TECHNICAL CASE STUDY

Sealed Electronics · Thermal De-Risking

CFD-Driven Thermal De-Risking of a 241 W Sealed Ruggedized Rack System

At a Glance

Advanced Thermal Solutions, Inc. (ATS) conducted a structured baseline-to-optimization CFD study on a ruggedized, sealed, 241 W rackmount system with a maximum ambient operating temperature of 55°C. The goal was to identify components exceeding their thermal limits and develop a custom cooling solution to reduce failure risk in demanding environments.

CUSTOMER OVERVIEW

The customer was developing a ruggedized sealed rackmount system for demanding environments. The thermal design had to manage multiple heat-dissipating components inside a closed enclosure while maintaining component temperatures within their operating limits at 55°C ambient.

- Sealed enclosure with limited natural heat escape paths (Figure 1)
- Multiple high-dissipation components distributed across the chassis
- Thermal reliability critical to reducing field failure risk

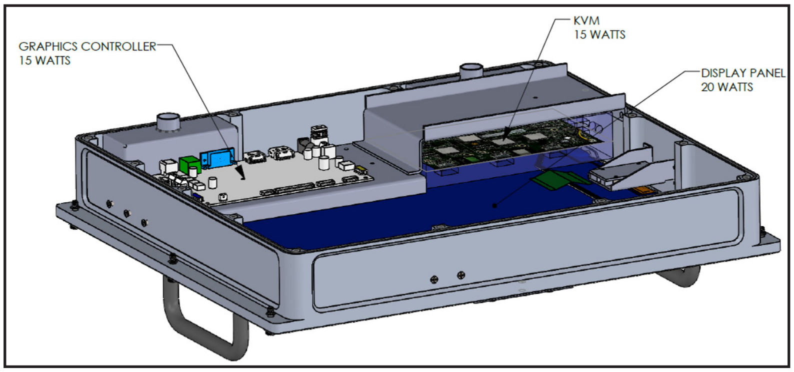

Figure 1. The 241 W Ruggedized Rackmount System

CHALLENGE

The 241 W system had to operate at up to 55°C ambient without exceeding component temperature limits. The main challenge was identifying hot components, poor heat-routing paths, and internal airflow recirculation within the sealed chassis, then converting those findings into a practical cooling redesign (Figure 2).

System constraints and power distribution:

- Total dissipation: 241 W
- Dual CPUs: 54 W
- Power modules: 80 W
- DC-DC converters: 32 W
- Graphics controller: 15 W
- KVM: 15 W
- Display: 20 W

The design also had to account for TIM compression sensitivity and maintain reliable contact performance within expected assembly tolerances.

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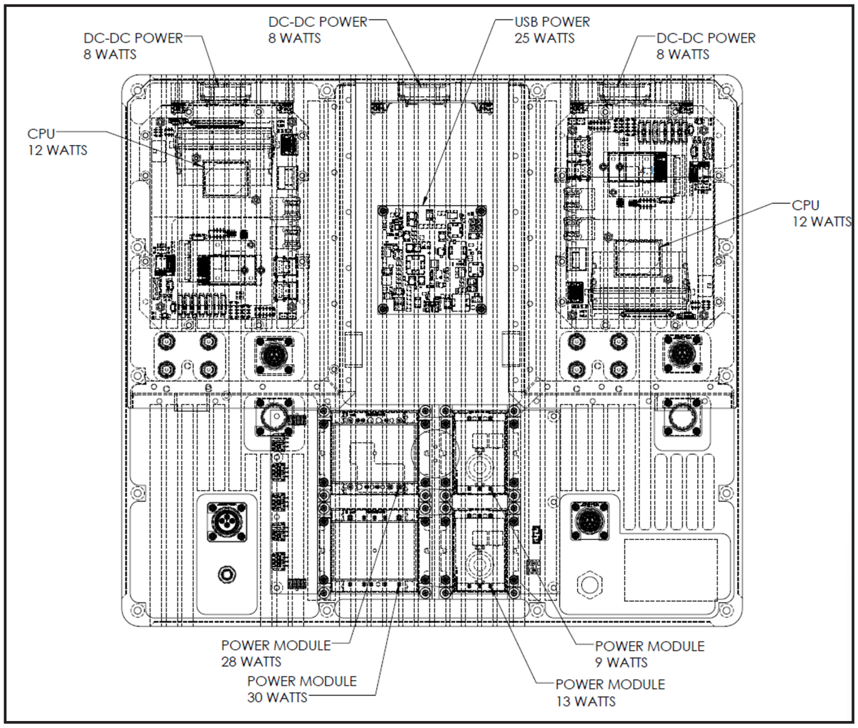

Figure 2. The Rackmount System Featured Multiple Heat-Dissipating Components

METHODOLOGY

ATS used a structured baseline-to-optimization CFD workflow to evaluate the sealed enclosure, identify dominant thermal bottlenecks, and improve thermal performance in progressive steps.

Baseline CFD Assessment

- Built a full CFD baseline model of the ruggedized rack system (Figure 3)
- Evaluated component hot spots, chassis surface temperatures, and airflow recirculation
- Identified insufficient heat routing to the chassis and localized cooling deficiencies (Figure 4)

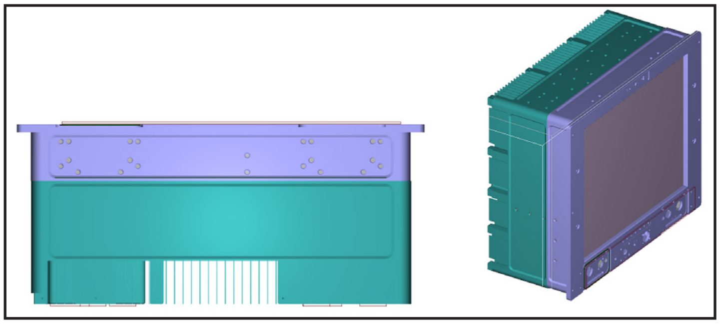

Figure 3. ATS Created a CFD Baseline Model of the Ruggedized Rack System

Critical Component	Target Maximum Operating Temperature (°C)	Base Line CFD Max Temperature (°C)
CPU_1	85°C	96.3°C
CPU_2	85°C	89.5°C
DC-DC converter	125°C	91.6°C
Graphics Card	80°C	119°C
Power Module	100°C	135°C
KVM Switch	45	173°C
Display Panel	NA	99°C

Figure 4. The ATS Baseline Study Showed that the Current Thermal Design was Not Sufficient to Meet All the Thermal Requirements

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METHODOLOGY

Optimization Investigation Areas

- Six heat pipe routing configurations (Figure 5)
- Replacement of the original pin-fin heat sink
- Fan push-pull reconfiguration
- Directed more airflow toward CPUs (Figure 6)
- Removal of internal airflow obstructions

ATS worked through three sequential CFD models of the enclosure, with all components meeting thermal requirements by model version 3.

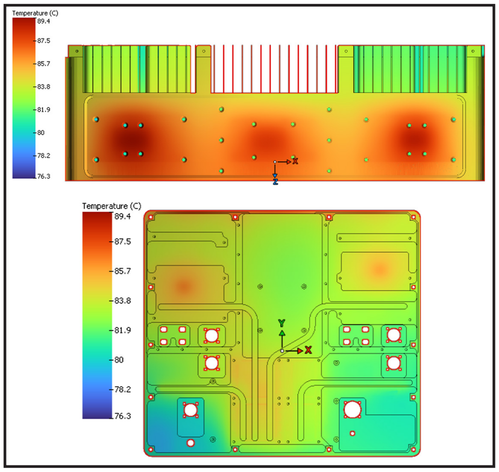

Figure 5. Surface Temperature Contours of the System's Rear Chassis

SOLUTION

ATS optimized the enclosure through a sequence of CFD-guided design changes that improved airflow efficiency, heat sink performance, and heat routing to critical components. The final solution combined revised heat pipe routing, heat sink replacement, fan reconfiguration, and obstruction removal to bring all components into compliance.

- Evaluated six heat pipe routing configurations
- Replaced the original pin-fin heat sink with an ATS MaxiFLOW heat sink (Figure 7)
- Reconfigured fans into a push-pull arrangement
- Directed more airflow toward the CPUs
- Removed internal obstructions that disrupted useful airflow
- Completed three progressive CFD model revisions to converge on the final design

This produced a practical custom cooling architecture that reduced hot spots and improved airflow reliability margin inside the sealed chassis.

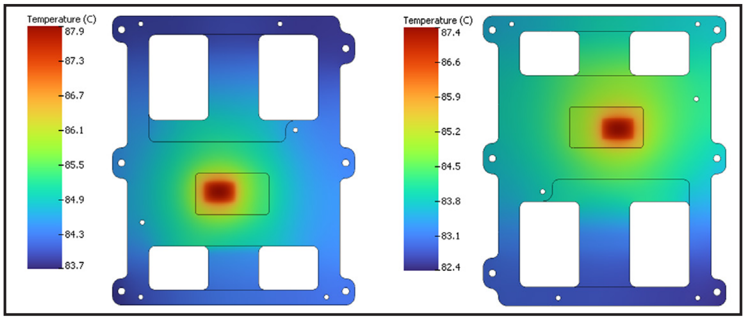

Figure 6. Surface Temperature Contours of the System's CPUs

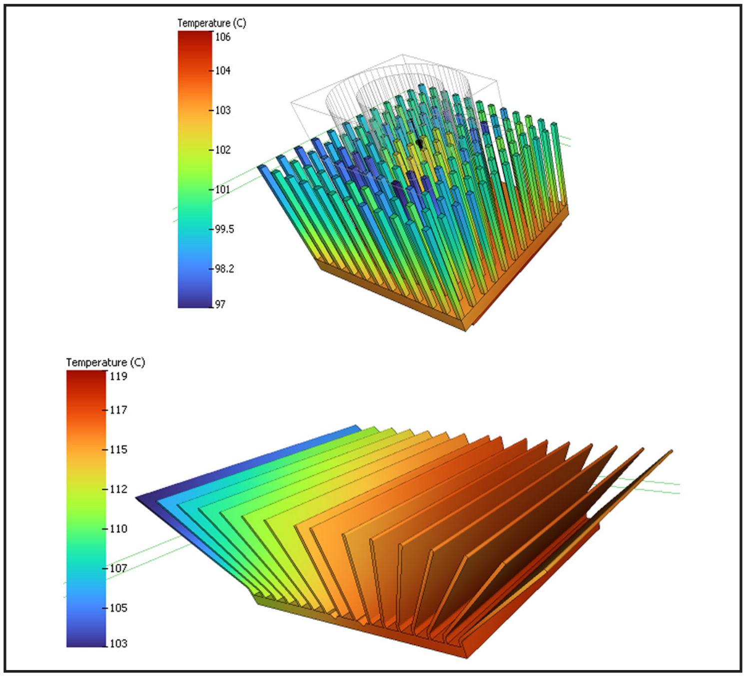

Figure 7. Surface Temperature Contours of the System's (top) Original Pin-Fin Heat Sink, and Its Replacement (bottom) ATS MaxiFLOW Heat Sink

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RESULTS & DATA

The optimization reduced peak temperatures and improved airflow efficiency, with model version 3 bringing all components within their thermal requirements.

Key findings:

- Baseline peak component temperatures reached up to 119°C
- Optimization reduced peak temperatures to compliant levels
- All components met thermal requirements by the third CFD model iteration
- Fan operating point shifted away from the unstable knee region
- Airflow efficiency and reliability margin improved

The study also showed that poor chassis heat routing and internal airflow recirculation were major causes of the original thermal shortfall.

Thermal engineering outcomes:

- Identified high-risk components early through baseline CFD
- Improved airflow delivery to CPUs and power-dense regions
- Enhanced heat sink effectiveness through MaxiFLOW replacement
- Reduced recirculation zones and internal obstructions
- Improved fan operating stability and airflow reliability

ANALYSIS & CONCLUSION

This study shows that sealed ruggedized systems require more than component-level cooling fixes. Reliable thermal performance depends on coordinated optimization of airflow paths, heat routing, fan operating point, and heat sink architecture across the full enclosure.

- Baseline CFD effectively exposed thermal risk before hardware failure
- Heat sink replacement alone was not enough without airflow reconfiguration
- Progressive CFD iterations enabled targeted, lower-risk design refinement
- The final design improved both thermal compliance and operating margin

ATS delivered a CFD-driven de-risking process that converted an insufficient baseline thermal design into a compliant, ruggedized cooling solution for a sealed 241 W rack system.