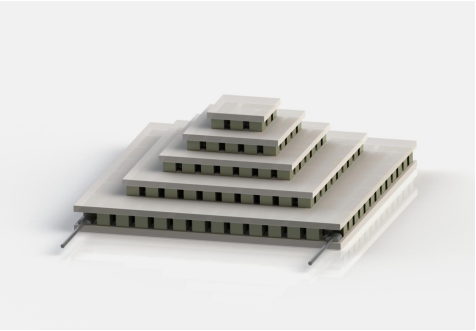
Technical Summary

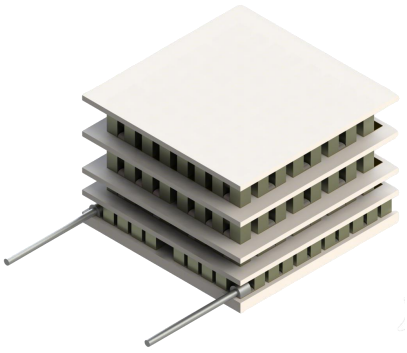
TEC Cooling for Blackbody Radiation Sources

Overview



Blackbody radiation sources serve as the “standard reference” for infrared thermometry and imaging system calibration. The uniformity and stability of the radiation temperature directly determine calibration accuracy. Medium- and low-temperature blackbodies (typically in the range of −40°C to +150°C) often use “resistive heating + compressor cooling/liquid nitrogen” schemes, or simple air cooling. These methods suffer from slow temperature control, low efficiency, and poor stability and uniformity. Temperature uniformity inside the cavity is limited by the heating/cooling approach, making improvements difficult. The systems are complex, bulky, and prone to interference. Liquid nitrogen requires regular refilling, increasing operating costs and creating safety and convenience issues. Traditional solutions cannot achieve precise “bidirectional” temperature control.

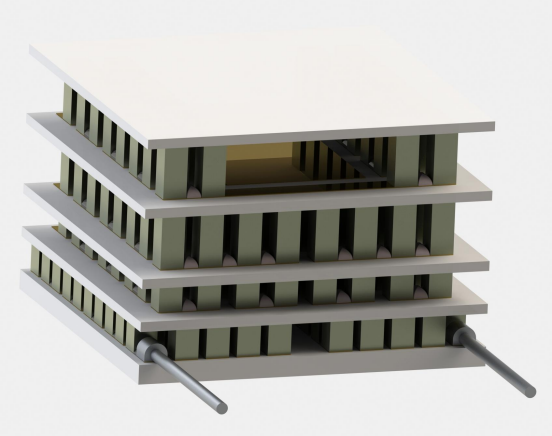
Blackbody source Performance Improvements



- **High-Precision Temperature Control**: Multi-channel TEC modules with PID control achieve ±0.01°C stability and <±0.1°C radiation surface uniformity, eliminating temperature differences and drift.
- **Bidirectional Temperature Control**: Supports both heating and cooling, ensuring stable radiation temperature under any environmental condition.
- **Fast Response with No Overshoot**: TEC startup response <30 s; heating/cooling rate improved by over 50%, quickly reaching and stabilizing at the setpoint, significantly improving calibration efficiency.
- **Vibration-Free and Silent Operation**: Fully electronic control with no mechanical parts, zero vibration and low noise, perfectly meeting high-precision blackbody radiation stability requirements.
- **Modular Integration**: Compact TEC modules (as small as 10×10×3 mm) can be customized in arrays for blackbody surfaces (Φ50 mm–Φ200 mm) without occupying extra space.

System-Level Impact

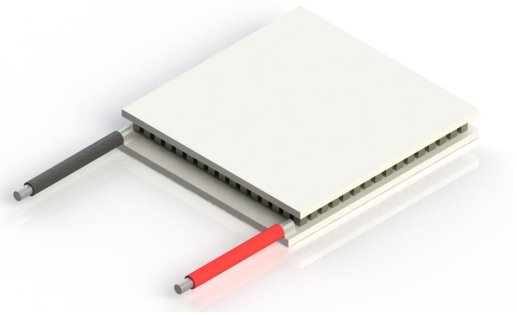
TEC cooling not only precisely controls the **blackbody** temperature but also stabilizes its thermal environment, delivering system-level benefits:



Extremely high temperature stability and uniformity: Improves calibration accuracy and repeatability, ensuring reliable infrared measurement and imaging outputs.

- **Fast response:** Enhances calibration efficiency and reduces system wait time.
- **Vibration-free and silent:** Avoids mechanical interference, improving measurement stability.
- **Modular and compact:** Easy to integrate into lab setups or industrial inspection systems, saving space.
- **Bidirectional temperature control:** Achieves precise heating and cooling under different environmental conditions.

Representative TEC Models for Blackbody source

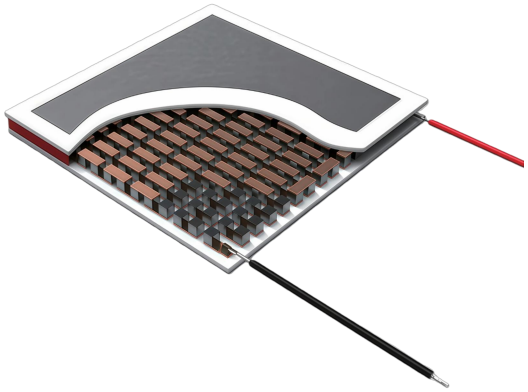


The following models represent typical **multi-stage TEC** platforms commonly used in precision **blackbody radiation sources**. They are provided for reference only and do not represent a complete product list.

Model	Stages	Typical ΔT	Typical Temperature Range	Typical Applications
BB-1	Single-stage	~50 K	-40°C ~ +50°C	Small-size blackbody calibration
BB-2	Single-stage	~70 K	-40°C ~ +80°C	Medium-size blackbody calibration, industrial inspection
Custom BB	Multi-stage	Customized	Customized	Large-size or high-precision blackbody systems

Electrical, mechanical, and thermal parameters can be customized based on specific blackbody and system requirements.

Advantages of TEC in Blackbody Applications



- Ultra-high precision: Temperature stability and uniformity reach top-level performance.
- Fast response: Rapid heating/cooling speeds, improving testing efficiency.
- Silent and vibration-free: Suitable for the most demanding laboratory and online inspection environments.
- Compact design: Easy to integrate and portable.
- Bidirectional temperature control: Enables truly dynamic and precise thermal management.

Test & Qualification Capability

Performance validation and reliability testing are conducted in dedicated laboratories, including:

- Environmental and thermal cycling tests
- Long-term stability and life testing
- Qualification aligned with **MIL-STD-883** and relevant industry standards

Test scope and qualification standards may vary depending on application requirements.

ABOUT P&N TECHNOLOGY,P&N EUROPE & i-TEC

P&N China and **i-TEC** provide thermoelectric cooling solutions for **high-end scientific and industrial applications.** P&N China focuses on large-area and system-level thermoelectric solutions, while i-TEC specializes in compact and multistage thermoelectric solutions for precision temperature control.

P&N Europe (est. 2018) supports European customers through technical sales and regional logistics coordination.

With over **20 years of experience** in thermoelectric technology, **we emphasize quality, reliability, and long-term performance** in our thermal management solutions and products.

Engineering Support & Contact

Our application engineering team provides support for:

- TEC selection and thermal modeling
- Module-level and System-level Integration
- Performance validation and reliability considerations

Contact us to discuss your thermal management requirements.
Technical consultation and sample evaluation are available.

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