Application Note

LU0808M / LU0915M / LU0980M Series
Broad Area Pump Laser Modules

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Short description: Important notes for the mounting and application of Lumics pump laser modules in TEC cooled 14-pin butterfly package.

This document describes requirements for the handling, mounting and operation for high power 14-pin butterfly pump laser modules. As final configurations and reliability requirements are highly dependant upon the specific application, Lumics can detail typical methods of mounting, but cannot confirm or guarantee the reliability of the attachment method for the application due to unspecified parameters such as variations in environmental temperature specifications, stresses specific to the mounting method, thermal paths for the system, etc. The end-user must confirm the final reliability and quality of any attachment method chosen.

Care must be taken to ensure that during any stage of pump assembly to a circuit board, that proper ESD/EOS practices are followed, and that the optical fiber pigtail is suitable protected from physical and thermal damage.

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1. **Introduction**

The Lumics 14-pin butterfly high power modules contain a single mode laser diode and are TEC cooled pump modules that dissipate up to about 3 Watts. Therefore, special attention must be paid to efficient thermal management. In order to optimize device performance and maintain high reliability, it is required to keep the laser diode operating within acceptable temperature limits not exceeding 70°C.

Waste heat generated by the laser diode is transferred to the heat sink on which the module is mounted. Therefore, the laser-diode-junction temperature rise depends on the overall thermal resistance $\Theta_{\text{total}}$ between the junction to the heat sink.

The overall thermal resistance $\Theta_{\text{total}}$ is the sum of all the thermal resistance components between the junction and the heat sink. Especially critical is the heat resistance between the base of the module-case to the heat sink, since it depends on the module mounting method.

The base of the 14 pin butterfly package has a surface roughness of a few µm and a flatness of better 50µm. The heat sink must have equal or better flatness values in order to maximize the total interface area which is in good thermal contact and to avoid lower effective area like air gaps.

High thermally-conductive material as well as solder may be used to eliminate air gaps from the pump module – heat sink interface. Suitable thermally conductive materials include phase change materials or thermal compounds. They are designed to conform to surface irregularities, thereby eliminating air voids to improve heat flow between thermal interfaces. But, generally these materials have a very low thermal conductance and therefore should not compensate for larger than a few tens of µm irregularities.

Low thermal resistance between heat sink and module base is most critical parameter for the broad area laser modules because of the very high power generated. Special care must also be taken over the pin soldering as well because of the high current values.

2. **Safety Precaution**

Please note that the optical fiber coupled output power, offered by Lumics pump laser modules, represents significant optical power in the infrared region. Be sure to follow standard safety protocol for eye and skin for Class IV IR lasers.

3. **Mounting of the Butterfly Package**

When mounting the 14-pin butterfly package, ensure that the butterfly pins have the right orientation. See Figure 1 for module mechanical and electrical schematic. Follow all integrated circuit standard practices including ESD prevention measures during the handling.
Figure (1)  Drawing of the 14 pin butterfly module package with dimensions in mm.

Figure (2)  Pin connections of the 14 pin butterfly module.
3.1 Heat Sink for Module Mounting

The design of the heat sink, which is intended to dissipate the heat, is crucial to the overall pump module performance and reliability. The goal of the heat sink design is to dissipate the heat from package base with minimized thermal resistance.

A well-designed heat sink in combination with a high-performance thermal interface and package mounting technique should guarantee that the case temperature of the module does not exceed the maximum temperature specified for each series (typically 70°C; refer to the maximum ratings in the data sheet). A failure to keep the package base below the specified maximum temperature will lead to laser module overheating and result in a module damage. The following general heat sink guidelines are recommended:

- Mount the butterfly pump module on a heat sink with flatness of 50 microns or less over the entire mating surface to the module.
- Mount the pump module on a heat sink with a surface finish of 0.8 µm or less.
- The heat sink should be design to handle at least maximum module heat dissipation through the life of the product. For total module power dissipation refer to the module specifications. Maximum module heat dissipation is approximately equal to total module power consumption (laser diode and TEC) minus the ex- fiber optical power. It can be as high as about 3W.
- Design a heat sink that is capable of keeping the pump module case temperature below the maximum rated temperature for all operating conditions. For maximum package base temperature refer to the pump module specification.

3.2 Mounting and Interface Materials

Ideally, thermally conductive materials are used as an interface between a pump module and the heat sink to account for any flatness/smoothness discrepancies between the two parts. Suitable thermally conductive materials include phase change materials and thermal compounds. All are designed to conform to surface irregularities, thereby eliminate air voids to improve heat flow between thermal interfaces.

Keep in mind, that generally these types of thermally conductive materials have high thermal resistance. Avoid conducting large area foils. The metal to metal contact area must be as large as possible. Perform a polishing process to the surface of the heat sink and the base of the module if needed.

The specific choice and implementation of a thermal interface material is highly dependant upon the customer’s specific application and reliability considerations.

Failure to follow a proper pump module mounting procedures to a properly prepared heat sink can result in high thermal resistances and module warpage, both of which can impact performance and may lead to catastrophic failure.
The metal to metal contact area must be as large as possible. Perform a polishing process to the surface of the heat sink and the base of the module if needed.

Use a thermal interface material with a thermal conductivity higher than 3W/mK.

Use only a thin layer of interface material to compensate for a maximum non-planarity of 100 microns between the pump module base and the heat sink mounting surface.

Prevent contaminating the pump module’s fiber strain relief (black boot) and fiber buffer with any thermal interface materials.

Bolt down the pump module to the heat sink in a X-style fashion (see Figure 3) with the initial torque set to 0.75 in lb and a final X-style bolt-down at 1.5 in lb.

![Figure (3)](image) The X-style fashion is recommended to bolt down the module onto the heat sink.

### 3.3 Soldering of the Module Leads

The pump module leads can be soldered to mounting surface using localized solder reflow techniques. The pin connections of the module are shown in Figure 2 above. Apply the following recommendations for the lead soldering process:

- Use a hand held iron with tip small enough to achieve reflow in less than 3 sec. to prevent module components damage.

- Do not exceed a lead temperature of 260°C during the soldering operation for more than 10 sec.

- Allow the module to cool down to ambient temperatures after the pump module leads are soldered.

- Prevent fiber heating above 85°C when performing any lead soldering operation.
A fiber-coupled pump module is easily damaged if a hot solder iron touches the fiber. While this may not immediately break the fiber, it will increase loss due to local stresses, and it will compromises the physical strength of the fiber and integrity of the recoat buffer.

### 3.4 Fiber Splicing and Handling

Splice losses must be kept below 0.25dB. Higher losses may have an impact on the quality of system performance and long-term reliability. Pump modules spliced with a high loss dissipate more heat to the local surrounding which may cause fiber buffer temperature increase or damage to the secondary surroundings. Fiber temperature increases can lead to catastrophic damage of the fiber or to long-term reliability considerations.

Maximum storage & exposure temperatures for optical buffer are 85°C as recommended by fiber manufacturers. Exposure of the buffer to temperatures above 85°C will likely cause permanent damage to the pigtail. Follow the proper procedure of fiber handling to avoid catastrophic damage in fiber in high power laser pumps:

- Do not expose the fiber to temperature higher than 85°C
- Always wear finger cots or gloves when handling fiber to avoid fiber contamination.
- Whenever is possible handle fiber in loops to prevent fiber damage. Do not drag fiber over equipment to avoid fiber damage. Avoid a fiber contact with any sharp object. Do not allow kinks or knots to develop in the fiber.
- Never use the fiber to pick up or support the weight of the laser pump. Always handle modules with two hands, one holding a package and other handling fiber coil to avoid fiber damage or break.
- Do not bend a fiber with a radius smaller than specified as minimum bending radius for each specific pump module series (refer to the module specification for a value).
- Avoid any contamination of fiber.
- Clean a fiber if contamination occurred, being especially considerate of the first ~5cm of buffer.

There are many materials commercially available for fiber optic cleaning. Some are marketed specifically for the fiber optic industry. Isopropyl alcohol is the most commonly used of the alcohols in fiber optic cleaning, due to its low cost and safety qualities (toxicity, flammability, environmental/disposal). Alcohol will loosen particular contaminants and aid in removing oils. It is used on swabs and wipes, by directly spraying, in soaking tubs, and in ultrasonic cleaners.
Adhesive type cleaners are used to remove particle contamination. It is important to select an adhesive in-line with the particular application so that the adhesive itself does not create a new source of contamination or damage.

4. Precautions for Electrostatic Discharge (ESD)

ESD damage to a laser diode is induced from the rapid flow of electrical charge between two bodies at different potentials, either through direct contact or through an induced electric field. ESD can cause catastrophic or latent damage and is of particular concern for the pump module’s laser diode.

Below are common recommended guidelines for preventing ESD damage to the pump modules:

- Refer to the pump module specification sheet for ESD voltage ratings.
- Use the provided shorting clips on 14-pin butterfly packages when the modules are disconnected from the operational circuit.
- Ground operators, equipment, transport carts/trays, pump modules or systems, and work surface to eliminate static electricity.
- Only use confirmed ESD dissipative coatings/surface finishes on fixtures/tooling used to assemble the pump modules.
- When manipulating pump modules, use ESD protective smocks, gloves and shoes/covers, dissipative bench-top mats and ESD protective flooring or matting.
- Remove or control static generating sources to voltages below the specified maximum for safe ESD handling.
- Install air ionizers as necessary for additional environmental control.
- Use electrically grounded soldering irons for soldering the pump module to the mounting surface.
- Use electrostatic shielding containers and antistatic or dissipative carriers.

5. Power Supply and TEC Controller

When designing or utilizing a laser diode (LD) module power supply, designers should refer to the specified Absolute Maximum Ratings in the data sheet of each series of high power laser modules. Electrical Overstress (EOS) damage occurs when a pump module is subjected to voltage or current levels beyond the maximum ratings. Some recommended guidelines for preventing EOS of pump module are:
Transient electrical stress to the pump module should be avoided or minimized through operational life. The maximum specified transient current time for a pump module should never be exceeded while operating a LD; refer to the Absolute Maximum Ratings specified within pump module specifications.

- Use transient suppression for power supplies.
- Use over voltage protection for power supplies and fuses at critical locations.
- Confirm modules are mounted with the correct electrical pin configuration as specified.
- Ensure that all operational and assembly equipment is properly grounded with no loose connections, which can lead to intermittent connections.
- Always ensure that the TEC controller is enabled and that the pump module is being actively cooled prior to turning on the laser diode controller. Allow the internal temperature of the pump module to stabilize at 25 +/- 2 °C before turning on the LD.

To the TEC control and operation:

Large capacity Thermoelectric Coolers (TECs) are used to control cooled pump module temperature for high power operation. Proper operational procedures for the TEC are critical for reliable performance of the modules during their lifetime. Pump module TECs typically are operated with closed-loop temperature controllers/power supply circuits. Closed-loop circuits allow maintaining internal temperatures of the pump modules at 25°C (nominally) for varying ambient temperatures. The TEC can be switched from a cooling mode to a heating mode by reversing the direction of current flow.

The pump module TEC operates from a DC power source. An important criterion for reliable high power pump module operation is to use a filtered DC current. DC ripple affects the TEC performance and, as the result, subsequent pump module performance and a lifetime.

The TEC power supply should be limited to the absolute maximum TEC current as specified for each model of pump module. The TEC can run at the absolute maximum TEC current only for a very limited duration without impacting module reliability. Pump module TECs operate with closed-loop temperature controller/power supply circuits. A thermistor is used to control the LD temperature within the pump module to 25°C through the specified operational ambient temperature range.

When the pump module is first turned on, there will be a transient current supplied to the TEC as it stabilizes via the feedback circuit. It is also important to note that the absolute maximum TEC current is different from the maximum operating current. The maximum operating current, is the current at which a TEC can operate at, for an unlimited time through the lifetime of the module. The EOL TEC Operating Current should not exceed 70% of absolute maximum current. The maximum operating current is specified for each series of pump modules.

See the following guidelines:

- Operate the TEC in constant temperature mode rather than in constant current mode utilizing temperature feedback from the module thermistor.
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- Limit TEC power supply ripple factor to less than 10%.
- Limit the TEC controller power supply to the absolute maximum TEC current rating
- Do not operate the TEC at its rated maximum current except as transient applied current during module start-up
- Limit the TEC operating current to about 70% of the specified TEC maximum current
- Make sure that all 14-pin butterfly package leads have electrical contact to avoid controller/power supply open circuits
- Ensure the TEC leads are connected to the proper electrical polarity, and ensure that the TEC power supply is turned off prior to mounting or un-mounting the pump module.
- Wait until the internal temperature has stabilized to 25 +/- 2°C after turning the LD on before making any TEC control changes.
- Do not leave a module operating without making sure that the internal laser temperature is at 25 +/- 2°C.

It is important to note that if the 14-pin butterfly package thermistor leads do not have electrical contact when the package is mounted and operated, the temperature controller/power supply loop will be open. An open loop TEC will run at its maximum available power supply current and can result in permanent module damage. This situation can arise for example by placing a pump module into an active TEC powered circuit board with pins 1 & 14 on the butterfly package placed first.