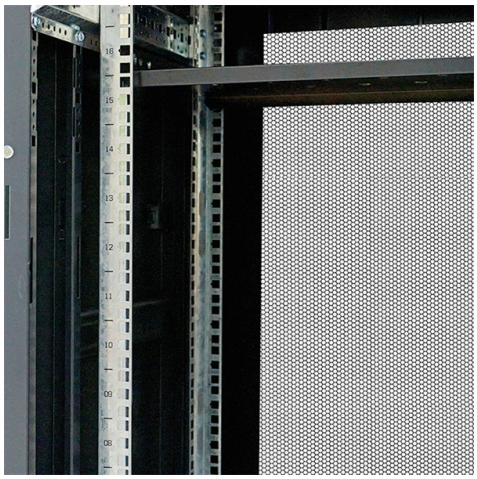
High Temperature Test Method for Optical Modules



Overview

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Key Takeaways

High-temperature testing of optical modules typically involves three-temperature cycling (-40℃, +25℃, +85℃) to verify electro-optical performance under extreme conditions.Overview of High-Temperature Testing

Optical modules, which include lasers (VCSEL/DFB), detectors (PIN/APD), driver ICs, and TIAs, are highly sensitive to temperature variations. High-temperature testing ensures that these modules maintain performance across their full operating range, which is critical for data centers, 5G front-haul, and co-packaged optics applications (SFF-8472, IEEE 802.3, ITU-T G.698) . Key parameters evaluated include:

• Output power

• Receiver sensitivity

• Extinction ratio

• Eye diagram quality

• Center wavelength drift

• Dispersion tolerance

Three-Temperature Test Method

The three-temperature test is the standard method for high-temperature evaluation:

• Temperature Nodes: Modules are tested at -40℃ (low), +25℃ (room), and +85℃ (high) .

• Test Procedure: Each module is cycled through these temperatures while monitoring electro-optical parameters.

• Challenges:

• Conventional compressor-based chambers require 30–60 minutes to switch between extreme temperatures, limiting throughput.

• DFB lasers have a center wavelength temperature coefficient of ~0.1 nm/℃, necessitating stable control within ±0.1℃ for reproducible measurements.

• Condensation after low-temperature tests can cause short circuits or contamination at optical interfaces.

• Fiber routing in large chambers can introduce extra loss due to bending .

High-Temperature Optical Sensing Techniques

For precise temperature monitoring during testing, fiber-optic sensors are often used due to their immunity to electromagnetic interference and ability to operate in harsh environments . Common methods include:

• Blackbody Radiation Sensors: Measure thermal radiation emitted from a heated blackbody cavity coupled to an optical fiber. Suitable for temperatures above 500°C .

• Fiber Bragg Grating (FBG) Sensors: Detect wavelength shifts in reflected light due to temperature changes.

• Distributed Temperature Sensors (DTS): Use Brillouin or Raman scattering to measure temperature along the fiber length, enabling distributed high-temperature monitoring up to 1100°C with sapphire-based sensors .

• Sapphire Fabry-Perot Sensors: Employ a sapphire cavity to measure optical path differences, achieving stability ±1°C at 1100°C and resolution

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