

Processor Cooling

By Pedro Ojeda

As Moore's Law continues to hold true for cutting edge processors, the challenges facing today's electronics manufacturers are also on the rise. Thermal considerations, specifically, are becoming more of an engineering challenge and are growing in complexity, variety and cost. Addressing thermal solutions for up-and-coming processors mark a clear distinction from prior thermal considerations. The days of a simple solutions like aluminum extrusion and fan combination are numbered as the market trend moves towards a decreasing footprint, greater levels of thermal energy and a need for more sophisticated thermal solutions.

Desktops

Current, high-end, desktop computers, comprising 37% of processor sales, clearly indicate a shift in desktop physical dimensions. Large manufacturers like Dell, Hewlett Packard and IBM have all introduced desktops that are hybrids of desktops and laptops. These "mini-desktops" are up to 50% smaller than the traditional mid size case. The use of a higher end processor in these enclosures can increase the case temperature considerably, resulting in a greater thermal load on the processor.



Dell Optiplex Series

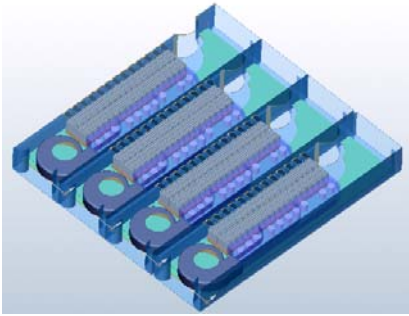
Consequently, copper solutions with a greater number of cooling fins are becoming more common in these applications. Increased pressure requirements are an inherent problem in heat sinks with greater fin densities. Therefore, specially designed fans and blowers are often the solution to address greater pressure drops across the heat sink. Ducting or channels are also incorporated to address greater thermal concentrations throughout the chassis.

Servers

Thermal considerations in server applications are often more challenging than those found in the desktop world. Although, there is generally more air volume for greater heat dissipation in servers, this is often offset by a greater amount of heat generated by multiple processors operating simultaneously. It is not uncommon to find an increase in thermal output of 400 to 600% compared to that of a high-end desktop. Thermal management in servers differs from desktops in another fundamental way. Where desktops applications are primarily concerned with heat dissipation at the processor level, server thermal management can range over the entire server system. The densely packed

configuration of today's server technology introduces added thermal energy and results in greater system pressure.

Thermal solutions developed to address these applications are often more complex and costly. In addition to providing greater airflow throughout the system against greater system pressures, the thermal solution is also bound by power consumption constraints and redundancy and reliability requirements.



4-Model Blower Configuration

It is common to see trays containing multiple blowers or a series of custom fan or blower configurations specifically designed to address system pressure and airflow requirements. Multiple air-moving devices also provide the added benefit of redundancy. In server applications, redundancy is important in that the system can continue to operate, without interruption, despite a failed component. Reliability concerns lead some manufacturers to explore passive solutions. No moving parts in passive solutions decreases the likelihood of failure and can result in reduced cost at the processor level. From a system level, however, passive thermal solutions generally require air-moving devices with greater output airflow and pressure at added expense.



DC Fan Tray

The amount of power needed to energize thermal solutions in server applications also presents a unique set of challenges. Server manufacturers have addressed power consumption concerns by increasing input DC voltages to 24Vdc, 36Vdc and higher voltages. The net effect has been to reduce the amount of current required to produce the same power when compared to a 12Vdc system. Certifying agencies like UL and TUV have stiffer requirements for systems operating above 42Vdc. In addition, consumer and regulatory agencies are also placing more emphasis on power efficiency thus requiring

manufacturers to redesign or incorporate more efficient designs in air-moving devices. These requirements add more features and greater cost to server thermal solutions.

Thermal Solutions Today

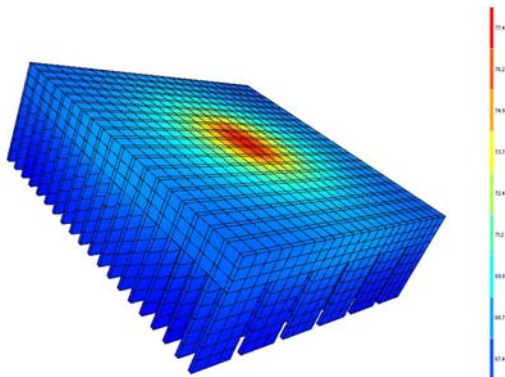
Heat sinks

Thermal solutions available today are often a hybrid of multiple technologies. In both desktop and server applications it is evident that aluminum and copper combinations play a growing role in addressing processor heat dissipation requirements. Geometric patterns for fins are regularly incorporated to optimize thermal saturation or to direct airflow across the heat sink. Folded fin technology is another method used to achieve greater fin



360° Radial Fin Design

density. Processor manufacturers like Intel® and AMD™ place constraints on the physical dimensions and weight of certified thermal solutions. The constraints serve as a guideline for developing thermal solutions but also serve as a limit on the amount of fins and fin area for heat sink.



Heat Sink Thermal Distribution

Fans

Thermal performance requirements for current processors dictate that thermal resistances for thermal solutions range from .32 to .35 °C/ Watt. Heat sinks play a critical role in absorbing thermal energy from the processor while fans are necessary to dissipate heat from the heat sink and out of the enclosure. Greater fin densities make for greater heat absorption but result in greater pressure drops along the heat sink. To meet today's thermal resistance requirements fans are designed to operate at speeds upward of 4000RPM to achieve the necessary airflow and pressure. Fan designers are also

introducing optimized blade geometries that optimize fan efficiencies, increase airflow and greater noise reduction. Oversized fans are also used to reduce fan speeds while maintaining airflow specifications. Oversized fans at lower speeds also assist in reducing fan noise when compared to smaller faster fans.

Blowers

Blowers are used in applications where pressure concerns exceed the capacity of fans. In computer electronics, blowers generally operate in environments requiring pressures less than 1 inch of water. Multiple blowers are often used where greater system pressures are required. The electronics industry is placing a greater emphasis on reducing the size of blowers while increasing performance.

Up and Coming Thermal Solutions

Many of the solutions for tomorrow's applications are squarely based on technologies available today. These technologies, in some cases, are not widespread but are gaining more momentum.

Heat Pipes/ Vapor Chambers

These devices are typically cylindrical copper tubes with an internal wicking structure, working fluid or powdered that is used to conduct heat from the processor to a series of cooling fins. Cost has been the major barrier for this technology to enter into the desktop and server market until recently. Heat pipes specifically, are becoming more visible as thermal solutions and are expected to play a significant role in thermal management solutions for subsequent processors.

Thermo Electric Cooling

Thermo-electric cooling devices can dissipate wattages in excess of 200W. TEC's that are currently in development hold the promise of 4X improvement in efficiency. Advancements in materials and manufacturing may enable these solutions to break into the desktop and servers thermal solutions market. Currently, TEC's are cost prohibitive for the PC market.

As computer technology continues to grow in complexity, performance and speed, the challenges facing thermal management are also on the rise. Several thermal solution technologies continue to evolve to address the continued demand for smaller, more efficient and cost effective thermal solutions.

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