Operator's Manual
Sapphire™ 488 HP OEM Laser
Optically Pumped Semiconductor Laser

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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.

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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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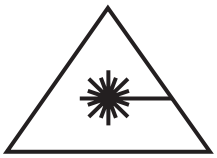
Preface

This manual contains user information for the Sapphire™ 488 HP OEM laser. The Sapphire laser is a modular component, sold for use in OEM equipment and is not to be used as a stand-alone laser. The OEM is responsible for compliance with all applicable safety regulations.

Read this manual carefully before operating the laser for the first time. Special attention should be given to the material in Section One, Laser Safety, 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.

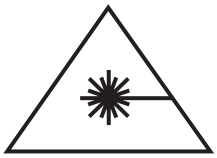
Export and re-export of lasers manufactured by Coherent are subject to U.S. Export Administration Regulations, which are administered by the Commerce Department. In addition, shipments of certain components are regulated by the State Department under the International Traffic in Arms Regulations.

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.

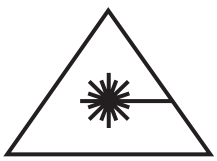
Patents

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

Préface

Ce manuel contient des informations sur le laser Sapphire HP. Le laser Sapphire 488 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

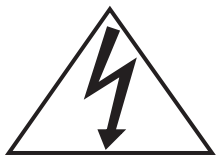
Coherent suit strictement les lois américaines en matière du contrôle des exportations

L'exportation et la revente de lasers 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.

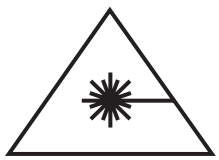
S'il y a un doute quant aux obligations imposées par la loi des Etats-Unis, une clarification doit être obtenue auprès de Coherent ou d'une agence gouvernementale appropriée.

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.

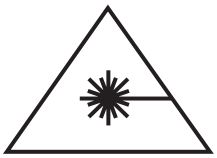
Patents

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 these precautions:

1. Observe all safety precautions in the operator's manual.
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, those 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 will remain 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 those present.
9. Advise all those 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. The FDA accession number is 90R2005-18.

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 (100 mW and 200 mW versions), or CLASS IV laser product (500 mW version). It emits VISIBLE AND INVISIBLE LASER RADIATION of 0.46 to 0.5 µm and 0.9 to 1 µm wavelength from the aperture in the front of the laser head. Collinear radiation of 0.79 to 0.82 µm may also be present.

Laser Radiation Emission Indicator

A yellow indicator light is provided on the front of the laser head. This light is illuminated when the laser pump diode is energized. This light meets the IEC-825 requirement that warning laser lights must be fail-safe or redundant.

Beam Shutter

A mechanical beam shutter is located at the beam exit location—see Figure 1-2 (p. 1-4).

Interlock

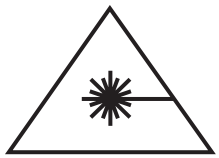
A normally closed remote interlock switch can be installed on the Sapphire OEM controller HP. For further details, refer to “Interlocks” (p. 3-14).

Dip Switch Settings

With the DIP switches located on the Sapphire OEM Controller HP, 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” (p. 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—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.

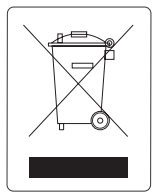


Figure 1-1. Waste Electrical and Electronic Equipment Label

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.

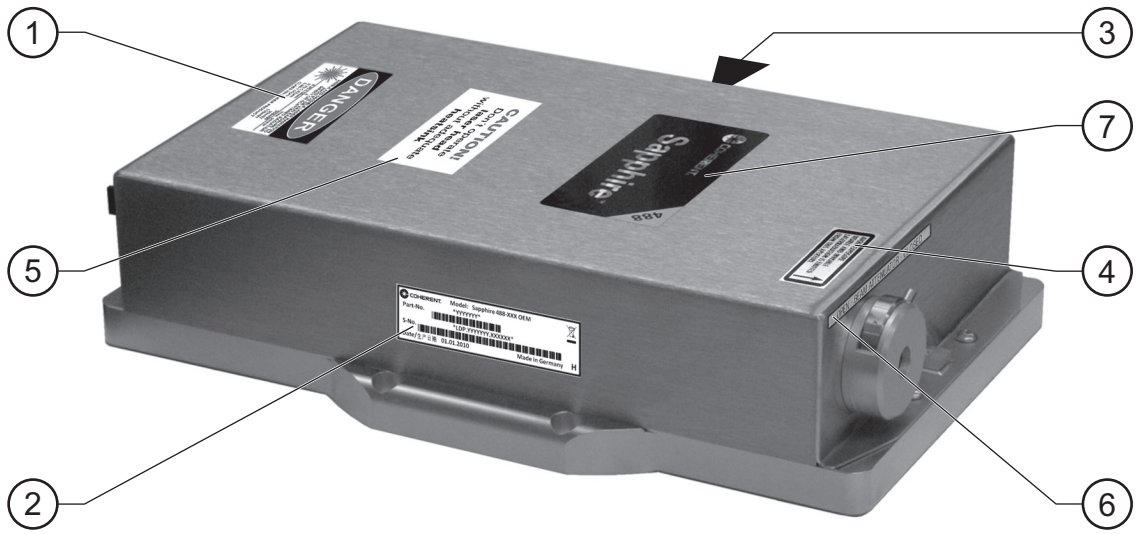
Table 1-1. China-RoHS Compliant Components

O = 小于 最高浓度值　　X = 大于 更多 最高浓度值

Description		铅 Pb	汞 Hg	镉 Cd	六价铬 Cr6+	多溴联苯 PBB	多溴二苯醚 PBDE
SAPPHIRE Laserhead	20	X	O	O	O	O	O
SAPPHIRE Powersupply		X	O	O	O	O	O
SAPPHIRE Heatsink		X	O	O	O	O	O
SAPPHIRE Controller		X	O	O	O	O	O
SAPPHIRE Headcable		X	O	O	O	O	O

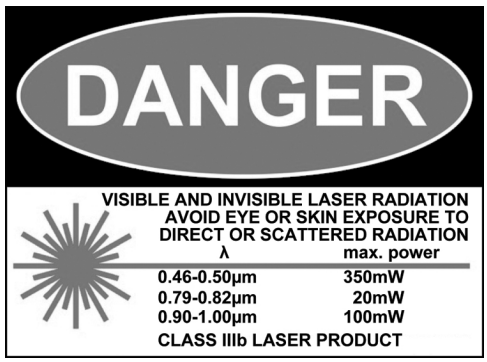
Location of Safety Labels

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

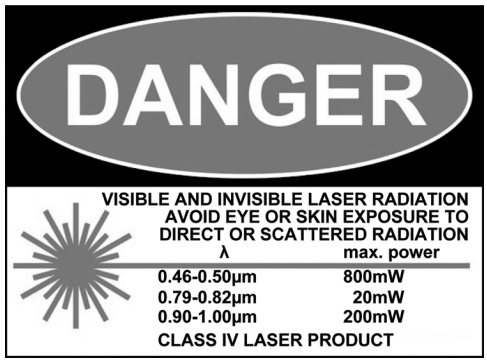


NOTE: KEY ON FOLLOWING PAGE

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



100 mW and 200 mW Versions



500 mW Version

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

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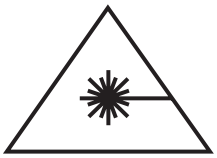
Figure 1-2. Safety Labels (Sheet 3 of 3)

FRENCH TRANSLATION/TRADUCTION FRANÇAISE
SECTION UN : SÉCURITÉ LASER

Sécurité Optique

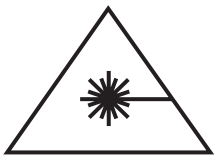
La lumière laser, du fait de ses propriétés particulières, ne présente pas les mêmes risques que les autres sources lumineuses traditionnelles. L'utilisation sécurisée de laser requiert que tous les utilisateurs de laser, et que chaque personne proche d un système laser, connaissent les dangers inhérents 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 vidéos, 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.
4. Ne jamais regarder directement le faisceau laser ou la lumière diffusée par une surface réfléchissante. Ne pas renvoyer la lumière laser dans la source laser.
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 protégent 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.
9. Conseiller tous les utilisateurs de laser de ces précautions. Il est préférable de se servir du laser dans une pièce ayant un accès contrôlé et limité.

Sécurité Electrique

Le laser Sapphire HP 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.

Classification d'émission de Laser

Le laser Sapphire HP est classé par le CDRH (United States National Center for Device and Radiological Health) comme un laser de classe IIIB (100mW et 200mW versions), respectivement classe IV (500mW version). Il émet une radiation laser dans le VISIBLE ET L'INVISIBLE à 0,46 - 0,5 µm et 0,9 - 1 µm 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

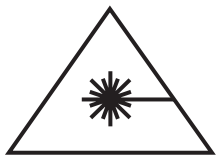
Un indicateur lumineux jaune est placé sur le devant du laser. Cet indicateur est éclairé quand la diode laser est alimentée.

Interlock / Auto Start

Dans la configuration par défaut, la boucle de sécurité (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 boucle de sécurité (interlock) ne rentre pas dans les recommandations de l IEC-825 pour laquelle les circuits boucle de sécurité (interlock) doivent être redondants, et pour laquelle le laser doit stopper si le circuit ne fonctionne pas (fail safe). Le circuit boucle de sécurité (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.

Paramétrage du Mini Commuta-teurs

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

Après une modification de paramétrage des mini commutateurs, l'utilisateur doit vérifier le bon functionnement du circuit de sécurité.

Waste Electrical and Electronic Equipment (WEEE, 2002)

La directive de rebut européenne de l'équipement électrique et électronique (WEEE) (2002/96/EC) est représentée par une étiquette croisée-dehors de récipient d'ordures. Le but de cette directive est réduire au minimum la disposition de WEEE en tant que déchets municipaux non triés et de faciliter sa collection séparée.

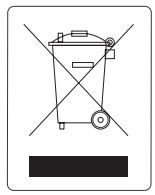


Figure 1-3. Pictogramme Concernant les Déchets d'Équipements Électriques et Électroniques

Conformité de RoHS

La directive de RoHS limite l'utilisation de certaines substances dangereuses dans l'équipement électrique et électronique. Tous les composants du système de laser de Sapphire HP sont RoHS conforme.

Emplacement des étiquettes de Sécurité

Se référer à la Figure 1-4 pour l'emplacement des étiquettes de sécurité.

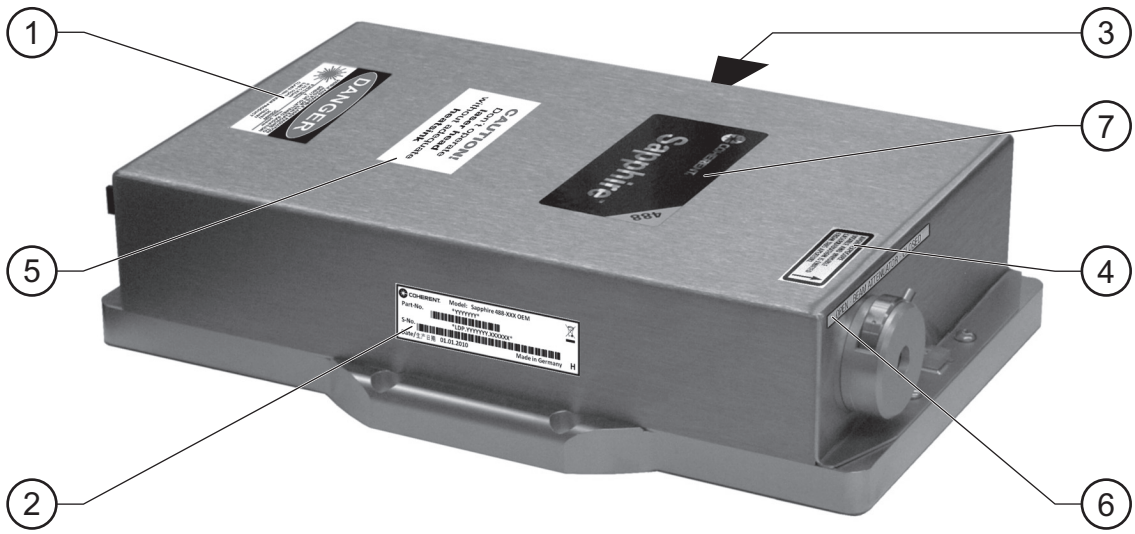


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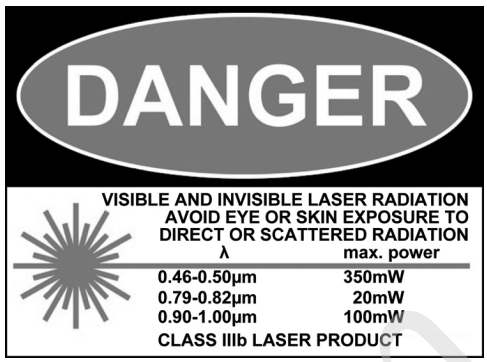
Figure 1-4. Etiquettes de Sécurité de la Tête Laser (Sheet 1 of 3)



Versions 100 mW et 200 mW

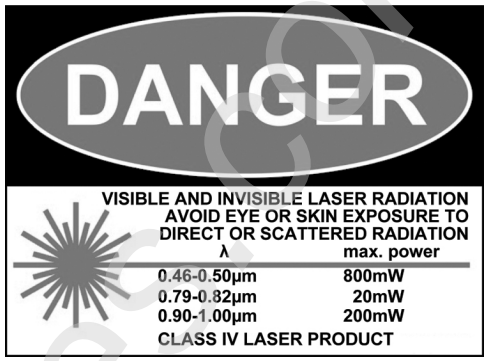


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Figure 1-4. Etiquettes de Sécurité de la Tête Laser (Sheet 2 of 3)

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Figure 1-4. Etiquettes de Sécurité de la Tête Laser (Sheet 3 of 3)

EG-Konformitätserklärung

Für das folgend bezeichnete Erzeugnis

EC Declaration of Conformity

For the following named product

Sapphire OEM Laser / Sapphire CDRH Laser
Optically Pumped Semiconductor Laser

bestehend aus Laserkopf und Netzteil, wird hiermit bestätigt, dass es den grundlegenden Anforderungen entspricht, die in der Richtlinie des Rates zur Angleichung der Rechtsvorschriften der Mitgliedsstaaten über die elektromagnetische Verträglichkeit (2004/108/EG), sowie der Niederspannungsrichtlinie (2006/95/EG) festgelegt sind.

consisting of laser head and power supply, 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 (2004/108/EG) and the low voltage directive (2006/95/EG).

Das o.g. Erzeugnis ist zur Erfüllung der Anforderungen gemäß EN 60825 ausgerüstet. Die tatsächliche Erfüllung der EN 60825 obliegt dem Integrator.

The above mentioned product is equipped to comply with EN 60825. The actual compliance to EN 60825 is the obligation of the integrator.

Diese Erklärung bezieht sich auf alle Exemplare, die dem Fertigungsstand ab dem folgenden Datum entsprechen:

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

01.01.2009

Zur Beurteilung des Erzeugnisses hinsichtlich elektromagnetischer Verträglichkeit wurden folgende Normen herangezogen

EN 61000-6-3 Emission (09.07)
EN 55022, Kl.B (05.08),
EN 61000-3-2 (10.06),
EN 61000-3-3 (06.09)
EN 61000-6-2 Suszeptibilität (03.06)
EN 61000-4-2 (12.09), -3 (06.08),
-4 (07.05),-5 (06.07),-6 (12.09), -11 (02.05)

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

EN 61000-6-3 Emission (09.07)
EN 55022, Kl.B (05.08),
EN 61000-3-2 (10.06),
EN 61000-3-3 (06.09)
EN 61000-6-2 Susceptibility (03.06)
EN 61000-4-2 (12.09), -3 (06.08),
-4 (07.05), -5 (06.07), -6 (12.09), -11 (02.05)

Zur Beurteilung des Erzeugnisses hinsichtlich der Niederspannungsrichtlinie wurden folgende Normen herangezogen :

EN 61010-1: 2001

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

EN 61010-1 : 2001

Diese Erklärung wird verantwortlich für den Hersteller

This declaration is given in account for the manufacturer

Coherent GmbH
Niederlassung Lübeck
Seelandstr. 9
23569 Lübeck

Coherent GmbH
Niederlassung / Branch Luebeck
Seelandstraße 9
23569 Lübeck, Germany

abgegeben durch
Dr. Reinhard Luger, Geschäftsführer

issued by
Dr. Reinhard Luger, General Manager

Lübeck, 10.12.2009

Figure 1-5. EC Declaration of Conformity

SECTION TWO: DESCRIPTION AND SPECIFICATIONS

System Description

The Sapphire 488 HP 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 488 nm.

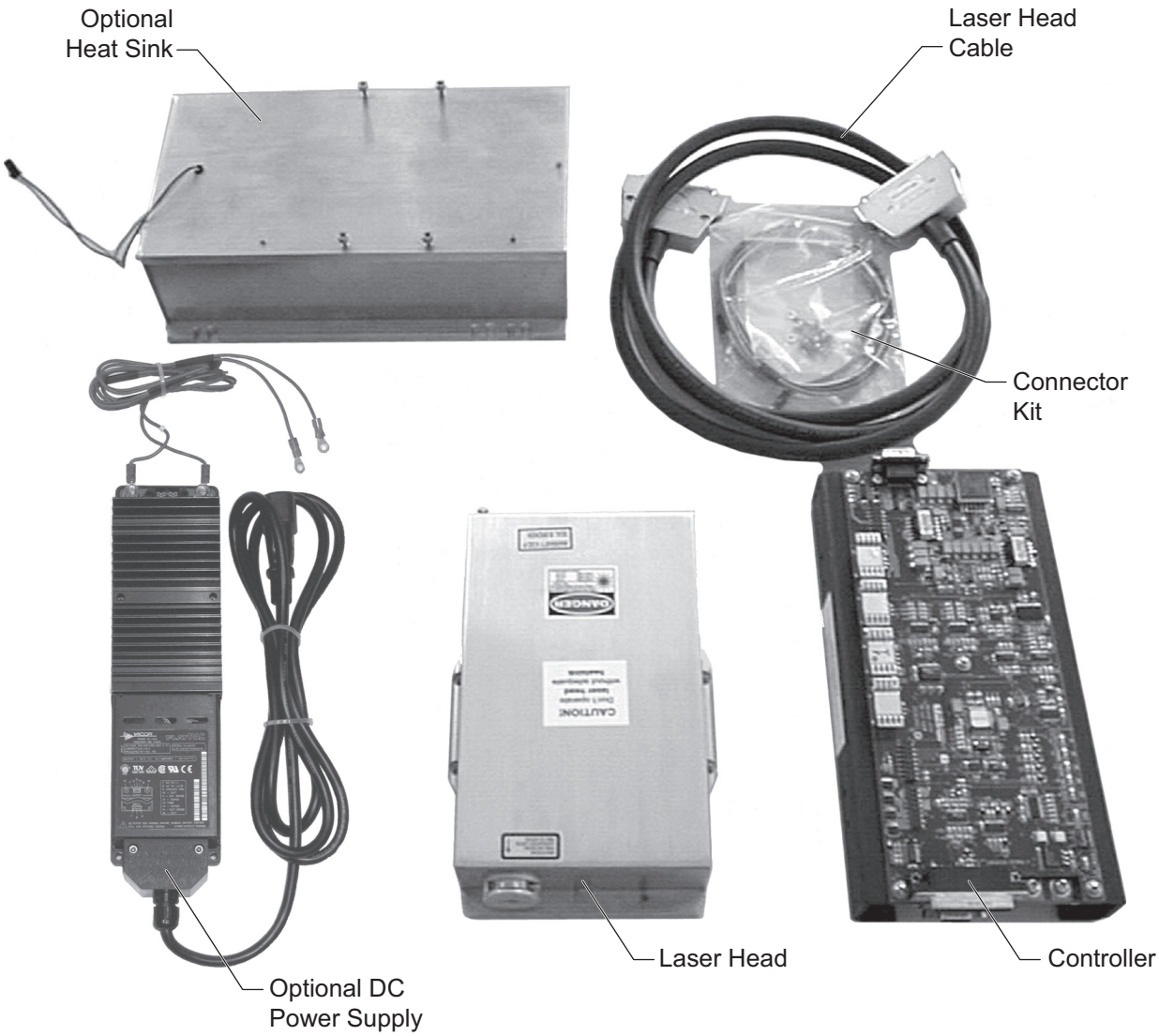


Figure 2-1. Sapphire Laser System

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

The Sapphire 488 HP laser system consists of:

- Laser head
- Controller (stack of PCB boards)
- Connector kit
- Head cable (head to OEM controller HP, standard 2 m, optional 1 m and 5 m)

The suffix "HP" distinguishes the OEM controller for the high power (100, 200, and 500 mW) Sapphire lasers from the "LP" version available for the smaller, low power Sapphire platform.

An optional DC power supply is available if the integrator does not provide their own DC source. Also, an optional heat sink is available if heat sinking is not included in the OEM integration.

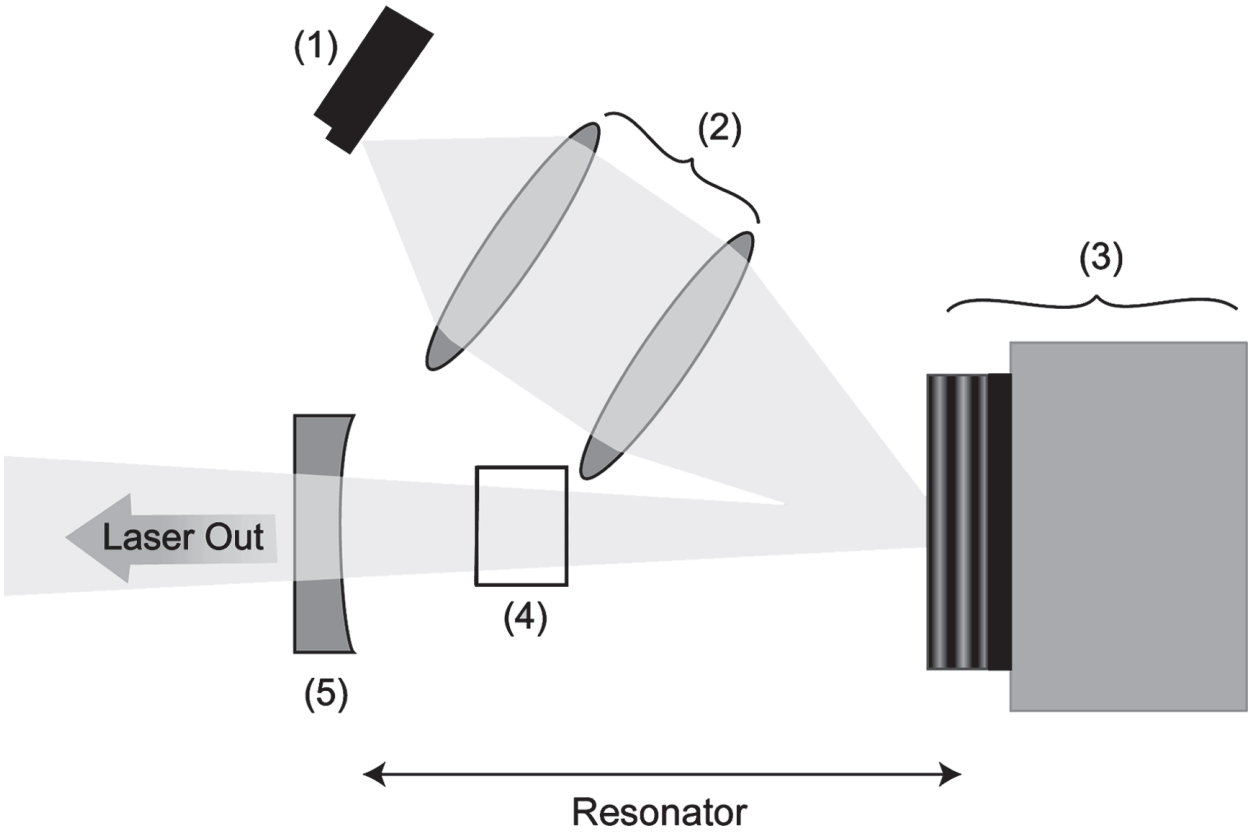
A heat sink is required to dissipate the heat from the Sapphire head, and is not included. This heat sink has to be provided by the user—see "Heat Sink Requirements" (p. 3-2). Improper heat sinking can lead to a shut off of the laser system!

Laser Head

The optical layout of the Sapphire is shown schematically in Figure 2-2 (p. 2-3). The Sapphire belongs to a class of Optically Pumped Semiconductor Lasers (OPSL™). This class is similar to a conventional VECSEL (Vertical External Cavity Surface Emitting Laser) but uses optical pumping instead of injection current to generate gain.

The output beam of the pump diode is focused onto the OPS-chip by a lens. The OPS-chip contains a DBR-mirror and forms the resonator together with the output coupler. 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 is coupled out of the resonator, passes through collimating lenses, and exits through the case window.

A thermoelectric cooler is integrated for stabilizing the diode laser and the resonator temperature. Excess heat is removed via the base-plate of the laser.



1. Pump diode
2. Focusing optic
3. OPS chip
4. Doubling crystal
5. Output coupler

Figure 2-2. Optical Schematic

Optional Heat Sink

The optional heat sink is available to ensure heat sinking of the laser head if this is not covered by the OEM integration. The heat sink has sufficient cooling capacity for ambient temperatures up to 40ºC. The integrated fan slaves the DC power from the Sapphire laser head. The cable is included. For dimensions, see Figure 2-7 (p. 2-10).

Sapphire Controller

The Sapphire OEM controller HP 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—refer to Table 3-1 (p. 3-14) for a description of the 25-pin Sub-D analog interface. Table 3-2 (p. 3-17) gives a description of the 9-pin Sub-D RS-232 interface. A

command set of RS-232 commands is given in Table 3-3 (p. 3-19). After power up, the OEM controller HP sets up all temperatures to the expected values, typically within 50 seconds. Light emission can be started when all temperatures have reached the set values.

Optional DC Power Supply

The optional self-contained power supply provides an output of 24 VDC. Two versions are available: one for U.S. standard plug (115 VAC) and one for European standard plug (230 VAC). Any DC power supply that complies with specifications listed in Table 2-1 (p. 2-6) can be used. Allow any DC supply to completely shut down before restart; otherwise, residual DC output voltages present during restart can lead to performance failures of the Sapphire laser. For example, the factory-offered optional DC supply, requires a 10 seconds pause before a restart.

Product Label Serial Numbers

Each Coherent Sapphire HP OEM laser head and Sapphire HP OEM laser controller has a label containing a unique serial number. This serial number consists of a part number and a production number, as shown in the following example.

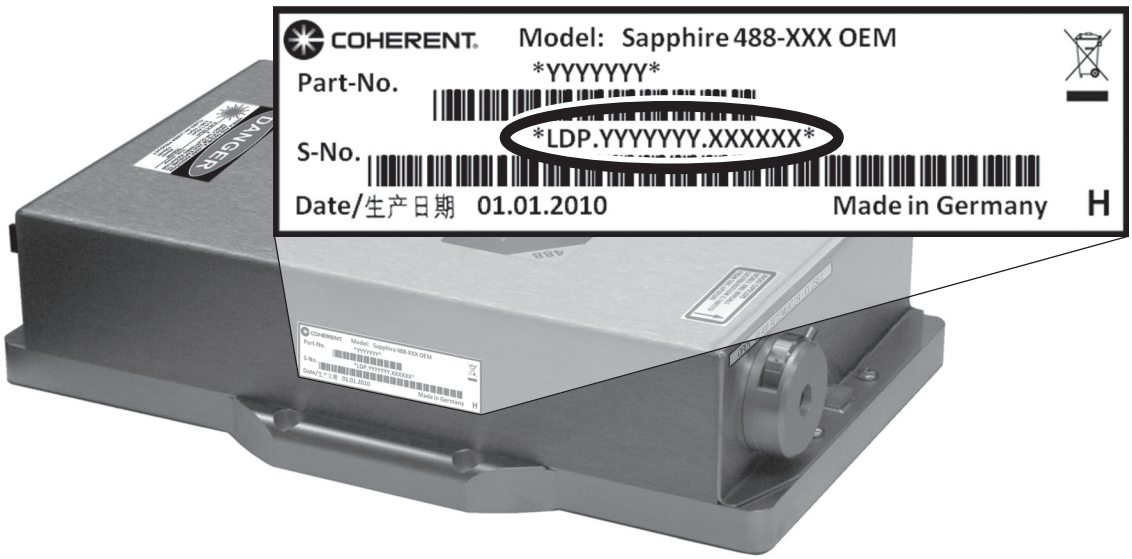


Figure 2-3. Label Identification - Laser Head

On the label in Figure 2-3:

- *YYYYYYY* = the part number
- *XXXXXX* = the production number

The *part number* describes the type of the component (for example, Sapphire 488 HP Laser Head, OEM, RoHS compliant). This number is important for ordering the correct product.

The *production number* consecutively numbers the individual laser components. Each production number is unique for a certain component. This number is important to clearly identify a certain component.

Laser *system* part numbers and production numbers are top level numbers, and are *not* noted on the labels of the individual components of the laser system.

Specifications

Table 2-1 lists specifications for the Sapphire laser.

Table 2-1. Specifications and Requirements

SAPPHIRE 488 HP		
Wavelength	488 nm ± 2 nm	
Output Power	100/200/500 mW @ 488 nm	
Power Range	100 and 200 mW versions: 10 to 110% adjustable. 500 mW version: 10 to 100% adjustable. Specifications are valid for 100% power. Recommended power range is 70 to 100% power.	
Noise		
Peak-to-Peak	20 Hz to 20 KHz: < 1%	
RMS	20 Hz to 2 MHz: < 0.5%	
Pointing Stability (over 2 hours)		
Temperature Range: ± 3°C, after warm-up	<± 30 µrad	
Long-Term Power Stability: (2 hours, ± 3°C)	< 2%	
Warm-up Time	< 5 min.	
Fundamental Beam Suppression	< 1 mW	
Maximum Base Plate Temperature	+ 50°C	
Maximum Heat Load from the Laser Head	100 and 200 mW versions: 60W max 500 mW version: 90W max	
BEAM PARAMETERS		
Spatial Mode	TEM_{00}, $M^2 < 1.1$	
Beam Waist Diameter (@ $1/e^2$)	0.65 to 0.75 mm	
Beam Waist Diameter Location	at exit window ± 200 mm (25% of Rayleigh range)	
Ellipticity	0.9 to 1.1	
Beam Divergence (full angle)	< 1.2 mrad	
Static Alignment (Reference: front & right side of baseplate)	± 0.25 mm (x, y) ± 2.5 mrad (angle)	
Polarization Ratio (bottom reference)	> 100:1; vertical	
ENVIRONMENTAL SPECIFICATIONS	**OPERATING**	**NON OPERATING**
Temperature	10 to 40°C (50 to 104°F)	-30 to 60°C (-22 to 140°F)
Altitude	0 to 10,000 ft.	0 to 70,000 ft.
Relative Humidity (w/o condensation)	0 to 90%	0 to 100%
Shock Tolerance (6 ms)	7 g laterally 15 g vertically	7 g laterally 15 g vertically
INPUT POWER REQUIREMENTS		
Input Voltage	24 VDC ± 5%	
Input Power	100 and 200 mW versions: < 75W 500 mW version: < 150W	
Ripple	< 5% peak to peak	

Dimensions

The dimensions of the Sapphire laser head, the Sapphire OEM controller HP, the optional DC power supply, and the optional heat sink are shown in the figures below.

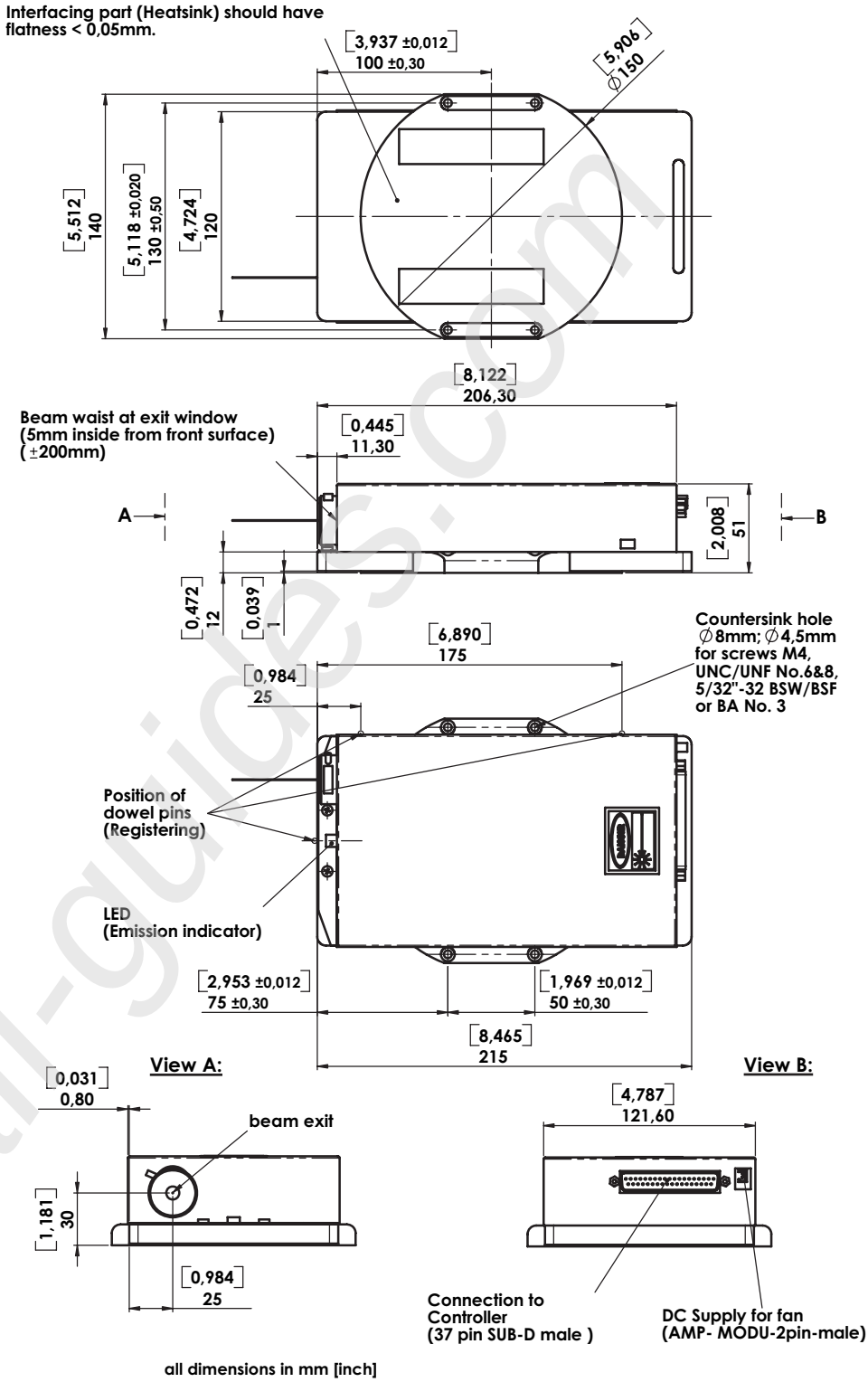


Figure 2-4. Sapphire Laser Head Dimensions

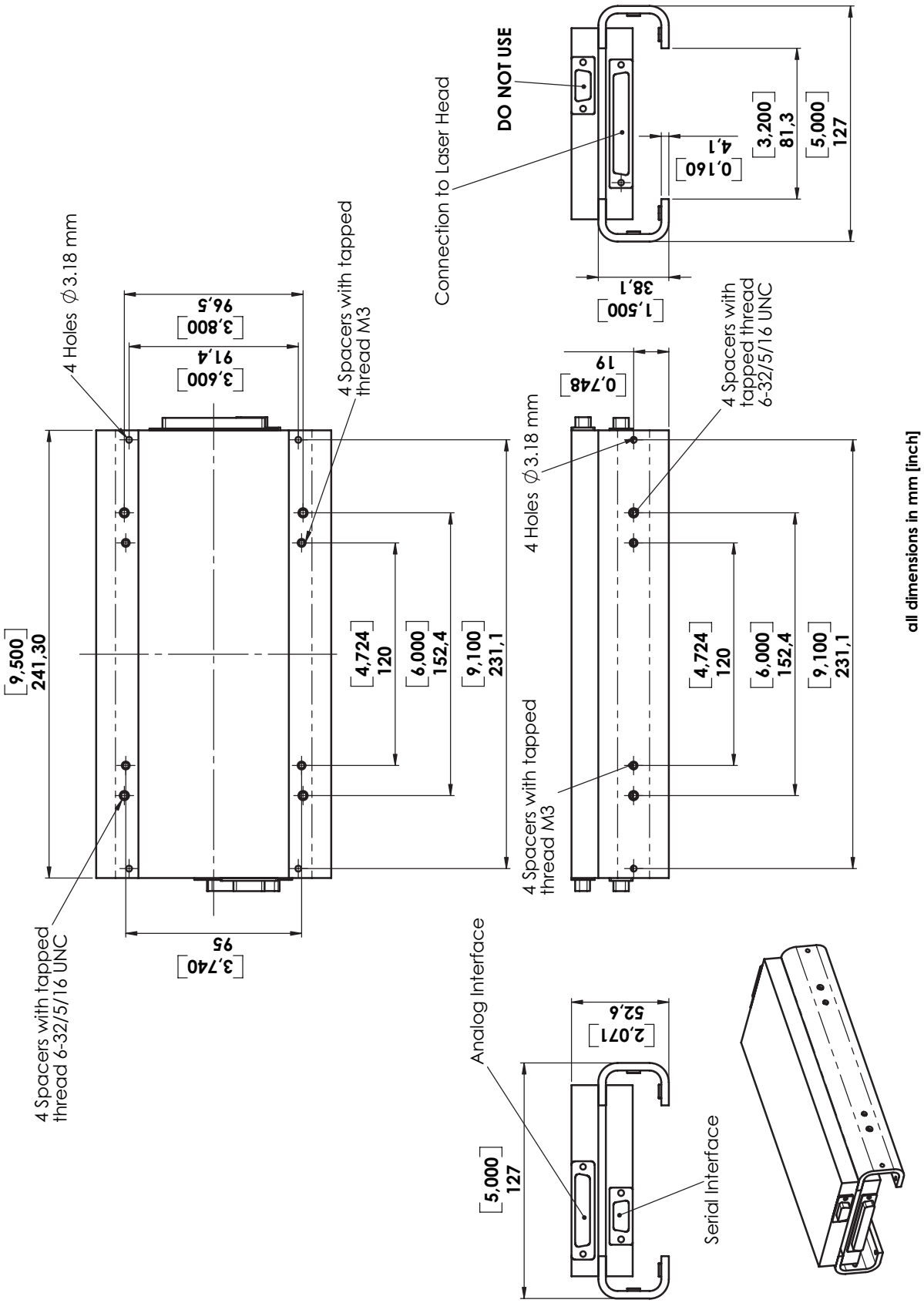


Figure 2-5. Sapphire Controller Dimensions

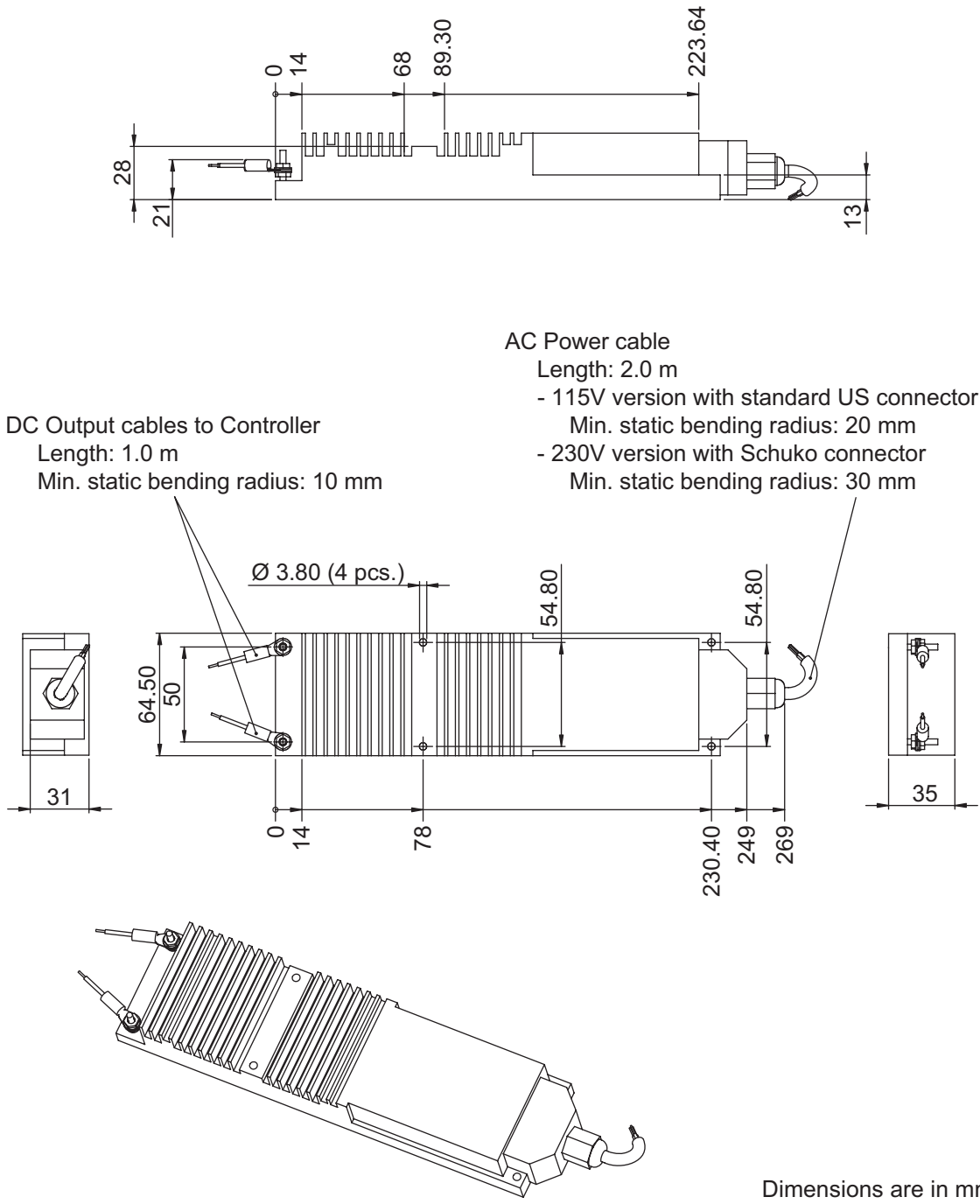


Figure 2-6. Optional DC Power Supply Dimensions

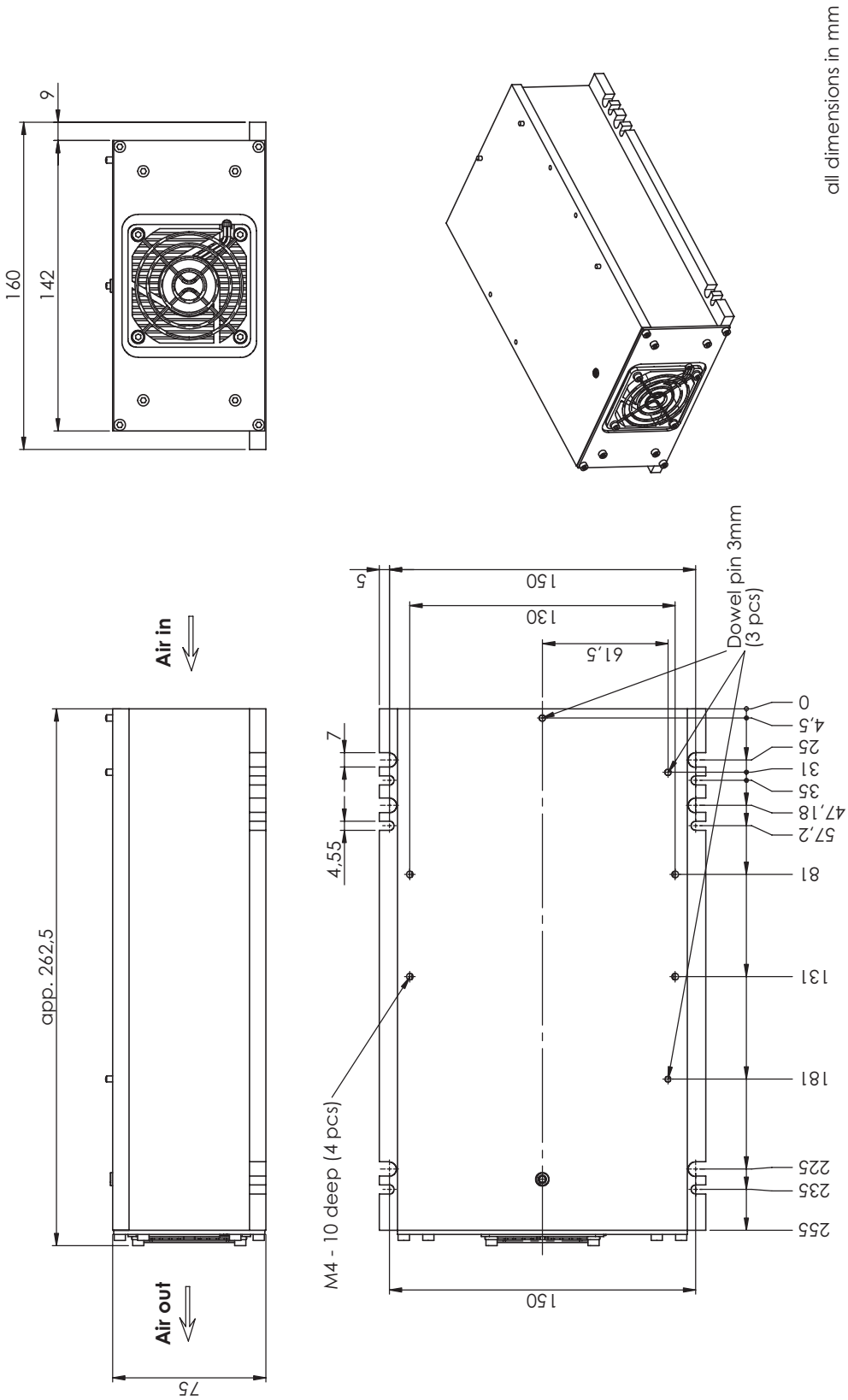


Figure 2-7. Optional Heat Sink for Laser Head Dimensions

SECTION THREE: INSTALLATION

After unpacking the system keep the shipping boxes for potential later shipments (See Section Five, Repackaging Procedure).

Installation

The installation procedure includes the following steps:

- Determine heat sink requirements and install heat sink.
- Connect system components.
- Connect a means of controlling (and monitoring) the laser system.
- Configure OEM controller HP DIP switches for desired mode.
- Connect the system to a power source.

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

Do not operate the system without a heat sink installed on the laser head. Improper heat sinking can damage the laser head.

Heat Sink Requirements

It is imperative that the laser head be adequately heat sinked; otherwise, it will overheat and shut down in a matter of seconds. Figure 3-1 shows the heat dissipation of the Sapphire laser head for a given baseplate temperature.

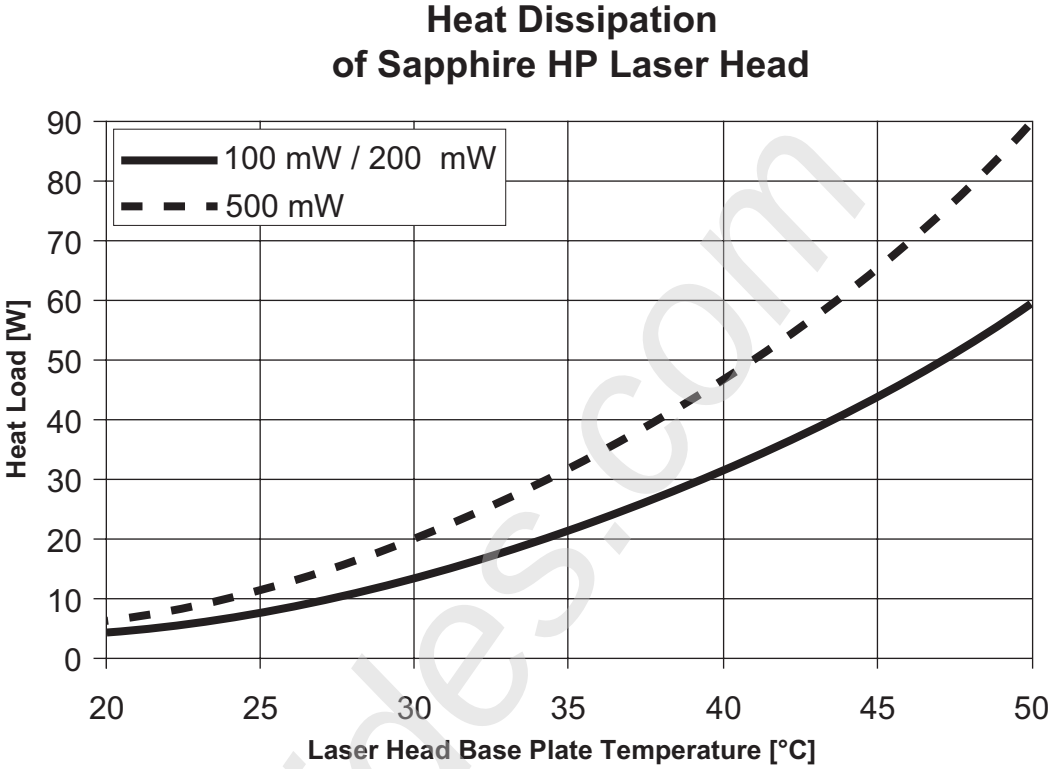


Figure 3-1. Heat Dissipation of the Sapphire Head

The graph shown in Figure 3-2 (p. 3-3) allows determination of the heat sink thermal impedance requirement based on the anticipated maximum ambient temperature.

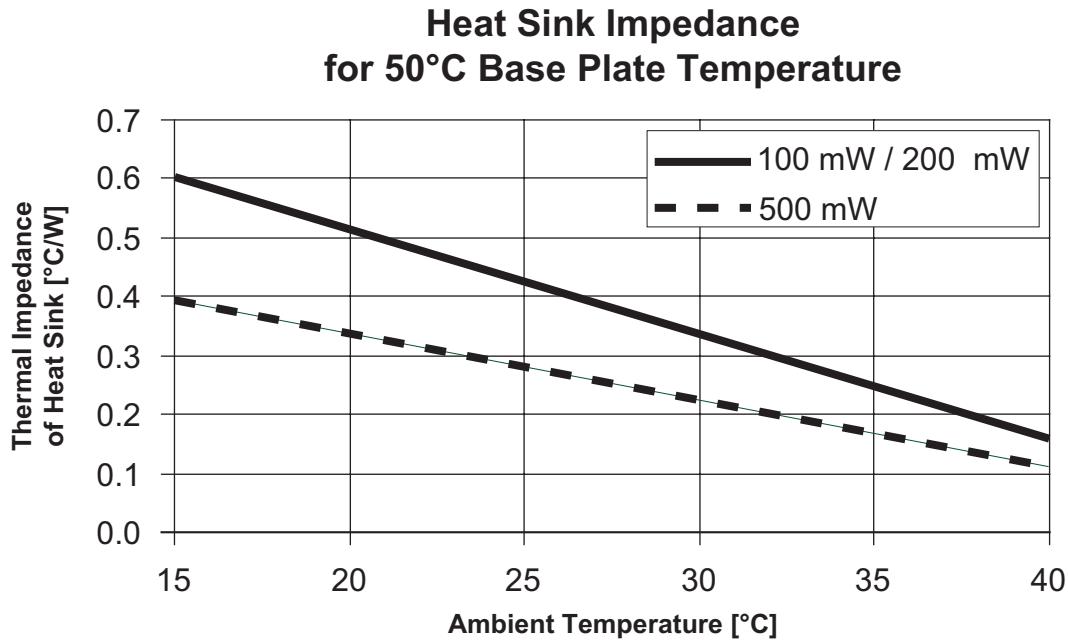


Figure 3-2. Heat Sink Requirements

For example, if the maximum expected ambient temperature is 35°C, then the heat sink thermal impedance needs to be 0.25ºC/Watt.

Note that the mounting surface of the heat sink must be very 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 (within ±0.05 mm over the mounting surface). Thermal heat compound should be used between the laser head and heat sink to maximize thermal contact.

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 using M4 screws:

1. Following the 1-2-3-4 sequence shown in Figure 3-3 (p. 3-4), torque the mounting screws to **0.5 Nm** (4.42 lbf-in).
2. Using the same 1-2-3-4 sequence shown in Figure 3-3, torque the mounting screws to **1.5 Nm** (13.28 lbf-in).

The overall flatness of the heat sink should be < 0.05 mm.

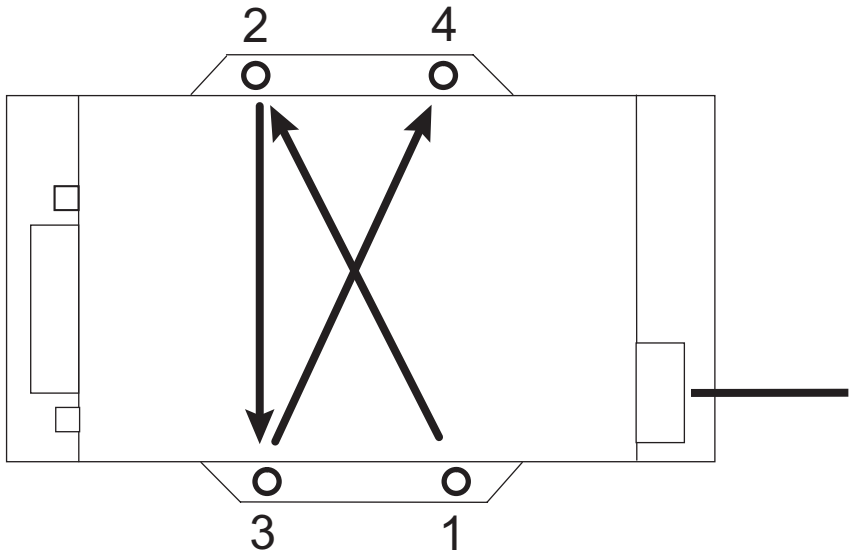


Figure 3-3. Sapphire Torque and Tightening Pattern

We recommend you use the dowel pins or similar references in the mounting of the Sapphire head. This allows to take benefit of the superior static beam alignment of Sapphire—see Figure 2-4 (p. 2-7).

The Sapphire OEM controller HP supports mounting in horizontal or vertical orientation.

Also, you have the option of using the threads or the screw holes in the OEM controller HP frame. For the inner threads, use standard M3; for the outer ones, UNC 6-32 5/16.

For the holes at the ends of the OEM controller HP frame, you can use both screw types. This mounting technique is illustrated in Figure 3-4—also refer to Figure 2-5 (p. 2-8) for Sapphire OEM controller HP dimensions.

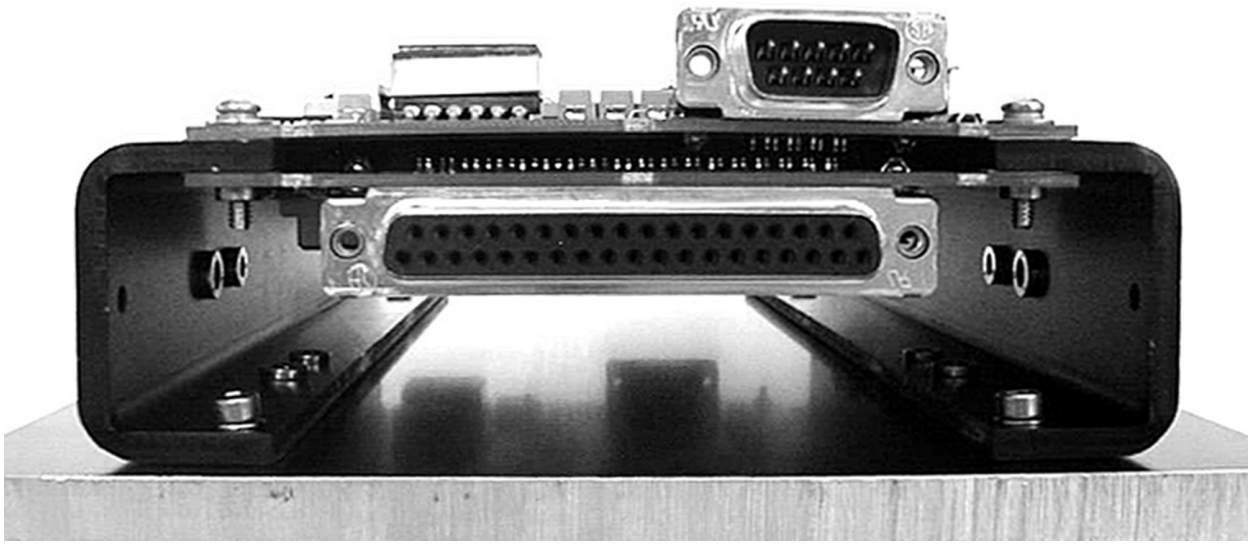


Figure 3-4. Mounting of the Sapphire Controller

Interconnections

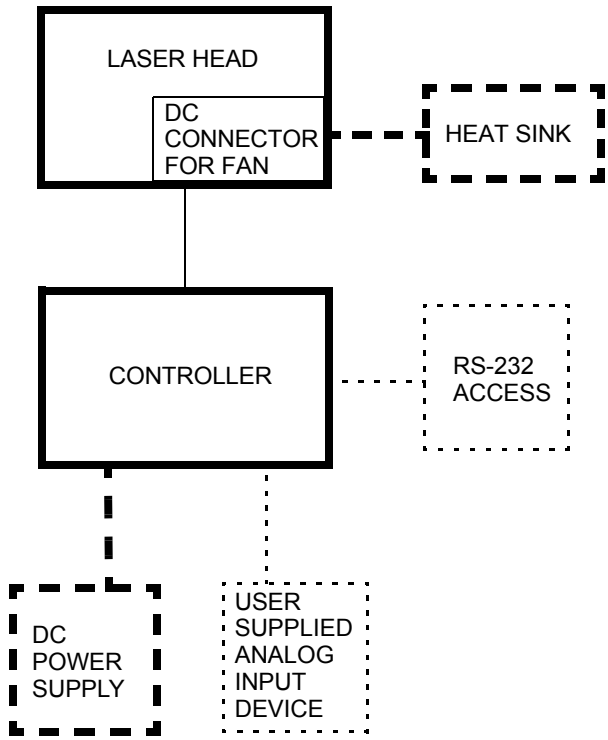
To assist in establishing the physical location of the laser system components, dimensions of the laser head, and the analog OEM controller HP are shown in Figure 2-4 (p. 2-7) and Figure 2-5 (p. 2-8), respectively.

Ensure that the laser head is adequately heat sinked as described in the previous paragraphs.
To prevent surge currents, do not apply power to the laser system until all connections have been completed.

1. If attached, remove the protective cap from the laser head connector.
2. Connect the laser system as shown in Figure 3-5 (p. 3-6).

Do not connect the laser system to any power source at this time.

The connectors on the Sapphire OEM controller HP do not tolerate major mechanical pressure—ensure strain relief to cables in the integration.

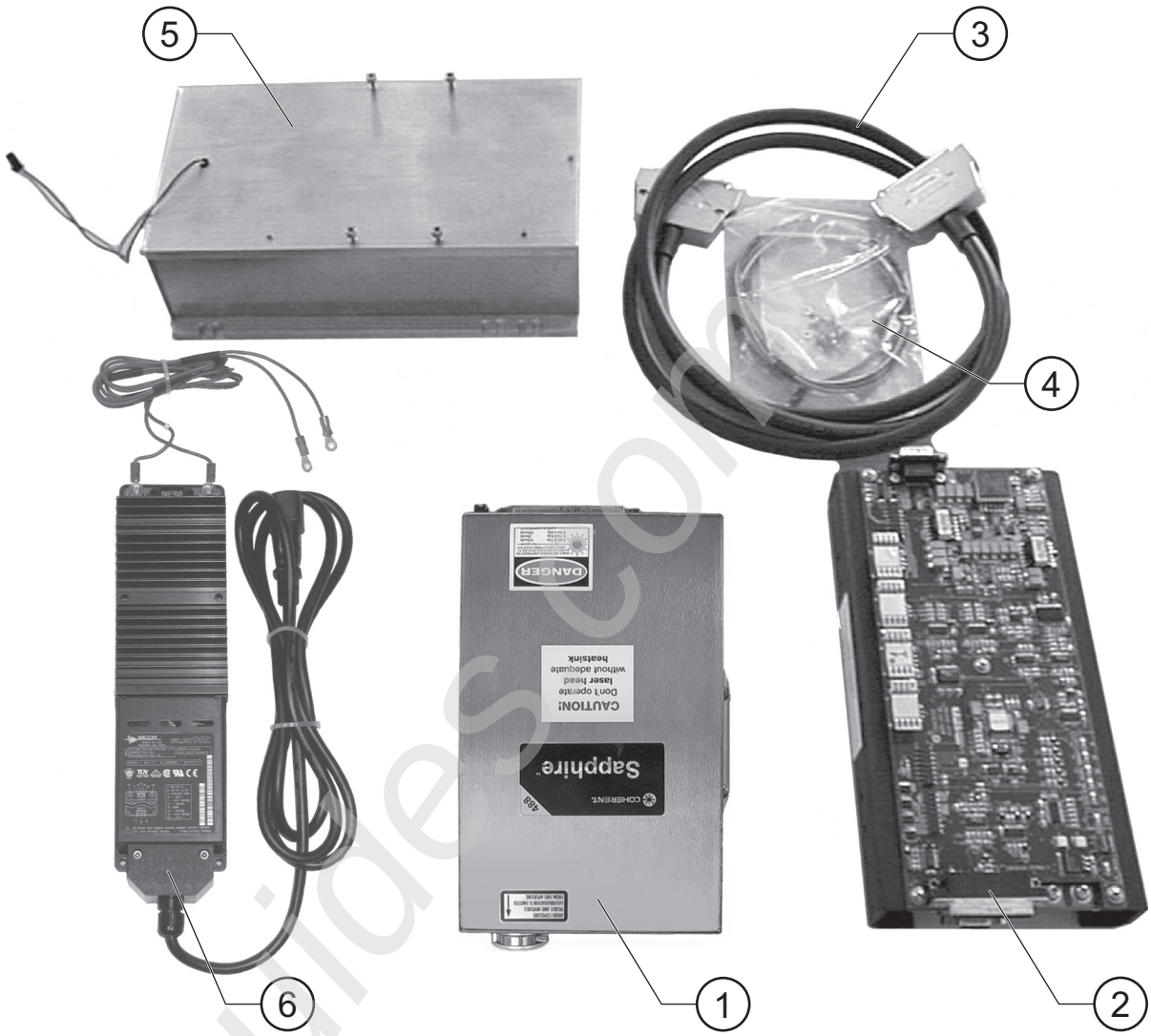


NOTES:

- - - - OPTIONAL EQUIPMENT

. . . . . USER-FURNISHED EQUIPMENT

Figure 3-5. Interconnection Diagram



1. Sapphire 488 HP OEM Head
2. Sapphire OEM Controller HP
3. Sapphire HP Head Cable 2 m
   (also available in 1 and 5 m length)
4. Sapphire HP Connector Kit
5. Sapphire HP Heat Sink (optional)
6. Sapphire HP DC Supply 115V (optional)
   Sapphire HP DC Supply 230V (optional)

Sapphire 488 HP OEM System includes items 1, 2, 3 and 4.

Figure 3-6. Sapphire Laser System Components

Connecting an External Fan

The DC voltage supplied from the OEM controller HP is available at the laser head to power an external fan (maximum current <500 mA)—see Figure 2-4 (p. 2-7) and Figure 3-5 (p. 3-6).

A spare plug is included in the connector kit, which is part of the system delivery volume. For pin assignments and the part numbers for the AMP connector see figure below.

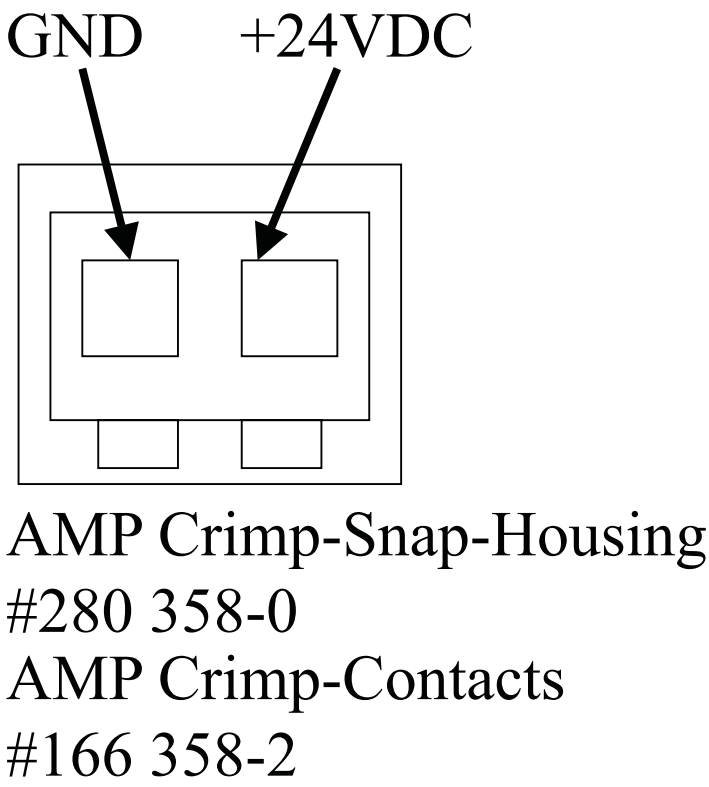


Figure 3-7. Fan Connector

Allow any DC Power Supply to completely shut down before restarting. A pause of >10 seconds is recommended when cycling the DC Power Supply.

Connecting a User-Furnished Power Supply

Any power supply that complies with the specifications listed in Table 2-1 (p. 2-6) can be used with the laser system; however, the optional power supply is recommended. The power supply and the OEM controller HP are pre-assembled then with flat connectors, a small one for ground (blue) and large one for +24 VDC (red)—refer to Figure 3-8, below.

If a user-furnished power supply will be used, a connector kit is supplied to assist in connecting this power supply to the OEM controller HP. The connector kit contains a two wire cable as well as screw adapters and small and large flat adapters for 24 VDC supply. Both possible configurations are shown in Figure 3-8, below.

Make sure to connect the DC Power Supply to the OEM controller HP with the correct polarity. Wrong polarity will destroy the OEM controller HP.

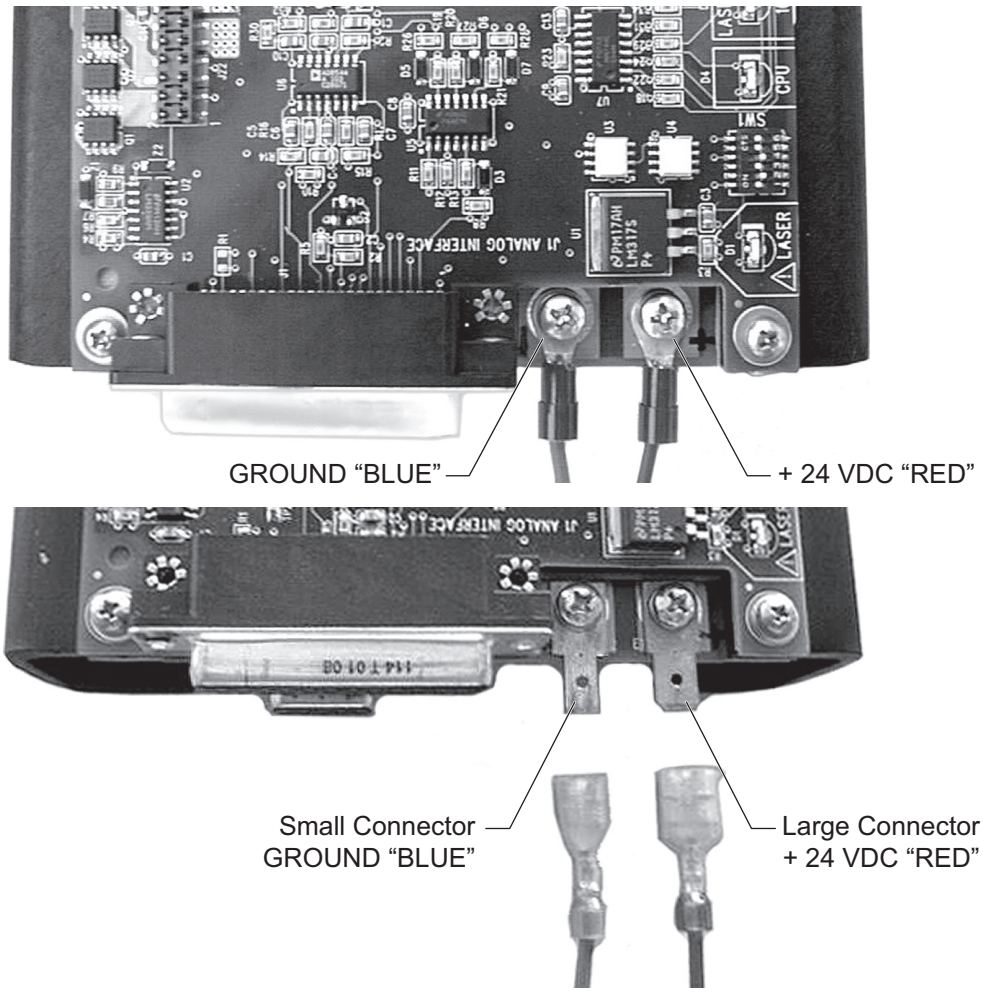
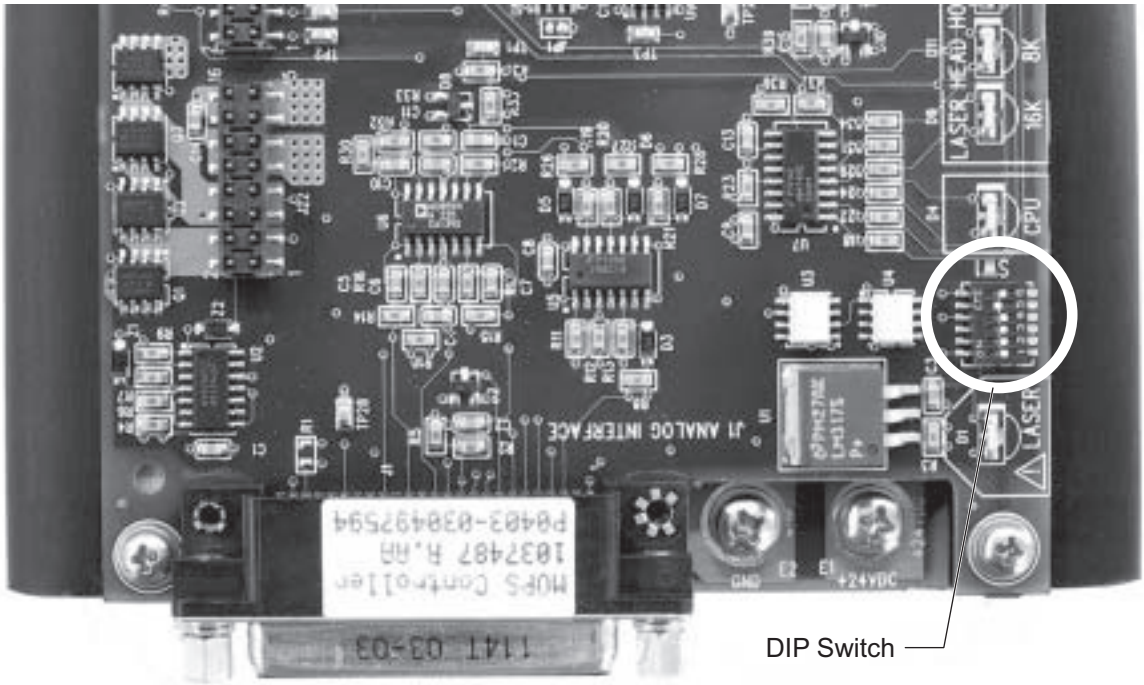


Figure 3-8. Connecting DC Supply to Controller

DIP Switch Settings

DIP switch locations are shown in Figure 3-9.



Change DIP Switch settings only at DC power OFF. Restart after DC power ON will reconfigure the new operation mode. Keep a delay of > 10 seconds between DC ON/OFF.

Figure 3-9. DIP Switch Location

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 Laser warning LED is **active**
SW 3-3 OFF Keyswitch at analog connector **required**
SW 3-4 OFF Autostart mode **disabled**
SW 3-5 ON Always set to ON
SW 3-6 OFF Always set to OFF

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

Refer to Table 3-1 (p. 3-14) for a detailed description of the analog interface connector.

Also, with these default settings an active start signal via analog interface or RS-232 interface (see following pages) is required to start the laser.

Autostart Settings of the DIP Switch

In case the user does not supply this external interface there exists an autostart setting that overrides the Interlock and keyswitch safety circuits. This is obviously an operation mode that requires the user to take care of laser safety in a very careful way and we strictly recommend to take extraordinary laser safety preparations for this mode.

In this mode the laser will start after a warm up period of typically 50 seconds.

These DIP switch settings are:

SW 3-1 ON Interlock at Analog interface **disabled**
SW 3-2 OFF Laser warning LED is **active**
SW 3-3 ON Keyswitch at analog connector **disabled**
SW 3-4 ON Autostart mode **enabled**
SW 3-5 ON Always set to ON
SW 3-6 OFF Always set to OFF

With autostart setting the laser will power up to the previously set power level (factory default, specified power, or any previously user set power).

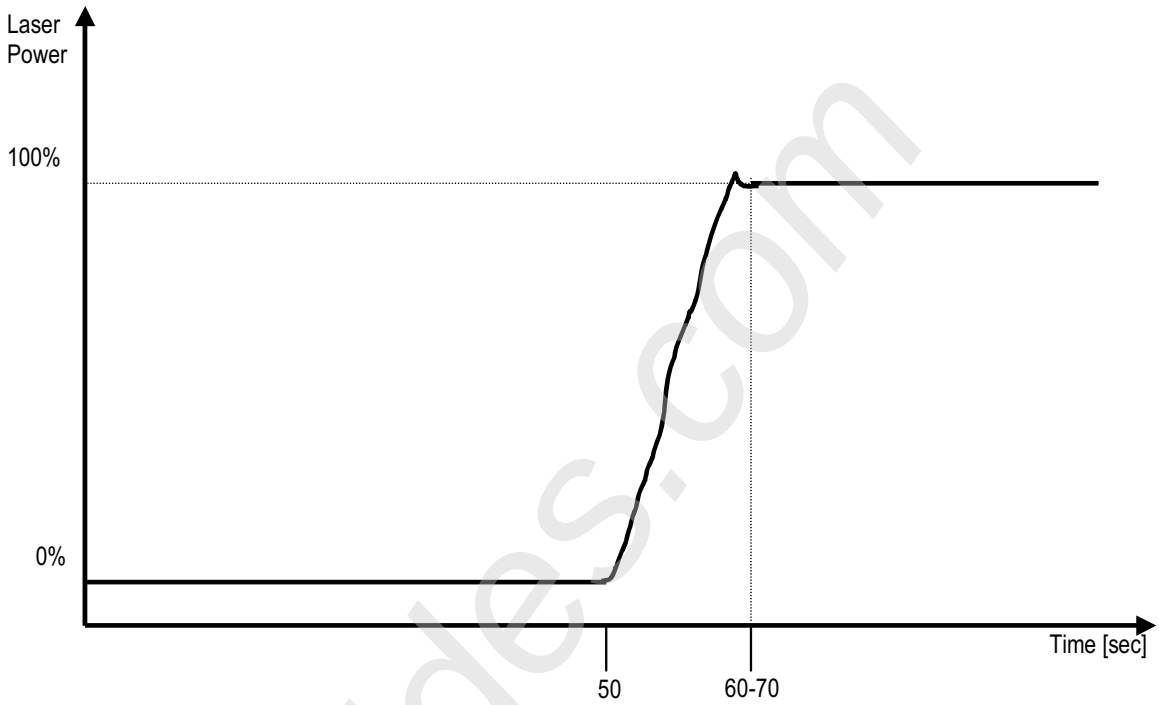


Figure 3-10. Typical Turn On Characteristics Diagram (from cold start)

A delay > 10 seconds between shutdown and restart of the OEM controller HP is recommended.

Adapting to Duty Cycles and Laser Ready Signal

If no laser light is required for more than one hour one might shut-down the laser completely. The warm-up procedure starts with a 50 seconds delay and is specified with less than 5 minutes. If the laser is shutdown via the DC supply, allow any DC supply to completely shutdown before restart. Otherwise residual DC output voltages present during restart can lead to performance failures of the Sapphire laser. The factory offered optional DC supply for example requires 10 seconds pause before a restart.

For shorter interruptions the Sapphire laser features a “Stand By mode”, where all temperatures in the cavity are maintained but the pump diode is cycled down and thus no optical activity takes place. From a lifetime point of view, this is practically equivalent to a completely switched off laser. The “Stand By Mode” is recommended for application interruptions for ten minutes and more. The Stand By Mode is set through Pin 4 of the analog interface (TTL Low sets to Standby, TTL High resumes operation). For more information on the analog interface, refer to “Controlling the Laser via Analog Signals” (p. 3-14).

If you are using the RS-232 interface 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 a few seconds—refer to “Controlling the Laser via an RS-232 Command Interface” (p. 3-16).

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).

Laser Warning Light

A yellow indicator light is provided on the front of the laser head. This light is illuminated when the laser pump diode is energized. This light meets the IEC-825 requirements that warning laser lights must be fail safe or redundant.

If the indicator light needs to be disabled for OEM integration reasons, refer to “DIP Switch Settings” (p. 3-10).

Mechanical Beam Shutter

A mechanical beam shutter is located at the beam exit location. A label indicates ON/OFF position.

Interlocks

Using the Interlock Loops

The Sapphire OEM controller HP can connect to an interlock loop. The loop is located at the analog connector (J1) Pin 1 and 3. The user has to provide a closed loop at these pins when this interlock is required by setting DIP switch 1 to OFF.

Using the Keyswitch Connection

To comply with the CDRH and IEC-825 regulations the customer may connect a keyswitch to the Sapphire OEM controller HP at the analog interface connector Pin 17, 19, and 20.

(To comply with the CDRH regulations the user has to provide some other components as well, which are not listed here).

Controlling the Laser via Analog Signals

Connect all components as shown in the paragraph Interconnections. Note that connecting cable for 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. If a CDRH key switch is attached, turn the CDRH key switch to the ON position (applicable if the key switch pins at the analog interface are connected to a key switch). Be aware the Pin 18 has to be at ground when applying DC power, to enable the analog interface power control (at Pin 7). Note that when the analog interface is enabled, the RS-232 interface is disabled for commands. If Autostart mode is disabled an OFF to ON reset at Pin 2 is required to turn on TEC and Laser.

Table 3-1. Pin-Out for External Analog Interface Connector (DB-25S Female) (Sheet 1 of 2)

SETTING	PIN	DESCRIPTION
Interlock	Pin 1 (+) & 3 (–)	Connect PIN 1 to 3 for Laser On (disabled by DIP Switch SW3-1 in On position) Can be used for laser warning light (LED) <24 VDC
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	Do not use

Table 3-1. Pin-Out for External Analog Interface Connector (DB-25S Female) (Sheet 2 of 2)

SETTING	PIN	DESCRIPTION
Spare Analog Input	Pin 6	Do not use
Laser Output Power Control	Pin 7	0 to 4.096V = 10 to 110% power (100 mW and 200 mW versions) 0 to 3.724V = 10 to 100% power (500 mW version) Minimum power if no connection 10 kOhm input impedance, input enabled by Pin 18
Power Monitor	Pin 8	10 mA max, 2V = nominal Power (100%)
LD Current Monitor	Pin 9	Analog signal, 1V for 2500 mA laser diode current, max.10 mA
Signal/Power return	Pin 10, 11, 14, 20, 21, 22, 24	Ground (return) for all signals and power
N/A	Pin 12	Not connected
DC Output	Pin 13	+ 5 VDC, 20 mA max
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 ± 4 mW (100 and 200 mW versions) 10 mW (500 mW version)
Keyswitch Connection	Pin 17 & 19	Connect SPDT Keyswitch with: Pole at Signal Return (Pin 20 or equivalent) Normally Closed Terminal at Pin 19 Normally Open Terminal at Pin 17 Laser will run when Pin 17 is shorted to Pin 20 Can be disabled by DIP Switch SW3-3 in ON
Analog Interface Enable	Pin 18	Enables Laser Control from Pin 2, 4, 7 PIN 18 to Ground : enabled PIN 18 no connection : disabled
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 CPU PCB only

The circuit figure below explains the control of the laser diode (LD) and TEC function using PIN 2 and PIN 4:

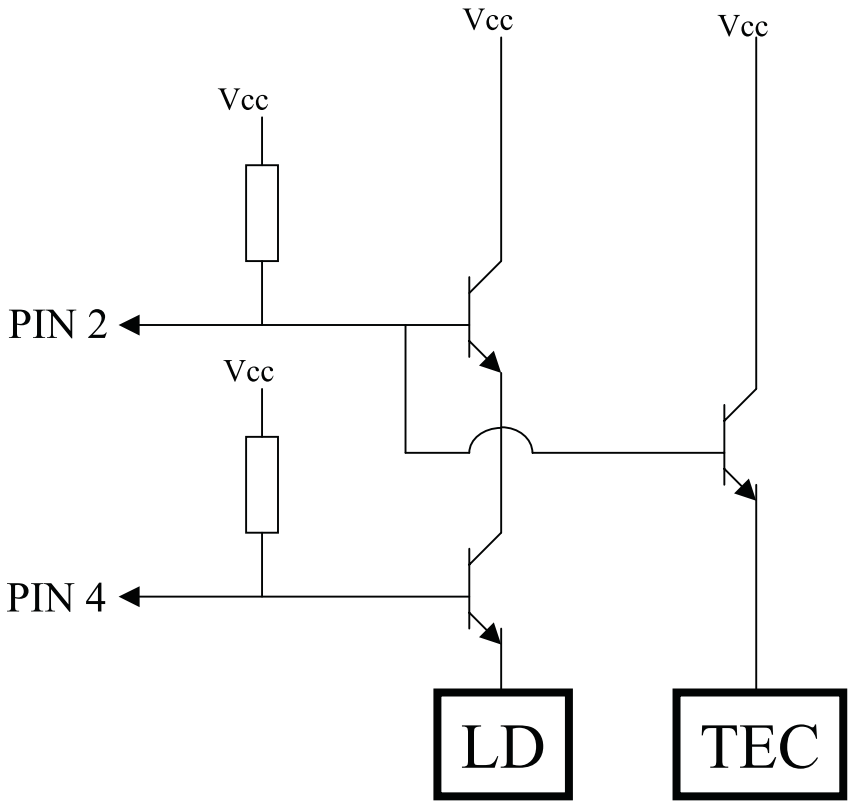


Figure 3-11. Sapphire Standby-ON-OFF

Controlling the Laser via an RS-232 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. When the analog interface is plugged in the RS-232 interface is disabled for commands. Supply the operating voltage to the DC power connector. Turn the CDRH keyswitch to the On position of applicable. Connect a serial cable (not included) to the OEM controller HP and establish the communication to the computer. The user can use a standard terminal emulator program that is included in standard PC operation systems. For a definition of the RS-232 pin assignments, see Table 3-2 (p. 3-17).

The settings of the OEM controller HP RS-232 interface are:

- 19200 baud
- no parity
- 8 data bits
- 1 stop bit
- No flow control

By using the commands in Table 3-3 (p. 3-19), the customer can control and query different parameters. Note that the laser will go through a warm-up cycle after applying the DC power. During this cycle the OEM controller HP will not accept any commands. The user has to query the error flag until he gets a zero back. A typical RS-232 startup sequence is shown below:

```
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=200     {output power = 200 mW}
Sapphire:0->?BT       {query base plate temp}
35                    {35ºC}
Sapphire:0->L=0       {laser off}
```

If the power level is not explicitly set, the laser will always start at the last-used power level.

Table 3-2. RS-232 Connector (DB-9 Female at Controller Board)

SETTING	PIN	DESCRIPTION
DCD	Pin 1	No connection
TXD	Pin 2	RS-232 transmitter on Controller PCB
RXD	Pin 3	RS-232 receiver on Controller PCB
DTR	Pin 4	Connected to DSR
GND	Pin 5	Signal Ground
DSR	Pin 6	Connected to DTR
RTS	Pin 7	Connected to CTS
CTS	Pin 8	Connected to RTS
RI	Pin 9	No connection

Hints For Software Integration

The Sapphire firmware supports a local echo as a default setting. That means the OEM controller HP directly returns each character you sent. The local echo can be switched of using the "E" command.

The "Sapphire" system prompt can also be switched off using the ">" command.

It might be easier to switch off the local echo and the system prompt for a proper handling in your own software.

Don't send more than one command after another. After the response you can directly send the next command or query.

A command will be answered by a CR LF (carriage return/line feed). If the command is wrong an additional error message string will be sent.

A query will be answered always by CR LF and a string. The string can be also an error message.

Warning: Communication faults of the RS-232 are mostly related to defect hardware like cables. In rough electromagnetic interference environments communication faults also can be more likely.

We strongly recommend to program a time-out to prevent potential faults caused by RS-232 communication. A time-out period of 1 second is sufficient. After such an event send a CR LF to clear the OEM controller HP 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, included unintended laser light emission.

RS-232 Commands and Queries

Most commands follow the format "**command**=<value>" and the queries follow "**?query**" format unless otherwise specified.

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

">"	Type: Query and Command This command turns on or off the command prompt. 1=ON 0=OFF
"BT"	Type: Query Read the BasePlate temperature setting. Value returned is in °C (degrees centigrade).
"C"	Type: Query Read laser diode current. Returns the value of measured current in Amps. To read back set current value, use "?sc" command.
"CLS"	Type: Command Clears text from a serial communication screen (only when VT100 emulation is being used)
"DT"	Type: Query Returns the value of measured temperature in degrees centigrade. To read back set diode temperature value, use "?dst" command.
"E"	Type: Query and Command Sets or reads Echo Off feature. This feature turns on or off character echo on serial communication terminal. This feature is useful if a computer script/program rather than a person was controlling the laser. 1=ON 0=OFF
"F"	Type: Query This command checks for faults in the system and if there is one, it returns that fault number. If there are multiple faults present in the system, it returns the first fault detected from a list of faults. See "?FL" or "?FF" queries for different ways to receive fault status.
"FF"	Type: Query This command checks for faults in the system if there is one, it returns a two-byte result in following format: MSB Bit 15: External Interlock Fault Bit 14: Diode Current Fault Bit 13: Power Supply Temperature Fault Bit 12: BasePlate Temperature Fault Bit 11: AUX Temperature Fault Bit 10: OPS Temperature Fault Bit 9: Resonator Temperature Fault Bit 8: Diode Temperature Fault Bit 7: A-to-D device Fault Bit 6: 12bit DAC device Fault Bit 5: 8bit DAC device Fault Bit 4: EEpot device Fault Bit 3: Diode Servo Temperature OK flag Bit 2: Power Supply EEPROM device Fault Bit 1: Head EEPROM device Fault LSB Bit 0: Diode Voltage Short Fault

Table 3-3. RS-232 Commands and Queries (Sheet 2 of 3)

"FL"	Type: Query This command checks for faults in the system and if there is one, it returns a list of all faults present. If there is no fault in the system, it says "system ok". This command shows faults in text rather than in number(s). See "?F" or "?FF" queries for different ways to receive fault status. Fault List: 0 System OK (No fault) 1 External Interlock Fault 2 Diode Temperature Fault 3 BasePlate Temperature Fault 4 Controller Temperature Fault 5 Diode Current Fault (under current or over current) 6 Head EEPROM fault 7 Controller EEPROM fault 8 EEpot1 fault 9 EEpot2 fault 10 ADC fault 11 Analog Interface fault
"HB"	Type: Query and Command If activated, the heartbeat function sets the laser to a definable status, if within an adjustable time no communication occurs on the RS-232 interface. The functionality is similar to a watchdog. See "HBT" for query and setting of the time value. The query ?HB reports the adjusted laser status to be set at an time-out event occurring. Whilst the heartbeat function is switched off by setting HB=0, the laser will behave as known, without any time-out event. Defined states at a time-out event are: HB=0 Heartbeat functionality inactive, no effect (default at delivery) HB=1 Set Laser Power to Min Laser Power HB=2 Turn Off Laser (equivalent to L=0) HB=3 Turn Off all TEC Servos and Laser (equivalent to L=0, SS=0)
"HBT"	Type: Query and Command The query ?HBT reports the adjusted time-out durance in seconds. HBT=xx sets the time-out durance to xx seconds, whereat 60 seconds is the maximum value.
"HH"	Type: Query Returns the usage hours stored in the HEAD EEPROM. The format is "?hh". Head Hours are updated every time there is at least minimum current flowing through the laser diode. See "psh" query to check the Power-Supply usage hours.
"HID"	Type: Query 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.
"K"	Type: Query This command is used to check the status of Key Switch (if implemented) in the hardware.

Table 3-3. RS-232 Commands and Queries (Sheet 3 of 3)

“L”	Type: Query and Command This command is used to Read or Set the Light Servo status. Setting L=1 will close the Light Servo, enabling automatic servo regulation. TEC servo MUST be ON (SS=1, automatic TEC servos regulation) to set L=1. Setting L=0 will set Light Servo to an OPEN state, disabling automatic servos regulation. L=0 will also turn off the Laser output. A query of this command (?L) will return status of the Light Servo.
“MAXLP”	Type: Query The query ?maxlp reports the maximum adjustable output power in mW.
“P”	Type: Query and Command This Command/Query sets or reads Laser Power. Light Servo MUST be enabled (L=1) to get a laser output using this command. A query returns the read power level of OPS unit. Value is numerical, in floating-points.
“PID”	Type: Query Reads the Power-Supply ID. Read value is numerical (floating point value).
“PSH”	Type: Query Returns the usage hours stored in the Controller EEPROM. The format is “?psh”. This value represents the on-time of Sapphire unit. This value starts updating every time Sapphire unit is turned on. See “hh” query to check the Head usage hours.
“PST”	Type: Query This query is used to read the Controller temperature. This is a value in ºC (degrees centigrade).
“SP”	Type: Query Reads Set Power
“SS”	Type: Query and Command This command is used to Read or Set the TEC Servos status. Setting SS=1 will the TEC Servos, enabling automatic servo regulation. Setting SS=0 will set the TEC Servos to an OPEN state, disabling automatic servo regulation. SS=0 will also turn off the Laser output. A query of this command (?SS) will return status of the TEC Servos.
“STA”	Type: Query The query ?STA reports the status of the laser. The reply is a number with the following value: 1 := Start Up 2 := Warm Up 3 := Standby 4 := Laser On 5 := Laser Ready 6 := Error
“SVPS”	Type: Query This query is used to read the software version stored in the Power-Supply EEPROM. Read value is numerical, in floating point.

Hours of Operation Display

Besides the readout of head or OEM controller HP hours through the RS-232 interface—Table 3-3 (p. 3-19) has a list of commands—for convenience there exists a binary coded display for the head-hours on the Sapphire OEM controller HP:

Five green LEDs show the hours of operation of the laser head in a binary code:

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

E.g., if D1 & D3 are ON, the head-hours would be 5000 to maximal 5999 hours. The display allows readouts to 31000 hours in 1000 hour increments. The LEDs are located on the upper PCB board of the Sapphire OEM controller HP (see Figure 3-12, below) and marked with "D1"…"D5."

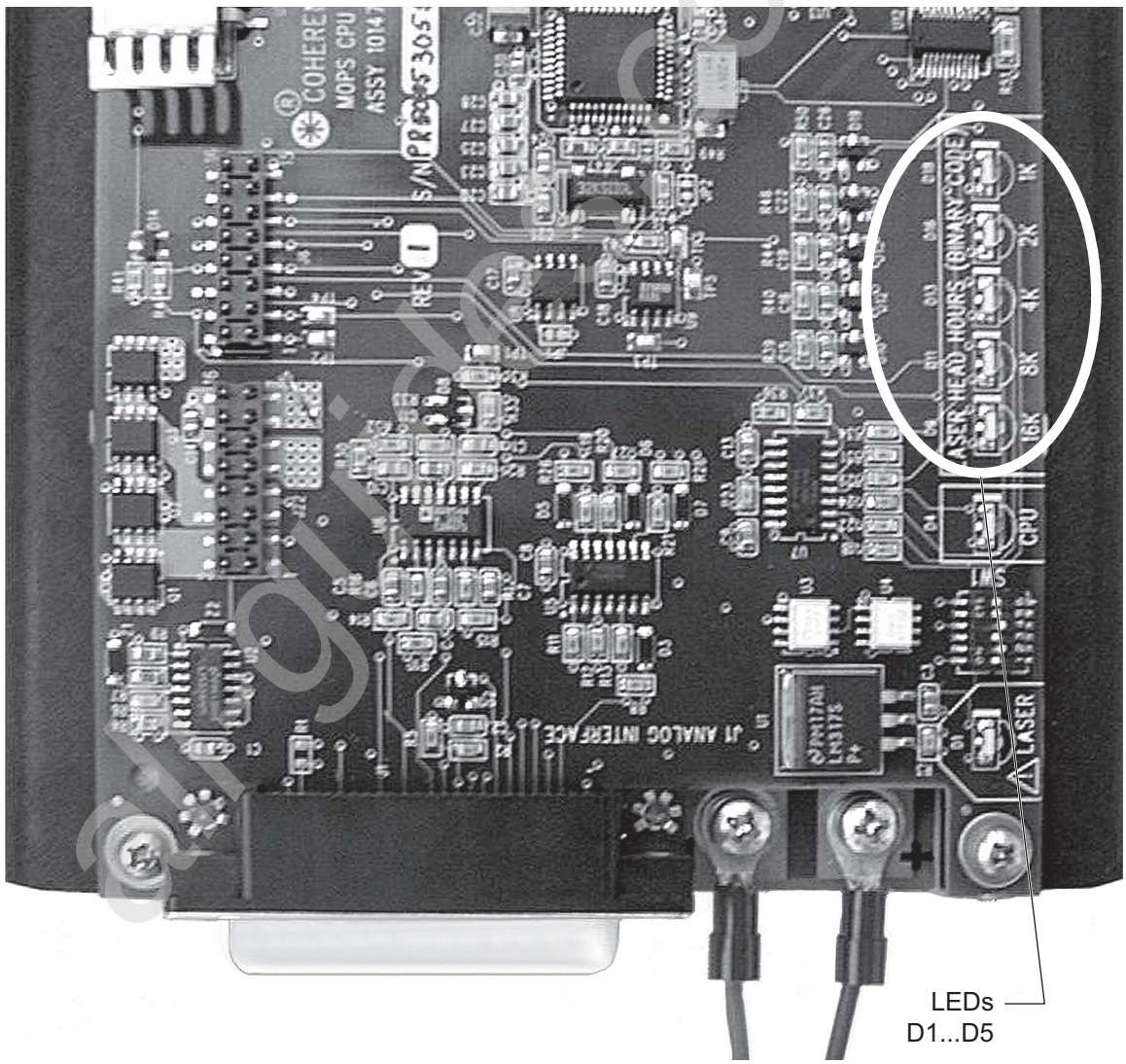


Figure 3-12. LEDs for Head-Hours

SECTION FOUR: TROUBLESHOOTING

If you experience problems with the Sapphire laser system, go through the checklists that appear in this section—refer to "Troubleshooting Procedures" (p. 4-5). If you are not successful in solving the problem, or need further assistance, contact our Technical Support Hotline at 1.800.367.7890 (1.408.764.4557 outside the U.S.), e-mail Product.Support@Coherent.com, or contact your local Coherent service representative.

Cleaning the Beam Output Window

Cleaning the Beam Output window may help restore optimum performance should any of the following circumstances occur:

- The laser output power decreases slightly over long-term operation in a dusty environment. This is especially the case with higher output power, which may ionize dust and deposit it on the aperture window.
- The output beam shows speckles or scattered light around the beam center.
- The beam is not round or transverse mode is not TEM_{00}.
- The output power is unstable.
- The output beam is noisy.

Figure 4-1. Beam Output Window Location

Cleaning Procedure

The laser head is a sensitive device—be careful when cleaning the Beam Output window.

The following supplies are needed to perform the cleaning procedure:

- Cotton swabs (approved for cleaning optical elements). ***The swabs must be dust- and lint-free***.
- Propanol (chemically pure). Follow all safety instructions when handling propanol. ***If you are not sure of the safety instructions, contact your vendor for more information***.

Before starting the cleaning procedure, make sure:

- The laser is powered off and not in operation.
- The output window can be easily accessed for cleaning. Unmount the laser head, if necessary.

Do not open the metallic cover lid under any circumstances. Opening the cover will void the warranty. There are no user-serviceable parts inside.

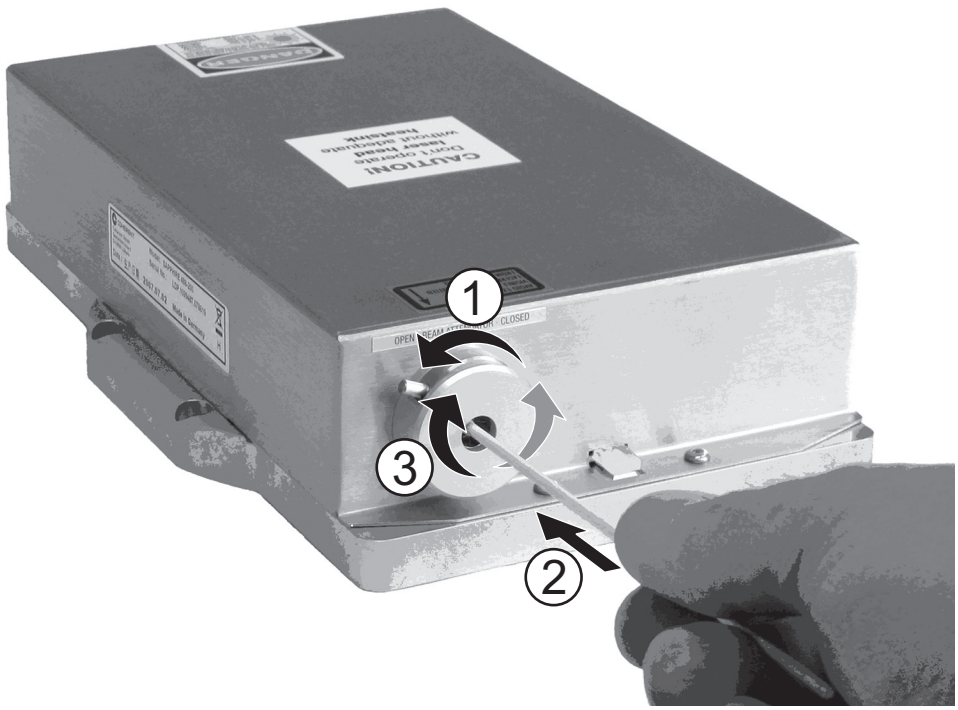


Figure 4-2. Cleaning the Output Window

The procedure:

1. Open the beam shutter—# 1 in Figure 4-2 (p. 4-2).
2. Carefully dip the cotton swab into the propanol. Use just enough propanol to moisten the cotton swab, but not enough to make it drip.
3. ***Using very low pressure***, gently insert the cotton swab into the aperture hole until the swab hits the bottom of the hole—# 2 in Figure 4-2 (p. 4-2).

Avoid dripping liquid into the Beam Output window. Make sure to use very low pressure when cleaning the window with the cotton swab.

---

4. Gently rotate the cotton swab back and forth several times from the center to the sides of the Beam Output window—# 3 in Figure 4-2 (p. 4-2).
5. Let the propanol dry completely and then visually inspect the Beam Output window to make sure that all stains, dust, and dirt have been removed. If the window is not completely clean, repeat the entire cleaning procedure.
6. Reconnect the power source.

Be sure that the propanol is dry before turning on the laser!

---

7. Turn on the laser and examine the output beam. If a problem persists, repeat the entire cleaning procedure.

LED Indicators On The Controller

There are two LEDs—DS1 and DS2—on the OEM controller HP next to the DC Power connector. DS1 indicates a closed interlock loop if SW3-2 is set to the OFF position. When SW3-2 is set to the ON position, DS1 is shorted.

DS2 indicates the working microprocessor.

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

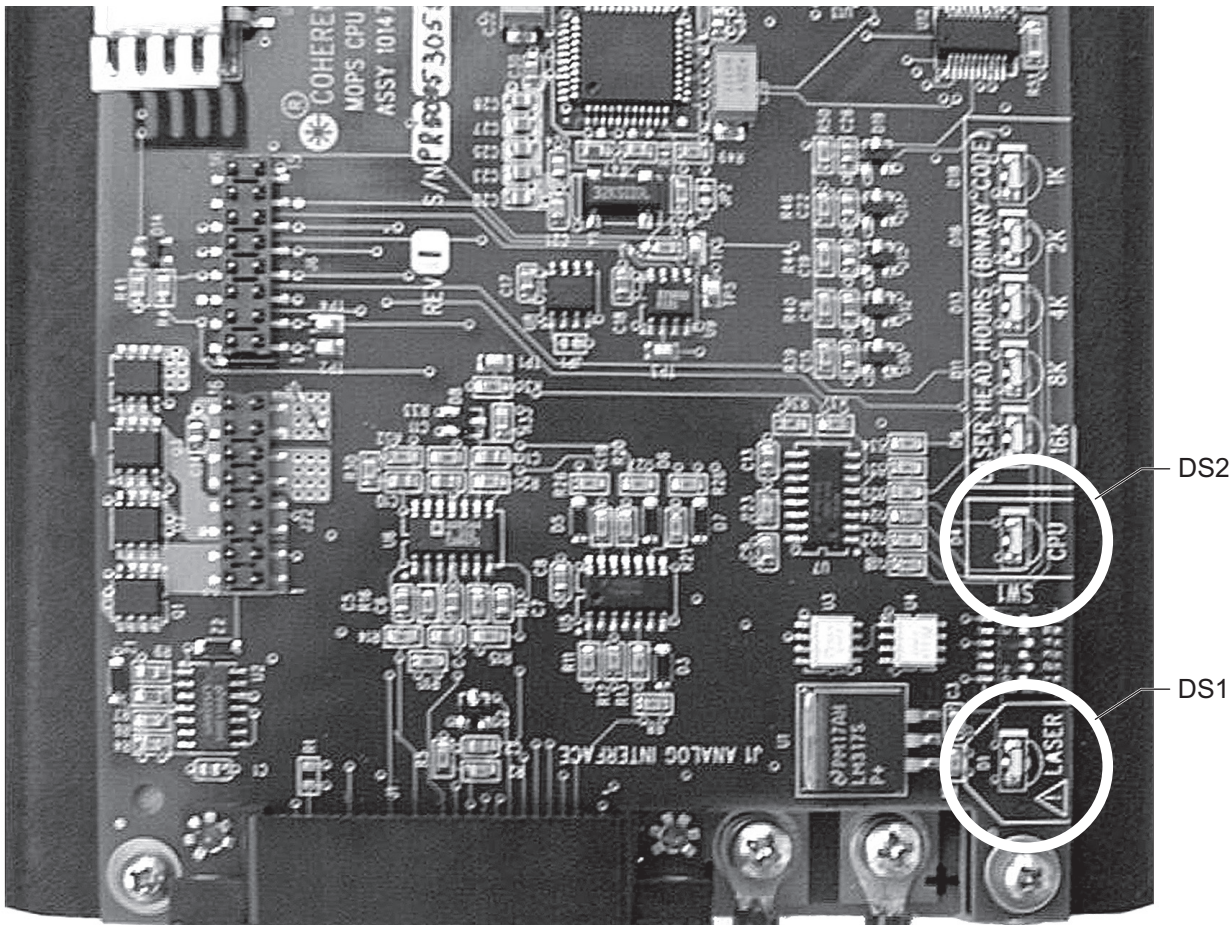


Figure 4-3. LED Indicators on the Controller

Troubleshooting Procedures

The following table lists possible problems, as well as references to the associated troubleshooting checklist located later in this section.

Table 4-1. Faults and Error Messages

PROBLEM	TROUBLESHOOTING REFERENCE
Interlock Chain Not Closed	Checklist 1 (p. 4-6)
System Does Not Turn On	Checklist 2 (p. 4-7)
System Shuts Down (RS-232 Control)	Checklist 3a (p. 4-8)
System Shuts Down (Analog Interface and Autostart)	Checklist 3b (p. 4-8)
Low Power (RS-232 Control)	Checklist 4a (p. 4-9)
Low Power (Analog Control)	Checklist 4b (p. 4-10)
Low Power (Autostart Mode)	Checklist 4c (p. 4-11)
Scattered Light Around the Main Beam (All Operating Modes)	Checklist 5 (p. 4-11)
Output Power Not Stable (All Operating Modes)	Checklist 6 (p. 4-12)
Beam Noise Out of Spec (All Operating Modes)	Checklist 7 (p. 4-12)
Controller Does Not Communicate With RS-232	Checklist 8 (p. 4-12)
Beam is Not Round or Transverse Mode is Not TEM_{oo}	Checklist 9 (p. 4-13)
Base Plate Temperature Exceeds 50ºC, Causing the System to Shut Down	Checklist 10 (p. 4-13))
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.	

Checklist 1: Interlock Chain Not Closed

DS1 indicator light (OEM controller HP, upper PCB, near the DC Power connector) illuminates if the interlock chain is closed. Follow this checklist if DS1 does not turn on.

This checklist assumes DS1 is operational. If the system turns on by turning SW3-3, switch #1, 2, and 3, to the ON position without DS1 illuminating, then DS1 is shorted.

[ ] Set SW3-1, SW3-2, and SW3-3 to the OFF position

[ ] Verify the supply voltage is between 22.8 and 25.2 VDC.

[ ] Place SW3-1, switch 1 to the ON position. If DS1 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 pin 5 and 6 of J3. Make sure the cathode of LED is connected to J3-6.

[ ] Place SW3-3, switch 3 to the ON position. If DS1 turns on, check the 2 position switch (customer-provided), then place SW3-3 back to the OFF position.

[ ] Return the OEM controller HP for repairs if DS1 still does not turn on or if the system does not turn on after the start delay.

[ ] Take into consideration that a delay of > 10 seconds between shut down and restart of the OEM controller HP is recommended.

Checklist 2:
System Does Not Turn On

System should lase about 60 seconds after turn on.

[ ] Verify the supply voltage is between 22.8 and 25.2 VDC and that the power supply is rated at ≥ 75 W (for the 100 and 200 mW versions or ≥ 150W (for the 500 mW version).

[ ] Observe the DS1 indicator light (OEM controller HP, hour PCD, next to the RS-232 (D3) connector). DS1 will illuminate if the interlock chain is closed. Refer to "Checklist 1: Interlock Chain Not Closed" (p. 4-6) if DS1 does not turn on.

[ ] Verify the DS2 indicator light (next to DS1) is blinking at 1 Hz (1 blink per second).

[ ] Replace the OEM controller HP if DS2 is still not blinking at 1 Hz.

[ ] Verify control signals at J1 (if an analog interface is used) or J2 (if an RS-232 used) are according to Table 3-1 (p. 3-14) or Table 3-2 (p. 3-17), respectively.
If you are not sure, position the SW3-3 switches to autostart operation. If the system operates in autostart, check the control signals (analog or RS-232 control).

[ ] If the control signals are ok, replace the OEM controller HP.

[ ] Replace the entire system if DS1 is on and DS2 blinks at 1 Hz but the system does not turn on.

[ ] Take into consideration that a delay of > 10 seconds between shut down and restart of the OEM controller HP is recommended.

[ ] Make sure the mechanical beam shutter is open.

Checklist 3a: System Shuts Down (RS-232 Control)

[ ] Check for proper heat sinking of the laser head—refer to "Checklist 10: Base Plate Temperature Exceeds 50ºC, Causing the System to Shut Down" (p. 4-13).

[ ] 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 and # 5 (assuming the ambient temperature is < 50ºC).

[ ] All other faults—excluding fault #3 and #1—replace the entire system.

[ ] If fault #3, measure the base plate temperature right before shut down. If it is above 50ºC, check for proper heat sinking.

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

[ ] Check for proper grounding of the laser head (head cover should be at earth ground potential).

[ ] Measure the base plate temperature at the time the system shuts down. If it exceeds 50ºC, check for proper heat sinking of the laser head—refer to "Checklist 10: Base Plate Temperature Exceeds 50ºC, Causing the System to Shut Down" (p. 4-13).

[ ] Replace the entire system.

Checklist 4a: Low Power (RS-232 Control)

Measure power only with a calibrated power meter before the beam hits any external optics or 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 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.

[ ] Verify the proper RS-232 command is issued. For example P=100 should result in 100 mW (?P=100 mW).

[ ] If the system does not respond to the ?P command, verify the proper RS-232 set up then replace the computer. If the problem remains, replace the OEM controller HP.

[ ] If the ?P response indicates low power, change the laser head.

[ ] Take into consideration that a delay of > 10 seconds between shut down and restart of the OEM controller HP is recommended.

[ ] Make sure the mechanical beam shutter is open.

[ ] Check the output window for contamination—for example, dust particles. If needed, clean the output window as described under “Cleaning the Beam Output Window” (p. 4-1).

Checklist 4b: Low Power (Analog Control)

Make sure power is measured by a calibrated power meter before it hits any external optics, or use an analog interface connector (J1, Pin 8+, 10-) to obtain an output power measurement (2V = 100%).

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

[ ] Adjust the voltage at J1, Pins 7+, 10- to 3.740V (100 and 200 mW versions); 4.096V (500 mW version)—this equals 100% of the nominal output power.

[ ] If measured power is low, the most likely cause is a defective laser head but the OEM controller HP can not be completely ruled out. Replace the laser head first. If power is still low, replace the OEM controller HP.

[ ] Take into consideration that a delay of > 10 seconds between shut down and restart of the OEM controller HP is recommended.

[ ] Make sure the mechanical beam shutter is open.

[ ] Check the output window for contamination—for example, dust particles. If needed, clean the output window as described under "Cleaning the Beam Output Window" (p. 4-1).

Checklist 4c: Low Power (Autostart Mode)

Make sure power is measured by a calibrated power meter before it hits any external optics, or use pins 8+, 10- or J1 (Analog interface connector) to obtain and output power measurement (2 V = 100%).

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

[ ] If measured power is less than maximum, the most likely cause is a defective laser head but and OEM controller HP can not be ruled out. Replace the laser head first.

[ ] When using autostart mode, power will be adjusted to the last setting. Systems shipped from Coherent are adjusted to operate at nominal output power. If RS-232 or the analog interface has been used prior to autostart, reconfigure the system to operate in RS-232 or analog mode and adjust the output power to maximum, then reconfigure the system to operate in autostart. This is necessary because the last set laser output power is automatically stored in non-volatile memory in the laser head.

[ ] Take into consideration that a delay of > 10 seconds between shut down and restart of the OEM controller HP is recommended.

[ ] Make sure the mechanical beam shutter is open.

[ ] Check the output window for contamination—for example, dust particles. If needed, clean the output window as described under “Cleaning the Beam Output Window” (p. 4-1).

Checklist 5: Scattered Light Around the Main Beam (All Operating Modes)

[ ] Beam is observed prior to hitting any external optics.

[ ] Replace the laser head.

[ ] Check the output window for contamination—for example, dust particles. If needed, clean the output window as described under “Cleaning the Beam Output Window” (p. 4-1).

Checklist 6:
Output Power Not Stable (All Operating Modes)

- [ ] Make sure power is measured before it hits any external optics.
- [ ] Allow the system to warm up for at least 5 minutes.
- [ ] Verify all cable connections are secure.
- [ ] If an analog interface is used, measure the output power control signal (J1, pin 7+, 10-) to make sure it is stable.
- [ ] Measure baseplate temperature over a 5 minute period. If baseplate temperature is not stable, check for proper heat sinking (refer to checklist #10).
- [ ] If power still fluctuates, the most likely cause is a defective laser head but OEM controller HP can not be completely ruled out.
- [ ] Take into consideration that a delay of > 10 seconds between shut down and restart of the OEM controller HP is recommended.

Checklist 7:
Beam Noise Out of Spec (All Operating Modes)

- [ ] Make sure beam noise is measured before a beam hits any external optics.
- [ ] Check for proper heat sinking.
- [ ] Verify there is no vibrations at the laser head.
- [ ] Check for proper grounding of the head cover.
- [ ] Replace the laser head.
- [ ] If customized power supply is used, make sure that it is below the recommended noise range—refer to Table 2-1 (p. 2-6).

Checklist 8:
Controller Does Not Communicate With RS-232

- [ ] Verify all connections are secure.
- [ ] Verify the RS-232 setting (baud rate, etc.)—refer to "Controlling the Laser via an RS-232 Command Interface" (p. 3-16).
- [ ] Make sure a straight (1-to-1) cable is used to connect the computer to the OEM controller HP. The length should not exceed 5 m.
- [ ] Use a second computer to exclude a defective computer RS-232 port.
- [ ] Replace the OEM controller HP.

Checklist 9:
Beam is Not Round or Transverse Mode is Not TEM_{oo}

- [ ] Make sure a beam is observed before it hits any external optics.
- [ ] Replace the laser head.

Checklist 10:
Base Plate Temperature Exceeds 50ºC, Causing the System to Shut Down

- [ ] Verify the proper size of the heat sink—refer to "Heat Sink Requirements" (p. 3-2).
- [ ] Verify proper operation of the heat sink (for example, 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.
- [ ] Verify the surface of the heat sink contacting the laser head is not bent.
- [ ] Verify the ambient temperature does not exceed 40ºC.
- [ ] Take into consideration that a delay of > 10 seconds between shut down and restart of the OEM controller HP is recommended.

SECTION FIVE: REPACKING PROCEDURE

The section contains the factory recommended repacking procedure for the Sapphire laser system. This procedure should be followed if the laser system is to be shipped to another location after initial installation, or returned to the factory for service.

It is recommended that you save the shipping box and packing materials, since these will be useful should you need to ship the laser.

The Sapphire laser system requires two shipping boxes, available as a set with part number TBD. Table 5-1, below, gives a complete listing of the contents of the shipping crate when the system is shipped from Coherent.

Table 5-1. Sapphire 488 HP Shipping Box Contents

1. Laser Head
2. Controller
3. Optional DC Power Supply
4. Optional Heat Sink
5. Laser Head Cable
6. Connector Kit
7. Operator's Manual

Close the beam shutter during transportation.

Figure 5-1. Beam Shutter Closed

Place all of the components back into original protective plastic bags before shipping!

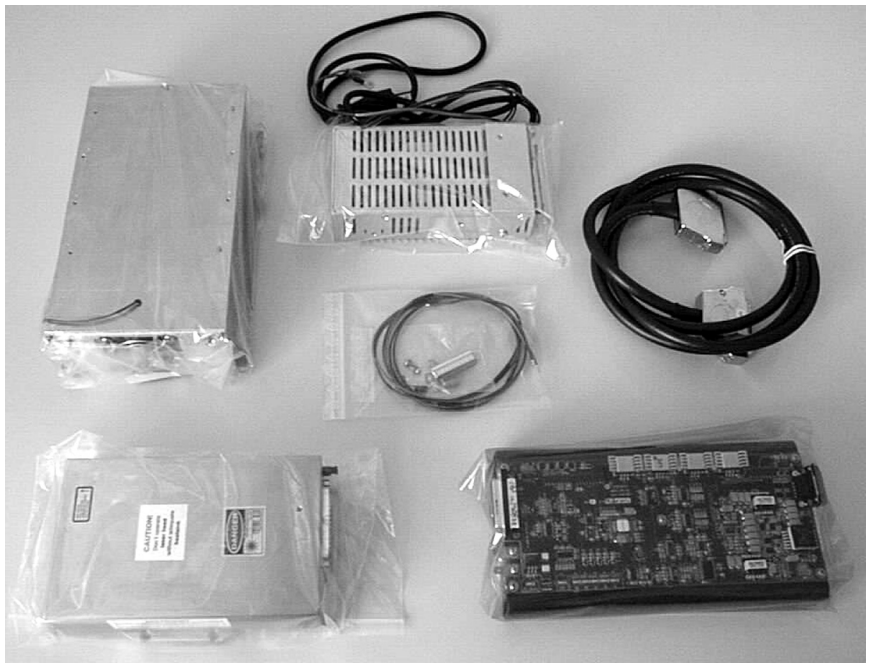


Figure 5-2. Packed Laser Components

Place the laser head and the OEM controller HP between foils for maximum protection in box 1.

Figure 5-3. Place Controller Between Foils

Figure 5-4 shows the proper arrangement of the Sapphire 488 HP laser system in box 1.

Figure 5-4. Proper Arrangement of Box 1 Before Shipping

Place the power supply and the heat sink into the foam material for maximum protection in box 2.

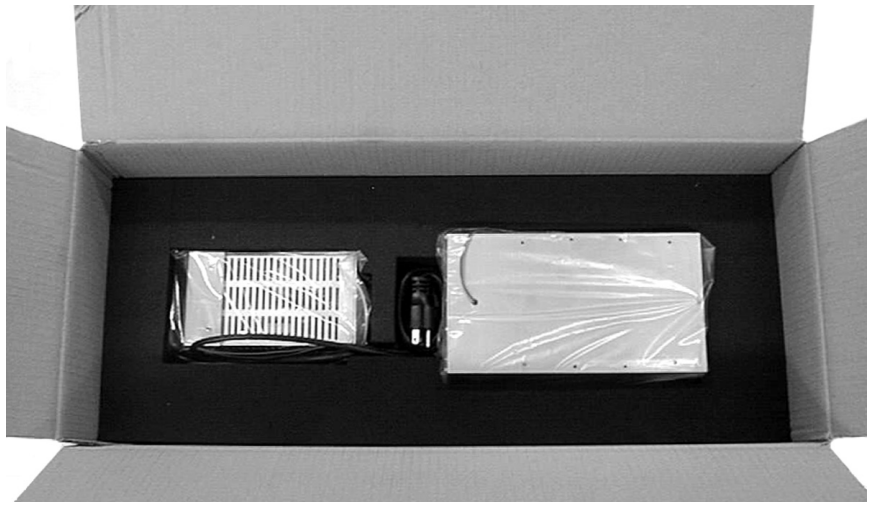


Figure 5-5. Proper Arrangement of Heat Sink and Power Supply in Box 2

Place the foam material cover on top of the unit before closing Box 1.

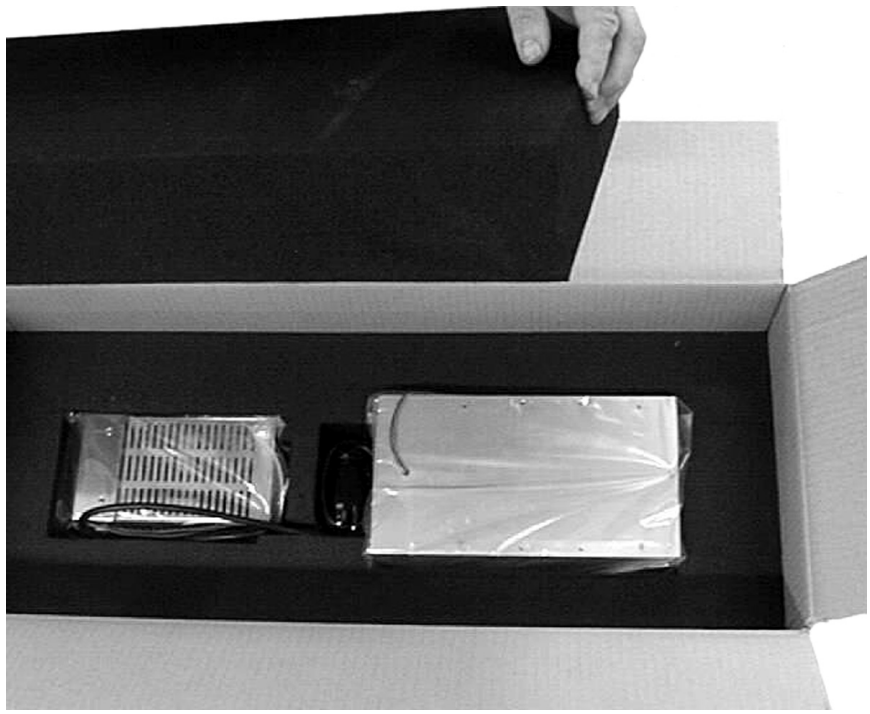


Figure 5-6. Place Power Supply and Heat Sink Between the Foam Material

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, 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.

APPENDIX B: ACCESSORIES

Power Meter Accessories

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

For the most common diagnostics 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.

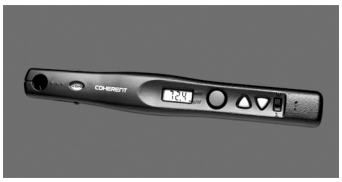
There are two primary sensor options for this meter:

- The PS10 provides high-resolution measurements—100 µW to 1W—and is best utilized for applications such as stability monitoring.
- The PS10Q—which offers measurements of 100 µW to 1W—is a thermally stabilized, amplified thermopile power sensor with a broad spectral response, high sensitivity, and a large active area.

	PART NUMBER
FieldMaxII-TO Laser Power Meter (RoHS)	1098579
PS10 Thermopile Sensor (CE) (RoHS)	1098350
PS10Q Thermopile Sensor with quartz aperture window (CE) (RoHS)	1098400

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 sensor head does not fit. With its built-in attenuator, this device is ready to measure output powers from 0.5 µW to 1 W.



	PART NUMBER
LaserCheck Laser Power Meter (RoHS)	1098293

GLOSSARY

°C	Degrees centigrade or Celsius
°F	Degrees Fahrenheit
µ	Micron(s)
µm	Micrometer(s) = 10^{-6} meters
µrad	Microradian(s) = 10^{-6} radians
µsec	Microsecond(s) = 10^{-6} seconds
$1/e^2$	Beam diameter parameter = 0.13534
AC	Alternating current
ADC	Analog-to-digital converter
Amp	Ampere(s)
CDRH	Center for Devices and Radiological Health
cm	Centimeter(s)
CPU	Central processing unit
DC	Direct current
EEPROM	Electrically erasable programmable read only memory
EMI	Electro Magnetic Interface
g	Gram(s) or earth's gravitational force (gravity)
GND	Ground
Hz	Hertz or cycles per second (frequency) (= 1/pulse period)
IR	Infrared (wavelength)
kg	Kilogram(s) = 10^3 grams
KHz	Kilohertz = 10^3 hertz
Kohm	Kilohm(s)
LD	Laser diode
LED	Light emitting diode
m	Meter(s) (length)
mA	Milliamp(s) = 10^{-3} Amperes
mAmp	Milliampere(s)
MHz	Megahertz = 10^6 hertz
mm	Millimeter(s) = 10^{-3} meters
mrad	Milliradian(s) = 10^{-3} radians (angle)
ms	Millisecond(s) = 10^{-3} seconds
mV	Millivolt(s)
mW	Milliwatt(s) = 10^{-3} Watts (power)
nm	Nanometer(s) = 10^{-9} meters (wavelength)
OEM	Original equipment manufacturer
OPS	Optically pumped semiconductor

OPSL	Optically pumped semiconductor laser
PCB	printed circuit board
rms	Root mean square (effective value of a sinusoidal wave)
RXD	Receive data
TEC	Thermo-electric cooler
TEM	Transverse electromagnetic mode (cross-sectional laser beam mode)
TTL	Transistor-to-transistor logic
TXD	Transmit data
V	Volt(s)
VAC	Volts, alternating current
VDC	Volts, direct current
VECSEL	Vertical External Cavity Surface Emitting Laser
W	Watt(s) (power)

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