SEMINEX APPLICATION NOTE

Handling and Operating the 14-Pin Butterfly Package

Rev. 1.0 — Laser & SOA Butterfly Handling Guide

Introduction

The 14-pin butterfly (BF) package is the standard mechanical and electrical interface for fiber-coupled semiconductor laser and SOA packages used in telecommunications, fiber amplifiers, sensing, and instrumentation. These hermetically sealed modules typically integrate a laser diode (LD), thermoelectric cooler (TEC), thermistor, and monitor photodiode (MPD) within a rectangular metal housing with dual rows of seven pins.

Because butterfly modules combine high optical power with extremely ESD-sensitive semiconductor junctions, improper handling can cause latent or catastrophic damage that may not appear until later system integration. In addition, the optical fiber pigtail, glass-to-metal feedthroughs, and TEC impose mechanical and thermal constraints that directly impact long-term reliability.

This application note outlines the handling, mounting, electrical, and operational practices required to maximize the performance and lifetime of 14-pin butterfly laser modules.

Table 1 summarizes the key handling parameters for quick reference.

Table 1. Key Handling Parameters at a Glance

Parameter	Requirement / Guideline
ESD Prevention, Work area	Grounded EPA (Electrostatic Protected Area), wrist strap, dissipative mat required
Heat sink flatness	25 µm or better over full base plate area
Heat sink material and finish	Copper preferred with 0.8 µm Ra or better
Thermal interface conductivity	≥1 W/(m·K); TIM material must cover full base including bolt-hole area
TIM Thickness	Thermal paste (10-50µm), Thermal epoxy & phase-change materials (25-50µm)
Mounting torque	0.75 in-lb to 0.9 in-lb max
Mounting sequence	Tighten in diagonal, cross-pattern sequence
Soldering temperature (lead)	≤260°C; ≤3 seconds dwell per joint
TEC Temperature	Operate TEC at 25°C throughout entire operation
Fiber cleanness	No particles on the fiber/connector tip
Fiber temperature	Avoid any solder iron contact at all times
Fiber stress	Avoid any stress on fiber and connectors, fiber bend radius typical 52 mm

Package Overview

The 14-pin butterfly package has an approximately 30 mm × 12.7 mm footprint, with body height. Fourteen pins, seven per side, extend from the long edges for PCB or socket connection. The fiber pigtail exits one short end through a strain-relief boot.

Table 2 shows a representative pin assignment for a standard 14-pin butterfly module. Exact pinouts vary by manufacturer and should always be verified against the device data sheet before making electrical connections.

Table 2. Representative 14-Pin Butterfly Pin-Out Type 1 Assignment

Pin	Signal / Function
1	TEC (+)
2	Thermistor
3	PD (+)
4	PD (–)
5	Thermistor
6–9	No Connect (reserved)
10	Laser Diode Anode (+)
11	Laser Diode Cathode (–)
12	No Connect (reserved)
13	Ground / Case (varies by manufacturer)
14	TEC (–)

> **WARNING:** Always verify pin functions using the specific device data sheet. Incorrect TEC polarity or improper MPD bias can permanently damage the module.

Electrostatic Discharge (ESD) Precautions

Electrostatic discharge (ESD) is one of the most common causes of laser diode failure. When a charged object — such as a person, tool, or non-dissipative surface — contacts or approaches the module pins, charge can rapidly discharge through the LD junction, causing critical damage to the package.

The LD junction in a 14-pin butterfly module is typically rated for only a few hundred volts under the Human Body Model (HBM), per GR-468-CORE / MIL-STD-883 Method 3015. In low-humidity environments, normal human movement can generate several kilovolts, making proper ESD protection essential.

ESD-Safe Work Area

All module handling must occur within a properly established electrostatic protected area (EPA). The following precautions are required:

- Ground all conductive work surfaces through a 1 MΩ resistor. Do not connect surfaces directly to hard ground.
- Personnel must wear grounded wrist straps with integral 1 MΩ resistors whenever handling modules. Verify wrist strap continuity before each work session.
- Use only ESD-safe gloves and avoid direct contact with module pins.
- Remove non-ESD-safe plastics, foam, and personal items from the work area.
- Maintain relative humidity between 40% and 60% where possible.
- Use air ionizers to neutralize charge on unavoidable insulating materials.
- Ensure all soldering irons, tweezers, fixtures, and handling tools are properly grounded.

Storage and Transport

Modules must remain in ESD-shielding bags or equivalent protective packaging whenever outside the EPA. Damaged shielding bags should not be used. Shorting clips or jumpers should be installed on unused pins, especially LD pins, to equalize potential during transport.

> **NOTE:** Even within an EPA, modules can accumulate damaging charge if left exposed near moving equipment, airflow, or nearby soldering activity. When not actively handled, return modules to their shielding bags.

Fiber Handling and Contamination Control

The optical fiber pigtail is the most mechanically fragile part of the assembly. Common failure modes include contamination at the fiber end face, bend-induced microcracks, and thermal damage to the acrylate buffer coating.

Fiber Contamination

In high-power laser applications, fiber contamination is especially critical. Optical power propagating in the cladding can generate localized heating near the module snout or boot. Dark contaminants — such as grease, flux, epoxy residue, or skin oils — absorb this light and can cause catastrophic fiber damage.

Observe the following handling practices:

- Always wear lint-free gloves or finger cots when handling the fiber.
- Inspect the first 50 mm of the fiber buffer under 10×–40× magnification before and after assembly. No dark contamination larger than 100 µm is acceptable.
- Clean contaminated fiber end faces using 99% IPA and lint-free foam or film swabs.
- Do not reuse swabs or re-dip used wipes into the IPA supply.
- Ensure compressed or canned air is free of oil and particulates before use. Do not spray from an inverted can.

Fiber Mechanical Handling

Never use the fiber pigtail to lift or support the module. Handle the package body only, and ensure the fiber is gently supported during placement and assembly.

Typical minimum bend radius is approximately 52 mm. Exceeding this limit increases optical loss and may initiate microcracks that propagate under thermal cycling. Tight bends or twisting can also induce birefringence, degrading wavelength locking in FBG-stabilized lasers.

- Never kink, twist, or bend the fiber below the specified minimum radius.
- Do not secure the fiber using solder, wire ties, or clamps that compress the buffer.
- Keep the fiber away from hot surfaces. The acrylate buffer is typically rated to 85°C maximum.
- Minimize axial twisting when routing or spooling the pigtail.

> **NOTE:** Fiber damage ranges from surface contamination (M0) to exposed glass (M4). M3 (cracked acrylate) and M4 (exposed glass) are reliability hazards and require device rejection. M1 and M2 indicate handling defects and should prompt process review.

Mounting

Heat Sink Requirements

The 14-pin butterfly package dissipates heat through its base plate, which must maintain good thermal contact with the system heat sink. Proper heat removal is essential for both performance and reliability. Excessive case temperature accelerates TEC degradation, increases LD threshold current drift, and may lead to TEC thermal runaway.

Heat sink thermal resistance must be low enough to keep the module base temperature within the limits specified in the device data sheet under worst-case operating conditions. Total power dissipation is approximately equal to LD drive power plus TEC power minus optical output power.

The heat sink mounting surface should meet the following requirements:

- Surface flatness: ≤ 25 µm across the contact area.

- Surface finish: ≤ 0.8 μm Ra.
- Thermal conductivity: ≥ 160 W/m·K using copper or aluminum alloy.

Thermal Interface Materials

A thermally conductive interface material (TIM) should be applied between the module base and heat sink to eliminate microscopic air gaps. Suitable TIMs include thermal epoxy, phase-change materials, and elastomeric thermal pads.

> **WARNING:** Semi-rigid TIMs, such as phase-change pads, must fully cover the base plate including the mounting hole regions. Incomplete coverage can create stress concentrations that warp the base plate and crack the glass-to-metal feedthroughs.

Use TIMs with thermal conductivity of at least 1 W/m·K. *Recommended TIM Thickness is 10-50μm for thermal paste and 25-50μm for thermal epoxy and phase-change materials*. Prevent all contact of thermal compounds from the fiber pigtail, strain-relief boot, or fiber buffer.

Mounting Sequence and Torque

Proper tightening sequence and torque are critical to avoid package distortion and feedthrough stress.

Recommended procedure:

- Position the module with TIM already applied.
- *Hand-tighten all screws in diagonal sequence, typically cross-pattern, to approximately 0.75 in-lb (8.5 N·cm). Perform a final tightening pass to 0.9 in-lb (10.2 N·cm). Do not exceed this value.*
- Use 316 stainless steel pan-head M2 screws or equivalent unless otherwise specified.

Lead Bending

If pin forming is required, use a dedicated lead-forming tool. The glass-to-metal feedthroughs are brittle and can crack if bending stress is transferred to the seal.

- Bend leads no closer than 1.5 mm from the package body.
- Use smooth bend radii rather than sharp creases.
- Commercial lead-forming dies are strongly preferred over manual methods.

> **NOTE:** Never bend pins using pliers or tweezers. Damage to the hermetic feedthrough seal may not be immediately visible and is not repairable without repackaging the device.

Soldering Module Leads

Pump module pins may be soldered directly to a PCB using localized reflow. The primary concerns during soldering are thermal stress on the glass-to-metal feedthroughs and preventing the fiber pigtail from exceeding 85°C.

- Use a temperature-controlled soldering iron with a tip small enough to complete reflow within 3 seconds. Longer dwell times can overheat the package.
- Do not exceed 260°C at the lead surface. If proper wetting cannot be achieved, inspect for contamination or insufficient flux rather than increasing temperature.
- Allow the module to cool to ambient temperature before soldering adjacent pins to minimize cumulative thermal stress.
- Keep the soldering iron away from the fiber pigtail. Brief contact with the fiber buffer can cause permanent coating damage and reduce long-term reliability.
- Use a grounded soldering iron to prevent ESD damage from AC leakage voltage at the tip.

> **NOTE:** Remove flux residue from module leads and the fiber boot area after soldering. Some flux residues are hygroscopic and may cause long-term corrosion.

Power Supply and Electrical Operation

Laser Diode Drive

The laser diode (LD) is a current-controlled device and must be driven by a low-noise, current-regulated supply. Voltage-regulated supplies are unsuitable because the LD forward voltage decreases with temperature, causing current to rise as the junction heats. This can lead to thermal runaway and rapid device failure.

The LD driver must provide the following characteristics:

- Current regulation with noise below 1 µA RMS (100 Hz to 10 MHz) for low-noise applications. Drive-current noise directly affects optical output noise and modulation performance.
- Soft-start current ramping to avoid sudden full-current application at power-up.
- Over-current protection set to no more than 110% of the maximum rated forward current.
- Reverse-voltage protection using a clamp or blocking diode. Typical LD reverse breakdown voltage is approximately 2 V.
- Supply transient suppression to protect against inductive switching spikes and other electrical disturbances.

Electrical Overstress

Electrical overstress (EOS) occurs when the module experiences excessive voltage or current, including transient events. Common causes include power supply surges, relay switching, or software-controlled current spikes. EOS damage is often indistinguishable from ESD damage during failure analysis. To minimize EOS risk:

- Never exceed the maximum rated LD forward current, even briefly.
- Enable and stabilize the TEC controller before turning on the LD driver.
- Verify pin polarity before applying power. Incorrect LD polarity can cause immediate catastrophic failure.
- Ensure all fixtures, power supplies, and test equipment are properly grounded before connecting the module.

TEC Control and Operation

The thermoelectric cooler (TEC) maintains the laser diode (LD) at a controlled temperature, 25°C during operation. Stable TEC operation is essential for wavelength stability, output power consistency, and long-term LD reliability.

Closed-Loop Temperature Control

The TEC must be operated in closed-loop mode using the thermistor as feedback. Open-loop constant-current operation is suitable only for brief diagnostics and should never be used during normal operation.

The thermistor is typically a 10 kΩ negative temperature coefficient (NTC) device at 25°C. The TEC controller adjusts current based on thermistor resistance to maintain the target temperature. A properly tuned PI control loop should stabilize the module within ±2°C of the setpoint in approximately 1.5 to 2 seconds. The LD should not be enabled until temperature stabilization is achieved.

TEC Current Limits

The TEC has separate maximum current ratings for cooling and heating operation. Because heating mode is more efficient, the allowable reverse-direction current is typically lower than the forward cooling current. Using symmetric current limits can cause thermal overshoot and potential TEC damage.

The maximum recommended operating current for long-term reliability is also lower than the absolute maximum transient rating.

- Limit TEC current to the specified end-of-life (EOL) operating current rating.
- Configure asymmetric TEC current limits according to the device data sheet.
- Limit TEC supply ripple to less than 10% of the DC operating current to reduce thermal cycling and solder fatigue.
- Verify that the TEC control loop and thermistor feedback are functioning before operation. An open thermistor circuit can drive the TEC to maximum current and rapidly overheat the module.

> **NOTE:** Never insert or remove a 14-pin butterfly module while the TEC supply is active. Momentary open-circuit thermistor detection during insertion can trigger a full-current TEC transient.

Monitor Photodiode (MPD) Operation

The monitor photodiode (MPD) generates a photocurrent proportional to the laser's rear-facet optical output. It may be used for output monitoring or as the feedback element in an automatic power control (APC) loop.

In most telecom-band butterfly modules, the MPD is a reverse-biased InGaAs photodiode. Proper reverse bias — typically around −5 V, depending on the device — is required for linear response and specified bandwidth. An unbiased or forward-biased MPD can produce inaccurate readings and destabilize APC operation.

- Apply the specified MPD reverse bias before enabling the LD. An unbiased MPD in an APC loop may drive the LD current to maximum.
- The MPD is highly ESD-sensitive and requires the same handling precautions as the LD.
- Do not connect the MPD to a current-measuring instrument without applying the proper reverse bias.
- Verify pin assignments carefully before applying voltage, as MPD and LD pins are often adjacent.

Storage and Shelf Life

Butterfly laser modules should be stored in their original ESD-shielding packaging in a controlled environment, typically 10°C to 35°C with relative humidity below 60% non-condensing. Prolonged exposure to elevated temperature or humidity can degrade pin finishes, promote intermetallic growth at internal solder joints, and embrittle the fiber buffer.

Modules should not be stored with the fiber under tension or bent below the recommended radius. Long-term mechanical stress can reduce fiber proof strength through stress corrosion, even without visible damage.

Before returning a partially used module to storage, reinstall shorting clips on all unconnected pins and reseal the module in an ESD-shielding bag before removing it from the EPA.

Summary

Proper handling of 14-pin butterfly laser modules is essential for achieving consistent performance and long operational life. ESD events, fiber damage, improper mounting, or incorrect TEC operation can introduce latent failures that may not appear until later in the product lifetime. The procedures outlined in this application note represent the minimum recommended practices for maintaining device reliability and rated performance. Any deviations from these guidelines should be carefully evaluated and documented before implementation in production environments.