments. To protect the electronics in these applications, they must be enclosed in a sealed chassis with no airflow. In these applications, a thin fan mounted directly on top of the IC is often the best miniature cooling solution available.

Low-profile fan heat sinks can help solve these cooling problems created by space, cost, and environmental constraints. They are small, some as small as 7 mm (0.3 inch), making them compatible with the CompactPCI limit of 7 mm or less. The small size does not compromise their reliability. They are available with long-lived, ball-bearing fans, with a typical lifetime of three to five years. Less reliable fans are available so it is important to select a vendor that offers life-testing data. These unique solutions can be attached directly to an IC, allowing newer, more powerful boards, which require increased cooling, to fit into CompactPCI spacing.



A CFD analysis shows how system level design is paramount for optimizing product performance and packaging since considerable heat needs to be removed from the air stream for 64 bit processors.