COMMENTARY

Dealing with Complexity: From Integrated Circuits to Data Centers

Improving electronics reliability via multi-scale, multi-physics simulation

Key Takeaways

While compute power has not exactly kept pace with Moore's Law, there is still a substantial increase in processing power per processor over last few years by the means of multi core, multi thread and GPU technologies. As the physical limitation of the size of an atom for transistor design is approached, heat generated in such densely packed processors is a key challenge faced by the industry.

Performance of all electronics devices degrades with increase in temperature or operation outside of the designed temperature range due to thermal expansion, reduced mobility of charge carriers, increased current leakage, and changes in electrical properties of the components. This is a critical warranty, safety, and performance reliability issue for all electronic device makers.

Electronics thermal management has a significant environmental sustainability dimension as well. Almost every watt of energy that is supplied to an electronics device becomes converted to heat that needs to be removed from the device by the means of a heat sink, cooling fan or coolant running within the device. This makes the energy footprint of electronics devices and data centers quite significant contributors to the issues of carbon footprint and sustainability. Data centers are currently estimated to use around 2% of global power and the trend is growing. Ensuring each data center runs efficiently will have a notable impact on energy consumption.

Data centers are the epitome of design complexity and operational efficiency. They are the modern equivalent of a thermal power plant and are mission critical for almost every business that relies on computers. Hence, a solution for the data center industry not only needs to address the design aspect but also needs to look at the operational monitoring and supervision, failure mitigation, and asset management.

Cadence® solutions are working to address these challenges at every scale starting with Celsius ™ EC Solver at the chip level and expanding to the data center level with its DataCenter Design Software ™ and DataCenter Insight Platform ™ (formerly 6SigmaDCX by Future Facilities). Together, they provide a comprehensive total solution for thermal management of electronics and data centers throughout the data center product lifecycle.

Copyright © 2023

Electronics Thermal Management Challenges and Solutions

The need for miniaturization and higher compute performance in electronics devices has led to increased heat generation and power densities, making thermal management a critical design requirement. Cooling solutions such as heat sinks, fans, and cold plates play a significant role in dissipating heat from electronic components. In addition, thermal management simulation software can reduce development costs and timelines, enabling more design options and robust solutions, and facilitate quicker regulatory approvals with digital evidence.[1]

The data center industry faces unique thermal management challenges due to increasing computing power and data storage demands. With the high cost of cooling, various techniques are used to increase levels of cooling as well as recover as much waste heat as possible. Physics-based simulation software powered by computational fluid dynamics (CFD) is crucial to ensure efficient cooling and overall energy efficiency.

Cadence's Celsius EC Solver, DataCenter Design Software, and DataCenter Insight Platform for electronics cooling, digital twin simulation and optimization, provide a thermal management solution at chip, board, cabinet/enclosure, and data center scales. A data center digital twin solution is a valuable addition to Cadence's EDA toolbox, providing design, monitoring, asset management, and predictive digital twin solutions on a "chip-to-chiller" scale. This comprehensive offering makes a compelling proposition for end users in the growing and mission-critical data center industry.

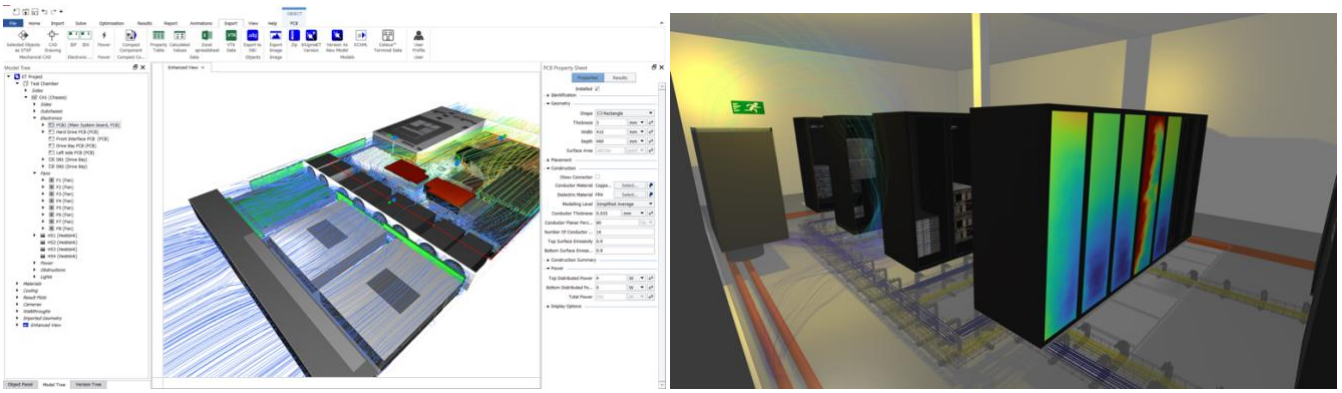


Figure 1—Cadence Software Solutions Showing Air Cooling Simulation for a Blade (left) and a Data Center Room of Racks (right)
(Courtesy Cadence)

Celsius Technology

Cadence's Celsius EC Solver is electronics cooling simulation software that helps designers address thermal management challenges early in the design process. The software offers over 100 objects designed for electronic devices, automatic mesh generation, and object-based meshing features. It has a parallel processing technology and can generate customizable reports and advanced post-processing features for high-quality 3D visualizations (Figure 2).

[1] Research for this commentary was partially supported by Cadence

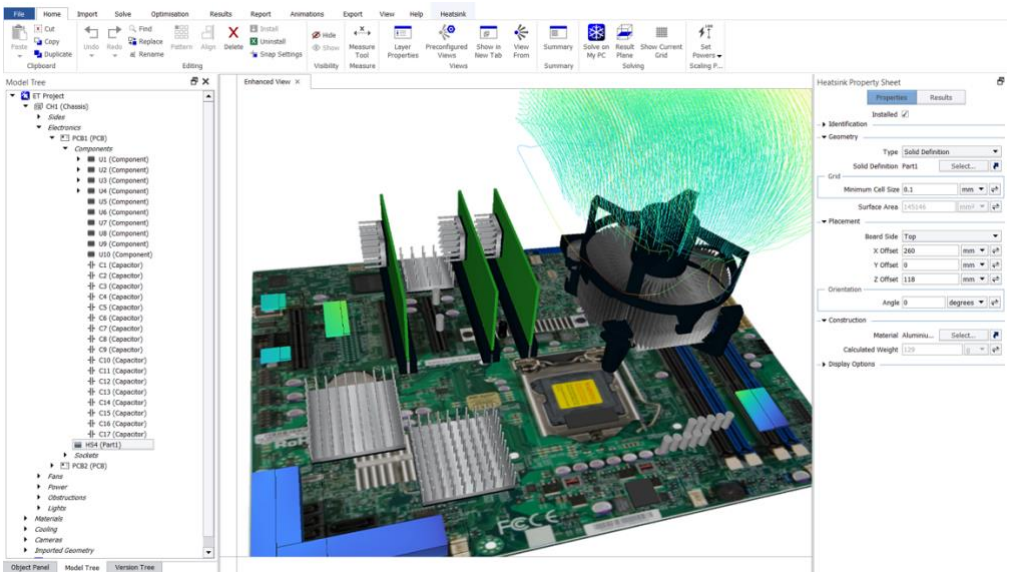


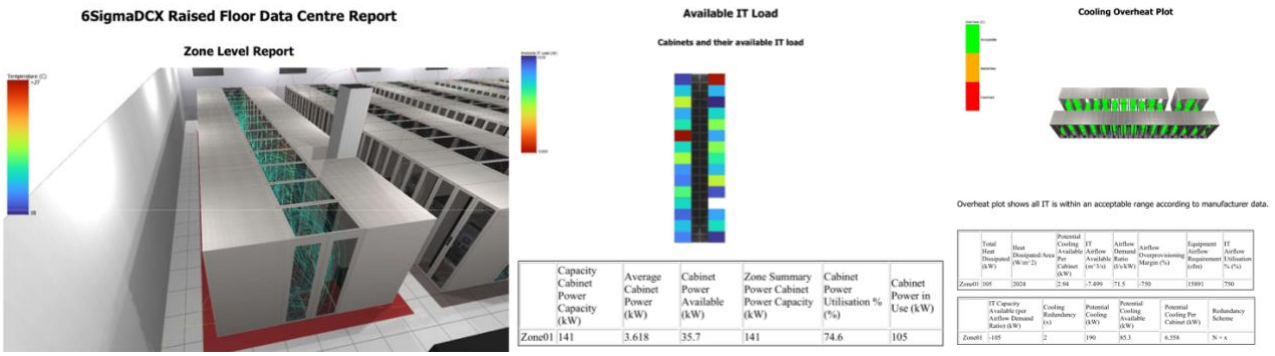
Figure 2—Celsius EC Solver Showing Detailed Electronics and Cooling Effects
(Courtesy Cadence)

The software uses a proprietary multi-level unstructured meshing technology that can handle convection, conduction, and radiation, enabling it to analyze airflow, temperature, and heat transfer in complex electronic systems. It is a scalable solution across hundreds of cores for handling highly complex systems reducing costly design iterations and engineering delays.

Celsius EC Solver is a powerful and advanced software tool for electronics cooling simulation and thermal management, enabling system designers to optimize thermal solutions and reduce the risks of product failures while maximizing performance up front in the design and development cycle.

DataCenter Design Software and DataCenter Insight Platform

Cadence's DataCenter digital twin solution combines a data center design stage with an operational stage. DataCenter Design Software and DataCenter Insight Platform, respectively, deliver physics-based simulation software to the data center industry that enables engineers to create digital twin models for both design and operations. It provides reporting capabilities for valuable data from simulation results for design capacity, installed use, and available resources (Figure 3). Cadence DataCenter Design Software and DataCenter Insight Platform support sustainable data center operations with features such as insights tables that display simulation results, live monitoring data, power usage effectiveness (PUE), and carbon usage.



	Capacity Cabinet Power Capacity (kW)	Average Cabinet Power (kW)	Cabinet Power Available (kW)	Zone Summary Power Cabinet Power Capacity (kW)	Cabinet Power Utilisation % (%)	Cabinet Power in Use (kW)
Zone01	141	3.618	35.7	141	74.6	105

Figure 3—DataCenter Design Software and Insight Platform Provide Data Center "Digital Twin" Design and Operation Simulation, Standard Reports, and More
(Courtesy Cadence)

These software solutions help optimize data centers and improve efficiency for colocation, hyperscale, and enterprise data centers, touching industry sectors such as aerospace, healthcare, automotive, and financial services. They address capacity planning, cooling optimization, and maximizing legacy system performance challenges and provide benefits such as improved data center efficiency and capacity utilization, streamlined processes, and cost-effective solutions. The DataCenter digital twin solutions from Cadence enable seamless integration with existing DCIM, building management systems (BMS), and other systems, mitigate risks through potential equipment failure and maintenance simulations, and provide ongoing capacity management and cost savings.

The software is a crucial solution for businesses looking to optimize their data centers, streamline costs, and enhance operational efficiency. They provide detailed simulation capabilities with ease of use for data center design and operations management.

Case Study: Rohde & Schwarz

Rohde & Schwarz (R&S) is a leading manufacturer of test and measurement (T&M), secure communications, monitoring and network testing, and broadcasting equipment. R&S knows that as electronic devices are becoming smaller, more sophisticated, and higher powered, thermal issues can affect performance and reliability. Increasingly, a key design requirement for these devices is thermal analysis.

The faster geometry preparation and solver time of Celsius EC Solver saved R&S designers precious product development time and enabled them to achieve an overall increase of 35% in efficiency. With the tool, R&S was able to implement a more "simulation-driven design" methodology (Figure 4) than with a traditional design, prototype, test, and improve iterative method.

"We wanted to have a tool that could directly use our CAD model in order to increase our productivity. It was a big surprise for us to see the functionality of Cadence's Celsius EC Solver. Due to our comparison, it is definitely the best tool for R&S in the field of thermal simulation" said Mr. Raimund Blankenburg of Rohde & Schwarz.

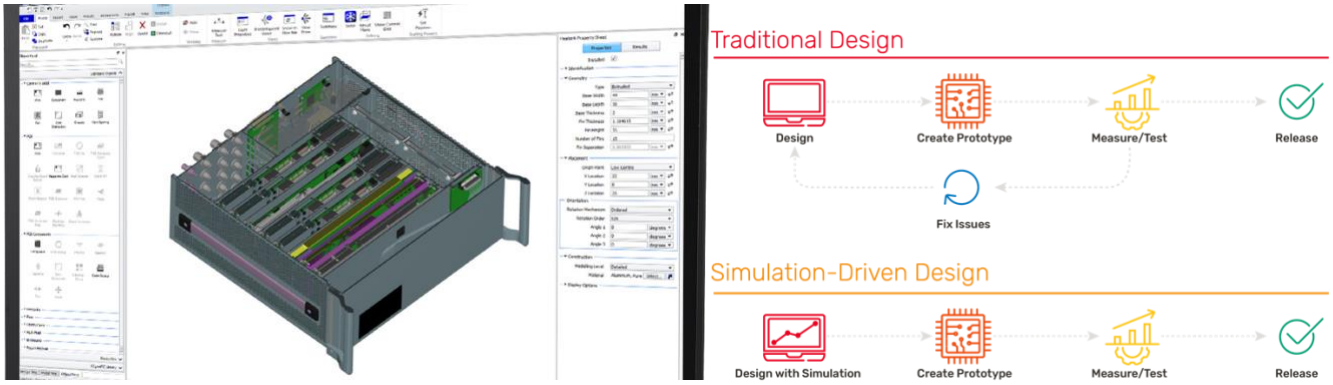


Figure 4—Celsius EC Solver Simulation-Driven Design Process Improves Electronics Cooling Solutions for R&S Test and Measurement Equipment While also Improving Designer Efficiency and Productivity
(Courtesy Cadence)

Case Study: Thésée DataCenter

Thésée DataCenter established the first Tier IV Uptime-certified colocation data center in France. Their goal was an interactive experience and an energy-efficient data center campus. This translated to following the specifications of 99.995% expected uptime, redundancy for every component, maximum capacity utilization, cost-effective energy usage, and a unique web service portal for customers.

Thésée DataCenter chose the Cadence DataCenter digital twin solutions, specifically its DataCenter Design Software and DataCenter Insight Platform, to help meet the exacting requirements. The benefits experienced from the use of the software not only met but surpassed expectations. A data center digital twin was able to solve every steady state and transient problem and helped ensure power, cooling, and capacity were optimized (Figure 5). The software also enabled the co-location provider to make informed decisions on IT deployment for its customers.

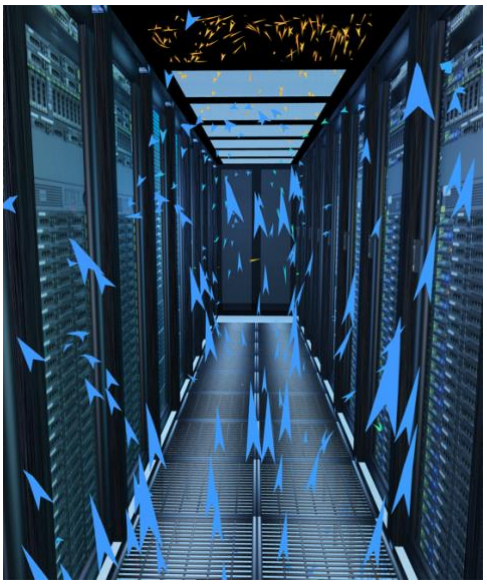


Figure 5—Cold Air Flowing from a Floor Tile in the Thésée DataCenter Designed with the Cadence DataCenter Digital Twin Software Solution
(Courtesy Cadence)

Mr. Christophe Bouniol, Thésée DataCenter, said: "The Cadence DataCenter Digital Twin Solution is an indispensable design and operating tool to achieve the level of performance and availability we have defined for ourselves."

Concluding Remarks

As more industries adopt electronic systems and cloud technologies, efficient thermal management is becoming a critical aspect of design and development. The Celsius EC Solver, DataCenter Design Software, and DataCenter Insight Platform deliver digital twin solutions that showcase Cadence's commitment to addressing the growing challenges in electronics and data center thermal management across various industries.

The integration of mechanical and electronic design and analysis tools in a single suite allows engineers and designers to address electronics and mechanical development challenges simultaneously. This multi-disciplinary, multiphysics, and multi-scale approach is in line with industry trends and highlights the need for comprehensive solutions that can tackle complex engineering problems.

By expanding its software suite to include these advanced thermal management solutions, Cadence is positioning itself as a key player in the simulation and analysis segment. It also strengthens the company's overall offerings and allows it to compete more effectively in a fast-growing industry vertical.

The addition of these thermal management solutions can help Cadence's customers optimize their designs for various applications, including automotive, aerospace, telecommunications, home appliances, manufacturing, retail, and media and entertainment. This can lead to more energy-efficient and reliable products, ultimately benefiting the end-users and the environment.

About CIMdata

CIMdata, an independent worldwide firm, provides strategic management consulting to maximize an enterprise's ability to design, deliver, and support innovative products and services by identifying and implementing appropriate digital initiatives. For forty years, CIMdata has provided industrial organizations and providers of technologies and services with world-class knowledge, expertise, and best-practice methods on a broad set of product lifecycle management (PLM) solutions and the digital transformation they enable. CIMdata also offers research, subscription services, publications, and education through certificate programs and international conferences. To learn more, visit www.CIMdata.com or email info@CIMdata.com.