SIMSCALE

ELECTRONICS COOLING | SIMULATION

PCB THERMAL PERFORMANCE

Numerical analyses provide an efficient and reliable answer to investigate the thermal performance of electronic boards.

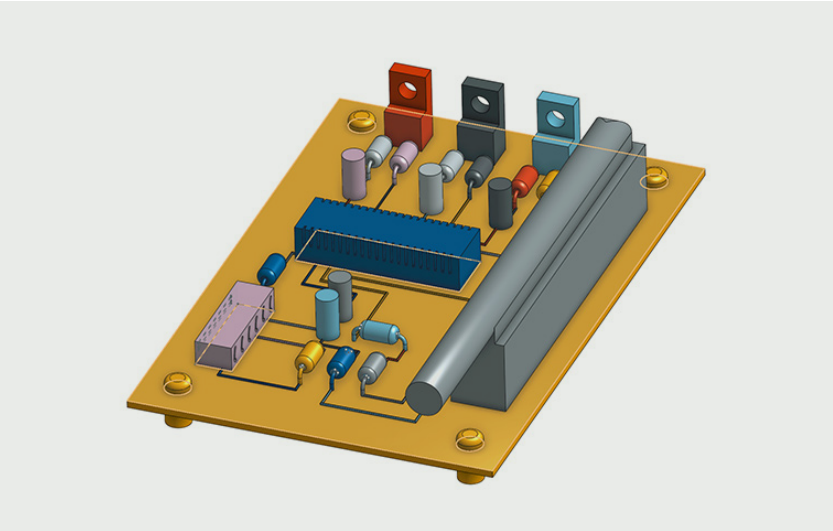
Challenge

Despite the significant manufacturing cost reduction of electronic boards and prototype enclosures for devices, **it is still a daunting and time-consuming task to analyze the thermal performance of a new design.**

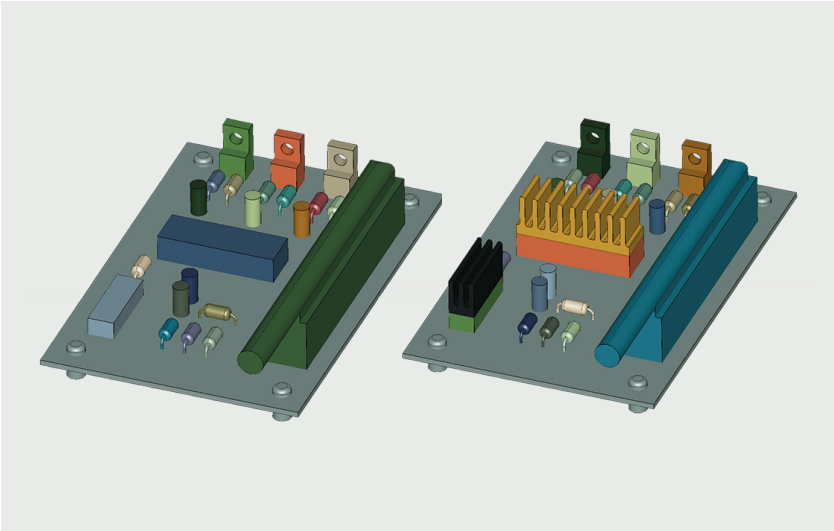
Project Goals

- Investigate **thermal performance** of a printed circuit board (PCB) with key components represented in the design
- Test if extra cooling components are required to remove heat from the processing chips using **solid heat transfer simulation**
- Analyze the natural convection cooling performance of two enclosure designs using **natural convection CFD**

PCB GEOMETRIES



Initial Representation of the System's Geometry
It is immediately noticeable that it contains multiple small details that will have an insignificant effect on the overall performance of the analysis.



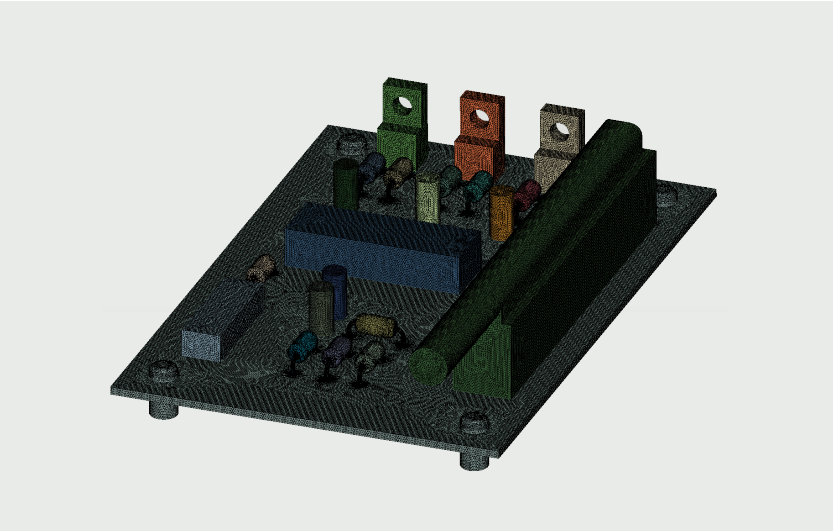
Two geometry branches were developed. The first one was used to investigate the **thermal cooling** of the solid elements **without** or **with additional radiators**.

ENCLOSURE GEOMETRIES

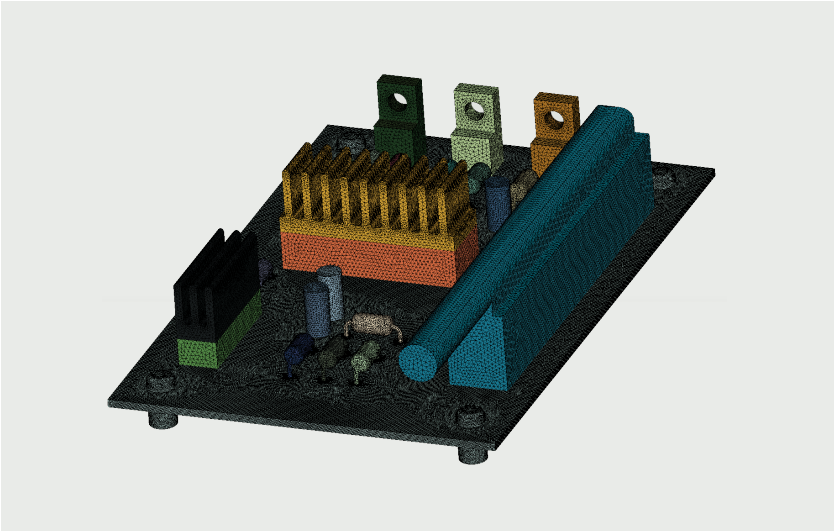


For **fluid flow simulations**, two versions of an enclosure were designed; a **basic version** and one with **extra top openings**.

PCB MESHES



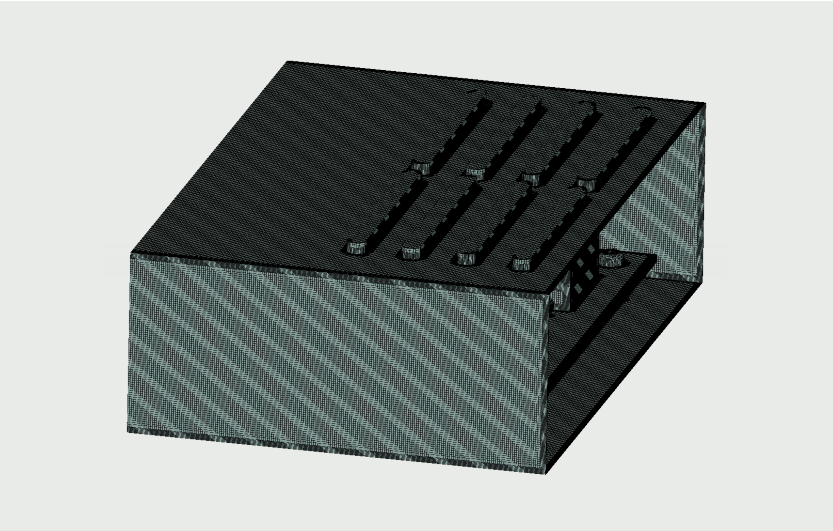
Fine **tetrahedral meshes** were prepared for **thermal conduction simulations** of the PCB. Both meshes consisted of approximately 1mln nodes.



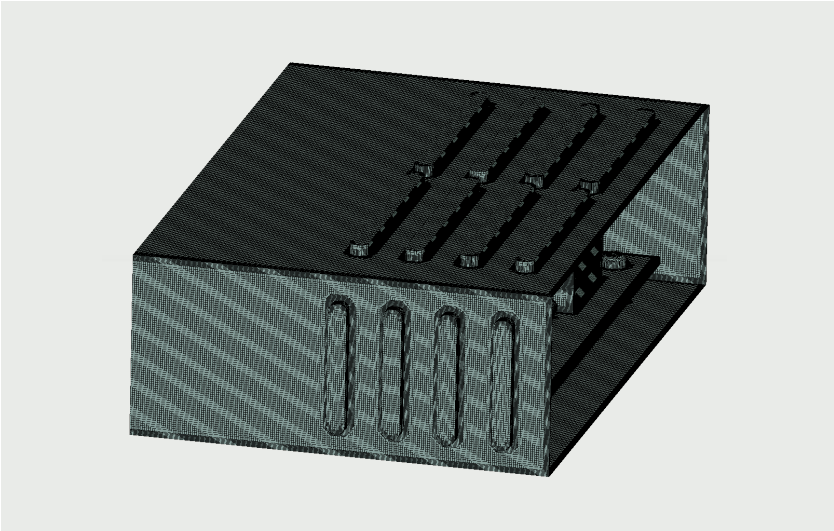
A different approach was applied during the preparation of the **meshes for CFD simulations**. In this case, we are required to discretize (mesh) the air flow domain. This is why the resulting meshes are "negative" representations of the geometry, with all the solid objects being void, and the mesh presenting the air volume.

ENCLOSURE MESHES

without top openings

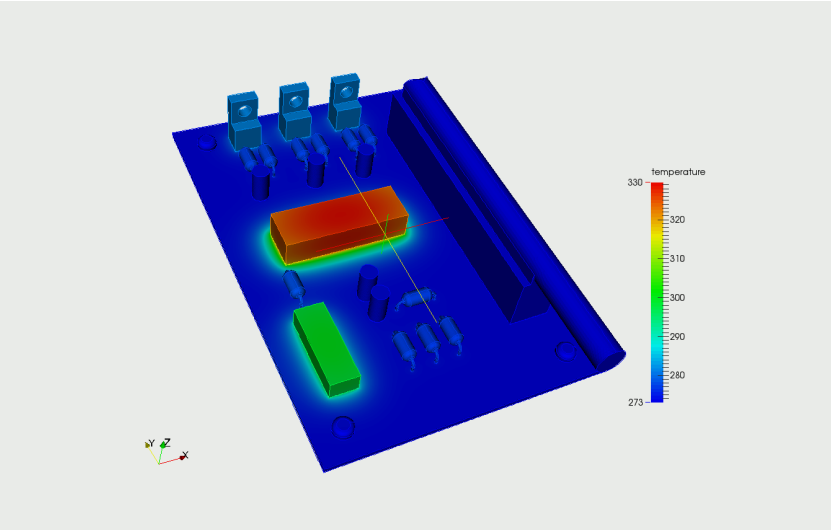


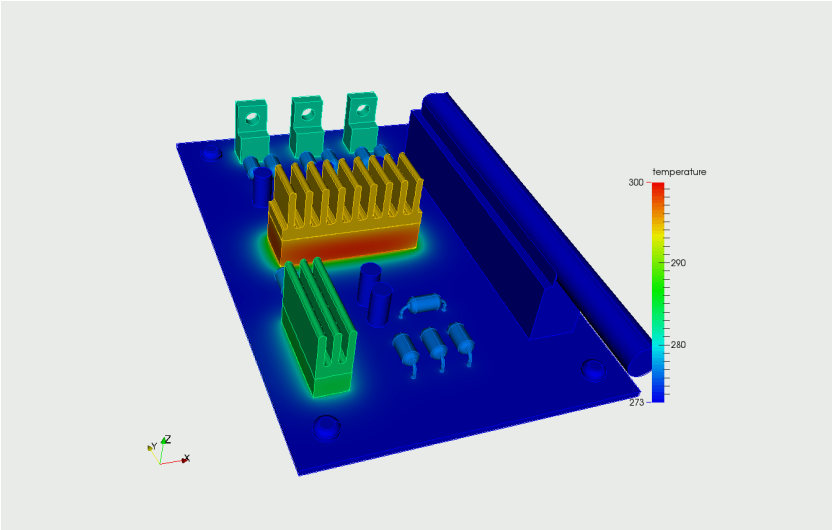
with top openings



Hexahedral meshes were prepared for two enclosure configurations, each consisting of approximately 2.82mln control volumes.

PCB SIMULATION





The first type of analysis performed was a **solid heat transfer analysis** of the printed circuit board with the aim of identifying the effect of including heat radiators on top of chip elements.

ANALYSIS TYPE
steady state*

MATERIALS
chips: quarz
board & power socket: plastic
capacitors & transistors: aluminium
resistors: metal

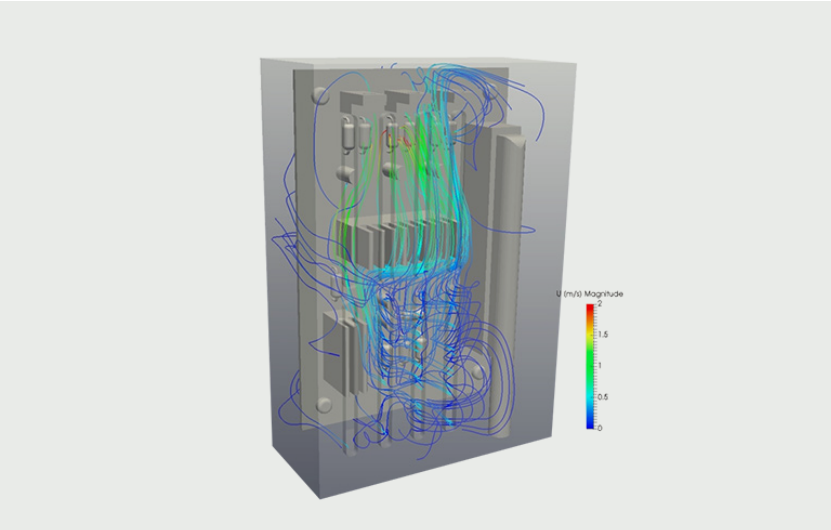
VOLUMETRIC POWER INPUT
250k W/m3

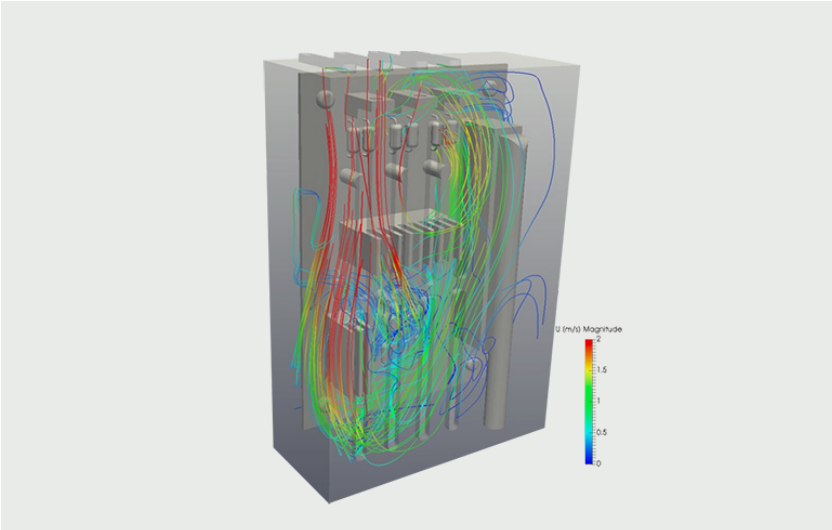
REQUIRED TIME
Despite running the analysis on big tetrahedral meshes, the results arrived after approximately 15 minutes of simulation time on 4-core machines.

*Which assumed that the device was operating for a long time and reached stable working conditions.

**All the external faces of the parts were undergoing cooling by a convective heat flux boundary condition with a reference temperature of 273K and the convective coefficient of 10 W/m2K.

ENCLOSURE SIMULATION





The **fluid flow simulations** used the results from the solid heat transfer simulations, as a reference to set up the temperature values for the heated elements on the printed circuit board.

ANALYSIS TYPE
steady state, turbulent convective heat transfer

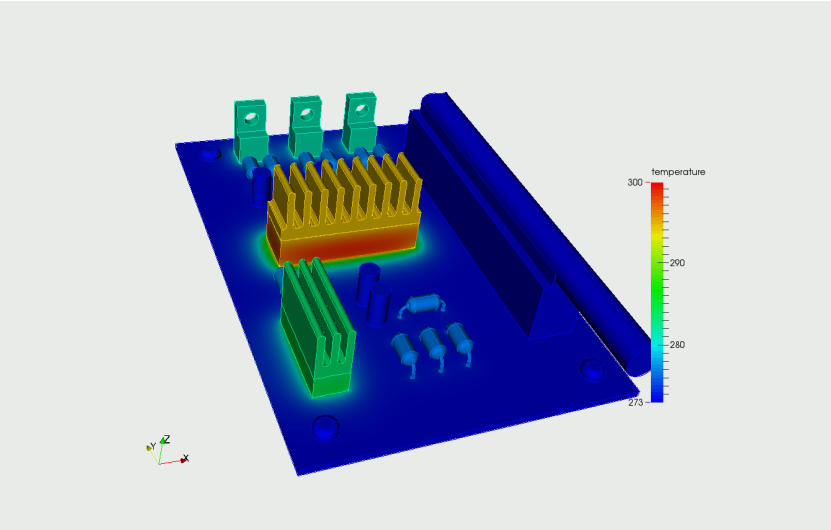
TEMPERATURES
heated elements: fixed
other components & external walls: adiabatic

MESH FACES
pressure-inlet-outlet boundary condition type*

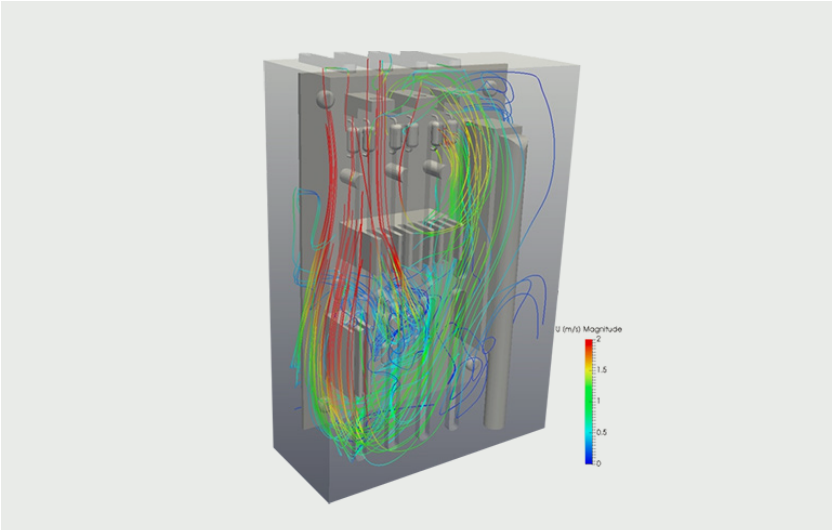
*Which allowed the air to flow in both directions.

REQUIRED TIME
The fluid flow simulations run on 32-core machines for approximately one hour each.

RESULTS



By applying the radiators, the **temperature** of the elements was **lowered by 30K**.



The main requirement of the CFD simulation was to investigate the effectiveness of the non-forced convective cooling of the printed circuit board while using two designs of the enclosure.

In can be clearly seen that **adding extra openings** at the top of the enclosure will **increase the airflow inside the device**.

CONCLUSION

The heat transfer simulations clearly presented the **benefits of using radiators on top of the heated chip** elements. Meanwhile, the CFD analysis proved that an enclosure **designed with extra openings placed on the top face can improve the cooling of the electronic elements**.

Find this project and use it as a template here.