AWN-TECM-08 · WHAT'S NEW AT ATI

High-Temperature TEC Modules for AI Data Center GPU Cooling

June 2026 · Analog Technologies, Inc. · 4-minute read

AI accelerators concentrate intense heat into compact die areas — but unlike laser diodes or imaging sensors, many of them can be operated at a noticeably higher controlled temperature. That difference is a quiet design opening.

ATI's high-temperature TEC modules are rated to **200 °C** maximum surface temperature, versus **125 °C** for regular modules. With the same heat sink and airflow at room ambient, that's about **2×** the heat-sink-to-ambient driving force and roughly **+30%** in theoretical no-load ΔTmax — enough headroom to fit more compute behind the same or smaller heat sink.

[Use the real ATI high-temperature TEC module product image here]

Alt text: ATI high-temperature TEC module for AI data center GPU cooling and high-density electronics thermal management.

SURFACE LIMIT **200 °C** Max TEC surface temperature, ATI high-temperature series	HEADROOM **+75 °C** Additional surface-temperature headroom vs. 125 °C TEC baseline
DRIVING FORCE **≈ 2×** Heat-sink-to-ambient driving force at Th = 175 °C vs. 100 °C, Tamb = 25 °C	ΔTMAX **≈ +30%** Higher theoretical no-load ΔTmax at Th = 175 °C vs. 100 °C

Key Takeaways

- **Surface-temperature rating:** 125 °C → 200 °C, a +75 °C lift before reliability headroom is taken.
- **Practical hot-side design point:** 100 °C → 175 °C, after a conservative 25 °C solder and reliability margin.
- **Heat-sink driving force at 25 °C ambient:** 75 °C → 150 °C — about 2× for the same heat sink and airflow.
- **Theoretical no-load ΔTmax:** ≈ 96 °C at Th = 100 °C → ≈ 125–126 °C at Th = 175 °C, roughly +30%.

- **Where it helps:** AI GPU and accelerator cooling, high-power ASIC/IC hot-spot control, power electronics, industrial electronics in elevated-ambient enclosures.

The high-temperature series is built for the cases where a regular TEC would already be at its limit — hot-side temperature, solder margin, heat-sink temperature, or long-term reliability. It uses the same compact footprints engineers already specify (**ATE1-19**, **ATE1-35**, **ATE1-71**, **ATE1-127**), so the mechanical design changes very little. What changes is the temperature ceiling.

> **Think of the heat sink as a highway carrying heat to ambient air.** Letting the heat sink run hotter widens the temperature drop to ambient — like opening more lanes for heat to leave the system without enlarging the highway itself.

Why It Matters

- **+75 °C of raw surface-temperature ceiling.** The maximum operating surface temperature moves from 125 °C to 200 °C — before any reliability margin is reserved.
- **The same +75 °C survives the headroom.** After a conservative 25 °C solder and reliability margin, the practical hot-side design point still rises from 100 °C to 175 °C.
- **About 2× the heat-rejection driving force.** At 25 °C ambient, heat-sink-to-ambient ΔT grows from 75 °C to 150 °C — twice the temperature gradient the heat sink had to work with, for the same fins and airflow.
- **About +30% in theoretical no-load ΔTmax.** Using the ATI white-paper ΔTmax-vs-Th method, ΔTmax rises from ≈ 96 °C at Th = 100 °C to ≈ 125–126 °C at Th = 175 °C.
- **Headroom traded for density, cost, or noise.** A smaller, lower-cost, or slower-fan heat sink frees space for compute, airflow paths, power delivery, or mechanical packaging in tight enclosures.

Numerical Comparison: Regular TEC vs. High-Temperature TEC

Same ambient temperature, same heat-sink size, same airflow. Heat dumping is estimated by the first-order relation $Q_{hs} \approx (T_{hs} - T_{amb}) / R_{\theta,hs\text{–}amb}$.

Parameter	Regular TEC Module	ATI High-Temperature TEC	Engineering Implication
Maximum TEC surface temperature	125 °C	200 °C	+75 °C additional ceiling
Practical hot-side / heat-sink temperature after 25 °C headroom	100 °C	175 °C	+75 °C more design headroom
Assumed ambient air	25 °C	25 °C	Same

Parameter	Regular TEC Module	ATI High-Temperature TEC	Engineering Implication
temperature			assumption
Heat-sink-to-ambient ΔT	**75 °C**	**150 °C**	**2.0× larger driving force**
Heat-dumping power of the same heat sink	**100%**	**≈ 200%**	**≈ +100% first-order**
Theoretical no-load ΔTmax	≈ 96 °C at Th = 100 °C	≈ 125–126 °C at Th = 175 °C	≈ +30% higher
Estimated heat-sink thermal requirement, same heat load	**100%**	**≈ 50%**	**Up to ≈ 50% lower, before margin**

Note: This is a first-order engineering estimate. Real heat-sink performance also depends on airflow, fin geometry, orientation, fan curve, ducting, radiation, dust, mounting flatness, TIM quality, and enclosure effects.

How the ΔTmax Number Was Estimated

ΔTmax is not a fixed constant. It tracks hot-side temperature Th: lift Th, and theoretical no-load ΔTmax goes with it. For an ATE1-127-class module rated near **66 °C at Th = 27 °C**, the ATI white-paper method gives about **96 °C at Th = 100 °C** and about **125–126 °C at Th = 175 °C**.

> **Formula.** $\Delta T_{max}(Th) = Th + 1/Z - \sqrt{2 \cdot Th/Z + 1/Z^2}$ where Th is in kelvin and Z is the module's figure of merit.

$Z \approx 2.5 \times 10^{-3}$ /K here, calibrated against the datasheet baseline.

CALCULATION WALKTHROUGH

```
Assumptions     // before any margin or derating
  Regular TEC max surface temperature   = 125 °C
  High-T TEC max surface temperature    = 200 °C
  Reliability / solder headroom         =  25 °C
  Ambient air temperature  Tamb         =  25 °C
  Figure of merit          Z            ≈ 2.5e-3 /K  (1/Z = 400 K)

Step 1 — Practical hot-side / heat-sink temperatures
  Regular:           125 − 25  →  100 °C
  High-temperature:  200 − 25  →  175 °C

Step 2 — Heat-sink-to-ambient driving force at 25 °C ambient
  Regular:           100 − 25  →   75 °C
```

```
  High-temperature:  175 − 25  →  150 °C
  Ratio:              150 / 75 →  2.0×    // first-order; same heat
sink, same airflow

Step 3 — Theoretical no-load ΔTmax  (Th in kelvin)
  At Th = 100 °C = 373 K:
    ΔTmax = 373 + 400 − √(2·373·400 + 400²) →  ≈ 96 °C
  At Th = 175 °C = 448 K:
    ΔTmax = 448 + 400 − √(2·448·400 + 400²) →  ≈ 125–126 °C
  Change:             (125 − 96) / 96     →  ≈ +30 %
```

These are theoretical no-load values, not guaranteed cooling capacity under load. Actual capacity still depends on Qc, current, voltage, mounting, TIM thickness, hot-side thermal resistance, controller limits, and derating curves.

Engineering caution. Higher theoretical ΔTmax is not a reason to operate the TEC as hot as possible. Elevated temperature lifts ΔTmax and heat rejection, but also raises material stress, system-level heat burden, and reliability risk. Reach for the high-temperature series when the application needs the headroom — and apply normal derating and lifetime checks either way.

Where This Helps Most

The high-temperature series earns its place when the controlled device can safely sit at an elevated setpoint and the system designer wants to push more heat through a smaller, quieter, or simpler thermal path.

- AI data center GPU and accelerator hot-spot cooling
- High-power ASIC, processor, and IC thermal management
- Power electronics cooling and hot-spot spreading
- Industrial electronics in elevated-ambient enclosures
- Automotive, aerospace, and defense electronics
- Semiconductor process equipment and heated instruments

Quick Engineering Answer

Q. What is a high-temperature TEC module used for in AI data center cooling?
A. A high-temperature TEC module is used when the hot side or heat sink must operate above the limit of a regular TEC module — about 125 °C. ATI high-temperature modules are rated to 200 °C, which roughly doubles the heat-sink-to-ambient driving force at 25 °C ambient and lifts theoretical no-load ΔTmax by about 30%.

Frequently Asked Questions

What is a high-temperature TEC module?

A thermoelectric cooler designed to operate with a higher allowable hot-side or surface temperature than a regular TEC module. ATI's high-temperature TEC modules are rated to about 200 °C maximum surface temperature, versus about 125 °C for regular TEC modules.

Why is this useful for AI data center GPU cooling?

AI GPUs and accelerators generate intense local heat but can usually be operated at a higher controlled temperature than precision optoelectronic devices. A high-temperature TEC module lets the heat sink follow them up, which grows the heat-sink-to-ambient ΔT and improves heat rejection for the same heat sink size and airflow.

Does a hotter heat sink always increase TEC cooling capacity?

No. A hotter heat sink improves heat rejection to ambient and lifts theoretical no-load ΔTmax, but actual capacity under load still depends on Qc, TEC current and voltage, thermal-interface quality, heat-sink resistance, and derating curves.

Can the heat sink really be reduced by about 50%?

As a first-order estimate, yes. Doubling the heat-sink-to-ambient ΔT from 75 °C to 150 °C doubles the heat-rejection driving force, so the same heat load can be carried by a heat sink with roughly half the original thermal capability — before margin. Real designs still need to verify airflow, fin geometry, fan curve, dust and aging, and enclosure effects.

What is the difference between ΔTmax and heat-sink-to-ambient ΔT?

ΔTmax is the maximum no-load temperature difference across the TEC module itself (Th − Tc). Heat-sink-to-ambient ΔT is the temperature difference between the heat sink and the surrounding air. They live in different parts of the thermal network and should not be added or interchanged — but both have to be sized correctly in a complete TEC thermal design.

How do I choose the right ATI high-temperature TEC module?

Start with the cooling load Qc, target device temperature, ambient temperature, allowable hot-side temperature, available voltage and current, footprint, and heat-sink thermal resistance. Compare ATI TEC datasheets (ATE1-19, ATE1-35, ATE1-71, ATE1-127) — or contact ATI for selection and customization help.

Animated Cartoon Image Idea

Scene: A compact AI server rack under load. A GPU die glows red; below it, a friendly ATI high-temperature TEC module pushes red heat arrows up into a noticeably smaller heat sink.

Motion: Heat arrows travel GPU → TEC module → heat sink → ambient air. As they move, the heat sink shrinks a little and a second AI processor slides into the freed server space.

Caption: *"More thermal headroom. More heat dumping. Denser AI compute."*

Alt text: *Animated cartoon showing an ATI high-temperature TEC module cooling an AI data center GPU and freeing space inside the server.*

Product and Datasheet Links

- **Selection guide:** High-Temperature Rectangular TEC Module Selection Guide — https://www.analogtechnologies.com/High_temperature_rectangular_TEC_module_price_list.html
- **Product line:** ATI TEC Modules — https://www.analogtechnologies.com/tec-module.html
- **Datasheet:** ATE1-19 — https://www.analogtechnologies.com/document/ATE1-19.pdf
- **Datasheet:** ATE1-35 — https://www.analogtechnologies.com/document/ATE1-35.pdf
- **Datasheet:** ATE1-71 — https://www.analogtechnologies.com/document/ATE1-71.pdf
- **Datasheet:** ATE1-127 — https://www.analogtechnologies.com/document/ATE1-127.pdf

Need help selecting the right TEC module?

> **Talk to ATI engineering.** Browse the high-temperature series, compare datasheets, or talk to ATI engineering about selection, customization, or thermal-budget review — for AI data center cooling, high-power IC cooling, power electronics, or any elevated-temperature thermal architecture.