Operator’s Manual
Sapphire 458/460/488/514/532/561/568
LP OEM Optically-Pumped Semiconductor Laser System
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Technical Support

In the U.S.:

Should you experience any difficulties with your laser or need any technical information, please visit our web site: www.Coherent.com. Additional support can be obtained by contacting our Technical Support Hotline at 1.800.367.7890 (1.408.764.4557 outside the U.S.) or e-mail (Product.Support@Coherent.com). Telephone coverage is available around the clock (except U.S. holidays and company shutdowns).

If you call outside our office hours, your call will be taken by our answering system and will be returned when the office reopens.

If there are technical difficulties with your laser that cannot be resolved by support mechanisms outlined above, e-mail or telephone Coherent Technical Support with a description of the problem and the corrective steps attempted. When communicating with our Technical Support Department via the web or telephone, the Support Engineer responding to your request will require the model and Laser Head serial number of your laser system.

Outside the U.S.:

If you are located outside the U.S. visit our web site for technical assistance or contact, by phone, our local Service Representative. Representative phone numbers and addresses can be found on the Coherent web site, www.Coherent.com.

Coherent provides telephone and web technical assistance as a service to its customers and assumes no liability thereby for any injury or damage that may occur contemporaneous with such services. These support services do not affect, under any circumstances, the terms of any warranty agreement between Coherent and the buyer. Operation of any Coherent laser with any of its interlocks defeated is always at the operator's own risk.
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Preface

This manual contains user information for the Sapphire™ LP OEM laser.

Read this manual carefully before operating the laser for the first time. Pay special attention to the material in “Section One: Laser Safety” on page 1-1 that describes the safety features built into the laser.

Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

U.S. Export Control Laws Compliance

It is the policy of Coherent to comply strictly with U.S. export control laws.

Export and re-export of lasers manufactured by Coherent are subject to U.S. Export Administration Regulations, which are administered by the Commerce Department. In addition, shipments of certain components are regulated by the State Department under the International Traffic in Arms Regulations.

The applicable restrictions vary depending on the specific product involved and its destination. In some cases, U.S. law requires that U.S. Government approval be obtained prior to resale, export or re-export of certain articles. When there is uncertainty about the obligations imposed by U.S. law, clarification should be obtained from Coherent or an appropriate U.S. Government agency.
Symbols Used in This Document

This symbol is intended to alert the operator to the presence of dangerous voltages associated with the laser that may be of sufficient magnitude to constitute a risk of electric shock.

This symbol is intended to alert the operator to the presence of important operating and maintenance instructions.

This symbol is intended to alert the operator to the danger of exposure to hazardous visible and invisible laser radiation.

Patents

U.S. Patent No. 5, 954, 978
U.S. Patent No. 6, 167, 068
U.S. Patent No. 6, 097, 742
U.S. Patent No. 5, 991, 318
French Translation/Traduction Francaise

Préface

Ce manuel contient des informations sur le laser Sapphire LP. Le laser Sapphire LP OEM est un module, vendu pour une utilisation dans un équipement OEM (Original Equipement Manufacturer) et non pour utilisation comme laser seul. La conformité avec toutes les réglementations en vigueur en matière de sécurité est sous la responsabilité du constructeur d'OEM.

Lire ce manuel attentivement avant une première utilisation du laser. Une attention particulière devra être porter à la Section 1, Sécurité Laser, qui décrit les précautions à prendre avec le laser.

L'utilisation de procédures de contrôle ou de réglages des performances autres que celles spécifiées ci-après peut conduire à une exposition risquée aux radiations laser.

Conformité Avec les Lois Américaines sur le Contrôle des Exportations

Coherent suit strictement les lois américaines en matière du contrôle des exportations

L'exportation et la revente de laser fabriqués par Coherent sont soumis aux règles de l'administration des exportations des Etats-Unis. De plus, l'envoi de certains composants est régulé par le département d'état sous les règles internationales du trafic d'armes.

Les restrictions peuvent varier selon le produit spécifié et sa destination. Dans certains cas, la loi américaine impose l'obtention de l'approbation du gouvernement américain au préalable pour la vente, l'exportation ou la revente.

S'il y a un doute quant aux obligations imposées par la loi des Etats-Unis, une clarification doit être obtenue auprès de Coherent ou d'une agence gouvernementale appropriée.
Symboles Utilisés dans ce Document

Ce symbole est destiné à avertir l'opérateur de la présence de tensions dangereuses, en relation avec le laser, qui peuvent être suffisamment élevées pour constituer un risque de choc électrique.

Ce symbole est destiné à avertir l'opérateur de la présence de mode opératoire et d'instructions de maintenance.

Ce symbole est destiné à avertir l'opérateur du danger que présente l'exposition à des radiations laser visible et invisible.

Patents

U.S. Patent No. 5, 954, 978
U.S. Patent No. 6, 167, 068
U.S. Patent No. 6, 097, 742
U.S. Patent No. 5, 991, 318
SECTION ONE: LASER SAFETY

Optical Safety

Laser light, because of its special properties, poses safety hazards not associated with light from conventional sources. The safe use of lasers requires that all laser users, and everyone near the laser system, are aware of the dangers involved. The safe use of the laser depends upon the user being familiar with the instrument and the properties of coherent, intense beams of light.

Direct eye contact with the output beam from the laser will cause serious damage and possible blindness.

Laser beams can ignite volatile substances such as alcohol, gasoline, ether and other solvents, and can damage light-sensitive elements in video cameras, photomultipliers and photodiodes. Reflected beams may also cause damage. For these reasons, and others, the user is advised to follow the precautions below.

1. Observe all safety precautions in the operator’s manual (this document).
2. Extreme caution should be exercised when using solvents in the area of the laser.
3. Limit access to the laser to qualified users who are familiar with laser safety practices and who are aware of the dangers involved.
4. Never look directly into the laser light source or at scattered laser light from any reflective surface. Never sight down the beam into the source.
5. Maintain experimental setups at low heights to prevent inadvertent beam-eye encounter at eye level.

Laser safety glasses can present a hazard as well as a benefit; while they protect the eye from potentially damaging exposure, they block light at the laser wavelengths, which prevents the operator from seeing the beam. Therefore, use extreme caution even when using safety glasses.
6. As a precaution against accidental exposure to the output beam or its reflection, individuals using the system should wear laser safety glasses as required by the wavelength being generated.

7. Use the laser in an enclosed room. Laser light remains collimated over long distances and therefore presents a potential hazard if not confined.

8. Post warning signs in the area of the laser beam to alert individuals present.

9. Advise all individuals using the laser of these precautions. It is good practice to operate the laser in a room with controlled and restricted access.

**Electrical Safety**

The Sapphire laser does not contain hazardous voltages. Do not disassemble the enclosure. There are no user-serviceable components inside. All units are designed to be operated as assembled. Warranty will be voided if the enclosure is disassembled.

**Laser Safety Requirements**

This laser product is intended to be sold to an original equipment manufacturer of electronic products for use as a component (or replacement thereof) in such electronic products. As such, this product is exempt from DHHS performance standard for laser products in accordance with paragraph 1040.10(a)(1).

The following information is provided to assist the OEM in complying with radiation safety standards.

**Laser Emission and Classification**

The Sapphire laser is classified by the United States National Center for Device and Radiological Health (CDRH) as a CLASS IIIB laser product. It emits VISIBLe AND INVISIBLE LASER RADIATION of the wavelengths (listed in Table 1-1) from the aperture in the front of the laser head.

**Table 1-1. Emitted Wavelengths**

<table>
<thead>
<tr>
<th>LASER TYPE</th>
<th>Emitted Wavelengths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sapphire LP 458 nm</td>
<td>0.45 to 0.50 μm and 0.90 to 1.00 μm</td>
</tr>
<tr>
<td>Sapphire LP 460 nm</td>
<td>0.45 to 0.50 μm and 0.90 to 1.00 μm</td>
</tr>
<tr>
<td>Sapphire LP 488 nm</td>
<td>0.45 to 0.50 μm and 0.90 to 1.00 μm</td>
</tr>
<tr>
<td>Sapphire LP 514 nm</td>
<td>0.50 to 0.55 μm and 1.00 to 1.10 μm</td>
</tr>
<tr>
<td>Sapphire LP 532 nm</td>
<td>0.50 to 0.55 μm and 1.00 to 1.10 μm</td>
</tr>
<tr>
<td>Sapphire LP 561 nm</td>
<td>0.55 to 0.57 μm and 1.10 to 1.20 μm</td>
</tr>
<tr>
<td>Sapphire LP 568 nm</td>
<td>0.56 to 0.58 μm and 1.10 to 1.20 μm</td>
</tr>
</tbody>
</table>

Collinear radiation of 0.79 to 0.82 μm may also be present.
Laser Safety

Laser Radiation Emission Indicator

A yellow indicator light is provided on the rear of the laser head. This light is illuminated when the laser pump diode is energized. This light may not meet the IEC-825 requirement that warning laser lights must be fail-safe or redundant. The Sapphire OEM Controller LP has been designed to accommodate a warning light that is fail-safe or redundant and meets the IEC-825 requirements. This light is part of the interlock system and must be supplied by the laser user. For further details, refer to the description of the interlock circuit under “Using a Laser Warning Light” on page 3-14.

Interlock

A normally closed remote interlock switch can be installed on the Sapphire OEM Controller LP. For further details, refer to the description of the interlock circuit under “Using a Laser Warning Light” on page 3-14.

DIP Switch Settings

With the DIP switches located on the Sapphire OEM Controller LP, the user has the opportunity to bridge the safety circuits and set the laser to Autostart mode. For more information, refer to “DIP Switch Settings” on page 3-10.

After the DIP switch settings have been changed in any way, the user should check the safety circuits for proper functionality.

Hazardous Radiation Exposure

Use of controls or adjustments or performance of procedures other than those specified in this manual may result in hazardous radiation exposure.

Waste Electrical and Electronic Equipment (WEEE, 2002)

The European Waste Electrical and Electronic Equipment (WEEE) Directive (2002/96/EC) is represented by a crossed-out garbage container label (see Figure 1-1, below). The purpose of this directive is to minimize the disposal of WEEE as unsorted municipal waste and to facilitate its separate collection.

Figure 1-1. Waste Electrical and Electronic Equipment Label
RoHS Compliance

The RoHS directive restricts the use of certain hazardous substances in electrical and electronic equipment. All components of the Sapphire laser system are RoHS compliant.

China-RoHS Compliance

The China-RoHS directive restricts the use of certain hazardous substances in electrical and electronic equipment. Refer to the following table for product components that are China-RoHS compliant.

Table 1-2. China-RoHS Compliant Components

<table>
<thead>
<tr>
<th>Description</th>
<th>Pb</th>
<th>Hg</th>
<th>Cd</th>
<th>Cr6+</th>
<th>PBB</th>
<th>PBDE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAPPHIRE Laserhead</td>
<td>X</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>SAPPHIRE Powersupply</td>
<td>X</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>SAPPHIRE Heatsink</td>
<td>X</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>SAPPHIRE Controller</td>
<td>X</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>SAPPHIRE Headcable</td>
<td>X</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
</tbody>
</table>
Location of Safety Labels

Refer to the following figure for the location of safety labels.

Key on Following Page

Figure 1-2. Safety Labels (Sheet 1 of 4)
(460 nm/ 10 mW and 488 nm/ 10/20/25/30 mW versions)

(488 nm/ 40/50/75 mW versions)

(458 nm/ 20/50/75 mW and 488 nm/ 100/150 mW versions)

Figure 1-2. Safety Labels (Sheet 2 of 4)
Figure 1-2. Safety Labels (Sheet 3 of 4)

(561 nm and 568 nm/ 50/75/100/150/200 mW versions)

(514 nm/ 20/50/75/100 mW and 532 nm/ 200/300 mW versions)

1.

2.

3.
Note: Color-coded Sapphire label indicates the wavelength (in this example, 488 nm)

5.

Figure 1-2. Safety Labels (Sheet 4 of 4)
EC Declaration of Conformity

For the following named product:

Sapphire OEM Laser System / Sapphire CDRH Laser System
Optically Pumped Semiconductor Laser

We declare that it complies with the basic requirements defined in the EC Directive on the harmonization of the laws of member states relating to electromagnetic compatibility (89/336/EEC) and the low voltage directive (73/23/EEC).

This declaration pertains to all products which are manufactured according to the manufacturing procedures valid on:

01.08.2009

The following standards were used to assess the product concerning electromagnetic compatibility:

Interference Emission
EN 50081-1
EN 55022, Cl.B

Interference Immunity
EN 50082-2
EN 61000-4-2,-3-4,5-6
EN 50204

The following standards were used to assess the product concerning low voltage compatibility:

EN 61010-1

This declaration is given in account for the manufacturer:

Coherent GmbH
Branch Luebeck
Seelandstraβe 9
23569 Lübeck/Germany

abgegeben durch
Reinhard Luger, Geschäftsführer

by
Reinhard Luger, General Manager

Unterschrift / Signature

Lübeck, August 6, 2009,
Figure 1-4. TÜV Certificate for Sapphire 488-XX YY and 460-10 YY
Figure 1-5. TÜV Certificate for Sapphire 488-XX YY, 561-XX YY, and 568-XX YY
Sécurité Optique

La lumière laser, du fait de ses propriétés particulières, ne présente pas les mêmes risques que les autres sources lumineuses traditionnels. L'utilisation sécurisée de laser requiert que tous les utilisateurs de laser, et que chaque personne proche d'un système laser, connaissent les dangers inhérents à l'utilisation d'une telle source lumineuse. L'utilisation sécurisée de laser dépend de l'habitude qu'a l'utilisateur avec les instruments et les propriétés d'une lumière cohérente et intense.

Le contact direct avec l'œil du faisceau laser peut provoquer des lésions importantes et une possible cécité.

Les faisceaux lasers peuvent enflammer des substances volatiles comme l'alcool, l'essence, l'éther ou d'autres solvants encore, et peut endommager des éléments sensibles à la lumière comme les caméras vidéo, les photomultiplicateurs et les photodiodes. Les faisceaux réfléchis peuvent aussi induire des dommages. Pour toutes ces raisons, il est conseillé à l'utilisateur de suivre les précautions suivantes.

1. Observer toutes les précautions de sécurité du manuel utilisateur.
2. Une attention particulière doit être prise quand des solvants sont utilisés dans la même salle que le laser.
3. L'utilisation de laser doit être limitée aux personnes qualifiées et habituées à une utilisation sans risque des laser et qui en sont informées des dangers.
5. Maintenir le montage expérimental à une faible hauteur pour éviter toute rencontre du faisceau laser avec les yeux.
Les lunettes de sécurité laser peuvent présenter un risque aussi bien qu'un avantage ; elles protègent les yeux d'une exposition potentiellement dangereuse, elles bloquent la lumière aux longueurs d'onde du laser, ce qui empêche l'opérateur de voir le faisceau laser. Par conséquent, prendre une attention particulière même avec l'utilisation de lunettes de sécurité.

6. Afin d'éviter une exposition accidentelle au faisceau de sortie du laser ou à une de ses réflexions, les utilisateurs du système doivent porter des lunettes de sécurité imposées par la longueur d'onde générée par le laser.

7. Utiliser le laser dans une pièce fermée. La lumière laser restera collimatée sur une longue distance, et peut ainsi présenter un risque si elle n'est pas confinée.

8. Placer des panneaux d'avertissement dans la zone où se trouve le faisceau laser pour avertir les personnes y étant présentes.


Sécurité Electrique

Le laser Sapphire LP ne présente pas de risques électriques. Ne pas démonter le boîtier. Il n'y a pas de composants utilisables à l'intérieur. Tous les boîtiers sont conçus pour être employés assemblés. La garantie sera annulée si le boîtier est démonté.

Recommandations sur la Sécurité Laser

Cet équipement laser est destiné à être vendu comme composant (ou pièce de rechange) pour un équipement électronique OEM (Original Equipement Manufacturer). Ainsi, ce produit est exempté de la norme DHHS pour les produits laser conformément au paragraphe 1040.10(a)(1). Les informations suivantes sont destinées à fournir une assistance aux OEM au niveau des normes de sécurité laser.

Émission et Classification Laser

Le laser Sapphire LP est classé par le CDRH (United States National Center for Device and Radiological Health) comme un laser de classe IIIb. Il émet une radiation laser dans le VISIBLE ET L'INVISIBLE de longueurs d'onde qui sont énumérés ci-dessous (se référer au Table 1-3), à partir de la sortie de la tête laser.
Une autre radiation à 0,79 - 0,82 µm, peut également être présente dans le faisceau laser.

### Radiation Laser
### Indicateur d'émission

Un indicateur lumineux jaune est placé sur le devant de la derrière du laser. Cet indicateur est éclairé quand la diode laser est alimentée.

### Interlock/Auto Start

Dans la configuration par défaut, l'Interlock est ouvert et le mode Auto Start est désactivé par des interrupteurs DIP. Pour plus d'informations se référer à la Section 3, DIP Switch Settings.

Le circuit intégré interlock ne rentre pas dans les recommandations de l'IEC-825 pour laquelle les circuits interlock doivent être redondants, et pour laquelle le laser doit stopper si le circuit ne fonctionne pas (fail-safe). Le circuit interlock est conçu pour être seulement utilisé dans des applications d'OEM.

### Risque Liés à Une Exposition Laser

L'utilisation de procédures de contrôle ou de réglages des performances autres que celles spécifiées ci-après peut mener à une exposition risquée aux radiations laser.

---

**Table 1-3. Longueurs d'Onde Émise**

<table>
<thead>
<tr>
<th>TYPE DE LASER</th>
<th>LONGUEURS D'Onde Émise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sapphire LP 458 nm</td>
<td>0.45 to 0.50 µm and 0.90 to 1.00 µm</td>
</tr>
<tr>
<td>Sapphire LP 460 nm</td>
<td>0.45 to 0.50 µm and 0.90 to 1.00 µm</td>
</tr>
<tr>
<td>Sapphire LP 488 nm</td>
<td>0.45 to 0.50 µm and 0.90 to 1.00 µm</td>
</tr>
<tr>
<td>Sapphire LP 514 nm</td>
<td>0.50 to 0.55 µm and 1.00 to 1.10 µm</td>
</tr>
<tr>
<td>Sapphire LP 532 nm</td>
<td>0.50 to 0.55 µm and 1.00 to 1.10 µm</td>
</tr>
<tr>
<td>Sapphire LP 561 nm</td>
<td>0.55 to 0.57 µm and 1.10 to 1.20 µm</td>
</tr>
<tr>
<td>Sapphire LP 568 nm</td>
<td>0.56 to 0.58 µm and 1.10 to 1.20 µm</td>
</tr>
</tbody>
</table>
Laser Safety

Paramétrage du Mini Commutateurs

Avec les mini commutateurs qui sont situés sur la carte de contrôle Sapphire OEM Controller LP, l'utilisateur a la possibilité de court-circuiter la boucle interlock et de régler la mode démarrage en automatique. (Référer à la section "Installation" / "DIP Switch Settings" s.v.p.)

Après une modification de paramétrage du mini commutateurs, l'utilisateur doit vérifier la bon fonction de circuit de sécurité.

Emplacement des Étiquettes de Sécurité

Se référer à la Figure 1-6 pour l'emplacement des étiquettes de sécurité.

Figure 1-6. Étiquettes de Sécurité (Sheet 1 of 4)
Figure 1-6. Etiquettes de Sécurité (Sheet 2 of 4)

(Versions 460 nm / 10 mW et 488 nm / 10/20/25/30 mW)

(Versions 488 nm / 40/50/75 mW)

(Versions 458 nm / 20/50/75 mW et 488 nm / 100/150 mW)
(Versions 561 nm et 568 nm / 50/75/100/150/200 mW)

1. [Image]

(Versions 514 nm / 20/50/75/100 mW et 532 nm / 200/300 mW)

2. [Image]

3. [Image]

Figure 1-6. Étiquettes de Sécurité (Sheet 3 of 4)
4.

5.

Figure 1-6. Étiquettes de Sécurité (Sheet 4 of 4)
SECTION TWO: DESCRIPTION AND SPECIFICATIONS

System Description

The Sapphire™ LP OEM System is a miniature solid state diode pumped laser system designed for OEM and industrial use. The Sapphire is an intracavity frequency-doubled laser system which uses an optical pumped semiconductor as the gain medium and provides visible output at 460 nm, 488 nm, 561 nm, or 568 nm, depending on the type. Refer to Table 2-1 on page 2-7 for output power and wavelength of each version.

The standard Sapphire can be remotely controlled and monitored using either the RS-232 interface or the analog interface.

The Sapphire laser system (see Figure 2-1 on page 2-2) consists of:
- Sapphire LP OEM laser head
- There are two different controller versions available:
  - OEM Controller LP (stack of PCB boards)
  - OEM Controller LP USB (single pcb)
- Sapphire Connector kit
- Connecting cable (head to OEM Controller LP—2 m (6 feet))

The suffix “LP” distinguishes the small platform Sapphire laser from the “HP” Sapphire systems, which come in a larger package and offer up to 500 mW output power.

An optional DC power supply is available if the integrator does not provide a DC source. There is also an optional heat sink (available as an accessory), if heat sinking is not included in the OEM integration.

---

A heat sink (not included with the Sapphire laser system) is required to dissipate the heat from the Sapphire head. This heat sink must be provided by the user (see “Heat Sink Requirement” on page 3-1). Improper heat sinking can lead to a shut-off of the laser head. Exposing the laser head to excessive heat outside the specification can cause permanent damage.
**Laser Head**

The Sapphire belongs to a class of Optically Pumped Semiconductor Lasers (OPSL™) that is similar to a conventional Vertical External Cavity Surface Emitting Laser (VECSEL), except it uses optical pumping instead of injection current to generate gain. Figure 2-2 on page 2-3 illustrates the optical layout of the Sapphire.
A lens focuses the output beam of the pump diode onto the OPS chip. The OPS chip contains a DBR mirror that—combined with the output coupler—forms the resonator. The resonator contains the gain material (OPS chip) and a frequency-doubling crystal. The resonator mirrors are high-reflecting for the fundamental wavelength of the OPS. The electric field intensity in the resonator is high enough for generating blue light in a non-linear process in the frequency-doubling crystal. The blue beam—coupled out of the resonator—passes through collimating lenses and exits through the case window.

An integrated thermoelectric cooler stabilizes the diode laser and the resonator temperature. Excess heat dissipates via the baseplate of the laser.

Figure 2-2. Optical Schematic
Optional Heat Sink

An optional heat sink is available (see Figure 2-10 on page 2-13) if heat sinking of the laser head is not covered by the OEM integration. This heat sink has sufficient cooling capacity for ambient temperatures up to 40°C. Using the attached cable, the integrated fan slaves the DC power from the Sapphire laser head.

Sapphire OEM Controller LP

The Sapphire OEM Controller LP drives the pump diode, controls active resonator parameters, and monitors the laser operation. It also provides a remote interlock, control, and status monitoring over an analog interface and RS-232 interface. For more information, refer to the following tables.

<table>
<thead>
<tr>
<th>TABLE #</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 3-3 on page 3-16</td>
<td>Describes the analog interface (25-pin sub-D)</td>
</tr>
<tr>
<td>Table 3-5 on page 3-20</td>
<td>Describes the RS-232 interface (9-pin sub-D)</td>
</tr>
<tr>
<td>Table 3-6 on page 3-23</td>
<td>Provides an RS-232 command set</td>
</tr>
</tbody>
</table>

Sapphire OEM Controller LP USB

The Sapphire OEM Controller LP USB drives the pump diode, controls active resonator parameters, and monitors the laser operation. It also provides a remote interlock, control, and status monitoring over an analog interface, an RS-232 interface, and a USB interface. For more information, refer to the following tables.

<table>
<thead>
<tr>
<th>TABLE #</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 3-4 on page 3-18</td>
<td>Describes the analog interface (26-pin IDC connector)</td>
</tr>
<tr>
<td>Table 3-5 on page 3-20</td>
<td>Describes the RS-232 interface (9-pin sub-D)</td>
</tr>
<tr>
<td>Table 3-6 on page 3-23</td>
<td>Provides an RS-232 command set</td>
</tr>
</tbody>
</table>

Typically within 40 seconds of power up, the OEM Controller LP and LP USB set all temperatures to the expected values. Light emission can be started once all temperatures are within one degree Celsius of the expected values.
Label Identification Numbers

Each Coherent Sapphire LP OEM laser head (Figure 2-3) and laser controller (Figure 2-4, below, and Figure 2-5 on page 2-6) has a label containing a unique serial number. This serial number consists of a part number and a production number.

On the label in Figure 2-3, above:
- XXXXXX = the part number
- YYYYYY = the production number

Figure 2-3. Label Identification - Laser Head

OPS-L OEM CTRL LP
XXXXXXX-AC
YYYYY-ZZZZZZ

Figure 2-4. Label Identification - Laser OEM Controller LP
On the label in Figure 2-4 on page 2-5 and Figure 2-5, above:

- XXXXXXX = the part number
- YYYY = the month and year of manufacture
- ZZZZZZ = the production number

**Explanation of Label Numbers**

A *part number* describes the type of the component—for example, Sapphire 488-20 Laser Head, OEM, RoHS compliant. Knowing this number ensures that the correct product is ordered.

Laser components are consecutively numbered with a unique *production number*. A production number clearly identifies each individual component within a laser system.

Laser system part numbers and production numbers are top-level numbers. They are not noted on the labels of the individual components of the laser system.
Optional DC Power Supply

The optional self-contained power supply provides an output of 13.2 VDC, although any DC power supply that complies with specifications listed in Table 2-1, below, can be used.

Be sure to shut down the DC power supply for at least ten seconds before restarting. This action prevents residual DC output voltages during restart which, in turn, can lead to start-up failure or damage of the Sapphire laser system.

Specifications

Specifications for the Sapphire laser are listed in Table 2-1, below.

Table 2-1. Specifications and Requirements (Sheet 1 of 2)

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SAPPHIRE 458/460/488/514/532/561/568 LP OEM</strong></td>
<td></td>
</tr>
<tr>
<td>Wavelength:</td>
<td>458 nm ± 2 nm; 460 nm ± 2 nm; 488 nm ± 2 nm; 514 nm ± 2 nm; 532 nm ± 2 nm; 561 nm ± 2 nm; 568 ± 2 nm</td>
</tr>
</tbody>
</table>
| Output power:                    | 20/50/75 mW @ 458 nm
                                      10 mW @ 460 nm
                                      10/20/25/30/40/50/75/100/150 mW @ 488 nm
                                      20/50/75/100/150 mW @ 514 nm
                                      200/300 mW @ 532 nm
                                      50/75/100/150/200 mW @ 561 nm & 568 nm |
| Noise:                           | 10 to 110% adjustable. Specifications are valid for 100% power. Recommended power range is 70 to 100% power. |
| P-P:                             | 20 Hz to 20 KHz: < 1%                                                       |
| RMS:                             | 20 Hz to 2 MHz: 0.25%                                                      |
| Pointing stability (over 2 hours)|                                                                             |
| Temperature range: ± 3ºC, after warm-up: | < 30 µrad                                                                  |
| Long-term power stability: (2 hours, ±3ºC) | < 2%                                                                      |
| Warm-up time:                    | < 5 minutes                                                                 |
| Fundamental beam emission:       | < 0.1 mW                                                                    |
| **BEAM PARAMETERS:**             |                                                                             |
| Transverse modes:                | $M^2 < 1.1$, TEMoo                                                          |
### Beam waist diameter (@ 1/e²):
0.65 to 0.75 mm

### Beam waist diameter location:
Front of laser, ± 200 mm

### Asymmetry:
0.9 to 1.1

### Beam divergence (full angle):
< 1.2 mrad (458/460/488/514/532 nm versions)
< 1.3 mrad (561 nm and 568 nm versions)

### Static alignment
(Reference: front & right side of baseplate):
± 0.25 mm (x, y)
± 2.5 mrad (angle)

### Polarization ratio (bottom reference):
> 100:1, vertical

### Maximum baseplate temperature:
+ 55ºC for 10/20/25/30 mW versions
+ 50ºC for versions of 40 mW and higher

### Static alignment
(Reference: front & right side of baseplate):
± 0.25 mm (x, y)
± 2.5 mrad (angle)

### Polarization ratio (bottom reference):
> 100:1, vertical

### Maximum baseplate temperature:
+ 55ºC for 10/20/25/30 mW versions
+ 50ºC for versions of 40 mW and higher

### Table 2-1. Specifications and Requirements (Sheet 2 of 2)

<table>
<thead>
<tr>
<th><strong>PARAMETER</strong></th>
<th><strong>DESCRIPTION</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam waist diameter (@ 1/e²):</td>
<td>0.65 to 0.75 mm</td>
</tr>
<tr>
<td>Beam waist diameter location:</td>
<td>Front of laser, ± 200 mm</td>
</tr>
<tr>
<td>Asymmetry:</td>
<td>0.9 to 1.1</td>
</tr>
<tr>
<td>Beam divergence (full angle):</td>
<td>&lt; 1.2 mrad (458/460/488/514/532 nm versions) &lt; 1.3 mrad (561 nm and 568 nm versions)</td>
</tr>
<tr>
<td>Static alignment (Reference: front &amp; right side of baseplate):</td>
<td>± 0.25 mm (x, y) ± 2.5 mrad (angle)</td>
</tr>
<tr>
<td>Polarization ratio (bottom reference):</td>
<td>&gt; 100:1, vertical</td>
</tr>
<tr>
<td>Maximum baseplate temperature:</td>
<td>+ 55ºC for 10/20/25/30 mW versions + 50ºC for versions of 40 mW and higher</td>
</tr>
</tbody>
</table>

### ENVIRONMENTAL SPECIFICATIONS

<table>
<thead>
<tr>
<th><strong>OPERATING</strong></th>
<th><strong>NON-OPERATING</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient temperature:</td>
<td>10 to 40ºC (50 to 104°F)</td>
</tr>
<tr>
<td>Altitude:</td>
<td>0 to 10,000 feet</td>
</tr>
<tr>
<td>Relative humidity (w/o condensation):</td>
<td>0 to 90%</td>
</tr>
<tr>
<td>Shock tolerance (6 ms):</td>
<td>7 g laterally 15 g vertically</td>
</tr>
</tbody>
</table>

### INPUT POWER REQUIREMENTS

<table>
<thead>
<tr>
<th><strong>INPUT POWER REQUIREMENTS</strong></th>
<th><strong>DESCRIPTION</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Input voltage:</td>
<td>+10.8 to 15 VDC</td>
</tr>
<tr>
<td>Input power:</td>
<td>&lt;60 W</td>
</tr>
<tr>
<td>Ripple:</td>
<td>&lt; 5% peak to peak</td>
</tr>
<tr>
<td>Load regulation:</td>
<td>&lt; 0.5%</td>
</tr>
</tbody>
</table>
The dimensions of the Sapphire laser head, the Sapphire OEM Controller LP, the optional DC power supply, and the optional heat sink are shown in the following figures:

**Figure 2-6. Sapphire Laser Head Dimensions**
6 holes Ø 4.3 mm in pcb; 6 spacers with tapped thread M4, UNC No.8 or 5/32"-32 BSW (as shown) are shipped; spacers with threaded bush are available on request.

all dimensions in mm

Figure 2-7. Sapphire OEM Controller LP Dimensions
Figure 2-8. Sapphire OEM Controller LP USB Dimensions
Figure 2-9. Optional DC Power Supply Dimensions
Figure 2-10. Optional Heat Sink for Laser Head Dimensions
SECTION THREE: INSTALLATION

After unpacking the system, keep the shipping boxes for potential later shipments (see “Section Five: Repacking Procedure” on page 5-1).

Installation

The installation procedure includes the following steps:

• Determine heat sink requirements and install the heat sink
• Connect the system components
• Connect a means of controlling (and monitoring) the laser system
• Configure the OEM Controller LP and LP USB DIP switches for the desired mode of operation
• Connect the system to a DC power source

The above tasks are described in the following paragraphs. After performing all of the tasks, the laser may be turned on and operated in accordance with the description presented later in this section.

Do not operate the system without a heat sink installed on the laser head. Improper heat sinking can lead to a system shut-down.

Heat Sink Requirement

It is imperative that the laser head be adequately heat sunked; otherwise, it will overheat and shut down in a matter of seconds. Figure 3-1 on page 3-2 shows the heat dissipation of the Sapphire laser head for a given baseplate temperature. The graph in
Figure 3-2, below, allows determination of the heat sink thermal impedance requirement based on the anticipated maximum ambient temperature.

**Figure 3-1. Heat Dissipation of the Sapphire Head**

**Figure 3-2. Heat Sink Requirements**
For example, if the maximum expected ambient temperature is 35°C, then the heat sink thermal impedance needs to be 0.8°C/watt.

Note that the mounting surface of the heat sink must be flat to ensure good thermal contact and to avoid damage to the laser head. Many extruded heat sinks are warped and the mounting surface should thus be milled flat (to < 0.05 mm over the mounting surface). Thermal heat compound may be used between the laser head and heat sink to maximize thermal contact.

---

No thermal compound can compensate for an uneven or rough heat sink surface. For best thermal conductivity, apply a very thin layer of thermal compound on a flat milled surface with a low roughness.

---

For an overview of heat sink technology, refer to any standard heat sink catalog.

---

**Mounting Specifications**

Use the following procedure to mount the Sapphire laser head onto the heat sink:

1. Lightly tighten down the M3 metric or 4-40 UNC screws in diagonal order (refer to Figure 3-3, below). Use DIN 125 ISO 7089 washers (3.2 mm inner diameter, 7 mm outer diameter) made of A2 material.

---

It is important to use washers to spread the pressure and ensure reliable, precise mounting.

---

*Figure 3-3. Torque and Tightening Pattern*
2. Using the correct torque, tighten down the screws in diagonal order (follow the 1-2-3-4 sequence shown in Figure 3-3 on page 3-3). The correct torque depends on the type of thread being used (M3 metric or 4-40 UNC) and the property class of steel used in the screw. A standard torque value for commonly used M3 screws is 100 Ncm = 1 Nm. The overall flatness of the heat sink should be < 0.05 mm.

To ensure the most reliable mount, torque the mounting screws twice:

- FIRST, torque all the screws to 0.25 Nm (2.21 lbf-in)
- SECOND, torque all the screws to 1 Nm (8.851 lbf-in)

---

To take advantage of the superior static beam alignment of Sapphire (see Figure 2-6 on page 2-9), Coherent recommends using dowel pins or similar references in the mounting of the Sapphire head.

Modifying the baseplate in any way could lead to damaging the laser and, thereby, voiding the warranty.

---

The standard mounting procedure for the Sapphire OEM Controller LP is to use threaded screws (M4, UNC No. 8 or 5/32”-32BSW) to attach the OEM Controller LP stack to the mounting surface, using the six spacers in the lower PC board. An example of this mounting technique is shown in the right-hand side of Figure 3-4 on page 3-5.

An alternative mounting procedure is to use spacers with bush, as shown on the left-hand side of Figure 3-4 on page 3-5. These optional spacers are available with M4 standard bush on request and can be easily replaced (unlike the existing threaded spacers in the lower PC board).

Another alternative procedure is to remove the spacers completely and mount the OEM Controller LP stack with screws via the through-holes.

---

Use the appropriate isolating washers to ensure electrical isolation and avoid damaging the PC board.

---

Refer to Figure 2-7 on page 2-10 for Sapphire OEM Controller LP dimensions.
Interconnections

To assist in establishing the physical location of the laser system components, laser head dimensions and the analog OEM Controller LP are shown on Figure 2-6 on page 2-9 and Figure 2-7 on page 2-10.

Ensure that the laser head is adequately heat sinked, as described under “Heat Sink Requirement” on page 3-1.

To prevent surge currents, do not apply power to the laser system until all connections are completed.

1. The laser head connector is protected from electrostatic discharge during shipping. Remove all materials from the connector.
2. Connect the laser system, as shown in Figure 3-5 on page 3-6.
Do NOT connect the laser system to any power source at this time.

The connectors on the Sapphire OEM Controller LP do not tolerate major mechanical pressure. Ensure strain relief to cables in the integration.

Figure 3-5. Interconnection Diagram
Table 3-1. Sapphire Laser System Components

<table>
<thead>
<tr>
<th>Item #</th>
<th>Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sapphire LP OEM Laser Head</td>
</tr>
<tr>
<td>2a</td>
<td>Sapphire OEM Controller LP</td>
</tr>
<tr>
<td>2b</td>
<td>Sapphire OEM Controller LP USB</td>
</tr>
<tr>
<td>3</td>
<td>Sapphire LP DC Power Supply (optional)</td>
</tr>
<tr>
<td>4</td>
<td>Sapphire LP Connector Kit</td>
</tr>
<tr>
<td>5</td>
<td>Sapphire LP Head Cable</td>
</tr>
<tr>
<td>6</td>
<td>Sapphire LP Heat Sink (optional)</td>
</tr>
</tbody>
</table>

Laser system part numbers are top-level numbers and are not noted on the individual components of the laser system. Each component has a label with a unique serial number and production number on it. Refer to “Label Identification Numbers” on page 2-5 for more information.
Connecting an External Fan

The DC voltage supplied from the OEM Controller LP is available at the laser head to power an external fan (max. current < 500 mA). For more information, refer to Figure 2-6 on page 2-9 and Figure 3-5 on page 3-6.

A spare plug is included in the Connector kit, which is part of the system delivery volume. Figure 3-6, below, shows the AMP Connector pin assignments and part numbers.

Do not connect or disconnect the fan plug while the controller is powered.

Figure 3-6. Fan Connector

![Fan Connector Diagram]

+ 12 VDC  GND

AMP Crimp-Snap-Housing
#280 358-0
AMP Crimp-Contacts
#166 358-2
Any power supply that complies with the specifications listed in Table 2-1 on page 2-7 can be used with the laser system; however, we recommend using the optional power supply. When using a user-furnished power supply, a Connector kit (supplied) assists with connecting the furnished power supply to the analog OEM Controller LP. The kit offers two options:

1. Connecting a preassembled cable (1.5 m) with the Molex plug on one end (to fit to the OEM Controller LP) and two single wires on the other end—Red (+DC) and Black (Ground).

2. Connecting a plain Molex plug to an existing DC line cable (refer to Figure 3-7, below).

**NOTE:** Pin assignment is different from Molex nomenclature.

### Figure 3-7. Molex Connector

<table>
<thead>
<tr>
<th>Pin Assignment</th>
<th>Function Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>+DC Input Power</td>
<td>Pin 1, 2, + 10.8 to + 15 VDC Main DC power. Use both pins due to high current.</td>
</tr>
<tr>
<td>DC Input Power Return</td>
<td>Pin 3, 4, DC Power Return, separated from signal ground by EMI filter. Use both pins due to high current.</td>
</tr>
<tr>
<td>Interlock</td>
<td>Pin 5 (+) to Pin 6 (–), &lt;+ 15 VDC, 12.5 mA typ. Connect pins for laser on (disabled by DIP Switch SW3-2 in on position) can be used for laser warning light (LED).</td>
</tr>
<tr>
<td>Keyswitch</td>
<td>Pin 7 (N.O.), Pin 8 (N.C.), Pin 9 (Com.), &lt;+ 15 VDC, 12.5 mA typ. Connect keyswitch for laser safety circuit (disabled by DIP Switch SW3-3 in on position). The laser operates when pins 7 and 9 are connected. Connect pins 8 and 9 when the keyswitch is off.</td>
</tr>
<tr>
<td>Chassis ground</td>
<td>Pin 10</td>
</tr>
</tbody>
</table>
DIP Switch Settings

Figure 3-8 and Figure 3-9 show the DIP switch locations.

Figure 3-8. DIP Switch Location—Sapphire OEM Controller LP

Figure 3-9. DIP Switch Location—Sapphire OEM Controller LP USB

The DIP switch settings should only be changed when the laser system is not powered.
**Default Settings of the DIP Switch**

The unit comes with the following default DIP switch settings:

- **SW 3-1**: OFF  Interlock at Analog interface required
- **SW 3-2**: OFF  Interlock at DC Power connector required
- **SW 3-3**: OFF  Keyswitch at DC Power connector required
- **SW 3-4**: OFF  Autostart mode disabled
- **SW 3-5**: ON  Always set to ON (*not present on the Sapphire OEM Controller LP USB*)
- **SW 3-6**: OFF  Always set to OFF (*not present on the Sapphire OEM Controller LP USB*)

DIP switch positions 5 and 6 are not present on the Sapphire OEM Controller LP USB.

These settings require the user to provide external interfacing (interlock and keyswitch closed in external circuit/wiring) to operate the Sapphire laser system.

Figure 3-11 on page 3-15 provides an interconnect diagram for the interlock and keyswitch connecting locations. Refer to Table 3-3 on page 3-16 for a detailed description of the Analog Interface connector.

Starting a laser with these default settings requires an active start signal via analog interface or RS-232 interface (see the following pages).

**Autostart Settings of the DIP Switch**

If the user does not supply this external interface, there is an autostart setting that overrides the interlock and keyswitch safety circuits.

This operational mode requires the user to carefully follow all laser safety procedures. Coherent highly recommends taking extraordinary laser safety preparations for this mode.
In this mode, the laser starts after a warm-up period of 40 seconds.

Autostart DIP switch settings:

- SW 3-1  ON  Interlock at Analog interface disabled
- SW 3-2  ON  Interlock at DC Power connector disabled
- SW 3-3  ON  Keyswitch at DC Power connector disabled
- SW 3-4  ON  Autostart mode enabled
- SW 3-5  ON  Always set to ON (not present on the Sapphire OEM Controller LP USB)
- SW 3-6  OFF  Always set to OFF (not present on the Sapphire OEM Controller LP USB)

With Autostart engaged, the laser powers up to the previously-set power level (either factory default, specified power, or user-set).

Figure 3-10. Turn On Characteristics Diagram (from cold start)
A user might want to shut down the laser completely if a laser light is not required for a longer period of time. The warm-up procedure starts with a 45-second delay and is specified with less than five minutes.

If the laser is shut down via the DC power supply, be sure to let the DC power supply completely shut down before restarting. This action prevents residual DC output voltages during restart which, in turn, can lead to performance failure of the Sapphire laser.

For shorter interruptions, the Sapphire laser features a Stand By mode. This mode maintains all cavity temperatures but cycles down the pump diode, thereby assuring that no optical activity takes place. From a lifetime point of view, this is basically equivalent to a completely switched-off laser. Stand By mode is recommended for application interruptions of ten minutes or longer and is set through Pin 4 of the analog interface (Run mode if no connection, Sleep mode if ground). For more information on the analog interface, refer to “Sapphire OEM Controller LP: Controlling the Laser via Analog Signals” on page 3-15 or “Sapphire OEM Controller LP USB: Controlling the Laser via Analog Signals” on page 3-17.

When using the RS-232 interface (see “Controlling the Laser via RS-232 or USB Command Interface” on page 3-19), the command “L=0” puts the laser in Stand By mode, and “L=1” resumes operation.

The typical time to resume set output power from Standby is less than five seconds.

Once the laser reaches stable output power from either cold start or Stand By mode at Pin 16, a “Laser Ready Signal” is available (TTL high).
Interlocks

Using the Interlock Loops

The Sapphire OEM Controller LP can connect to two different interlock loops:

1. One loop is located at the Analog connector (J1), pins 1 and 3. When this interlock is required, setting DIP switch 1 to OFF provides a closed loop at these pins.

2. The other interlock loop is located at the DC Power connector (J3), pins 5 and 6. When this interlock is required, setting DIP switch 2 to OFF provides a closed loop at these pins.

Either one or both interlock loops can be used.

Using the Keyswitch Connection

To comply with CDRH and IEC-825 regulations, the user may connect a keyswitch to the Sapphire OEM Controller LP at the DC connector, pins 7, 8, and 9. Refer to Figure 3-11 on page 3-15 for details.

To comply with CDRH regulations, the user has to provide other components not listed here.

Using a Laser Warning Light

To comply with CDRH and IEC-825 regulations, the user may create a warning light by connecting LED(s) in the interlock loop. This light is on whenever the interlock loops are closed and DC power is applied. If the voltage drop across the LED(s) is less than 5 VDC, the interlock circuit provides 12.5 mA. Connect the LED(s) as shown in the following table.

Table 3-2. Laser Warning Light Connections

<table>
<thead>
<tr>
<th>LED LOCATION</th>
<th>LED ANODE</th>
<th>LED CATHODE</th>
<th>DIP SWITCH SETTING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analog Interface (J1)</td>
<td>J1 – 1</td>
<td>J1 – 3</td>
<td>SW3 – 1 OFF</td>
</tr>
<tr>
<td>DC Power Connector (J3)</td>
<td>J3 – 5</td>
<td>J3 – 6</td>
<td>SW3 – 2 OFF</td>
</tr>
</tbody>
</table>
**Sapphire OEM Controller LP: Controlling the Laser via Analog Signals**

Connect all components as explained under the heading, “Interconnections” on page 3-5. Note that the connecting cable for the Analog interface is not included. The connector is a standard 25-pin sub-D female connector.

Provide or disable the necessary interlock connection at the Analog interface connector. Supply the operating voltage to the DC connector and, if applicable, turn the CDRH Key switch to the ON position.

When the Analog interface is active, the RS-232 interface is disabled for commands.

If Autostart mode is disabled, turn on TEC and Laser by resetting Pin 2 from OFF to ON.

---

**Figure 3-11. Interlock Connection Diagram**
### Table 3-3. Pin-Out for External Analog Interface Connector (DB-25S Female) - Non-USB Controller Version

<table>
<thead>
<tr>
<th>SETTING</th>
<th>PIN</th>
<th>DESCRIPTION</th>
</tr>
</thead>
</table>
| Interlock                           | Pin 1 (+) and Pin 3 (−) | < 15 VDC, 12.5 mA typ. connect pins for laser on (disabled by DIP switch SW3-1 in ON position)  
Can be used for laser warning light (LED)  
ON/OFF Control | Pin 2 | Turns ON/OFF TEC and Laser  
PIN 2 to Ground Off  
PIN 2 no connection On  
If Autostart mode is disabled, an OFF to ON reset at Pin 2 is required to turn on TEC and Laser. |
| Standby/Run Mode Control            | Pin 4 | PIN 4 to Ground Standby  
PIN 4 no connection Run Mode                                                                                                      |
| Spare Digital Input                 | Pin 5 | Not to be connected.                                                                                                               |
| Spare Analog Input                  | Pin 6 | Not to be connected.                                                                                                               |
| Laser Output Power Control          | Pin 7 | Analog input 0 to +2.048V, 7-bit resolution. Range from MINLP to MAXLP, where “MINLP” means the minimum adjustable laser power, and “MAXLP” is the maximum adjustable laser power. Refer to “Controlling the Laser via RS-232 or USB Command Interface” on page 3-19 for further description of MINLP and MAXLP values.  
Minimum power if no connection. 10 Kohm input Impedance enabled by PIN 18 |
| Power Monitor                       | Pin 8 | Analog output, max. 10 mA drive capability.  
Scaling: 100% power = 2V                                                                                                                |
| LD Current Monitor                  | Pin 9 | Analog signal, 1V for 1000 mA laser diode current, max. 10 mA drive capability.                                                                                                    |
| Signal/Power Return                 | Pin 10, 11, 14, 20, 21, 22, 24 | Ground (return) for all signals and power                                                                                                          |
| N/A                                 | Pin 12 | Not to be connected.                                                                                                               |
| DC Output                           | Pin 13 | +12 VDC, 20 mA max. (output comes directly from DC supply)                                                                                                                                  |
| Base Temp Monitor                   | Pin 15 | Analog output temperature monitor signal  
(0 to 4.096V for 0 to 100°C)                                                                                                                |
| Laser Ready                         | Pin 16 | TTL Logic  
High when Output Power is Set Power ± 1 mW                                                                                             |
| Not Used (Key inserted)             | Pin 17 | Keying plug installed. PIN must be removed from the mating connector at this location.                                                                                                             |
| Analog Interface Enable             | Pin 18 | Enables Laser Control from pins 2, 4, and 7  
Pin 18 to Ground: enabled  
Pin 18 no connection: disabled                                                                                                           |
| Spare Digital Output                | Pin 19 | Not to be connected.                                                                                                               |
| Fault Output                        | Pin 23 | TTL logic output, high when laser is in a fault mode                                                                                                                                         |
| Chassis Ground                      | Pin 25 | Connects to connector shell, and mounting holes on OEM Controller LP PCB only                                                        |
Connect all components as explained under “Interconnections” on page 3-5. Note that the connecting cable for the analog interface is not included. The connector is a standard 26-pin IDC connector.

Provide or disable the necessary interlock connection at the Analog Interface connector. Supply the operating voltage to the DC connector and, if applicable, turn the CDRH Key switch to the ON position.

When the analog interface is active, the RS-232 interface is disabled for commands.

If Autostart mode is disabled, turn on TEC and laser by resetting Pin 3 from OFF to ON.

Figure 3-12, below, indicates the pinning for the Sapphire OEM Controller LP USB analog interface.
### Table 3-4. Pin-Out for External Analog Interface Connector (26-Pin IDC) - USB Controller Version

<table>
<thead>
<tr>
<th>SETTING</th>
<th>PIN</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interlock</td>
<td>Pin 1 (+)</td>
<td>&lt; 15 VDC, 12.5 mA typ. connect pins for laser on (disabled by DIP switch SW3-1 in ON position) Can be used for laser warning light (LED)</td>
</tr>
<tr>
<td></td>
<td>Pin 5 (−)</td>
<td></td>
</tr>
<tr>
<td>ON/OFF Control</td>
<td>Pin 3</td>
<td>Turns ON/OFF TEC and Laser PIN 3 to Ground Off PIN 3 no connection On If Autostart mode is disabled, an OFF to ON reset at Pin 3 is required to turn on TEC and Laser.</td>
</tr>
<tr>
<td>Standby/Run Mode Control</td>
<td>Pin 7</td>
<td>PIN 7 to Ground Standby PIN 7 no connection Run Mode</td>
</tr>
<tr>
<td>Spare Digital Input</td>
<td>Pin 9</td>
<td>Not to be connected.</td>
</tr>
<tr>
<td>Spare Analog Input</td>
<td>Pin 11</td>
<td>Not to be connected.</td>
</tr>
<tr>
<td>Laser Output Power Control</td>
<td>Pin 13</td>
<td>Analog input 0 to + 2.048V, 7-bit resolution. Range from MINLP to MAXLP, where “MINLP” means the minimum adjustable laser power, and “MAXLP” is the maximum adjustable laser power. Refer to “Controlling the Laser via RS-232 or USB Command Interface” on page 3-19 for further description of MINLP and MAXLP values. Minimum power if no connection. 10 Kohm input Impedance enabled by PIN 10</td>
</tr>
<tr>
<td>Power Monitor</td>
<td>Pin 15</td>
<td>Analog output, max. 10 mA drive capability. Scaling: 100% power = 2V</td>
</tr>
<tr>
<td>LD Current Monitor</td>
<td>Pin 17</td>
<td>Analog signal, 1V for 1000 mA laser diode current, max. 10 mA drive capability.</td>
</tr>
<tr>
<td>Signal/Power Return</td>
<td>Pin 2, 14, 16, 18, 19, 21, 22</td>
<td>Ground (return) for all signals and power</td>
</tr>
<tr>
<td>N/A</td>
<td>Pin 23</td>
<td>Not to be connected.</td>
</tr>
<tr>
<td>DC Output</td>
<td>Pin 25</td>
<td>+ 12 VDC, 20 mA max. (output comes directly from DC supply)</td>
</tr>
<tr>
<td>Base Temp Monitor</td>
<td>Pin 4</td>
<td>Analog output temperature monitor signal (0 to 4.096V for 0 to 100°C)</td>
</tr>
<tr>
<td>Laser Ready</td>
<td>Pin 6</td>
<td>TTL Logic High when Output Power is Set Power ± 1 mW</td>
</tr>
<tr>
<td>N/A</td>
<td>Pin 8</td>
<td>Not to be connected.</td>
</tr>
<tr>
<td>Analog Interface Enable</td>
<td>Pin 10</td>
<td>Enables Laser Control from pins 3, 7, and 13 Pin 10 to Ground: enabled Pin 10 no connection: disabled</td>
</tr>
<tr>
<td>Spare Digital Output</td>
<td>Pin 12</td>
<td>Not to be connected.</td>
</tr>
<tr>
<td>Fault Output</td>
<td>Pin 20</td>
<td>TTL logic output, high when laser is in a fault mode</td>
</tr>
<tr>
<td>Chassis Ground</td>
<td>Pin 24</td>
<td>Connects to connector shell and mounting holes on OEM Controller LP PCB only</td>
</tr>
</tbody>
</table>
The circuit figure shown below explains the control of the laser diode (LD) and TEC function using Pin 2/3 and Pin 4/7:

**Figure 3-13. Sapphire Standby-ON-OFF**

**Controlling the Laser via RS-232 or USB Command Interface**

Connect all components as shown in the paragraph Interconnections. Provide the necessary interlock connection at the Analog interface and/or DC power connector. Supply the operating voltage to the DC power connector. If applicable, turn the CDRH keyswitch to the ON position. Connect a serial cable (not included) to the OEM Controller LP and establish the communication to the computer. The user can utilize a standard terminal emulator program that is included in standard PC operation systems. For a definition of the RS-232 pin assignments, refer to Table 3-5 on page 3-20.

The settings of the OEM Controller LP RS-232 interface are:

- 19200 baud
- no parity
- 8 data bits
- 1 stop bit
- No flow control
A cable with straight through connections (i.e., Pin 1 connects to Pin 1, Pin 2 connects to Pin 2, etc.) allows communication with the 9-pin RS-232 connector on most personal computers.

By using the commands in Table 3-6, the user can control and query different parameters. Note that the laser will go through a warm-up cycle after applying DC power. During this cycle the OEM Controller LP will not accept any commands; the user has to query the error flag until there is a zero back response. Here is a typical RS-232 startup sequence:

Sapphire:0-> {system prompt}
Sapphire:0->?FF {checking for errors}
0 {no errors, warm-up cycle complete}
Sapphire:0->L=1 {laser on}
Sapphire:0->P=20 {output power = 20 mW}
Sapphire:0->?BT {query baseplate temp}
35 {35°C}
Sapphire:0->L=0 {laser off}

If the power level is not explicitly set, the laser always starts at the last power level used.

Table 3-5. RS-232 Connector (DB-9 Female on OEM Controller LP Board)

<table>
<thead>
<tr>
<th>SETTING</th>
<th>PIN</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>DCD</td>
<td>Pin 1</td>
<td>No connection</td>
</tr>
<tr>
<td>TXD</td>
<td>Pin 2</td>
<td>RS-232 transmitter on OEM Controller LP PCB</td>
</tr>
<tr>
<td>RXD</td>
<td>Pin 3</td>
<td>RS-232 receiver on OEM Controller LP PCB</td>
</tr>
<tr>
<td>DTR</td>
<td>Pin 4</td>
<td>Connected to DSR</td>
</tr>
<tr>
<td>GND</td>
<td>Pin 5</td>
<td>Signal Ground</td>
</tr>
<tr>
<td>DSR</td>
<td>Pin 6</td>
<td>Connected to DTR</td>
</tr>
<tr>
<td>RTS</td>
<td>Pin 7</td>
<td>Connected to CTS</td>
</tr>
<tr>
<td>CTS</td>
<td>Pin 8</td>
<td>Connected to RTS</td>
</tr>
<tr>
<td>RI</td>
<td>Pin 9</td>
<td>No connection</td>
</tr>
</tbody>
</table>
Connecting and Installing the USB Interface

The new Sapphire LP OEM USB controller supports digital USB control via a mini-USB connector. When installed, it serves as a virtual COM port and generates a new COM port at the computer. Access to this interface is then comparable to the RS-232 access.

When the USB and RS-232 interfaces are connected at the same time, USB supersedes the RS-232 interface by deactivating the RS-232 line until the supply power of the Sapphire controller is turned off and on again.

Controlling the Laser via the USB Command Interface

The Sapphire OEM Controller LP digital interface now supports USB via a standard mini-USB connector. The following figure shows the location of the USB connector.

![Image of the USB connector location](Image)

**Figure 3-14. Location of the Mini-USB Connector**
Hints For Software Integration

- The Sapphire firmware supports a local echo as a default setting; that is, the OEM Controller LP directly returns each character you send. To switch off the local echo, use the “E” command.
- To switch off the “Sapphire” prompt, use the “>” command.
- When working with their own software, some users find it advantageous to switch off the local echo and the system prompt.
- Don’t send more than one command at a time. After receiving a response to one command, the next command or query can be sent.
- A command is answered by a CR LF (carriage return/line feed). If the command is wrong, an additional error message string is sent.
- A query is always answered by CR LF (carriage return/line feed) and a string. The string may also be an error message.

RS-232 communication faults are often related to defective hardware components, for example, cables. Communication faults are also more common in rough electromagnetic interference environments. Ensure proper ground connection and shielding of the cable.

- Coherent strongly recommends a timeout program to prevent potential faults caused by RS-232 communication. After every command or query, the response of the Sapphire controller has to be completed before sending a new command or query to the controller. An interval of at least 500 ms between two commands or queries is sufficient. In case of a communication error, send a CR LF (carriage return/line feed) to clear the OEM Controller LP communication buffer.
- To handle temperature faults, etc., repeatedly use the “?FL” or the “?FF” query.

Activating the echo is recommended to verify that the CPU and digital communications are actively working. If activated, echo allows the user to check whether the Sapphire laser system sends an echo as a response to a sent command or query. If the echo is missing, block the laser beam until there is verification that the CPU and digital communications are properly working. Blocking the laser beam excludes malfunctions, including unintended laser light emission.
RS-232 Commands and Queries

Unless otherwise specified, most commands follow the “command=<value>” format and queries follow the “?query” format.

**Table 3-6. RS-232 Commands and Queries (Sheet 1 of 4)**

<table>
<thead>
<tr>
<th>Command</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>“&gt;”</td>
<td>Query and Command</td>
<td>Turns the command prompt ON or OFF. 1=ON 0=OFF</td>
</tr>
<tr>
<td>“BT”</td>
<td>Query</td>
<td>Reads the BasePlate temperature and returns the value in °C (degrees centigrade).</td>
</tr>
<tr>
<td>“C”</td>
<td>Query</td>
<td>Reads the laser diode current and returns the measured current value (in amps). Use the “?sc” command to read back the set current value.</td>
</tr>
<tr>
<td>“CLS”</td>
<td>Command</td>
<td>Clears text from a serial communication screen (only when using VT100 emulation).</td>
</tr>
<tr>
<td>“DST”</td>
<td>Query</td>
<td>Reads the Diode Set temperature in the system. This is a value in °C (degrees centigrade).</td>
</tr>
<tr>
<td>“DT”</td>
<td>Query</td>
<td>Returns the value of the measured temperature in °C (degrees centigrade). Use the “?dst” command to read back the set diode temperature value.</td>
</tr>
<tr>
<td>“E”</td>
<td>Query and Command</td>
<td>Sets or reads the Echo Off feature. This feature turns the serial communication terminal character echo ON or OFF and is useful if the laser is controlled by a computer script/program, rather than a person. 1=ON 0=OFF</td>
</tr>
<tr>
<td>“F”</td>
<td>Query</td>
<td>Checks for faults in the system and, if it finds one, returns the fault number. If there are multiple faults present in the system, it returns the first fault detected from a list of faults. See the “?FL” or “?FF” queries for different ways to receive fault status.</td>
</tr>
</tbody>
</table>
### Table 3-6. RS-232 Commands and Queries (Sheet 2 of 4)

<table>
<thead>
<tr>
<th>“FF”</th>
<th>Type: Query</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A reply of “8192” means that the laser is running fault-free and stable—it does not indicate a fault.</td>
</tr>
</tbody>
</table>

Checks for faults in the system and, if it finds one, returns a two-byte result using the following format:

- **MSB:**
  - 15: Not Implemented
  - 14: Not Implemented
  - 13: Laser Ready
  - 12: EEPROM2 fault
  - 11: EEPROM1 fault
  - 10: OEM Controller LP EEPROM fault
  - 9: Head EEPROM fault
  - 8: System Warming/Waiting for TEC servo to reach target temperature.
  - 7: Diode Temperature Fault (only Light servo turned OFF)
  - 6: BasePlate Temperature Fault (only Light servo turned OFF)
  - 5: Analog Interface Fault
  - 4: Diode Current Fault
  - 3: OEM Controller LP Temp. Fault (both TEC and Light servo’s turned OFF)
  - 2: BasePlate Temperature Fault (both TEC and Light servo’s turned OFF)
  - 1: Diode Temperature Fault (both TEC and Light servo’s turned OFF)

- **LSB:**
  - 0: External Interlock Fault

<table>
<thead>
<tr>
<th>“FL”</th>
<th>Type: Query</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Checks for faults in the system and, if it finds one, returns a list of all faults present. If there are no faults in the system, it responds with “system ok.” This command shows faults in text rather than in numbers. See the “?F” or “?FF” queries for different ways to receive fault status.</td>
</tr>
<tr>
<td></td>
<td>Fault List:</td>
</tr>
<tr>
<td>0</td>
<td>System OK (No fault)</td>
</tr>
<tr>
<td>1</td>
<td>External Interlock Fault</td>
</tr>
<tr>
<td>2</td>
<td>Diode Temperature Fault</td>
</tr>
<tr>
<td>3</td>
<td>BasePlate Temperature Fault</td>
</tr>
<tr>
<td>4</td>
<td>OEM Controller LP Temperature Fault</td>
</tr>
<tr>
<td>5</td>
<td>Diode Current Fault (under current or over current)</td>
</tr>
<tr>
<td>6</td>
<td>Head EEPROM fault</td>
</tr>
<tr>
<td>7</td>
<td>OEM Controller LP EEPROM fault</td>
</tr>
<tr>
<td>8</td>
<td>EEPROM1 fault</td>
</tr>
<tr>
<td>9</td>
<td>EEPROM2 fault</td>
</tr>
<tr>
<td>10</td>
<td>ADC fault</td>
</tr>
<tr>
<td>11</td>
<td>Analog Interface fault</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>“H”</th>
<th>Type: Query</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Help - Returns a list of available queries.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>“HH”</th>
<th>Type: Query</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Returns the usage hours stored in the HEAD EEPROM, using the format “?hh.” Head Hours are updated every time there is at least minimum current flowing through the laser diode. See the “PSH” query to check the Power Supply usage hours.</td>
</tr>
</tbody>
</table>
### Table 3-6. RS-232 Commands and Queries (Sheet 3 of 4)

<table>
<thead>
<tr>
<th>Command</th>
<th>Type: Query / Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>“HID”</td>
<td>Query</td>
<td>Reads the Head ID. Value is numerical (floating point value). Only the integer part of the value is significant. Discarding the position after the decimal point is recommended.</td>
</tr>
<tr>
<td>“K”</td>
<td>Query</td>
<td>Checks the status of Key Switch (if implemented) in the hardware.</td>
</tr>
<tr>
<td>“L”</td>
<td>Query and Command</td>
<td>Reads or sets the Light Servo status. Setting L=1 closes the Light Servo and enables the automatic servo regulation. Setting L=0 sets the Light Servo to an OPEN state and disables automatic servo regulation. L=0 also turns the Laser output OFF. Querying this command (?L) returns the Light Servo status.</td>
</tr>
<tr>
<td>“LT”</td>
<td>Query</td>
<td>Displays laser type and nominal power.</td>
</tr>
<tr>
<td>“MAXLP”</td>
<td>Query</td>
<td>Returns the maximum adjustable output power.</td>
</tr>
<tr>
<td>“MINLP”</td>
<td>Query</td>
<td>Returns the minimum adjustable output power.</td>
</tr>
<tr>
<td>“MCR”</td>
<td>Query</td>
<td>Returns whether the Laser Head reached the diode current limit (reply “1”), or if there is sufficient headroom (reply “0”). Note that for repeatable tests, the laser has to previously be set to maximum power (refer to the “P” command, below).</td>
</tr>
<tr>
<td>“NOMP”</td>
<td>Query</td>
<td>Return the nominal output power.</td>
</tr>
<tr>
<td>“P”</td>
<td>Query and Command</td>
<td>Sets or reads the Laser Power. To get a laser output using this command, Light Servo MUST be enabled (L=1). A query returns the actually measured Sapphire output level in a numerical and floating-point value. For queries and commands, the unit is mW.</td>
</tr>
<tr>
<td>“PI”</td>
<td>Query</td>
<td>Reads the Power-In value from the Analog Interface connector and returns the value in an A-to-D count (12 bit value).</td>
</tr>
<tr>
<td>“PSH”</td>
<td>Query</td>
<td>Returns the usage hours stored in the OEM Controller LP EEPROM, in the format “?psh.” This value—which represents the on-time of the Sapphire unit—updates every time the Sapphire unit is turned on. See “HH” query to check the Head usage hours.</td>
</tr>
<tr>
<td>“PST”</td>
<td>Query</td>
<td>Returns the controller temperature.</td>
</tr>
<tr>
<td>“SP”</td>
<td>Query</td>
<td>Reads the set power (i.e., setpoint of the output power). The set power can be changed by using the “P” command.</td>
</tr>
</tbody>
</table>
Table 3-6. RS-232 Commands and Queries (Sheet 4 of 4)

<table>
<thead>
<tr>
<th>Command</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>“STA”</td>
<td>Query</td>
<td>Reads status of laser head: 1 = Start up, 2 = Warmup, 3 = Standby, 4 = Laser on, 5 = Laser ready, 6 = Error</td>
</tr>
<tr>
<td>“SVPS” OR “SV”</td>
<td>Query</td>
<td>Reads the software version stored in the Power-Supply EEPROM. The read value is numerical, and expressed in floating point.</td>
</tr>
<tr>
<td>“T”</td>
<td>Query and Command</td>
<td>Reads or sets the TEC Servo status. Setting T=1 closes the TEC Servo and enables the automatic servo regulation. Setting T=0 sets the TEC Servo to an OPEN state and disables automatic servo regulation. T=0 also turns the Laser output OFF. Querying this command (?T) returns the TEC Servo status.</td>
</tr>
<tr>
<td>“WAVE”</td>
<td>Query</td>
<td>Returns the nominal laser wavelength.</td>
</tr>
</tbody>
</table>

**Hours of Operation Display**

This display is only available with the Sapphire OEM Controller LP—it is not available on the Sapphire OEM Controller LP USB.

In addition to the RS-232 interface readout of the Head and OEM Controller LP hours (see Table 3-6 on page 3-23 for a list of commands), the Sapphire OEM Controller LP also displays the Head hours. Five green LEDs show—in binary code—the hours of laser head operation:

D1..D5= 1000,2000,4000,8000,16000 hours.

For example, if D1 and D3 are ON, the Head hours are 5000 to 5999 hours (maximum). The display allows readouts—in 1000-hour increments—up to 31000 hours. The LEDs are located on the upper PCB board of the Sapphire OEM Controller LP (see Figure 2-7 on page 2-10) and are marked with “D1”..“D5.”
SECTION FOUR: TROUBLESHOOTING

Use the following checklists if you are experiencing problems with the Sapphire laser system. Should the problem persist, or if you need further assistance, contact either Coherent Technical Support in the US (1-800-367-7890), or a worldwide local Coherent service representative (connect to www.Coherent.com for worldwide contact information).

LED Indicators on the OEM Controller LP

(refer to Figure 4-1, below, or Figure 4-2 on page 4-2) There are two LEDs (DS1 and DS2) next to the RS-232 connector on the OEM Controller LP (on the Sapphire OEM Controller LP USB there is a CPU LED and an Interlock LED, which are located close to the DC power connector). The left LED (DS1) (the Interlock LED on the USB version) indicates a closed interlock loop if SW3-2 is set to the OFF position (refer to Figure 4-1, below). When SW3-2 is set to ON, DS1 (the Interlock LED on the USB version) is shorted.

The LED on the right side (DS2) (the CPU LED on the USB version) indicates the working microprocessor:

- Slow blinking (1 sec.) normal operation
- Fast blinking fault situation
- Constant ON or OFF microprocessor on hold

Figure 4-1. LED Indicators on the OEM Controller LP
Troubleshooting Procedures

The following table presents a list of possible problems, along with a reference to the associated troubleshooting checklist located in this section.

Table 4-1. Faults and Error Messages

<table>
<thead>
<tr>
<th>PROBLEM</th>
<th>TROUBLESHOOTING REFERENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interlock chain not closed</td>
<td>Checklist 1 (page 4-3)</td>
</tr>
<tr>
<td>System does not turn on</td>
<td>Checklist 2 (page 4-4)</td>
</tr>
<tr>
<td>System shuts down (RS-232 control)</td>
<td>Checklist 3a (page 4-5)</td>
</tr>
<tr>
<td>System shuts down (Analog interface and Autostart)</td>
<td>Checklist 3b (page 4-5)</td>
</tr>
<tr>
<td>Low power (RS-232 control)</td>
<td>Checklist 4a (page 4-6)</td>
</tr>
<tr>
<td>Low power (Analog control)</td>
<td>Checklist 4b (page 4-7)</td>
</tr>
<tr>
<td>Low power (Autostart mode)</td>
<td>Checklist 4c (page 4-7)</td>
</tr>
<tr>
<td>Scatter light around the main beam (all operating modes)</td>
<td>Checklist 5 (page 4-8)</td>
</tr>
<tr>
<td>Output power not stable (all operating mode)</td>
<td>Checklist 6 (page 4-8)</td>
</tr>
<tr>
<td>Beam noise out of spec (all operating modes)</td>
<td>Checklist 7 (page 4-8)</td>
</tr>
<tr>
<td>OEM controller LP or LP USB does not communicate with RS-232</td>
<td>Checklist 8 (page 4-9)</td>
</tr>
<tr>
<td>OEM Controller LP USB does not communicate with USB</td>
<td>Checklist 9 (page 4-10)</td>
</tr>
<tr>
<td>Beam is not round or transverse mode is not TEM_00</td>
<td>Checklist 10 (page 4-10)</td>
</tr>
<tr>
<td>Baseplate temperature exceeds permissible temperature, causing the system to shut down</td>
<td>Checklist 11 (page 4-10)</td>
</tr>
</tbody>
</table>

If the laser system or components are being returned directly to Coherent, an RMA (Return Material Authorization) number is required. Contact Coherent or an authorized representative.
The DS1 Indicator light (OEM Controller LP, lower PCB, near the D9, RS-232 connector)—respectively, the Interlock LED on the OEM Controller LP USB—illuminates if the interlock chain is closed. Follow this checklist if DS1—respectively, the Interlock LED—is not illuminated.

For a better understanding of this checklist, refer to Figure 3-11 on page 3-15.

This checklist assumes DS1—respectively, the Interlock LED—is operational. If the system activates by turning SW3-3, switches 1, 2, and 3 to the ON position without DS1—respectively, the Interlock LED—illuminating, then DS1—respectively, the Interlock LED—is shorted.

|   | Turn off DC power supply. |
|   | Set SW3-1, SW3-2, SW3-3 to the OFF position. |
|   | Turn on DC power after a 10-second delay. |
|   | Verify the supply voltage is between 10.8 and 15 VDC. |
|   | Place SW3-1, switch 1 to the ON position. If DS1—respectively, the Interlock LED on the OEM Controller LP USB—turns on, check the interlock or switch at J1-1 to J1-3, then place SW3-1 back to the OFF position. |
|   | Verify there is an interlock jumper or a working LED between pins 5 and 6 of J3. Make sure the cathode of the LED is connected to J3-6. |
|   | Place SW3-3, switch 3 to the ON position. If DS1—respectively, the Interlock LED on the OEM Controller LP USB—turns on, check the 2 position switch (customer provided), then place SW3-3 back to the OFF position. |
|   | If DS1—respectively, the Interlock LED on the OEM Controller LP USB—still does not turn on or the system does not turn on after the start delay, return the OEM Controller LP for repairs. |
Checklist 2: System Does Not Turn On

The system should last about 40 seconds after turn on.

[ ] Cycle DC power OFF/ON with a 10-second delay.

[ ] Verify the supply voltage is between 10.8 and 15 VDC and the power supply is rated at ≥ 60W.

[ ] Observe the DS1 indicator light (OEM Controller LP, Hour PCD, next to RS-232 (D3) connector)—respectively, the Interlock LED on the OEM Controller LP USB. DS1—respectively, the Interlock LED—is illuminated if the interlock chain is closed. Refer to “Checklist 1: Interlock Chain Not Closed” on page 4-3 if DS1—respectively, the Interlock LED—does not turn on.

[ ] Verify the DS2 indicator light (next to DS1—respectively, the Interlock LED on the OEM Controller LP USB) is blinking at 1 Hz (1 blink per second).

[ ] Cycle the DC power supply OFF/ON with a 10-second delay if DS2—respectively, the CPU LED on the OEM Controller LP USB—does not blink at 1 Hz. Replace the OEM Controller LP if DS2—respectively, the CPU LED—is still not blinking at 1 Hz.

[ ] Verify the control signals at J1 (if the Analog interface is used) or J2 (if RS-232 is used) are in accordance with Table 3-3 on page 3-16 or Table 3-5 on page 3-20. If not sure, turn off the DC power and position the SW 3 switches to autostart operation. Then re-connect the DC power supply to the system. If the system operates in autostart, check the control signals (Analog or RS-232 control).

[ ] If the control signals are good, replace the OEM Controller LP.

[ ] If DS1—respectively, the Interlock LED on the OEM Controller LP USB—is ON and DS2—respectively, the CPU LED on the OEM Controller LP USB—blinks at 1 Hz but the system does not turn on, replace the entire system.
### Checklist 3a: System Shuts Down (RS-232 Control)

- Check for proper heat sinking of the laser head.
- Check the temperature of the baseplate and heat sink.
- Check for proper grounding of the laser head (the laser head cover should be at earth ground).
- Issue the “?FL” command
- If fault #1, correct the external interlock connection
- Replace the laser head if any of the following faults are ON: 2, 5, or 6 (assuming the ambient temperature is < 40°C).
- All other faults—excluding faults 3 and 1—replace the entire system.
- If fault #3, measure the baseplate temperature right before shut down and, if the temperature is above the maximum-allowed baseplate temperature, check for proper heat sinking.

### Checklist 3b: System Shuts Down (Analog Interface and Autostart)

- Check for proper grounding of the laser head (the head cover should be at earth ground potential).
- Measure the baseplate temperature at the time the system shuts down. If the baseplate temperature exceeds the permissible temperature, check for proper heat sinking of the laser head (refer to “Checklist 10: Beam is Not Round or Transverse Mode is Not TEMo0” on page 4-10).
- Replace the entire system.
Checklist 4a: Low Power (RS-232 Control)

Measure power (using a calibrated power meter) before the beam hits any external optics, and also use the “?P” command to obtain output power measurement from the system.

If the system does not achieve the specified maximum power level, make sure that the power level is set to the maximum level via the RS-232 command. The system will always power-up to the previously-set power level.

[ ] Make sure the output window is clean. Refer to “Cleaning the Output Window” on page 4-11 for the proper cleaning procedure.

[ ] Verify the proper RS-232 command is issued. For example, P=10 should result in 10 mW (?P=10 mW).

[ ] If the system does not respond to the “?P” command, verify the proper RS-232 is set up and then replace the computer. Note that some portable PCs or USB-to-RS-232 converters may have weak RS-232 driver circuits which may, in turn, lead to a less robust RS-232 communication. If the problem persists, replace the OEM Controller LP.

[ ] For testing purpose, set the laser power to its maximum value by sending “P=XXX”, whereas “XXX” represents the maximum power. Then query “?MCR”. If the response is “0”, the actual power should reach the set value—this can be checked by “?P”, which returns the actual power. If the response to “?MCR” is “1” and the “?P” response indicates low power, then the pump diode has insufficient current head room and the laser head needs to be replaced. After the test, remember to set the laser power back to its former value.
Troubleshooting

Checklist 4b: Low Power (Analog Control)

Make sure power is measured by a calibrated power meter before it hits any external optics, or use the Analog Interface connector (J1, Pin 8+, 10-) to obtain an output power measurement. Refer to “Sapphire OEM Controller LP: Controlling the Laser via Analog Signals” on page 3-15 or “Sapphire OEM Controller LP USB: Controlling the Laser via Analog Signals” on page 3-17 for the correct power vs. voltage slope.

If the system does not achieve the specified maximum power level, use the RS-232 command to verify the power level is set to the maximum level. The system will always power-up to the previously-set power level.

- Verify the output window is clean. Refer to “Cleaning the Output Window” on page 4-11 for the proper cleaning procedure.

- Apply voltage at J1, Pin 7+, 10-, to 2.048V (2.048 mV corresponds to 110% of the nominal output power).

- If measured power is low, the most likely cause is a defective laser head, although the OEM Controller LP cannot be completely ruled out. First replace the laser head. If power is still low, replace the OEM Controller LP.

Checklist 4c: Low Power (Autostart Mode)

Make sure power is measured by a calibrated power meter before it hits any external optics, or use either pins 8+ and 10-, or J1 (the Analog Interface connector) to obtain the output power measurement.

If the system does not achieve the specified maximum power level, use the RS-232 command to verify the power level is set to the maximum level. The system will always power-up to the previously-set power level.

- Verify the output window is clean. Refer to “Cleaning the Output Window” on page 4-11 for the proper cleaning procedure.

- If measured power is less than maximum, the most likely cause is a defective laser head, although the OEM Controller LP cannot be ruled out. Replace the laser head first.

- When using Autostart mode, power is adjusted to the last setting. Systems shipped from Coherent are adjusted to nominal power. If the RS-232 or Analog interface has been used prior to autostart, reconfigure the system to operate in RS-232 or Analog mode, adjust the output power to maximum, and then reconfigure the system to operate in Autostart.
<table>
<thead>
<tr>
<th>Checklist 5: Scattered Light Around the Main Beam (All Operating Modes)</th>
<th>[ ] The beam is observed prior to hitting any external optics.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[ ] Verify the output window is clean. Refer to “Cleaning the Output Window” on page 4-11 for the proper cleaning procedure.</td>
</tr>
<tr>
<td></td>
<td>[ ] Replace the laser head.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Checklist 6: Output Power Not Stable (All Operating Modes)</th>
<th>[ ] Make sure power is measured before it hits any external optics.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[ ] Allow the system to warm up for at least five minutes.</td>
</tr>
<tr>
<td></td>
<td>[ ] Verify the output window is clean. Refer to “Cleaning the Output Window” on page 4-11 for the proper cleaning procedure.</td>
</tr>
<tr>
<td></td>
<td>[ ] Verify all cable connections are secure.</td>
</tr>
<tr>
<td></td>
<td>[ ] If the Analog Interface is used, measure the output power control signal (J1, Pin 7+, 10-) to make sure it is stable.</td>
</tr>
<tr>
<td></td>
<td>[ ] If power still fluctuates, the most likely cause is a defective laser head, although the OEM Controller LP can not be completely ruled out.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Checklist 7: Beam Noise Out of Spec (All Operating Modes)</th>
<th>[ ] Make sure beam noise is measured before the beam hits any external optics.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[ ] Verify the output window is clean. Refer to “Cleaning the Output Window” on page 4-11 for the proper cleaning procedure.</td>
</tr>
<tr>
<td></td>
<td>[ ] Check for proper heat sinking.</td>
</tr>
<tr>
<td></td>
<td>[ ] Verify there are no vibrations at the laser head.</td>
</tr>
<tr>
<td></td>
<td>[ ] Check proper shielding and the electrical connection of the shielding with both sub-D connectors. Use a genuine Coherent head cable.</td>
</tr>
<tr>
<td></td>
<td>[ ] Check for proper grounding of the head cover.</td>
</tr>
<tr>
<td></td>
<td>[ ] Replace the laser head.</td>
</tr>
</tbody>
</table>
Checklist 8: OEM Controller LP or LP USB Does Not Communicate With RS-232

[ ] Verify all connections are secure.

[ ] If a mini-USB cable is connected to the Sapphire OEM controller LP USB, disconnect the mini-USB connector and then turn the DC power of the Sapphire Controller off and—after a 10 second delay—on again. A connected USB cable activates the USB interface and will overrule the RS-232 interface. Note: An activated USB interface is indicated by a glowing “USB-LED,” located next to the mini-USB connector on the controller pcb.

[ ] When using a USB-to-COM converter, verify that the driver for the COM port converter is properly installed. The PC operating system should correctly list the COM port in the devices list.

[ ] Verify all RS-232 or USB settings (baud rate, etc.) For a complete list of settings, refer to “Controlling the Laser via RS-232 or USB Command Interface” on page 3-19.

[ ] Make sure a straight (1-to-1) cable is used to connect the computer to the OEM Controller LP or LP USB. Cable length should not exceed 5 m. The cable should be properly shielded.

[ ] Use a second computer to exclude a defective RS-232 or USB port on the first computer.

[ ] Replace the OEM Controller LP or LP USB.
Checklist 9:
OEM Controller LP USB Does Not Communicate With USB

[ ] Verify all connections are secure. An activated and properly connected USB interface is indicated by a glowing “USB-LED,” located next to the mini-USB connector on the controller pcb.

[ ] Verify that the driver for the Virtual COM port is properly installed. The PC operating system should correctly list the Virtual COM port in the devices list.

[ ] Verify all RS-232 settings (baud rate, etc.). For a complete list of settings, refer to “Controlling the Laser via the USB Command Interface” on page 3-21.

[ ] Make sure that a regular mini-USB cable is used to connect the computer to the OEM Controller LP USB. Cable length should not exceed 5 m. The cable should be properly shielded.

[ ] Use a second computer to exclude a defective USB port on the first computer.

[ ] Replace the OEM Controller LP USB.

Checklist 10:
Beam is Not Round or Transverse Mode is Not TEM\text{00}

[ ] Make sure the beam is observed before it hits any external optics.

[ ] Verify the output window is clean. Refer to “Cleaning the Output Window” on page 4-11 for the proper cleaning procedure.

[ ] Replace the laser head.

Checklist 11:
Baseplate Exceeds Permissible Temperature, Causing the System to Shut Down

[ ] Verify the proper size of the heat sink (refer to “Heat Sink Requirement” on page 3-1).

[ ] Verify the proper operation of the heat sink (that is, if a fan is used to cool the heat sink, make sure it is operating properly).

[ ] Verify the heat sink compound is applied evenly between the laser head and the heat sink. Ensure that any thermal conductive compound used is only thinly applied. No compound can properly compensate for an uneven surface.

[ ] Verify the surface of the heat sink contacting the laser head is not bent.

[ ] Verify the ambient temperature does not exceed 40°C.
Cleaning the Output Window

Should any of the following symptoms appear, cleaning the output window (see Figure 4-3, below, for window location) may restore optimal performance:

- The output beam shows speckles or there is scattered light around the beam center
- The beam is not round or transverse mode is not TEM00
- There is low output power
- The output power is not stable
- The output beam is noisy

The laser head is a sensitive device—handle the output window with care.

Figure 4-3. Output Window
Cleaning Supplies

Cleaning the output window requires:

- Cotton swabs—which are approved for cleaning optical elements (that is, dust- and lint-free)
- Propanol—must be chemically pure

Follow all safety instructions when using propanol (Figure 4-4). If you do not have a copy of the safety instructions for using propanol, contact your vendor before following the cleaning procedure explained below.

Figure 4-4. Propanol
Cleaning Procedure

To avoid electrical shock, make sure the laser is powered OFF before cleaning the output window.

Do not open the cover. Opening the cover will void the warranty. There are no user-serviceable parts inside.

1. Dip the cotton swab into the propanol—using just enough propanol to moisten the cotton swab, but not enough to make it drip.

2. Gently move the cotton swab several times across the surface of the output window (Figure 4-5, below), starting from the center of the window and working towards the outside.

To avoid propanol dripping into the output hole, use very low pressure on the cotton swab when cleaning the output window.

Figure 4-5. Cleaning the Output Window
3. After completing the cleaning procedure, let the propanol dry.

4. Inspect the output window for cleanliness. If stains, dirt, or dust remain, repeat the cleaning procedure until the window is clean.

Be sure that the propanol is dried before turning on the laser.

5. Turn on the laser and examine the output beam for the symptoms listed under “Cleaning the Output Window” on page 4-11. If any symptoms still appear, repeat the cleaning procedure.
SECTION FIVE: REPACKING PROCEDURE

This section presents the factory-recommended repacking procedure for the Sapphire laser system. This procedure should be followed when shipping the laser system to another location after initial installation, or when returning the system to the factory for service.

Coherent recommends saving the shipping box and packing materials for possible later use.

The Sapphire laser system requires one shipping box for the laser system components and a second box for the optional accessories, available as a set (part number 1037015). Table 5-1, below, lists a complete inventory of the items shipped with the Sapphire laser system.

Table 5-1. Sapphire Shipping Crate Contents

<table>
<thead>
<tr>
<th>Box 1:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laser Head</td>
</tr>
<tr>
<td>OEM Controller LP</td>
</tr>
<tr>
<td>Laser Head Cable</td>
</tr>
<tr>
<td>Connector Kit</td>
</tr>
<tr>
<td>Operator’s Manual</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Box 2:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optional DC Supply</td>
</tr>
<tr>
<td>Optional Heat Sink</td>
</tr>
</tbody>
</table>
Seat the protective plastic cap into the laser emission aperture before shipping.

Figure 5-1. Protective Laser Emission Cap

Place all the components into the original protective plastic bags before shipping.

Figure 5-2. Packed Laser Components
For maximum protection, place the laser head and the OEM Controller LP between foils in Box 1.

Figure 5-3. Place Laser Head Between Foils

Figure 5-4, below, shows the proper arrangement of the laser head and the OEM Controller LP in Box 1.

Figure 5-4. Proper Arrangement of Box 1 Before Shipping
For maximum protection, place the power supply and the heat sink between foils in Box 2.

Figure 5-5. Place Power Supply Between Foils

Figure 5-6, below, shows the proper arrangement of the power supply and the heat sink in Box 2.

Figure 5-6. Proper Arrangement of Box 2 Before Shipping
APPENDIX A: WARRANTY

Coherent, Inc. warrants Sapphire™ laser systems to the original purchaser (the Buyer) only, that the laser system, that is the subject of this sale, (a) conforms to Coherent's published specifications and (b) is free from defects in materials and workmanship.

Laser systems are warranted to conform to Coherent's published specifications and to be free from defects in materials and workmanship for a period of twelve (12+1) months. Replacement units shipped within warranty, carry the remainder warranty of the failed unit.

Responsibilities of the Buyer

The buyer is responsible for providing the appropriate utilities and an operating environment as outlined in the product literature. Damage to the laser system caused by failure of buyer's utilities or failure to maintain an appropriate operating environment, is solely the responsibility of the buyer and is specifically excluded from any warranty, warranty extension, or service agreement.

The Buyer is responsible for prompt notification to Coherent of any claims made under warranty. In no event will Coherent be responsible for warranty claims made later than seven (7) days after the expiration of warranty.

Limitations of Warranty

The foregoing warranty shall not apply to defects resulting from:

- Components and accessories manufactured by companies, other than Coherent, which have separate warranties
- Improper or inadequate maintenance by the buyer
- Buyer-supplied interfacing
- Operation outside the environmental specifications of the product
- Unauthorized modification or misuse
- Improper site preparation and maintenance
- Manipulating or opening the housing
Coherent assumes no responsibility for customer-supplied material. The obligations of Coherent are limited to repairing or replacing, without charge, equipment which proves to be defective during the warranty period. Replacement sub-assemblies may contain reconditioned parts. Repaired or replaced parts are warranted for the duration of the original warranty period only. The warranty on parts purchased after expiration of system warranty is ninety (90) days. Our warranty does not cover damage due to misuse, negligence or accidents, or damage due to installations, repairs or adjustments not specifically authorized by Coherent.

Warranty applies only to the original purchaser at the initial installation point in the country of purchase, unless otherwise specified in the sales contract. Warranty is transferable to another location or to another customer only by special agreement which will include additional inspection or installation at the new site. Coherent disclaims any responsibility to provide product warranty, technical or service support to a customer that acquires products from someone other than Coherent or an authorized representative.

THIS WARRANTY IS EXCLUSIVE IN LIEU OF ALL OTHER WARRANTIES, WHETHER WRITTEN, ORAL OR IMPLIED, AND DOES NOT COVER INCIDENTAL OR CONSEQUENTIAL LOSS. COHERENT SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.
Power Meter Accessories

Coherent offers a variety of instruments for laser test and measurement. For additional detailed information, including product selection guides, visit our website at www.Coherent.com.

For the most common diagnostic need—measuring the output power of the Sapphire—we recommend two different types of power meters that are ideal fits to the Sapphire product family. These meters are discussed, next.

First Recommendation

We highly recommend the FieldMaxII-TO™—a full-featured power meter that supports interchangeable power sensors and offers capabilities like onboard statistical analysis and computer interfacing via USB. This meter comes with installable applications software and LabVIEW drivers.

There are two primary sensor options for this meter:

- The PS10 provides high-resolution measurements—100 μW to 1W—and is best utilized for applications such as stability monitoring.
- The fast response time of the PM2—2 mW to 2W—makes this sensor perfectly suited for applications such as laser tuning.

FieldMaxII-TO Laser Power Meter (RoHS)
PS10 High-Sensitive Thermopile Sensor (RoHS)
PM2 Air-Cooled Thermopile Sensor (RoHS)

Note: Contact Coherent for part numbers.
Alternative Recommendation

LaserCheck™ — a hand-held, inexpensive laser power meter that is self-contained for easy storage — is specifically designed to provide power measurements. Its compact size enables measurements in optical set-ups where a standard detector head does not fit. With its built-in attenuator, this device is ready to measure output powers from 0.5 µW to 1W.

LaserCheck™ Power Meter (RoHS)

Note: Contact Coherent for part numbers.
### Glossary

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>°C</td>
<td>Degrees centigrade or Celsius</td>
</tr>
<tr>
<td>°F</td>
<td>Degrees Fahrenheit</td>
</tr>
<tr>
<td>µ</td>
<td>Micron(s)</td>
</tr>
<tr>
<td>µm</td>
<td>Micrometer(s) = 10⁻⁶ meters</td>
</tr>
<tr>
<td>µrad</td>
<td>Microradian(s) = 10⁻⁶ radians</td>
</tr>
<tr>
<td>µsec</td>
<td>Microsecond(s) = 10⁻⁶ seconds</td>
</tr>
<tr>
<td>1/e²</td>
<td>Beam diameter parameter = 0.13534</td>
</tr>
<tr>
<td>AC</td>
<td>Alternating current</td>
</tr>
<tr>
<td>ADC</td>
<td>Analog-to-digital converter</td>
</tr>
<tr>
<td>Amp</td>
<td>Ampere(s)</td>
</tr>
<tr>
<td>CDRH</td>
<td>Center for Devices and Radiological Health</td>
</tr>
<tr>
<td>cm</td>
<td>Centimeter(s)</td>
</tr>
<tr>
<td>CPU</td>
<td>Central processing unit</td>
</tr>
<tr>
<td>DC</td>
<td>Direct current</td>
</tr>
<tr>
<td>EEPROM</td>
<td>Electrically erasable programmable read only memory</td>
</tr>
<tr>
<td>EMI</td>
<td>Electro Magnetic Interface</td>
</tr>
<tr>
<td>g</td>
<td>Gram(s) or earth’s gravitational force (gravity)</td>
</tr>
<tr>
<td>GND</td>
<td>Ground</td>
</tr>
<tr>
<td>Hz</td>
<td>Hertz or cycles per second (frequency) (= 1/pulse period)</td>
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<td>IR</td>
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<td>kg</td>
<td>Kilogram(s) = 10³ grams</td>
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<td>KHz</td>
<td>Kilo hertz = 10³ hertz</td>
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<td>LD</td>
<td>Laser diode</td>
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<td>Light emitting diode</td>
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<td>m</td>
<td>Meter(s) (length)</td>
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<td>mA</td>
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<td>mm</td>
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<tr>
<td>mrad</td>
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<td>ms</td>
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<td>mV</td>
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<td>mW</td>
<td>Milliwatt(s) = 10⁻³ Watts (power)</td>
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<td>nm</td>
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<td>Original equipment manufacturer</td>
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<td>Optically pumped semiconductor</td>
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<td>Definition</td>
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<td>OPSL</td>
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<td>rms</td>
<td>Root mean square (effective value of a sinusoidal wave)</td>
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<td>Receive data</td>
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<td>TEC</td>
<td>Thermo-electric cooler</td>
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<td>Transverse electromagnetic mode (cross-sectional laser beam mode)</td>
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<td>TTL</td>
<td>Transistor-to-transistor logic</td>
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<td>TXD</td>
<td>Transmit data</td>
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<td>V</td>
<td>Volt(s)</td>
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<td>VAC</td>
<td>Volts, alternating current</td>
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<td>VECSEL</td>
<td>Vertical External Cavity Surface Emitting Laser</td>
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