Increasing Productivity and Revenue with Computational Applications

With computational applications based on highly accurate multiphysics models, everyone wins. Both the app developer and its end users can benefit from innovation with reduced risk while minimizing production costs — or by introducing an entirely new revenue stream.

by **JENNIFER SEGUI**

HeatSinkSim is a cutting-edge computational tool, created by the simulation specialists at AltaSim Technologies, that until recently would not have been possible to develop in a realistic, competitive timeframe. The application's user-friendly interface extends multiphysics modeling and virtual prototyping capabilities to any engineer interested in optimizing their heat sink designs for power electronics.

Relevant to any product development process or design task, simulation applications can help resolve workflow bottlenecks in large companies and provide custom design capabilities to small companies and startups, where it is often impractical to keep dedicated simulation engineers on staff.

"Whether you're at a large company or a startup, if you're going to change the future and dominate the marketplace, you need to replace traditional design tools with something that is different, predictive, and represents the real world. Multiphysics modeling and simulation applications, such as HeatSinkSim, will enable and set the pace for engineering innovation," explains Jeff Crompton, cofounder and principal at AltaSim.

With professional insight and examples, this article will equip you with practical guidelines, and the inspiration to move forward with a simulation-driven product design workflow that reduces your development costs and time to market.

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>
> — JEFF CROMPTON, PRINCIPAL AND COFOUNDER, ALTASIM TECHNOLOGIES

⇨ FROM DESIGN GOAL TO INNOVATIVE PRODUCT

The roadmap for integrating simulation into your product design workflow is straightforward with simulation applications, making expensive trial-and-error prototyping the primary design method of the past. To illustrate, let us consider common goals for heat sink design and optimization for power electronics, and the subsequent development and use of the HeatSinkSim app to meet and exceed those goals. Although you may not be working on heat sink design specifically, you can readily apply the methods and workflow described here to another product or process.

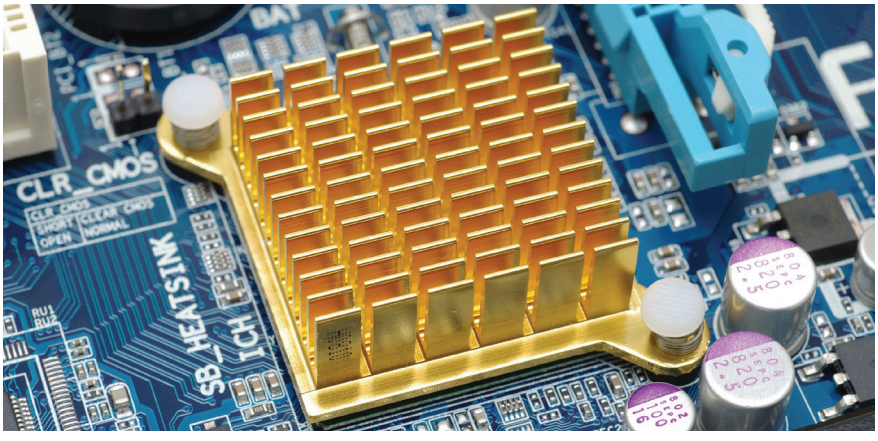

FIGURE 1. Vertical plate fin heat sink mounted on a PCB with power electronic components that drive critical continuous manufacturing operations.

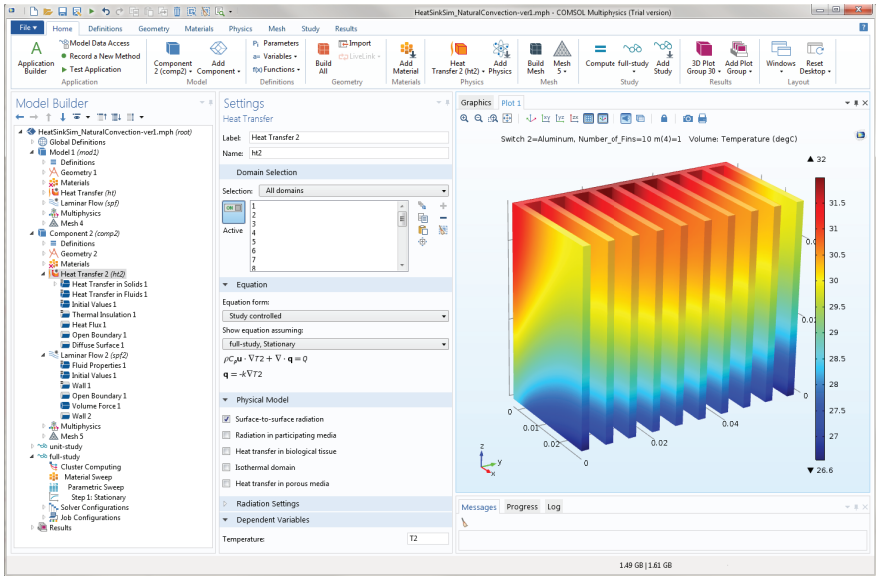

FIGURE 2. COMSOL Desktop showing the Model Builder through which you define your model geometry, materials, and physics. Then mesh your geometry, solve, and postprocess your results.

The overall objective in this example is the timely delivery of high quality products and services to market, through the reliable long-term operation of the power electronics that drive the automated manufacturing processes behind essentially all consumer goods. As higher production yields are required, increased performance demands of the electronics combined with their decreasing size results in higher power densities and operating temperatures, which can compromise extended operation.

To prevent higher operating temperatures from reducing the reliability of the control systems for manufacturing processes, the cooling of electronic components through passive heat dissipation and natural convection is necessary. Heat sinks are therefore integrated with the electronics on printed circuit boards (PCBs), as shown in Figure 1. The heat sink design shown in the figure uses an array of fins to increase the surface area available for heat to escape. The quantity, size, spacing, and thermal conductivity of the fins, for example, will affect the performance of the heat sink for a given applied power. Ultimately, there are many variables that need to be taken into account when optimizing the design of a heat sink to ensure the electronics remain well below their maximum operating temperature. But, what is the best way to optimize the heat sink design considering all of the variables involved?

Although physical prototyping has and continues to hold a necessary place in the product design cycle to ensure high quality, virtual prototyping via multiphysics simulation significantly cuts the time and expenses associated with the process by reducing the number of prototypes required and allowing assessment of viability early in the design cycle.

Using COMSOL Multiphysics® software, AltaSim developed and validated a multiphysics model of the heat sink shown in Figure 1, which serves as an indispensable tool for design optimization. You can get a good impression for the model setup process from Figure 2, which outlines the steps via the node order in the Model Builder window.

From the validated heat sink model, AltaSim developed a custom application using the Application Builder, a built-in feature in COMSOL Multiphysics shown in Figure 3. Their simulation app, HeatSinkSim, is shown in Figure 4. By using the Application Builder, they created an easy-to-use interface that allows any user to run complex engineering analyses, including those who are not simulation specialists. Central to the Application Builder are its Form Editor and Method Editor, which allow you to readily add Form objects to the app's user interface as well as

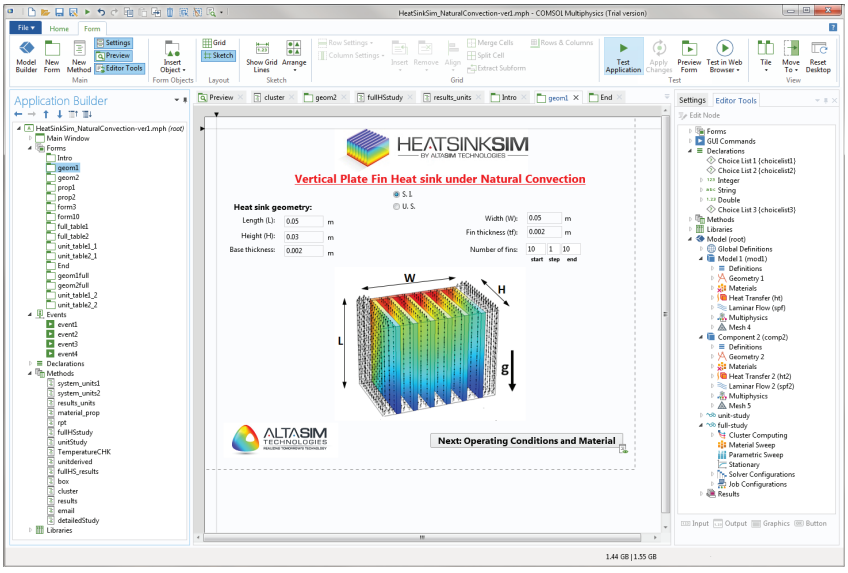

FIGURE 3. COMSOL Desktop® showing the Application Builder through which you design simulation applications based on your multiphysics models using the Form Editor and Method Editor.

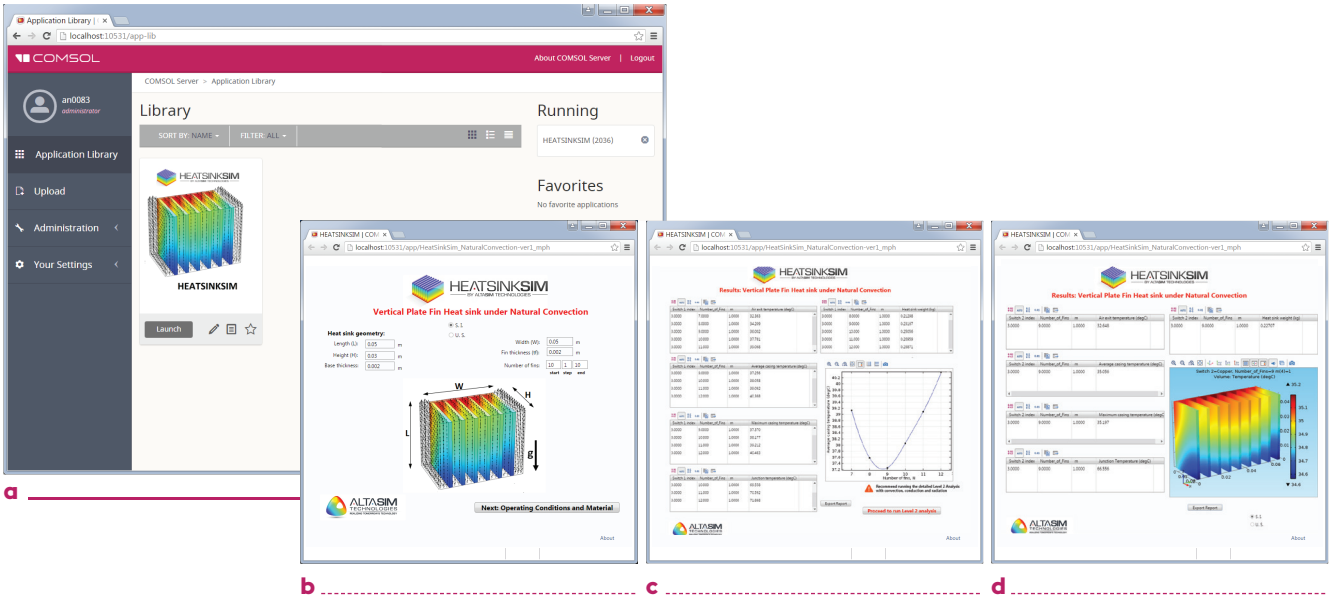

FIGURE 4. Log into COMSOL Server™ product using a browser. Then run HeatSinkSim from COMSOL Server in a separate browser tab or window (a). Through the simulation application in (b), you specify the geometry, materials, and operating conditions. The app offers two levels of analysis. Results from a Level 1 analysis (c) indicate that a Level 2 analysis (d) is recommended, which entails a full 3D conjugate heat transfer study.

customized functionality in Java® code methods that are run in response to user input.

Results from the HeatSinkSim app are shown in Figure 4, demonstrating the two different levels of analysis that are available. A *Level 1* heat transfer analysis solves the conjugate heat transfer problem and includes fluid flow with conduction, convection, and radiation. Results are shown in one-dimensional line plots of temperature vs. design parameters, such as the number of fins in the heat sink. A *Level 2* analysis performs a more detailed heat transfer simulation for a more accurate three-dimensional solution, but takes longer to run. If temperatures reach the user-defined operating limits during an initial Level 1 analysis, a Level 2 analysis is recommended to the user by HeatSinkSim.

In planning your simulation-driven workflow, it is important to consider logistics such as who will set up and validate the initial multiphysics model, design the simulation app based on that model, and ultimately perform design evaluation and optimization using the app. The ability to create an app based on a multiphysics model adds flexibility and makes planning your workflow easier since more people can run simulations through an app.

"If you recognize that you can develop simulation apps that are predictive and represent real-world situations with real dimensions and operational characteristics, then you can also look at the number of potential users that could benefit from simulation apps," says Crompton. "There are an estimated 80 million scientists and engineers around the world that are potential users of computational apps, compared to just 750 thousand that are currently using computer-aided engineering (CAE) tools."

Instead of running all of the analyses themselves, which can create a workflow bottleneck, simulation applications can help your simulation specialists make time to develop new tools and features that require their expertise. In case you do not have or intend to have simulation specialists on staff, you still have the option of outsourcing the model and app development to COMSOL Certified Consultants, such as AltaSim, or purchasing access to an existing simulation app — HeatSinkSim is just one example.

With simulation apps available to you and your colleagues, you can rely on highly accurate multiphysics models to predict the real-world performance of your product or process. By improving your understanding and reducing the time and cost associated with prototyping, you can get your innovative solution to market first.

Returning to the example of heat sink design optimization for power electronics, using HeatSinkSim offers a competitive advantage by improving access to simulation capabilities that help to ensure that safe operating

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temperatures are maintained, and consequently, continuous manufacturing operations.

⇨ DISTRIBUTION AND REVENUE

Providing the means to access and run simulation applications is just as important as deciding who will be developing and using them to achieve your design goals. Through a local installation of the COMSOL Server™ product, your colleagues or customers can readily access simulation apps through a COMSOL client or web browser. Figure 4a shows a web browser with the Application Library for the COMSOL Server installation, through which you can launch the HeatSinkSim app. AltaSim uses the dashboard to manage app access and feature availability.

COMSOL Server is a product designed to run on anything from a standard laptop or desktop computer, to state-of-the-art supercomputing clusters. When choosing hardware that meets your specific needs, cost, availability, model complexity, and desired solution time are all factors to consider. If you would like results as fast as possible, but without the responsibility of managing hardware or the related security concerns, a supercomputing center may be an attractive option.

To provide access to HeatSinkSim, AltaSim partners with AweSim, an organization that aims to strengthen economic competitiveness by providing simulation-driven design capabilities to small and midsized manufacturers. Behind AweSim is the Ohio Supercomputing Center (OSC), which operates three major systems. HeatSinkSim runs on a node on the Oakley cluster, which is an HP Intel® Xeon® machine with more than 8300 cores for parallel computation. By submitting a request to AweSim to use HeatSinkSim, you are provided with an account at OSC, enabling you to log in remotely from a web browser on your own computer to run the app on their supercomputing clusters.

Through the AweSim distribution method, users can first try out HeatSinkSim, and then pay for the features and time that they use. By developing simulation apps, not only can you expand access to highly accurate multiphysics modeling capabilities, but pay-per-use access to apps can open up a new revenue stream for your organization as well.

⇨ A BETTER, FLEXIBLE PRODUCT DESIGN WORKFLOW

The HeatSinkSim app by AltaSim is not only an example of a solution to meet your design goals, but is also a product itself, developed and validated by experienced simulation specialists. By using the multiphysics modeling, application design, and distribution capabilities of COMSOL Multiphysics and COMSOL Server throughout the product development cycle, you can bring simulation to everyone, adding flexibility to your workflow that can improve quality and reduce risks and costs, while delivering your best possible product to market in a competitive timeframe. ❖

Executive Summary

HEATSINKSIM: BEHIND THE INTERFACE

To provide thermal design engineers with accurate tools, AltaSim Technologies is developing computational applications (apps) from detailed physics-based simulations. Apps include custom interfaces that allow the user to run multiphysics analyses by changing, for example, design parameters and operating conditions. HeatSinkSim is an app that examines the effect of heat sink design on thermal dissipation in power electronic components, potentially saving months of remediation measures later in the development process.

AltaSim is making the app available for general access and use with on-premise workstations or clusters as well as through secure connectivity to hosted parallel computing resources. Individual users can also perform further customization.

Benefits of app-based virtual prototyping

- Unified company approach
- Expert mathematical modeling knowledge accessible to designers and engineers
- Decisions based on predictive physics-based analysis
- Cost-effective

App management, deployment, and use

- Administrators can deploy, distribute, and manage apps with COMSOL Server™
- Users connect to COMSOL Server to access apps and run multiphysics analysis from a browser or COMSOL Client
- Apps are cluster computing enabled
- 24/7 worldwide access

Jeff Crompton, principal and cofounder, AltaSim Technologies

The AltaSim staff has over a century of collective experience in the development, application, and exploitation of multiphysics computational analysis and simulation. As founding members of the COMSOL Certified Consultants program, AltaSim combines its expertise in COMSOL Multiphysics® software and ability to extend its functionality with fundamental knowledge of physics, mechanics, computational science, and real-world processes.