Millennia Pro *s*-Series

Diode-Pumped, CW Visible Laser Systems

User's Manual

These laser products comply 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, maintain, and service your *Millennia Pro s-Series* diode-pumped, continuous-wave, visible laser. The system comprises the *Millennia Pro s* laser head, either a *Model J40* or *Model J80* power supply, and the *Millennia* Controller (a table-top unit provided with the system).

There are four different models of the laser head, according to their output power: the *Millennia Pro 5sJ, 6sJ, 8sJ,* or *10sJ*. The laser head is water-cooled, and an optional chiller is available for this purpose.

Chapter 1, "Introduction," contains a brief description of the *Millennia Pro s-Series* system and the accessories provided with it.

Chapter 2, "Laser Safety," contains important information on safety. A *Millennia Pro s* laser is a Class IV device and, as such, emits laser radiation that can permanently damage eyes and skin. This section contains information about these hazards and offers suggestions on how to safeguard against them. To minimize the risk of injury or expensive repairs, be sure to read this chapter—then carefully follow these instructions.

Chapter 3, "Laser Description," contains a short section on laser theory regarding the Nd:YVO_4 crystal and second harmonic generation used in the *Millennia Pro s-Series*. It is followed by a more detailed description of the laser system. This chapter concludes with tables of system specifications and outline drawings.

Chapter 4, "Controls, Indicators, and Connections," describes the *Millennia* controls, and Chapter 5 "Installation" helps you prepare your site for the installation of the system by a Spectra-Physics technician.

Chapter 6, "Operation," describes in detail how to operate the laser.

Chapter 7, "Maintenance and Troubleshooting," is intended to help you guide your Spectra-Physics field service engineer to the source of any problems. *Do not attempt repairs yourself while the unit is still under warranty*; instead, report all problems to Spectra-Physics for warranty repair. This chapter includes a replacement parts list.

Chapter 8, "Customer Service," contains a list of world-wide Spectra-Physics Service Centers you can call if you need help. Should you experience any problems or you are in need of technical information or support, please contact Spectra-Physics.

This product has been tested and found to conform to Directive 73/23/EEC governing product safety using standards EN 60950: 1997, EN 61010-1: 2001 and EN 60825-1: 1994, and it conforms to Directive 89/336/EEC governing electromagnetic compatibility using standard EN 61326-1 w/ A1: 1997 as listed in the official *Journal of the European Communities*. Refer to the "CE Declaration of Conformity" statements in Chapter 2.

This product conforms to the requirements of 21 CFR 1040.10 CDRH and are compliant to Underwriters Laboratory UL1950 and uses a power supply that is a UL recognized (ULR) component.

This equipment has been designed and tested to comply with the limits for a Class A digital device pursuant to Part 15 of the FCC Rules.

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. The last page 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

Refer to specification EN-309, "Plug, Outlet and Socket Couplers for Industrial Uses," listed in the official *Journal of the European Communities, f*or information regarding the equipment needed in order to provide the electrical service listed under "Specifications" at the end of Chapter 3.

Environmental Specifications

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

Indoor use

Altitude:	up to 3000 m
Temperatures:	18°C to 35°C
Maximum relative humidity:	85% non-condensing for temperatures up to 35°C.
Mains supply voltage:	do not exceed ± 10% of the nominal voltage
Insulation category:	II
Pollution degree:	2

FCC Regulations

This equipment has been tested and found to comply with the limits for a Class A digital device pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Modifications to the laser system not expressly approved by Spectra-Physics could void your right to operate the equipment.

CDRH and UL Regulations

This product conforms to the requirements of 21 CFR 1040.10 CDRH and are compliant to Underwriters Laboratory UL1950 and are listed as ULR for recognized components.

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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.

Laser radiation is present.

Condition or action may present a hazard to personal safety.

Condition or action may present an electrical hazard to personal safety.

Condition or action may cause damage to equipment.

Action may cause electrostatic discharge and cause damage to equipment.

Condition or action may cause poor performance or error.

Text describes exceptional circumstances or makes a special reference.

Do not touch.

Appropriate laser safety eyewear should be worn during this operation.

Refer to the manual before operating or using this device.

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	mill	(10^{-3})	m	femto	(10^{-15})	f
kilo	(10^{3})	k	micro	(10^{-6})	μ	atto	(10^{-18})	a

Abbreviations

These abbreviations may be found in this manual:

AC	alternating current
AOM	acousto-optic modulator
AR	antireflection
CDRH	Center of Devices and Radiological Health
CW	continuous wave
DC	direct current
E/O	electro-optic
fs	femtosecond or 10^{-15} second
HR	high reflector
IR	infrared
OC	output coupler
ps	picosecond or 10^{-12} second
PZT	piezo-electric transducer
RF	radio frequency
SCFH	standard cubic feet per hour
TEM	transverse electromagnetic mode
Ti:sapphire	Titanium-doped Sapphire
UV	ultraviolet
λ	wavelength

Unpacking and Inspection

Unpacking Your Laser

Your *Millennia® Pro s-Series* system 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 containers. If there is any major damage (holes in the containers, crushing, etc.), insist that a representative of the carrier be present when you unpack the contents.

To move the laser system, set the power supply on a cart and place the laser head and controller on top of it, then roll the entire system to the table or mounting area. If your system includes a rack-mountable chiller, place it on the cart first with the power supply, etc., on top of it. The power supply weighs about 25–26 kg (55–58 lb) and *takes two people to move it safely.* The same is true for the chiller. The laser head is fairly light, approximately 10 kg (22 lb), and can be picked up by one person.

Warning! 

To prevent damage to the fiber bundle, be careful when moving the laser head that the umbilical cable is not flexed tighter than the 6 in. (15 cm) minimum radius. Also, be careful not to snag any of the various cables extending from the power supply.

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 containers. If you file a damage claim, you may need them 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

The following components comprise a *Millennia Pro s-Series* system:

- *Millennia Pro s* laser head
- *Model J40* or *Model J80* power supply
- *Millennia* controller

The *Millennia Pro s* laser head is water-cooled. An optional recirculating chiller is available for supplying the specified water flow.

Verify all components are present. The laser head, power supply, and controller are shipped in one container; the chiller if included is shipped separately.

Accessories

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

- 1 US or European power cord (about 2.5 m)
- Table clamp kit: 3 clamps, 3 pairs of nested spherical washers, 3 mounting screws
- 13 mm wrench
- 4 x 10-32 stake screws for mounting the power supply
- 2 keys for the power supply
- A REMOTE jumper plug for RS-232 only operation
- An ANALOG jumper plug
- An INTERLOCK jumper plug
- Fuses

The following items are included when your *Millennia Pro s-Series* system is shipped as a pump laser for the *Tsunami*® Ti:sapphire oscillator:

- 3 pedestal legs with required foot clamps for beam height adjustment
- A pair of telescoping beam tubes
- An adaptor ring for the *Tsunami* Ti:sapphire oscillator that allows it to accept the smaller diameter beam tubes used by the *Millennia Pro s* laser head.

Chapter 1 Introduction

The Millennia Pro s-Series Advantage

Figure 1-1: ***Millennia Pro s-Series***

The Spectra-Physics *Millennia® Pro s-Series* is a family of a diode-pumped, frequency-doubled CW visible lasers capable of providing from 5 Watts to more than 10 Watts of laser power at the green wavelength of 532 nm. The *Millennia® Pro s* design features a rugged laser head for simple, hands-off operation that delivers exceptional power stability and beam-pointing performance.

The *Millennia Pro s-Series* continues the innovative technology developed for the highly regarded *Millennia®* series, and is now pumped by a high power, long-lifetime ProLite® series diode laser. Since the pump diode is the only consumable in a solid state laser system, choice of the ProLite design significantly reduces the long-term cost of ownership.

The ProLite diode laser is packaged into an industry-leading FC*bar*™ fiber-coupled diode module that is field-replaceable for greater convenience. The fiber output end in the laser head is mechanically indexed for reproducible pump beam position and consistent installation, thereby minimizing any downtime.

The system is available with two versions of the power supply, either the *Model J40* with one FC*bar* pump module, or the higher-power, *Model J80*, with two modules.

The FC*bar* module forms the heart of the system power supply that provides both control and energy to the *Millennia Pro s* laser head. The power supply is a compact, rack-mountable unit that operates from a standard single-phase outlet, and it includes microprocessor-based logic circuitry for control of the laser system.

The system is controlled either by serial commands through the RS-232 interface or by the *Millennia* Controller in stand-alone operation. The *Millennia Pro s-Series* is available in four models, each producing CW TEM_{00} output at 532 nm as summarized in the following table:

Table 1-1: Millennia Pro s-Series Systems

Model	Typical Output Power	System Power Supply
Millennia Pro 5s	> 5 W	*Model J40*
Millennia Pro 6s	> 6 W	*Model J40*
Millennia Pro 8s	> 8 W	*Model J80*
Millennia Pro 10s	> 10 W	*Model J80*

The Laser System

A *Millennia Pro s-Series* system comprises these basic components:

- *Millennia Pro s* laser head
- *Model J40* or *Model J80* power supply
- *Millennia* Controller

The laser head is cooled by chilled water. An optional recirculating chiller is available that meets the cooling requirements.

Laser Head

The *Millennia Pro s* laser head is a sealed aluminum chassis covered by an external housing. The laser head has an emission indicator and a shutter. The shutter provides a safe, mechanical method of blocking the output beam, and is opened and closed via electronic command.

Inside of the sealed chassis is the optical resonator, the neodymium yttrium vanadate laser crystal (Nd:YVO_4, simply called “vanadate”), the optics that direct diode laser pump light from the optical fiber, the lithium triborate (LBO) frequency-doubling crystal, and the output beam telescope.

The *Millennia Pro s* employs an X-cavity design that allows the laser head to be designed with an absolute minimum footprint. The vanadate gain medium is end-pumped by one or two fiber-coupled, FC*bar* modules.

Fiber-coupling allows the diode laser module(s) to be located in the power supply, thereby removing its heat load from the laser head and facilitating diode module replacement without the need for realigning the cavity. The *Millennia Pro 5s J* and *Pro 6s J* use one module, the *Millennia Pro 8s J* and *Pro 10s J* each use two.

In the frequency-doubling limb of the X-cavity, the infrared beam from the vanadate crystal is focused into an LBO crystal that generates the green output beam at the 532 nm wavelength. The noncritically phase-matched LBO doubling crystal is housed in an oven that maintains the crystal at an optimum temperature for stable output.

The cavity end mirror in the frequency-doubling limb has high-reflective coatings for both infrared and green wavelengths so that frequency-doubled light is generated both in the reflected pass as well as in the first pass through the LBO crystal. The green beam exits the cavity through a dichroic output coupler.

The *Millennia Pro s* utilizes an enhanced version of Spectra-Physics' patented QMAD intracavity doubling technology to provide ultra-low optical noise of less than 0.04% rms in an exceptionally short cavity length. This revolutionary breakthrough has enabled Spectra-Physics to develop the smallest, high power diode-pumped CW green lasers available today.

Power Supply

The *Model J40* power supply houses one fiber-coupled FC*bar* diode module that pumps the *Millennia Pro s* laser head. The *Model J80* houses two such diode modules. The diode module(s) is operated at significantly less than its rated power in order to maintain ideal operating conditions for the diode laser and, thus, ensure a long lifetime. The all solid state power supply stabilizes diode laser temperature using a thermo-electric cooler (TEC). It also contains the control logic and power modules for the system, and a forced-air cooling unit.

The power supply is rack-mountable and air cooled, requiring no water or external cooling connections. The unit is auto-ranging for electrical power from a standard power source. A power/control cable and fiber-optic cable(s) reside inside an umbilical that connects the laser head to the power supply.

Controller

The *Millennia* Controller provides local control of the system via an 8-foot cable that connects to the front of the power supply.

A simple, menu-driven control program using "soft" keys and clear, large characters on a back-lit display provides easy control and monitoring of the system. The intuitive, layered menu structure provides options for operating the laser along with diagnostic information.

For users who prefer to operate the laser remotely, either directly or via a computer program, a standard RS-232 serial link is provided on the power supply to connect to a computer or terminal.

Chiller

The *Millennia Pro s* laser head is water cooled, and an optional recirculating chiller is available that meets the cooling requirements of the system.

The optional chiller recirculates filtered water through the laser head to regulate the temperature of the vanadate crystal. Because the chiller provides a closed-loop cooling system, the *Millennia Pro s-Series* system requires no facility water connections. The cooling temperature is displayed on the chiller for easy monitoring. Information about the operation of the chiller is included in the chiller manual if shipped with the system.

If cooling water is provided by a user-supplied system, the cooling water flow must meet the specifications and the standards for the coolant listed in the section “Chiller Specifications” on page 3-14.

Note that the water hoses to the laser head are routed through the umbilical for convenience.

Patents

The *Millennia Pro s-Series* system is manufactured under the following patents:

4,653,056	4,761,786	4,942,582
4,656,635	4,785,459	5,080,706
4,665,529	4,837,771	5,127,068
4,701,929	4,872,177	5,410,559
4,723,257	4,894,839	5,412,683
4,739,507	4,908,832	5,436,990
4.756.003	4,913,533	5,446,749

Chapter 2 Laser Safety

A Spectra-Physics *Millennia® Pro s-Series* laser is a *Class IV—High Power Laser* whose beam is, by definition, a safety and fire hazard. Take precautions to prevent accidental exposure to both direct and reflected beams. Diffuse as well as specular beam reflections can cause severe eye or skin damage. The use of controls or adjustments, or the performance of procedures other than those specified herein, may result in hazardous radiation exposure.

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.

This safety section should be reviewed thoroughly prior to operating the *Millennia Pro s-Series* system, and the safety precautions listed herein should be followed carefully.

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 IV 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; even diffuse reflections are hazardous.
- Avoid blocking the output beam or its reflections with any part of the body.
- Establish a controlled access area for laser operation. Limit access to those trained in the principles of laser safety.
- Post prominent warning signs near the laser operating area (Figure 2-1).
- Set up experiments so the laser beam is either above or below eye level.
- Provide enclosures for beam paths whenever possible.
- Set up shields to prevent any unnecessary specular reflections.
- Set up a beam dump to capture the laser beam and prevent accidental exposure (Figure 2-2).

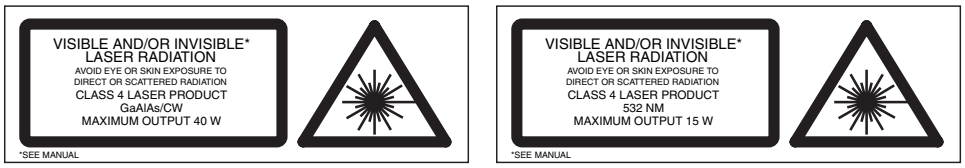


Figure 2-1: These CE and CDRH standard safety warning labels would be appropriate for use as entry warning signs (EN 60825-1, ANSI Z136.1 Section 4.7).

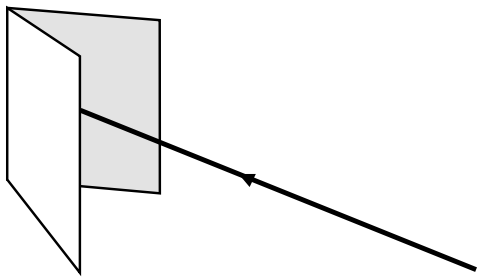


Figure 2-2: Folded Metal Beam Target

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).

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

Maximum Emission Levels and Protective Eyewear

It is recommended that laser-safe eyewear be worn at all times when the *Millennia Pro s* laser is on. The following are the maximum emission levels possible for this *Millennia Pro s* product. Use this information for selecting appropriate laser safety eyewear and implementing appropriate safety procedures. These values do not imply actual system power or specifications.

Emission Wavelength	Maximum Power
532 nm – laser output wavelength (second harmonic)	15 W
809 nm – diode laser emission (each fiber)	40 W
1064 nm – fundamental operation wavelength	<< 1 W

During normal operation, the operator will not be exposed directly to fundamental or diode laser emission. However, removing the sealed housing cover will not only invalidate the warranty, but will also expose the operator to hazardous levels of fundamental and diode laser radiation.

** 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.*

Safety Devices

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

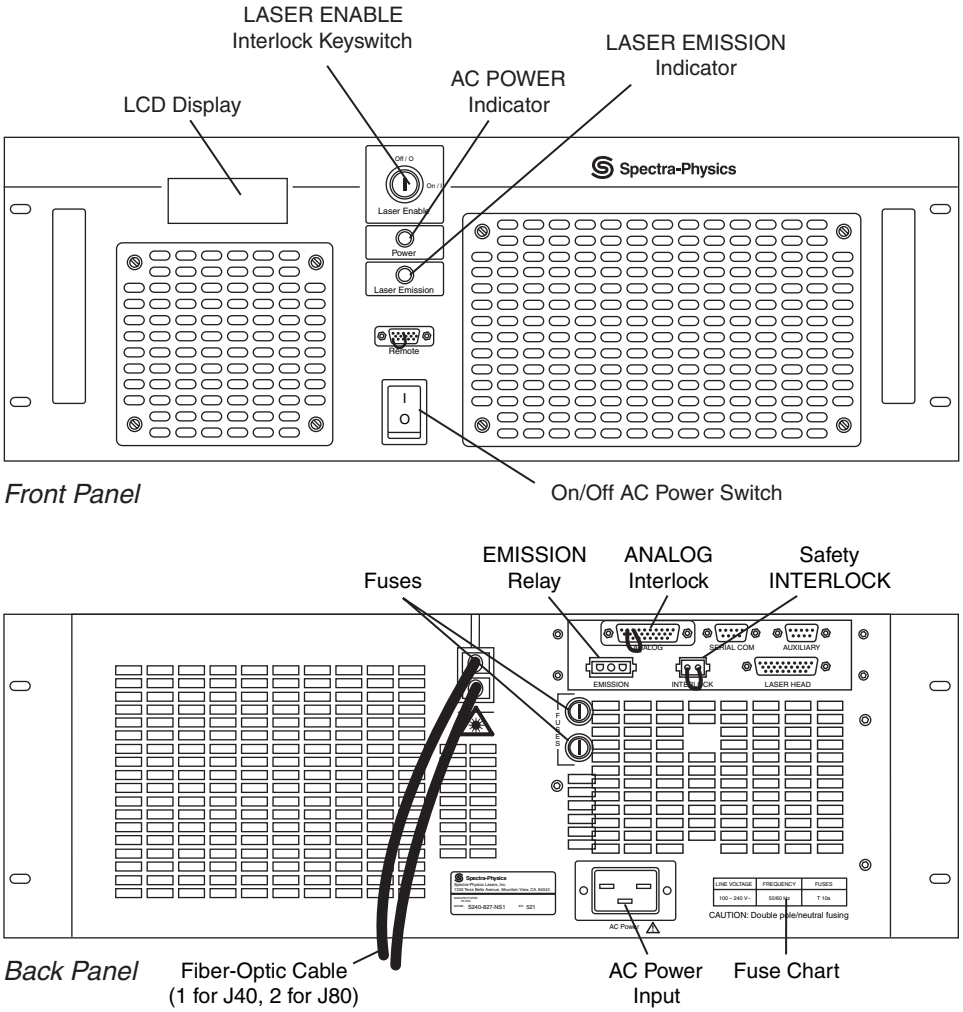


Figure 2-3: Safety devices on the *Model J40* or *Model J80* power supply

Power Switch and Indicator

This switch provides ac power to the control circuits if the LASER ENABLE keyswitch is also on. When on, the yellow LED on the power supply indicates that ac power is applied to the system control circuits.

Interlock Keyswitch

The LASER ENABLE keyswitch provides interlock safety to prevent unauthorized personnel from using the system when the key is turned to the OFF position and the key is removed. Turning the key to the ON position closes the interlock and allows the diode laser to be energized if the POWER switch is also on.

Laser Emission Indicators

The LASER EMISSION indicator (green) on the power supply (Figure 2-3) and the Emission indictor on the *Millennia* Controller (red) (Figure 2-8) turn on about 3 seconds prior to when the laser is either emitting or is capable of emitting laser light.

The Emission indictor on the laser head (white) (Figure 2-4) comes on only when the laser is either emitting or is capable of emitting laser light.

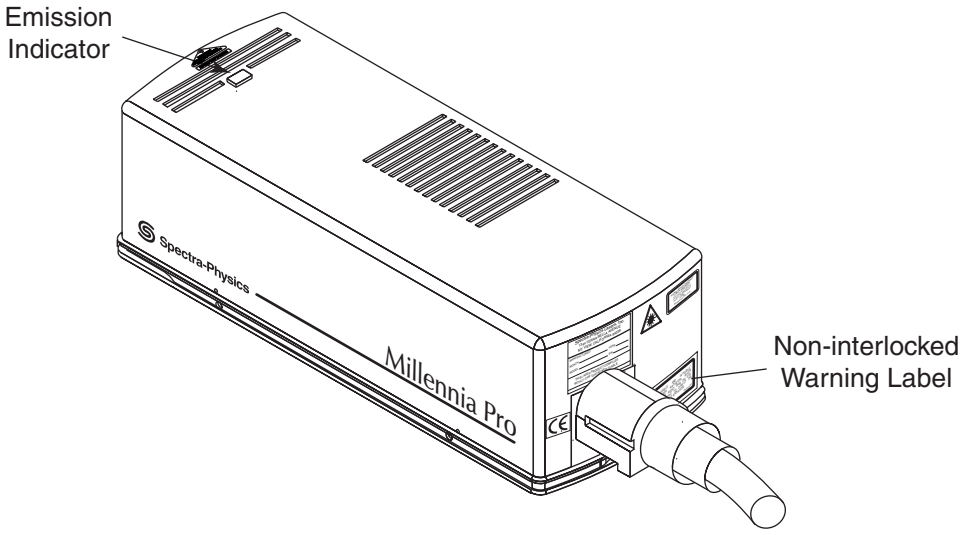


Figure 2-4: *Millennia Pro s* Laser Head

An emission relay connector on the back of the power supply (Figure 2-3) can be used to turn on and off a user-installed emission indicator. When the laser is off (i.e., there is no emission), there is closure between pins 3 and 1 and an open between pins 3 and 2 (see the schematic in Figure 2-5). The opposite is true when there is emission or emission is imminent. There is no power supplied by these terminals. This circuit is rated for 30 Vac at 1 A. See Chapter 5 for information about the parts that mate to the emission relay connector.

This relay turns on 3 seconds before actual emission occurs.

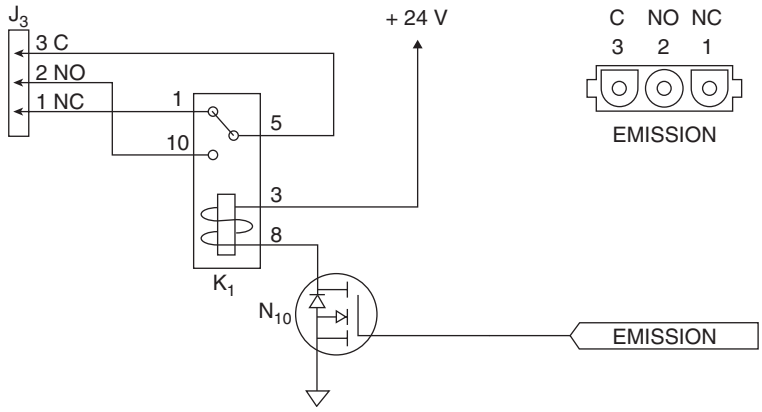


Figure 2-5: The EMISSION Relay Connector Schematic

Interlocks

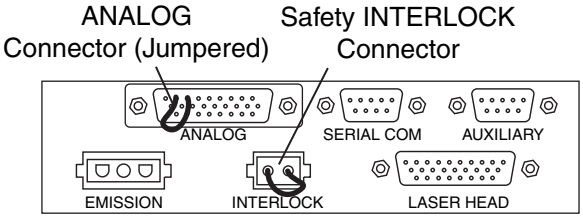


Figure 2-6: ANALOG Jumper and Safety INTERLOCK Jumper

Safety Interlock

The INTERLOCK connector on the *Model J40* and *Model J80* power supplies can be used as a remote safety interlock that can be wired to an external safety switch to turn off the laser in the event the switch is opened. However, to ensure that the laser can turn on even when this interlock is not used, the *Model J40* or *Model J80* is shipped with a shorting jumper plug (Figure 2-7) that defeats the interlock. See Chapter 5 for information about mating parts for this connector.

Note

To allow the diode laser to turn on, the two INTERLOCK contacts *must* either be wired to a safety switch or be shorted together using the jumper plug provided. The ANALOG jumper should always be installed!

Figure 2-7: INTERLOCK (left) and ANALOG (right) Jumper Plugs

To use this interlock, remove the jumper plug from the INTERLOCK connector, and either remove the jumper inside or use a similar connector without a jumper to wire to a perimeter safety switch. The switch can be attached to an access door or to other auxiliary safety equipment. Wire the switch as "normally closed" so that when the door or safety device is opened and the switch opens, the pump power to the laser is immediately turned off, thus preventing injury to personnel.

The LASER HEAD connector is also part of the interlock loop: if the laser head cable is disconnected, the diode pump laser in the power supply is turned off.

ANALOG Interlock Jumper

The ANALOG port is not used on this system. Because the system interlock circuit loops through this connector, a jumper plug (Figure 2-7) is provided to close the interlock circuit. Do not remove the ANALOG jumper plug from this connector. Doing so will prevent the laser from turning on.

Cover Safety Interlocks

The laser head and power supply covers are not interlocked. Neither unit should be opened by the user.

Changing the diode laser module in the power supply is restricted to personnel trained by Spectra-Physics. The entire system is to be turned off and the ac power cord disconnected when a diode laser module is changed, and the covers are to be installed before power is turned on again. The laser head and power supply are not intended to be run with the covers removed. Therefore, there are no cover interlocks. Labels under the power supply cover also warn of high voltages and state that power must be off before the internal covers can be removed.

Shutter

The internal electromechanical laser head shutter is controlled either by the *Millennia* Controller connected to the REMOTE connector on the power supply front panel, or by software commands via the RS-232 interface on the back panel. Its interlock fault and fail-safe mode is the closed position.

CDRH Requirements for Operating the Millennia Pro s-Series without the Millennia Controller

The *Millennia Pro s* laser head and the *Model J40* or *Model J80* power supply comply with all CDRH safety standards when operated with the *Millennia* Controller. However, when the laser is operated through the SERIAL COM interface (i.e., without the *Millennia* Controller), you must provide the following in order to satisfy CDRH regulations:

- **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. It is required on any control panel that affects laser output.

- **A safety key**—when the power supply interlock key is not accessible, you must provide a safety key to prevent unauthorized use. The password feature of your personal computer (in the CMOS Setup program) or the Windows* operating system meets this requirement.

* *Windows is a registered trademark of the Microsoft corporation.*

Maintenance Necessary to Keep this Laser Product in Compliance 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 that all features of the product identified on the CDRH Radiation Control Drawing (found later in this chapter) function properly. Also, make sure that all warning labels remain firmly attached.

1. Verify that opening the user-installed safety switch, or that removing the safety INTERLOCK jumper (Figure 2-6) on the *Model J40* or *Model J80* power supply terminates and prevents laser operation.
2. Verify that the laser can only be turned on when the key switch is in the ON position, and that the key can only be removed when the switch is in the OFF position.
3. Verify that the emission indicators on the laser head, the power supply and the Controller provide a signal visible to the user when the laser emits accessible laser radiation that exceeds the accessible emission limits for Class I.*
4. Verify the time delay between turn-on of the emission indicators and startup of the laser; it must give enough warning to allow action to avoid exposure to laser radiation.
5. Verify that the 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 to the 400 to 1400 nm range.*

CE/CDRH Radiation Control Drawing

Refer to the CE/CDRH Warning Labels on the next page.

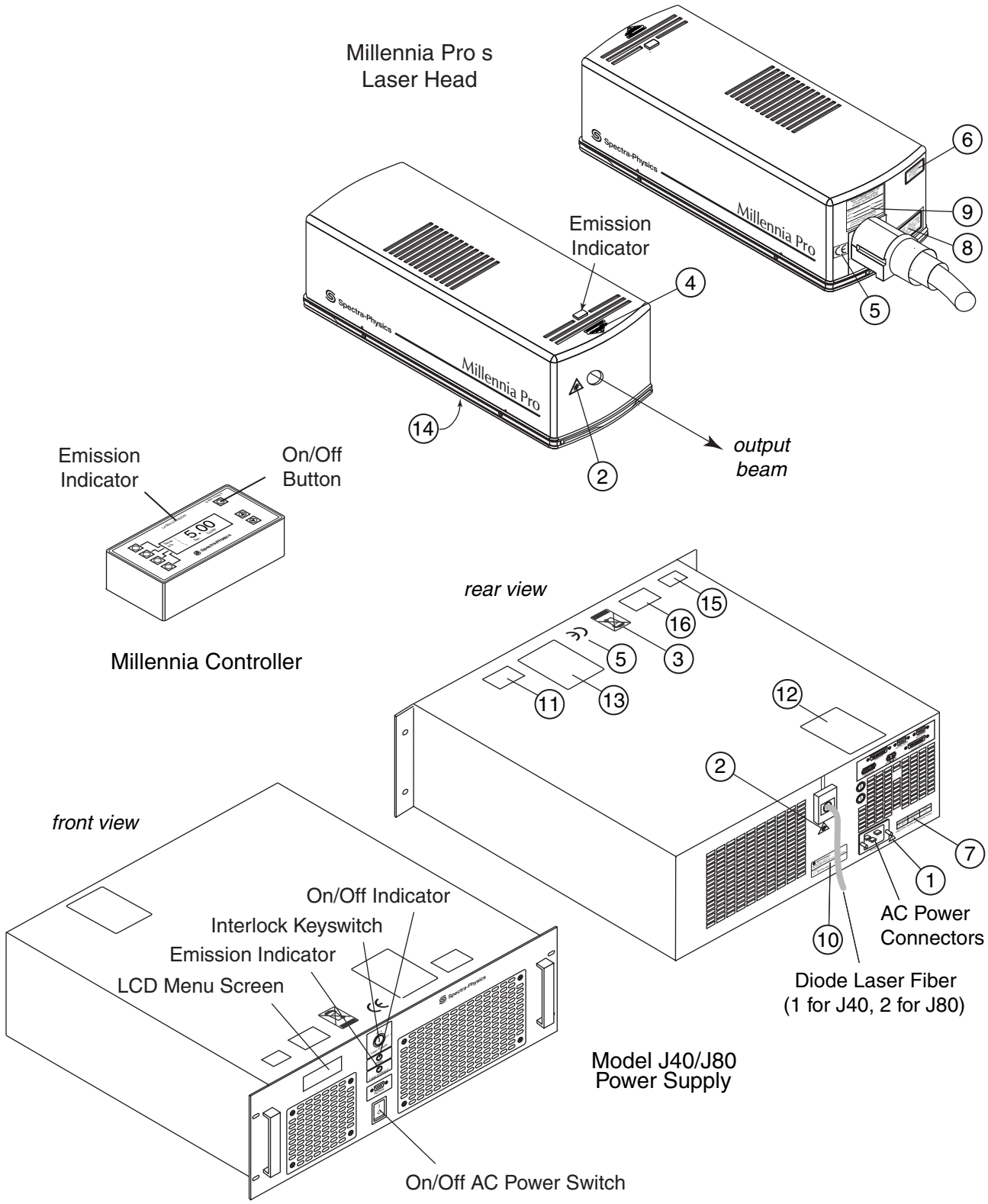
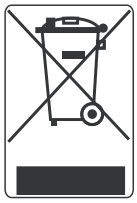


Figure 2-8: CE/CDRH Radiation Control Drawing

CE/CDRH Warning Labels

CE Caution Label (1)

CE Aperture Label (2)



WEEE Label (3)

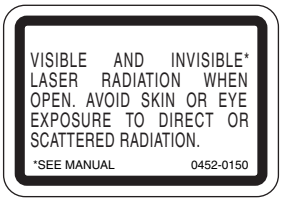
CDRH Aperture Label (4)

CE Certification Label (5)

CE Danger Label Laser Radiation (6)

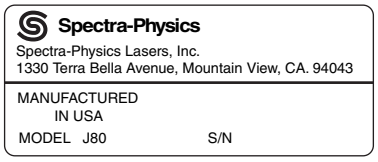
LINE VOLTAGE	FREQUENCY	FUSE F1 F2
100 – 240 V~	47 – 63 Hz	T 10A 250 V

Fuse Label Power Supply (7)

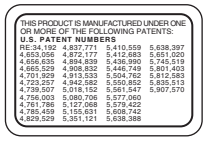


Non-interlocked Housing Label (8)

Laser Head Serial and Identification Label (9)

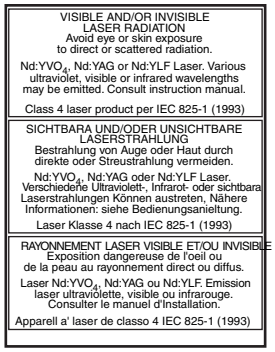


Power Supply Serial and Identification Label (10)

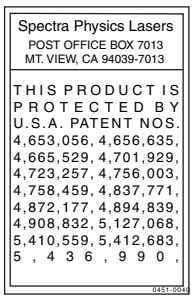


Patent Label Power Supply (11)

CE Warning Label Interlock Defeated (12)

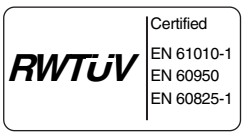


CE Warning Label (13)



Patent Label Laser Head (14)

Registered UL Label (15)



TUV Certified Label Power Supply (16)

Figure 2-9: CE/CDRH 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 2-1: Label Translations

Label No.	French	German	Spanish	Dutch
Aperture Label (4)	Ouverture Laser - Exposition Dangereuse - Un rayonnement laser visible et/ou invisible est emis par cette ouverture.	Austritt von sichtbarer und unsichtbarer Laserstrahlung! Bestrahlung vermeiden!	Por esta abertura se emite radiacion laser visible e invisible; evite la exposicion.	Vanuit dit apertuur wordt zichtbare en onzichtbare laserstraling geemiteerd! Vermijd blootstelling!
Danger Laser Radiation (6)	Rayonnement laser visible et/ou invisible*. Exposition dangereuse de l'œil ou de la peau au rayonnement direct ou diffus. Laser de classe 4. 532 nm. Puissance maximum 15 W. *Voir manuel	Sichtbare und/oder unsichtbare Laserstrahlung. Bestrahlung von Auge oder Haut durch direkte oder Streustrahlung vermeiden. Laser Klasse 4; 532 nm; maximale Ausgangsstrahlung: 15 W. *Siehe Bedienungsanleitung.	Radiación láser visible y/o invisible. Evitar la exposición directa ó dispersa sobre la piel o los ojos. Producto láser Clase 4 532 nm, Potencia máxima 15 W. *Ver manual.	Zichtbare en/of onzichtbare* laser straling. Vermijd blootstelling aan ogen of huid door directe of gereflecteerde straling. Klasse 4 laser produkt; 532 nm, maximaal uittredend vermogen 15 W. *Zie handleiding
CE Non-Interlocked Label (8)	Rayonnement Laser Visible et Invisible en Cas D'Ouverture; Exposition Dangereuse de L'œil ou de la Peau au Rayonnement Direct ou Diffus.	Beim Öffnen Austritt von sichtbarer und unsichtbarer Laserstrahlung; Bestrahlung von Auge oder Haut durch direkte oder Streustrahlung vermeiden.	Cuando se abre existe Radiación Laser Visible e Invisible; Evite que los ojos y la piel queden expuestos tanto a la radiación directa como a la dispersa.	Zichtbare en niet zichtbare laser-straling wanneer geoend; vermijd blootsteling aan huid of oog aan disecte straling of weerkaatsingen.
Patent Labels (11, 14)	Ce produit est fabriqué sous l'un ou plusieurs des brevets suivants.	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 3 on page 2-10.

The main 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.

CE Declaration of Conformity

We,

Spectra-Physics
1335 Terra Bella Avenue
Mountain View, CA. 94043
United States of America

declare under our sole responsibility that the:

Millennia Pro s Diode-Pumped, Solid State Laser System with Model J40 or J80 power supply, Millennia Controller or compliant, user-supplied, pc-based controller, and Neslab Merlin 25, Neslab KMC 100 or Lytron Kodiak RC006 chiller

manufactured after November 3, 2003,

meets the intent of EMC Directive 89/336/EEC: 1989, for electromagnetic compatibility and 73/23/EEC: 1973, for low voltage directives. Compliance was demonstrated to the following specifications as listed in the official *Journal of the European Communities*:

EMC Directive 89/336/EEC: 1989

EN 61326-1 w/A1: 1997

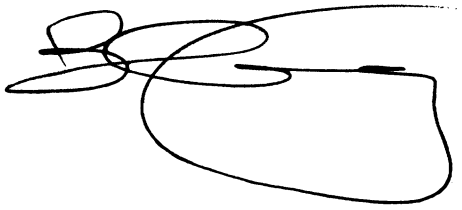
Low Voltage Directive 73/23/EEC: 1973

EN 61010-1: 2001, Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use

EN 60825-1: 1997, Safety of laser products- Part 1 Equipment classification, requirements, and users guide

EN 60950: 1997, Safety of Information Technology Equipment, including electrical business equipment

I, the undersigned, hereby declare that the equipment specified above conforms to the above Directives and Standards.



Bruce Craig
Director of Engineering and Marketing
Solid-State Lasers
Spectra-Physics
October 27, 2003

Sources for Additional Information

Laser Safety Standards

Safe Use of Lasers (Z136.1)
American National Standards Institute (ANSI)
11 West 42nd Street
New York, NY 10036
Tel: (212) 642-4900

Occupational Safety and Health Administration (Publication 8.1-7)
U. S. Department of Labor
200 Constitution Avenue N. W., Room N3647
Washington, DC 20210
Tel: (202) 693-1999
Internet: 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: www.acgih.org/home.htm

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

Compliance Engineering
Canon Communications LLC
11444 W. Olympic Blvd.
Los Angeles, CA 90064
Tel: (310) 445-4200

International Electrotechnical Commission
Journal of the European Communities
EN60825-1 Safety of Laser Products — Part 1: Equipment classification, requirements and user's guide
Tel: +41 22-919-0211 Fax: +41 22-919-0300
Internet: www.iec.ch

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

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

Equipment and Training

Laser Safety Guide
Laser Institute of America
13501 Ingenuity Drive, Suite 128
Orlando, FL 32826
Tel: (407) 380-1553, or toll-free
(800) 34LASER
Internet: 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: lfw.pennnet.com/home.cfm

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

Chapter 3 Laser Description

A Brief Review of Laser Theory

Emission and Absorption of Light[*]

Laser is an acronym derived from Light Amplification by Stimulated Emission of Radiation. Thermal radiators, such as the sun, emit light in all directions, the individual photons having no definite relationship with one another. But 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 atomic or molecular structure of materials. The contemporary model of atomic structure describes an electrically neutral system composed of a nucleus with one or more electrons bound to it. Each electron occupies a distinct orbital that represents the probability of finding the electron at a given position relative to the nucleus. Each orbital has a characteristic shape that is defined by the radial and angular dependence of that probability, e.g., all s orbitals are spherically symmetrical, and all p orbitals surround the x, y, and z axes of the nucleus in a double-lobed configuration (Figure 3-1).

The energy of an electron is determined by the orbital that it occupies, and the overall energy of an atom depends on the distribution of its 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 from one energy level to another—a transition—happens when the atom either absorbs or emits energy. Upward transitions can be caused by collision with a free electron or an excited atom, and 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 ν is the frequency of the photon.

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

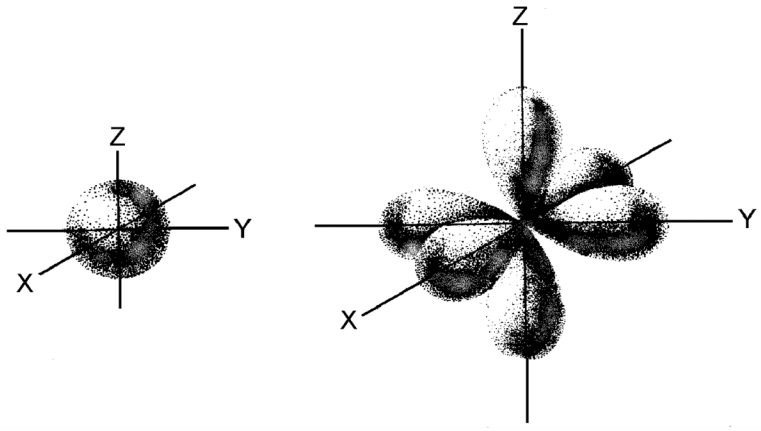


Figure 3-1: Electrons occupy distinct orbitals that are defined by the probability of finding an electron at a given position, the shape of the orbital being determined by the radial and angular dependence of the probability.

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

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

Spontaneous decay can also occur without emission of a photon, the lost energy taking another form, e.g., transfer of kinetic energy by collision with another atom. An atom excited to E_2 can also be stimulated to decay to E_1 by interacting with a photon of frequency ν, emitting energy in the form of 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 absorption, and both spontaneous and stimulated emission phenomena, using them to create conditions favorable to light amplification. The following paragraphs describe these conditions.

Population Inversion

The net absorption at a given frequency is the difference between the rates of emission and absorption at that frequency. It can be shown that the rate of excitation from E_1 to E_2 is proportional to both the number of atoms in the lower level (N_1) and the transition probability. Similarly, the rate of stimulated emission is proportional to the population of the upper level (N_2) and the transition probability. Moreover, the transition probability depends on the flux of the incident wave and a characteristic of the transition called its "cross section." The absorption coefficient depends only on the difference between the populations involved, N_1 and N_2, and the flux of the incident wave.

When a material is at thermal equilibrium, there exists a Boltzmann distribution of its atoms over the array of available energy levels with most atoms in the ground state. Since the rate of absorption of all frequencies exceeds that of emission, the absorption coefficient at any frequency is positive.

If enough light of frequency ν is supplied, the populations can be shifted until $N_1 = N_2$. Under these conditions the rates of absorption and stimulated emission are equal, and the absorption coefficient at frequency ν is zero. If the transition scheme is limited to two energy levels, it is impossible to drive the populations involved beyond equality; that is, 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 employed, and if their relationship satisfies certain requirements described below, additional excitation can create a population inversion where $N_2 > N_1$.

A model four-level laser transition scheme is depicted in Figure 3-2. A photon of frequency ν_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., atoms that occupy it have a relatively long lifetime, the population will grow rapidly as excited atoms cascade from above. The E_3 atom will eventually decay to E_2, emitting a photon of frequency ν_2.

Finally, if E_2 is unstable, its atoms will rapidly return to the ground state, E_1, keeping the population of E_2 small and reducing the rate of absorption of ν_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, the absorption coefficient at ν_2 becomes negative. Light is amplified as it passes through the material, which is now called an "active medium." The greater the population inversion, the greater the gain.

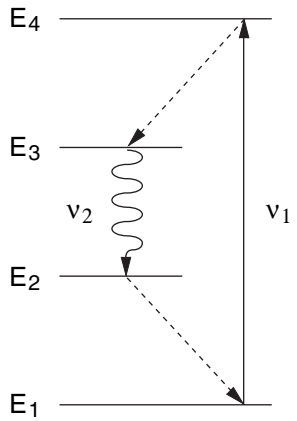


Figure 3-2: A Typical Four-level Transition Scheme

A four-level scheme has a distinct advantage over three-level systems, where E_1 is both the origin of the pumping transition and the terminus of the lasing transition. Also, the first atom that is pumped contributes to the population inversion in the four-level arrangement, while over half of the atoms must be pumped from E_1 before an inversion is established in the three-level system.

Resonant Optical Cavity

To sustain lasing action, the gain medium must be placed in a resonant optical cavity. The latter can be defined by two mirrors that provide feedback to the active medium, i.e., photons emitted parallel to the cavity axis are reflected back into the cavity to interact with other excited states. Stimulated emission produces two photons of equal energy, phase, and direction from each interaction. The two photons become four, four become eight, and the numbers continue to increase geometrically until an equilibrium between excitation and emission is reached.

Both cavity mirrors are coated to reflect the wavelength, or wavelengths, of interest while transmitting all others. One of the mirrors, the output coupler, transmits a fraction of the energy stored within the cavity, and the escaping radiation becomes the output beam of the laser.

The laser oscillates within a narrow range of frequencies around the transition frequency. The width of the frequency distribution, the "linewidth," and its amplitude depend on the gain medium, its temperature, and the magnitude of the population inversion.

Linewidth is determined by plotting gain as a function of frequency and measuring the width of the curve where the gain has fallen to one half maximum ("full width at half maximum", or FWHM, Figure 3-3).

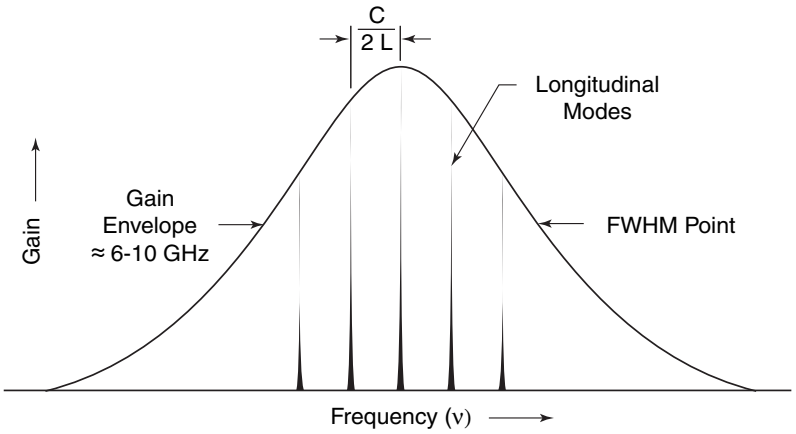


Figure 3-3: Frequency Distribution of Longitudinal Modes for a Single Line

The output of the laser is discontinuous within this line profile. A standing wave propagates within the optical cavity, and any frequency that satisfies the resonance condition

$$\nu_m = \frac{mc}{2L} \qquad [3]$$

will oscillate, where ν_m is the frequency, c is the speed of light, L is the optical cavity length, and m is an integer. Thus, the output of a given line is a set of discrete frequencies, called "longitudinal modes," that are spaced such that

$$\Delta n = \frac{c}{2L} \qquad [4]$$

Nd^{3+} as a Laser Medium

In commercial laser designs, the source of excitation energy for the gain medium is usually optical or electrical. Arc lamps are often employed to pump solid state lasers, and the output of one laser can be used to pump another, e.g., a Ti:sapphire laser can be pumped by an argon ion laser or a diode laser can be used to pump a solid state laser. The *Millennia Pro s-Series* uses the output from a diode laser to pump Nd^{3+} ions doped in a yttrium vanadate crystalline matrix (Nd:YVO_4).

The properties of neodymium-doped matrices, such as yttrium aluminum garnet (Nd:YAG) and yttrium lithium fluoride (Nd:YLF), are the most widely studied and best understood of all solid state laser media. The four-level Nd^{3+} ion scheme is shown in Figure 3-4. The active medium is triply ionized neodymium that has principle absorption bands in the red and near infrared. 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 (about 60 µs for Nd:YVO_4).

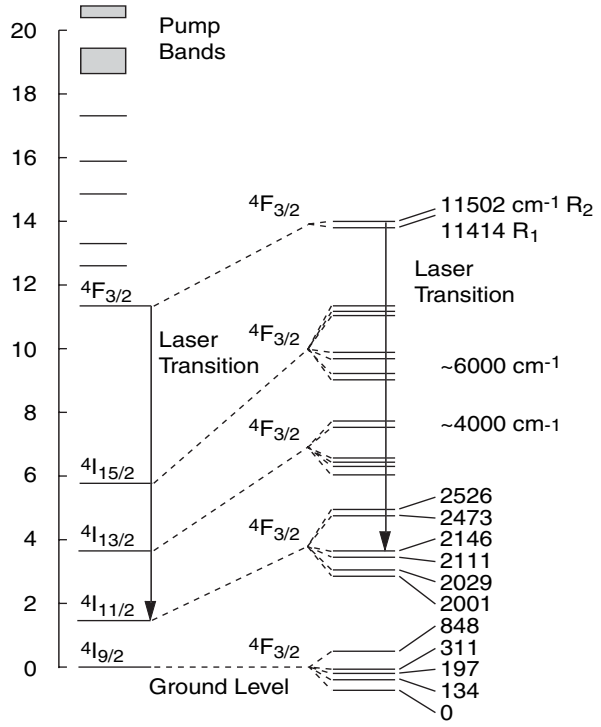


Figure 3-4: Energy Level Scheme for the Nd^{3+} Ion

The most probable lasing transition is to the $^4I_{1/2}$ state, where a photon at 1064 nm is emitted. Because electrons in that state quickly relax to the ground state, its population remains low. Hence, it is easy to build a population inversion. At room temperature the emission cross section of this transition is high, so its lasing threshold is low. While there are competing transitions from the same upper state, most notably at 1319, 1338, and 946 nm, all have lower gain and a higher threshold than the 1064 nm transition. In normal operation, these factors and wavelength-selective optics limit oscillation to 1064 nm.

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 3-5 shows the monochromaticity of the emission spectra of a diode laser compared to a krypton arc lamp and a black body source and compares that with the absorption spectra of the Nd^{3+} ion. 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. It also reduces thermal loading since any pump light *not* coupled into the medium is ultimately removed as heat.

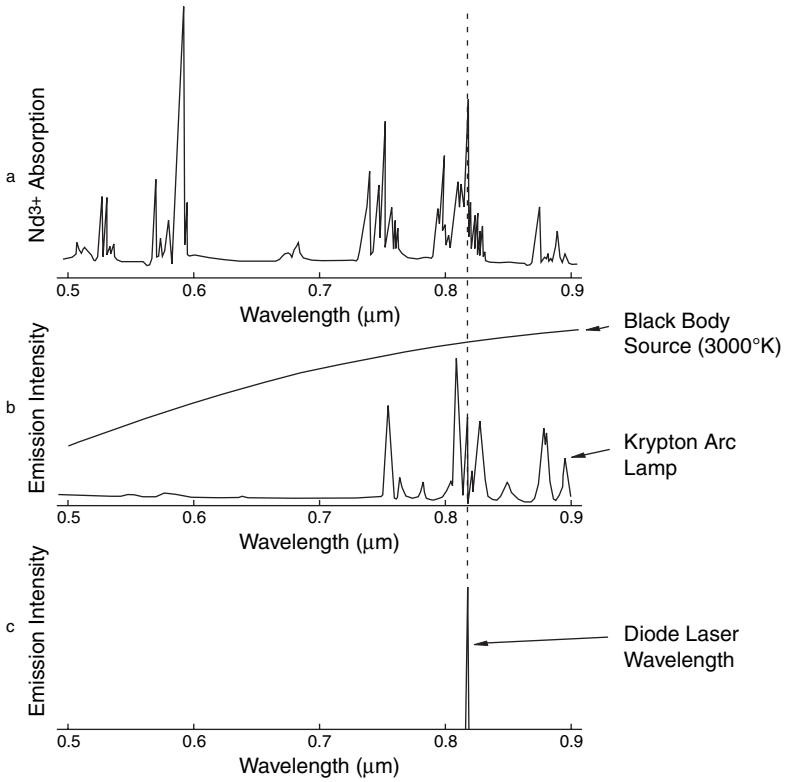


Figure 3-5: Nd^{3+} absorption spectra compared to emission spectra of a (a) black body source, (b) a krypton arc lamp and (c) a diode pump laser.

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 with the region in the laser gain medium that is occupied by the excited laser modes of oscillation.

The maximization of this overlap is referred to as mode matching. In most applications, the TEM_{00} laser mode is often desired for its low optical noise, low divergence, and its ability to focus to a tight spot. In applications that prefer TEM_{00} output, it is also advantageous to suppress higher-order laser modes. A longitudinal pumping geometry provides optimal mode matching to produce this mode.

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 3-6 shows a schematic of a mode matching design of this type.

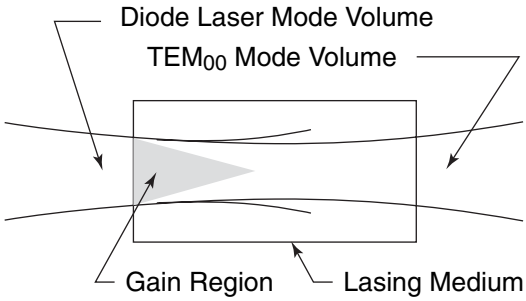


Figure 3-6: Mode Matching

For higher output power levels, a larger diode laser having a larger emission region is necessary. The diameter of the TEM_{00} mode volume must also be expanded to effectively mode match the volume of the extended diode laser emission region. However, increasing the TEM_{00} mode volume raises the solid state laser threshold. This is undesirable when attempting to create an efficient diode laser design.

At Spectra-Physics, we use diode laser bars made from a single monolithic piece of semiconductor material that typically contains ten to twenty diode lasers. The bars are ideal as high power pump sources. These devices have the same high efficiency as the discrete diode laser devices, yet they allow for the manufacture of a much simpler and more reliable high power pump laser design than is possible in a design using discrete devices.

However, the active emission area for these new devices is increased from the 200 µm range found in low power diode lasers, to 1 cm: a "ribbon of light." The use of these bars has, therefore, been limited due to the difficulty of mode matching their outputs.

A number of attempts by some manufacturers to couple the output of a diode laser bar into a multimode optical fiber, with discouraging results. Coupling efficiencies are on the order of 60–70%, with a numerical aperture of 0.4. This makes for an expensive, inefficient pump source.

At Spectra-Physics, we have developed and patented a highly efficient method of fiber coupling the output of the diode laser bar, called FC*bar*™. FC*bar* technology enables the high power available from the diode laser bar(s) to efficiently end-pump the laser crystal. This is done by first collimating the output of the bar with a cylindrical microlens of high numerical aperture. The highly asymmetric light is then coupled into a fiber bundle.

The multimode optical fiber bundle is actually several fibers that are drawn together in a round bundle, where the output end is 1 to 1.5 mm in diameter with a numerical aperture of about 0.1. Typically, 85 to 90 percent of the diode laser light is transmitted by the bundle; this high coupling efficiency and brightness results in high power diode-pumped laser designs.

Frequency Doubling

In the *Millennia Pro s-Series*, the high output power from the diode laser is used to end-pump the Nd:YVO_4 lasing medium. The resulting 1064 nm output is converted to visible light through frequency doubling (or second harmonic generation) in a nonlinear crystal. The *Millennia Pro s* uses a 90°, noncritically phase-matched, temperature-tuned lithium triborate (LBO) nonlinear crystal as its doubling medium.

Although LBO has a lower nonlinear coefficient than other materials, it offers several advantages: (a) noncritical phase matching means co-linear fundamental and second harmonic beams, which facilitates alignment, (b) there is no spatial "walk-off" of the fundamental and second harmonic beams, which preserves the high spatial mode quality and favors a long interaction length for higher gain, and (c) the crystal can be easily optimized for maximum conversion efficiency by simply changing its temperature (with no realignment of the laser cavity).

In frequency doubling, the second harmonic power ($P_{2\omega}$) is given by:

$$P_{2\omega} \propto \frac{d_{eff}^2 P_\omega^2 l^2 [\phi]}{A} \quad [5]$$

where d_{eff} is the effective nonlinear coefficient, P_ω 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. Since the second harmonic output is dependent upon the square of the fundamental peak power, very high conversion efficiencies can be achieved by enhancing the intensity of the fundamental wave through intracavity frequency doubling or through the use of an external-cavity resonant-doubler. The former is used in the *Millennia Pro s*.

Historically, free-running intracavity-doubled, diode-pumped, solid state lasers have typically yielded chaotic output with large amplitude fluctuations that render the laser output useless for most scientific applications. This was first identified at Spectra-Physics* in a short cavity diode-pumped Nd:YAG laser with a KTP intracavity doubler; it has since become known as the "green problem." Part of the cause of the instability arises from nonlinear coupling of axial modes via sum-frequency mixing in the laser cavity.

The problem can be circumvented by forcing oscillation on a single longitudinal mode. However, this adds considerable complexity to the laser, since it requires an actively stabilized ring cavity (and it may also have power limitations). The *Millennia Pro s* overcomes this chaotic noise problem with the simple, patented**, QMAD (Quiet Multiaxial Mode Doubling) technology, which makes use of many axial modes (see Figure 3-7).

* *T. Baer. J. Opt. Soc. Am. B3, 1175 (1986).*
** *patent number 5,446,749*

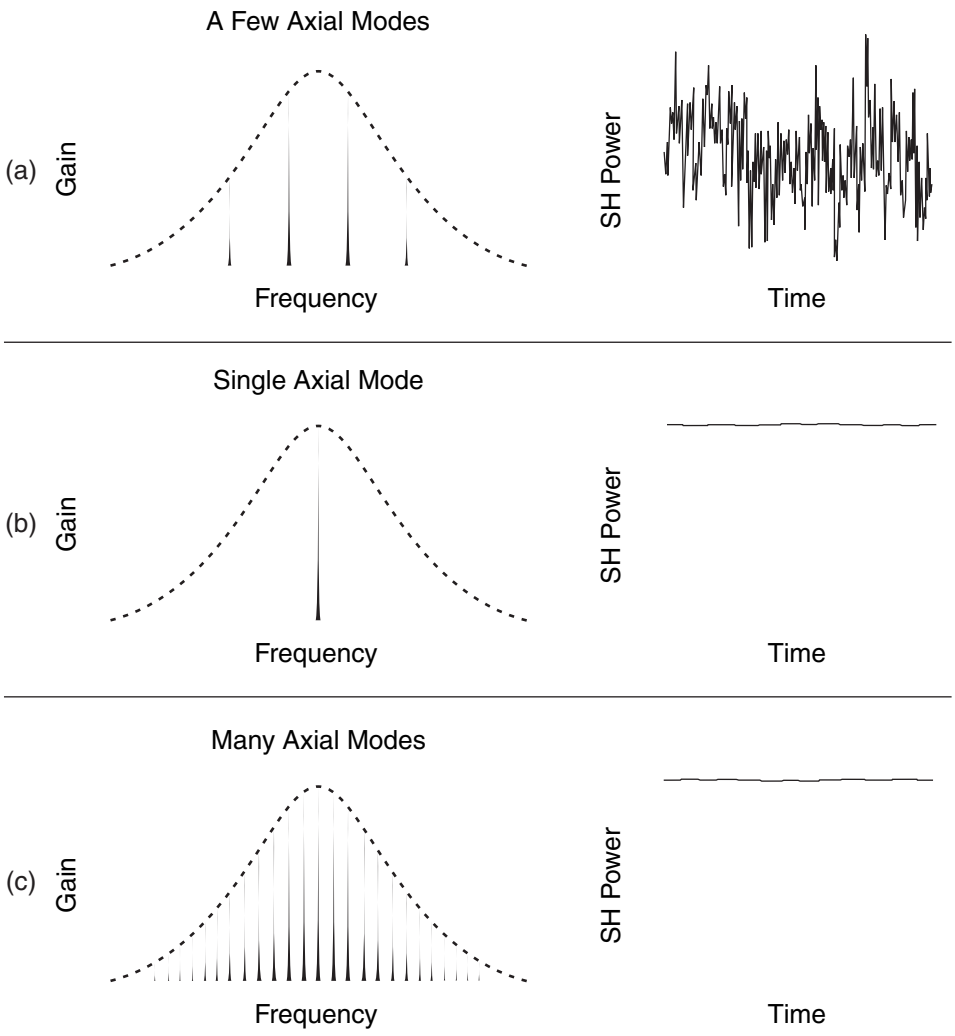


Figure 3-7: The quiet multiaxial mode-doubling (QMAD) solution to the "green problem." (a) The "green problem." Intracavity frequency doubling in a laser with a few axial modes produces large amplitude fluctuations in the second harmonic output resulting from nonlinear coupling of the modes through sum-frequency mixing. (b) The single-frequency solution forces oscillation on a single axial mode to eliminate mode coupling. (c) The QMAD solution produces oscillation on many axial modes, effectively averaging the nonlinear coupling terms to provide highly stable second-harmonic output.

The laser cavity in the *Millennia Pro s* allows oscillation of over 100 longitudinal modes. This facilitates quiet intracavity doubling by reducing the relative power in each axial mode so that no one mode reaches sufficient peak power to induce high nonlinear loss. Effectively, there is an averaging of the nonlinear coupling terms and the resultant frequency-doubled output exhibits extremely low amplitude noise (about an order of magnitude lower than that of an ion laser).

The Millennia Pro s-Series System

The *Millennia Pro s-Series* system comprises these basic components:

- *Millennia Pro s* water-cooled laser head
- *Model J40* or *Model J80* air-cooled power supply
- *Millennia* Controller

An optional recirculating chiller is available for cooling the laser head.

The following sections describe the laser head and power supply hardware. The *Millennia* Controller is described in Chapter 6, "Operation." The chiller is described in the user's manual shipped with that unit.

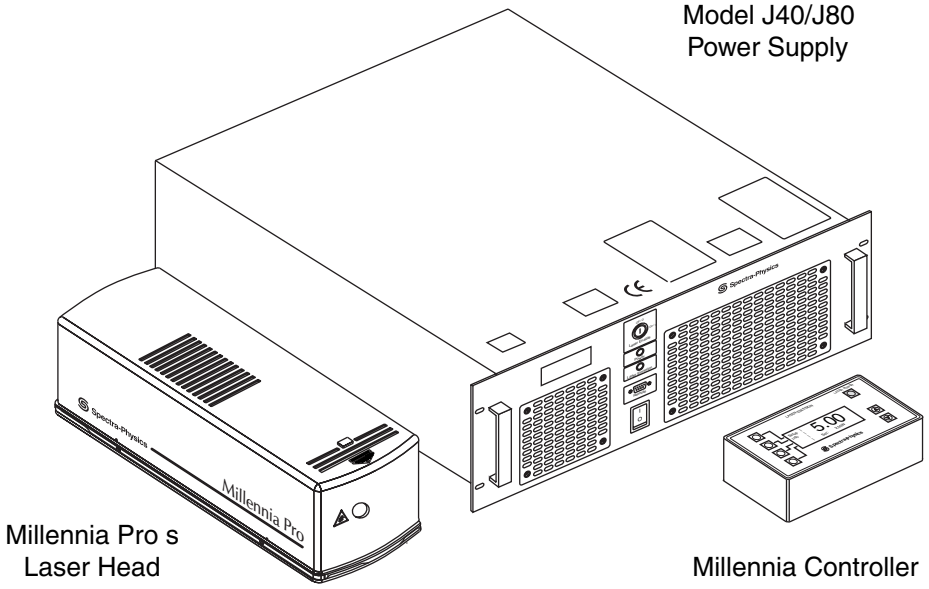


Figure 3-8: *Millennia Pro s-Series* System (chiller not shown)

The Millennia Pro s Laser Head

The optical cavity of the *Millennia Pro s* laser head uses an X-cavity resonator (Figure 3-9). In this design, the fiber-coupled output from either one or two FC*bar* diode modules is used to end-pump a crystal or "rod" of vanadate. The vanadate crystal is the driving engine of the laser. It absorbs the diode laser light and emits its own laser beam light at 1064 nm, which is resonated (and confined) in the *Millennia Pro s* cavity.

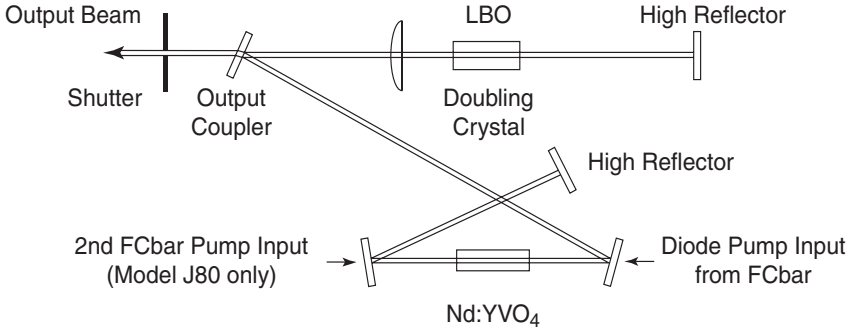


Figure 3-9: Optical Design of the *Millennia Pro s* Laser Head

The vanadate crystal provides a very high small-signal CW gain, and is capable of producing over 20 W of near diffraction-limited infrared power with a conversion efficiency of the light from the diode pump source of greater than 50%. The crystal is mounted on a structure (the "tower") that is thermally isolated from the laser head chassis.

The fiber-coupled FC*bar* design enables the astigmatic light from the diode modules to be transformed to round beams of exceptional brightness that are suitable for an efficient end-pumping geometry. In addition, by allowing the diode laser bar to be placed in the power supply, this design removes its heat load from the laser head and facilitates the replacement of the diode laser in the field, because replacement does not require realignment of the laser cavity.

A telescope is used to focus the pump light through a dichroic fold mirror and into the vanadate laser crystal. This dichroic mirror is highly transmissive at the diode pump laser wavelength and highly reflective at 1064 nm.

Frequency Doubling

Frequency-doubling converts the 1064 nm light from the laser crystal to the green 532 nm light that becomes the output of the laser.

A noncritically phase-matched lithium triborate (LBO) crystal placed in the cavity converts the intracavity light to the green 532 nm wavelength. LBO offers a large acceptance angle, which makes it insensitive to any slight misalignment of the *Millennia Pro s* cavity. A compact, low power, temperature-regulating oven is used to maintain the crystal at the appropriate phase-matching temperature to keep the 532 nm power optimized.

The patented Quiet Multi-Axial Mode Doubling (QMAD) technique provides exceptionally low-noise performance. It uses a very large number of axial modes and balances gain, nonlinear conversion, and excited-state lifetime to provide high power and extremely stable amplitude.

Virtually all the doubled light passes through the dichroic output coupler where the beam is then directed out of the laser. A beam splitter and photodiode sample the output and provide feedback to the pump laser driver to provide a constant output in power mode operation. A shutter placed outside the cavity enclosure attenuates the beam until commanded to open either by the Controller or via remote command.

A dichroic output coupler allows the 532 nm light to exit the cavity while reflecting the 1064 nm light back into the cavity. The 90° polarization rotator aligns the polarization to the vertical axis required in many applications.

Light Pick-off and Power Control

A beam splitter near the output of the laser head samples a small portion of the green beam and directs it to the photodetector for the power control feedback circuit. Power mode is the standard operating mode for the *Millennia Pro s*; the control loop adjusts the diode pump current to keep the power constant to within ± 1% of the set point.

The Model J40 and J80 Power Supplies

The *Model J40* or *J80* power supplies provide the diode laser pump light that powers the *Millennia Pro s* laser heads. They also contain the electrical power and control circuitry for the system. The logic control hardware is housed in the top section of the power supply. A thermo-electric cooler is used to cool the diode module(s).

The power supplies are air cooled and need no water or external cooling connections. For electrical power they require a standard 110 or 220 Vac 10 A power source. The power supplies can be mounted in a standard 19 in. rack. A power/control cable and fiber-optic cable(s) reside inside the umbilical that connects the laser head to the power supply.

The FC*bar* System

The pump source for the *Millennia Pro s* laser head is either a *Model J40* power supply that houses one 40 W diode laser bar, or a *Model J80* that houses two such bars. An integral optical fiber bundle transports the output from the lasers in the diode bar to the laser head, where it is focused into the end of the laser crystal. This diode laser module transport concept is the "fiber-coupled bar," or FC*bar*™ technology that was discussed earlier.

FC*bar* technology enables the high power available from the lasers in the diode bar to efficiently end-pump the Nd:YVO_4 laser crystal. To stabilize the output wavelength of the diode lasers, the module is mounted directly on a temperature regulated heatsink. Because the coupling technology is so efficient (85 to 90 percent of the diode laser light is available at the output of the fiber bundle), the 40 W diode laser module can be significantly derated to increase its operating lifetime.

The FC*bar* module mates with the fiber bundle through precision connections that are assembled and aligned at the factory. The bundle is then terminated at the laser head with an industry standard fiber-optic connector. This provides a precise and repeatable attachment of the bundle to the laser head and allows an FC*bar* module to be replaced in the field, if necessary, without requiring an alignment of the cavity.

Note

The ProLite® diode laser packaged in the FC*bar* module in the power supply is often referred to simply as the "diode" in the context of this manual (e.g. the "diode current").

System Control

To turn the unit on and off and to provide operational control, the hand-held *Millennia* Controller uses a simple, menu-driven interface. Chapter 6 describes the Controller and its use in detail. The system can also be controlled via the standard RS-232 interface on the back of the power supply by a user-written program of serial commands. Chapter 6 also provides a list of the serial commands available, and instructions on how to use the serial port.

Specifications

Table 3-1: Millennia Pro s Laser Output Characteristics[1]

	10s J	*8s J*	*6s J*	*5s J*
Power	> 10 W	> 8 W	> 6 W	> 5 W
Wavelength	532 nm			
Spatial Mode[2]	TEM_{00}			
Beam diameter at 1/e² points[3]	2.3 mm ± 10%			
Beam divergence, full angle[3]	< 0.5 mrad ± 10%			
Polarization[4]	> 100:1 vertical			
Power Stability[5]	± 1%			
Beam Pointing Stability[6]	≤ 2 µrad/°C			
Noise[7]	< 0.04% rms			
Boresight Tolerance				
Nearfield	± 0.25 mm			
Farfield	< 3 mrad			

[1] *Due to our continuous quality improvement program, specifications are subject to change without notice.*
[2] *M^2 < 1.1; beam ellipticity < 10%.*
[3] *Measured at the exit port.*
[4] *Vertical polarization standard; horizontal polarization available on request.*
[5] *Measured over a 2-hour period after a 15 minute warm-up.*
[6] *Measured as far-field x and y positions, after a 30 minute warm-up.*
[7] *Measured over a 10 Hz to 0.1 GHz bandwidth at the specified output power*

Table 3-2: Utilities

AC power input	100 to 240 Vac ± 10%, 50/60 Hz, single phase
Power consumption	
***Model J80* Power Supply**	500 W typical 1100 W maximum
***Model J40* Power Supply**	275 W typical 700 W maximum
Heat dissipation[1]	
***Model J80* Power Supply**	≈460 W typical
***Model J40* Power Supply**	≈250 W typical

[1] *Note that the chiller will also produce heat. Consult your chiller manual for details.*

Table 3-3: Fuse Ratings for F1, F2 (J40 and J80)

Supply Voltage	Rating	Type
100–240 Vac, 50/60 Hz	10 A	T 10A 250 V

Table 3-4: Dimensions and Weights

Laser Head		
size (w x h x d)	13.5 x 10.4 x 35.0 cm (5.3 x 4.1 x 14.0 in.)	
weight	10 kg (22 lb)	
umbilical length[1]	4 m (13.1 ft)	
(smallest static bend radius)	15 cm (6 in.)	
Controller		
size (w x h x d)	16.5 x 4.5 x 8.3 cm (6.5 x 1.75 x 3.25 in.)	
Controller cable length[1]	2.5 m (8 ft)	
Power Supply	***Model J40***	***Model J80***
size (w x h x d)	48.3 x 17.5 x 45.5 cm (19.0 x 6.9 x 17.9 in.)	48.3 x 17.5 x 45.5 cm (19.0 x 6.9 x 17.9 in.)
weight	25.0 kg (55 lb)	26.4 kg (58 lb)
air flow	2.8 m^3/min (100 cfm)	2.8 m^3/min (100 cfm)
AC power cord length[1]	2.5 m (8 ft)	2.5 m (8 ft)

[1] *cable lengths are approximate*

Chiller Specifications

Warning! 

It is critical that the chiller meet the requirements for cooling the laser head. Failure to do so will result in poor performance, and possibly damage the laser. Such damage is not covered by the warranty.

The following requirements must be met by the chiller in order to properly cool the *Millennia Pro s* laser head. Refer to the manual provided with the chiller for its dimensions, specifications and utility requirements.

Table 3-5: Chiller Requirements

- The chiller should use distilled (not de-ionized) water.
- The chiller should dissipate at least 100 W.
- The chiller output must flow use a partial flow liquid filter of 10 mm or smaller filter size.

water flow rate	0.5 liter/minute minimum 2.0 liter/minute maximum 1.0 liter/minute recommended @ 180 kPa (26 psi)
water temperature	18 ±0.5°C (64.4 ±1.0°F)
pressure at the laser head inlet	
minimum	170 kPa (25 psi)
maximum	310 kPa (45 psi
recommended	220 kPa-235 kPa (32-34 psi)

Outline Drawings

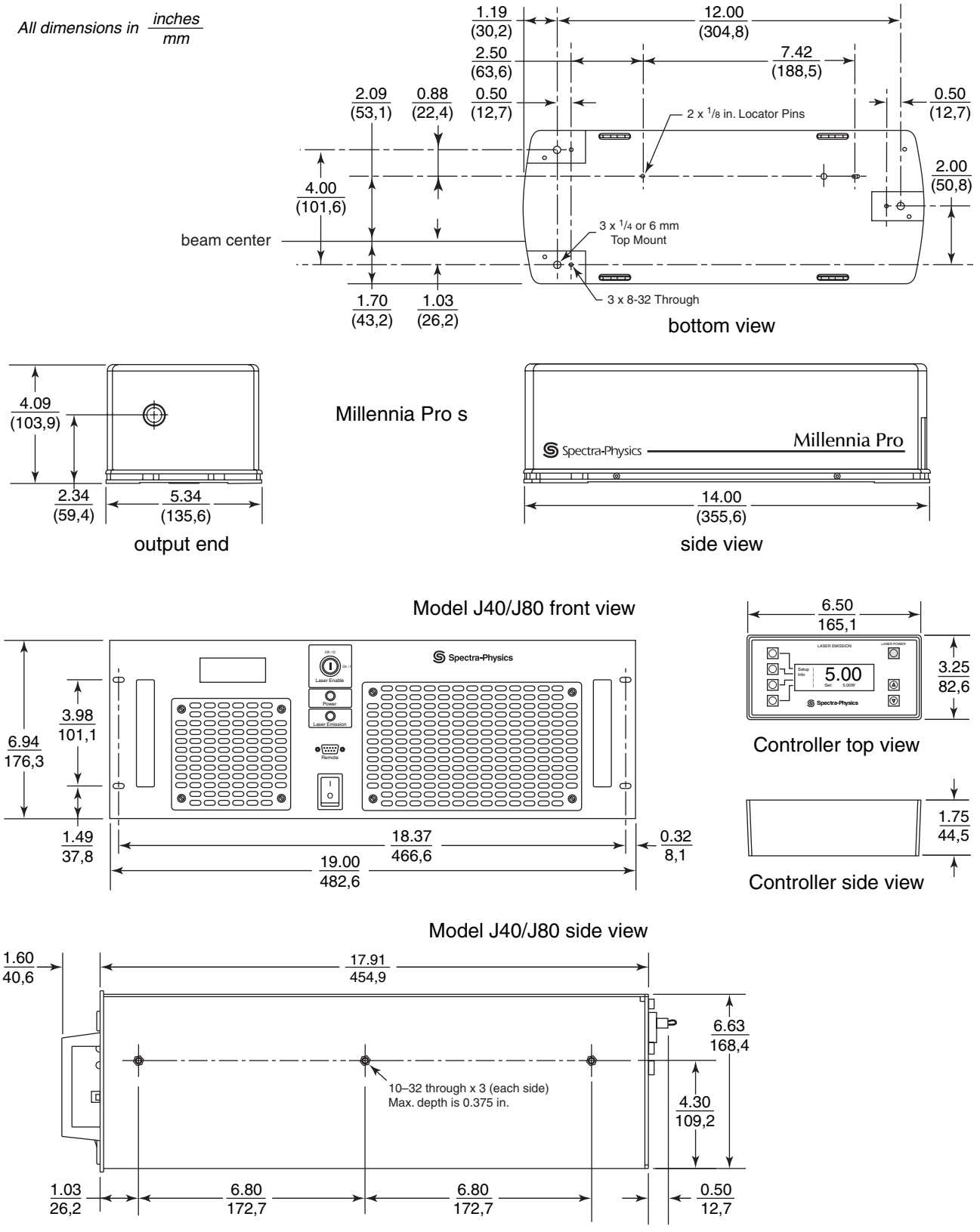
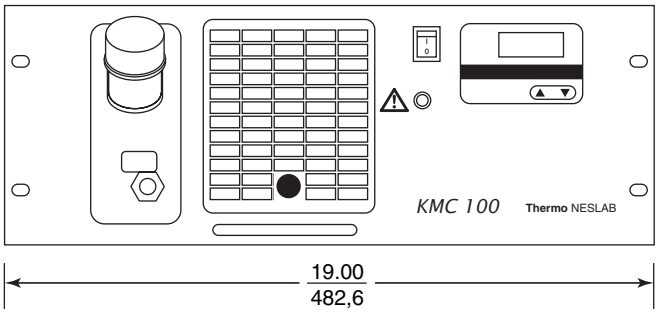
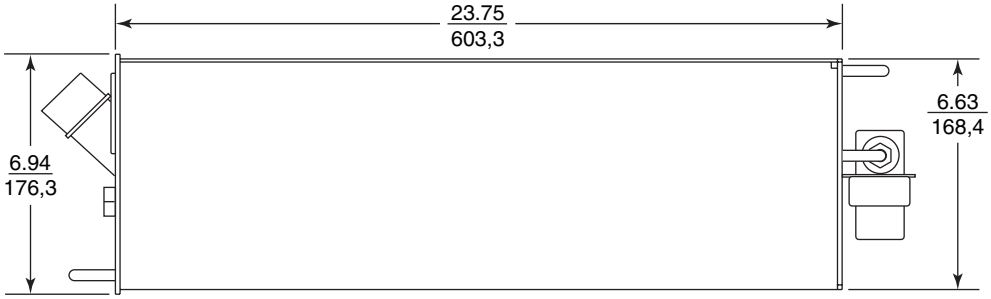


Figure 3-10: Outline Drawings for Laser Head, Controller and Power Supply



Model KMC 100, Front Panel



Model KMC 100, Side Panel

Figure 3-11: Outline Drawing for *Model KMC-100* Chiller

Note

The chiller outline drawing shown above is for a typical chiller for the *Millennia Pro s-Series* system. Consult the chiller user's manual for the specifics for the chiller used with your system

Chapter 4 Controls, Indicators and Connections

Introduction

This section defines the user controls, indicators and connections of the *Millennia Pro s-Series* system. It is divided into three sections: the *Millennia Pro s* laser head, the *Millennia* Controller and the *Model J40/J80* power supply. Information on the chiller can be found in the chiller user's manual.

The Millennia Pro s Laser Head

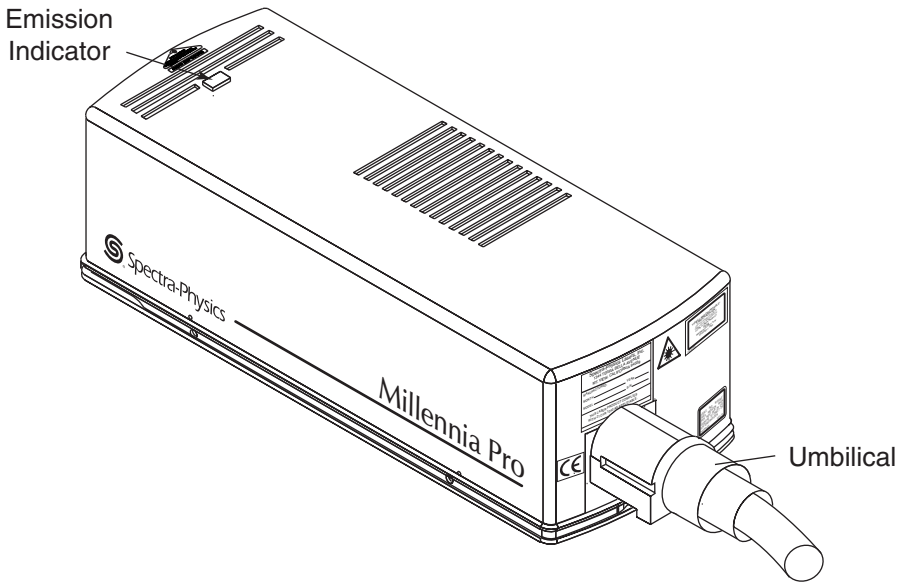


Figure 4-1: The *Millennia Pro s* Laser Head

Internal Controls

There are no user-serviceable parts inside the *Millennia Pro s* laser head; no adjustment is required.

Legs

Legs (3)—(shipped with the *Tsunami*® when ordered) provide a means to set the laser beam to a height appropriate for pumping a Spectra-Physics *Tsunami* oscillator. The legs are machined posts that screw into the 8–32 holes on the 3 mounting pads located on the bottom of the laser head. Table clamps are provided. There are no height adjustments.

Indicator

Laser emission indicator (white)—is off when there is no emission, and comes on when the laser head is emitting or is capable of emitting laser light (e.g. after depressing the ON button on the *Millennia* Controller for 3 seconds).

Connections

Umbilical connector—connects the umbilical, which contains the fiber-optic cable(s) that provides pump laser energy to the laser head from the laser diode module in the power supply. *This umbilical is permanently attached to the power supply and laser head: do not try to remove it.* The umbilical also encloses the cooling water hoses from the chiller.

Control cable connector (26-pin D-sub)—connects the control cable to the laser head from the power supply (from the LASER HEAD connector).

The Millennia Controller

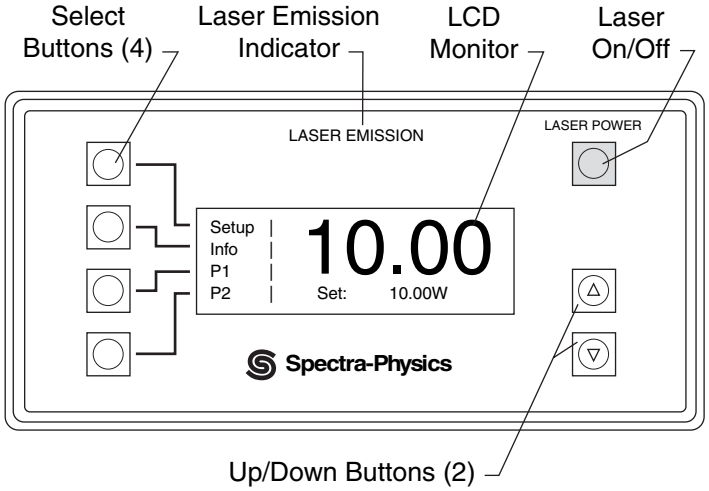


Figure 4-2: The *Millennia* Controller

Controls

Seven buttons on the Controller operate the *Millennia Pro s* laser:

Select buttons (4)—are located to the left of the LCD screen and are used to select one of four possible actions shown on the left side of the screen. For example, pressing the top left button brings up the Setup menu. When the up/down arrows are shown on the screen, pressing the associated button scrolls the text.

LASER POWER button—performs 3 functions: (a) it begins the laser warm-up cycle, (b) turns on the laser and (c) turns off the laser. (Note: the power supply ac power must be on and the LASER ENABLE interlock key-switch set to ON in order for the laser to turn on).

If the laser is in Standby mode, press the LASER POWER button once to begin the warm-up cycle (otherwise, the rocker switch on the power supply starts the warm-up cycle).

When the warm-up cycle completes, press and hold in the LASER POWER button for at least 3 seconds to turn on the laser. The red LASER EMISSION on the Controller turns on and flashes while the button is held in. Following the 3 second CDRH delay, the laser head is capable of emitting radiation.

At this point, the LASER EMISSION indicator on the Controller stops flashing and stays on. The emission indicator on the laser head also comes on. Pins 2 and 3 on the *Model J40* or *J80* power supply EMISSION connector close to activate any user-installed indicator.

If the LASER POWER button is released before the 3 second delay is completed, the sequence resets.

Up/down buttons—are located in the lower right corner of the panel, and increase or decrease the value displayed on the screen (such as a power setpoint), or allow the operator to select a parameter from a list to be changed or displayed.

Shutter—blocks the output beam when output is not requested. The shutter is controlled manually via the Setup menu on the Controller or via the SERIAL COM interface using the serial software (see Chapter 6).

Indicators

LCD monitor—provides feedback and control of the laser, depending on which menu is displayed. Large digits always display *actual output power.* Below the output power display, and shown in smaller text, is the output power setpoint. ("RS-232 Enabled" is shown if the system is being operated remotely via the serial link).

LASER EMISSION indicator (red)—is off when there is no emission, flashes for 3 seconds prior to laser emission while the ON button is depressed, then stays on when laser output is present.

Connections

There are no connectors on the Controller. The 2.5 m control cable is permanently attached—do not try to remove it. The cable plugs into the 15-pin REMOTE connector on the front of the *Model J40/J80* power supply.

The *Model J40/J80* Power Supplies

This section defines the user controls, indicators and connections of the *Model J40* or *J80* power supply. These power supply models are air cooled with one (*Model J40*) or two (*Model J80*) output fiber-optic cables on the rear panel. Both versions have similar controls, indicators and connections.

The controls and indicators are located on the front panel, while connections are on the rear panel.

The power supplies are autoranging and accept input from a 100 to 240 Vac, 50 to 60 Hz single-phase source. The power supply is delivered with all necessary jumpers in place. The front and rear panels are described below from left to right, top to bottom.

Caution!

Provide at least 6 inches of clearance from the front and back of the *Model J40* or *J80* power supply to allow cool air to enter the front and for the heated exhaust air to exit the rear panel. Inadequate cooling will cause the system to overheat and shut down. Damage to components caused by insufficient cooling is not covered by the warranty.

Front Panel

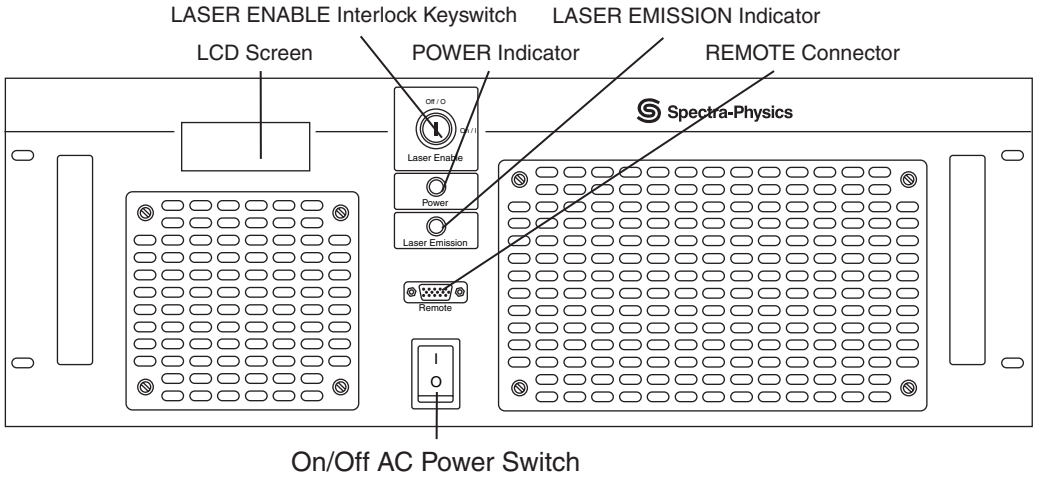


Figure 4-3: The *Model J40* or *J80* Power Supply Front Panel

LCD display—displays the status, including status codes, of the power supply during boot-up and normal operation. During startup, this panel displays the status of the self-diagnostics program. If a problem occurs, all warnings, including system operation errors, are displayed on this panel as well as the control device.

LASER ENABLE interlock keyswitch—provides interlock safety to prevent unauthorized use of the laser when the key is turned to the OFF position and the key is removed. When the ac power switch is on and the key is turned to the ON position, the power supply performs an internal diagnostic check, and the laser head doubling crystal oven is allowed to warm up. Control then transfers to the *Millennia* Controller or to the host system (via the RS-232 link), depending on your configuration.

POWER indicator (yellow)—turns on immediately when line power is applied to the system and the keyswitch is turned on.

LASER EMISSION indicator (green)—shows that power is supplied to the diode pump module(s), and that laser emission is present or imminent.

REMOTE connector (15-pin D-sub)—is used for controlling the laser locally with the *Millennia* Controller.

AC power on/off switch—provides ac power to the *Model J40* or *J80* power supply. See the description of the LASER ENABLE keyswitch for more information.

Note

Because the power supply must be on in order for the doubling oven to remain on, it is recommended that, to permit a short warm-up period, the AC POWER ON/OFF keyswitch be left in the ON position at all times (unless the system is going to be off for an extended period of time) and that the *Millennia* Controller or RS-232 serial commands be used to turn the system on and off.

If security is an issue, it is best to turn the power supply off and remove the key from the keyswitch.

Air intake—allows cooling air to be drawn into the power supply. The heated exhaust air is then vented from the rear panel.

Rear Panel

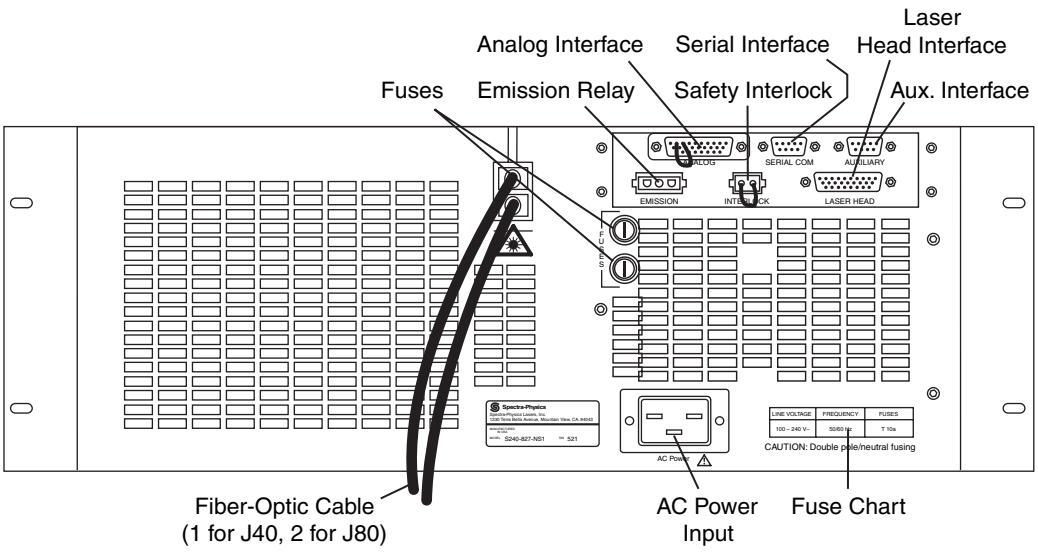


Figure 4-4: The *Model J40/J80* Rear Panel

Fiber-optic cable(s)—is permanently attached to the diode module(s) inside the power supply and must be replaced along with the diode module(s). The clamping device on the panel provides strain relief for the cable(s) and must be removed prior to removing the diode module(s) from the system. The fiber-optic cable feeds into the umbilical.

SERIAL COM connector (9-pin, D-sub)—provides for optional computer control of the system using the serial language described in Chapter 6, "Operation." Refer to the pin descriptions in Table 4-1 and see "Serial Port" on page 4-7 for more information.

AUXILIARY connector—is not used on this system.

ANALOG connector (26-pin, D-sub)—is jumpered (the plug is shown in Figure 4-5) as it comes from the factory and is not used on the *Millennia Pro s* laser. *The jumper plug must always be attached to the connector or the laser will not start, or will shut it off if it is already on.*

Figure 4-5: The ANALOG Jumper Plug

EMISSION relay connector (3-pin AMP)—provides a relay that can be used to turn on and off a user-installed indicator that warns of the presence of laser emission. See "Emission Connector" on page 4-7 for more information.

INTERLOCK connector (2-pin AMP)—provides attachment for a user-supplied safety switch. These contacts must be shorted together before the laser will operate. A defeating jumper plug (Figure 4-6) is installed at the factory to permit operation without a safety switch. See "Safety Interlock Connector" on page 4-8 for more information.

Figure 4-6: The INTERLOCK Jumper Plug

LASER HEAD connector (27-pin, D-sub)—provides attachment for the control cable to the *Millennia Pro s* laser head.

AC POWER connector—provides attachment for the IEC-320-C13 power cord provided with the unit. Connect the cord to a standard power source capable of providing single phase power between 100 and 240 Vac.

Air exhaust—these grills allow heated air to be expelled from the power supply.

Connector Interface Descriptions

Serial Port

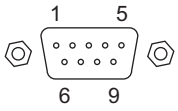


Figure 4-7: The 9-Pin SERIAL COM Port

Table 4-1: IBM-PC/AT Serial Port Pinout

	Computer or Terminal			*Model J40* or *J80*	
RS-232-C Signal Name	**Signal**	**Pin No. (25-Pin)**	**Pin No. (9-Pin)**	**Pin No.**	**Signal**
Transmit Data	TXD	2	3	3	RXD
Receive Data	RXD	3	2	2	TXD
Not Connected	RTS	4	7	–	CTS
Not Connected	CTS	5	8	–	RTS
Not Connected	DSR	6	6	–	DTR
Not Connected	DCD	8	1	–	DCD
Not Connected	DTR	20	4	–	DSR
Signal Ground		7	5	5	
Protective Ground		1	SHELL	SHELL	

Emission Connector

This connection is used to turn on and off a user-installed external emission indicator. When there is no laser emission, there is closure between the NC and C terminals and an open between the NO and C terminals. The opposite is true when there is emission or emission is imminent. Refer to the circuit diagram in Figure 4-8 below.

There is no power supplied by these terminals. This circuit is rated for 30 Vac at 1 A. The mating connector is AMP part number 350766-1, which uses male crimp pins, AMP part number 350218-1. The AMP pins are designed for specific wire gauges, so choose the appropriate wire. Other connectors will fit these jacks, including solder-cup and “IDC” style connectors.

Pin #	Description
3	Common (C)
2	Normally Open (NO)
1	Normally Closed (NC)

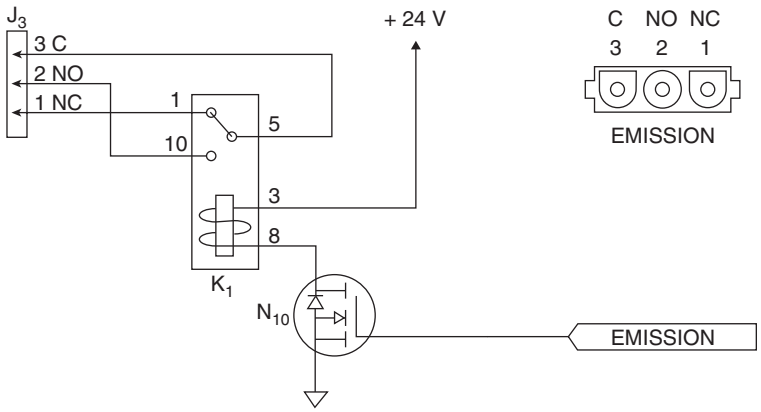


Figure 4-8: The *Model J40* or *J80* Emission Connector Circuit

Safety Interlock Connector

This is a system interlock that must be closed for operation. The plug provided with the system can be replaced with a connector that is wired to auxiliary safety equipment (such as a door switch) to shut off the laser when actuated (opened).

Such a switch must be designed for a 12 V 100 mA signal. The mating connector is AMP part number 350777-1, which uses female crimp pins, AMP part number 350536-1. The AMP pins are designed for specific wire gauges, so choose the appropriate wire. Other connectors will fit these jacks, including solder-cup and "IDC" style connectors.

Pin #	Description
1	System Interlock
2	System Interlock Return

Chapter 5 Installation

Warning! 

The installation procedures in this chapter are not intended for the initial installation of your laser. Please call your Spectra-Physics service representative to arrange an installation appointment, *which is part of your purchase agreement*. Allow only personnel authorized by Spectra-Physics to install and adjust your laser. You will be charged for repair of any damage incurred if you attempt to install the laser yourself, and such action might also void your warranty.

This section provides detailed instructions and information for planning the initial setup of the *Millennia® Pro s-Series* system. If you have not set up the system before, or you are moving it to a new location, please review this section in detail.

When you received your laser, it was packed with the laser head and power supply already connected. Do not disconnect the umbilical cables from either end!

System Installation Considerations

Be sure to follow all safety precautions for laser use while handling or storing the laser. Be sure to install all laser safety devices before using the laser. Refer to the Chapter 2, "Laser Safety" for more information on this topic.

Except for a small screwdriver, all the tools and equipment needed to set up the *Millennia Pro s* laser are in the accessory kit.

The laser head is fastened to the mounting surface using the clamps, screws and nested spherical washers provided with the system. The clamps can be used on optical tables with either metric spacing or English hole spacing.

The power supply, chiller, and laser head together produce less than 1500 W (5 kBTU per hour) of waste heat for models using the *Model J80* power supply, or less than 850 W (2.9 kBTU per hour) for models using the *Model J40*. Provide enough cooling capacity to prevent room over-heating.

The fiber-optic cable(s) in the umbilical has a minimum bend radius of 6 in. (15 cm). Consider both the minimum bend radius and strain relief as you route the umbilical from the power supply to the laser head.

Warning! 

Do not twist or bend the umbilical to a radius of less than 6 in. (15 cm). Doing so can damage the fibers inside. Such damage is not covered by your warranty.

Mounting the Laser Head

Note

If you are installing the power supply in a standard rack, first follow the instructions later in this chapter for installing the power supply before mounting the laser head.

The laser head arrives with the control cable already connected to the head and held in place by a bracket. The laser head is permanently connected to the power supply by the umbilical. Move both units to a stable location within 4 m (the length of the umbilical) of where the laser is to be installed.

The laser head should be secured to an optical table or other flat mounting surface. Three slots are provided in the bottom edge of the mounting base for this purpose, two near the output bezel and one at the center rear. Also supplied are three laser head clamps that can be used on an optical table with either metric hole spacing (175 mm) or English (1 in.) spacing.

Note

Do not use the holes on the bottom plate of the laser head to mount the *Millennia Pro s* laser.

1. If the *Millennia Pro s* is going to be used to pump a Spectra-Physics *Tsunami*® laser, screw the 3 legs included in the *Tsunami* accessory kit into the holes shown in Figure 5-1 until they are secure. The 3.5 in. legs raise the laser off the table to a beam height of approximately 5.8 in. (14.8 cm).

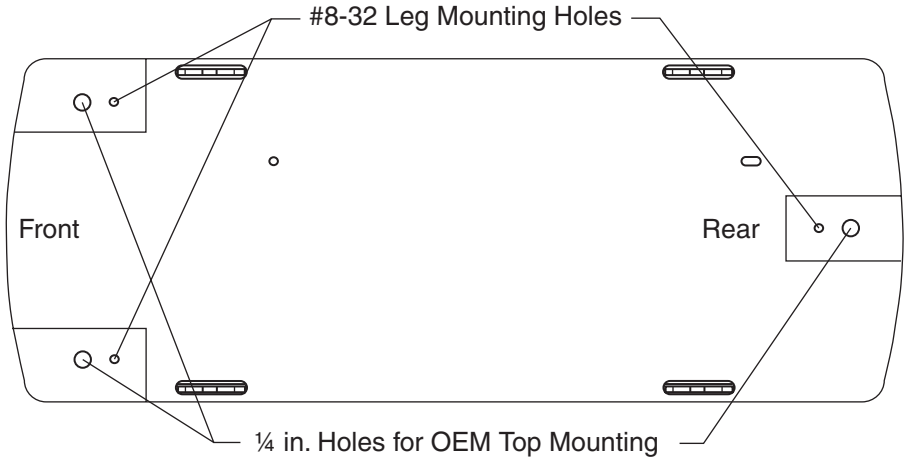


Figure 5-1: Location of leg mounting holes on the bottom of the laser head. The second set of holes are for OEM use only.

2. Secure the laser head to the table.
   a. If the laser is to be mounted directly to the table (no legs), insert the three laser head clamps (provided) into the slots in the mounting base as shown in Figure 5-2. Then, using table mounting screws along with the nested spherical washers (also provided), fasten the laser to the table via the desired mounting holes.

b. If legs are used to raise the laser head off the table, clamp them in place with the 3 foot-clamps provided with the legs. Slide a U-shaped end over the foot of each leg, place a table mounting screw through the slot and fasten the leg to the table.

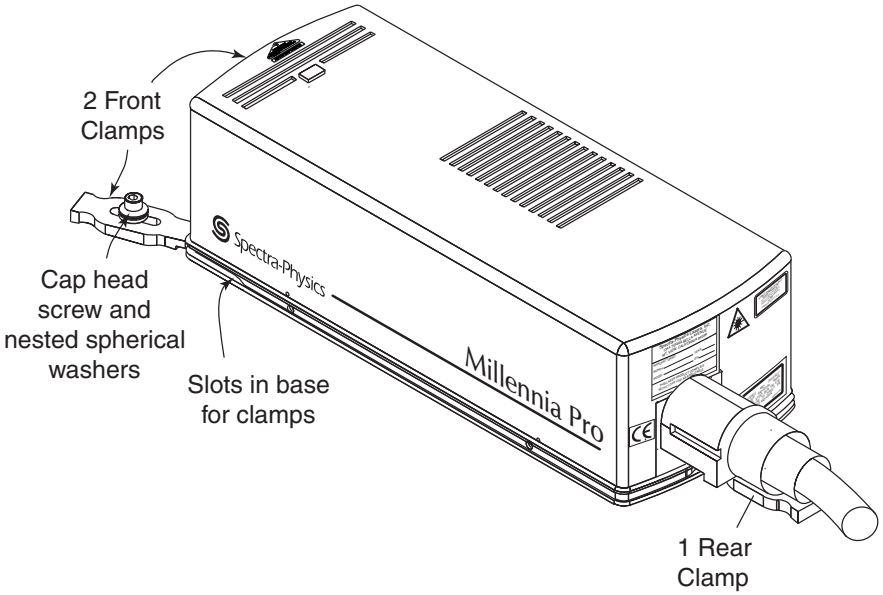


Figure 5-2: Laser head mounting clamps and base slots

Mounting the Chiller and Power Supply

There are three ways to position the chiller and power supply:

- If the system includes a floor-standing chiller on rollers, refer to "Mounting the Power Supply and Chiller as Stand-Alone Units" below.
- If the system includes a rack-mountable chiller (such as the Thermo-NesLab *Model KMC-100* and optional rack kit), refer to "Mounting the Power Supply and Chiller in the Optional Rack" below.
- If the components are to be mounted in a standard enclosed rack, see "Mounting the Power Supply and Chiller in a Standard Rack" below.

Although the rack-mountable *Model J40* or *J80* power supply and the *Model KMC-100* chiller do not need to be rack-mounted, we recommend mounting them in the optional open-air, 19-inch rack to save lab space. Once mounted, this entire unit can be rolled out of the way under a table.

Caution!

Provide at least 6 inches of clearance from the front and back of the power supply to allow cool air to enter the front and for the heated exhaust air to exit the rear panel. Inadequate cooling will cause the system to overheat and shut down. Damage to components caused by insufficient cooling is not covered by the warranty.

Mounting the Power Supply and Chiller as Stand-Alone Units

Place the power supply in a convenient location within 4 m of the laser head (the length of the umbilical), and place the floor-standing chiller nearby. Be careful that the heat generated by the power supply and chiller does not adversely affect the laser.

Ensure that the electrical cables and umbilical are safely routed and not under any strain or compression. Avoid conditions where the cables can be stepped on. Use caution when moving the power supply to prevent damage to the fiber-optic cable. Do not step on or roll objects over the umbilical.

Mounting the Power Supply and Chiller in a Standard Rack

The following describes the procedure for installing the power supply into a standard 19 in. (48.3 cm) enclosed rack. The laser head and power supply are permanently connected via the umbilical. Therefore, three people are needed to install the power supply into an enclosed rack.

Place the rack in a convenient location less than 4 m (the length of the umbilical) from where the laser head will be located.

Install the chiller in the rack first. Determine the support for the chiller in the rack, then use two people to safely lift the chiller and slide it into the rack and onto the support surface. Use screws to fasten the chiller front panel to the rack.

Caution!

The chiller must be mounted in the lowest slot in the rack so that any leak or condensation will not drip onto equipment below it.

Next, install the power supply in the rack. With one person holding the laser head, two people should carefully lift the power supply. The person with the laser head can now pass it through the rack from the front and out the back. The people holding the power supply can now slide it into the rack and onto the support structure.

Be careful that the heat generated by the power supply will not adversely affect the laser. Provide filtered ventilation air so that it flows into the bottom of the rack enclosure, past the power supply without obstruction, and exhausts from the top. Do not add shelves between units or over-heating will result.

Fasten the front panel of the power supply to the rack using four screws.

Caution!

The four screws used to mount both the chiller and the power supply are only meant to secure them in place, *not to support them*. Provide slides or rails to support the weight of these units. Mounting holes are provided on the side of the power supply for attaching slides. Refer to “Outline Drawings” on page 3-15 for hole locations and sizes.

Install the laser head following the procedures listed earlier.

Mounting the Power Supply and Chiller in the Optional Rack

The optional rack is shipped along with the system in a separate box. It consists of two parts, the rack base with 4 lockable casters pre-installed, and a vertical rack component that mounts to one end of the base. The rack provides room for mounting two 7-inch rack panels, such as the power supply and chiller.

Holes for rail support are provided along the sides of the power supply (refer to "Outline Drawings" on page 3-15 for dimensions and hole locations). The rack-mountable chiller must be supported from the bottom. The mounting holes on the front panels are for locking these units into the rack, not for supporting them.

Please read these instructions completely before beginning the installation.

1. When installing the power supply, to prevent the laser head from being pulled off the table by the umbilical, place it on the floor or, alternatively, **secure it in place** on a table or other mounting surface (refer to "Mounting the Laser Head" above.)
2. Remove the bubble pack from both rack components, taking care not to scratch the coated surfaces.
3. Place the rack base on the floor. Note the end of the base that has a notch in each corner (Figure 5-3), then set the **chiller** on the base so that its front panel faces the notched end (Figure 5-4) and sticks out over the end. Next, place the **power supply** on top of the chiller and align their front panels (Figure 5-5). The chiller **must be on the bottom** to prevent damage caused by any leaks or condensation.

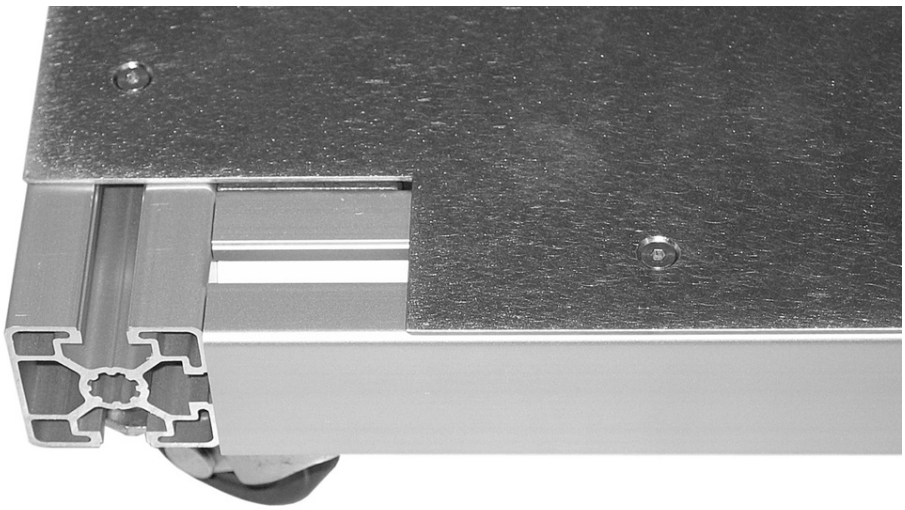


Figure 5-3: The mounting rail notch on the rack base. The mounting bolt for the vertical rack engages the slot to the right.

Figure 5-4: The chiller shown set on the base facing the two notches (away from the camera).

Figure 5-5: The chiller and a power supply shown set on the base.

4. Attach the vertical rack to the notched end of the base.
   a. Loosen the T-shaped locking bolt and its nut (Figure 5-6) on each end of the rack (loosen the nut to the end of the threads, but keep it attached). Orient the bolts to the slots in the base (Figure 5-3).

Figure 5-6: One end of the vertical rack showing the locking bolt (upper bolt).

   b. Drop the rack into place so that the locking bolts engage the slots. There has to be enough free play for the bolt to extend completely down into the slot and turn 90 degrees.
   c. Align the front of the rack to the base.
   d. Tighten the locking nuts to 18 lb/ft.

      Tightening the locking nut automatically turns the T-bolt 90 degrees inside the slot to its locking position, then pulls the rack tight to the base. Loosening the nut does just the opposite; it realigns the bolt with the slot for easy removal.

Figure 5-7 shows the fully assembled unit before the power supply and chiller panels are secured to the rack.

Figure 5-7: The power supply and chiller on the rack.

5. Using the 8 mounting screws from the system accessory kit, secure the chiller and power supply to the rack.

Connecting the System

Refer to interconnect drawing Figure 5-8.

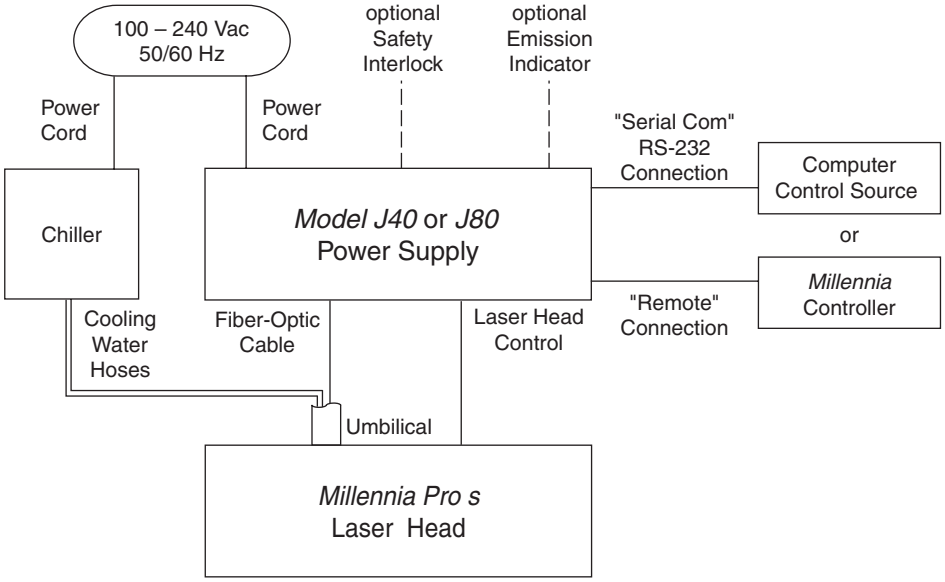


Figure 5-8: Interconnect Drawing, *Millennia Pro s*

1. Set the *Millennia* Controller or the computer in a convenient location.
2. The system arrives with the control cable connected to the laser head. Connect the free end of the control cable to the 27-pin D-sub LASER HEAD connector located on the power supply (see Figure 5-9).

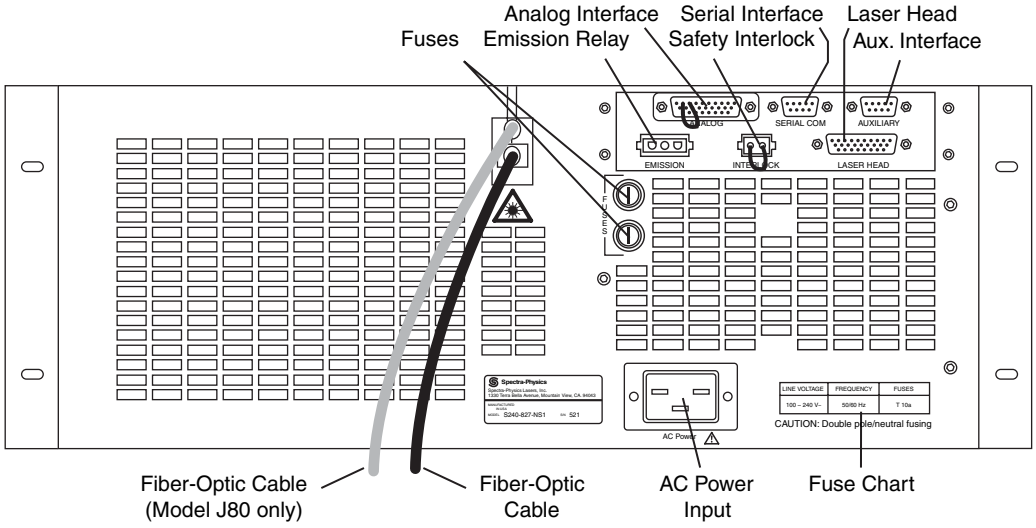


Figure 5-9: The rear panel of the *Model J40/J80* power supply

3. The two pins of the INTERLOCK connector on the rear panel of the power supply must be jumpered or connected to an external, closed safety switch or the laser will not turn on. To use the INTERLOCK safety switch, refer to the detailed description of this circuit in Chapter 4 in the section “Connector Interface Descriptions.”

If you are not going to employ a safety switch, the 2-pin jumper plug (P/N 0129-3815) should be inserted into the INTERLOCK connector (see Figure 5-9).

4. Verify that the 26-pin ANALOG connector next to the fiber-optic cable (see Figure 5-9) contains a jumper plug (P/N 0129-4024).
5. Attach the control device.
   a. If you ordered your system to be configured at the factory for control via the SERIAL COM port *only*, skip to step c.
   b. Connect the *Millennia* Controller cable from the Controller to the 15-pin REMOTE connector on the front of the power supply. If necessary, remove the jumper plug from the connector and store it in a safe place.
   c. If you are using serial commands to control the laser system, attach a standard 9-pin serial control cable (not provided) between the serial port of your host controller (typically a PC computer) and the RS-232 connection on the power supply rear panel.

      Refer to Chapter 4, “Controls, Indicators and Connections”for pin descriptions. Also refer to “Controlling the System Using the SERIAL COM Interface” on page 6-14.

      If the system is to be operated solely by the computer and not by the *Millennia* Controller, the REMOTE jumper plug must be plugged into the connector on the front panel.

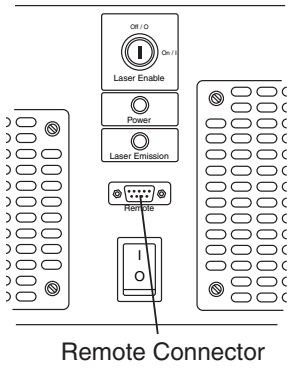


Figure 5-10: The REMOTE connector on the power supply front panel

6. If an emission indicator lamp is required, in addition to those on the laser head and the power supply front panel, use the EMISSION relay connector (Figure 5-9) on the rear panel of the power supply to turn a lamp on and off. To use the EMISSION relay, refer to the detailed description of this circuit in Chapter 4 in the section “Connector Interface Descriptions.”
7. Attach the provided IEC power cord to the power connector on the power supply and fasten it to the receptacle retaining screws so that it does not pull out. Plug the other end into a facility power outlet that can supply 100 to 240 Vac, 15 A single phase power.

A Schuko type plug is provided to European countries. If you received a plug inappropriate for your area, call your Spectra-Physics regional distribution center to obtain one (refer to Chapter 8, "Customer Service," for telephone numbers).

8. Verify that the correct fuses are in place for the power supply. Refer to "Specifications" on page 3-13.

Connecting the Chiller

Refer to the user's manual that came with the chiller for detailed information on installing and starting it.

1. Mount the chiller on the floor, table top or in a rack close enough to the power supply so that the cooling hoses from the umbilical can reach the connections on the back of the chiller. Refer to "Mounting the Chiller and Power Supply" above.

Warning! 

Do not place the chiller above the laser. If the unit develops a leak or condensation forms, dripping water may damage the laser or other objects below it.

2. Screw both hoses onto the chiller and tighten.

   The hose connections are not polarized. Finger tight is enough: do not overtighten.

3. Verify there is water in the chiller, then turn on the chiller. Verify water is flowing and that there are no leaks at the hose connections.
4. Set the chiller temperature for 18°C (64.4°F).

This completes the installation of the *Millennia Pro s-Series* system.

Moving the System

To move the system:

Rack-mounted systems—place the laser head and Controller on top of the power supply or rack and roll the system to its new location.

Non-rack-mounted systems—disconnect the chiller supply lines at the chiller and drain the lines. Then set the chiller and power supply on a cart and the laser head and Controller on top of the power supply, then roll the entire system to its new location. Make sure the cooling lines are reconnected and tightly fastened to the chiller before restarting the laser after moving it.

Alignment

There is no alignment procedure for the *Millennia Pro s-Series* system: there are no knobs to adjust or optics to change.

When you are ready to turn on the laser, refer to Chapter 6, "Operation."

Chapter 6 Operation

The Spectra-Physics *Millennia® Pro s* laser is a *Class IV—High Power Laser* whose beam is, by definition, a safety and fire hazard. Take precautions to prevent accidental exposure to both direct and reflected beams. Diffuse as well as specular beam reflections can cause severe eye or skin damage.

Please read this entire chapter and Chapter 2 on laser safety before using your laser for the first time. This chapter contains information for operating the laser system locally, using the *Millennia* Controller, or remotely, using a computer and the system commands explained later in this chapter.

After your *Millennia Pro s* has been installed, we strongly suggest leaving the power supply power switch in the "on" position at all times. Doing so drastically reduces the warm-up time by keeping the SHG doubling crystal oven on, and it will help protect the crystal, especially in humid environments.

Using the Millennia Controller

The *Millennia* Controller (Figure 6-1) is a convenient device for operating the *Millennia Pro s* laser locally.

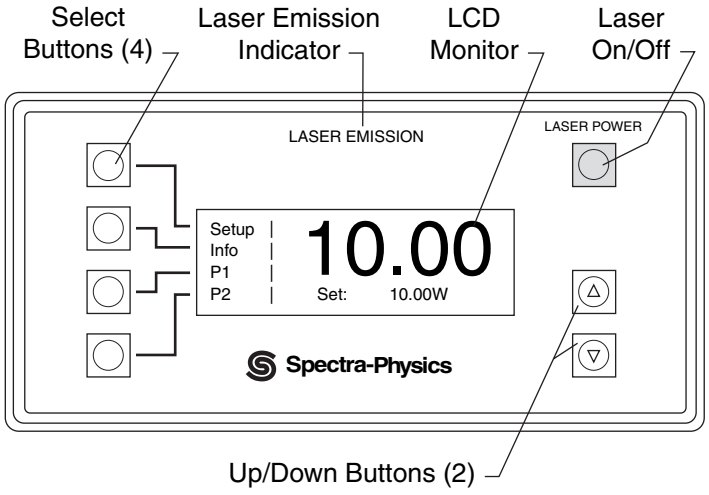


Figure 6-1: The *Millennia* Controller

Use the four buttons on the left side of the Controller to select one of the four possible options shown on the left side of the screen. For example, press the top left button to go to the Setup menu or the next button down to go to the Info menu, etc. Not all menus use all of the buttons.

The LASER POWER button turns the laser on and off.

The up/down buttons in the lower right corner either increase or decrease the value displayed on the screen (such as the power setpoint), or allow the selection or change of a parameter from a list on the display.

What is shown on the screen depends on the menu selected. The large digits always display *actual output power*, and below that in smaller text is the output power setpoint. "RS-232 Enabled" is displayed if the system is set for remote operation via the serial link.

The function of each menu is summarized in the following list. The use of the Controller to select and perform these functions is described in the next section.

- Use the Main menu to monitor laser output power and to set the power output level.

  The Main menu displays a status message indicating if the system is under remote control (serial commands for remote control of the laser by a computer are listed at the end of this chapter).

- Use the Setup menu to open and close the shutter and to run the SHG crystal optimization routine. The Setup menu also lets you activate or deactivate Standby mode and to set the time delay before Standby is activated. Main menu power setpoints P1 and P2 are also set using the Setup menu.

  The Setup menu is accessed from the Main menu.

- Use the Info menu to view the pump diode current level, the temperature of the diode pump laser, the temperature status of the SHG doubling crystal ("warming" or "stable") and the revision numbers for the *Millennia* software. Also included is a history (HST) line that shows the last three system status codes.

  The Info menu is accessed from the Main menu.

- The Standby menu is displayed anytime the power supply is left on but there has been no laser emission for a time greater than the standby delay time setting.

  The Standby menu is accessed from the Setup menu.

- The Warm-up menu is displayed after the system is powered up from a cold start (i.e., the power supply was turned off after the last time it was used). It allows the operator to monitor the warm-up process.

Each of the menus is described in greater detail below.

The Menu System

Four menus—Main, Setup, Standby, and Information—are used to control and monitor the system. Sample menu displays are shown in Figure 6-2.

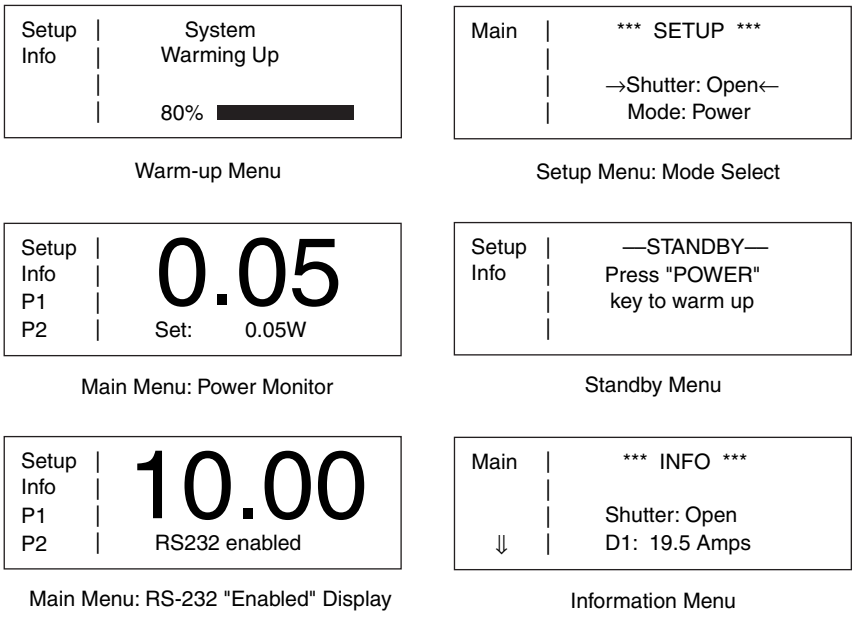


Figure 6-2: The *Millennia Pro s* Menus

The upper left-hand frame shows the warm-up menu that is displayed soon after the system is powered up from a cold start (i.e., the power supply was turned off after the last time it was used). It allows the operator to monitor the warm-up process, which takes about 35 minutes. If the system is being controlled remotely using the serial interface, a query command allows the operator to monitor the warm-up process (refer to the "Queries" section later in this chapter).

The Standby menu is displayed anytime the power supply is left on but there has been no laser emission for a time greater than the Standby Delay time setting.

The Main, Setup, Standby, and Info menus are further described in the following sections.

The Main Menu

When the system is ready for operation following the warm-up sequence, the Main menu is displayed. From here the operator can set the output power and monitor system performance. The large numbers indicate actual output power; the smaller numbers below it indicate either the power setpoint (the desired output power) or "RS-232 Enabled" when the system is set to operate remotely via the SERIAL COM port.

Power mode (with the laser system in local control) is displayed in the figure below. When the system is tracking properly, actual output power and setpoint are the same, ± 0.01 W.

To change the power setpoint, either press one of the preset power setpoint keys (P1 or P2) to move directly to a power previously set in the Setup menu, or use the up/down buttons to set a new value. Note that when the up/down buttons are held in, the setpoint numerical update pauses from time to time. This is normal.

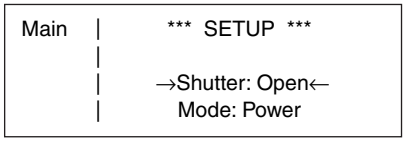
If an error occurs, "Error" flashes in the lower left corner of the Main menu. To display the source of the error, press the lower left button (status codes and their definitions are listed in Appendix A.) When the problem is corrected, the error message turns off. If the error code is generated by the power supply, it is logged on the history (HST) line in the Info menu.

Menus available from the Main menu are Setup and Info.

The Setup Menu

Use the Setup menu to:

- open and close the shutter,
- run the SHG optimization routine,
- activate or deactivate Standby mode,
- set the time delay before Standby is activated, and
- set the Main menu preset power values for P1 and P2.



To access this menu from the Main menu, use the two lower left buttons to scroll the menu up and down. The selected item is the one between the horizontal arrows (the example screen above shows the shutter status, which can be set to open or close). To change the value for the selected item, use the up/down buttons to the right of the screen.

Note

Changes are activated upon return to the Main menu.

Selections include:

- Shutter: Open, Closed
- Mode: Power, SHG Opt, RS-232
- Stdby: 15 min, 30 min, 1 hour, 4 hours, Never
- P1 Set: any value between 0.05 W and the maximum
- P2 Set: any value between 0.05 W and the maximum

Shutter

The shutter, when closed, mechanically blocks the laser beam.

Modes

Power mode adjusts the pump diode laser current as necessary to maintain constant output power. It is the normal method of operating the laser.

Note

Current mode operation is not available on the *Millennia Pro s-Series*.

To provide optimum conversion efficiency, the SHG optimization routine ("SHG Opt") automatically optimizes the temperature of the LBO doubling crystal, thereby optimizing the efficiency of second harmonic conversion. Maintaining the optimum conversion efficiency will minimize the amount of pump diode laser current needed to reach the specified output power. The SHG Opt routine is typically run at installation, and should not need to be run again unless the ambient environment has changed significantly. The routine takes about 15 minutes to complete.

Under certain conditions, small manual adjustments to the SHG temperature may be required to maintain peak performance. This capability is provided through a selection on the SHG display.

The Setup menu also indicates when control of the laser via commands from a host computer or similar device has been established. When serial control is activated, "RS-232 Enabled" is displayed on the Main menu, and the laser can be controlled in parallel by commands from either the host computer or the *Millennia* Controller.

Instructions for establishing a remote connection are provided later in "Controlling the System Using the SERIAL COM Interface" on page 6-14. The software commands for serial control are explained later under "The Command/Query Language" on page 6-15.

Stdby

Standby ("Stdby"), when active, causes an automatic system power down whenever the power supply is left on but no laser emission has been present for a time greater than the "Stdby Delay" time setting. This is the preferred off condition for day-to-day operation.

Standby can be defeated by setting the delay time to "Never."

P1, P2 Set

P1 SET and P2 SET allow the user to preset two power levels that can be selected from the Main menu during operation by pressing one of the two lower left buttons on that screen. See the Main menu description above.

Pressing the Main button from the Setup menu activates the values just selected and then displays the Main menu.

The Standby Menu

Once Standby mode is activated via the Setup menu, the Standby menu automatically displays whenever the *Model J40* or *J80* power supply is on but laser emission is off for more than the pre-set time (the "Stdby Delay" time—see the Setup menu). This is the recommended, over-night "off" condition. Refer to "Turning On the Laser, Warm Start" and "Turning Off the Laser" later in this chapter.

This display is not shown when the system is started cold—that is, when the power supply has been turned off; it can only be accessed from the Setup menu.

```
Setup  |      —STANDBY—
Info   |    Press "POWER"
       |     key to warm up
       |
```

The Info Menu

The Info ("information") menu shows whether the shutter is open or closed, and provides diagnostic information on the diode laser(s) and the SHG doubling crystal. It contains a history (HST) line that displays the three most recent system status codes. The codes and their definitions are listed in Appendix A. The Info menu is accessed from the Main menu.

```
Main   |      *** INFO ***
       |
       |    Shutter: Open
  ⇓    |    D1  :19.5 Amps
```

Use the select buttons on the left side of the Controller (not the up/down buttons on the right side) to scroll the screen – note the down arrow in the figure above. Two lines or three are displayed at a time as follows, from top to bottom:

Note

For systems that employ two diode modules, the status of the second diode laser will be listed following the status of the first, where applicable (e.g. D_2: 20.6Amps).

- Status of the shutter (open/closed)
  Example: Shutter: Open
- Drive current for the diode laser D_1
  Example: D1: 19.9A
- Temperature of diode D_1, degrees Celsius
  Example: D1: 19.5C
- History buffer —last three status codes
  Example: HST: 001 003 005

- Status of the SHG doubling crystal temperature status
  (Stable is displayed when the proper temperature is reached.)
  Example: SHG: Stable
- Tower temperature, degrees Celsius
  Example: TWR: 22.2C
- Diode hours—total time the diode has been used
  Example: D1: 11.2hrs
- Diode initial current (original factory setting)
  Example: D1Icur: 36.7A
- Diode initial temperature (original factory setting)
  Example: D1Itmp: 23.0C
- Diode module serial number(s)
  Example: D1serial# xxxxxxxxxxxxxx
- Present SHG setting (coarse/fine)
  Example: SHG: +3088/8
- *Millennia* system type
  Example: IDN Mil Pro 5sJ
- *Millennia* software revision
  (Have this revision number available whenever calling for service.)
  Example: PS: 0456-9100C
- Controller firmware revision
  Example: Rmt: 6.04

Pressing the "Main" button returns the display to the Main menu.

System Startup/Shutdown

There are two turn-on sequences. The cold start turn-on sequence is used when the system starts with the power supply turned off. The warm start sequence is used when the system is in Standby mode (when the laser is off but the power supply has been left on).

Note

When Standby mode is activated, the system automatically powers down after the preset delay time, and the Standby menu is displayed. To restart the unit, follow the procedure for a warm start turn-on.

Turning On the Laser, Cold Start

1. Verify all connectors are plugged into the power supply and laser head (they should never be disconnected—if they have been, refer to Chapter 5, "Installation," for instructions on re-connecting them).
2. Turn on the power supply ac power switch.
3. Turn on the chiller. Verify it is set to 18°C.

   Refer to the chiller user's manual for instructions on setting the temperature.
4. Turn on the power supply keyswitch.

Power Supply Startup

As the system starts up, the message sequence below is displayed on the power supply LCD screen. If an error occurs during startup, the screen alternates between displaying the status code and the normal screen information.

"EEPROM Initialization"

"Spectra-Physics
Model Millennia Pro s"
(followed by the version number and date of software release)

"Boot Test 1 ... 12"

"Success.
Boot Test Passed"

"*** Status ***"
"Status Code = 5"
"Laser Diode: OFF"
"Ready" (alternates with) "xx% Warm-up"

If the keyswitch is not set to ON, the system will not start up and "System Error, Open Interlock" is displayed. Simply set the keyswitch to ON to clear the error message and enable the system.

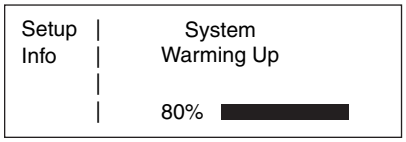
Controller Startup

5. The following message is displayed on the Controller as the system turns on:

"Spectra-Physics Lasers
Vr: X.XX
Waiting xx sec for communication"

"Welcome to the new Millennia"

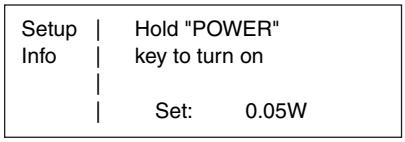
After the welcome message, the system begins a warm-up cycle that can take up to 35 minutes (if the power supply had been turned off). To indicate progress, a time bar displays warm-up status from 0 to 100%:



Note

It is normal to require greater than 60% of full current for the diode pump laser(s) before reaching the threshold for green output power.

6. When the system has warmed up, the following screen is displayed:



Press and hold in the LASER POWER button until the laser starts. When the button is pressed, the LASER EMISSION light on the Controller flashes for a few seconds. Then, when laser emission occurs, the LASER EMISSION light stops flashing and remains on, and radiation is available when the shutter is opened.

At this point, the Main menu is displayed and output power ramps up slowly to 0.05 W.

7. Use the Setup menu to open the shutter.

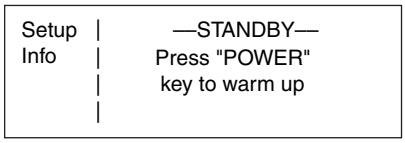
   If the shutter is closed, no emission will occur until it is opened via the Setup menu or through software.

8. From the Main menu, set laser output power using the up/down buttons or by pressing the P1 or P2 button. Actual output power will follow the setpoint value.

This completes the cold start procedure. The system is now ready for use.

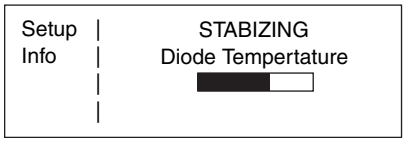
Turning On the Laser, Warm Start

This procedure assumes the unit was left in Standby mode after it was last used. When this is the case, the following Standby prompt is displayed.



1. Check that the chiller is on and set it for 18°C.
2. Press the LASER POWER button to begin the short warm-up cycle.

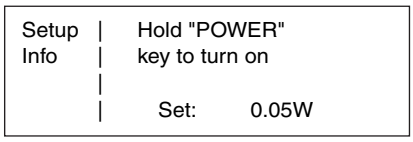
   The following prompt is displayed for about 2 minutes while the diode module temperature stabilizes:



Note

It is normal to require greater than 60% of full current for the diode pump laser(s) before reaching the threshold for green output power.

3. When the system has warmed up, the following screen is displayed:



Press and hold in the LASER POWER button until the laser starts. When the button is pressed, the LASER EMISSION light on the Controller flashes for a few seconds. Then, when laser emission occurs, the LASER EMISSION light stops flashing and remains on, and radiation is available when the shutter is opened. (The shutter will be in the same position it was in when the system went into Standby.)

At this point, the Main menu is displayed and output power ramps up to the previously set power level.

4. Use the Setup menu to open the shutter.
5. From the Main menu, set laser output power using the up/down buttons or by pressing the P1 or P2 button. Actual output power will follow the setpoint value.

This completes the warm start procedure. The system is now ready for use.

Turning Off the Laser

Note

We suggest you leave the *Millennia Pro s* in Standby when not in use: turn off the laser, but leave the power supply ac power switch in the "on" position. Leave the chiller running. This combination reduces warm-up time and keeps the SHG crystal at optimum operating temperature.

To turn off the laser:

1. Close the shutter via the Setup menu, or issue the serial command *SHUTTER:0*.
2. Press the LASER POWER button on the *Millennia* Controller to turn off the laser, or issue the serial command *OFF*.
3. Turn the keyswitch on the power supply to OFF and remove the key to prevent unauthorized use. **Leave the ac power switch on the power supply in the "on" position.**

   If Standby has been activated, the system will go to Standby automatically after the pre-set time delay. If the laser is not going to be used for an extended period of time, turn off the power supply completely.
4. Turn off the chiller.

This completes the turn off sequence.

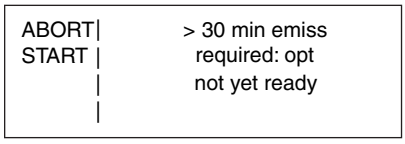
Setting the SHG Crystal Temperature

Optimizing the doubling crystal temperature optimizes the conversion efficiency for the green output power, and thereby minimizes the diode current that is required to reach a specified output. The SHG optimization routine ("SHG Opt") provides this optimization. After this routine is run at installation, it should not need to be run again, unless the laser environment changes significantly. Refer to Chapter 7, "Maintenance and Troubleshooting," for a description of problems that indicate invoking this routine.

In some circumstances, manual adjustment of the crystal temperature might be required. This manual adjustment procedure is described below.

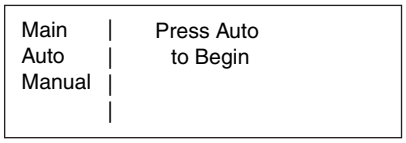
Automatic Optimization

The automatic routine takes about 15 minutes to run. However, it is recommended that the laser be operated at maximum power for 1 hour before running this routine. If the system has been on for less than 30 minutes and the operator tries to start this routine, the following screen is displayed:

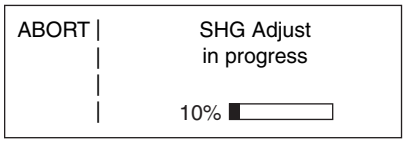


To start the routine:

1. Set the laser output power to a level somewhat below its maximum value (e.g. select 9.0 W for a 10 W system). If the doubling crystal temperature needs adjustment, the actual laser output might be less than the commanded value.
2. Select the Setup menu, then select SHG Opt and press the Main menu button to activate the selection.
3. A screen similar to the one below is displayed. Press the Auto button.



4. The shutter will close and the routine will begin. During the progress of the routine, a screen similar to the one below is displayed.



If the procedure must be aborted, press the "Abort" button at any time to return to the Setup menu. The display will show "Aborted" and the system mode and power level will return to the settings that were in effect prior to invoking the routine.

5. When the optimization process is complete, the laser will be left at maximum power in power mode with the shutter closed, and the Main menu will display the present power level. If specified output power was not achieved, the display will show "Aborted" and the laser will be returned to the mode and power level that were in effect at the time the routine was invoked.

Manual Optimization

Under certain conditions, running the automatic routine will not produce an increase in the power of the green output beam, even though the temperature of the doubling crystal needs adjustment. In this case, as described in step #4 above, the display for the automatic SHG routine will show "Aborted" at the end of the routine.

For Controller firmware version 6.04 and higher, it is then possible for the user to proceed with manual adjustments to the doubling crystal temperature.

Note

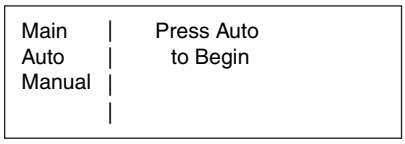
If you have an earlier version of the Controller firmware, you will need to contact your Spectra-Physics representative to arrange for a service call to make the adjustment.

Proceed to manually adjust the doubling crystal temperature as follows:

Note

The fine adjustment has a range of ±50 counts. If you reach the limit of the fine adjustment without improving the output power of the laser, exit the manual adjustment and contact your Spectra-Physics representative.

1. Set the laser output power to a level somewhat below its maximum value (e.g. select 9.0 W for a 10 W system). If the doubling crystal temperature needs adjustment, the actual laser output might be less than the commanded value.
2. Select the Info screen and record the operating current at the commanded power setting.
3. Select the Setup menu, then select SHG Opt and press the Main menu button to activate the selection. A screen similar to the one shown below is displayed.



4. Press the button for Manual operation.

Note

The *Millennia Pro s* system enters constant current operating mode when manual SHG adjustment is selected.

5. A display similar to the one shown below will appear. Make note of the initial value of the fine adjustment for the crystal temperature.

```
Main  | *  SHG Adjust  *
      |    Power:      9.05W
      |
      |    Fine  :        20
```

6. To determine whether the optimum crystal temperature is a higher or a lower temperature, proceed as follows:
   a. Increase the value of the fine adjustment by a value of 10 and wait one minute to see if the laser output power changes.
   b. If the power increases, return the fine adjustment to its initial value and skip to step 7.
   c. If the power does not change, increase the fine adjustment by another count of 10 and wait another minute to see if the output power changes. Continue adding to the fine adjust level in this manner until a change in output power is observed.

      If the power increases, return the fine adjust level to the last value that it did *not* cause a change and go to step 7.
   d. If the power decreases, return the fine adjustment to its initial value and then decrease it by a count of 10. Wait one minute to see if the output power changes. Continue decreasing the fine adjust level in this manner until an increase in output power is observed.

      When the power increases, return the fine adjust level to the last value that it did *not* cause a change and proceed to step 7.
7. To set the temperature to its proper value, change the fine adjust by values of 2 in the direction that improves the output power as determined in step 6, waiting one minute between changes for the adjustment to take effect. Continue with this adjustment until the power starts to decrease, then return to the optimum value.
8. When the crystal temperature has been manually optimized, return to the Main menu and set the laser to the same output power as selected in step #1. Go to the Info menu and take note of the operating current. Confirm that has been lowered for the selected power output level.
9. If this procedure fails to return the output power to its proper operating level, contact your Spectra-Physics representative.

Controlling the System Using the SERIAL COM Interface

Pinout/Wiring

The power supply SERIAL COM port accepts a standard 9-pin D-sub male/female RS-232 extension cable that can be plugged directly into a PC computer. Data flow is hardware controlled.

A desktop or notebook PC running Windows HyperTerminal is recommended for initial setup and testing. Figure 6-3 shows the pinout of the SERIAL COM interface. Table 6-1 describes the wiring of the 9-pin SERIAL COM interface.

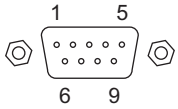


Figure 6-3: The 9-Pin SERIAL COM Port

Table 6-1: The Serial Com Interface

	Computer or Terminal			Model J40 or J80	
RS-232-C Signal Name	**Signal**	**Pin No. (25-Pin)**	**Pin No. (9-Pin)**	**Pin No.**	**Signal**
Transmit Data	TXD	2	3	3	RXD
Receive Data	RXD	3	2	2	TXD
Signal Ground		7	5	5	
Protective Ground		1	SHELL	SHELL	

Communications Parameters

9600 baud
No parity
8 data bits
1 stop bit
Hardware Control: None

The baud rate defaults to 9600 each time the system is turned on. There are no dip switches to set. A faster setting will make no difference in performance.

Enable: Echo local typed characters.
Enable: Send line feeds
The command terminator is ';' or '<CR>'.
All queries and commands reply with '<CR> <LF>'

The Command/Query Language

The commands and queries listed in this section allow the user to create his own program for operating the *Millennia Pro s-Series* system. Each command and query is explained and an example given.

Command/Query/Response Format

All commands and responses are in ASCII format. Commands to the system are terminated by an ASCII carriage return, a line feed, or both. All responses from the *Millennia Pro s* are terminated by an ASCII line feed character. In the examples that follow, a carriage return is indicated by <CR> and a line feed by <LF>.

Commands

ON — Turn On Laser

ON<CR>

The response to this command depends on whether or not the system is warmed up. Use the *?WARMUP%* query (see "Queries") to determine the progress of the warm-up cycle (see table below).

A response of "0" means the system is in Standby. If this is the case, issue an *ON* command to begin the temperature stabilization cycle. When the response to the *?WARMUP%* query reaches "100%", the laser can be started. Do not issue an *ON* command while the response to *?WARMUP%* is "1 to 99".

If the response to *?WARMUP%* is...	The response to *ON* is...
0	to begin diode temperature stabilization (approximately 2 minutes)
1 to 99	an execution error (the EXE_ERR bit in the status byte is set.)
100	the diode laser(s) turns on, and *Millennia Pro s* output ramps to the most recently set power

Note

When the laser turns on, it will be in the mode (power or RS-232) that was in effect when the laser was turned off.

OFF — Turn Off Laser

OFF<CR> Turns off the diode laser(s), but the SHG crystal oven remains on and its temperature stabilized for a quick warm-up time. Latched interlocks are cleared. The system enters Standby when the diode laser(s) has been turned off for more than the delay time set for Standby (see Setup menu).

P:x.xx — Set Power

Sets laser output power to the nearest hundredth of a Watt. The minimum setting is 0.05 W. The maximum is 10.50 W for the *Millennia Pro 10s*, 8.50 W for the *8s*, 6.05 W for the *6s*, or 5.20 W for the *5s*. Commands outside this range are ignored.

P:4.95<CR> Sets the laser output power to 4.95 W.

SHGOPT:x — Run SHG Optimization

SHGOPT:1<CR> Begins SHG optimization.

SHGOPT:0<CR> Abort SHG optimization.

SHUTTER:x — Open or Close the Shutter

SHUTTER:1<CR> Opens the shutter.

SHUTTER:0<CR> Closes the shutter.

STDBYDLY:xxx — Sets Standby Delay (in minutes)

This command sets the delay time from the last command that was received until the system goes into Standby. Standard values for xxx, in minutes, are:

0, 15, 30, 60, 120 and 240.

Variables entered not matching these values will be rounded to the next highest value.

STDBYDLY:0<CR> Never enter Standby.

STDBYDLY:45<CR> Rounded up to 60 minutes delay.

STDBYDLY:60<CR> 60 minutes delay.

Queries

?Cx — Get Diode Laser Operating Current Status

?C1<CR> Requests the current value in Amps for the diode laser (C1 indicates diode 1, C2 indicates diode 2). A typical response is "25.36A1<LF>," meaning 25.36 Amps for diode 1.

?EC — System Status Code Query

?EC<CR> Returns the same status code as that displayed on the *Millennia* Controller, if it is attached. Refer to the status code listing in Appendix A for explanations.

?H — History Buffer Query

?H<CR> Returns a 16-byte (16 code) status code list from the "history buffer" with the most recent status codes listed first.

?HSx— Get Heatsink Temperature

?HS1<CR> Requests the temperature of the heatsink for the specified diode module (1 or 2). The system returns a value in the form xx.xxCx, where C is degrees Celsius and the last x is a 1 or 2, depending on the diode module heatsink addressed.

?IDN — Get Identification String

?IDN<CR> Requests a system identification string. The system returns an ASCII string that consists of four fields: manufacturer, product, software revision number, and serial number (or "0" if the latter is not implemented). A typical return would be:

"Spectra Physics Lasers, Millennia PRO 5sJ, SN/Head/SN-PS, 0456-9100C <LF>"

?ONHRS — Get System Hours

?ONHRS<CR> Requests total time that the system has been run.

?OPTIMO — Get System Optimization Status

?OPTIMO<CR> Requests the status of system readiness for optimization. The system returns a 1 if the system is ready or a 0 if it needs more time for thermal stabilization.

?P — Get Power Status

?P<CR> Requests the value of the laser output power in Watts. A typical return would be "4.90 W<LF>".

?PCTOPT — Get SHG Percent Optimization Routine Status

?PCTOPT<CR> Requests system status of completion (in percent) of the optimization routine. The system responds with:
"0<LF>" if it is inactive (not running),
"xxx%<LF>" when it is xxx% completed, (e.g., 50%)
"–1<LF>" if the routine was aborted,
"–2<LF>" if the routine has timed out,
"–3<LF>" if the coarse search failed, or
"–4<LF>" if the fine search was exhausted.

?PSET — Last Power Command Query

?PSET<CR> Returns the value for the last power command set to the system ("P%"), not the actual laser output power. A typical response might be "0.20W<LF>".

?PSREV — Power supply Software Revision Query

?PSREV<CR> Returns a *Model J40* or *J80* power supply software revision number similar to "0456-9100C<LF>".

?RMREV — Controller Firmware Revision Query

?RMREV<CR> Returns the Controller firmware revision number. A typical response is "6.04<LF>".

?STDBYDLY — Get Standby Delay Status

?STDBYDLY<CR> Requests standby delay status. The system responds with "0<LF>" (which means "never enter Standby"), or "15, 30, 60, 120 or 240<LF>" for the present setting in minutes before entering Standby.

?SHGOPT — Get SHG Optimization Routine Status

?SHGOPT<CR> Requests the status of the SHG optimization routine (checks to see if it is running). The system responds "0<LF>" if it is not running and "1<LF>" if it is.

?SHGS — Get SHG Oven Status

?SHGS<CR> Requests the status of the SHG oven. The system responds "0S<LF>" if the temperature is settled, "1S<LF>" if the oven is heating, and "2S<LF>" if it is cooling. Values less than zero indicate an error (such as a broken wire or loose cable).

?SHUTTER — Get Shutter Status

?SHUTTER<CR> Requests the status of the shutter. The system responds "1<LF>" if the shutter is open and "0<LF>" if it is closed.

?SNn — Get Diode Module Serial Number

?SN1<CR> Returns the serial number as an ASCII number for diode pump module n, where n is 1 or 2.

?STB — Get Status Byte

This query requests a system status byte that indicates which command errors (if any) have occurred and whether the laser is on or off. The integer value returned represents the sum of the value of the bits in the status byte. The bit positions are defined in Table 6-2 on page 6-21. Each time a status byte is requested, its register is cleared so that a new status byte can be generated.

The status register accumulates the most recent commands and tracks their validity. Consider the following sequence of commands:

P:12<CR> Since the requested power is out of range, the EXE_ERR bit is set.

P:5<CR> Valid command, sets power to 5 Watts.

ON<CR> Valid command, turns on the diode laser(s).

?STB<CR> Reads and clears the status byte.

The status byte returned would be "194<LF>" since the ANY_ERR, LASER_ON, and EXE_ERR bits are set (194 = 2 + 64 + 128). Table 6-2 describes all the possible errors; Table 6-3 lists all the possible combinations.

?WARMUP% — Get Warm-up Status

?WARMUP%<CR> Reads the status of the system warm-up time as a percent of the predicted total time (see the table below). The system responds with a value similar to "050%<LF>." When the response is "100%<LF>," the laser can be turned on.

Note: an error condition, such as an open interlock, may not affect the *?WARMUP%* command. To check for other errors, request the status byte with the *?STB* query command.

System Status	?WARMUP%
Initial ac power-on warm-up.	Between 1% and 99%
System is ready to turn on the diode laser(s).	100%

System Status	?WARMUP%
System is in Standby.	0%
System is warming up after leaving Standby.	between 1% and 99%

Table 6-2: Query Errors

Binary Digits	Decimal Value	Name	Interpretation
0	1	CMD_ERR (CE)	Command error. Something was wrong with the command format, the command was not understood
1	2	EXE_ERR (EE)	Execution Error A command was properly formatted, but could not be executed. For example, a power command of "P:0<CR>" was sent, when the minimum allowed power is 0.2 Watts.
2	4	(reserved)	
3	8	SHGOPT_ACT	If set, the SHG optimization routine is active; if not set, it is inactive.
4	16	(reserved	
5	32	SYS_ERR (SE)	Any "system" error. (An open interlock, or an internal diagnostic)
6	64	LASER_ON (LO)	Indicates that laser emission is possible.
7	128	ANY_ERR (AE)	Any of the error bits are set.

Table 6-3: Possible Query Error Combinations

Binary Digits	Decimal Value	Errors Returned
0100 0000	64	LO
1000 0001	129	CE + AE
1000 0010	130	EE + AE
1000 0011	131	CE + EE + AE
1010 0000	160	SE + AE
1010 0001	161	CE + SE + AE
1010 0010	162	EE + SE + AE
1010 0011	163	CE + SE + EE + AE
1100 0001	193	CE + LO + AE
1100 0010	194	EE + LO + AE
1100 0011	195	CE + EE + LO + AE
1110 0000	224	SE + LO + AE
1110 0001	225	CE + SE + LO + AE
1110 0010	226	EE + SE + LO + AE
1110 0011	227	CE + EE + SE + LO + AE

This completes the operation section.

Chapter 7 Maintenance and Troubleshooting

The Spectra-Physics *Millennia® Pro s* is a *Class IV—High Power Laser* whose beam is, by definition, a safety and fire hazard. Take precautions to prevent accidental exposure to both direct and reflected beams. Diffuse as well as specular beam reflections can cause severe eye or skin damage. Always wear proper eye protection when working on the laser and follow the safety precautions in Chapter 2, "Laser Safety."

Maintenance

The *Millennia Pro s* laser head requires no routine maintenance. *There is no reason to remove the outer cover from the laser head; there are no user-serviceable parts inside the laser!* The cavity mirrors are permanently fixed in their optimum alignment at the factory using Spectra-Physics patented technology. Realigning the cavity optics in the field is not necessary; alignment at the factory is performed using special tooling.

To retain a clean intracavity environment, all components are cleaned to stringent standards prior to assembly and alignment at the factory. The inner cover of the laser is secured and sealed and should only be removed by an authorized service engineer in an environment specified for cleanliness, humidity, and temperature. *Removing the sealed cover in the field will compromise the cleanliness of the intracavity space, degrade laser performance, and void the warranty!*

Replacing the diode module in the power supply is not recommended except when performed by someone trained by Spectra-Physics. Call your Spectra-Physics service representative when you suspect a low power diode module or when its optical fiber is damaged, and the diode module needs replacement.

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 the mechanical parts immediately surrounding them.

Regular maintenance for the *Millennia Pro s-Series* is limited to replacing the air filter in the *Model J40* or *Model J80* power supply, as described below.

Cleaning the Air Filter

Periodically inspect the air filter that is located behind the right-hand grill on the power supply front panel. When operating in a dusty or open environment, it is prudent to check often. When the filter becomes dirty, clean it according to the procedure below.

An indication that the filter might be dirty is when the power supply displays a status code 101 on its LCD screen. This is a warning that the diode laser heatsink is approaching an over-temperature condition; it does not shut off the system at this time. (This condition can also be caused by lack of cool air flowing through the unit, i.e., either the room air entering the unit is too hot, there is not enough clearance to the front and rear panels to allow enough cool air to enter and leave the power supply, or the heatsink fan has failed.) If this condition goes unheeded, the heatsink will over-heat, a status code 105 will be issued and the system will shut down.

Procedure

Danger!

This procedure requires that the power supply be opened. There are high-voltage components inside that can shock and cause harm. Before opening the system, turn off ac line power to the unit and disconnect the power cord!

To clean the air filter:

1. Turn off power to the power supply and unplug the line cord.
2. Remove the four screws that hold the air entry grill in place (Figure 7-1) and remove the grill.

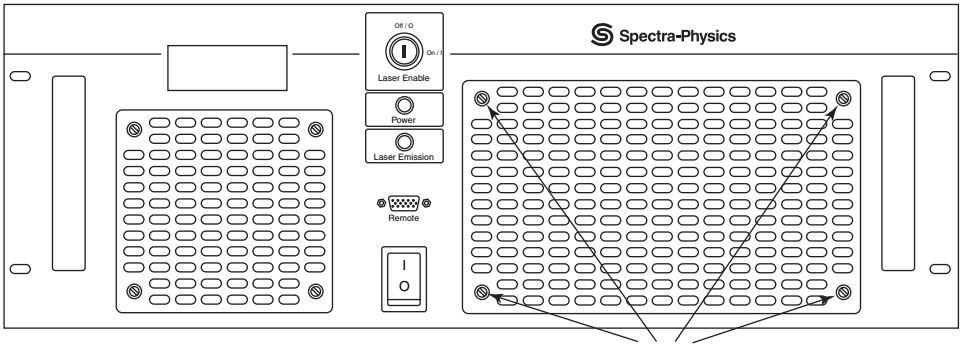


Figure 7-1: The *Model J40/J80* Air Filter Panel

3. Remove the air filter from the inside of the grill by pulling it off the hook and loop tape, then clean it by rinsing it with water and drying with a blower. Do not use solvents to clean the filter!

   In the event the filter becomes damaged due to repeated cleanings, or if cleaning is unsuccessful, replacement filters are available from Spectra-Physics. Refer to Table 7-1, "Replacement Parts," at the end of this chapter.

4. Before installing the filter, inspect it to confirm the cleaning process has been effective, that it has not been damaged and that it is fairly dry. Then install the clean or new filter by aligning it squarely over the hook and loop tape and pressing it into place.
5. Install the grill in the front panel using the 4 screws removed earlier.
6. Plug in the power cord and turn on the system as you would normally.

Troubleshooting

Service Training Programs

The *Millennia Pro s-Series* diode-pumped, solid state lasers are designed for hands-off operation. This product does not require alignment or routine cleaning of cavity optics. Service is generally limited to the power supply. All components in the power supply are replaceable. However, unauthorized repair may void the warranty.

Spectra-Physics offers service training programs to train personnel in the diagnosis of problems and the repair of the power supply. These training programs are tailored to suit the needs of the customer and can be conducted on-site or at our factory. For more information or to schedule a training program, contact your sales representative.

Troubleshooting Guide

This troubleshooting guide is for use by the user. It is provided to assist in isolating some of the problems that might arise while using the system. A complete repair procedure is beyond the scope of this manual. For information concerning the repair of this unit by Spectra-Physics, please call your local service representative. A list of world-wide service sites is included at the end of Chapter 8. Before calling, note the software revision number of your system. It can be found on the Info Menu by scrolling to the bottom of the list of specifications displayed on the screen.

Symptom: The Controller screen does not light up.

Possible Causes	Corrective Action
Power is not available to the system.	If the power supply fan is off: a. verify that the power cord is plugged in. b. verify that the power supply fuses are not blown.
Power supply has failed.	Call your Spectra-Physics service representative.

Symptom: Low power

Possible Causes	Corrective Action
The beam is clipped.	Call your Spectra-Physics service representative.
The SHG temperature is not adjusted correctly.	Adjust the SHG temperature for maximum output power - see “Setting the SHG Crystal Temperature” in Chapter 6. Then allow the unit to stabilize for 1 to 2 hours and, if necessary, adjust again. For long term stability, lower the SHG count in the Setup menu by about 5 to 10 counts.
Diode(s) may have degraded.	Call your Spectra-Physics service representative.

Symptom: Low power

The chiller is not turned on or there is poor or no water flow.	Verify that the chiller is turned on and its reservoir is full. Make sure all the water fittings are connected. Check the chiller's filter screen at the pump and clean it if necessary. Refer to the chiller manual.

Symptom: High optical noise

Possible Causes	Corrective Action
The SHG temperature is not adjusted correctly.	Adjust the SHG temperature for maximum output power - see "Setting the SHG Crystal Temperature" in Chapter 7. Then allow the unit to stabilize for 1 to 2 hours and, if necessary, adjust again. For long term stability, lower the SHG count in the Setup menu by about 5 to 10 counts.
The chiller is not turned on or there is poor or no water flow.	Verify that the chiller is turned on and its reservoir is full. Make sure all the water fittings are connected. Check the chiller's filter screen at the pump and clean it if necessary. Refer to the chiller manual.

Symptom: Bad mode

Possible Causes	Corrective Action
The SHG temperature is not adjusted correctly	Adjust the SHG temperature for maximum output power - see "Setting the SHG Crystal Temperature" in Chapter 7. Then allow the unit to stabilize for 1 to 2 hours and, if necessary, adjust again. For long term stability, lower the SHG count in the Setup menu by about 5 to 10 counts.
The beam is clipped.	Call your Spectra-Physics service representative.

Symptom: The *Millennia Pro s* shuts itself off in Power Mode.

Possible Causes	Corrective Action
The SHG temperature is not adjusted correctly.	Adjust the SHG temperature for maximum output power - see "Setting the SHG Crystal Temperature" in Chapter 7. Then allow the unit to stabilize for 1 to 2 hours and, if necessary, adjust again. For long term stability, lower the SHG count in the Setup menu by about 5 to 10 counts.
Incorrect pick-off calibration (power readout).	Call your Spectra-Physics service representative.

Symptom: The *Millennia Pro s* will not lase.

Possible Causes	Corrective Action
The shutter is not open.	Access the Setup menu and command the shutter to open.
The *Millennia Pro s* and power supply have not completed the turn-on sequence	The *Millennia Pro s* turn-on will take approximately 35 min. to complete from a cold start. Allow enough time for the turn-on sequence.
An interlock is either open or has been opened and closed.	An error message should be displayed on the *Millennia* Controller. Ensure that the LASER ENABLE key on the power supply is in the ON position. Verify that any switch connected to the INTERLOCK connector on the power supply is closed or that the jumper plug is in place. Verify that the ANALOG jumper plug is in place. Press the LASER POWER button once to clear the error, then restart the system as you would normally.

Symptom: Long-term stability/beam pointing is poor.

Possible Causes	Corrective Action

Symptom: Long-term stability/beam pointing is poor.	
The laser head is not properly mounted.	Review the “Laser Head Mounting Considerations” section in Chapter 5 and ensure that the laser head is mounted properly.
The routing mirrors are not installed correctly.	If routing mirrors are used as part of the beam delivery setup, ensure that they are assembled and locked down correctly.

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
Diode laser module assembly, new (for *J80* power supply)	PDMJ-M1030
Diode laser module assembly, new (for *J40* power supply)	PDMJ-M530-26
Controller, *Millennia*	TREM-C2-J1
Replacement Air Filters (package of 3 filters)	0129-9323S

Chapter 8 Customer Service

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.

Spectra-Physics maintains major service centers in the United States, Europe, and Japan. Additionally, there are field service offices in major United States cities. 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 the "Service Centers" listing located at the end of this section.

Order replacement parts directly from Spectra-Physics. For ordering or shipping instructions, or for assistance of any kind, contact your nearest sales office or service center. You will need your model and serial numbers available when you call. Service data or shipping instructions will be promptly supplied.

To order optional items or other system components, or for general sales assistance, dial **1 (800) SPL-LASER** in the United States, or **1 (650) 961-2550** 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 does not apply to any instrument or component not manufactured by Spectra-Physics. When products manufactured by others are included in Spectra-Physics equipment, the original manufacturer's warranty is extended to Spectra-Physics customers. When products manufactured by others are used in conjunction with Spectra-Physics equipment, this warranty is extended only to the equipment manufactured by Spectra-Physics.

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.

This warranty is valid for units purchased and used in the United States only. Products shipped outside the United States are subject to a warranty surcharge.

Returning the Instrument for Repair

Contact your nearest Spectra-Physics field sales office, service center, or local distributor for shipping instructions or an on-site service appointment. You are responsible for one-way shipment of the defective part or instrument to Spectra-Physics.

We encourage you to use the original packing boxes to secure instruments during shipment. If shipping boxes have been lost or destroyed, we recommend that you order new ones. Instruments can be returned only in Spectra-Physics containers.

Warning! 

Always drain the cooling water from the laser head before shipping. Water expands as it freezes and it can damage the laser. Even during warm spells or summer months, freezing may occur at high altitudes in the cargo hold of an aircraft. Such damage is excluded from warranty coverage.

To drain the laser head, turn off the laser system and chiller, then disconnect the laser head cooling lines from the chiller and allow the lines to drain into a bucket. Then use a shop vacuum or similar device to suck out any water that might remain in the laser head. Because the cooling system is designed to operate at less than 40 psi (275 kPa), *do not use a high-pressure air device to blow it out.* Doing so can dislodge water seals in the laser head and damage it. *Such damage is not covered under your warranty.*

To drain the chiller, place a tray below the drain valve, then remove the reservoir fill cap and open the drain valve to allow the reservoir to empty. Refer to the chiller user manual for detailed instructions on getting all the water out.

Service Centers

Benelux

Telephone: (31) 40 265 99 59

France

Telephone: (33) 1-69 18 63 10

Germany and Export Countries*

Spectra-Physics GmbH
Guerickeweg 7
D-64291 Darmstadt
Telephone: (49) 06151 708-0
Fax: (49) 06151 79102

Japan (East)

Spectra-Physics KK
East Regional Office
Daiwa-Nakameguro Building
4-6-1 Nakameguro
Meguro-ku, Tokyo 153
Telephone: (81) 3-3794-5511
Fax: (81) 3-3794-5510

Japan (West)

Spectra-Physics KK
West Regional Office
Nishi-honmachi Solar Building
3-1-43 Nishi-honmachi
Nishi-ku, Osaka 550-0005
Telephone: (81) 6-4390-6770
Fax: (81) 6-4390-2760
e-mail: niwamuro@splasers.co.jp

United Kingdom

Telephone: (44) 1442-258100

United States and Export Countries**

Spectra-Physics
1335 Terra Bella Avenue
Mountain View, CA 94043
Telephone: (800) 456-2552 (Service) or
(800) SPL-LASER (Sales) or
(800) 775-5273 (Sales) or
(650) 961-2550 (Operator)
Fax: (650) 964-3584
e-mail: service@spectra-physics.com
sales@spectra-physics.com
Internet: www.newport.com/lasers

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

Appendix A Status Codes

Listed below are all the status codes and messages that might be displayed while using the *Millennia® Pro s-Series* system. Most codes are self-explanatory and most errors can be corrected by the operator. In the event the error cannot be corrected or the action required to correct the error is not known, call your Spectra-Physics service representative. Before calling, write down the code and message, and the version number of the system software.

Code 0 to 126 are generated by the *Model J40* or *Model J80* power supply, codes 127 and up are generated by the *Millennia Pro s* laser head. Codes 142 to 147 are latched interlock messages that indicate the power supply shut off without a command to do so. These latched interlock messages are cleared by either:

a. pressing the LASER POWER switch on the Controller, or

b. sending the *OFF* command through the RS-232 port.

The Info menu HST line on the Controller lists the three most recent status codes with the most recent listed first. The RS-232 *?H* query reports the most recent 16 codes, again with the most recent listed first.

Table A-1: Status Codes, Firmware Version 0456-9100 rev B

Code (LCD Line 2)	LCD Line 3	LCD Line 4	Action
0	(in History buffer only)	(in History buffer only)	System OK
1	Laser ON	PowerMode OK	
2	Laser ON	CurrentMode OK	
3	Laser ON	PowerMode Adjust	
4	Laser ON	CurrentMode Adjust	
5	Laser Diodes OFF	Ready	Ready to turn on
8	Sleep Mode OK		Press power button
10	Low Flow	In Chiller	Check chiller function and settings
11	Low Level	In Chiller	Check chiller function and settings
25	Diode Temps.	At Setpoint	Call Spectra-Physics Service
54	ZModem Trans.	Failure	Check RS-232 cable
56	Watchdog expired	turn laser key	Cycle keyswitch on
58	Watchdog working	normally	
88	Diode Therm Short		Call Spectra-Physics Service
89	Diode Therm Open		Call Spectra-Physics Service

Table A-1: Status Codes, Firmware Version 0456-9100 rev B

Code (LCD Line 2)	LCD Line 3	LCD Line 4	Action
90	Diode MaxT Exceed		Call Spectra-Physics Service
91	Diode Over Temp.		Call Spectra-Physics Service
92	Diode Under Temp.		Call Spectra-Physics Service
100	Diode Temperature		Call Spectra-Physics Service
101	HSink Over Temp.		Call Spectra-Physics Service
102	HSink Under Temp.		Call Spectra-Physics Service
103	HSink Therm Short		Call Spectra-Physics Service
104	HSink Therm Open		Call Spectra-Physics Service
105	HSink MaxT Exceed		Call Spectra-Physics Service
116	Interlocks	Cleared	
117	Fuse Interlock		Check fuses and electrical service
118	System Interlock		Call Spectra-Physics Service
119	User Interlock		Check user installed safety switch or jumper plugs; cycle power off/on
120	Key Switch ILK		Cycle AC power and keyswitch off/on
121	Remote Interlock		Check jumper plugs; cycle power off/on
122	Head Interlock		Make sure laser head cover has not been loosened; call Spectra-Physics Service
123	Boot test	Fail	Call Spectra-Physics Service
124	Boot Test	In Progress	
131	Head Overtemp	Check Chiller	Check chiller and hoses; Call Spectra-Physics Service
141	Head Error, no comm.	Check IIC or cables	Check cable connections
149	Tower Temp	Too high	Check chiller and hoses; call Spectra-Physics Service
150	Diode EEPROM IIC	Check IIC or cables	Check cable connections
151	Main EEPROM IIC	Check IIC or cables	Check cable connections
152	Error Diode #1	Hours invalid	Call Spectra-Physics Service
153	Error Diode #2	Hours invalid	Call Spectra-Physics Service
201	Current Calib.	Diode 1	Call Spectra-Physics Service
202	Current Calib.	Diode 2	Call Spectra-Physics Service
205	Temp. Calib.	Diode 1	Call Spectra-Physics Service
206	Temp. Calib.	Diode 2	Call Spectra-Physics Service
209	SHG temperature	Setting	Verify doubling crystal temperature; run SHG Optimization routine

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 using your Spectra-Physics instrument or its manual—problems that did not require a formal call or letter to our service department, but that you feel should be remedied. We are always interested in improving our products and manuals, and we appreciate all suggestions.

Thank you.

From:

Name _____

Company or Institution _____

Department _____

Address _____

_____

Instrument Model Number _____ Serial Number _____

Problem: _____

_____

_____

_____

_____

Suggested Solution(s): _____

_____

_____

Mail To:

Spectra-Physics, Inc.
Quality Manager
1330 Terra Bella Avenue, M/S 15-50
Post Office Box 7013
Mountain View, CA 94039-7013
U.S.A.

E-mail: sales@spectra-physics.com
www.newport.com/lasers

FAX to:

Attention: Quality Manager
(650) 961-7101