THERMOELECTRIC SOLUTIONS

JARO Thermoelectric Modules and System-Level Thermal Support

TEC and TEG modules, selection guidance, and the hot-side cooling hardware that makes them work

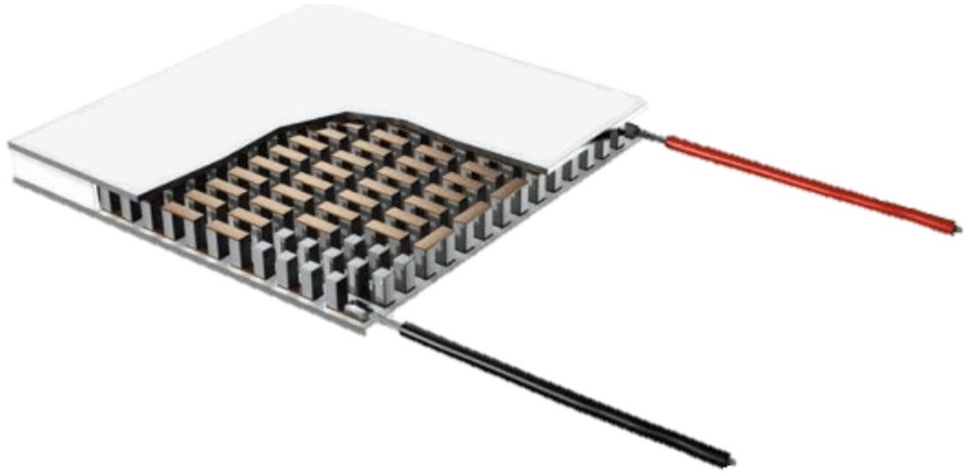


Photo: JARO thermoelectric module (pellet array)

JARO Thermal, Inc. | Product & Technology Overview | 2026

We Keep the World Cool™

WHO WE ARE

A Thermal Solution Provider, Not Just a Module Supplier

JARO Thermal supplies the full heat path, so a TEC can be specified together with the hardware that removes its heat.

- Cooling fans and blowers move the air across the hot-side heatsink
- Heatsinks, thermal modules and liquid cooling set the hot-side temperature
- TEC and TEG modules pump heat or convert it to power

Why it matters
A TEC's real cooling result depends on how well its hot side is cooled. One supplier for the module and its heat-rejection path means one thermal budget, one contact and fewer interface surprises.

DC / AC / EC Cooling Fans

Blowers

Heatsinks & Thermal Modules

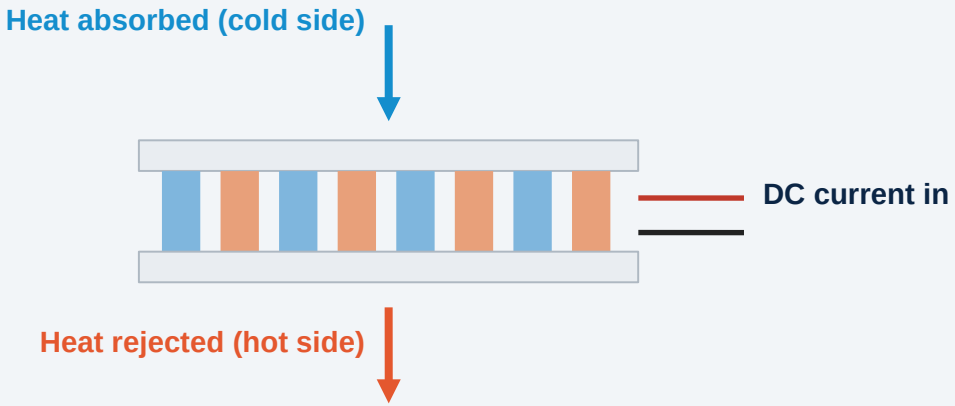
Liquid Cooling Solutions

Thermoelectric Modules (TEC)

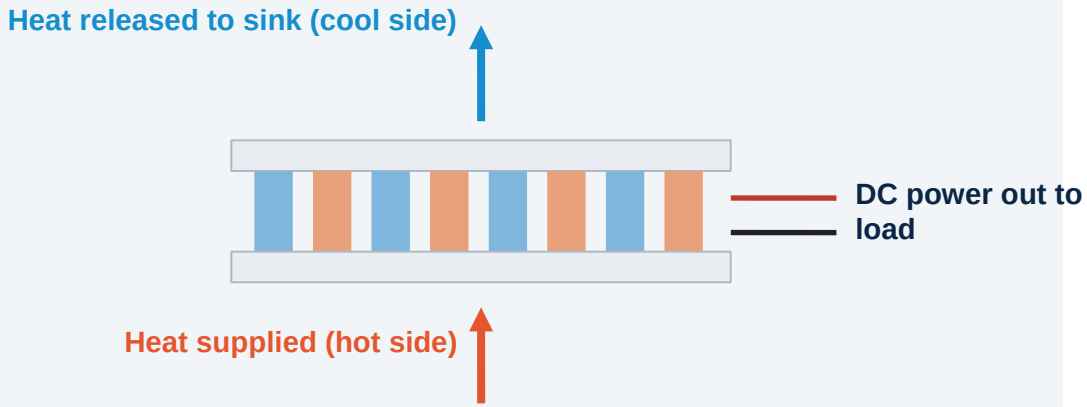
Thermoelectric Generators (TEG)

One Device Physics, Two Operating Modes

Peltier effect → TEC (cooling / heating)

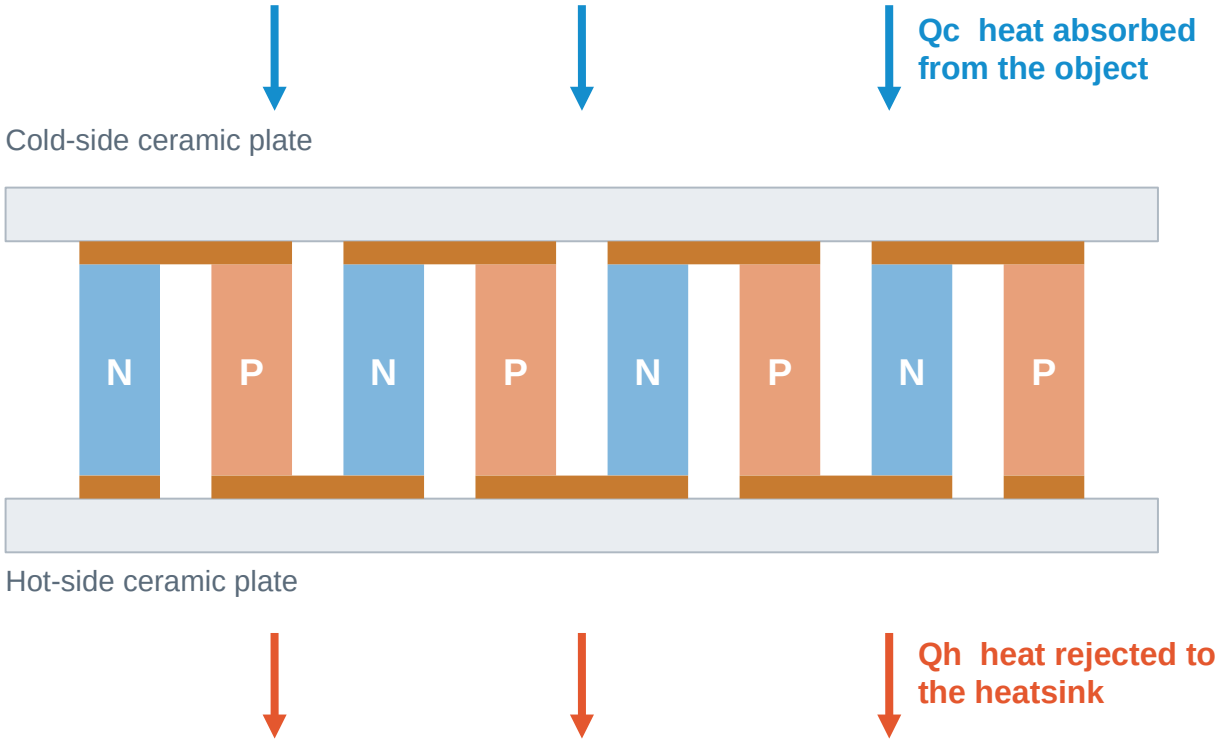


Seebeck effect → TEG (power generation)



	TEC (Peltier mode)	TEG (Seebeck mode)
Input	DC electrical power	Temperature difference across the module
Output	Heat pumped from cold side to hot side	DC electrical power into a load
Key metrics	Qc (W), ΔT (°C), COP	Output power (W), conversion efficiency (%)
Control	Current level and polarity (reverse polarity to heat)	Load resistance; max power at matched load

A TEC Is a Heat Pump: The Hot Side Rejects Qc Plus Power



Energy balance

$$Qh = Qc + V \times I$$

The heatsink must remove the pumped heat plus all electrical input power.

Construction

P- and N-type bismuth telluride (Bi_2Te_3) pellets between two ceramic plates, joined by copper conductors.

Reversible

Reverse the DC polarity and the module heats instead of cools — useful for set-point control above and below ambient.

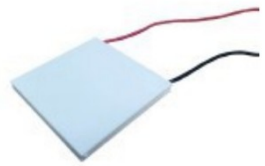
Hot side is mandatory

A TEC is never a stand-alone cooler. Without hot-side cooling the module overheats quickly and can be damaged.

Schematic only — not to scale. P- and N-type pellets: electrically in series, thermally in parallel.

PRODUCT PORTFOLIO

Six Product Families for Six Design Problems

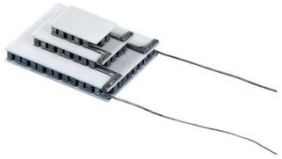


TEC1

Single-Stage

General-purpose cooling and heating; widest power range

9 models · Imax 3–15 A

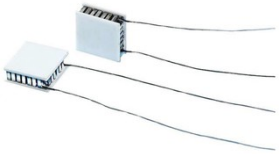


TEC2 / TEC3

Multi-Stage

Two or three stages for larger ΔT at low heat load

5 + 3 models · ΔTmax 83–110 °C

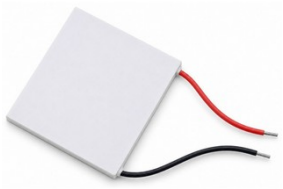


TEM

Miniature

Compact footprints, down to 1.6 × 1.6 mm, for local cooling

9 models · Qmax 0.56–13.4 W



TER

High-Reliability

Designed for repeated heating and cooling cycles

9 models · Imax 4–17 A



TES

Small-Pellet

Pellets ≤ 1.0 × 1.0 mm; low drive current

3 models · Imax 1–3 A



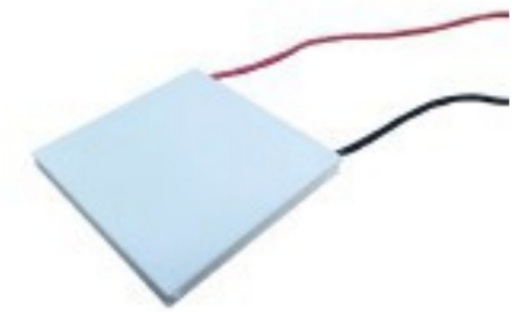
TEG

Power Generation

Converts a temperature difference into DC power

3 models · 1.3–2.1 W max output

General-Purpose Cooling and Heating



The default choice when the required ΔT is moderate and heat load drives the selection.

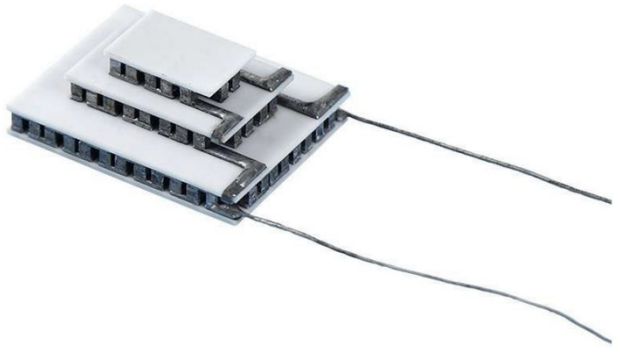
- Pellet size ≥ 1 mm
- Footprints from 10 × 10 mm to 62 × 62 mm
- Same 40 × 40 mm footprint offered at 3, 4, 6 and 8 A ratings to match the power supply

Part No.	Imax (A)	Vmax (V)	ΔTmax (°C)	Qmax (W)	Size L×W×H (mm)
JC-TEC1-00708	8.0	0.85	66	3.92	10×10×2.90
JC-TEC1-06308	8.0	7.64	65	35.28	40×20×4.15
JC-TEC1-09906	6.0	12.0	65	42.33	50×25×3.55
JC-TEC1-12704	4.0	16.6	77	37.6	40×40×4.3
JC-TEC1-12706	6.0	16.6	77	53.4	40×40×3.8
JC-TEC1-12708	8.0	16.6	77	75.2	40×40×3.5
JC-TEC1-12710	10.0	15.4	65	88.9	62×62×5.55
JC-TEC1-19903	3.0	26.0	77	44.2	40×40×4.3
JC-TEC1-19915	15.0	24.13	70	208.95	40×40×3.0

Typical applications: electronics enclosures, scientific instruments, medical and biotech equipment, consumer appliances

Ratings at Qc = 0 (ΔTmax) or ΔT = 0 (Qmax) with I = Imax; never simultaneous. Full datasheets and performance curves available on request.

Larger ΔT for Low-Temperature Spot Cooling



Part No.	Imax (A)	Vmax (V)	ΔTmax (°C)	Qmax (W)	Cold / hot stage (mm), H
JC-TEC2-25411	11.0	30.8	85	212.7	30×30 / 40×40, H 6
JC-TEC2-19002	1.6	17.2	104	11.0	15×30 / 30×30, H 8
JC-TEC2-03805	4.8	4.1	105	4.00	12×12 / 15×15, H 5
JC-TEC2-11105	5.0	13.3	110	12.25	14×14 / 14×27, H 4
JC-TEC2-08806	5.5	11.1	105	13.0	15×15 / 30×30, H 7

Stacked stages reach a larger ΔT than a single stage, at a lower heat load.

- Each added stage raises ΔTmax but lowers Qmax and COP
- Cold stage is smaller than the hot stage (pyramid build)
- Three-stage TEC3 for even larger ΔT: next slide

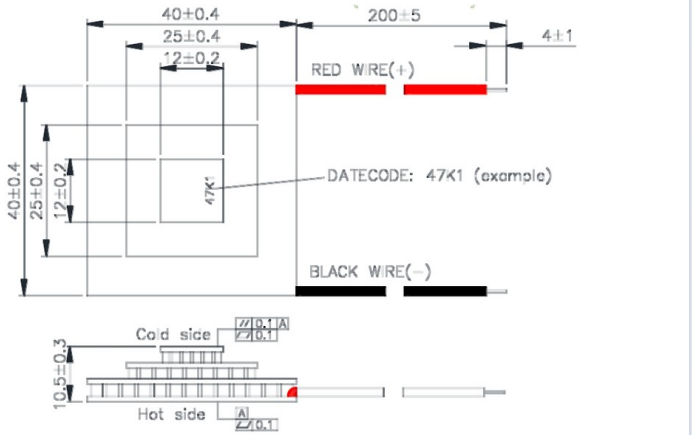
Why multi-stage?

Each lower stage must pump the heat of the stage above it plus that stage's input power, so stages grow larger toward the hot side. Choose multi-stage only when a single stage cannot reach the required ΔT at the needed heat load.

Typical applications: infrared detectors, CCD/CMOS image sensors, inspection and analytical instruments, precision thermal control

Ratings at Qc = 0 (ΔTmax) or ΔT = 0 (Qmax) with I = Imax; never simultaneous. Full datasheets and performance curves available on request.

Three Stages for the Largest Temperature Difference



Outline drawing: JC-TEC3-19304-0017 (12 / 25 / 40 mm stages)

For the largest ΔT at a small heat load; rated at Th = 27 °C and 50 °C.

- ΔTmax ≥ 110 °C at Th = 50 °C (JC-TEC3-19304)
- Up to 116 W Qmax at 24.8 A (JC-TEC3-47325)
- Solder, sealing and lead wire set per model

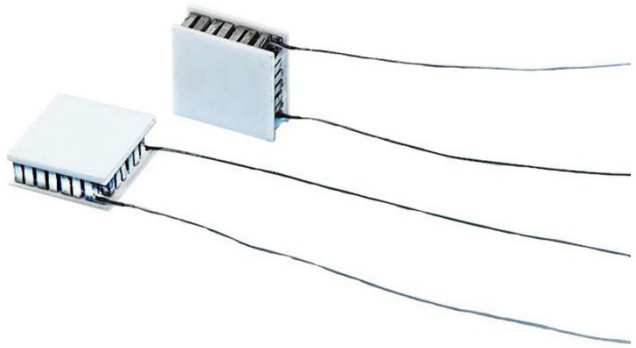
Typical applications: cooled IR and photon detectors, CCD/CMOS imaging in medical and inspection tools, laboratory cold stages

Part No.	Th (°C)	Imax (A)	Vmax (V)	ΔTmax (°C)	Qmax (W)	ACR (Ω)
JC-TEC3-19304-0017	27	4.50	15.40	≥ 100	7.55	2.95
	50	4.50	16.44	≥ 110	8.46	3.43
JC-TEC3-22907-0016	27	7.31	15.37	≥ 83	14.97	3.22
	50	7.29	16.44	≥ 92	16.79	3.74
JC-TEC3-47325-0018	27	24.82	57.23	≥ 90	116.44	1.96
	50	24.77	61.24	≥ 100	130.58	2.28

Part No.	Stages C / M / H (mm)	H (mm)	Solder	Sealing	Lead wire
JC-TEC3-19304-0017	12 / 25 / 40	10.5	SnSb 238 °C	None	#20 PTFE 200 mm
JC-TEC3-22907-0016	20 / 25 / 30	7.0	SnBi 138 °C	RTV silicone	#22 silicone 150 mm
JC-TEC3-47325-0018	40 / 50 / 62	8.5	SnAgCu 217 °C	RTV silicone	#16 silicone

Source: JARO specifications. Square stages; ceramic Al_2O_3 both sides. ACR tolerance ±10%. ΔTmax at Qc = 0 and Qmax at ΔT = 0, both at I = Imax; never simultaneous.

Precise, Local Cooling in Compact Packages



For small heat loads where space, not capacity, is the constraint.

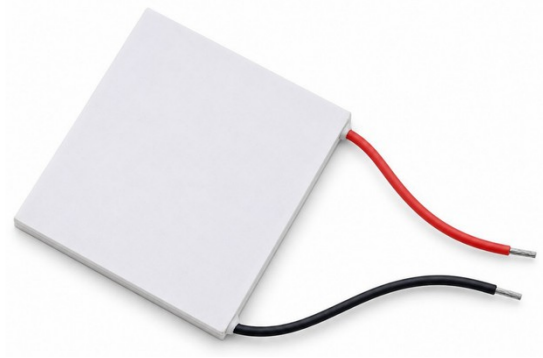
- Footprints from 1.6 × 1.6 × 0.9 mm
- Qmax 0.56–13.4 W; ΔTmax 73–74 °C
- Fast thermal response from low thermal mass

Part No.	Imax (A)	Vmax (V)	ΔTmax (°C)	Qmax (W)	Size L×W×H (mm)
JC-TEM1-00801	1.0	0.97	73	0.56	1.6×1.6×0.9
JC-TEM1-01501	1.3	1.8	73	1.64	1.8×2.6×0.8
JC-TEM1-02401	1.0	2.9	73	1.6	2.5×4×1.2
JC-TEM1-03001	1.0	3.63	73	2.1	3×6×1
JC-TEM1-03302	2.25	4.0	73	5.2	4×11×2
JC-TEM1-03502	2.5	4.5	74	5.0	6.05×12.2×1.65
JC-TEM1-04103	3.7	5.0	74	10.3	6×6×1.1
JC-TEM1-04504	4.0	5.4	74	12.4	6×16.5×1.63
JC-TEM1-12601	1.53	15.28	74	13.39	12.6×12.6×1.6

Typical applications: laser diodes and optical transceivers, sensors, compact electronic and optical devices

Ratings at Qc = 0 (ΔTmax) or ΔT = 0 (Qmax) with I = Imax; never simultaneous. Full datasheets and performance curves available on request.

Built for Repeated Heating and Cooling Cycles



For instruments that switch between heating and cooling many times a day.

- RoHS-compliant solder materials
- Wide range: 8.7–124 W Qmax; Imax 4–17 A
- Suited to frequent heating/cooling switching

Part No.	Imax (A)	Vmax (V)	ΔTmax (°C)	Qmax (W)	Size L×W×H (mm)
JC-TER1-03104	4.0	3.76	75	8.68	20×20×4.05
JC-TER1-03216	16.0	4.2	77	37.8	28.4×25.4×3.6
JC-TER1-07108	8.0	8.61	75	41.75	60×15×3.45
JC-TER1-07115	15.0	9.3	77	77.8	40×40×4.7
JC-TER1-07217	17.0	9.3	77	89.4	34×30×2.3
JC-TER1-10809	9.0	14.2	77	71.9	40×20×3.1
JC-TER1-12708	8.0	16.0	77	75.0	40×40×3.8
JC-TER1-15208	8.0	19.9	77	90.0	76.7×16.8×2.8
JC-TER1-28006	6.0	36.7	77	124.3	76×35×4.1

Typical applications: PCR and thermal cyclers, scientific instruments, biomedical equipment

Ratings at Qc = 0 (ΔTmax) or ΔT = 0 (Qmax) with I = Imax; never simultaneous. Full datasheets and performance curves available on request.

Small Pellets for Low Drive Current and Compact Size



Part No.	Imax (A)	Vmax (V)	ΔTmax (°C)	Qmax (W)	Size L×W×H (mm)
JC-TES1-07101	1.0	9.3	77	5.3	23×23×5.85
JC-TES1-07102	2.0	9.3	77	10.5	23×23×4.15
JC-TES1-12703	3.0	15.4	77	28.2	30×30×3.35

Series defined by pellet size: P/N pellet cross-section ≤ 1.0 × 1.0 mm.

- Imax only 1–3 A: suits battery or current-limited supplies
- More couples per area than standard pellets
- Overall module size varies by model

Same 127 couples, smaller footprint

JC-TES1-12703
30 × 30 mm
3 A · 15.4 V · 28.2 W

JC-TEC1-12706
40 × 40 mm
6 A · 16.6 V · 53.4 W

Smaller pellets fit the same couple count in less area, at half the drive current; capacity scales down accordingly.

Typical applications: battery-powered and portable devices, compact instruments, low-current control systems

Ratings at Qc = 0 (ΔTmax) or ΔT = 0 (Qmax) with I = Imax; never simultaneous. Full datasheets and performance curves available on request.

Heat In, DC Power Out: Solid-State Power Generation



Converts a temperature difference directly into DC power, with no moving parts.

- Output power rises with the temperature difference
- Maximum power at matched load: R_load = R_internal
- Full datasheets available on request

Typical applications: waste-heat recovery, remote and off-grid power for sensors and monitoring

Part No.	Max output (W)	Internal R (Ω)	Max temp. (°C)	Efficiency (%)	Size (mm)
JC-TEG1-127-1.0-2.0	1.3	8.0	210	3.0	30×30×4.2
JC-TEG1-127-1.0-1.6	1.6	6.5	210	3.0	30×30×3.8
JC-TEG1-127-1.0-1.3	2.1	5.0	210	3.0	30×30×3.6

Matched-load output

$P_{max} = V_{oc}^2 / (4 \cdot R_{internal})$

Voc (open-circuit voltage) is proportional to ΔT, so output power rises roughly with ΔT^2. Keeping the cold side cool is as important as heating the hot side. Shorter pellets (1.3 mm) give lower internal resistance and higher output at the same ΔT.

Output power and efficiency depend on hot- and cold-side temperatures and load.

KEY PARAMETERS

Datasheet Ratings Are Limits, Not Operating Points

ΔTmax — Largest ΔT the module can reach, with zero heat load (Qc = 0) at I = Imax

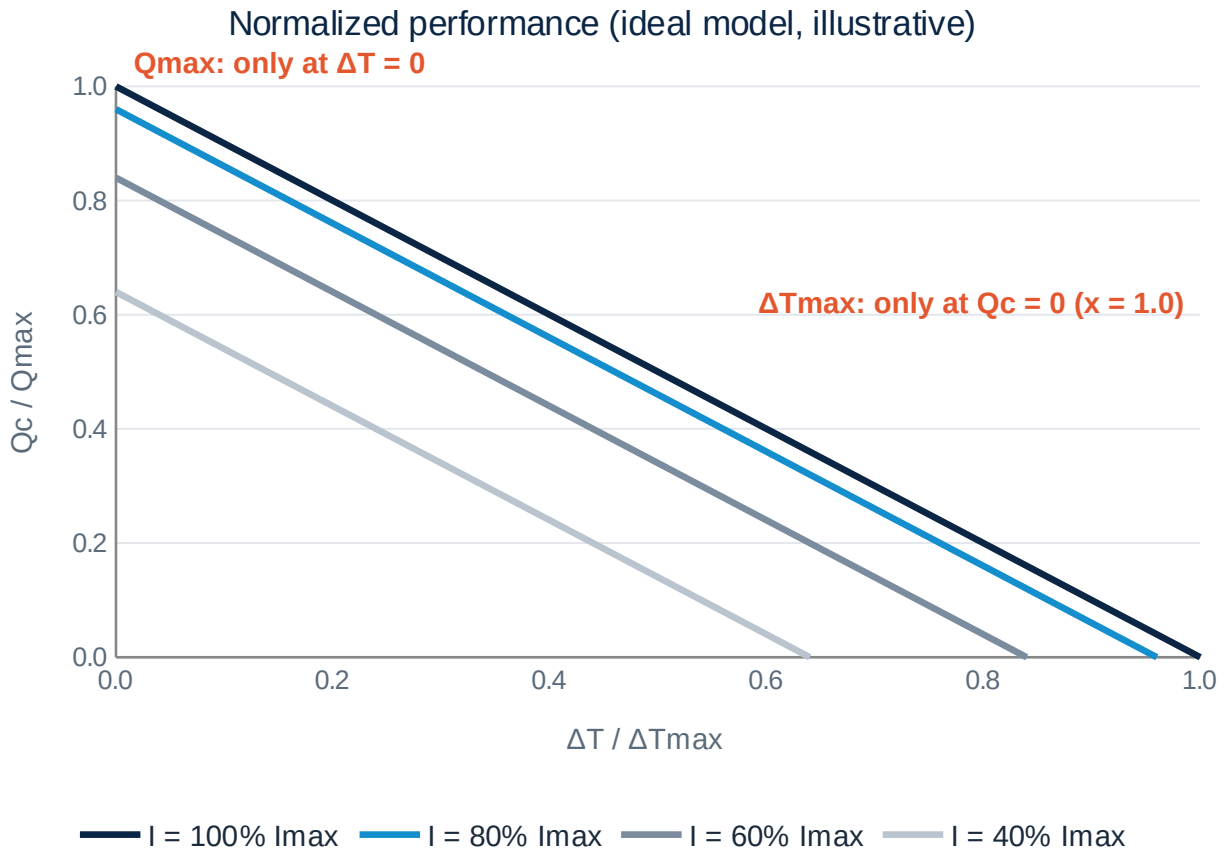
Qmax — Largest heat it can pump, with zero temperature difference (ΔT = 0) at I = Imax

Imax — Current that produces ΔTmax; above it, cooling decreases

Vmax — Voltage across the module at Imax and ΔTmax

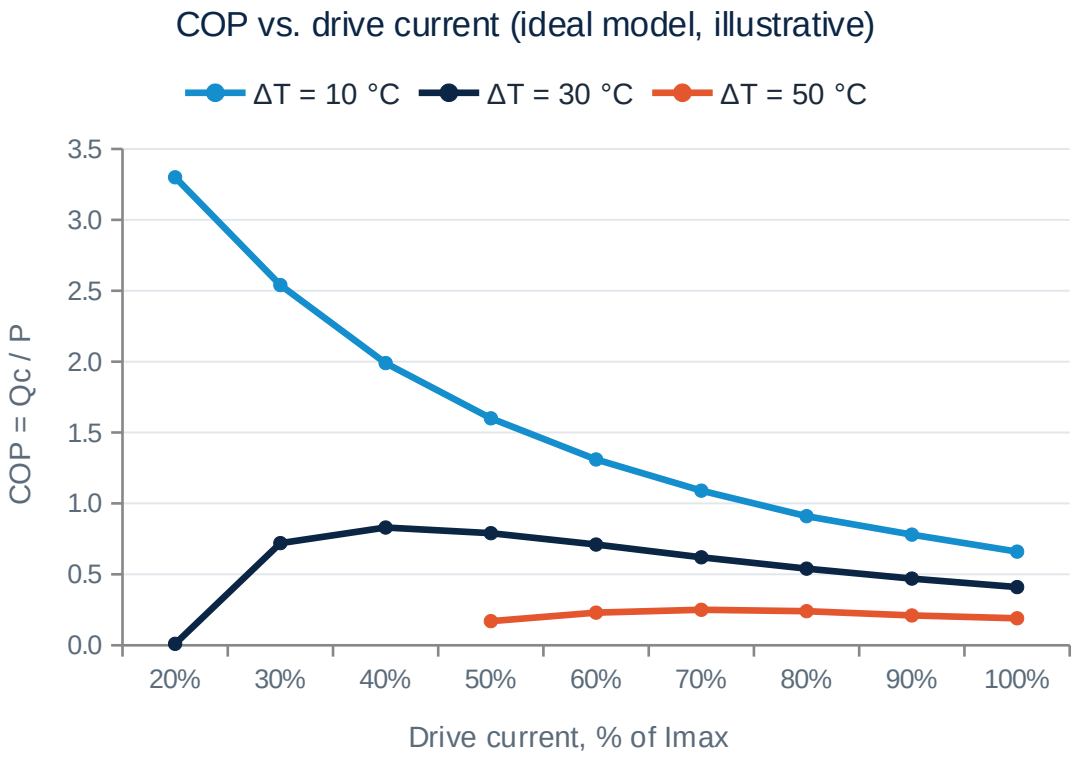
ACR — AC resistance; the main incoming-inspection check

All ratings are quoted at a stated hot-side temperature (Th, e.g., 27 °C or 50 °C). Compare modules only at the same Th. Real applications operate between the two limits, on the curve for the chosen current.



Ideal thermoelectric model at fixed cold-side temperature; Qc/Qmax = 2i − i² − ΔT/ΔTmax, i = I/Imax. Use model-specific curves for design.

Run Below Imax for Efficiency, Control, and Long Life



Generic 127-couple module, Th = 27 °C, ΔTmax ≈ 70 °C, ideal model. COP is highest at partial current and falls as ΔT rises.

Electrical drive and control

- Use smooth DC; filter PWM drive, since current ripple adds I²R loss
- Closed-loop PID with the sensor at the cooled object
- H-bridge driver to switch between cooling and heating
- Never exceed Imax or Vmax; design for partial current

Thermal cycling and reliability design

- Ceramic, copper and solder expand differently: cycling stresses joints
- Limit ΔT swing and ramp rate; avoid on/off control
- Even clamping at 10–21 kg/cm²; thermal grease 0.1–0.5 mm thick
- Edge sealing against condensation below dew point

The Hot Side Sets the Real Performance

Worked example (illustrative numbers)

1. **Heat to reject**
   Qh = Qc + P = 30 W + 50 W = 80 W

2. **Hot-side temperature**
   Th = T_amb + R_hs × Qh = 35 + 0.25 × 80 = 55 °C

3. **Required ΔT**
   Object at 20 °C → ΔT = 55 − 20 = 35 °C, not 15 °C

4. **Better heatsink**
   R_hs = 0.125 °C/W → Th = 45 °C → ΔT = 25 °C

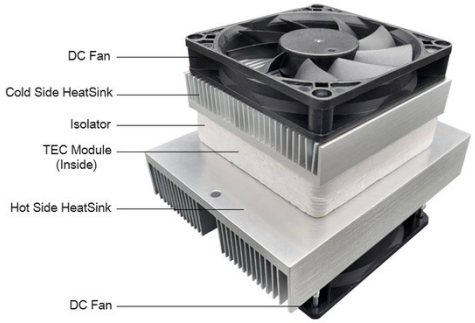
Every 1 °C rise at the hot side adds 1 °C to the ΔT the TEC must deliver. R_hs = heatsink-to-ambient thermal resistance.

Hot-side cooling options from JARO's product range

Heatsink + axial fan
Most common; compact, low cost

Blower + ducted heatsink
High static pressure, dense layouts

Liquid cold plate
High heat flux or remote heat rejection



Thermoelectric assembly (air-to-air)
TEC, cold- and hot-side heatsinks, isolator and DC fans in one unit, as shown. Used for enclosure cooling, telecom base-station and battery cabinets, outdoor power cabinets, and food and beverage cooling.

From Material to Verified Module

1 Material

P/N Bi_2Te_3 semiconductor; hot-extruded polycrystalline process

2 Design

Couple count, pellet size and layout set by the application

3 Assembly

Pellets cut and soldered to conductors on ceramic plates

4 Testing

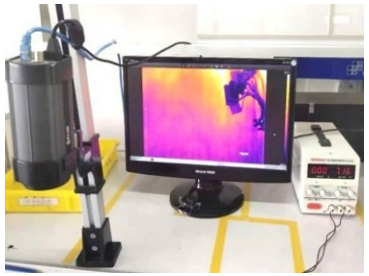
Resistance, ΔT and cooling performance

5 Integration

Module built into assemblies or customer systems



XRF RoHS analyzer



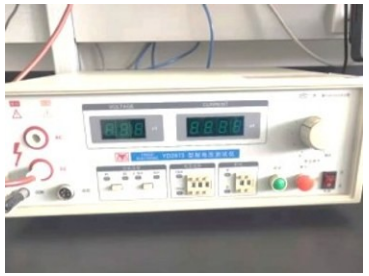
Infrared thermal imaging



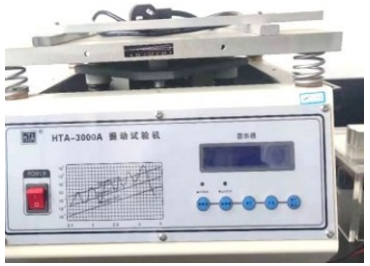
ΔT performance tester



LCR meter (AC resistance)



AC dielectric withstand tester



Vibration tester

JARO in-house production and quality verification equipment.

TARGET APPLICATIONS

Where JARO Thermoelectric Products Fit



Medical & Life Science

PCR cycling, blood analyzers, sample cooling, cooled imaging detectors

TER · TEC1 · TEM · TEC2 · TEC3



Optical Communication

Laser diodes, optical transceivers and fiber-optic components

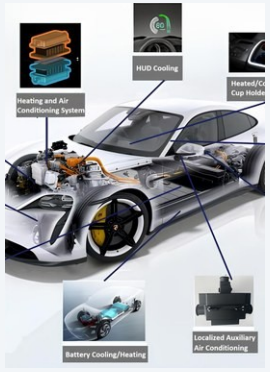
TEM · TES · TEC1



Semiconductor & Electronics

Wafer inspection and lithography tools, cooled IR and image sensors

TEC1 · TEC2 · TEC3 · TER



Automotive

Camera, LiDAR and sensor cooling, seat and cabin climate, car refrigerators

TEC1 · TEM · TES · TEG



Consumer Products

Dehumidifiers, portable coolers, heated/cooled wearables, hot/cold beauty devices

TEC1 · TES · TER · TEM



Industrial & Energy

Cabinet cooling assemblies, analyzers with cooled sensors, waste-heat power

TEC1 · TEC2 · TEC3 · TEG

Series listed in order of typical fit; see the selection matrix on the next slide. Starting points, not qualifications or customer references.

SELECTION MATRIX

Which Series Fits Which Application

Series	Medical & Life Science	Optical Comm.	Semiconductor & Electronics	Automotive	Consumer	Industrial & Energy
TEC1 Single-stage	●	○	●	●	●	●
TEC2 Two-stage	○	○	●	–	–	○
TEC3 Three-stage	○	–	●	–	–	○
TEM Miniature	○	●	○	●	○	–
TER High-reliability	●	–	○	–	○	–
TES Small-pellet	○	○	–	○	●	–
TEG Power generation	–	–	–	○	–	●

● Primary fit ○ Also suitable, depending on heat load, ΔT and size – Not a typical fit

Selection guidance only, not qualifications or customer references. Final choice depends on the required Qc, ΔT, hot-side cooling and available power; JARO engineering can confirm a specific module.

NEXT STEP

Send us your application requirements

1. **You share**
   Heat load, target and ambient temperature, power supply, space and operating mode

2. **We analyze**
   Operating point, ΔT budget and hot-side cooling

3. **We recommend**
   Module plus heatsink, fan or liquid solution and quotation

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