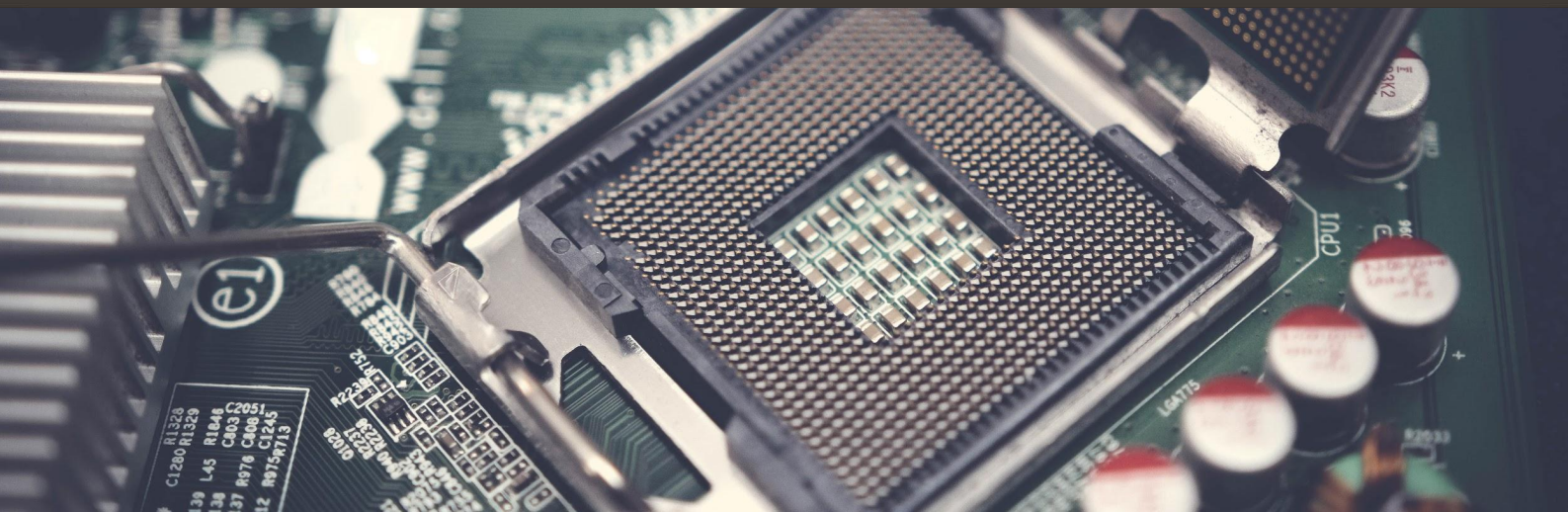


WHITE PAPER

ELECTRONICS COOLING THE ULTIMATE GUIDE

This paper describes the essentials of electronics design and dives into how to investigate heat flow and visualize temperature distribution to develop the best cooling strategy for electronics. Topics covered are electronics cooling techniques, common problems, the difference between active and passive cooling, how to optimize electronics designs, and more.



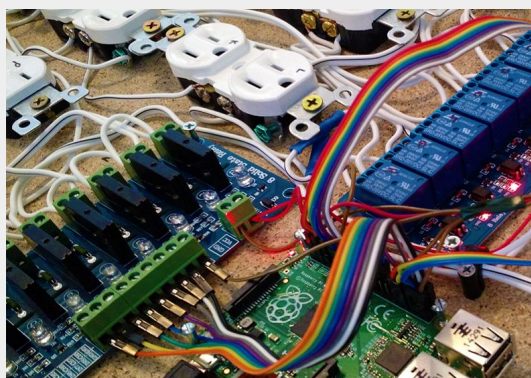
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Introduction

The rise of electronics in recent years and their continued miniaturization have led to a sharp increase in power density. Due to this, the adequate removal of heat flux as well as uniform power dissipation have become the main goals in thermal management. In tackling this design challenge, electronics cooling emerges as the vital process of cooling components within electronic systems to prevent overheating and ensure performance.

In the following guide, the field of electronics cooling will be explained in full, including the market, background, cooling techniques, main challenges faced by engineers, and solutions to optimizing and testing an electronic design.



The Electronics Market

Every second, millions of people are using electronic devices at home, in the office, or on the go. On that scale, hundreds of billions of electronic components are embedded in objects that are used daily, from cars and home appliances to working tools and utilities. The key players in the electronics industry are facing a very demanding market. They must constantly adapt to swiftly changing trends, rapidly release new products, and continuously offer cheaper and better solutions that incur fewer expenses.



The Digital Economy

It's no secret that the digital age we live in is perpetuated by the increasing boom in electronic innovation. This technological growth has infiltrated every aspect of human life, including how we communicate, work, and even entertain ourselves and others. There are no exceptions to this trend, from computers and communication networks to smart mobiles and healthcare devices. Smart car engines are controlled by embedded chips, helping users to drive more safely. The Internet of things (IoT) is connecting devices for nearly all markets, from manufacturing processes to smart homes. In fact, more than 4.4% of global manufacturing value arises from electronic equipment.

In this race for creating the best product on the market, best-in-class electronics manufacturers are using engineering simulation to address emerging thermal design challenges. These top performers are thus able to launch complex and reliable devices faster, saving time and costs.

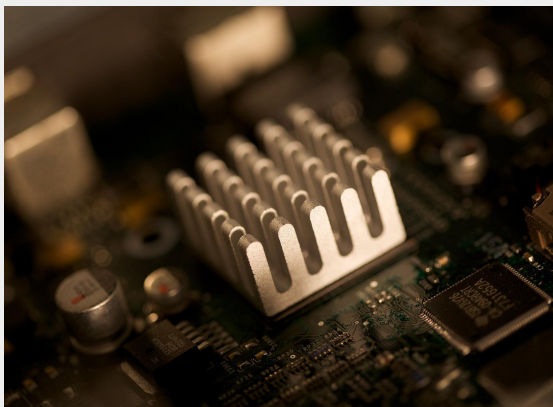


Why is Electronics Cooling Important?

in absence of right cooling strategy the lifespan of components can decrease , and the respective electronic device will operate at an optimal level.

Adversely, failure to effectively cool electronics and microprocessors can lead to loss of energy and even system malfunction or destruction.

Therefore, high-performance microchips and electronic devices of all shapes, sizes, and levels of functionality need innovative thermal design techniques. Furthermore, coolants with high heat transfer capability are also essential to improve the heat removal rate and thus maintain normal operating temperature.



What Are Common Problems in Electronics Cooling?

The requirements of low cost and small size are getting increasingly stringent for all electronics applications.



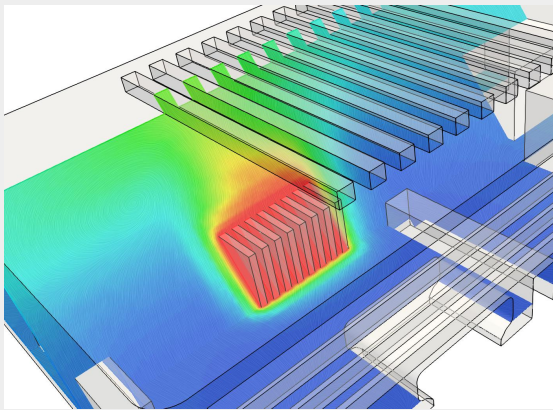
For example, in the automotive industry, the price of electronic systems is a major driver of the overall hardware design. Recently, automotive engine control modules (EMCs) have decreased in size and cost, while their required functionality and operating temperatures have significantly increased. This poses a problem in the realm of thermal management.

Following this, electronic cooling processes are forced to become more efficient as products' complexity and customers' performance requirements augment.

What Electronics Cooling Techniques Are There?

When it comes to electronic systems, there are four chief cooling techniques explained below in order of complexity.

Natural Convection



This type of heat transport is used as a passive cooling strategy and requires the use of heat sinks, usually made from copper or aluminum. In this case, no external force is required to generate fluid motion. In contrast, air surrounding a heat source becomes less dense due to buoyancy forces, which induce thermal expansion.

Forced Convection

This mechanism requires artificially produced air velocity from a fan within the electronic system to provide additional levels of cooling.

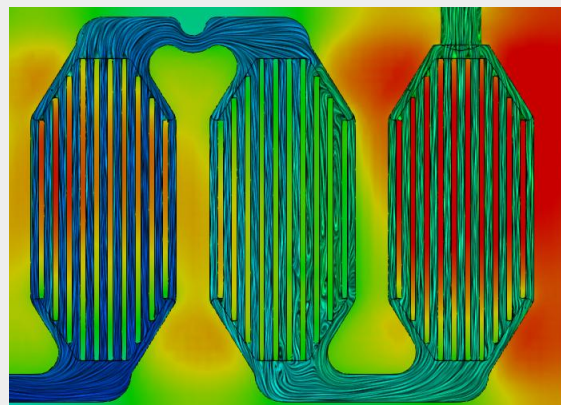
Fluid Phase Change

This technique, also known as 're-circulation cooling', is based on closed loop heat pipes integrated into the system. These allow for an accelerated transfer of heat through evaporation and condensation.

Liquid Cooling

Also known as water cooling, this solution can ensure rapid heat removal.

Incorporating cold plates, a heat exchanger, and a pump system to circulate cold fluid past a heat source, it can have considerable results for thermal performance.



What is the Difference between Passive and Active Cooling?

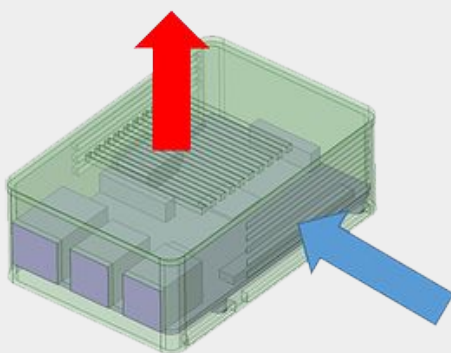
Cooling strategies can be divided into two main categories, applied depending on product configuration, noise considerations, and energy efficiency goals.

Passive Cooling

Passive thermal management refers to cooling solutions that rely on the thermodynamics of conduction, convection, and radiation for heat transfer.

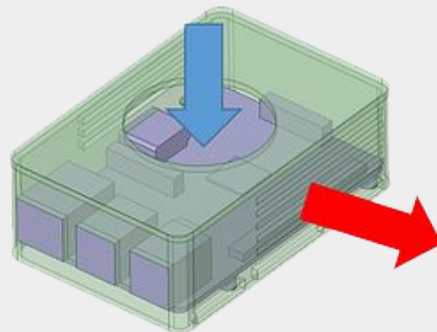
The main advantages of passive cooling are energy efficiency, noise reduction, easy implementation, and low cost.

This technique utilizes heat spreaders, heat sinks, heat pipes or thermal interface materials (TIM) to dissipate heat and maintain optimal operating temperatures for electronic devices.



Active Cooling

Active cooling relies on external devices and the use of energy to induce heat transfer.



Through active cooling technologies, the rate of fluid flow increases during convection, which speeds up the heat removal rate.

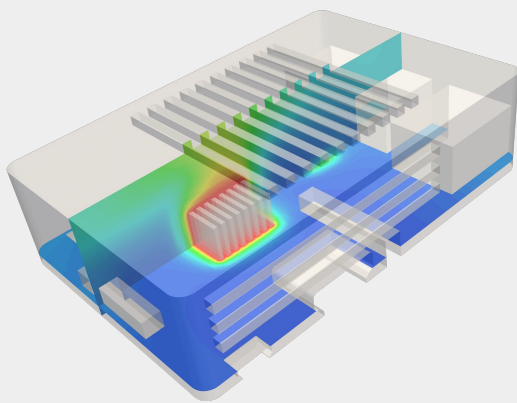
The advantages of active cooling are significantly higher efficiency in heat dissipation and faster results.

These solutions include fans, liquid cooling systems or thermoelectric coolers (TECs), which can be used to optimize thermal management on all levels and reduce failure risk.

How to Optimize an Electronic Design

FEA and CFD simulation tools are used in addressing thermal management issues in electronic design, by enabling the investigation of fluid flow, as well as temperature and heat flux distribution in and around an electronic system.

1. Identify the Best Cooling Solution

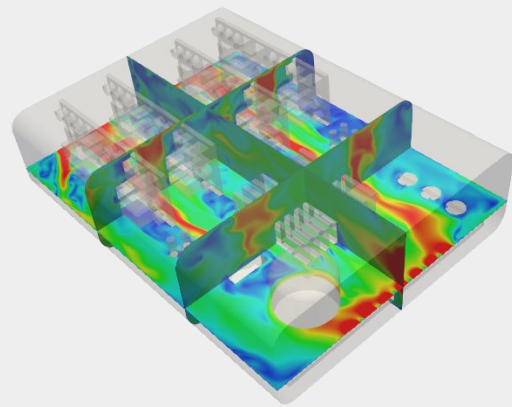


Electronics designers have multiple options to keep their products cool.

Would passive cooling be enough to prevent thermal damage or is active cooling better despite its energy costs and noise concerns?

With computer-aided engineering, you can evaluate your options and choose the most appropriate thermal design strategy for your configuration based on numerical simulation results.

2. Find the Right Placement for Fans and Heat Sinks



Fans and heat sinks are widely used in electronics for heat dissipation.

It is important to optimize the fluid path and ensure that the heat sinks are placed in such a way that they don't impede the internal flow.

Visualizing the airflow and temperature distribution around components in electronic enclosures helps to identify the best possible placement of fans and heat sinks for a more efficient cooling process.



3. Test Enclosure Dimensions

The physical size of the enclosure is the primary factor in determining its ability to dissipate heat, making it a fundamental factor in thermal design.

Engineering simulation tools allow you to analyze the heat flow and decide on the best dimensions of an electronics enclosure and ensure the effectiveness of the cooling strategy for semiconductors.

4. Validate Material Decisions

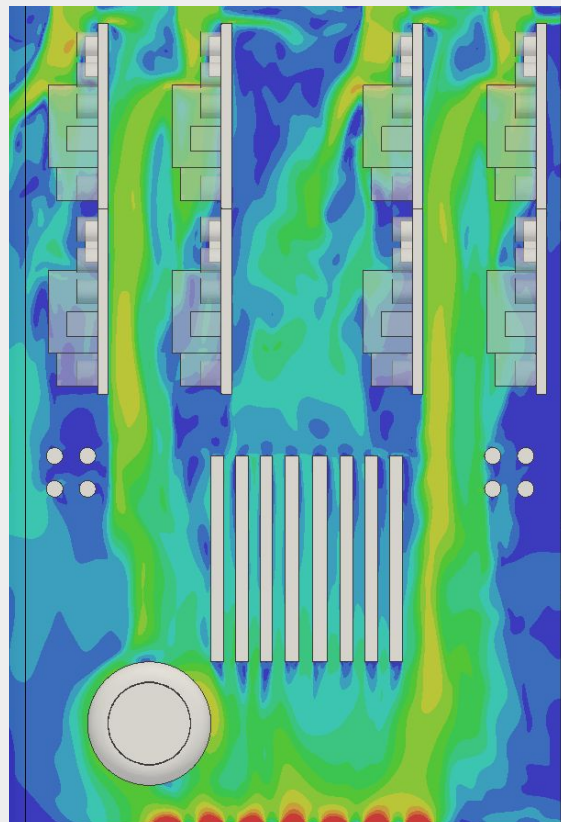
Materials' thermo-physical properties can largely determine a product's thermal performance, making them an important factor in electronics design.

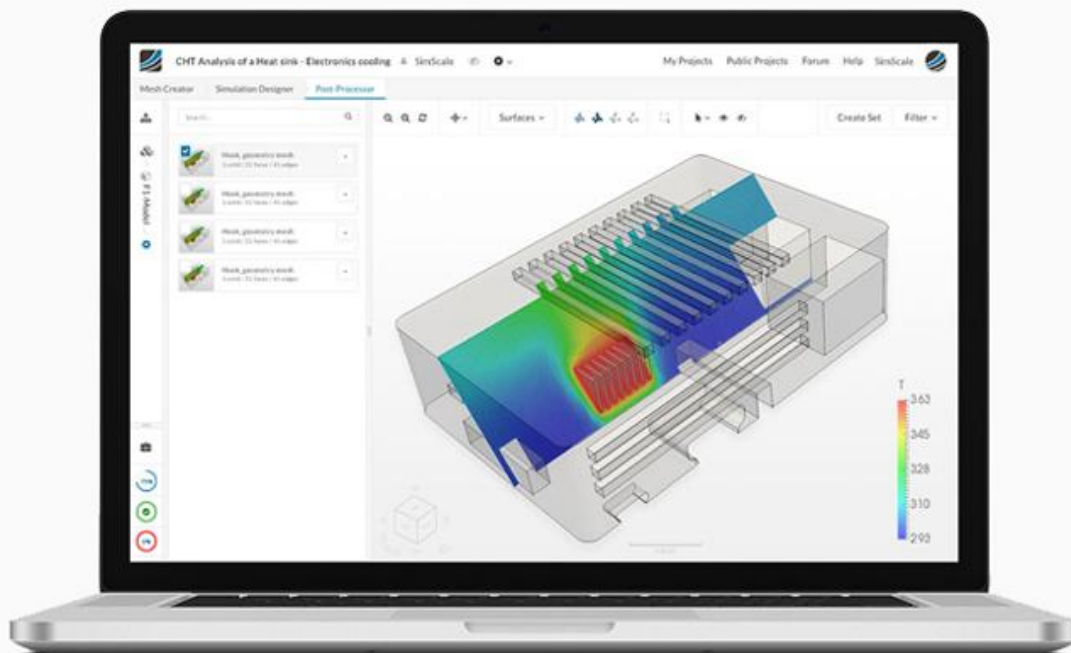
The thermal conductivity of copper or silicon can change over the expected range of operating temperatures. Thermal analysis enables engineers to validate material decisions and test their conductivity for a faster cooling process, keeping semiconductors cool enough to prevent failure.

5. Ensure Energy Efficiency

The increasing energy costs and the need for reducing energy consumption are driving the demand for not only effective but also energy-efficient cooling solutions.

Engineering simulation aids in identifying the optimal thermal management solution for a specific product—be it active or passive cooling—, compare designs, and eliminate excessive components.





About SimScale

SimScale is a cloud-based CAE platform that gives instant access to **FEA, CFD, and thermal simulation** technology for quick and reliable testing and optimization of electronics designs.

By harnessing the power of the cloud, SimScale is revolutionizing the simulation industry, allowing every engineer and designer to virtually test and optimize their designs online.

With SimScale, you can run complex fluid dynamics, solid mechanics and thermostructural simulations in parallel without leaving the web browser.

Why SimScale?

Accessible: Get instant access to a premium cloud-based simulation platform that enables you to virtually test and optimize electronic designs end-to-end in a web browser—from anywhere, anytime.

Cost-efficient: As a SaaS application, SimScale requires zero investment in high-performance hardware, licenses or maintenance. The yearly subscription is a fraction of the cost of on-premises CAE software.

For everyone: Having access to dedicated support, learning resources, and consulting services, you get reliable simulation results fast, with no need to hire an expert.





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