TECHNICAL CASE STUDY

Power Electronics · CFD Optimization

ATS

Thermal Architecture Optimization of Dual Power Supply Modules

At a Glance

Advanced Thermal Solutions, Inc. (ATS) engineered CFD-driven thermal optimization for two power supply module architectures, Gen 4 and Gen 2, operating at 45°C ambient. The study focused on clustered 20–25 W power devices, airflow utilization, and reusable cooling hardware across both generations.

CUSTOMER OVERVIEW

The customer was developing two related power supply module generations with clustered high-dissipation components. ATS was asked to validate thermal performance, improve component placement, and develop a practical cooling strategy that supported both compliance and design commonality.

- Two module generations requiring thermal validation at 45°C ambient
- Clustered MOSFETs, bridge rectifiers, transformers, and power-stage components
- Need for layout, airflow, and heat sink optimization across both designs

CHALLENGE

The governing constraint was localized heating from 20–25 W power devices placed in compact layouts. ATS needed to keep critical components below a 138°C limit while improving airflow through the heat sink fins and preserving manufacturable layout changes.

Major Gen 4 heat contributors per board:

- PFC Inductor: 15 W
- Bridge Rectifier: 20 W
- PFC Switch and Diode: 20 W
- Transformer: 25 W
- LLC Switch: 24 W
- EMI Filter: 6 W
- Miscellaneous: 4 W

The core challenge was improving airflow through the heat sink, reducing shadowing from nearby components, and creating a practical cooling architecture that worked across both layouts.

Thermal Architecture Optimization of Dual Power Supply Modules

Methodology

ATS used CFD temperature and velocity modeling to evaluate each architecture and guide component placement, fan selection, heat sink design, and cross-generation reuse.

Optimization approach:

- Modeled Gen 4 and Gen 2 at 45°C ambient
- Analyzed temperature and velocity contours for each layout
- Repositioned components to improve airflow and heat sink access
- Used conservative lumped models for MOSFETs and transformers
- Validated fan operating point against chassis impedance

Gen 4 Thermal Optimization

For Gen 4, ATS recommended repositioning MOSFETs and connectors to open the airflow path and enable a common MOSFET heat sink. A 34 CFM high-pressure fan was selected to support stable flow through the heat sink fin field (Figures 1-3).

Gen 4 Optimization Actions

- Relocated MOSFETs to enable a common heat sink
- Moved connectors to eliminate airflow shadowing
- Relocated the microcontroller to improve inlet airflow
- Selected a 34 CFM high-pressure fan
- Modeled MOSFETs and transformer conservatively using lumped properties

Gen 4 Critical Component Results:

- MOSFET case temperature: approximately 97.5°C
- Bridge rectifier case temperature: approximately 94.4°C
- Transformer maximum temperature: approximately 115°C
- All critical components below the 138°C allowable limit

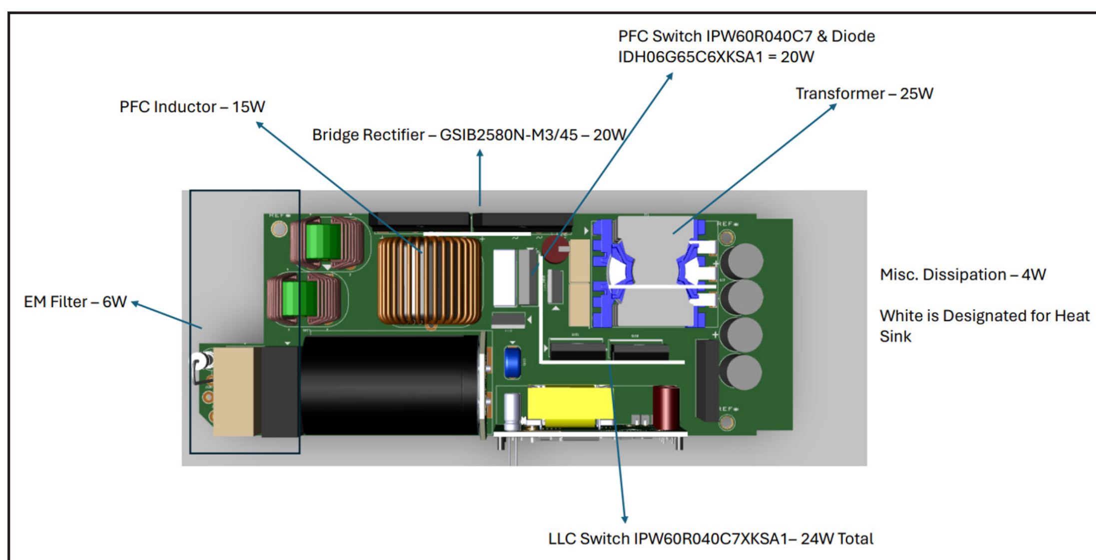

Figure 1.
Gen 4 Power Dissipation Map and Heat Sink Area Allocation

Thermal Architecture Optimization of Dual Power Supply Modules

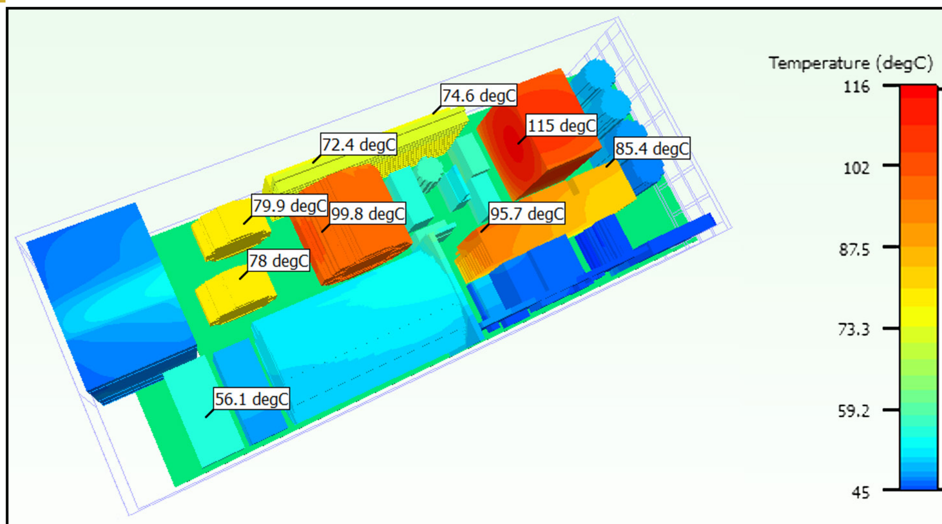

Figure 2.
Gen 4 Power Supply - Temperature Contours

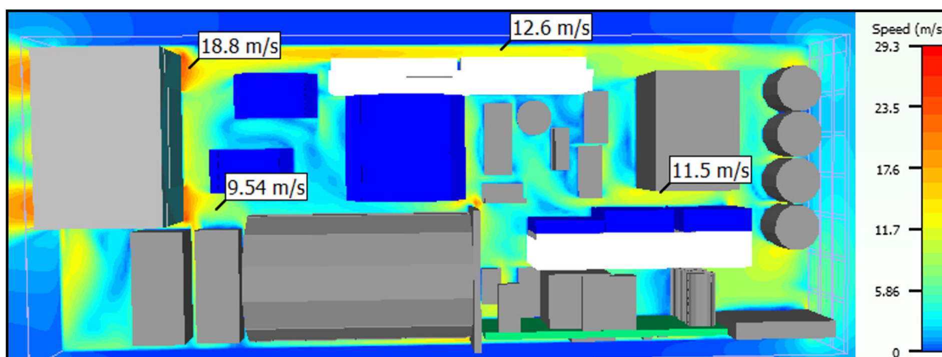

Figure 3.
Gen 4 Power Supply - Velocity Contours

Gen 2 Thermal Optimization

For Gen 2, ATS adapted the Gen 4 cooling strategy to a tighter layout. The MOSFET heat sink was kept common with Gen 4, while a copper spreader was added between bridge rectifiers where a finned heat sink could not fit (Figures 4-6).

Gen 2 Optimization Actions

- Reduced power levels per component compared with Gen 4
- Limited space prevented a finned heat sink for the bridge rectifier
- Copper spreader added between bridge rectifiers for heat sharing
- MOSFET heat sink kept identical to Gen 4 for design commonality

Gen 2 Critical Component Results:

- MOSFET case temperature below the 138°C limit
- Bridge rectifier case temperature below the 138°C limit
- Transformer maximum temperature: approximately 111°C
- Stable performance achieved with shared heat sink strategy

Thermal Architecture Optimization of Dual Power Supply Modules

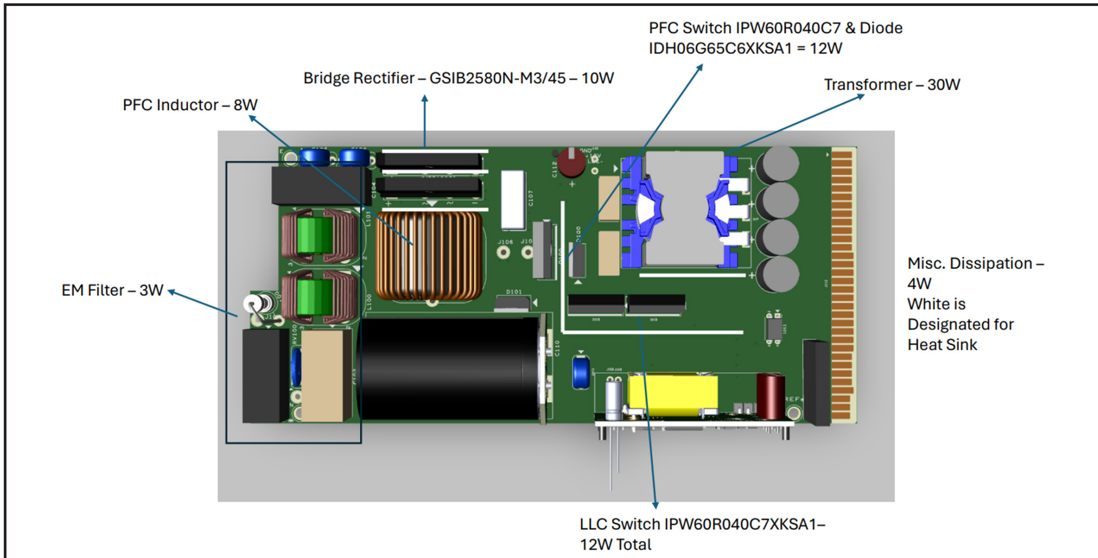

Figure 4.
Gen 2 Power Dissipation Map and Heat Sink Area Allocation

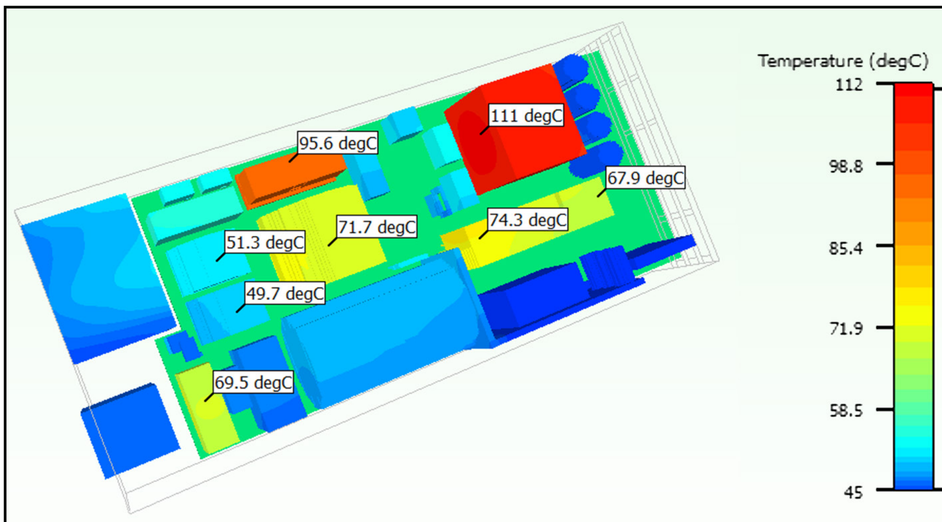

Figure 5.
Gen 2 Power Supply - Temperature Contours

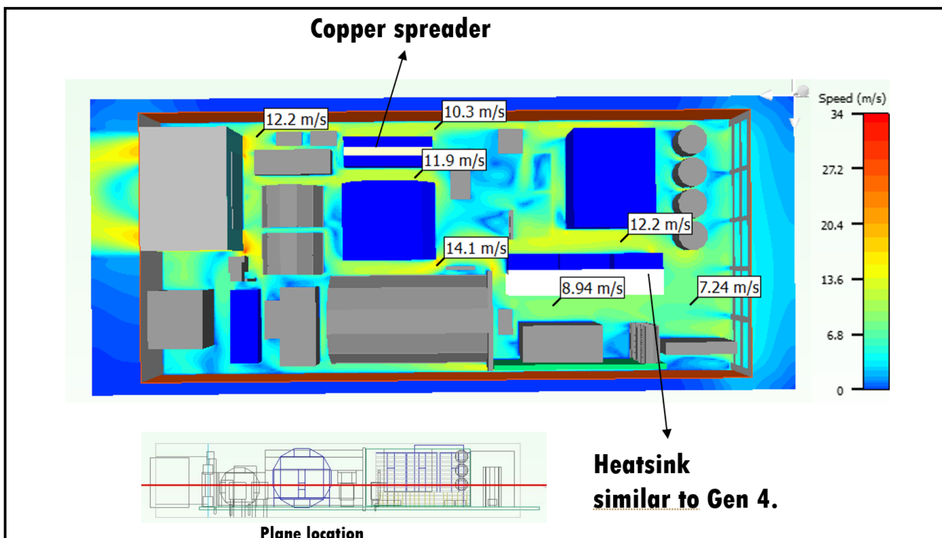

Figure 6.
Gen 2 Power Supply - Velocity Contours

Thermal Architecture Optimization of Dual Power Supply Modules

SOLUTION

ATS developed a cross-generation thermal strategy combining component relocation, shared MOSFET heat sinks, fan curve validation, and targeted heat spreading where space was limited.

- Common MOSFET heat sink used across Gen 4 and Gen 2
- Connector and component relocation improved heat sink airflow
- 34 CFM high-pressure fan provided stable operating margin
- Copper spreader replaced a finned heat sink in space-limited Gen 2
- Conservative component modeling preserved design margin

RESULTS & DATA

Both architectures met the 138°C component temperature limit at 45°C ambient. Velocity contours confirmed improved airflow through the common heat sink fins after component relocation.

Thermal engineering outcomes:

- Component relocation improved airflow utilization
- Common heat sink enabled consistent MOSFET cooling across generations
- Copper spreader effectively replaced a finned heat sink in Gen 2
- Selected fan provided a stable operating point in both architectures
- Conservative transformer modeling ensured thermal margin

ANALYSIS & CONCLUSION

This study shows that compact power supply thermal optimization depends on coordinated layout, airflow, heat sink, and fan operating point decisions. ATS validated both Gen 4 and Gen 2 designs while preserving cooling commonality wherever possible.

- CFD-driven layout optimization reduced airflow shadowing
- Common heat sink strategy simplified cross-generation implementation
- Fan curve and system impedance coupling confirmed stable airflow delivery
- Data-backed compliance validation confirmed margin at 45°C ambient

ATS delivered a practical thermal architecture for two power supply generations, combining CFD modeling, heat sink commonization, fan selection, and targeted spreading solutions.

Take control of your thermal performance with expert analysis and design services, contact ATS to speak with our engineers and start optimizing your system today.

ADVANCED THERMAL SOLUTIONS, INC. 781-769-2800 ATS-HQ@QATS.COM WWW.QATS.COM