BEATING THE HEAT

Simulation helps an electronic product operate safely at a higher ambient temperature.

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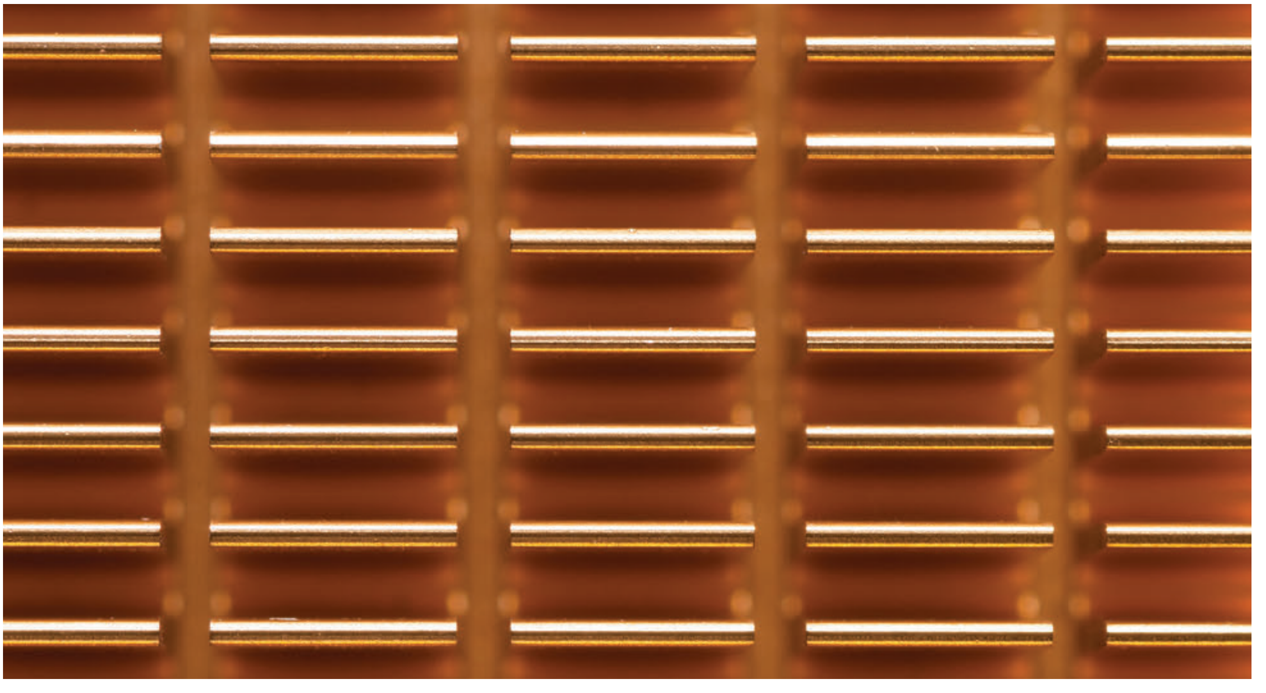

Electronic assemblies must dissipate thermal energy from components to prevent premature failure due to overheating. Radian Thermal Products specializes in designing and building innovative custom heat sink designs that help to solve thermal problems. Recently, a manufacturer of telecommunications products asked Radian to help cool a pluggable card that was overheating. Radian engineers simulated the design with ANSYS Icepak electronics cooling simulation software. Using simulation, the team discovered that the fin density on the heat sinks in the original design prevented air from reaching downstream components and that variations in component height reduced the effective thermal conductivity. Engineers redesigned the cooling system using a larger number of smaller heat sinks attached to single components. They employed the ANSYS Workbench parameter manager to optimize the number of fins, fin thicknesses and other design parameters. The optimized design operates safely at ambient temperatures that are 20 C higher than the original design.

ORIGINAL CONCEPT DESIGN

A manufacturer of telecommunications products designed a pluggable card with several integrated circuits and heat sinks that fit into an Advanced Telecommunications Computing Architecture (ATCA) rack mount chassis. Simulation showed that the heat sinks cooled the chips they were attached to, but other components experienced excessive temperatures. Radian engineers began addressing this issue by obtaining information from the manufacturer such as the space available for heat sinks,

ANSYS Icepak helps Radian to quickly and efficiently diagnose thermal management issues and generate optimized designs.

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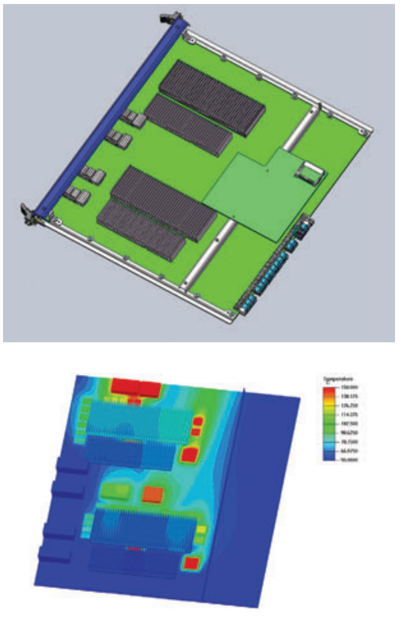
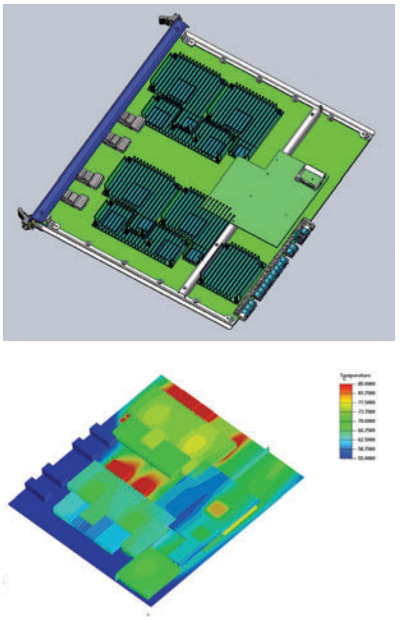


Original concept design and ANSYS Icepak simulation



Radian's redesign and simulation

dissipated power, power supply size, fan size and placement, target ambient temperature, attachment methods, and maximum allowable junction temperatures for the components. The maximum junction temperature is the highest internal temperature that a component is rated to withstand without damage. Traditionally, thermal management design is based on engineering experience and instinct. In the past, companies usually needed to build and test numerous prototype designs to understand and resolve thermal problems. Advanced simulation tools like ANSYS Icepak enable engineers to reduce costs and time to market by verifying a design's proof of concept with accurate thermal results prior to building a prototype. In this case, the manufacturer had already created a relatively simple heat-sink design and performed a thermal simulation with a non-ANSYS simulation tool. The simulation results showed that junction temperatures were too high but did not provide a clear path to resolve the thermal issues.

MODELING WITH ANSYS ICEPAK

Radian engineers are familiar with multiple thermal simulation tools but utilize ANSYS Icepak because of its powerful design optimization capabilities. The Workbench parameter manager makes it possible to run parametric studies and design of experiments. In addition, ANSYS DesignXplorer can be used with the parameter set to drive design of experiments, to carry out goal-driven optimization, and to perform Six Sigma analysis to investigate design robustness.

The manufacturer provided 3-D solid models of the original design to Radian engineers, who imported a mechanical computer-aided design (MCAD) model of the enclosure and an electronic computer-aided design (ECAD) model for the printed circuit boards into Icepak using CAD integration tools provided by the ANSYS Workbench environment. Engineers then created the simulation model geometry by dragging and dropping smart objects — such as fans, circuit boards, vents, openings, heat sinks and enclosures — into the imported geometry. They entered values to precisely match the geometric information, material properties and boundary conditions. Icepak generated a body-conformal mesh that represents the true shape of components and distributed the mesh appropriately to resolve fluid and thermal boundary layers. Radian customized the meshing parameters to refine the mesh and optimize the trade-off between computational cost and solution accuracy. ANSYS Icepak uses computational fluid dynamics (CFD) to determine the fluid flow and all modes of heat transfer — conduction, convection and radiation — in this case, for a steady-state thermal flow simulation. To reduce computational time, the team ran the solver in parallel on a multi-core machine. The solver yielded the fluid flow and heat transfer information for the entire simulation domain. The results were post-processed in ANSYS Icepak to visualize the airflow patterns and temperature distribution using velocity vector plots, temperature contours and fluid particle traces. Summary reports stated the calculated variable quantities. The post-processing capabilities available in ANSYS Icepak are critical to diagnose cooling performance.

OPTIMIZING THE DESIGN

Radian's simulation results were similar to the manufacturer's simulation and showed junction temperatures up to 150 C

MULTIPHYSICS SIMULATION OF A PRINTED CIRCUIT BOARD
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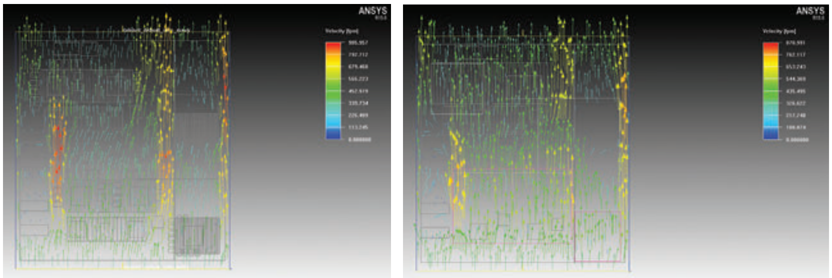
at an ambient temperature of 55 C. Based on these results, the board would need to be derated to an ambient temperature of 30 C. With this rating, the board could survive normal operating conditions in a telecommunications provider's central office but would likely fail if the ambient temperature rose due to a problem, such as an air conditioning outage. To enhance design robustness, the manufacturer wanted to ensure that the product could operate at an ambient temperature of 55 C.

The airflow patterns clearly showed that the original heat sinks were choking off the airflow from the fan and preventing air from reaching downstream components. Radian engineers addressed this problem by reducing the number of fins to promote airflow through the heat sink. To determine the optimum heat-sink design, Radian engineers used the Workbench parameter manager to run a parametric study of the



▲ Airflow for original (left) and redesigned card (right)

OPTIMIZATION IN ELECTRONICS THERMAL MANAGEMENT USING ANSYS ICEPAK AND ANSYS DESIGNXPLORER
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number of fins, fin thickness, fin height, heat-sink material and different base materials. The results showed, as expected, that the optimal design had fewer and thinner fins. The simulation results also showed that coplanarity issues resulted in poor heat transfer where heat sinks were connected to multiple components of varying heights. Radian engineers corrected this issue by designing separate heat sinks for each of the major heat dissipaters. The new design improved the bond between components and heat sinks, thereby promoting optimal heat transfer.

Radian engineers considered adding a heat pipe, which efficiently transfers heat from a hot spot to a heat sink located some distance away. A heat pipe contains a liquid that turns into vapor when it absorbs heat from a thermally conductive surface attached to a hot component. The vapor travels to the other end of the heat pipe, which is much cooler, and condenses back into a liquid. The liquid then returns to the hot interface through capillary action, and the cycle repeats. Simulation showed that the heat pipe provided further performance improvements. The Icepak model was updated, and a new simulation showed that the final design achieved a 65 C reduction in temperature in the hottest area on the board.

Radian's U.S.-based manufacturing facility provided initial prototype heat sinks within three days. The manufacturer performed final physical tests that matched the simulation results and accepted the Radian design. The product is now on the market with a maximum junction temperature of 85 C at 55 C ambient. Radian is manufacturing the production heat sinks in its Asia facilities. The thermal performance of the product has been verified in the field.

ANSYS Icepak helps Radian to quickly and efficiently diagnose thermal management issues and generate optimal designs. The manufacturer's proof-of-design tests have confirmed the accuracy of Radian's Icepak simulations within a 7 percent margin. These results would not have been possible without simulation.