# Excelsior

## Diode-Pumped, CW Lasers

*User's Manual*

This laser product complies with performance standards of United States Code of Federal Regulations, Title 21, Chapter 1 – Food and Drug Administration, Department of Health and Human Services, Subchapter J – Parts 1040.10 or 1040.11, as applicable.

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# Preface

This manual contains information you need in order to safely install, operate and service your *Excelsior* diode-pumped CW laser. An *Excelsior* system consists of one of several models of laser head that produce laser light from 1064 nm to 473 nm, along with one of two very similar *Excelsior* power supplies. The power supplies are small, stand-alone units that provide power, control and monitoring functions for the laser.

Chapter 1, "Introduction," contains a brief description of the laser system, its components and patent information.

Chapter 2, "Laser Safety," is required reading before the system is installed and operated. *Excelsior* lasers are Class 3b or Class 4 devices and, as such, emit laser radiation that can cause permanent eye damage. Chapter 2 contains descriptions of these hazards as well as information on how to safeguard against them. Included are descriptions of the laser labels and safety devices. To minimize the risk of injury or need for expensive repairs, be sure to read this chapter and carefully follow its instructions.

Chapter 3, "Laser Description," contains a short section on laser theory regarding the principles used in the *Excelsior* laser. The theory section is followed by a more detailed description of the *Excelsior* laser and concludes with specifications for the various *Excelsior* models.

Chapter 4, "Controls, Indicators, and Connections," describes the various features of the system.

Chapter 5, "Installation," describes the procedures and requirements for installing the laser and power supply/controller.

Chapter 6, "Operation," describes methods of operating the laser using the power supply by itself or, optionally, using analog signals provided through the power supply interface to operate it remotely.

Chapter 7, "Troubleshooting and Service," will help guide you to the source of any problems with the laser. *Do not attempt repairs yourself while the unit is still under warranty*; instead, report all problems to Spectra-Physics for warranty repair.

The "Customer Service," section in Chapter 7 provides information regarding service calls and warranty issues. Should you experience any problems with the your *Excelsior* laser, or if you are in need of technical information or support on any issues related to its use, refer to the list of world-wide Spectra-Physics service centers in this section.

Every effort has been made to ensure that the information in this manual is accurate. All information in this document is subject to change without notice. Spectra-Physics makes no representation or warranty, either express or implied, with respect to this document.

In no event will Spectra-Physics be liable for any direct, indirect, special, incidental or consequential damages resulting from any defects in this documentation.

Finally, if you encounter any difficulty with the content or style of this manual, or encounter problems with the laser itself, please let us know. At the end of this manual is a form to aid in bringing such problems to our attention.

Thank you for your purchase of Spectra-Physics instruments.

# Environmental Specifications

## CE Electrical Equipment Requirements

For information regarding the equipment needed to provide the electrical service requirements listed in “Specifications” on page 3-10, please refer to specification EN-309, “Plug, Outlet and Socket Couplers for Industrial Uses,” listed in the official *Journal of the European Communities.*

## Environmental Specifications

The environmental conditions under which the laser system will function are listed below:

**Indoor use**

| | |
|---|---|
| Vibration: | $< 1.5$ m/s$^2$ (0.15 G), 15 Hz−200 Hz |
| Laser Head | |
| Temperature: | 10°C to 40°C |
| Maximum relative humidity: | < 80% non-condensing over the allowed temperature range |
| Insulation category: | II |
| Pollution degree: | 2 |

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# Warning Conventions

The following warnings are used throughout this manual to draw your attention to situations or procedures that require extra attention. They warn of hazards to your health, damage to equipment, sensitive procedures, and exceptional circumstances. All messages are set apart by a thin line above and below the text as shown here.

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**Danger! Laser Radiation** — Laser radiation is present.

**Danger!** — Condition or action may present a hazard to personal safety.

**Danger!** — Condition or action may present an electrical hazard to personal safety.

**Warning!** — Condition or action may cause damage to equipment.

**Warning! ESD** — Action may cause electrostatic discharge and cause damage to equipment.

**Caution!** — Condition or action may cause poor performance or error.

**Note** — Text describes exceptional circumstances or makes a special reference.

**Don't Touch!** — Do not touch.

**Eyewear Required** — Appropriate laser safety eyewear should be worn during this operation.

Refer to the manual before operating or using this device.

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# Standard Units

The following units, abbreviations, and prefixes are used in this Spectra-Physics manual:

| Quantity | Unit | Abbreviation |
|---|---|---|
| mass | kilogram | kg |
| length | meter | m |
| time | second | s |
| frequency | hertz | Hz |
| force | newton | N |
| energy | joule | J |
| power | watt | W |
| electric current | ampere | A |
| electric charge | coulomb | C |
| electric potential | volt | V |
| resistance | ohm | Ω |
| inductance | henry | H |
| magnetic flux | weber | Wb |
| magnetic flux density | tesla | T |
| luminous intensity | candela | cd |
| temperature | Celsius | C |
| pressure | pascal | Pa |
| capacitance | farad | F |
| angle | radian | rad |

| Prefixes | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| tera | ($10^{12}$) | T | deci | ($10^{-1}$) | d | nano | ($10^{-9}$) | n |
| giga | ($10^{9}$) | G | centi | ($10^{-2}$) | c | pico | ($10^{-12}$) | p |
| mega | ($10^{6}$) | M | milli | ($10^{-3}$) | m | femto | ($10^{-15}$) | f |
| kilo | ($10^{3}$) | k | micro | ($10^{-6}$) | μ | atto | ($10^{-18}$) | a |

# Unpacking and Inspection

## Unpacking Your Laser

Your *Excelsior* laser was packed with great care, and its container was inspected prior to shipment—it left Spectra-Physics in good condition. Upon receiving your system, immediately inspect the outside of the shipping container. If there is any major damage (holes in the container, crushing, etc.), insist that a representative of the carrier be present when you unpack the contents.

Carefully inspect your laser system as you unpack it. If any damage is evident, such as dents or scratches on the covers, etc., immediately notify the carrier and your Spectra-Physics sales representative.

**Keep the shipping container.** If you file a damage claim, you may need it to demonstrate that the damage occurred as a result of shipping. If you need to return the system for service at a later date, the specially designed container assures adequate protection.

## System Components

Two components comprise an *Excelsior* laser system:

- *Excelsior* laser head
- *Excelsior* power supply

The power supply and laser head are fairly light and can be handled easily by one person.

Verify both components are present. The laser head and power supply are shipped in one container.

## Accessories

Included with the laser is this manual, a packing slip listing all the parts shipped and an accessory kit. The following accessories are shipped standard with the system:

- 1 LASER HEAD cable, 1.8 m (6 ft)
- 1 REMOTE interlock jumper plug
- 1 power cord
  Japan: 2 m (PSE compliant)
  All others: 2 m (UL, CSA compliant) and 2.5 m (SEMKO, NEMKO, FIMKO, DEMKO, KEMA, VDE, SEV and ÖVE compliant)
- 2 sets of keys

# Chapter 1 Introduction

## General Information


**Figure 1-1: The Standard DPSS *Excelsior* Laser Head**

Spectra-Physics *Excelsior* lasers produce a continuous laser beam from an exceptionally compact package. These small, rugged, diode-pumped, solid-state lasers are especially well suited for applications requiring a low-noise, high quality, continuous wave (CW) beam. All *Excelsior* lasers are designed to operate at constant output power. However, several models allow the operator to vary laser power from 50% to 100% via an external interface. Table 1-1 on page 1-2 lists the different models.

These lasers deliver efficient, stable light with the excellent spatial mode that is critical for applications in graphics, photo finishing and flow cytometry. Individual *Excelsior* models operate in either single or multiple longitudinal mode. Again, refer to Table 1-1.

The *Excelsior* laser heads are designed for precision mounting and alignment of the beam, which, together with the specified boresight of the output, simplifies the task of designing the master optical train, or replacing a laser head in the master system. All optical components, including the diode pump source, are contained in the laser head itself.

The lasers are powered and controlled by a small, separate power supply/controller unit. The power supply interface allows the laser to be monitored and operated using analog signals applied to the connector on the back of the power supply. All *Excelsior* models use a similar power supply to deliver electrical power to the laser head through the cable provided with the system.

**Note** Excelsior laser heads are completely interchangeable with same models, as are the power supplies. In case the laser head or power supply needs to be exchanged, the new unit is simply fastened in place and the cabling connected. No adjustment or calibration is needed.

### Table 1-1: *Excelsior* Lasers[1]

| Excelsior Model | Power | Longitudinal Mode | Adjustable? |
|---|---|---|---|
| Excelsior-473-10-CDRH | 10 mW@ 473 nm | single | 50 to 100% |
| Excelsior-473-50-CDRH | 50 mW@ 473 nm | single | 50 to 100% |
| Excelsior-505-20-CDRH | 20 mW@ 505 nm | multi | 50 to 100% |
| Excelsior-515-50-CDRH | 50 mW@ 515 nm | single | 50 to 100% |
| Excelsior-532-20M-CDRH | 20 mW @532 nm | multi | no |
| Excelsior-532-50-CDRH | 50 mW @532 nm | single | 50 to 100% |
| Excelsior-532-100-CDRH | 100 mW @532 nm | single | 50 to 100% |
| Excelsior-532-150-CDRH | 150 mW @532 nm | single | 50 to 100% |
| Excelsior-532-200-CDRH | 200 mW @532 nm | single | 50 to 100% |
| Excelsior-532-300-CDRH | 300 mW @532 nm | single | no |
| Excelsior-542-50-CDRH | 50 mW @542 nm | single | 50 to 100% |
| Excelsior-561-20-CDRH | 20 mW @561 nm | single | 50 to 100% |
| Excelsior-561-50-CDRH | 50 mW @561 nm | single | 50 to 100% |
| Excelsior-561-100-CDRH | 100 mW @561 nm | single | 50 to 100% |
| Excelsior-561-150-CDRH | 150 mW @561 nm | single | 50 to 100% |
| Excelsior-594-50-CDRH | 50 mW @594 nm | multi | 50 to 100% |
| Excelsior-1064-500-CDRH | 500 mW @1064 nm | single | 50 to 100% |
| Excelsior-1064-800-CDRH | 800 mW @1064 nm | single | 50 to 100% |

[1] *Values are for illustration only; refer to Chapter 3 for specified values.*

### Table 1-2: *Excelsior* Power Supply/Controllers

| Power Supply Models | Used With These Lasers |
|---|---|
| Excelsior-PS-CDRH | Excelsior-473-10/50-CDRH<br>Excelsior-532- 20M-CDRH<br>Excelsior-532-50/100/150/200-CDRH<br>Excelsior-542-50-CDRH<br>Excelsior-561-25/50-CDRH<br>Excelsior-1064-500/800-CDRH |
| Excelsior-PS-XC-CDRH | Excelsior-505-20-CDRH<br>Excelsior-515-50-CDRH<br>Excelsior-532-300-CDRH<br>Excelsior-561-100/150-CDRH<br>Excelsior-594-50-CDRH |

## Patents

The *Excelsior* lasers are manufactured under one or more of the following US patents:

| | |
|---|---|
| 4,756,003 | |
| 4,872,177 | |
| 5,870,415 | |
| 7,189,703 | |
| 3,046,562 | (Japanese patent) |

# Chapter 2 Laser Safety

**Danger!** Laser Radiation

The Spectra-Physics *Excelsior* lasers are *Class IIIb and Class 4—High Power Lasers* whose beams are, by definition, safety hazards. Take precautions to prevent accidental exposure to both direct and reflected beams. Diffuse as well as specular beam reflections can cause severe eye damage.

*Because the infrared (IR) beam of the 1064 nm lasers is invisible, it is especially dangerous.* Infrared radiation passes easily through the cornea of the eye, which, when focussed on the retina, can cause instantaneous and permanent damage!

Always wear proper eye protection when working on the laser and follow the safety precautions given in this chapter. Refer to the product model number label for wavelength (nm).

**Note**

This user information is in compliance with section 1040.10 of the *CDRH Laser Products Performance Standards* from the Health and Safety Act of 1968.

## General Hazards

Hazards associated with the use of diode-pumped lasers generally fall into the categories listed below. At all times while working with these lasers, please be aware of these potential hazards and act accordingly. You are responsible for your health and the health of those working around you.

- Exposure to laser radiation can result in damage to the eyes or skin.
- Exposure to chemical hazards, such as particulate matter or gaseous substances, can be health hazards when they are released as a result of laser material processing or as by-products of the lasing process itself. When these lasers are used to pump dye laser systems, be aware that the dyes used can be extremely hazardous to your health if inhaled or, in some cases, even touched.
- Exposure to high-voltage electrical circuits present in the laser power supply and associated circuits can result in shock or even death.
- Possible health risks are present if pressurized hoses, cylinders, liquids and gasses used in laser systems are damaged or misused.

## Precautions for the Safe Operation of Class IIIb High Power Lasers

- Wear protective eyewear at all times; selection depends on the wavelength and intensity of the radiation, the conditions of use, and the visual function required. Protective eyewear is available from suppliers listed in the *Laser Focus World*, *Lasers and Optronics*, and *Photonics Spectra* buyer's guides. Consult the ANSI and ACGIH standards listed at the end of this section for guidance.
- Maintain a high ambient light level in the laser operation area so the eye's pupil remains constricted, reducing the possibility of damage.
- To avoid unnecessary radiation exposure, keep the protective cover on the laser head at all times.
- Avoid looking at the output beam; diffuse reflections are hazardous.
- Establish a controlled access area for laser operation. Limit access to those trained in the principles of laser safety.
- Enclose beam paths wherever possible.
- Post prominent warning signs near the laser operating area (Figure 2-1).
- Install the laser so that the beam is either above or below eye level.
- Set up shields to prevent any unnecessary specular reflections or beams from escaping the laser operation area.
- Set up a beam dump to capture the laser beam and prevent accidental exposure (Figure 2-2).


**Figure 2-1: These standard safety warning labels are appropriate for use as entry warning signs (EN 60825-1: 2007, ANSI Z136.1, Section 4.7).**

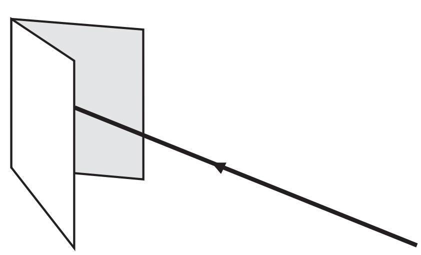


**Figure 2-2: Folded Metal Beam Target**

**Danger!**
Laser Radiation

Use of controls or adjustments, or performing the procedures described in this manual in a manner other than specified may result in hazardous radiation exposure.

**Danger!**

Operating this laser without due regard for these precautions or in a manner that does not comply with recommended procedures may be dangerous. At all times during installation, maintenance or service of your laser, avoid unnecessary exposure to laser or collateral radiation* that exceeds the accessible emission limits listed in "Performance Standards for Laser Products," *United States Code of Federal Regulations*, 21CFR1040.10(d).

* *Any electronic product radiation, except laser radiation, emitted by a laser product as a result of or necessary for the operation of a laser incorporated into that product.*

Follow the instructions contained in this manual to ensure proper installation and safe operation of your laser.

## Safety Devices

Figure 2-3 and Figure 2-4 (on the next page) show the locations of the safety devices on the laser head and power supply.

The laser head includes a manually operated shutter. All control and monitoring of the laser is through the power supply or, optionally, through the CONTrol connector on the power supply back panel.

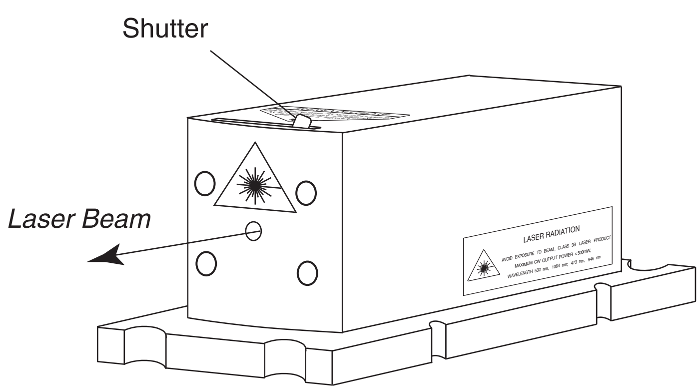



**Figure 2-3: Laser Head Manual Shutter**

**Note**

There is no emission indicator on the laser head itself. In order to remain in compliance with CDRH Standards, the laser head must be operated using the 1.8 meter laser control cable provided with the system. When connected to the power supply, this cable keeps the laser head within the CDRH-specified distance from the emission indicator located on the power supply front panel.

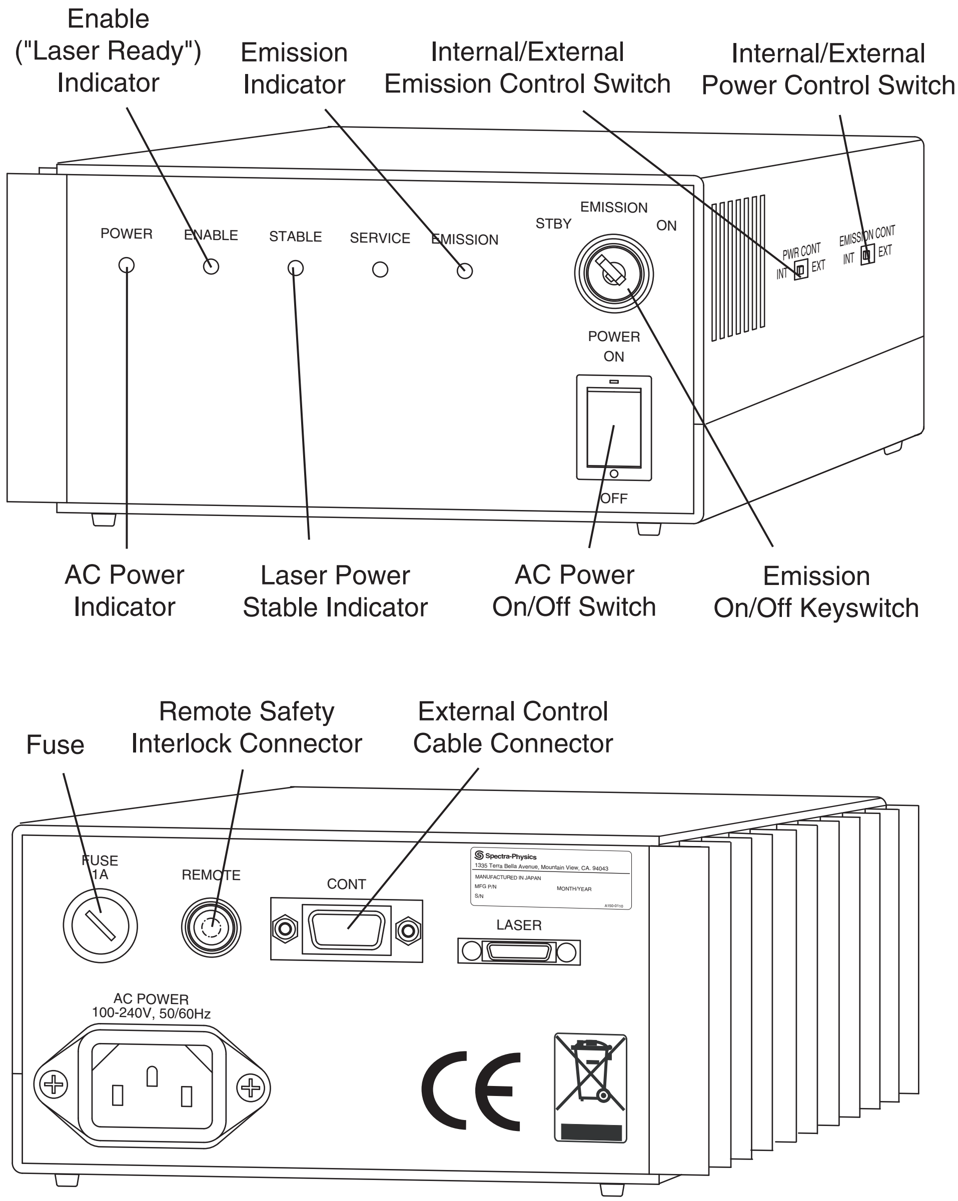



**Figure 2-4:** ***Excelsior*** **Power Supply Safety Devices**

### *On/Off AC Power Switch*

Turning on the POWER rocker switch activates the power supply circuitry, as indicated by the white POWER indicator on the front panel. Activating this switch begins the process of warming the laser head components to operating temperature, which typically takes between 2 and 5 minutes.

### *AC Power Indicator*

This indicator turns on when the ac power is turned on.

### *Enable Indicator*

When the laser head components have warmed to their operating temperature (following turning on the POWER switch), this indicator glows steadily. The laser is now ready to operate.

### *Emission Keyswitch*

The keyswitch provides interlock safety to prevent unauthorized personnel from using the laser when the key is turned to the STBY position and removed.

If the POWER switch has been turned on and the ENABLE indicator is on and the EMISSION CONTROL switch has been set to INT, turning on the EMISSION keyswitch will turn on the laser (following a safety delay of 3 to 5 seconds). If the shutter is open, the laser will emit a laser beam.

Optionally, if the EMISSION CONTROL switch has been set to EXT, the *Excelsior* laser can be turned on when a suitable control signal is applied to Pin 2 of the CONTrol connector on the back of the power supply. See Chapter 6 for details of this method of operation.

### *Stable Indicator*

This indicator turns on when laser power reaches its set value and becomes stable, and it remains on as long as laser power is stable. The laser typically reaches its set operating power and becomes stable about 10 seconds (DPSS-CDRH) or 30 seconds (DPSS-XC-CDRH) after turning on the EMISSION keyswitch or after an *On* command has been received at Pin 2 of the CONTrol interface connector.

### *Emission Indicator*

This indicator turns on when the EMISSION keyswitch is turned on (see the prerequisites for turning on the keyswitch above), and emission occurs 3 to 5 seconds later. (Note: this indicator does not blink during the delay as it does on some other laser systems).

If the REMOTE interlock circuit is opened (see the description below), laser emission stops immediately and this indicator turns off. If the REMOTE interlock switch is then closed again, one of the following actions occur:

- On a standard Class 3b laser or extended cavity (XC) laser, if the keyswitch is still in the ON position, the EMISSION indicator turns on again immediately and the laser turns on again following a safety delay of 3 to 5 seconds.
- On a standard Class 4 laser, if the keyswitch is still in the ON position, the keyswitch must first be turned off, then back on again in order to resume operation. After it is turned back on, the EMISSION indicator turns on again and the laser will turn on again after a safety delay of 3 to 5 seconds.

Pin 1 of the CONTrol connector can be used to control an external emission indicator. See Chapter 6 for an example of a circuit used for this purpose.

## *Internal/External Emission Control Switch*

This slide switch provides the option to turn the laser on and off by means of the EMISSION keyswitch, or via a signal applied to Pin 2 on the CONTrol connector on the back of the power supply. See Chapter 6 for details on how to use this option.

## *Internal/External Power Control Switch*

The PWR CONTROL switch, when set to EXT, is used to enable external control of laser output power for all *Excelsior* lasers. When set to INT, output is at full power. INT is also the required setting for operating the lower-power *Excelsior* lasers. Output power is controlled externally by means of an analog signal applied to Pin 8 of the CONTrol connector on the back of the power supply. See Chapter 6 for details on how to use this option.

## *Safety Interlocks*

### Safety Interlock

The 2-pin REMOTE interlock connector on the back of the power supply can be wired to one or more external, normally-closed safety switches, all wired in series, to stop laser emission in the event any one of these switches is opened. Such a switch is typically attached to a laboratory door or critical access point so that the switch opens when the door is opened, thus turning off the laser.

To ensure that the laser can operate when this interlock is not used, the system is shipped with a shorting jumper plug (Figure 2-5) that closes the interlock control loop.

**Figure 2-5: REMOTE Interlock Jumper Plug**

### Cover Safety Interlocks

Do not open the *Excelsior* laser head or power supply covers. The system is not designed to be operated with its covers removed. Therefore, the units do not have cover safety interlocks.

When the diode pump laser in the *Excelsior* head requires replacement, the entire laser head is replaced as a unit. Before starting any replacement procedure, the power supply must be disconnected from the AC outlet.

## Maximum Emission Levels

The following are the maximum emission levels possible for the different *Excelsior* laser systems. Use this information for selecting appropriate laser safety eyewear and implementing appropriate safety procedures. These values do not imply actual system specifications.

**Table 2-1: Maximum Emission Levels**

| Emission Wavelength | Design Power | Maximum Output Power |
|---|---|---|
| 808 nm Diode | | 0.1 W |
| 473 nm Laser Head | 10 mW | 0.1 W |
| 473 nm Laser Head | 50 mW | 0.1 W |
| 505 nm Laser Head | 20 mW | 0.1 W |
| 515 nm Laser Head | 50 mW | 0.3 W |
| 532 nm Laser Head | 20 mW | 0.5 W |
| 532 nm Laser Head | 50 mW | 0.5 W |
| 532 nm Laser Head | 100 mW | 0.5 W |
| 532 nm Laser Head | 150 mW | 0.5 W |
| 532 nm Laser Head | 200 mW | 0.5 W |
| 532 nm Laser Head | 300 mW | 0.5 W |
| 542 nm Laser Head | 50 mW | 0.3 W |
| 561 nm Laser Head | 25 mW | 0.2 W |
| 561 nm Laser Head | 50 mW | 0.2 W |
| 561 nm Laser Head | 100 mW | 0.3 W |
| 561 nm Laser Head | 150 mW | 0.3 W |
| 594 nm Laser Head | 50 mW | 0.3 W |
| 1064 nm Laser Head | 500 mW | 1.5 W |
| 1064 nm Laser Head | 800 mW | 1.5 W |

## Requirements for Safely Operating the Excelsior Laser with a User-Provided Control Device

When the *Excelsior* laser system is controlled by a device provided by the user or by software written by the user, the following must be provided:

- **A keyswitch**—that limits access to the laser and prevents it from being turned on. It can be a real key lock, a removable computer disk, a password that limits access to computer control software, or a similar "key" implementation. The laser must only operate when the "key" is present and in the "on" position.
- **An emission indicator**—that indicates laser energy is present or can be accessed. It can be a "power-on" lamp, a computer display that flashes a statement to this effect, or an indicator on the control equipment for this purpose. It need not be marked as an emission indicator so long as its function is obvious. Its presence is required on any control panel that affects laser output.

## Schedule of Maintenance in Accordance with Center for Devices and Radiological Health (CDRH) Regulations

This laser product complies with Title 21 of the *United States Code of Federal Regulations*, Chapter 1, subchapter J, parts 1040.10 and 1040.11, as applicable. To maintain compliance with these regulations, once a year, or whenever the product has been subjected to adverse environmental conditions (e.g., fire, flood, mechanical shock, spilled solvent, etc.), verify all features of the product identified on the *Excelsior* CDRH Radiation Control Drawing (Figure 2-6 on page page 2-9) function properly. Also, make sure that all warning labels remain firmly attached.

1. Verify that opening any safety interlock switch used with the system prevents laser operation.
2. Verify the laser can only be turned on when the EMISSION keyswitch is in the ON position, and that the key can only be removed when the switch is in the STBY position.
3. Verify the EMISSION indicator(s) provides a visible signal when the laser emits accessible laser radiation that exceeds the accessible master system emission limits for Class I.*
4. Verify the time delay between turn-on of the EMISSION indicator(s) and the start of laser emission; it must give enough warning to allow action to avoid exposure to laser radiation.
5. Verify the mechanical shutter closes and actually blocks laser radiation emission.

If any of the above items fail to operate as noted and you cannot correct the error, please call your Spectra-Physics service representative for assistance.

* *0.39 µW for continuous-wave operation where output is limited from 400 nm to 1400 nm.*

## Excelsior Radiation Safety Control Drawings

**Refer to the warning labels on page 2-10.**

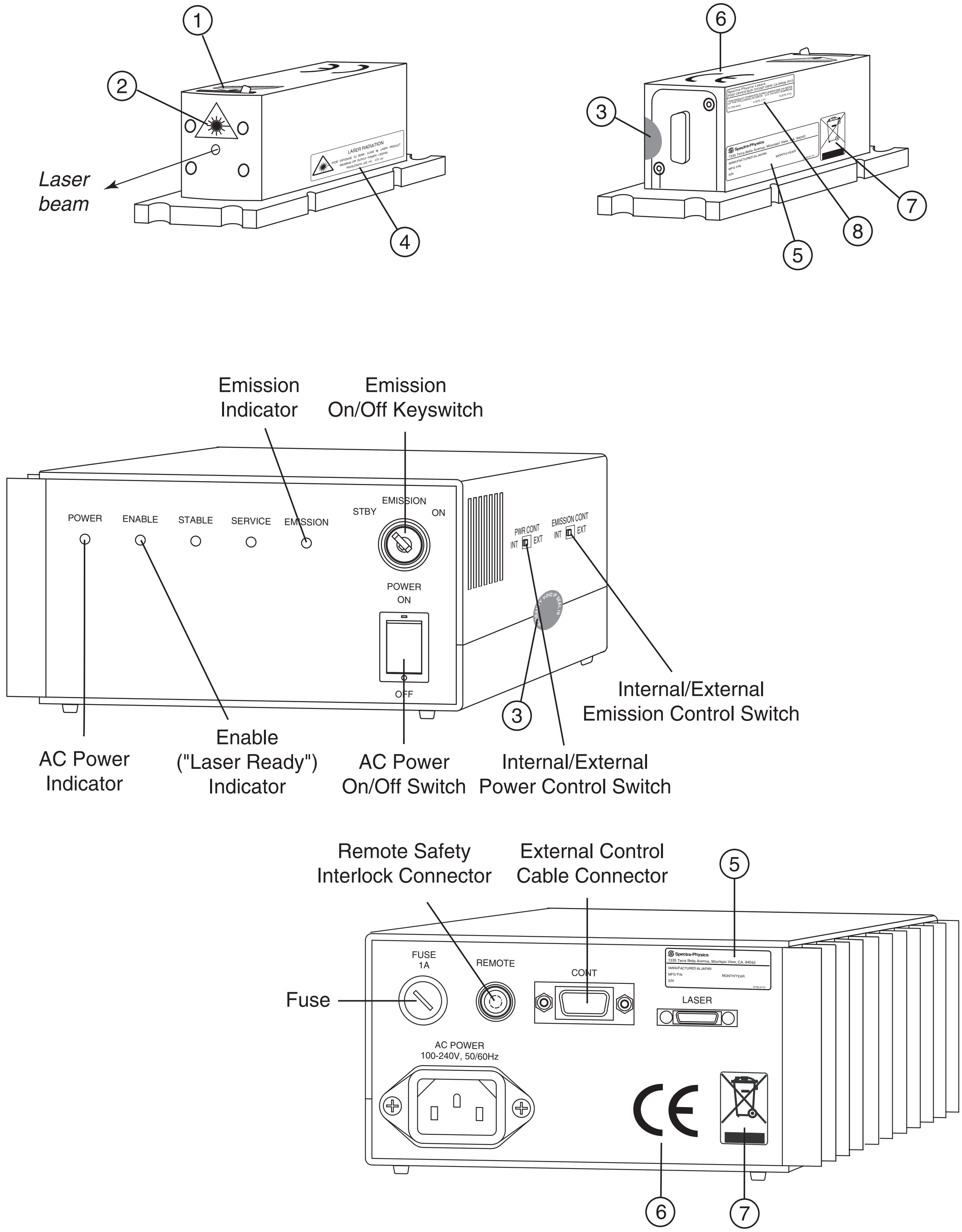
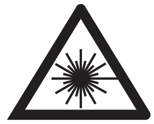



**Figure 2-6:** ***Excelsior*** **Radiation Control Drawings**

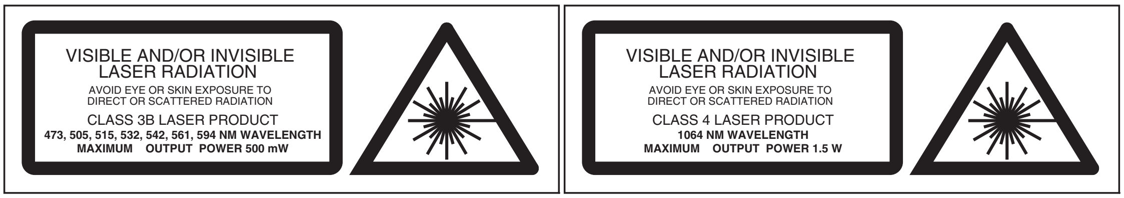
## Excelsior Warning Labels


Aperture Label, Laser Head (1)

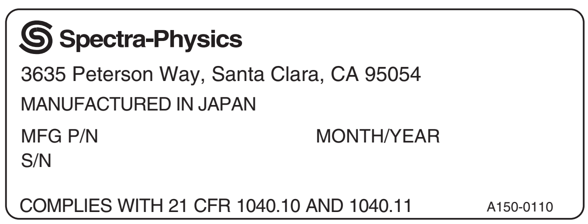


CE Aperture Label (2)


Warranty Seal (3)

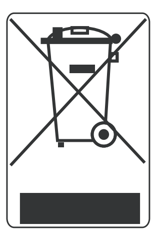



CE Danger Label (4)




Serial Number Label (5)

CE Certification Label (6)



WEEE Label (7)


Patent Label (8)

**Figure 2-7: *Excelsior* Warning Labels**

## *Label Translations*

For safety, the following translations are provided for non-English speaking personnel. The number in parenthesis in the first column corresponds to the label number listed on the previous page.

**Table 2-2: Label Translations**

| Label No. | French | German | Spanish | Dutch |
|---|---|---|---|---|
| Aperture Label (1) | Ouverture Laser - Exposition Dangereuse - Un rayonnement laser visible et/ ou invisible est émis par cette ouverture. | Austritt von sichtbarer und unsichtbarer Laserstrahlung! Bestrahlung vermeiden! | Por esta abertura se emite radiación láser visible e invisible; evite la exposición. | Vanuit dit apertuur wordt zichtbare en onzichtbare laserstraling geemitteerd! Vermijd blootstelling! |
| CE Danger Label (4) | Rayonnement laser Exposition Dangereuse, Appareil a laser de Classe 3b. Puissance maximum 500 mW, Longueur d'onde 473, 505, 515, 532, 542, 561, 594 nm | Laserstrahlung Bestrahlung vermeiden. Laser Klasse 3b. Maximale Ausgangsleistung 500 mW Wellenlänge 473, 505, 515, 532, 542, 561, 594 nm | Radiación láser Evite la exposición, Producto láser Clase 3b. Potencia máxima 500 mW Longitud de onda: 473, 505, 515, 532, 542, 561, 594 nm | Laser-straling Vermijd blootstelling! Klasse 3b laser produkt. Max. output vermogen 500 mW, Golflengtebereik 473, 505, 515, 532, 542, 561, 594 nm |
| CE Danger Label (4) | Rayonnement laser Exposition Dangereuse, Appareil a laser de Classe 4. Puissance maximum 1.5 W, Longueur d'onde 1064 nm | Laserstrahlung Bestrahlung vermeiden. Laser Klasse 4. Maximale Ausgangsleistung 1.5 W Wellenlänge 473, 1064 nm | Radiación láser Evite la exposición, Producto láser Clase 4. Potencia máxima 1.5 W Longitud de onda: 1064 nm | Laser-straling Vermijd blootstelling! Klasse 4 laser produkt. Max. output vermogen 1.5 W, Golflengtebereik 1064 nm |
| Patent Label (8) | Ce produit est fabriqué sous l'un ou plusieurs des brevets suivants des Etats Unis: | Dieses Produkt wurde unter Verwendung einer oder mehrerer der folgenden US-Patente hergestellt: | Este producto esta fabricado con una o más de las siguientes patentes de los Estados Unidos: | Dit product is gefabriceerd met een of meer van de volgende USA patenten: |

## Waste Electrical and Electronic Equipment Recycling Label

To Our Customers in the European Union:

As the volume of electronics goods placed into commerce continues to grow, the European Union is taking measures to regulate the disposal of waste from electrical and electronic equipment. Toward that end, the European Parliament has issued a directive instructing European Union member states to adopt legislation concerning the reduction, recovery, re-use and recycling of waste electrical and electronic equipment (WEEE).

In accordance with this directive, the accompanying product has been marked with the WEEE symbol. See Label 7 on page 2-10.

The purpose of the symbol is to designate that, at the end of its useful life, the accompanying product should not be disposed of as normal municipal waste, but should instead be transported to a collection facility that will ensure the proper recovery and recycling of the product's components. The symbol also signifies that this product was placed on the market after 13 August, 2005. At this time, regulations for the disposal of waste electrical and electronic equipment vary within the member states of the European Union. Please contact a Newport / Spectra-Physics representative for information concerning the proper disposal of this product.

## Sources for Additional Information

### *Laser Safety Standards*

*Safe Use of Lasers* (Z136.1)
American National Standards Institute (ANSI)
25 West 43rd Street, 4th Floor
New York, NY 10036
Tel: (212) 642-4900

Occupational Safety and Health Administration (Osha Standard, 01-05-001-pub8-1.7
U. S. Department of Labor
200 Constitution Avenue N. W., Room N3647
Washington, DC 20210
Tel: (202) 693-1999
Internet: http://www.osha.gov

*A Guide for Control of Laser Hazards,* 4th Edition, Publication #0165
American Conference of Governmental and
Industrial Hygienists (ACGIH)
1330 Kemper Meadow Drive
Cincinnati, OH 45240
Tel: (513) 742-2020
Internet: http://www.acgih.org/home.htm

Laser Institute of America
13501 Ingenuity Drive, Suite 128
Orlando, FL 32826
Tel: (800) 345-2737
Internet: http://www.laserinstitute.org

International Electrotechnical Commission
*Journal of the European Communities*
IEC 60825-1 Safety of Laser Products — Part 1: Equipment classification, requirements and user's guide
Tel: +41 22-919-0211   Fax: +41 22-919-0300
Internet: http://www.iec.ch

Cenelec
35, Rue de Stassartstraat
B-1050 Brussels, Belgium
Tel: +32 2 519 68 71
Internet: http://www.cenelec.eu

Document Center, Inc.
111 Industrial Road, Suite 9
Belmont, CA 94002
Tel: (650) 591-7600
Internet: http://www.document-center.com

## *Equipment and Training*

*Laser Safety Guide*
Laser Institute of America
13501 Ingenuity Drive, Suite 128
Orlando, FL 32826
Tel: (800) 34LASER
Internet: http://www.laserinstitute.org

*Laser Focus World Buyer's Guide*
Laser Focus World
Pennwell Publishing
98 Spit Rock Road
Nashua, NH 03062
Tel: (603) 891-0123
Internet: http//:pennwell.365media.com/laser focus world/search.html

*Photonics Spectra Buyer's Guide*
Photonics Spectra
Laurin Publications
Berkshire Common
PO Box 4949
Pittsfield, MA 01202-4949
Tel: (413) 499-0514
Internet: http://www.photonics.com

# Chapter 3 System Description

## A Brief Review of Laser Theory

### *Emission and Absorption of Light*[1]

*Laser* is an acronym derived from Light Amplification by Stimulated Emission of Radiation. Because the laser is an oscillating amplifier of light, and because its output comprises photons that are identical in phase and direction, it is unique among light sources. Its output beam is singularly directional, monochromatic, and coherent.

Radiant emission and absorption take place within the arrangement of the electrons in atoms or molecules. Each electron occupies a distinct orbital that represents the probability of finding the electron at a given position relative to the nucleus. The energy of an electron is determined by the orbital that it occupies and the over-all energy of an atom—its energy level depends on the distribution of electrons throughout the available orbitals.

Each atom has an array of energy levels: the level with the lowest possible energy is called the ground state, and higher energy levels are called excited states. If an atom is in its ground state, it will stay there until it is excited by external forces.

Movement of an electron from one energy level to another—a transition—happens when the atom either absorbs or emits energy. Transitions in both directions can occur as a result of interaction with a photon of light. Consider a transition from a lower level whose energy content is $E_1$ to a higher one with energy $E_2$. It will only occur if the energy of the incident photon matches the energy difference between levels, i.e.,

$$h\nu = E_2 - E_1 \qquad [1]$$

where $h$ is Planck's constant and $\nu$ is the frequency of the photon.

Likewise, when an atom excited to $E_2$ decays to $E_1$, it loses energy equal to $E_2 - E_1$. The atom may decay spontaneously, emitting a photon with energy $h\nu$ and frequency

$$\nu = \frac{E_2 - E_1}{h} \qquad [2]$$

[1] *"Light" will be used to describe the portion of the electromagnetic spectrum from the infrared to the ultraviolet.*

Spontaneous decay can also occur without emission of a photon. An atom excited to $E_2$ can also be stimulated to decay to $E_1$ by absorbing a photon of frequency $\nu$, then emitting a pair of photons that are identical to the incident one in phase, frequency, and direction. This is known as stimulated emission. By contrast, spontaneous emission produces photons that have no directional or phase relationship with one another.

A laser is designed to take advantage of both stimulated and spontaneous emission and absorption as well, using them to create conditions favorable for light amplification. The following paragraphs describe these conditions.

## *Population Inversion*

A material in thermal equilibrium has most of its atoms or molecules in their ground state. As a result, the rate of absorption of incident light at all frequencies exceeds that of emission.

If enough light at the correct frequency $\nu$ is supplied, electrons in a lower energy level will absorb light energy and shift to an upper level until the populations of two levels are equal, $N_1 = N_2$. For transition between two levels, $N_2$ can never exceed $N_1$ because every upward transition is matched by one in the opposite direction. However, if three or more energy levels are involved in the transition, a population inversion can occur where $N_2 > N_1$.

A model four-level laser transition scheme is depicted in Figure 3-1. A photon of frequency $\nu_1$ excites—or "pumps"—an atom from $E_1$ to $E_4$. If the $E_4$ to $E_3$ transition probability is greater than that of $E_4$ to $E_1$, and if the lifetime of an atom at $E_4$ is short, the atom will decay almost immediately to $E_3$. If $E_3$ is metastable, i.e., electrons occupy it for a relatively long time, the population will grow rapidly as excited electrons cascade from above.

The $E_3$ electron will eventually decay to $E_2$, emitting a photon of frequency $\nu_2$. Finally, if $E_2$ is unstable, its electrons will rapidly return to the ground state, $E_1$, keeping the population of $E_2$ small and reducing the rate of absorption of $\nu_2$. In this way the population of $E_3$ is kept large and that of $E_2$ remains low, thus establishing a population inversion between $E_3$ and $E_2$. Under these conditions, light is amplified as it passes through the material, which is now a gain medium.

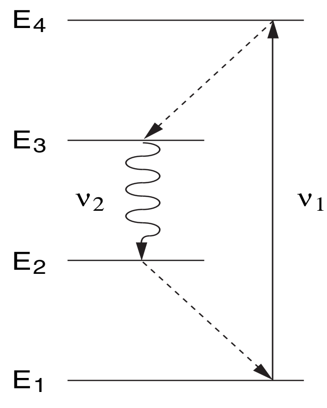



**Figure 3-1: A Typical Four-level Transition Scheme**

## *Resonant Optical Cavity and Cavity Modes*

Most laser materials must be placed in a resonant optical cavity to achieve useful levels of amplified light. This cavity is typically two mirrors placed facing each other to form a resonator that reflects light back and forth through the gain material placed between them. Both resonator mirrors are coated to reflect the laser wavelength (thus containing it within the cavity) while transmitting all others (thus removing them from the cavity).

As the reflected light passes through the gain material, stimulated emission produces two photons. The two photons are trapped in the resonator and are reflected through the gain to become four, four become eight, and the numbers continue to increase geometrically until an equilibrium is reached where the excitation rate and emission rate of the gain medium are equal.

The light in the resonator forms standing waves with frequencies that depend on the resonator design. Standing wave frequencies that are amplified in the gain material form the circulating light in the cavity. This is the energy that is transmitted through the output coupler as the laser beam.

There is one standing wave pattern, or cavity mode, that has the simplest possible form, termed $TEM_{00}$. $TEM_{00}$ operation results from choosing the mirror curvatures and the shape and pumping geometry of the laser material so that gain is confined along the central axis of the material. (This is further discussed in the section "Diode-Pumped Laser Design" below.)

The $TEM_{00}$ mode appears brightest in the center and attenuates smoothly toward the edges of the beam. The spectral content of the light in this mode arises from the standing waves formed along the axis of the cavity, with frequencies determined by the separation between the resonator mirrors. The difference in frequency ($\Delta f$) between any two of these "longitudinal modes" is given by

$$\Delta f = \frac{c}{2nl} \qquad [3]$$

where $c$ is the speed of light, $n$ is the refractive index, and $l$ is the distance between the cavity mirrors. The number of such longitudinal modes in the laser output is determined by the number of such modes that fall under the bandwidth of the gain material as shown in Figure 3-2.

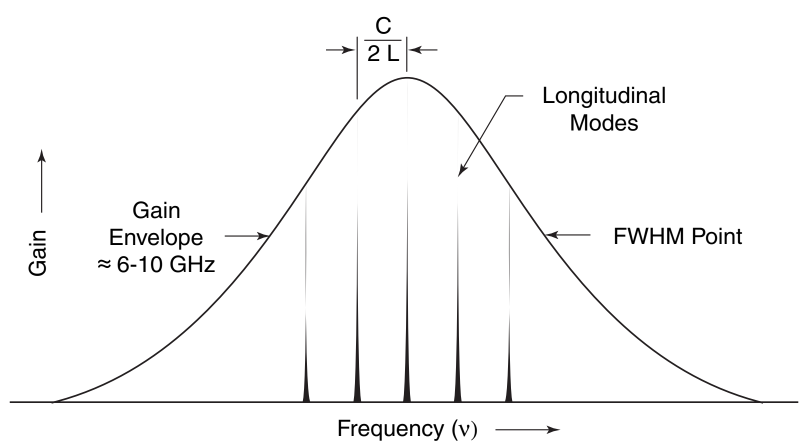



**Figure 3-2: Frequency Distribution of Longitudinal Modes**

## *Single Longitudinal Mode Operation*

Some laser applications benefit from a beam with only a single longitudinal mode. From equation 3 it can be seen that reducing the separation between the resonator mirrors will increase the frequency spacing of the longitudinal modes and sometimes enable only a single mode to remain within the gain bandwidth of the laser material. Often however the gain bandwidth is so large that the mirror separation would have to be impractically short to result in only a single mode remaining. Although the *Excelsior* lasers are very small, they still produce numerous longitudinal modes due to the broad gain bandwidth of the neodymium-based crystals.

A variety of means exist to eliminate all but one longitudinal mode in such a case, including the insertion of an etalon into the resonant cavity. An etalon is type of resonator and, in its simplest form, is just a thin, flat piece of glass resembling a microscope slide. Placed intracavity, the mode separation of this thin element will limit the modes allowed to resonate.

## *$Nd^{3+}$ as a Laser Medium*

The output of one laser can be used to excite or "pump" the gain medium of another laser, e.g., a diode laser can be used to pump a solid-state laser. The *Excelsior* lasers use a diode laser to pump $Nd^{3+}$ ions added to either a crystal of yttrium vanadate ($Nd:YVO_4$) or yttrium aluminum garnet (Nd:YAG).

The properties of neodymium-doped crystals are the most widely studied and best understood of all solid-state laser media. The four-level Nd:YAG ion scheme is shown in Figure 3-3. The active medium is ionized neodymium, which has principle absorption bands in the red and near infrared.

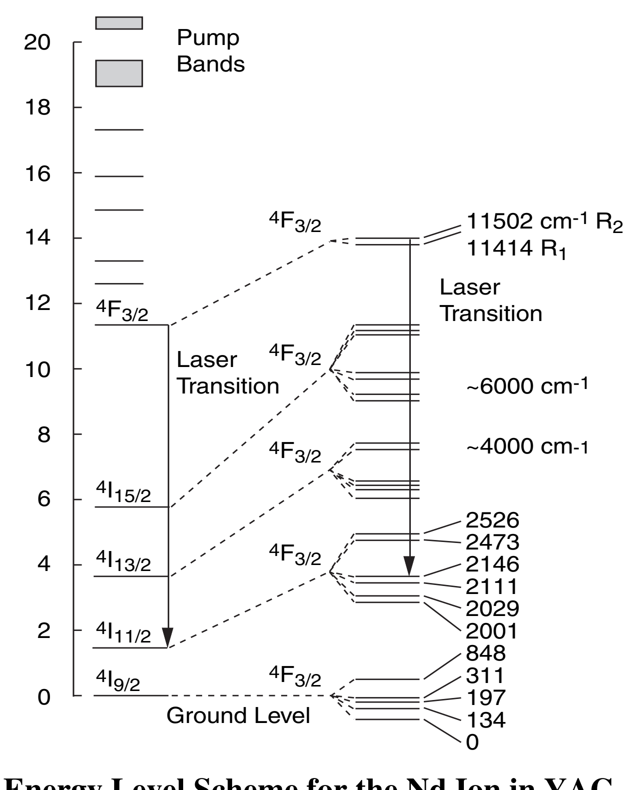



**Figure 3-3: Energy Level Scheme for the Nd Ion in YAG**

The electrons in the neodymium ions are very efficient at absorbing the diode laser light, which excites them to the "pump bands" shown in the figure. The excited electrons quickly drop to the $^4F_{3/2}$ level, the upper level of the lasing transition, where they remain for a relatively long time.

The most probable laser transition is to the $^4I_{1/2}$ state, which emits photons at 1064 nm. Because electrons in that state quickly relax to the ground state, the population of this state remains low. Hence it is easy to build a population inversion where the number of electrons in the higher energy level exceeds the number in the lower level.

There are several different laser transitions in neodymium that start from the same upper state. These transitions compete for the same population of electrons, and, if left to themselves, the 1064 nm transition will dominate. The blue *Excelsior* lasers employ vanadate ($Nd:YVO_4$) crystals to produce the 1064 nm wavelength for doubling to 532 nm. Vanadate is a popular solid-state laser material for small- to medium-power solid-state lasers due to its low threshold for lasing, along with its large cross section for stimulated emission.

Neodymium can be made to lase at other wavelengths, at 946 nm in particular. This 946 nm transition has a lower gain and a higher threshold than the 1064 nm transition. When lasing at this wavelength is desired, it can be achieved by choosing the proper wavelength-selective coatings for the resonator mirrors. Such coatings transmit a high percentage of any 1064 nm light that might be present, thus decreasing the rate of stimulated emission for this wavelength and allowing the 946 nm transition to lase.

The 946 nm transition is referred to as "quasi three level" because the lower laser level lies so close to the $^4I_{9/2}$ ground state. Despite this small difference in energy, the lower laser level still empties quickly enough to allow CW operation for this wavelength. However, the small difference in energy from the ground state does mean that the material will "self-absorb" at the lasing wavelength.

Self-absorption is a parasitic effect in which the laser light is absorbed by the laser crystal itself. The lower laser level for the quasi three level transition in vanadate is significantly populated by electrons thermally excited from the ground state, resulting in absorption of the 946 nm light as the electrons then make the reverse transition to the upper laser level. Nd:YAG exhibits the same effect, but thermal population of the lower laser level is less, so the blue *Excelsior* lasers employ YAG crystals to produce the 946 nm wavelength for doubling to 473 nm. Self-absorption can also be reduced somewhat by carefully engineering the diode pump design.

### *Diode-Pumped Laser Design*

Diode lasers combine very high brightness, high efficiency, monochromaticity and compact size in a near-ideal source for pumping solid-state lasers. Figure 3-4 shows the emission spectra of a diode laser compared to a black body source. The near-perfect overlap of the diode laser output with the $Nd^{3+}$ absorption band ensures that the pump light is efficiently coupled into the laser medium. Any pump light *not* coupled into the medium must ultimately be removed as heat.

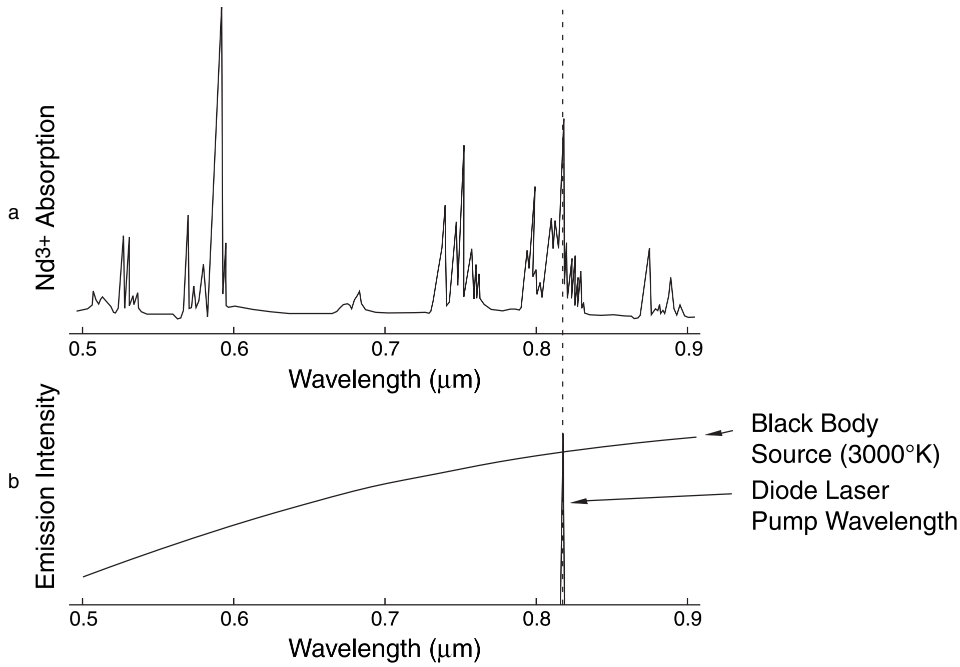



**Figure 3-4: $Nd^{3+}$ absorption spectra compared to emission spectra of a Black Body Source (a) and a Diode Laser (b).**

One of the key elements in optimizing the efficiency of a solid-state laser is maximizing the overlap of the regions of the active medium excited by the pumping source and the active medium occupied by the laser mode. The maximization of this overlap is often called mode matching, and in most applications, $TEM_{00}$ is the laser mode that is most desired. A longitudinal pumping geometry provides this sort of optimal mode match.

Longitudinal pumping allows the diode laser output to be focused on a volume in the active medium that best matches the radius of the $TEM_{00}$ mode. In general, the $TEM_{00}$ mode radius is chosen to be as small as possible to minimize the solid-state laser threshold. Figure 3-5 shows a schematic of a mode-matching design of this type.

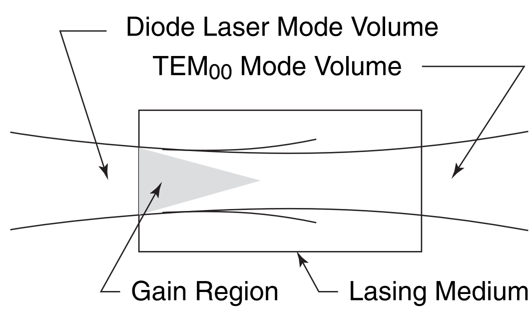



**Figure 3-5: Mode Matching**

## *Frequency Doubling*

In the *Excelsior*, the infrared output from a neodymium-based laser crystal is converted to visible light through frequency doubling (also called "second harmonic generation") in a nonlinear crystal. Frequency doubling occurs when an intense laser beam enters a nonlinear crystal and generates a second beam at half the incident wavelength. The blue *Excelsior* lasers use a lithium triborate (LBO) crystal as the doubling medium; the green lasers use a potassium titanyl phosphate (KTP) crystal.

Phase matching is a requirement of nonlinear optics to achieve an efficient conversion of the fundamental incident light to a new wavelength. To produce any significant output at the new wavelength, the fundamental light wave and the converted light wave must stay in phase over a sufficient length in the nonlinear material to allow the conversion to take place.

In most nonlinear materials, however, the indices of refraction at the two wavelengths will be significantly different, causing the two waves to become rapidly out of phase unless special techniques are employed. One such technique takes advantage of the birefringence of nonlinear crystals.

The indexes of refraction of the two light waves can be made to match exactly if the direction of propagation and the polarization orientation of the beams within the crystal are carefully controlled. This technique is referred to as "critical phase matching." LBO and KTP are nonlinear crystals that lend themselves well to this technique.

The high nonlinear coefficient of KTP has made it historically a very popular material for conversion of lower power 1064 nm infrared lasers to green wavelengths. KTP can be fabricated in a specialized structure that keeps the infrared and green beams in an approximate phase-matched condition over a longer distance than in a typical bulk crystal.

Although LBO has a comparatively smaller nonlinear coefficient, it produces no spatial "walk-off" of the fundamental and second harmonic beams. This favors a long interaction length for higher gain. Consequently LBO has subtle advantages that provide superior conversion efficiency of CW infrared laser light to blue wavelengths.

The second harmonic power ($P_{2\omega}$) produced by frequency doubling is given by:

$$P_{2\omega} \propto \frac{d_{eff}^2 P_{\omega}^2 l^2 [\phi]}{A} \qquad [4]$$

where $d_{eff}$ is the effective nonlinear coefficient, $P_{\omega}$ is the fundamental input power, $l$ is the effective crystal length, $[\phi]$ is a phase-matching factor, and $A$ is the cross-sectional area of the beam in the crystal.

The important point to note from equation 4 is that the second harmonic output is dependent upon the square of the fundamental peak power. High conversion efficiencies can therefore be achieved by placing the doubling crystal within the laser resonator itself (called "intracavity frequency doubling") to take advantage of the high circulating intensity. This is the optical design used in the *Excelsior*.

## The Excelsior Lasers

Table 1-1 and Table 1-2 list the various *Excelsior* laser models. The power supply/controller provides electrical power, control and monitoring signals to the laser head. Output power on most *Excelsior* lasers models can be varied from 50 to 100% using an external control signal connected to an interface on the power supply. A few, however, are design for operation at constant power only.

### *The Excelsior Laser Head*

The *Excelsior* laser head provides maximum reliability with minimum complexity and size. The inherent operation is so stable and the output so quiet that no adjustments are needed for normal operation.

#### Laser Cavity Design

The *Excelsior* uses a compact linear cavity for convenient end-pumping of the laser crystal.

**Note** The diode pump laser in the *Excelsior* laser head is sometimes referred to simply as the "diode" in this manual, e.g., the "diode current."

The infrared light generated by the laser crystal is intracavity frequency doubled to produce either green or blue output; that is, the output of a vanadate crystal at 1064 nm is doubled to 532 nm in the green lasers, and the output of a YAG crystal at 946 nm is doubled to 473 nm in the blue laser. A dichroic output coupler transmits a fraction of the doubled light out of the resonator while confining the rest of the doubled light and virtually all of the infrared beam inside the laser head.

The infrared pump power of the diode laser is mode-matched in the laser crystal. This, together with the design of the resonator optics, results in $TEM_{00}$ output. The lasers also operate in single longitudinal mode, except for the lowest power green model, which has multiple longitudinal mode output (refer to the tables of specifications at the end of this chapter).

Single longitudinal mode operation is achieved by inserting an etalon in the intracavity space to broaden the spacing of the longitudinal modes beyond the bandwidth of the laser gain so that only one mode at a time fits within the gain spectrum.

The *Excelsior* laser head includes an output telescope assembly that expands and collimates the beam before it exits the laser head. Refer to the tables of specifications for exact details. (Some models of the *Excelsior* produced for integration into the optical train of an OEM master system are available without collimation. If interested, contact Spectra-Physics for additional information.)

All models of the *Excelsior* include an internal detector to measure output power. The detector is part of a servo-loop that maintains constant laser output power over the lifetime of the device by adjusting the current of the diode pump laser.

### Mechanical and Thermal Design

The laser resonator is machined from a solid piece of brass for exceptional thermal and mechanical stability. The waste heat produced by the diode pump laser (typically less than 2 W) is removed from the laser head by thermal conduction through the baseplate. The laser crystal is set to a stable operating temperature of about 45°C by a thermo-electric cooler (TEC) located in the head beneath the laser cavity.

The mechanical design of the miniature laser head allows for mounting it using precision alignment pins. Together with the excellent stability and boresight specifications of the *Excelsior*, this facilitates both the design of the optical train of the application as well as the replacement of the laser head when the diode pump laser eventually reaches its end-of-life condition.

## *The Excelsior Power Supply/Controller*

Power for the laser, as well as monitoring and control capability, is provided by one of two small, separate power supply/control units. A standard 15-pin D-sub connector is used for the LASER connector on the *Excelsior-PS-XC-CDRH* model, while a 26-pin SDR connector is used on the *Excelsior-PS-CDRH* model.

The *Excelsior* power supply provides output signals proportional to laser output power and diode laser pump current, as well as an alarm for the diode lifetime and a status signal that can be used to control an external laser emission indicator. These features are all available through the CONTrol interface on the back of the *Excelsior* power supply.

The safety circuit of the *Excelsior*, accessed through the 2-pin REMOTE connector on the back of the power supply, must be closed in order for the laser to operate. An interlock jumper plug (Figure 3-6) is provided with the system to allow the laser to operate when an optional interlock safety switch (e.g., a switch across a laboratory door) is not employed.

**Figure 3-6: REMOTE Interlock Jumper Plug**

The power supply contains two main components: a switching power supply and a control pc board. The switching power supply provides +5 Vdc to the control pc board with a maximum drive current of 5 A or 8 A (depending on model). The control pc board supplies low-noise, regulated DC current to the laser head to drive the diode laser and a thermo-electric cooler.

## Specifications

This page and the next one are to be discarded and replaced with the 11 x 17 Specifications fold-out page.

# Outline Drawings

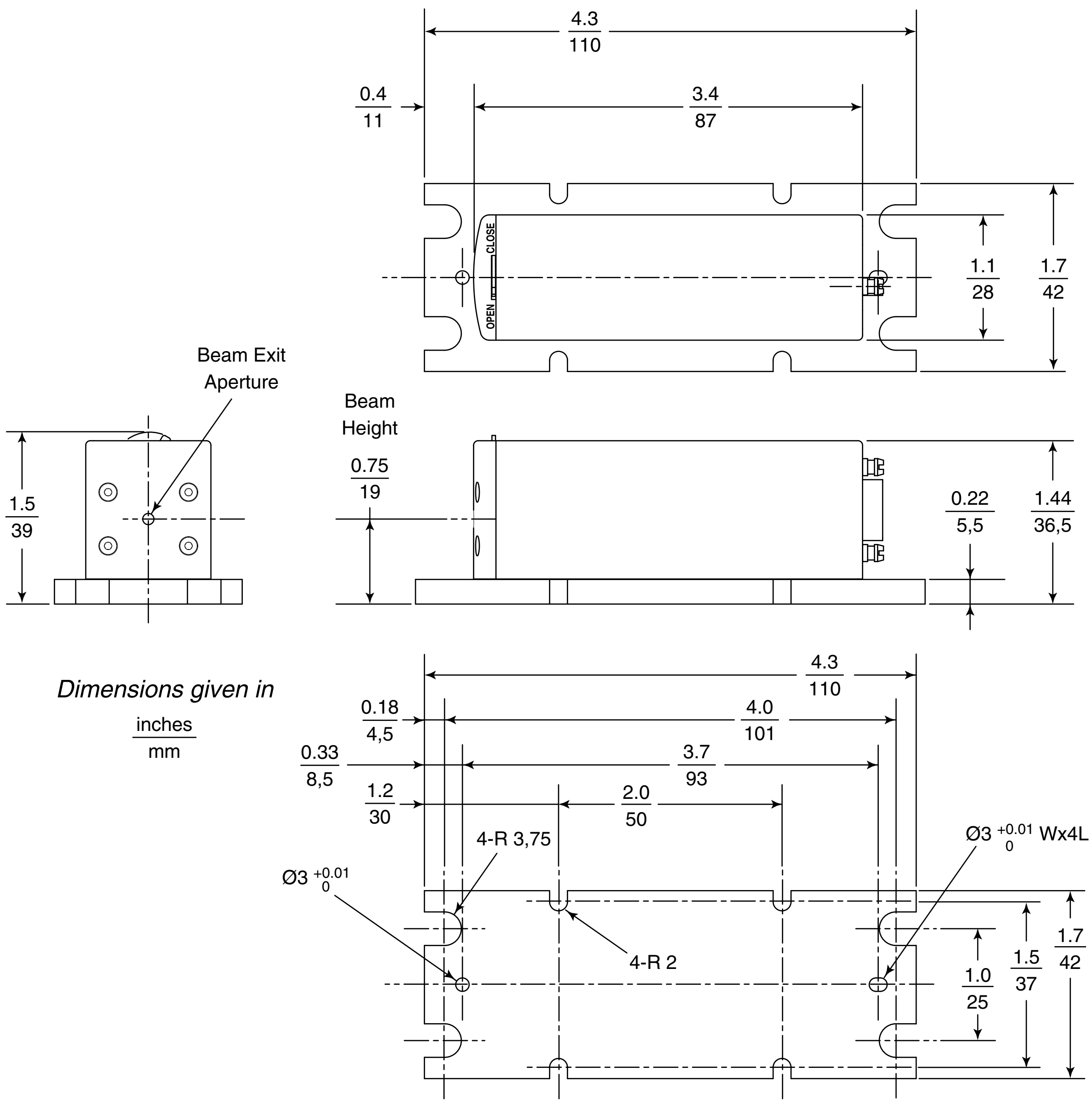



**Figure 3-7: Outline Drawing of the *Excelsior DPSS-CDRH* Laser Head**

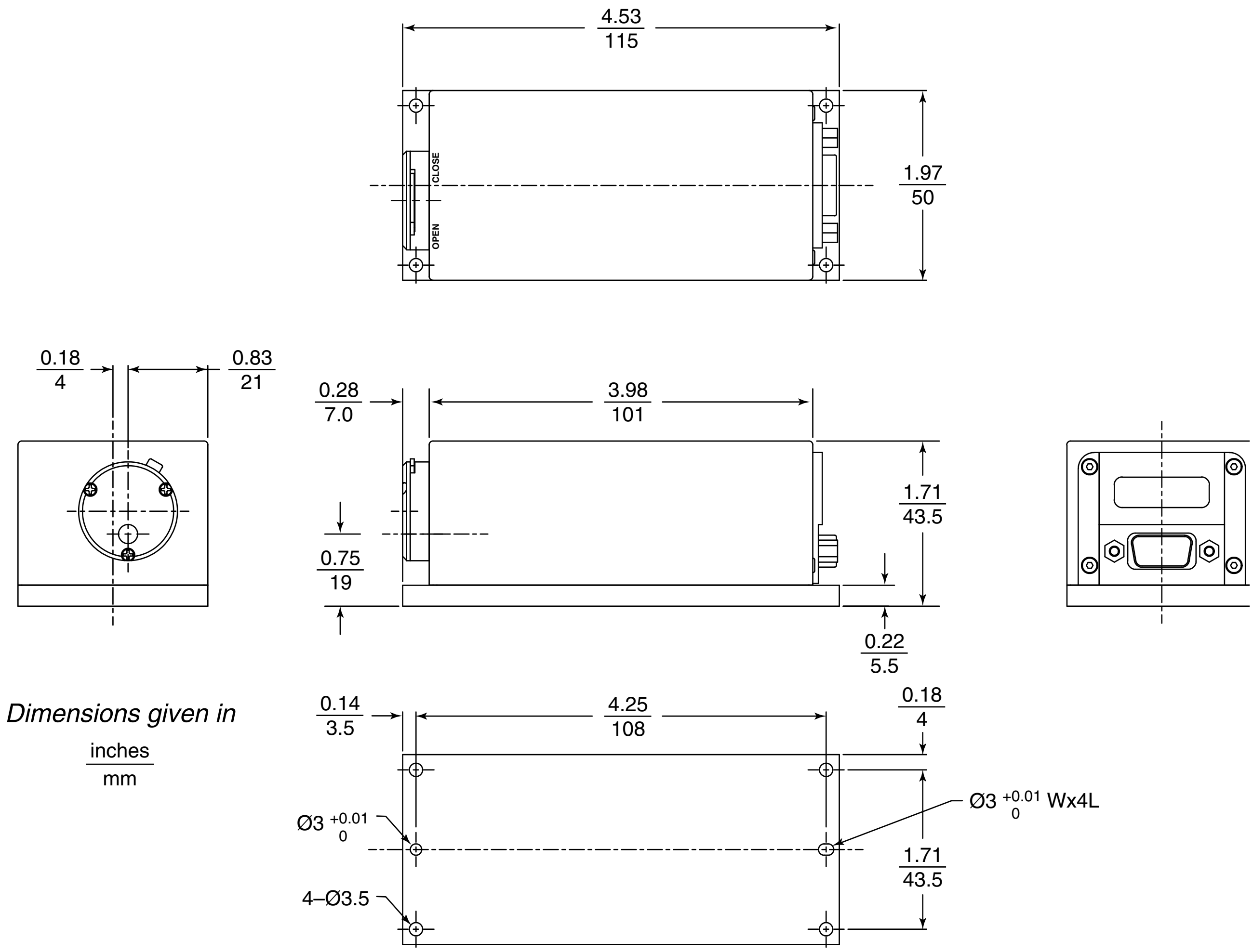
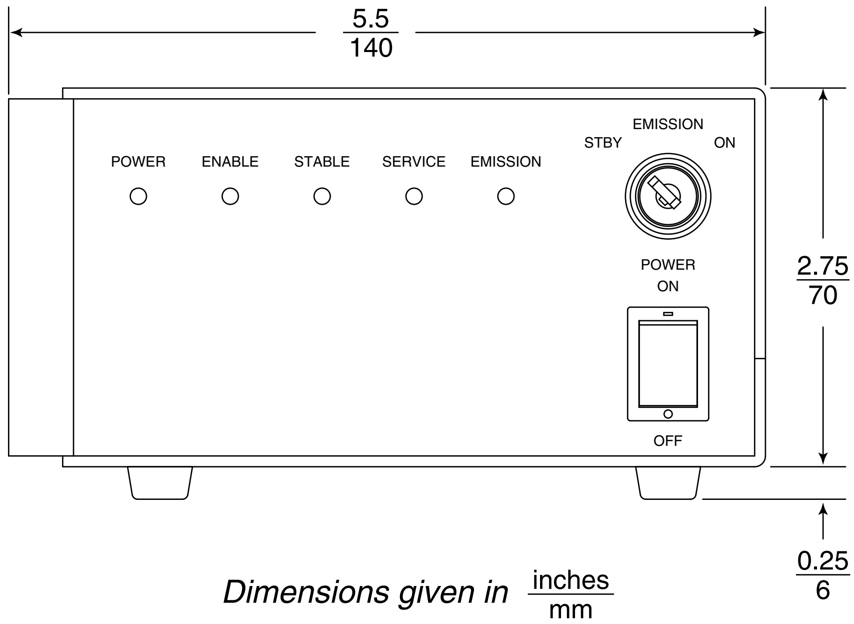



**Figure 3-8: Outline Drawing of the *Excelsior DPSS-XC-CDRH* Laser Head**



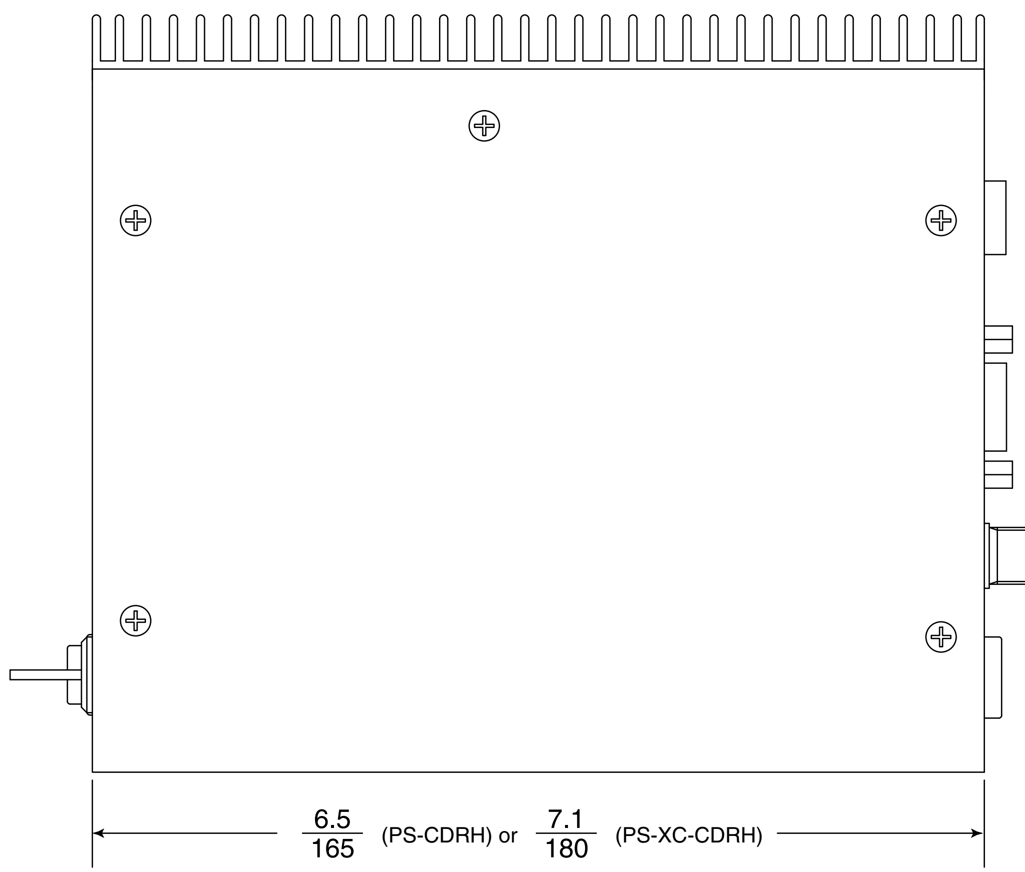




**Figure 3-9: Outline Drawing of *Excelsior* Power Supply/Controller**

# Chapter 4 Controls, Indicators and Connections

This section defines the user controls, indicators and connections of the *Excelsior* laser head and power supply. Chapter 6 describes how to use these features to operate the laser.

## The Excelsior Laser Head

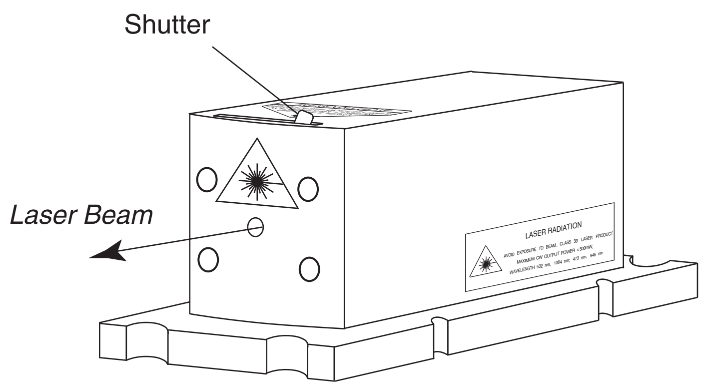



**Figure 4-1: The Standard *Excelsior* Laser Head**

### *Controls*

**Shutter—**is opened and closed by means of the lever on the top of the laser head near the output end. The shutter is open when it is pushed to the left (when looking in the direction of the laser beam) to the OPEN position.

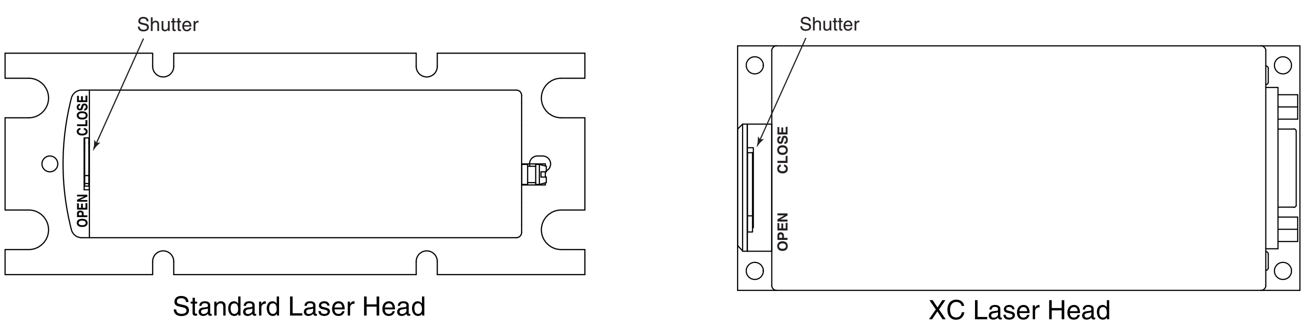



**Figure 4-2: Shutter "Open/Close" Designations**

### Connections

**LASER cable connector (rear panel, not shown)**—provides connection for a control cable (supplied) that provides control signals and power to the laser head from the power supply/controller. One of two types of connectors is present:

- the *Excelsior-CDRH* laser head has a 26-pin SDR connector.
- the *Excelsior-XC-CDRH* laser head has an HD 15-pin D-sub connector.

## Excelsior Power Supply/Controller

### Front Panel

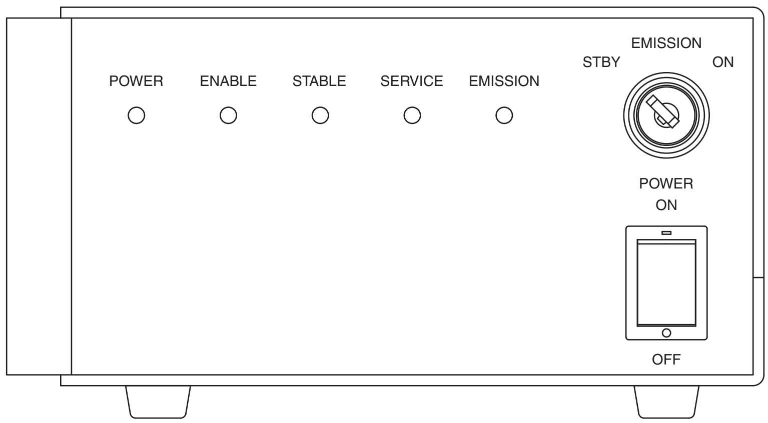



**Figure 4-3: The Power Supply/Controller Front Panel**

Two power supplies are available for the *Excelsior* series lasers: one for the standard laser head and one for the extended laser head. They appear to be the same, but some functions differ slightly. These differences are noted below under “standard” and “extended.”

#### Controls

**EMISSION keyswitch**—provides interlock safety to prevent unauthorized personnel from using the laser when the key is turned to the STBY position and removed.

If the POWER switch has been turned on and the ENABLE indicator is on and the EMISSION CONTROL switch has been set to INT, turning on the EMISSION keyswitch will turn on the laser (following a safety delay of 3 to 5 seconds). If the shutter is open, the laser will emit a laser beam.

Optionally, if the EMISSION CONTROL switch has been set to EXT, the *Excelsior* laser can be turned on by applying a suitable control signal to Pin 2 of the CONTrol connector on the back of the power supply. However, the POWER switch must already be on and EMISSION keyswitch must be in the STBY position prior to sending the *On* signal. See Chapter 6 for details of this method of operation.

**POWER ON/OFF switch**—turns on power to the power supply. When switched on and the internal circuits respond properly, the POWER indicator on the front panel turns on. Once on, the laser head resonator begins to warm to its operating temperature, which typically takes between 2 to 5 minutes. The ENABLE indicator turns on when warm-up is complete.

### Indicators

**POWER indicator**—turns on when the POWER switch is turned on and the internal circuits respond properly.

**ENABLE indicator**—turns on when the laser resonator has warmed to its operating temperature, which is about 2 to 5 minutes after the POWER switch has been turned on. Once this light is on, the laser can be turned on.

**STABLE indicator**—turns on when laser power reaches its set value and becomes stable, and it remains on as long as laser power is stable. The laser typically reaches its set operating power and becomes stable about 10 seconds (DPSS-CDRH) or 30 seconds (DPSS-XC-CDRH) after turning on the EMISSION keyswitch or after an *On* command has been received at Pin 2 of the CONTrol interface connector.

**SERVICE indicator**—turns on when diode laser current rises to 95% of the factory-set current limit. This indicates that a replacement laser head is needed (although not immediately). Laser emission will be stable until the current reaches the 100% limit. When the limit is exceeded, emission will continue, but power may decrease and/or fluctuate.

**EMISSION indicator**—turns on when the EMISSION keyswitch is turned on (see the prerequisites for turning on the keyswitch above), and emission occurs 3 to 5 seconds later. (Note: this indicator does not blink during the delay as it does on some other laser systems).

If the REMOTE interlock circuit is opened (see the description below), laser emission stops immediately and this indicator turns off. If the REMOTE interlock switch is then closed again, one of the following actions occur:

- On a standard Class 3b laser or extended cavity (XC) laser, if the keyswitch is still in the ON position, the EMISSION indicator turns on again immediately and the laser turns on again following a safety delay of 3 to 5 seconds.
- On a standard Class 4 laser, if the keyswitch is still in the ON position, the keyswitch must first be turned off, then back on again in order to resume operation. After it is turned back on, the EMISSION indicator turns on again and the laser will turn on again after a safety delay of 3 to 5 seconds.

Pin 1 of the CONTrol connector can be used to control an external emission indicator. See Chapter 6 for an example of a circuit used for this purpose.

## *Back Panel*

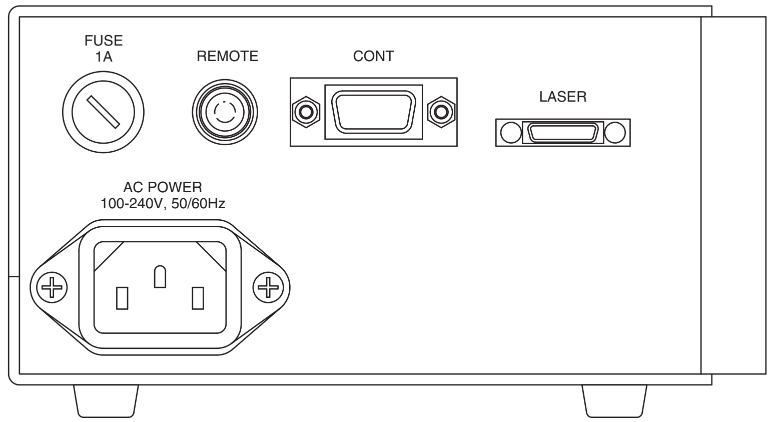



**Figure 4-4: The Power Supply/Controller Back Panel**

### Connections

**AC POWER connector**—provides attachment for an IEC power cable. The cable provides ac power to the system and accepts service from 47 to 63 Hz at 90 to 264 Vac.

**FUSE holder**—holds a 5.2 mm x 20 mm, fast-acting cartridge fuse. The required fuse is:

- *Excelsior-PS-CDRH* 250 V, 1 A
- *Excelsior-PS-XC-CDRH* 250 V, 2 A

**REMOTE interlock connector (2-pin)**—provides attachment for a user-supplied safety switch. These contacts must be shorted together before the laser will operate. A defeating interlock jumper plug (Figure 4-5) is installed at the factory to permit operation without a safety switch.

**Figure 4-5: REMOTE Interlock Jumper Plug**

To turn on the laser again following an interlock fault (when the two contacts were opened), close the contacts again (resolve the fault issue) and do one of the following:

On a standard Class 3b Laser, if the keyswitch is still in the ON position, the laser will turn on again automatically after a safety delay of 3 to 5 seconds.

On a standard Class 4 laser, the keyswitch must be turned off, then back on again in order to resume operation following a safety delay of 3 to 5 seconds.

On an extended cavity laser, if the keyswitch is still in the ON position, the laser will turn on again automatically after a safety delay of 3 to 5 seconds.

**CONTrol connector (HD 15-pin D-sub, female)**—provides various optional external control functions. Examples for controlling the laser using these functions are given in Chapter 6, “Operation.” The user is to provide the control cable. Each pin function is described in Table 4-1. The pin numbering sequence is shown in Figure 4-6 as you look into the panel connector. Numbering proceeds from right to left.

Refer to Chapter 6 for circuit descriptions.

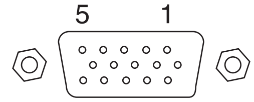



**Figure 4-6: External Control Connector Pin Numbering**

**Table 4-1: External Control (CONT) Connector Pin Functions**

| Pin | Type | Description | Function |
|---|---|---|---|
| 1 | Output | $\overline{\textit{Laser STABLE}}$ | This pin becomes internally shorted to ground through a transistor when the laser reaches stable operation, i.e., when laser output power is at the specified level and “stable,” and laser head temperature is within the proper operating range. The shutter can be opened at this time.<br>Refer to “Using the External Stable Signal (Pin 1)” on page 6-3. |
| 2 | Input | $\overline{\textit{Laser ON/OFF}}$ | When this pin is shorted to ground, the laser will turn on following a 3 to 5 second delay.<br>Refer to “Turning the Laser On and Off (Pin 2)” on page 6-2 for instructions. |
| 3 | Output | $\overline{\textit{Laser ENABLE}}$ | This pin becomes internally shorted to ground through a transistor when laser head temperature is within the proper operating range. The laser may be turned on at this time.<br>Refer to “Using the External Enable Signal (Pin 3)” on page 6-3 for instructions. |
| 4 | Output | *Current Monitor* | This pin provides an output signal proportional to the current of the diode pump laser. The scale is 100 mV/Amp, and maximum signal is 160 mV (corresponding to 1.6 A). |
| 5 | Output | *Laser Power Monitor* | This pin provides an output signal that is approximately proportional to the power output of the laser. Actual signal level depends on the laser model. When nominal power (100%) is emitted from the laser, the voltage on Pin 5 is about 100 mV (typically 96 to 98 mV).<br>Example: a Pin 5 signal of 50 mV for the *Excelsior-532-150* indicates that laser power is about 75 mW. |
| 6 | Ground | | |
| 7 | Ground | | |

**Table 4-1: External Control (CONT) Connector Pin Functions**

| Pin | Type | Description | Function |
|---|---|---|---|
| 8 | Input | *External Power Control* | This pin is used to vary the output power of the lasers listed in Table 6-1.<br>Refer to “Changing Laser Output Power (Pin 8)” on page 6-4 for instructions. |
| 9 | Output | *+12 Vdc* | This pin provides +12 Vdc @ 20 mA (max). This output can be used for external power control or for driving an external LED for indicating status. |
| 10 | Output | *SERVICE Alarm* | Indicates the diode pump laser in the laser head is nearing its end of life. To employ this “open collector” alarm, refer to “Using the Service Alarm Signal (Pin 10)” on page 6-4. |
| 11 | Ground | | |
| 12 | Ground | | |
| 13 | N/A or Output | Reserved or *Thermistor Alarm* | Must be open on an *Excelsior-PS-CDRH*) or it provides a thermistor alarm on a *Excelsior-PS-XC-CDRH*). For the latter, it indicates that the thermistor circuit inside the laser head has opened. To employ this “open collector” alarm, refer to “Using the Thermistor Alarm (Pin 13)” on page 6-6. |
| 14 | N/A | Reserved | Must be open |
| 15 | N/A | Reserved | Must be open |

**LASER connector** — provides power, control and monitoring to and from the laser head. This connector mates to the 1.8 m (6 ft) control cable, which restricts the laser head to the CDRH maximum distance from the EMISSION indicator on the power supply. Two types of connectors are used:

- a 26-pin 3M SDR connector is used on the *Excelsior-PS-CDRH* power supply.
- a standard 15-pin D-sub connector is used on the *Excelsior-PS-XC-CDRH* power supply.

## *Controls on the Power Supply Side Panel*

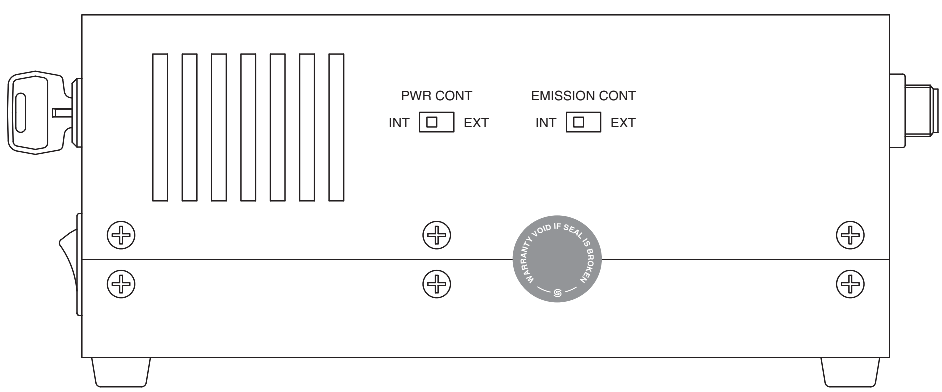



**Figure 4-7: The Power Supply Side Panel**

**PWR CONT switch**—allows *Excelsior* output power to be controlled remotely. Refer to the description of the CONTrol connector on page 4-5 above and “Changing Laser Output Power (Pin 8)” on page 6-4.

**EMISSION CONT switch**—allows the *Excelsior* laser to be turned on and off remotely via Pin 2 of the CONTrol connector. Refer to the CONTrol connector on page 4-5 and “Turning the Laser On and Off (Pin 2)” on page 6-2.

# Chapter 5 Installation

Detailed descriptions of the signals and connectors for the *Excelsior* laser system are provided in Chapter 4, “Controls, Indicators, and Connections.” Examples of how to operate the laser using either the controls on the power supply/controller itself or via external signals applied to the CONTrol interface connector on the power supply are given in Chapter 6, “Operation.”

A control cable provides control, power, monitoring and diagnostic signals between the laser head and the power supply. Depending on the system, either a 15-pin to 15-pin cable is provided (Standard CDRH systems) or a 26-pin to 26-pin cable is provided (XC CDRH systems). The cable is attached between the LASER connector on the back of the power supply and the connector on the laser head. If external control is desired, the user must provide a cable with a 15-pin D-sub connector on one end for connection to the CONTrol interface connector on the back of the power supply.

## Power

The power supply provides low-noise, regulated, high current to the laser head to drive the diode laser. The power supply is auto-ranging and requires a single-phase ac electrical source of 90–264 Vac at 47 to 63 Hz. The *Excelsior-PS-CDRH* requires a maximum of 40 W of ac power and is capable of providing 13 W of dc power to a standard laser head. The *Excelsior-PS-XC-CDRH* requires a maximum of 70 W of ac power and is capable of providing 28 W of dc power to an XC laser head.

## Thermal Management

Management of the heat load produced by the laser is critical to maintaining its specified output. The laser head must be mounted on a heatsink capable of maintaining its baseplate temperature below 50°C but greater than 10°C. The diode pump laser in the laser head will produce several watts of waste heat that must be removed through the baseplate by the heatsink (see Figure 5-1).

Cooler ambient temperatures for the environment of the laser will make the job of dissipating waste heat through the baseplate easier (see Figure 5-2).

The *Excelsior* power supply produces a significant current load to power the thermo-electric cooler (TEC) inside the laser head. Consequently, a reliable means to remove waste heat from the power supply must be provided as well. The relatively large heatsink on the side of the power supply is sufficient to remove heat from the inside of the housing as long as the ambient temperature meets the following specifications.

Ambient temperature (operating):

10°C–40°C (< 80% RH) for the power supply and laser head.

Baseplate of laser head (operating):

10°C–50°C for the laser head belonging to Groups A and C

10°C–45°C for the laser head belonging to Group B

**Table 5-1: Heat Dissipation, Laser Head**

| Standard Laser Head | | XC Laser Head |
|---|---|---|
| **Group A** | **Group B** | **Group C** |
| Excelsior-473-10-CDRH | Excelsior-473-50-CDRH | Excelsior-505-20-CDRH |
| Excelsior-532-50/100-CDRH | Excelsior-532-150/200-CDRH | Excelsior-515-50-CDRH |
| Excelsior-532-20M-CDRH | Excelsior-542-50-CDRH | Excelsior-532-300-CDRH |
| | Excelsior-561-20/50/75-CDRH | Excelsior-561-100/150-CDRH |
| | Excelsior-1064-500/800-CDRH | Excelsior-594-30/50-CDRH |

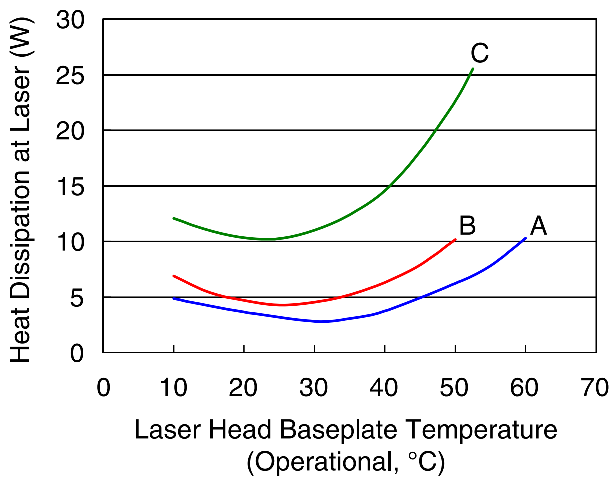



**Figure 5-1: Heat Dissipation of the Laser Head**

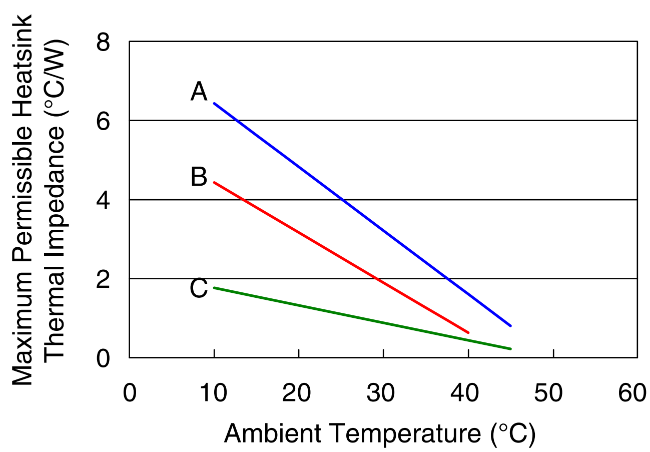



**Figure 5-2: Maximum Permissible Heatsink Thermal Impedance**

## Installing the Hardware

### *Mounting the Laser Head*

Follow standard practice to mount the laser head on a suitable heatsink that meets the requirements described in the preceding section.

Refer to the outline drawings at the end of Chapter 3 for mounting hole locations. Holes and slots are provided for precision alignment pins. (Note that slots are provided only on *Excelsior-DPSS-CDRH* lasers.) Position the laser head in the desired location, then use four M3 (or 4-40) screws and washers to mount the laser head using the mounting holes/slots on the front and back of the baseplate; or use four smaller screws and washers to use the slots on the sides of the baseplate.

The boresight specifications are with respect to the axis of the precision alignment hole and slot. Note that the beam height is located 19 mm (about ¾ in.) above the baseplate mounting surface.

The heatsink surface for the laser head must be flat to 0.050 mm or better. The laser head can withstand a small amount of vibration and still perform to specification. Refer to the specifications listed at the end of Chapter 3 for more information.

### *Mounting the Power Supply*

The power supply is a standard table-top device. Refer to the outline drawing in Figure 3-9 on page 3-14.

### *Connecting the Cables*

1. Connect the 1.8 m (6 ft) laser head cable provided between the connector on the laser head and the LASER connector on the back of the power supply.
2. If desired, wire a remote safety switch (or series of switches) to the 2-pin REMOTE connector on the back of the power supply. These 2 pins must be shorted in order for the laser to operate. A jumper is supplied to short the pins if an optional safety switch is not employed. The jumper can be modified (jumper removed) for use as a connector for a safety switch.

**Figure 5-3: REMOTE Connector Jumper Plug**

3. Connect the power supply ac power cable to your utility power source.
4. The external control interface (through the CONTrol connector on the back of the power supply) allows the laser to be turned on and off from a remote signal source connected to Pin 2. If a remote control signal is

to be used, the EMISSION CONT switch on the side of the power supply must be set to EXT. If it is *not* to be used, this switch *must* be set to INT.

5. The external control interface also allows the output power of some laser models to be controlled externally using a remote signal source at Pin 8. (A list of compatible laser heads is provided in Table 5-2.) If laser power is to be controlled externally, the PWR CONT switch on the side of the power supply must be set to EXT. Otherwise, this switch should be left in the INT position for continuous, maximum power output.

If external control of the laser is desired, proceed to connect the CONTrol connector on the power supply.

**Table 5-2: Lasers capable of variable output power[1, 2]**

| | |
|---|---|
| *Excelsior-473-10* | *Excelsior-542-50* |
| *Excelsior-473-50* | *Excelsior-561-25* |
| *Excelsior-505-20* | *Excelsior-561-50* |
| *Excelsior-515-50* | *Excelsior-561-100* |
| *Excelsior-532M-20* | *Excelsior-561-150* |
| *Excelsior-532-50* | *Excelsior-594-50* |
| *Excelsior-532-100* | *Excelsior-1064-500* |
| *Excelsior-532-150* | *Excelsior-1064-800* |
| *Excelsior-532-200* | |

[1] *These lasers will only operate at constant full power when the PWR CONTROL switch is set to INT.*
[2] *These lasers meet specified parameters only at 100% laser output power.*

## *External Control Connector*

The following directions are provided if you intend to operate the laser remotely using the CONTrol interface connector.

1. Set the EMISSION CONT and/or the PWR CONT switches to EXT, as appropriate. The PWR CONT switch should be set to EXT for remote control only for the lasers listed in Table 5-2. Otherwise, this switch should be set to INT for all lasers for continuous, maximum output power.
2. Connect a cable with a 15-pin D-sub connector to the CONTrol connector. The pin numbering sequence is shown in Figure 5-4 (as you look at the power supply connector). Numbers proceed from right to left. Pin 2 provides on/off control. Pin 8 provides power output control. Use one of the ground pins (Pins 6, 7, 11 or 12) for reference (Ground). Pin descriptions are given in Table 5-3. Directions for operating the laser remotely are provided in Chapter 6.

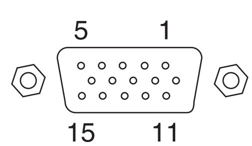



**Figure 5-4: External CONTrol Interface Connector Pin Numbering**

## Table 5-3: External Control (CONT) Connector Pin Functions

| Pin | Type | Description | Function |
|---|---|---|---|
| 1 | Output | $\overline{\textit{Laser STABLE}}$ | This pin becomes internally shorted to ground through a transistor when the laser reaches stable operation, i.e., when laser output power is at the specified level and “stable,” and laser head temperature is within the proper operating range. The shutter can be opened at this time.<br>Refer to “Using the External Stable Signal (Pin 1)” on page 6-3. |
| 2 | Input | $\overline{\textit{Laser ON/OFF}}$ | When this pin is shorted to ground, the laser will turn on following a 3 to 5 second delay.<br>Refer to “Turning the Laser On and Off (Pin 2)” on page 6-2 for instructions. |
| 3 | Output | $\overline{\textit{Laser ENABLE}}$ | This pin becomes internally shorted to ground through a transistor when laser head temperature is within the proper operating range. The laser may be turned on at this time.<br>Refer to “Using the External Enable Signal (Pin 3)” on page 6-3 for instructions. |
| 4 | Output | *Current Monitor* | This pin provides an output signal proportional to the current of the diode pump laser. The scale is 100 mV/Amp, and maximum signal is 160 mV (corresponding to 1.6 A). |
| 5 | Output | *Laser Power Monitor* | This pin provides an output signal that is approximately proportional to the power output of the laser. Actual signal level depends on the laser model. When nominal power (100%) is emitted from the laser, the voltage on Pin 5 is about 100 mV (typically 96 to 98 mV).<br>Example: a Pin 5 signal of 50 mV for the *Excelsior-532-150* indicates that laser power is about 75 mW. |
| 6 | Ground | | |
| 7 | Ground | | |
| 8 | Input | *External Power Control* | This pin is used to vary the output power of the lasers listed in Table 6-1.<br>Refer to “Changing Laser Output Power (Pin 8)” on page 6-4 for instructions. |
| 9 | Output | *+12 Vdc* | This pin provides +12 Vdc @ 20 mA (max). This output can be used for external power control or for driving an external LED for indicating status. |
| 10 | Output | *SERVICE Alarm* | Indicates the diode pump laser in the laser head is nearing its end of life. To employ this “open collector” alarm refer to “Using the Service Alarm Signal (Pin 10)” on page 6-4. |
| 11 | Ground | | |
| 12 | Ground | | |
| 13 | N/A or Output | Reserved or *Thermistor Alarm* | Must be open on an *Excelsior-PS-CDRH*) or it provides a thermistor alarm on a *Excelsior-PS-XC-CDRH*). For the latter, it indicates that the thermistor circuit inside the laser head has opened. To employ this “open collector” alarm, refer to “Using the Thermistor Alarm (Pin 13)” on page 6-6. |
| 14 | N/A | Reserved | Must be open |
| 15 | N/A | Reserved | Must be open |

# Chapter 6 Operation

**Danger!**
Laser Radiation

The Spectra-Physics *Excelsior* lasers are *Class IIIb and Class 4—High Power Lasers* whose beams are, by definition, safety hazards. Take precautions to prevent accidental exposure to both direct and reflected beams. Diffuse as well as specular beam reflections can cause severe eye damage.

*Because the infrared (IR) beam of the 1064 nm lasers is invisible, it is especially dangerous.* Infrared radiation passes easily through the cornea of the eye, which, when focussed on the retina, can cause instantaneous and permanent damage!

Always wear proper eye protection when working on the laser and follow the safety precautions in Chapter 2, "Laser Safety." Refer to the product model number label for wavelength (nm).

Detailed descriptions of signals and connectors are given in Chapter 4, "Controls, Indicators, and Connections."

## Operating the Laser from the Power Supply

The simplest way to operate the laser is to allow it to run at constant (maximum) power and to use the EMISSION keyswitch on the power supply to turn the laser on and off.

### *Turning the Laser On and Off*

1. Always start the laser with the shutter closed. Also be sure that the beam will be terminated by the target, a power detector or other suitable beam block.
2. Turn on the POWER switch. The POWER indicator will illuminate. The laser head will take 2 to 5 minutes to reach operating temperature, at which time the ENABLE indicator will turn on.
3. Turn on the EMISSION keyswitch. The EMISSION indicator will illuminate and, after a CDRH delay of 3 to 5 seconds, the *Excelsior* will produce laser radiation.

**Note**

If the EMISSION keyswitch is turned on before the ENABLE indicator turns on, the laser will not start. If this happens, turn off the keyswitch and turn on the keyswitch. Then turn on the keyswitch on again.

4. Wait a few seconds for laser output power to stabilize. Once stabilized, the STABLE indicator will illuminate.
5. Open the shutter to unblock the laser output beam.
6. To turn the laser off, turn the EMISSION keyswitch to STBY, remove the key and close the shutter. This is the recommended “off” condition when the laser is going to be used frequently—it saves warm-up time.

   If the laser is not to be used for an extended period (e.g., when turned off over night), also turn off the ac POWER switch or utility power.

## Operating the Laser Using the External Control Interface

All laser functions can be controlled by applying remote analog signals to the CONTrol interface connector on the back of the power supply. Table 5-3 on page 5-5 defines the function of each pin of that connector. Note that ground pins for the CONTrol connector are Pins 6, 7, 10 and 11.

Before using a remote source to control the laser, the EMISSION CONTROL switch on the side of the power supply must be set to EXT (Figure 4-7). Then, leaving the EMISSION keyswitch set to STBY, apply ac power to the power supply and turn on the POWER switch. The following discussions assume that this has already been done. To return the system to internal control and maximum output power, set the EMISSION CONTROL switch back to INT.

### *Turning the Laser On and Off (Pin 2)*

The laser can only be turned on after the resonator has reached normal operating temperature and the ENABLE signal, Pin 3, is pulled low (see “Using the External Enable Signal (Pin 3)” on page 6-3). When the laser is stable, the STABLE signal, Pin 1, is pulled low (see “Using the External Stable Signal (Pin 1)” on page 6-3.)

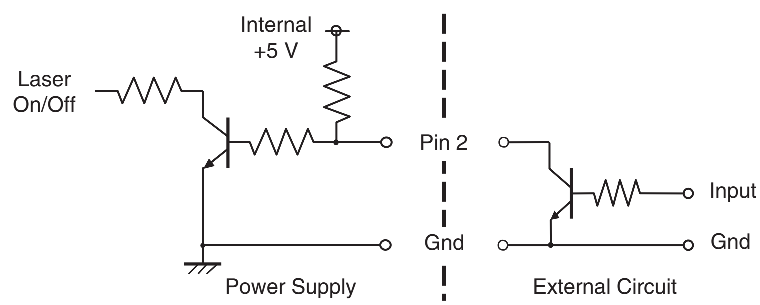



**Figure 6-1: Example of a typical laser On/Off control circuit.**

Use a switching circuit similar to that shown in Figure 6-1 to turn the laser on and off. When the external transistor connected to Pin 2 is turned on, thus pulling Pin 2 low, the diode pump laser turns on and emission occurs. After the laser has received this *On* command, it is ready to perform to specifications after 3 to 5 seconds. Note: the external transistor in the figure above can be replaced by a simple mechanical switch or relay.

### *Using the External Enable Signal (Pin 3)*

When laser head temperature is within normal operating range (i.e., when the resonator has stabilized), an internal transistor connected to Pin 3 turns on, thus pulling Pin 3 low.

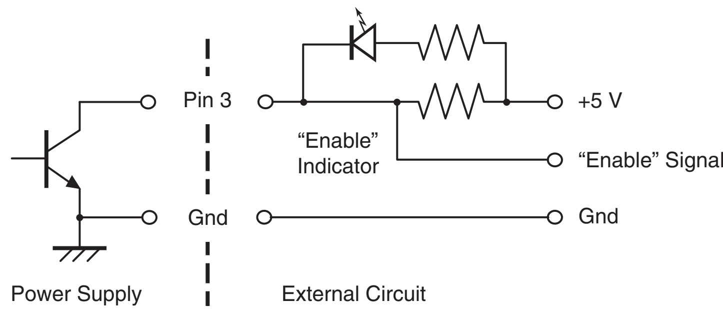



**Figure 6-2: Example Circuit for a Remote Enable Signal/Indicator**

A circuit similar to that shown in Figure 6-2 can be used to signal a remote controller that the laser is ready to be turned on, or it can be used to turn a remote Enable indicator on and off as shown in the example. The Pin 3 transistor can sink up to 20 mA maximum.

**Note**

An *On* signal from the EMISSION keyswitch or from a TTL-low signal applied to Pin 2 will only be accepted when ENABLE is active low.

### *Using the External Stable Signal (Pin 1)*

When laser head temperature has reached normal operating range and the laser has been turned on and output power has stabilized, an internal transistor connected to Pin 1 turns on, thus pulling Pin 1 low. This signals the laser is ready to use following a 3- to 5-second CDRH delay.

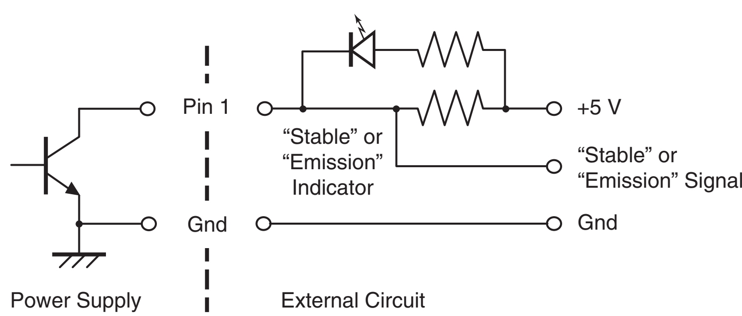



**Figure 6-3: Example Circuit for a Remote Stable/Emission Signal/ Indicator**

A circuit similar to that shown in Figure 6-3 can be used to signal a remote controller that the laser is stable and emission has occurred, or it can be used to turn a remote Enable or Emission indicator on and off. The Pin 3 transistor can sink up to 20 mA maximum.

### *Using the Service Alarm Signal (Pin 10)*

The SERVICE alarm is activated on Pin 10 (the pin is pulled low) when the diode laser drive current reaches 95% of the factory-set maximum limit.

Figure 6-4 shows an example of a circuit that can be used for monitoring the SERVICE alarm remotely. The Pin 10 transistor can sink up to 20 mA maximum.

**Note**

To allow the laser head to become fully stabile, the Pin 10 signal is disabled for the first 5 minutes after the EMISSION keyswitch is turned on.

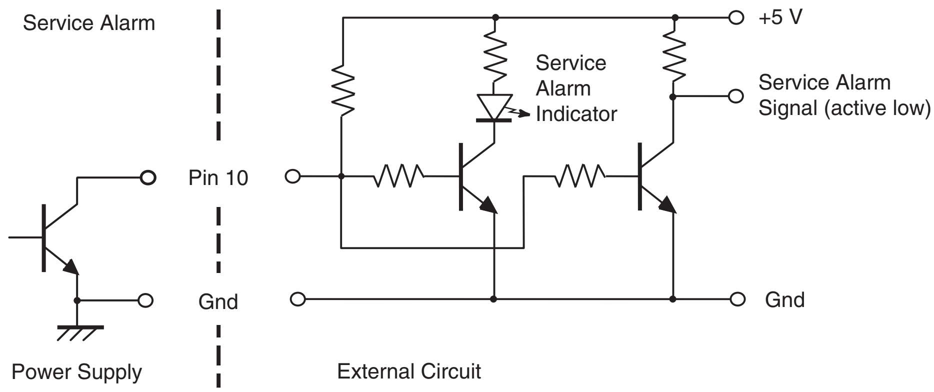



**Figure 6-4: Example or a Service Alarm Circuit**

### *Changing Laser Output Power (Pin 8)*

The output power of the lasers listed in Table 6-1 can be varied from 50% to 100% by varying the voltage on Pin 8 from 0 to 5 V. To implement this, the PWR CONTROL switch located on the side of the power supply (Figure 4-7) must first be set to EXT.

**Caution!**

Be sure the PWR CONTROL switch is set to INT for *Excelsior* models NOT listed in Table 6-1; those lasers will *not* operate if this switch is mistakenly set to EXT.

**Table 6-1: Lasers capable of variable output power[1, 2]**

| | |
|---|---|
| *Excelsior-473-10* | *Excelsior-542-50* |
| *Excelsior-473-50* | *Excelsior-561-25* |
| *Excelsior-505-20* | *Excelsior-561-50* |
| *Excelsior-515-50* | *Excelsior-561-100* |
| *Excelsior-532M-20* | *Excelsior-561-150* |
| *Excelsior-532-50* | *Excelsior-594-50* |
| *Excelsior-532-100* | *Excelsior-1064-500* |
| *Excelsior-532-150* | *Excelsior-1064-800* |
| *Excelsior-532-200* | |

[1] *These lasers will only operate at constant full power when the PWR CONTROL switch is set to INT.*
[2] *These lasers meet specified parameters only at 100% laser output power.*

**Note** Operating the laser below 50% of its rated power is not recommended. The full set of *Excelsior* specifications are guaranteed only at the 100% power level.

Figure 6-5 shows two simple external circuits for making these adjustments. Table 6-2 lists the recommended parameters for $R_1$ and $VR_1$. Note that although the input at Pin 8 is shown as 0 to 5 V, this corresponds to 0 to 100% of output power, whereas actual adjustment should only go from 50% to 100% output power.

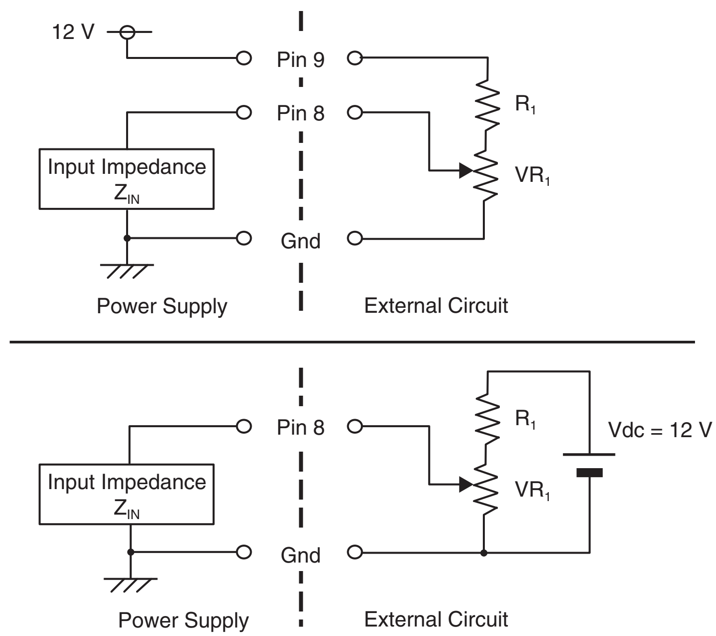



**Figure 6-5: Example Circuits for Varying Laser Output Power**

**Table 6-2: Recommended Parameters for $R_1$ and $VR_1$ in Figure 6-5**

| Controller | Input Impedance $Z_{IN}$ | Value for $VR_1$[1] | Value for $R_1$[1] | Voltage to Pin 8 (Corresponding to 0–100% output power) |
|---|---|---|---|---|
| Excelsior–PS–CDRH | 18 kΩ | 1 kΩ<br>2 kΩ<br>5 kΩ<br>10 kΩ | 1.2 kΩ<br>2.2 kΩ<br>5.1 kΩ<br>8.2 kΩ | 0 V – 5 V |
| Excelsior–PS–XC–CDRH | 26 kΩ | 1 kΩ<br>2 kΩ<br>5 kΩ<br>10 kΩ | 1.2 kΩ<br>2.4 kΩ<br>5.6 kΩ<br>9.1 kΩ | 0 V – 5 V |

[1] *If Vdc in the bottom figure is not 12 V, the resistance of $VR_1$ and $R_1$ should be modified accordingly.*

### *Monitoring Laser Output Power (Pin 5)*

Laser output power can be monitored remotely at Pin 5, which provides an output signal that is approximately proportional to laser output power. Actual output at Pin 5 depends on laser model. For example:

*Excelsior-PS-CDRH*: At full output power, the signal is 95 to 100 mV.

Example: a Pin 5 signal of 50 mV for the *Excelsior-473-10-CDRH* indicates that laser power has fallen to about 5 mW.

*Excelsior-PS-XC-CDRH*: At full output power, the signal is approximately 2 V.

In order to avoid affecting the automatic power control circuit inside the controller, the input impedance of the external circuit should be greater than 10 kΩ, preferably greater than 100 kΩ.

### *Using the 12 Vdc Output (Pin 9)*

Pin 9 provides a 12 Vdc source that can be used with Pin 8 to vary laser output power (see “Changing Laser Output Power (Pin 8)” on page 6-4). Figure 6-6 shows a schematic of the 12 Vdc circuit. The impedance $Z_{OUT}$ of the external user circuit must not draw more than 20 mA total from Pin 9.

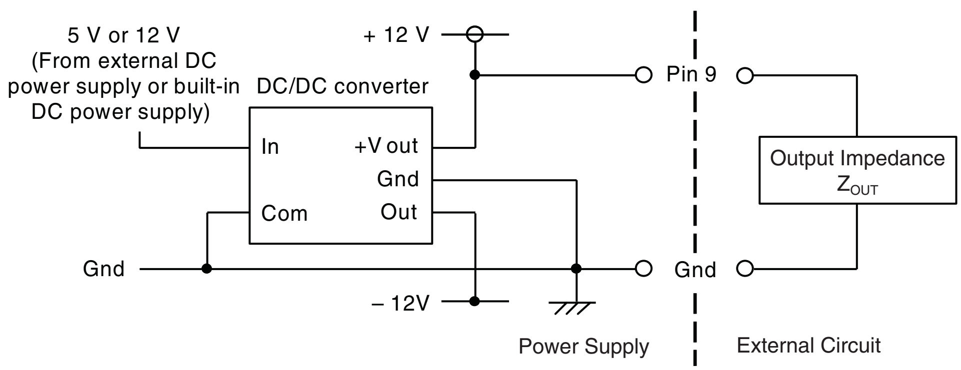



**Figure 6-6: The 12 Vdc Supply Circuit**

### *Using the Thermistor Alarm (Pin 13)*

A thermistor inside the laser head is used as part of a circuit to control the temperature of the laser resonator. When an “open” thermistor occurs, such as when a wire breaks on the thermistor (from shock and/or vibration), the thermistor alarm is activated on Pin 13 (the pin goes low). When this alarm occurs, temperature control and laser emission are terminated. Figure 6-7 shows an example circuit. The Pin 13 transistor can sink up to 20 mA maximum.

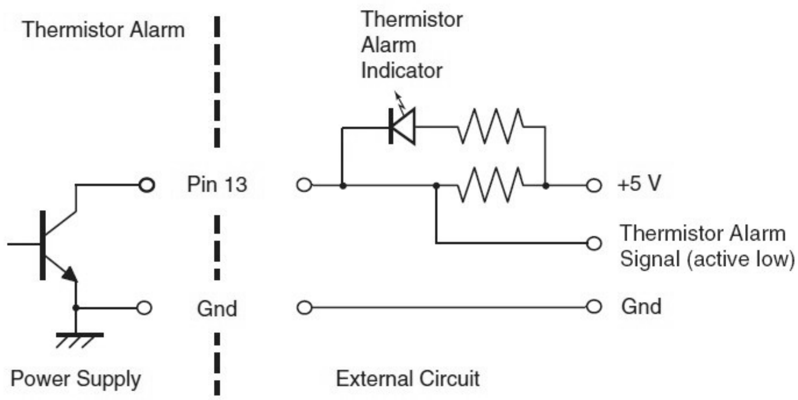


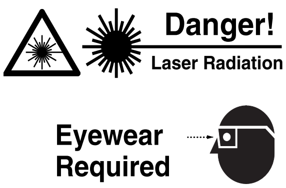

**Figure 6-7: Thermistor Alarm Example Circuit**

## Interlock Jumper Plug

An interlock jumper plug (Figure 6-8) is provided with the system to allow operation without an optional external safety interlock circuit wired to the REMOTE connector. Make sure that either a normally closed (NC) switch or shorting device is wired to this connector or, if none is to be used, that the jumper plug is installed.

**Figure 6-8: REMOTE Interlock Jumper Plug**

# Chapter 7 Troubleshooting and Service




The Spectra-Physics *Excelsior* lasers are *Class IIIb and Class 4—High Power Lasers* whose beams are, by definition, safety hazards. Take precautions to prevent accidental exposure to both direct and reflected beams. Diffuse as well as specular beam reflections can cause severe eye damage.

*Because the infrared (IR) beam of the 1064 nm lasers is invisible, it is especially dangerous.* Infrared radiation passes easily through the cornea of the eye, which, when focussed on the retina, can cause instantaneous and permanent damage!

Always wear proper eye protection when working on the laser and follow the safety precautions in Chapter 2, "Laser Safety." Refer to the product model number label for wavelength (nm).

## Maintenance

The *Excelsior* laser head requires no routine maintenance. *There is no reason to remove the outer cover because there are no user-serviceable parts inside the laser head.* This cover should only be removed by an authorized service engineer.

To retain a clean intracavity environment, all components are cleaned to stringent standards prior to assembly and alignment at the factory. The cover of the laser module inside the laser head is secured and sealed and should never be opened. *Removing the module cover will compromise the cleanliness of the intracavity space, degrade laser performance and void the warranty.*

Replacing the diode pump laser can only be performed at a Spectra-Physics facility by someone trained and authorized by Spectra-Physics. Call your Spectra-Physics service representative when you suspect that the diode pump laser is at its end of life (e.g., the Service indicator has turned on).

All parts that normally come in contact with laboratory or industrial environments retain surface contamination that can be transferred to optical components during handling. Indeed, skin oils can be very damaging to optical surfaces and coatings and can lead to serious degradation problems under intense laser illumination. It is, therefore, essential that only clean items come into contact with optical components and to the mechanical parts immediately surrounding them.

## Service Training Programs

*Excelsior* lasers are designed for hands-off operation. This product does not require alignment nor routine cleaning of cavity optics. Service is generally limited to replacing the entire laser head. Spectra-Physics offers service training programs to train personnel in diagnosing problems.

## Troubleshooting

This troubleshooting guide is intended to assist you in identifying some of the problems that might arise while using the system. For information about repairing the laser, please call your Spectra-Physics representative. A list of world-wide service sites is included at the end of this chapter.

**Symptom: No laser beam**

| Possible Causes | Corrective Action |
|---|---|
| Shutter is closed. | Verify the hand-operated shutter is open (set to the left). |
| Loose cable connector | Verify that all cables are securely connected. |
| Improper settings for the internal/external control switches | If laser is controlled internally, both the PWR CONTROL and the EMISSION CONTROL switches must be set to INT. |
| **External control** | |
| No *On* signal applied to the CONT connector | If laser power is controlled externally, the EMISSION CONTROL switch must be set to EXT.<br>Pin 2 of the CONT connector must be pulled to ground to turn on the laser. |
| Improper settings for external power control | If laser power is controlled externally, the PWR CONTROL switch must be set to EXT. The ac POWER switch and the EMISSION keyswitch must both be on.<br>Pin 8 of the CONT connector must receive a suitable input signal for external power control. |

**Symptom: Low power**

| Possible Causes | Corrective Action |
|---|---|
| Incorrect power measurement | Ensure that output power is measured as it leaves the laser head before the output beam enters any external optical elements. |
| Shutter is clipping the beam | Verify the hand-operated shutter is fully open. |
| Loose cable connector | Verify that all cables are securely connected. |
| Laser is not warmed up | Allow the laser to warm up for at least 5 minutes. |
| Dirty output window | Clean the laser head output window. |
| Laser head temperature outside operating range | Measure the temperature of the baseplate. If it is below 10°C or exceeds 50°C (or 45°C for Group B models), verify the ambient temperature is within the allowable operating range and correct if necessary. Refer to Table 5-1, Figure 5-1 and Figure 5-2.<br>Verify the laser head baseplate is properly heat-sinked. |

**Symptom: Low power**

| | |
|---|---|
| Reflected laser light is destabilizing the laser | Ensure that light reflected from any external optical elements does not reflect back through the window of the laser head. |
| Diode pump laser has reached its end of life | Contact your Spectra-Physics service representative about replacing the laser head. |
| Improper settings for internal power control | For internal power control, the PWR CONTROL switch must be set to INT. |
| **External control** | |
| Incorrect settings for external power control | If the laser power is controlled externally, set the PWR CONTROL switch to EXT, and provide a stable, low-noise 5 V signal to Pin 8 of the CONT connector.<br>Do not set the output power level below 50% of the maximum specified output power for your *Excelsior* laser model. |
| Incorrect use of external power control | Only the *Excelsior* lasers listed in Table 6-1 are designed for external power control.<br>If your model is suitable only for internal power control, verify the PWR CONTROL switch is set to INT. |

**Symptom: High optical noise**

| Possible Causes | Corrective Action |
|---|---|
| Loose cable connector | Verify that all cables are securely connected. |
| Improper setting for the PWR CONTROL switch | Verify the PWR CONTROL switch is set to INT.<br>If laser power is controlled externally, set the PWR CONTROL switch to EXT, and provide a stable, low-noise 5 V signal to Pin 8 of the CONT connector. |
| Laser is not warmed up | Allow the laser to warm up for at least 5 minutes. |
| Laser head temperature is outside operating range | Measure the temperature of the baseplate. If it is below 10°C or exceeds 50°C (or 45°C for Group B models), verify the ambient temperature is within the allowable operating range and correct if necessary. Refer to Table 5-1, Figure 5-1 and Figure 5-2.<br>Verify the laser head baseplate is properly heat-sinked. |
| Reflected laser light is destabilizing the laser | Ensure that light reflected from any external optical elements does not reflect back through the window of the laser head. |
| Improper ground | Check the grounding of the laser head and the power supply. |
| Vibration is outside operating limits | Verify any vibration experienced by the laser head is within operating limits. |
| External noise source | Verify that there are no strong electromagnetic noise sources near the system. If output power is controlled externally, verify the voltage signal applied to Pin 8 of the CONT connector is low-noise. |

**Symptom: Bad transverse mode**

| Possible Causes | Corrective Action |
|---|---|
| Improper setting for the PWR CONTROL switch | Verify the PWR CONTROL switch is set to INT.<br>If the laser power is controlled externally, set the PWR CONTROL switch to EXT and provide a stable, low-noise 5 V signal to Pin 8 of the CONT connector. |
| Laser is not warmed up | Allow the laser to warm up for at least 5 minutes. |
| Dirty output window | Clean the laser head output window. |

**Symptom: Bad transverse mode**

| | |
|---|---|
| Laser head temperature is outside operating range | Measure the temperature of the baseplate. If it is below 10°C or exceeds 50°C (or 45°C for Group B models), verify the ambient temperature is within the allowable operating range and correct if necessary. Refer to Table 5-1, Figure 5-1 and Figure 5-2.<br>Verify the laser head baseplate is properly heat-sinked. |
| Reflected laser light is destabilizing the laser | Ensure that light reflected from any external optical elements does not reflect back through the window of the laser head. |

**Symptom: Output power is unstable**

| Possible Causes | Corrective Action |
|---|---|
| Loose cable connector | Verify that all cables are securely connected. |
| Improper settings for the PWR CONTROL switch | Verify that the controller PWR CONTROL switch is set to INT.<br>If laser power is controlled externally, set the PWR CONTROL switch to EXT and provide a stable, low-noise 5 V signal to Pin 8 of the CONT connector. |
| Laser is not warmed up | Allow the laser to warm up for at least 5 minutes. |
| Laser head temperature is outside operating range | Measure the temperature of the baseplate. If it is below 10°C or exceeds 50°C (or 45°C for Group B models), verify the ambient temperature is within the allowable operating range and correct if necessary. Refer to Table 5-1, Figure 5-1 and Figure 5-2.<br>Verify the laser head baseplate is properly heat-sinked. |
| Reflected laser light is destabilizing the laser | Ensure that light reflected from any external optical elements does not reflect back through the window of the laser head. |

## Replacement Parts

The following is a list of parts that may be purchased to replace broken, worn-out or misplaced components.

**Table 7-1: Replacement Parts**

| Description | Part Number |
|---|---|
| *Excelsior* 10 mW @ 473 nm, single mode | Excelsior-473-10-SLM-CDRH |
| *Excelsior* 50 mW @ 473 nm, single mode | Excelsior-473-50-SLM-CDRH |
| *Excelsior* 20 mW @ 505 nm, multi mode | Excelsior-505-20-MLM-CDRH |
| *Excelsior* 50 mW @ 515 nm, single mode | Excelsior-515-50-SLM-CDRH |
| *Excelsior* 20 mW @ 532 nm, multi mode | Excelsior-532-20-MLM-CDRH |
| *Excelsior* 50 mW @ 532 nm, single mode | Excelsior-532-50-SLM-CDRH |
| *Excelsior* 100 mW @ 532 nm, single mode | Excelsior-532-100-SLM-CDRH |
| *Excelsior* 150 mW @ 532 nm, single mode | Excelsior-532-150-SLM-CDRH |
| *Excelsior* 200 mW @ 532 nm, single mode | Excelsior-532-200-SLM-CDRH |
| *Excelsior* 300 mW @ 532 nm, single mode | Excelsior-532-300-SLM-CDRH |
| *Excelsior* 25 mW @ 561 nm, single mode | Excelsior-561-25-SLM-CDRH |
| *Excelsior* 50 mW @ 561 nm, single mode | Excelsior-561-50-SLM-CDRH |
| *Excelsior* 100 mW @ 561 nm, single mode | Excelsior-561-100-SLM-CDRH |
| *Excelsior* 150 mW @ 561 nm, single mode | Excelsior-561-150-SLM-CDRH |
| *Excelsior* 50 mW @ 594 nm, multi mode | Excelsior-594-50-MLM-CDRH |
| *Excelsior* 500 mW @ 1064 nm, single mode | Excelsior-1064-500-SLM-CDRH |
| *Excelsior* 800 mW @ 1064 nm, single mode | Excelsior-1064-800-SLM-CDRH |
| *Excelsior* Power Supply for standard laser heads | Excelsior-PS-CDRH |
| *Excelsior* Power Supply for extended cavity (XC) laser heads | Excelsior-PS-XC-CDRH |
| *Excelsior* Laser Head Cable for standard laser, 1.8 m (6 ft) | Excelsior-Laser-Cable-CDRH |
| *Excelsior* Laser Head Cable for extended cavity laser, 1.8 m (6 ft) | Excelsior-Laser-Cable-XC-CDRH |
| *Excelsior* Remote Connector | Excelsior-Connector-CDRH |
| *Excelsior* Power Supply “Emission” Key | Excelsior-Key-CDRH |

## Customer Service

At Spectra-Physics, we take great pride in the reliability of our products. Considerable emphasis has been placed on controlled manufacturing methods and quality control throughout the manufacturing process. Nevertheless, even the finest precision instruments will need occasional service. Our instruments have excellent service records compared to competitive products, and we strive to provide excellent service to our customers in two ways: by providing the best equipment for the price and by servicing your instruments as quickly as possible.

When calling for service inside the United States, dial our toll free number: **1 (800) 456-2552**. To phone for service in other countries, refer to "Service Centers" on page 7-7.

Order replacement parts directly from Spectra-Physics. For assistance of any kind, contact your sales office or service center. You will need your model and serial numbers available when you call. To order optional items or other system components, or for general sales assistance, dial **1 (800) SPL-LASER** in the United States, or **1 (408) 980-4300** from anywhere else.

### *Warranty*

All parts and assemblies manufactured by Spectra-Physics are unconditionally warranted to be free of defects in workmanship and materials for the period of time listed in the sales contract following delivery of the equipment to the F.O.B. point.

Liability under this warranty is limited to repairing, replacing, or giving credit for the purchase price of any equipment that proves defective during the warranty period, provided prior authorization for such return has been given by an authorized representative of Spectra-Physics. Spectra-Physics will provide at its expense all parts and labor and one-way return shipping of the defective part or instrument (if required). In-warranty repaired or replaced equipment is warranted only for the remaining portion of the original warranty period applicable to the repaired or replaced equipment.

This warranty also does not apply to equipment or components that, upon inspection by Spectra-Physics, is found to be defective or unworkable due to abuse, mishandling, misuse, alteration, negligence, improper installation, unauthorized modification, damage in transit, or other causes beyond the control of Spectra-Physics.

This warranty is in lieu of all other warranties, expressed or implied, and does not cover incidental or consequential loss.

### *Returning the Instrument for Repair*

Contact your nearest Spectra-Physics field sales office, service center, or local distributor for shipping instructions. You are responsible for one-way shipment of the defective part to Spectra-Physics. Instruments can be returned only in Spectra-Physics containers. We encourage you to use the original packing boxes to secure instruments during shipment. If shipping boxes have been lost or destroyed, we recommend ordering new ones.

## Service Centers

**Belgium**

Telephone: 0800-11 257
Fax: 0800-11 302

**China**

Newport Corporation
Beijing Representative Office
Room 2305, Building B, Tri-Tower
No. 66 Zhongguancun East Road
Beijing 100080
P. R. China
Telephone: (86) 10-6254-7746
Fax: (86) 10-6255-6373

**France**

MICRO-CONTROLE
Spectra-Physics S.A.
1, rue Jules Guesde - Bât. B
ZI. Bois de l'Epine - BP189
9106 Evry CEDEX, France
Telephone: +33-1-60-91-68-68
Fax: +33-1-60-91-68-69
Internet: france@newport-fr.com

**Germany and Export Countries***

Newport Spectra-Physics GmbH
Guerickeweg 7
D-64291 Darmstadt, Germany
Telephone: +49-(0) 06151-708-0
Fax: +49-(0) 06151-708-217
Internet: verkauf@newport-de.com

**Japan (East)**

Spectra-Physics K.K.
4-6-1 Nakameguro Meguro-ku
Tokyo 153-0061, Japan
Telephone: +81-3-3794-5511
Fax: +81-3-3794-5510
Internet: spectra-physics@splasers.co.jp

**Japan (West)**

Spectra-Physics K.K.
Nishi-honmachi Solar Building, 3-1-43 Nishi-honmachi Nishi-ku
Osaka 550-0005, Japan
Telephone: +81-6-4390-6770
Fax: +81-6-4390-2760
Internet: spectra-physics@splasers.co.jp

**And all European and Middle Eastern countries not included on this list.*

**Netherlands**

Newport Spectra-Physics B.V.
Vechtensteinlaan 12-16
3555 XS Utrecht
Netherlands
Telephone: 0900 555 5678
Fax: 0900 555 5679
Internet: netherlands@newport-de.com

**Taiwan**

Newport Corporation
Room A, 10F, No. 80, Sec. 1, Jianguo N. Rd.
Zhongshan
District, Taipai City 104, Taiwan (R.O.C.)
Telephone: +886-2-2508-4977
Fax: +886-2-2508-0367
Internet: sales@newport.com.tw

**United Kingdom**

Newport Spectra-Physics Ltd-Registered Office
Unit 7, Library Avenue
Harwell Science & Innovation Campus, Didcot.
Oxfordshire, OX11 0SG
Telephone: +44 1235 432710
Fax: +44 1235 821045
Internet: sales@newport.com.uk

**United States and Export Countries***

Spectra-Physics
3635 Peterson Way
Santa Clara, CA 95054-2809
Telephone: (800) 456-2552 (Service) or
(800) SPL-LASER (Sales) or
(800) 775-5273 (Sales) or
(408) 980-4300 (Operator)
Fax: (408) 980-6921
e-mail: service@spectra-physics.com
sales@spectra-physics.com
Internet: www.spectra-physics.com

**And all non-European or Middle Eastern countries not included on this list.*

# Notes

# Report Form for Problems and Solutions

We have provided this form to encourage you to tell us about any difficulties you have experienced in either using your Spectra-Physics instrument or its manual—problems that did not require a formal call or letter to our service or marketing departments, but that you feel should be remedied. We are always interested in improving our products and manuals and we appreciate all suggestions.

Send all instrument related questions to:

Spectra Physics
A Newport Corporation Brand
Service Manager
3635 Peterson Way
Santa Clara, CA 95054
FAX: (408) 980-3584

Send all manual related questions to:

Spectra Physics
A Newport Corporation Brand
Senior Director Product Marketing
3635 Peterson Way
Santa Clara, CA 95054
FAX: (408) 980-7101

Thank you.

**From:**

Name ______________________________

Company or Institution ______________________________

Department ______________________________

Address ______________________________

______________________________

Instrument Model Number ____________________ Serial Number ____________________

**Problem:** ______________________________

______________________________

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______________________________

**Suggested Solution(s):** ______________________________

______________________________

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