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BeamLok™ 2060 and 2080

Ion Lasers

User's Manual

Spectra-Physics

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Table of Contents

Preface iii

Warning Conventions xi

Standard Units xiii

Unpacking and Inspection xv

System Components xv
Accessory Kit xv

Chapter 1: Introduction 1-1

Emission and Absorption of Light* 1-1
Population Inversion 1-2
Argon as an Excitation Medium 1-4
Resonant Optical Cavity 1-7
Resonator Structural Considerations 1-9
Conclusion 1-11
System Description 1-12
BeamLok Laser Head 1-12
Model 2580 Power Supply 1-13
Model 2470 Remote Control 1-13
Model 2474 BeamLok Remote Control 1-13
BeamLok Argon Specifications 1-14
BeamLok Model 2080 Krypton Specifications 1-16
BeamLok Outline Drawings 1-19
BeamLok Options 1-20
BeamLok Optics 1-20
Patents 1-22

Chapter 2: Laser Safety 2-1

Precautions for the Safe Operation of Class IV–High Power Lasers 2-1
Maintenance Necessary to Keep these Laser Products in Compliance with Center for Devices and Radiological Health (CDRH) Regulations 2-3
CDRH Requirements for a Custom Remote Control or for Operation with the Model 2680 Computer Interface Board 2-3
Laser Head and Power Supply Cover Interlocks 2-4
Laser Head 2-4
Power Supply 2-5
Operation with the Prism Cover Off 2-6
CE/CDRH BeamLok 2060 Radiation Control Drawing 2-7

CE/CDRH BeamLok 2080 Radiation Control Drawing 2-8
EC Declaration of Conformity 2-9
Sources for Additional Information 2-10
Laser Safety Standards 2-10
Equipment and Training 2-10

Chapter 3: Installation 3-1

Power Supply Connectors and Indicators 3-1
Laser Head Controls and Indicators 3-3
Gas Autofill System 3-4
Intracavity Shutter 3-4
Laser Head Hatch 3-5
Electrical Connections 3-6
Connecting to Electrical Service 3-6
Connecting the Laser Head Umbilical to the Power Supply 3-7
Operation in Deep UV (275 – 306 nm)—BeamLok 2080 ONLY 3-7
Control Connections 3-8
Installing the Model 2470 Remote Control Module 3-8
Installing the Computer Interface Cable 3-8
Water Connections 3-10
Closed-Loop Cooling Systems 3-11
Laser Head Inspection 3-11
Adjusting the Height of the Laser Head 3-11
Water Testing the System 3-11

Chapter 4: Operation 4-1

Starting the Laser 4-1
First Time Start-Up 4-1
Daily Start-Up Procedure 4-2
Adjusting for Maximum Output Power 4-2
Wavelength Selection 4-3
Prism 4-3
Wavelength-Selective Mirrors 4-3
Adjusting the Aperture for TEM_{00} Output 4-4
Changing Optics 4-6
Changing the Output Coupler and High Reflector 4-6
Changing to a Prism 4-7
Etalons 4-8
Shutdown Procedure 4-8

Chapter 5: Model 2470 Remote Control Module 5-1

Model 2470 Remote Control Module Controls and Indicators 5-2
Interlock STATUS Indicators 5-2
FILL Indicator 5-3
EMISSION Indicator 5-4
Key and REMOTE/COMPUTER Switches 5-4
METER Function Switch 5-4

MODE Switch and Control Knobs 5-4
RANGE Switch 5-5
Internal DIP Switch Settings 5-6
Setting SW_1 Defaults 5-6
Changing the Settings on SW_1 5-7

Chapter 6: BeamLok™ 6-1

Operation 6-1
Remote Control Module 6-2
Power-Up Mode Selection 6-3
Aligning the BeamLok Position Detector 6-3

Chapter 7: Model 2680 Computer Interface 7-1

Functional Overview 7-1
Computer Control and Diagnostic Functions 7-1
Power Supply Connectors 7-2
Commands 7-2
Command Set Summary 7-3
Sample Program Listings 7-4
Status Commands 7-4
Control Commands 7-7
Power Supply "On" Default Condition 7-8
Initializing the Interface 7-8
IEEE 488 Interface 7-9
Operation 7-9
Remote Reset 7-9
Serial Poll Status Byte 7-10
SW_2 DIP Switch Setting 7-11
RS-232-C Interface 7-12
Operation 7-12
Data Transfer and Handshaking 7-13
SW_1 DIP Switch Setting 7-13
SW_3 DIP Switch Setting 7-14
Message Formats 7-15
Command Format 7-15
Response Format 7-16

Chapter 8: Maintenance 8-1

Notes on the Cleaning of Laser Optics 8-1
Equipment Required 8-2
Cleaning Solutions Required 8-3
General Procedures for Cleaning Optics 8-3
Cleaning Mirrors 8-5
Cleaning the Prism Assembly 8-5
Cleaning Plasma Tube Windows 8-8
Cleaning the BeamLok Beam Splitter and Routing Mirror 8-10
Replacing the Water Filter 8-11

Cleaning the Power Supply Water Filter Screen 8-11

Chapter 9: Service and Repair 9-1

Vertical Search Alignment Procedure 9-2
Mirror Alignment 9-3
Adjusting the Mirrors for Apparent Maximum Power 9-3
"Walking the Mirrors" to Assure Maximum Power 9-4
Plasma Tube Alignment 9-5
Bore Alignment 9-5
Aligning on the Aperture 9-7
Locking Down the Magnet 9-8
Troubleshooting 9-8

Chapter 10: Customer Service 10-1

Warranty 10-1
Warranty Return Procedure 10-2
Service Centers 10-3

Appendix A: Sample BASIC Programs A-1

Examples.bas A-1
Laser.bas A-4

List of Figures

Figure 1-1: Electrons occupy distinct orbitals 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. 1-2
Figure 1-2: A typical four-level laser transition scheme (a) compared to that of visible argon (b). One electron collision ionizes neutral argon, and a second pumps the ion to an excited state. 1-3
Figure 1-3: Energy Levels of the 4p–4s Argon Ion Laser Transitions 1-5
Figure 1-4: Relative output power behavior of singly and doubly ionized argon transitions 1-6
Figure 1-5: Frequency Distribution of Longitudinal Modes for a Single Line 1-8
Figure 1-6: Etalon Loss Minimum Tuned to Laser Gain Maximum 1-9
Figure 1-7: The relationship of resonator structural members affects the stability of laser output. ... 1-10
Figure 1-8: Lengthening the radius of curvature of the output coupler enhances output by increasing the mode volume of the cavity. 1-11
Figure 1-9: Using a high reflector with negative radius in an actively stabilized system increases the mode volume of the cavity, decreases divergence, and increases beam size. 1-12
Figure 2-1: These standard safety warning labels would be appropriate for use as entry warning signs (ANSI 4.3.10.1). 2-2
Figure 2-2: Folded Metal Beam Target 2-2
Figure 2-3: Laser Head Safety Interlock Key 2-5
Figure 2-4: Power Supply Safety Interlock Switch 2-5
Figure 2-5: A portion of the intracavity beam is reflected upward from each face of the prism. 2-6
Figure 2-6: BeamLok 2060/65 Radiation Control Drawing 2-7
Figure 2-7: BeamLok 2080/85 Radiation Control Drawing 2-8
Figure 3-1: Model 2580 Power Supply Connector Panel 3-1

Figure 3-2: BeamLok 2060 and 2080 Laser Head Control Panel 3-3
Figure 3-3: Laser Head Interior (Output End) 3-5
Figure 3-4: Model 2580 Power Supply and Electrical Connections 3-7
Figure 4-1: Transverse Modes 4-5
Figure 4-2: Removing the Output Coupler 4-7
Figure 4-3: BeamLok 2060 and 2080 Optics Assemblies 4-8
Figure 5-1: Model 2470 Remote Control Module 5-1
Figure 5-2: Model 2470 Remote Control Indicators and Ranges 5-2
Figure 6-1: BeamLok detects changes in beam position and adjusts the output coupler to compensate. 6-1
Figure 6-2: Model 2474 BeamLok Remote Control Module 6-2
Figure 6-3: DIP Switch S_2 determines the default status of BeamLok. 6-3
Figure 6-4: BeamLok Module. 6-4
Figure 6-5: The BeamLok assembly shown open. 6-5
Figure 7-1: Model 2580 Power Supply Connector Panel 7-2
Figure 7-2: Diagram of the serial poll status byte indicating the function of each bit. 7-10
Figure 7-3: Model 2680 Computer Interface PC Board 7-12
Figure 7-4: Standard RS-232-C Interconnections 7-13
Figure 8-1: Cleaning the Mirror Surface 8-3
Figure 8-2: Lens Tissue Folded for Cleaning 8-4
Figure 8-3: BeamLok 2060 and 2080 Single-line Prism Assemblies 8-6
Figure 8-4: A portion of the intracavity beam is reflected upward from each face of the prism. 8-7
Figure 8-5: Plasma Tube Endbell Showing Shroud 8-9
Figure 8-6: BeamLok Module. 8-10
Figure 9-1: Schematic Representation of Ideal Resonator Alignment 9-1
Figure 9-2: Vertical Search Technique 9-3
Figure 9-3: Misaligned Mirrors Allow Lasing at Reduced Power 9-4
Figure 9-4: Misaligned Plasma Tube Allows Lasing at Reduced Power 9-5
Figure 9-5: Plasma Tube Alignment Adjustments—Cathode End 9-6

List of Tables

Table 3-1: BeamLok 2060and 2080 Cooling Water Requirements 3-10
Table 5-1: SW_1 DIP Switch Function Settings 5-6
Table 5-2: Remote Connector Pin Assignments 5-8
Table 6-1: BeamLok DIP Switch S_2 Functions 6-3
Table 7-1: SAMPLE a 7-5
Table 7-2: BeamLok Display 7-5
Table 7-3: "SAMPLE 8" Decimal to Power Range and BeamLok Status Conversion 7-5
Table 7-4: READ 4 7-6
Table 7-5: READ 5 7-6
Table 7-6: SET 2, n 7-7
Table 7-7: WRITE 6, n 7-7
Table 7-8: WRITE 7, n 7-8
Table 7-9: SW_2 DP Switch Settings for Selecting Device Address 7-11
Table 7-10: SW_1 Baud Rate Settings 7-14
Table 7-11: SW_1 Mode Select Settings 7-14
Table 7-12: CI Command Abbreviations 7-16
Table 9-1: Troubleshooting 9-9
Table 9-2: Replacement Parts 9-9

Preface

This manual contains information needed for day-to-day operation and maintenance of both the BeamLok™ 2060 and BeamLok 2080 laser systems. Most of the information is common to both systems; anything unique to one system is clearly indicated as such. Instructions for installing, operating, maintaining, and troubleshooting your system are included, as well as a list of replacement parts.

The BeamLok 2060 and 2080 lasers emit laser radiation that can permanently damage eyes and skin. The "Laser Safety" section contains information about these hazards and offers suggestions on how to safeguard against them. To minimize the risk of injury or expensive repairs, carefully follow these instructions.

While this manual contains a brief installation procedure, it is not intended as a guide to the initial installation and alignment of your laser. Please wait for the Spectra-Physics Lasers service engineer who has been assigned this task as part of your purchase agreement. Allow only those qualified and authorized by Spectra-Physics Lasers to install and set up your laser system.

The "Maintenance" section contains information you need to keep your laser clean and operational on a day-to-day basis, where-as "Service and Repair" is intended to help you guide your Spectra-Physics Lasers 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 Lasers for warranty repair.

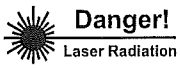
This product has been tested and found to conform to "Directive 89/336/EEC for Electromagnetic Compatibility." Class A compliance was demonstrated for "EN 50081-2:1993 Emissions" and "EN 50082-1:1992 Immunity" as listed in the official *Journal of the European Communities*. Refer to the "EC Declaration of Conformity" in Chapter 2.

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

Thank you for your purchase of Spectra-Physics Lasers instruments.

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.

Danger! 

Conditions or action may cause injury or present a hazard to personal safety.

Warning! 

Condition or action may cause damage to equipment.

Caution! 

Condition or action may cause poor performance or error.

Note 

Text describes exceptional circumstances or makes a special reference.

Don't Touch! 

Do not touch.

Eyewear Required 

Appropriate laser safety eyewear should be worn during this operation.

Standard Units

The following standard units, abbreviations, and prefixes are used in Spectra-Physics Lasers manuals:

Quantity	Unit	Abbreviation
angle	radian	rad
area	square meter	m^2
capacitance	farad	F
electric charge	coulomb	C
electric current	ampere	A
electric potential	volt	V
energy	joule	J
force	newton	N
frequency	hertz	Hz
inductance	henry	H
length	meter	m
luminous intensity	candela	cd
magnetic flux	weber	Wb
magnetic flux density	tesla	T
mass	gram	g
power	watt	W
pressure	pascal	Pa
resistance	ohm	Ω
temperature	kelvin	K
time	second	s
volume	cubic meter	m^3

Prefixes

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

Unpacking and Inspection

Your laser was packed with great care and its containers inspected prior to shipment. It left Spectra-Physics Lasers in good condition. Upon receiving your laser, immediately inspect the outside of the shipping containers. If there is any major damage (holes in the containers or cracked wooden frame members), insist that a representative of the carrier be present when you unpack the contents.

Carefully inspect your laser as you unpack it. If you notice any damage, such as dents or scratches on the cover, or broken knobs, immediately notify the carrier and your Spectra-Physics Lasers sales representative.

Keep the shipping containers. If you file a damage claim, you may need the containers to demonstrate that the damage occurred as a result of shipping. If you need to return the laser for service, these specially designed crates assure adequate protection.

Warning! 

Spectra-Physics Lasers considers itself responsible for the safety, reliability, and performance of the BeamLok ion laser system only under the following conditions:

- All field installable options, modifications, or repairs are performed by persons trained and authorized by Spectra-Physics Lasers.
- The equipment is used in accordance with the instructions provided in this manual.

System Components

- BeamLok laser head
- Model 2580 power supply with optional Model 2680 computer interface (if ordered)
- Model 2670 remote control

Accessory Kit

Included with the laser system is this manual, a packing slip listing all the components shipped with this order, and an accessory kit containing the following items:

- two hoses (cooling system water supply and return lines)

- a water filter with two extra filter cartridges
- plumbing fittings for connecting the water filter (provided) into the system supply line
- a tool kit containing various Allen wrenches and drivers for aligning and maintaining your laser
- a plastic hemostat
- a packet of Kodak Lens Cleaning Paper™
- an optional prism assembly (if ordered with the system)
- keys (2) for the Model 2670 remote control
- 80 A fuses (3) for the power supply
- various small, medium-current fuses (8) for the power supply
- interlock defeat keys (2) for the laser head cover interlock
- a set of table clamps
- any optional optics assemblies that were ordered

You will need to supply several items, including:

- spectrophotometric-grade (HPLC) acetone and methanol for optics cleaning
- clean, lint-free finger cots or powder-less latex gloves for optics cleaning

Chapter 1 Introduction

Emission and Absorption of Light*

Laser is an acronym derived from Light Amplification by Stimulated Emission of Radiation. Thermal radiators, such as the sun, scatter 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, direction, and amplitude, it is unique among light sources. Its output beam is singularly directional, intense, 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 1-1). The energy of an electron is determined by the orbital that it occupies, and the over-all energy of an atom—its energy level—depends on the distribution of 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 excited states. If an atom is in its ground state, it will stay there until it is excited by an external energy source.

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 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.,

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

where h is Planck's constant, and υ is the frequency of the photon.

* *"Light" will be used to describe the portion of the electromagnetic spectrum from far infrared (ir) to ultraviolet (uv).*

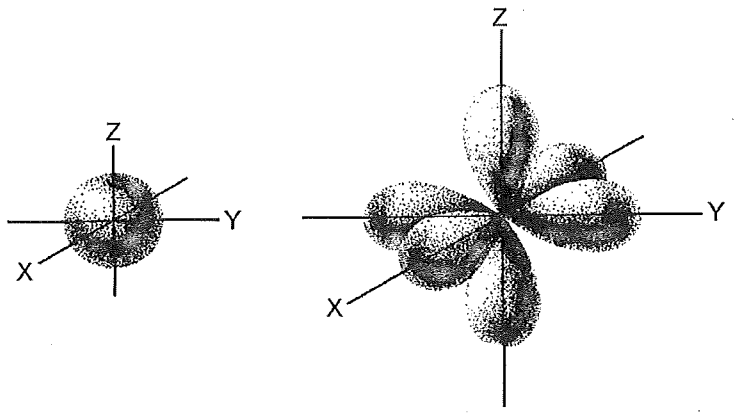


Figure 1-1: Electrons occupy distinct orbitals defined by the probability of finding an electron at a given position, the shape of the orbital being determined by the radial and angular dependence of the probability.

Likewise, when an atom excited to E_2 decays to E_1, it loses energy equal to $E_2 - E_1$. Because its tendency is toward the lower energy state, the atom may decay spontaneously, emitting a photon with energy $h\upsilon$ and frequency υ equal to:

$$\upsilon = (E_2 - E_1)/h \qquad [2]$$

Spontaneous decay can also occur without emission of a photon, the lost energy taking another form, e.g., the 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 υ, thereby shedding energy in the form of an additional photon that is identical to the incident one in phase, frequency, and direction. 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 absorption coefficient 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." It can also be shown that the transition cross section is the same regardless of direction. Therefore, 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, a Boltzmann distribution of its atoms over the array of available energy levels exists with nearly all 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 υ is supplied, the populations can be shifted until $N_2 = N_1$. Under these conditions the rates of absorption and stimulated emission are equal, and the absorption coefficient at frequency υ 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 exist, and if their relationship satisfies certain requirements described below, additional excitation can create a population inversion, in which $N_2 > N_1$.

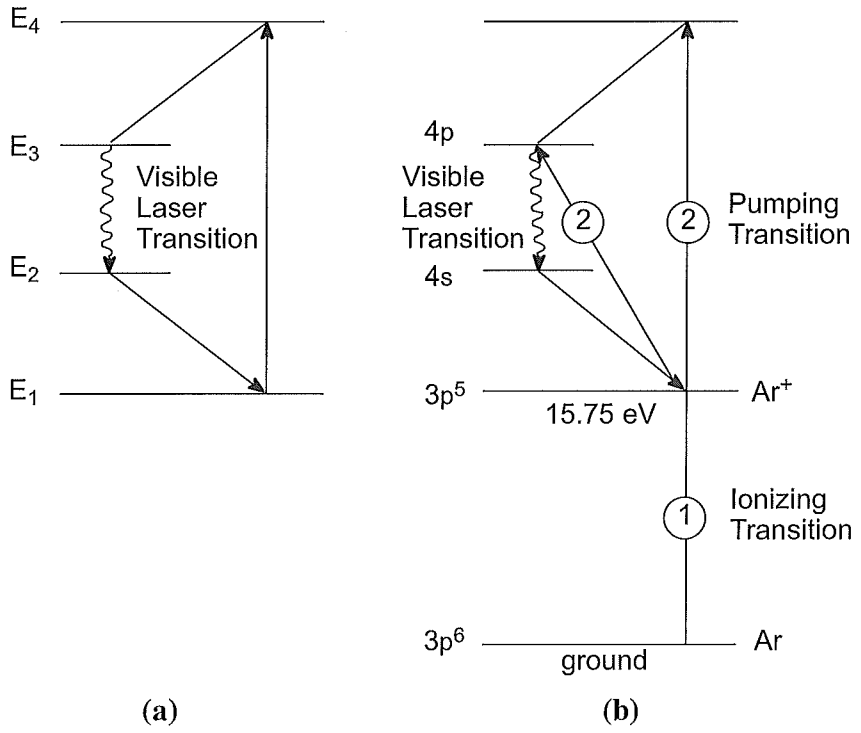


Figure 1-2: A typical four-level laser transition scheme (a) compared to that of visible argon (b). One electron collision ionizes neutral argon, and a second pumps the ion to an excited state.

A model four-level laser transition scheme is depicted in Figure 1-2 (a). A photon of frequency υ_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 E_4 is unstable, the atom will decay almost immediately to E_3. If atoms that

occupy E_3 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 υ_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 υ_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 υ_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.

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

In commercial laser designs the source of excitation energy is usually optical or electrical: arc lamps are often employed to pump solid-state lasers; the output of one laser can be used to pump another, e.g., a liquid dye laser is often pumped by an ion laser; and an electric discharge is generally used to excite gaseous media like argon or krypton.

Argon as an Excitation Medium

The properties of argon are probably the best understood of all the ionized gas laser media. Its transition scheme is compared to the model in Figure 1-2 (b), and its visible energy level diagram is depicted in Figure 1-3. The neutral atom is pumped to the 4p energy level—the origin of the lasing transition—by two collisions with electrons. The first ionizes the atom, and the second excites the ion from its ground state (E_1) either directly to the 4p energy level (E_3) or to E_4, from which it cascades almost immediately to 4p. The 4p ions will eventually decay to 4s (E_2), emitting a photon either spontaneously or when stimulated to do so by a photon of equivalent energy. The wavelength of the photon depends on the specific energy levels involved, but it will be between 400 and 600 nm. The ion decays spontaneously from 4s to the ionic ground state, emitting a photon in the vacuum ultraviolet (uv)—about 74 nm—as it leaves the lower level of the lasing transition.

The population in the ionic ground state at any given time is small. Recombination processes return ions to the neutral atom energy level scheme; therefore, there is no tendency toward a self-absorption "bottleneck," a population buildup in the lower laser levels.

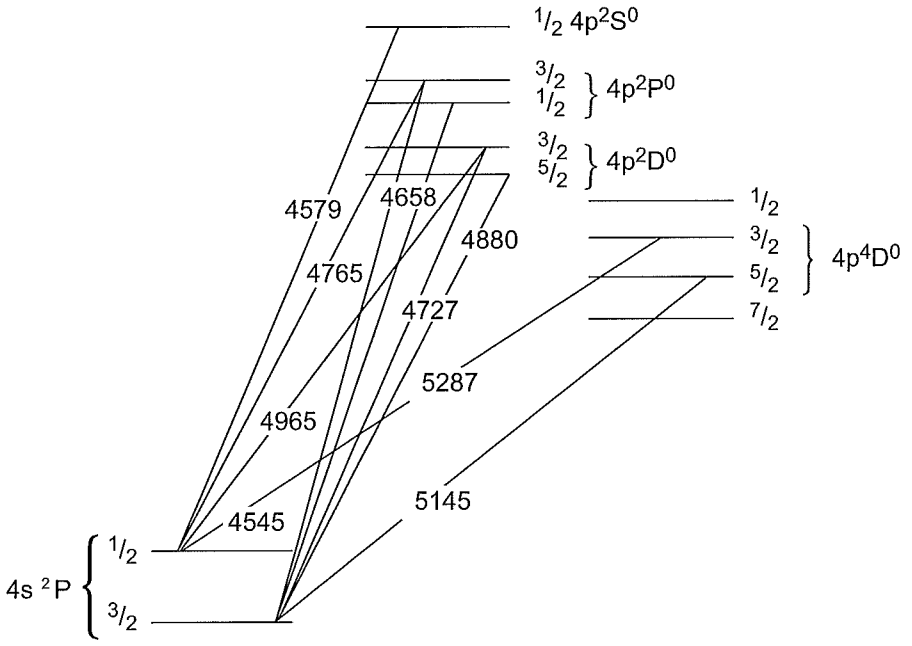


Figure 1-3: Energy Levels of the 4p–4s Argon Ion Laser Transitions

The existence of a limited number of lower states for a large number of visible laser transitions suggests that strong competition between lines with common lower levels may exist. Such competition would manifest itself as improved performance for a given line during single-line operation, compared to its strength when all lines are present. Although competition exists, its effect is minor, and single-line operation improves the power of principal lines by less than 10%. Therefore, the use of a prism or other dispersing element in continuous-wave argon ion lasers is not necessarily advantageous, except in single-line applications.

Ion laser gain is directly affected by several factors including discharge current density, magnetic field, and gas pressure. Since two collisions with free electrons are required to pump an argon atom to the upper level of visible lasing transitions, the gain of the medium varies as the square of the current density. Below saturation, the multimode, all-lines output of an ion laser can be expressed as

$$P = kJ^2V \qquad [3]$$

where P is the output power, J is the current density (A/cm^2), V is the volume of the active medium, and k is a constant.

Visible output saturates at a current density of about 800 A/cm^2, while uv transitions require even higher current densities (see Figure 1-4). Uv radiation is a product of transitions between excited states of doubly ionized argon (Ar^{2+}), the ground state of which is about 43 eV above that of the neutral atom. By comparison, the ground state of singly ionized argon (Ar^{+}) is only about 16 eV above the neutral atom ground state. So two electron collisions, or a single collision with an extremely energetic electron, are required to move between the Ar^{+} and Ar^{2+} ground states. If the current density exceeds the saturation point of visible transitions the additional energy drives argon ions to the doubly ionized state: uv output appears to rise exponentially with current density to a point beyond the design limit of available exciters.

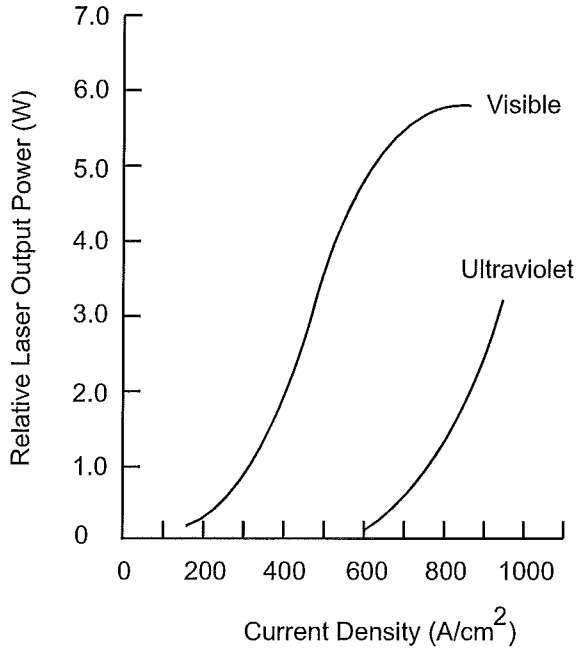


Figure 1-4: Relative output power behavior of singly and doubly ionized argon transitions

A magnetic field enveloping the plasma discharge enhances the population inversion. It tends to force free electrons toward the center of the plasma tube bore, thus increasing the probability of a pumping collision. Unfortunately, the magnetic field also causes Zeeman splitting of the laser lines, which elliptically polarizes the output, causing partial loss at the polarization-sensitive plasma tube windows. Susceptibility to the Zeeman effect varies from line to line, and each has an optimum magnetic field strength.

Ion laser gain is also strongly dependent on gas pressure. For example, argon uv output is highest at low pressure. Reducing the number of argon atoms increases the time between collisions with free electrons, which increases the average electron energy. This creates conditions favorable to the high energy collisions required to excite argon ions to the Ar^{2+} ground state. Other lines respond better at higher pressures. For optimum performance, gas pressure should be uniform along the length of the discharge region. The pressure-balanced design of the Spectra-Physics Lasers plasma tube allows this to happen.

Resonant Optical Cavity

A resonant optical cavity, which is defined by two mirrors, provides feedback to the active medium. Photons that are emitted parallel to the cavity axis are reflected, returning to interact with other excited ions. Stimulated emission produces two photons of equal energy, phase, and direction from each interaction. The two become four, four become eight, and the numbers continue to increase geometrically until an equilibrium between excitation and emission is reached.

Both 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 that is stored within the cavity, and the escaping radiation becomes the output beam of the laser.

For broadband—or "all-lines"—operation, the mirrors reflect a number of lines within a limited wavelength range (about 70 nm maximum). Several sets of broadband optics are available to cover different groups of laser lines.

Adding a prism to the cavity limits oscillation to a single line. The dispersion of the prism allows only one line to be perfectly aligned with the high reflector, so the tilt of the prism determines which line will oscillate.

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 the gain of each frequency and measuring the width of the curve where the gain has fallen to one-half maximum (full width at half maximum, see Figure 1-5).

Line broadening depends on the relative velocities of the excited ions as they radiate. If the ion is stationary at the time of stimulated emission, the product photons will possess exactly the transition frequency. If the ion is moving toward the stimulating photon, the resultant frequency will be higher than that of the transition; likewise, if the ion is moving away, the frequency will be lower.

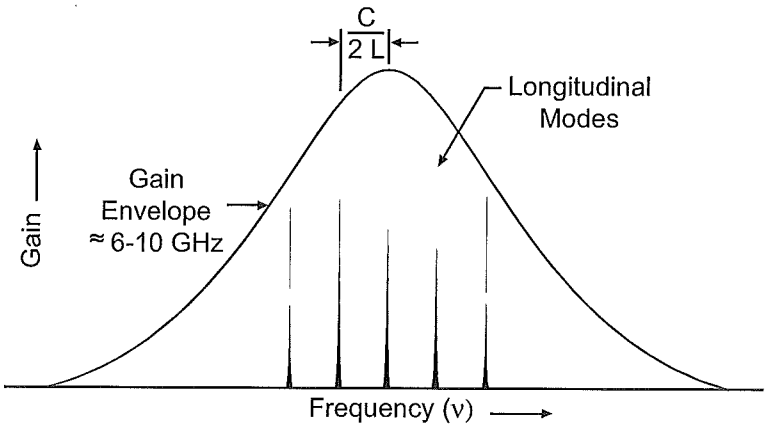


Figure 1-5: Frequency Distribution of Longitudinal Modes for a Single Line

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

$$\upsilon_m = mc/2L \qquad [4]$$

will oscillate, where υ_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"— spaced such that

$$\Delta\upsilon = c/2L \qquad [5]$$

An etalon, which is a frequency-selecting element, must be inserted in the cavity in order to promote the lasing of a single longitudinal mode. Spectra-Physics Lasers utilizes an optional Fabry-Perot interferometer that acts as a bandpass filter and introduces enough loss in all other modes to prevent them from reaching the lasing threshold (Figure 1-6). The coherence length—the distance over which the output beam maintains a fixed phase relationship—is inversely proportional to the linewidth:

$$l_c = c/\Delta\upsilon \qquad [6]$$

When the laser output is changed from single line to single frequency, the coherence length increases enormously. If the linewidth is reduced from 6 GHz (single line) to about 3 MHz (single frequency), the coherence length increases from 50 mm to 20 m.

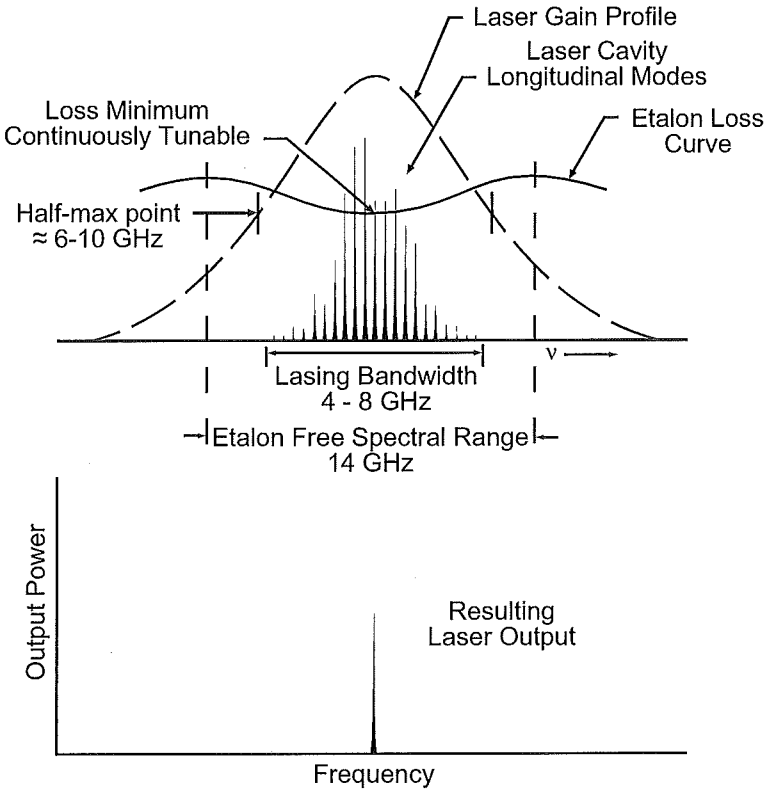


Figure 1-6: Etalon Loss Minimum Tuned to Laser Gain Maximum

Resonator Structural Considerations

The stability of the oscillating frequency depends on the design of the resonator structure. Small changes in cavity length, which have several sources including temperature changes and mechanical shifts, will cause corresponding changes in the resonant frequency.

Cavity length changes due to temperature can be expressed as

$$\Delta L = \alpha L \Delta T \qquad [7]$$

where L is the cavity length, α is the thermal expansion coefficient of the resonator structure, and ΔT is the temperature change. In order to eliminate frequency drift either α or ΔT must be zero. The choice of materials affects the length stability of the structure. The ideal material has both a low thermal expansion coefficient and a high ability to distribute heat evenly, causing a low ΔT along the length of the structure.

Frequency stability also depends on the mechanical rigidity of the resonator structure. Modulation due to *jitter*, the microphonic movement of cavity mirrors, can be caused by the flow of the cooling water, external shock to the resonator structure, and acoustic noise. Isolation of the resonator from both the plasma tube, through which the cooling water flows, and the case that surrounds the laser, the source of other vibrations, helps reduce jitter.

The mechanical design of the structure also contributes to jitter-free operation. The most stable configuration is an arrangement of three resonator members in an equilateral triangle (Figure 1-7). As one of the angles increases, the resistance to flexure, in a plane represented by the longest side of the triangle, is reduced. The extreme case, in which all three members lie in the same plane, is the least rigid, its strength coming only from the members themselves. The BeamLok™ 2060 and 2080 resonators approach the ideal equilateral triangle. The graphite rods are enveloped in low-expansion steel tubes to strengthen the structure and for increased resistance to flexure. This design results in inherent mechanical stability that provides stable power and beam pointing performance.

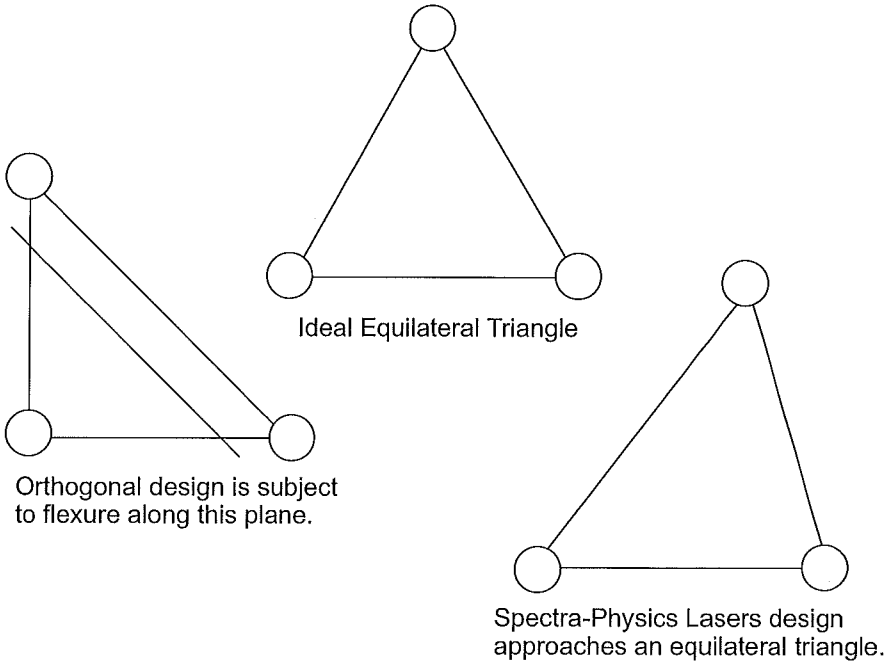


Figure 1-7: The relationship of resonator structural members affects the stability of laser output.

Conclusion

Several factors influence ion laser output. The optical power can be calculated from

$$P0 = TAI_s \left(\frac{2\alpha_0 L}{T + \beta} - 1 \right) \quad [8]$$

where T is the output coupler transmission, A is the cross-sectional area of the beam, I_s is a saturation parameter, α_0 is the small signal gain, L is the gain length, and β is the sum of all cavity losses.

The transmission of the output coupler should be the greatest of the cavity losses: it should be greater than the sum of all others. Ideally β, which is caused by unwanted absorption, reflection, diffraction, and transmission, should be zero. Cleanliness of plasma tube processing operations, which eliminates contaminants that can find their way to the inside surfaces of the windows, is essential to improved ion laser output. Cleanliness of other cavity elements, including both mirrors and the outside window surfaces, is also very important. A sealed cavity with an intracavity passive catalyst contributes to overall performance by keeping these surfaces clean.

The cross-sectional area, and therefore the volume of the gain region, can be increased by enlarging the bore and using a long radius output coupler (Figure 1-8). The use of long-radius optics requires an extremely rigid resonator structure. Increasing the mode volume of the cavity while maintaining a constant current density increases the laser output power.

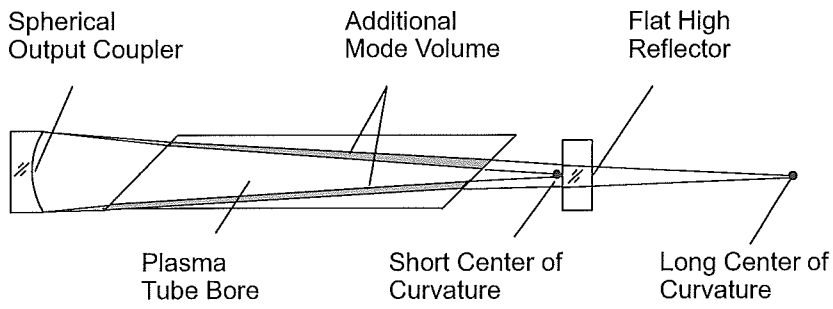


Figure 1-8: Lengthening the radius of curvature of the output coupler enhances output by increasing the mode volume of the cavity.

With its advanced plasma tube design, high-field magnet, actively stabilized output, thermally compensated graphite composite resonator, and high-current power supply, the BeamLok 2060/2080 is a system that delivers visible and uv output to match the most exacting standards.

System Description

The BeamLok™ ion laser system consists of a BeamLok laser head, plasma tube, Model 2580 power supply, Model 2470 system remote control module, and a Model 2474 BeamLok remote control module. These components make up a laser system that is extremely reliable and convenient to use.

BeamLok Laser Head

The BeamLok laser head comprises a mechanical resonator, the plasma tube, the magnet, and the BeamLok beam-positioning module. The three-bar resonator is temperature compensated, extremely rigid, and stable. The resonator and plasma tube combine to provide excellent beam pointing characteristics. To this we add the BeamLok beam pointing module for an output beam of outstanding power and pointing stability.

BeamLok is an active beam positioning system. When engaged, the output beam of the laser is locked onto a fixed reference point beyond the cavity. When the beam moves, the output mirror responds to restore position. BeamLok consists of a mirror actuator, detector, system electronics, and a Model 2474 BeamLok remote module.

The Spectra-Physics Lasers BeamLok™ 2060 and 2080 ion lasers represent another major step in the evolution of laser technology. By incorporating an actively stabilized output, it is able to use a negative radius high reflector to further increase the mode volume of the cavity, and again increase output power (Figure 1-9).

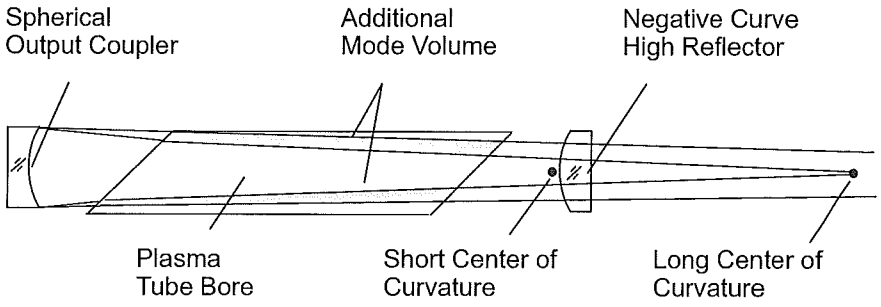


Figure 1-9: Using a high reflector with negative radius in an actively stabilized system increases the mode volume of the cavity, decreases divergence, and increases beam size.

The plasma tube incorporates the latest in cold-disc metal-ceramic technology and patented Q-M Endbells™ to prolong tube lifetime by eliminating internal window contamination. Q-M Endbells employs a patented window coating to protect the window from long-term uv radiation damage, and a modified optical contact bond to seal the window to the endbell assembly. This essentially eliminates residual contamination inherent in traditional "hard seal" bonding agents.

An automatic gas fill system keeps the tube filled to optimum pressure. This system can be disabled for short-term processes that cannot be interrupted; however, a safety override feature prevents tube damage by maintaining a minimum threshold fill value. Internal pressure equalization and clean room assembly mean the tube will provide long and trouble-free service.

The BeamLok lasers do not require an intracavity purge. Instead, an intracavity passive catalyst inside each cavity seal minimizes the build-up of contaminating ozone (O_3) by converting it to molecules of harmless oxygen (O_2). This eliminates the requirement for a gas supply, filters, driers, etc.

Model 2580 Power Supply

The Model 2580 power supply is compact and convenient to use. Patented switched-resistor technology provides power regulation for wide-range, stable output power with low noise. With all the controls available on a remote control (see below) the supply may be placed under the table, out of the way. An optional computer interface may be added (refer to chapter 7, "Model 2680 Computer Interface Board").

Model 2470 Remote Control

The Model 2470 remote control module offers current and power mode controls, digital display of current, voltage, or power, and status indicators for all interlock functions. The power meter has six sensitivity ranges from 0.3 W up to 100 W and provides continuous power readings. There is also an analog meter to assist in tuning the laser.

Model 2474 BeamLok Remote Control

The Model 2474 BeamLok remote control contains all the electronics needed to interface to and drive the three-axis output coupler. It also contains a display to show the position of the beam on the position detector when BeamLok is off, and, when on, to show the range of actuator movement available. A single control, a button, turns it on an off: there are no other controls.

BeamLok Argon Specifications[1]

	λ (nm)	BeamLok 2060/65							BeamLok 2080/85		
		-4S	-5S	-6S	-7S	-10S	-10-SA	-12S	-15S	-20S	-25S
Visible Multiline[2] Power (W)	454.5–514.5	4	5	6	7	10	10	12	15	20	25
Visible Single Line[2] Power (W)	454.5	.05	.12	.14	.15	.18	–	–	.4	.6	.8
	457.9	.25	.35	.42	.45	.55	–	–	1.2	1.4	1.5
	465.8	.10	.15	.18	.19	.24	–	–	.4	.6	.8
	472.7	.12	.20	.24	.26	.32	–	–	.6	1.0	1.3
	476.5	.5	.60	.72	.77	1.0	–	–	1.8	2.4	3.0
	488.0	1.3	1.5	1.8	1.9	2.4	–	–	6	7	8
	496.5	.5	.6	.72	.77	1.0	–	–	1.8	2.4	3.0
	501.7	.3	.4	.48	.51	.64	–	–	1.0	1.4	1.8
	514.5	1.7	2.0	2.4	2.6	3.0	–	–	7	9	10
	528.7	.2	.35	.42	.45	.55	–	–	1.0	1.4	1.8
Mid uv Multiline[3] Power (W)	333.6–363.8	.4	.5	.75	1.0	.3[6]	.3[6]	–	2/3/4	4/5/6	5/6/7
uv Single Line[3,4] Power (W)	351.1 & 351.4	.10	.17	.20	.25	–	–	–	.7/1/1.3	1.3/1.5/1.7	1.5/1.7/2
	363.8	.10	.17	.20	.25	–	–	–	.7/1/1.3	1.3/1.5/1.7	1.5/1.7/2
Other Wavelength Groups[5]	275.4–305.5	–	–	–	–	–	–	–	.2/.5/.7	.7/1/1.3	1/1.3/1.5
	300.3–335.8	–	–	–	–	–	–	–	.5/1/1.5	1.5/2/2.5	2/2.5/2.7
	351.1–418.3	–	–	–	–	–	–	–	1.0/1.5/2.0	2.0/3/3.5	3/3.5/4

[1] *Specifications subject to change without notice.*

[2] *Single-line powers for argon lasers are specified at 514.5 nm and 488.0 nm. Powers of all other lines indicated are nominal. Firm specifications require special testing and, in some cases, special optics, and are only available at the time of purchase. All output power specifications, except multiline, refer to* TEM_{00} *operation.*

[3] *Only available with BeamLok 2065/2085 models.*

[4] *Additional uv prism or WSMs are necessary to access single uv wavelengths.*

[5] *Only available with BeamLok 2085 models. Specifications require testing with purchased optics sets and are only available at the time of laser purchase or with plasma tube exchange.*

[6] *Only available as an option with BeamLok 2060-10S or BeamLok 2060-10-SA models. Firm specifications require testing with purchased optics sets and are only available at the time of laser purchase or with plasma tube exchange.*

BeamLok Argon Specifications (cont.)[1]

	BeamLok 2060/65	BeamLok 2080/85
Beam Diameter[2] at 1/e² points	1.7 mm	1.9 mm
Beam Divergence,[2] full angle	.45 mrad	.45 mrad
Polarization, vertical	> 100:1	> 100:1
Cavity Length, with prism	1.17 m	1.78 m
without prism	1.10 m	1.71 m
Mode Spacing, with prism	133 MHz	84 MHz
without prism	136 MHz	87 MHz
Noise (rms)[3]		
power mode	0.3%	0.3%
current mode	0.4%	0.4%
Noise (rms)[4]		
power mode		
10 Hz to 500 Hz	0.03%	0.05%
10 Hz to 2 kHz	0.05%	0.08%
10 Hz to 20 kHz	0.10%	0.15%
10 Hz to 2 MHz	0.15%	0.20%
Stability, power mode[5]		
with BeamLok on, 8 hr period	± 0.5%	± 0.5%
with BeamLok on, 2 hr period	± 0.3%	± 0.3%
Stability, current mode[5]		
with BeamLok on, 8 hr period	± 1.0%	± 1.0%
Beam Pointing Stability[6]		
position offset	< 0.5 µm/°C	< 0.5 µm/°C
angular offset	< 5.0 µrad/°C	< 5.0 µrad/°C
Single Frequency[7]		
Temperature Range for Mode-hop Free Operation	≤10°C	≤10°C
Frequency Drift[6,8]	≤50 MHz/°C	≤50 MHz/°C
Frequency Jitter[6,9]		
with J-Lok	≤2 MHz	≤3 MHz
without J-Lok	≤10 MHz	≤15 MHz
Conversation Efficiency[10]	≥60%	≥60%

[1] *Specifications subject to change without notice.*

[2] *At 514.5 nm for Argon. At other wavelengths, assuming no change in optical configuration, the diameter is given by:* $dia_1/dia_2 = (\lambda_1/\lambda_2)^{1/2}$.

[3] *At 514.5 nm for argon, 10 Hz to 2 MHz.*

[4] *Multiline (454–514 nm) specification. Available with Silent Lite option at the time of original system purchase.*

[5] *Power stability after 15-min warm-up.*

[6] *After a 30-min warm-up with BeamLok engaged.*

[7] *Specifications are for BeamLok laser operating with the Z-Lok accessory package and appropriate Wavelength Selective Mirror (WSM).*

[8] *Z-Lok systems is capable of being locked to an external reference, such as an iodine cell. Frequency drift of 10 MHz has been demonstrated with this technique.*

[9] *As measured in the range from 10 Hz to 500 Hz, at the minimum required water flow for the given laser.*

[10] *Of the specified single line* TEM_{00} *power for a given laser model.*

BeamLok Model 2080 Krypton Specifications [1]

λ (nm)	Output Power[1,2]
406.7	1.0
413.1	**2.5**
415.4	.35
All-Lines Violet	5.0
468.0	.5
476.2	.4
482.5	.4
All-Lines Blue/Green	3.5
520.8	.7
530.9	1.5
568.2	1.1
All-Lines Green/Yellow	3.3
575.3	.2
593.3	.2
631.2	.2
647.1	**3.5**
676.4	.9
All-Lines Red	4.6

[1] *Specifications subject to change without notice.*

[2] *Single-line powers for Krypton lasers are specified as TEM_{00} at 413.1 nm and 647.1 nm. Powers of all other lines indicated are normal. Firm specifications require special testing and, in some cases, special optics, and are only available at the time of purchase.*

BeamLok Model 2080 Krypton Specifications (cont.)[1]

	BeamLok 2080
Beam Diameter[2] at 1/e² points	2.0 mm
Beam Divergence,[2] full angle	.5 mrad
Polarization, vertical	> 100:1
Cavity Length, with prism	1.78 m
without prism	1.71 m
Mode Spacing, with prism	84 MHz
without prism	87 MHz
Noise (rms)[3]	
power mode	0.3%
current mode	0.4%
Stability, power mode[5]	
with BeamLok on, 8 hr period	± 0.5%
with BeamLok on, 2 hr period	± 0.3%
Stability, current mode[5]	
with BeamLok on, 8 hr period	± 1.0%
Beam Pointing Stability[6]	
position offset	< 0.5 μm/°C
angular offset	< 5.0 μrad/°C
Single Frequency[7]	
Temperature Range for Mode-hop Free Operation	≤ 8°C
Frequency Drift[6,8]	≤ 50 MHz/°C
Frequency Jitter[6,9]	
with J-Lok	≤ 3 MHz
without J-Lok	≤ 15 MHz
Conversation Efficiency[10]	≥ 50%

[1] *Specifications subject to change without notice.*

[2] *At 647.1 nm for Krypton. At other wavelengths, assuming no change in optical configuration, the diameter is given by:* $dia_1/dia_2 = (\lambda_1/\lambda_2)^{1/2}$.

[3] *At 647.1 nm for argon, 10 Hz to 2 MHz.*

[4] *Power stability after 15-min warm-up.*

[5] *After a 30-min warm-up with BeamLok engaged.*

[6] *Specifications are for BeamLok lasers operating with the Z-Lok accessory package.*

[7] *As measured in the range of 10 Hz to 500 Hz, at the minimum required water flow for the laser.*

[8] *Of the specified line* TEM_{00} *power for a give laser mode.*

BeamLok Specifications (cont.)[1]

BeamLok 2060/65 Mechanical

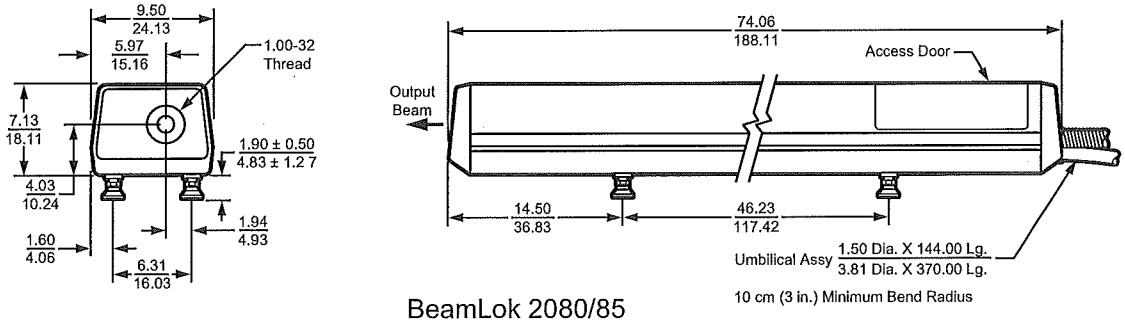
Electrical	
Input Power	3-phase with ground
Voltage	208 V_{ac} +10%,– 5%
Current (max.)	60 A per phase at 208 V
Power Consumption	21 kW
Weight	
Laser Head	66.0 kg (145 lb)
Power Supply	79.5 kg (175 lb)
Water	
Heat Load	1200 Btu/min (water) 24 Btu/min (air)
Flow Rate (min)	11.3 l/min (3.0 gal/min)
Water Pressure[2] (min)	172 kPa (25 psig)
Inlet Temperature	10–35°C (50–95°F)

BeamLok 2080/85 Mechanical

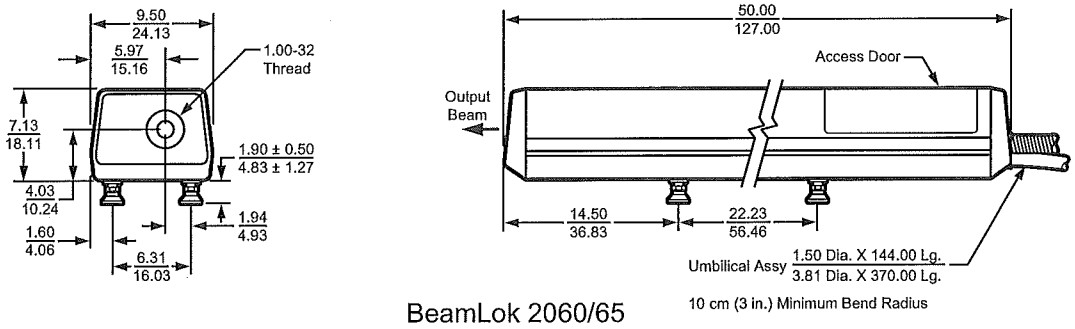
Electrical	
Input Power	3-phase with ground
Voltage	480 V_{ac} + 8%, – 5%
Current (max.)	73 A per phase at 480 V
Power Consumption	57 kW
Weight	
Laser Head	100.0 kg (220 lb)
Power Supply	79.5 kg (175 lb)
Water	
Heat Load	3220 Btu/min (water) 24 Btu/min (air)
Flow Rate (min)	18.9 l/min (5.0 gal/min)
Water Pressure[2] (min)	414 kPa (60 psig)
Inlet Temperature	10–35°C (50–95°F)

[1] *Specifications subject to change without notice.*
[2] *Defined as the difference between the exit back pressure and the input pressure.*

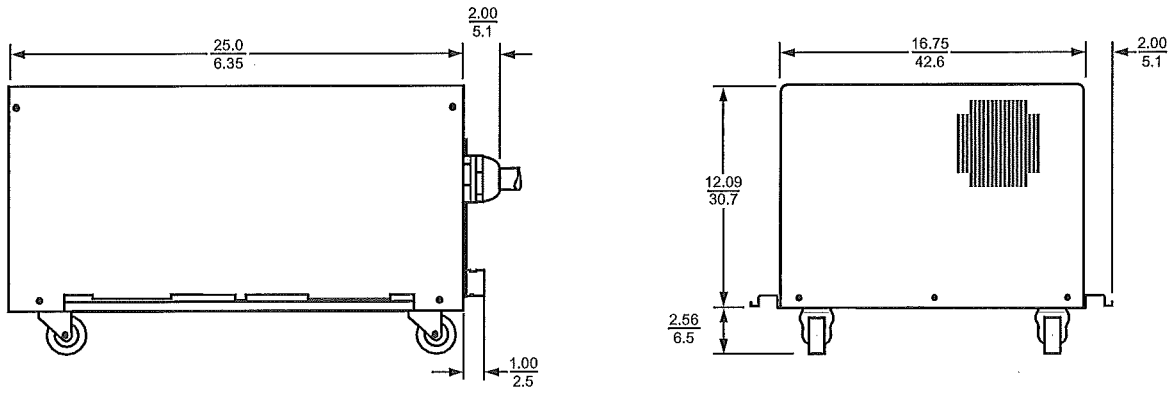
BeamLok Outline Drawings



BeamLok 2080/85



BeamLok 2060/65



Model 2580

All dimensions in inches / cm

BeamLok Options

- **Deep uv kit** (DUV 1)—complete package for deep uv (275 – 305 nm) operation of BeamLok 2085 laser. Includes deep uv optics, purge filter, and purge lines.
- **Z-Lok package** (587-XX)—active single frequency includes Model 587 etalon, Model 5870 electronics module, and wavelength selective mirror. Provides active cavity stabilization for mode-hop elimination, and automatic etalon alignment for optimum power.
- **J-Lok package** (588-XX)—jitter reduction package includes Model 450-01 interferometer, Model 5880 electronics, beam splitter, and Model 381 mount. Provides jitter reduction for all BeamLok lasers in the low to mid-frequency range.
- **Computer interface module** (2680)—provides both IEEE 488 and RS-232-C ports for computer control of any BeamLok laser.
- **Silent Lite Option (SLO)**—low noise option for BeamLok Models 2080 and 2060.

BeamLok Optics

Optic Sets:

- **UV-275**—optics set for 275.4–305.5 operation of a BeamLok 2085
- **UV-300**—optics set for 300.3–335.8 operation of a BeamLok 2085
- **UV-351**—optics set for 351.1–418.3 operation of a BeamLok 2085
- **UV-333-L(S)**—optics set for 333.6–363.8 operation of a BeamLok 2085/2065

Wavelength Selective Mirrors:

λ (nm)	BeamLok 2060/65	BeamLok 2080/85
351.1, 351.4	—	G3873-020
363.8	G3873-906	G3873-023
488.0	G3873-027	G3873-022
514.5	G3814-043	G3873-021

Prisms:

0428-6086[1]	Visible prism for BeamLok 2060/65 and 2080/85
0428-6085	uv prism for BeamLok 2060/65 and 2080/85

[1] *Standard BeamLok systems include this option.*

BeamLok 2060/65 Optics:[1]

λ (nm)	Description	Part Number
333–364	Output Coupler	G3873-007
333–364	High Reflector	G3802-028/G0326-001[2]
364	Output Coupler	G3873-906[3]
458–514	Output Coupler	G3814-006
458–514	High Reflector	G3802-009[3]/G0326-005[2]
488	Output Coupler	G3873-027[3]
514	Output Coupler	G3814-043[3]
275–1090	Etalon	Model 587[3]

BeamLok 2080/85 Optics:[1]

λ (nm)	Description	Part Number
275–306	Output Coupler	G3873-018[3]
275–306	High Reflector	G3802-029[3]/G0326-002[2,3]
300–336	Output Coupler	G3873-019[3]
300–336	High Reflector	G3802-035[3]/G0326-003[2,3]
333–364	Output Coupler	G3873-017
333–364	High Reflector	G3802-028/G0326-001[2]
350–351	Output Coupler	G3873-020[3]
364	Output Coupler	G3873-023[3]
351–420	Output Coupler	G3873-024[3]
351–420	High Reflector	G3802-036[3]/G0326-004[2,3]
458–514	Output Coupler	G3873-026
458–514	High Reflector	G3802-009/G0326-005[2]
488	Output Coupler	G3873-022[3]
514	Output Coupler	G3873-021[3]

[1] *All optics are included with a standard model, except where noted.*
[2] *The use of these optics results in a larger mode and higher TEM_{00} power.*
[3] *These optics are optional and must be ordered in addition to the standard optics.*

Patents

The BeamLok laser system is manufactured or marketed under one or more of the following U.S.A. patents:

4, 063, 808	4, 203, 080	4, 442, 524
4, 613, 972	4, 615, 034	4, 649, 547
4, 668, 906	4, 677, 640	4, 683, 575
4, 685, 109	4, 685, 110	4, 719, 404
4, 706, 256	4, 715, 039	4, 816, 741
4, 719, 638	4, 809, 293	4, 974, 228
4, 872, 104	4, 947, 102	5, 002, 371
4, 982, 078	4, 988, 942	5, 047, 609

Chapter 2 Laser Safety

Danger!



The Spectra-Physics Lasers BeamLok™ 2060 and 2080 are *Class IV–High Power Lasers* whose beams are, by definition, safety and fire hazards. 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.

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 vendors 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. This keeps the eye's pupil constricted, thus reducing the possibility of eye damage.
- To avoid unnecessary radiation exposure, keep all protective covers in place during normal operation.
- Avoid looking at the output beam; even diffuse reflections are hazardous.
- Avoid blocking the output beam or its reflection with any part of your body.
- Establish a controlled-access area for laser operation. Limit access to persons trained in laser safety principles.
- When operating in the uv range, provide adequate ventilation to reduce the hazard of toxic contamination due to bombardment of atmospheric elements by the laser beam.
- Post warning signs prominently near the laser operation area (Figure 2-1).
- Operate the laser at the lowest beam intensity possible, given the requirements of the application.
- Expand the beam whenever possible to reduce beam intensity.
- Set up experiments so the laser beam is either above or below eye level.

- Provide enclosures for beam paths whenever possible.
- Set up a beam block (Figure 2-2) to capture the laser beam and prevent accidental exposure.
- Set up shields to prevent stray reflections from escaping the laser operating area.

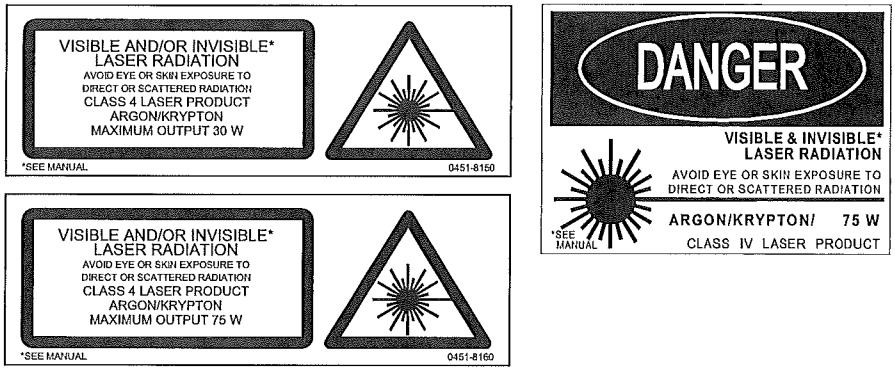


Figure 2-1: These standard safety warning labels would be appropriate for use as entry warning signs (ANSI 4.3.10.1).

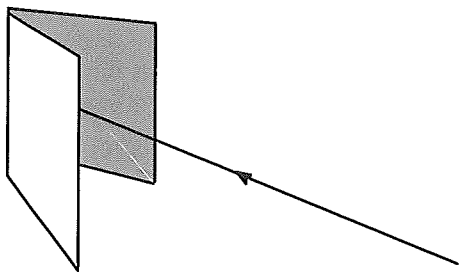


Figure 2-2: Folded Metal Beam Target

Caution! 

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

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

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

Follow instructions contained in this manual for proper installation and safe operation of your laser.

Maintenance Necessary to Keep these Laser Products in Compliance with Center for Devices and Radiological Health (CDRH) Regulations

These laser products comply 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), check to see that all features of the product identified on the radiation control drawing (Figure 2-6) function properly. Also, make sure that all warning labels remain firmly attached.

1. Verify removing the auxiliary interlock (INTLK AUX) connector on the power supply prevents laser operation.
2. Verify 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 the emission indicator provides a visible signal when the laser emits accessible laser radiation that exceeds the accessible emission limits for Class I.* Also verify the signal provides an advance warning sufficient to allow action to avoid radiation exposure.
4. Verify the time delay between turn-on of the emission indicator and starting of the laser; it must give enough warning to allow action to avoid exposure to laser radiation.
5. Verify the beam attenuator actually blocks access to laser radiation.
6. Verify the safety interlock stops emission of laser or collateral radiation upon removal or displacement of the interlocked laser head or power supply covers.
7. Verify, when the safety interlock is defeated, the defeat key is clearly visible and prevents replacement of the cover while in place.

CDRH Requirements for a Custom Remote Control or for Operation with the Model 2680 Computer Interface Board

The BeamLok 2060 and 2080 laser heads and the Model 2580 power supply comply with all CDRH safety standards when operated with a Model 2470 remote control module. However, when the laser and power supply are operated without the remote control, through either the REMOTE interface or the Model 2680 computer interface, you must provide the following in order to satisfy CDRH regulations:

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

- **Keyswitch**—a means of limiting laser access. It can be a real key lock, a removable computer disk, a password that limits access to computer control software, or a similar implement. The laser must only operate when the key is present and in the ON position.
- **Emission indicator**—indicates that laser energy is, or can be, accessible. It can be a "power-on" lamp, computer display, or similar indicator on the control equipment. It need not be marked as an emission indicator, so long as its function is obvious. Its presence is required on any control panel that affects laser output.
- **Remote interlock connector**—prevents laser operation when removed.

Laser Head and Power Supply Cover Interlocks

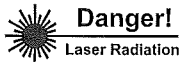
The BeamLok 2060 and 2080 systems have safety interlocks in both the laser head cover and power supply cover. Removing either of these covers causes the main power contactor to open, shutting off electrical power to the laser. The covers must be on, or the interlocks defeated, before the laser will operate.

Laser Head

Installing the safety interlock key (Figure 2-3) in the laser head allows the laser to operate with its cover removed.

Danger! 

Both the laser head and power supply contain electrical circuits operating at lethal voltage and current levels. Be extremely careful whenever the protective cover is removed from either unit, or when the laser head hatch cover is open. Do not touch high voltage terminals or components.



While the laser head cover is removed, be extremely careful to avoid exposure to laser or collateral radiation.

The laser head cover cannot be replaced until the safety interlock key has been removed. Shut off the laser before removing the interlock key and replacing the cover.

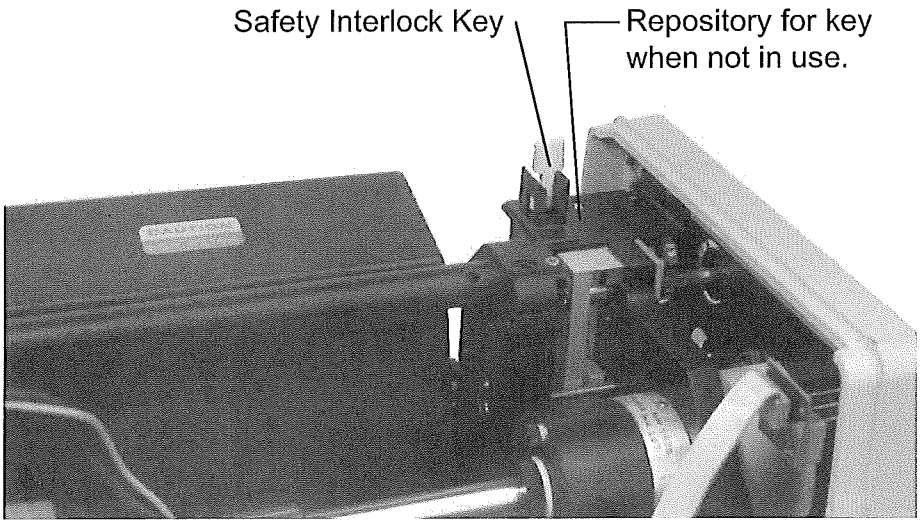


Figure 2-3: Laser Head Safety Interlock Key

Power Supply

Pulling up the power supply cover interlock switch (Figure 2-4) allows the power supply to operate with its cover removed. Be extremely careful to avoid contact with high voltage when operating the system with the cover off.

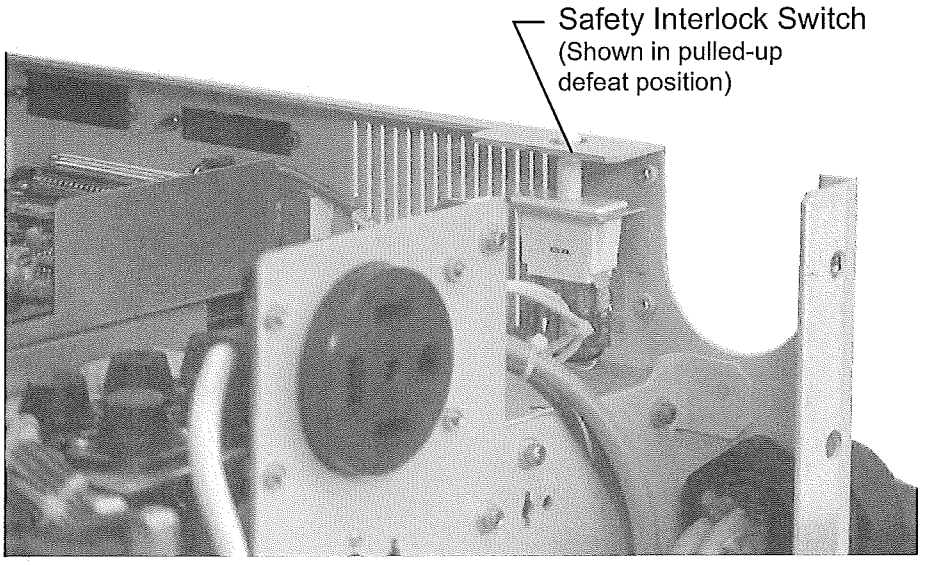


Figure 2-4: Power Supply Safety Interlock Switch

Operation with the Prism Cover Off

Danger!
Laser Radiation

If the prism assembly is installed with its cover off, a portion of the intracavity beam is reflected upward from each face of the prism (Figure 2-5). Avoid eye contact with these beams.

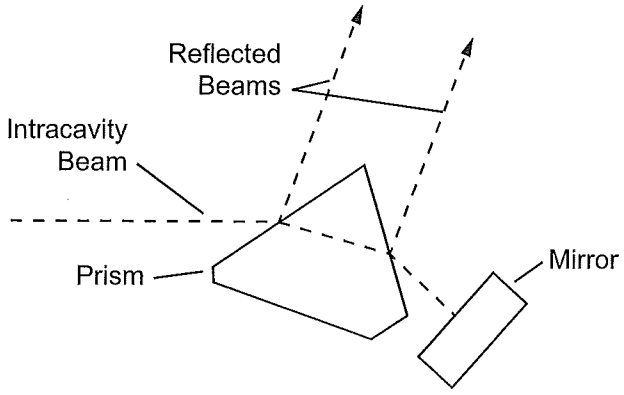
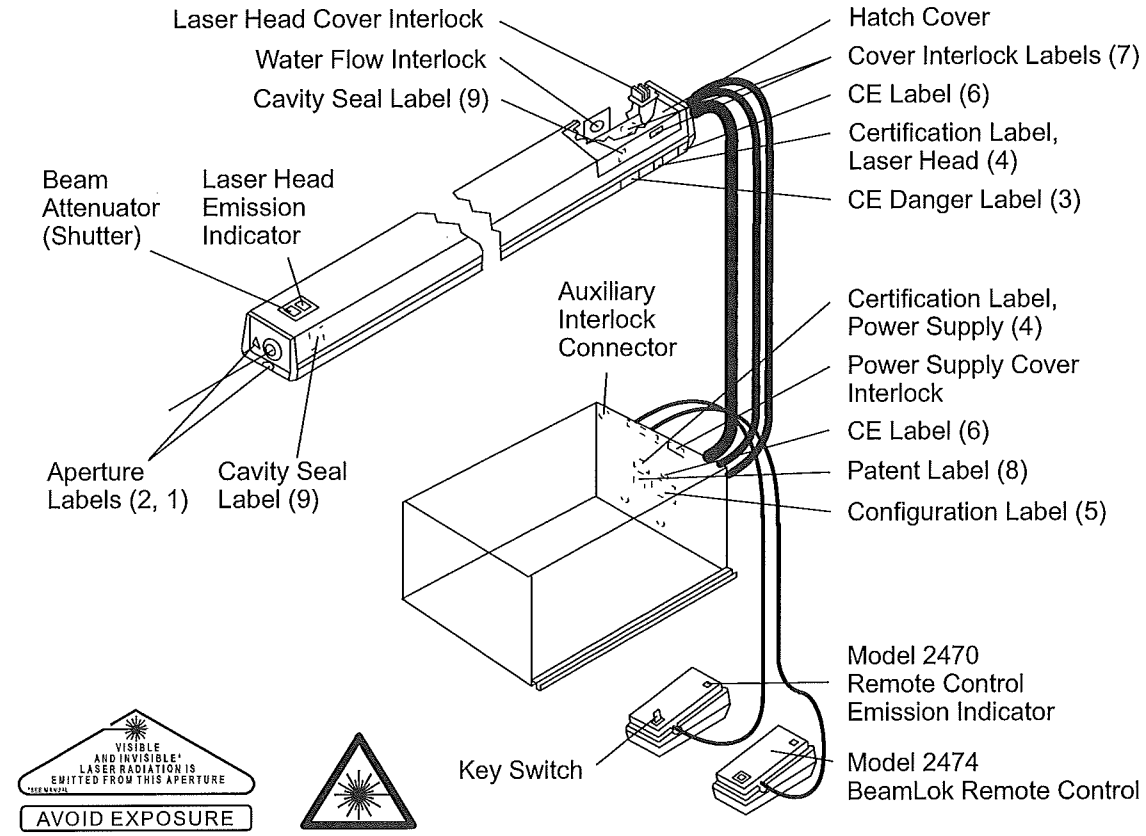


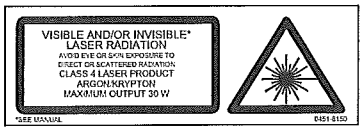
Figure 2-5: A portion of the intracavity beam is reflected upward from each face of the prism.

CE/CDRH BeamLok 2060 Radiation Control Drawing

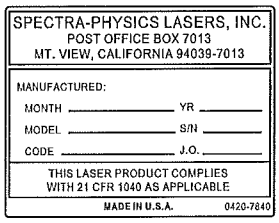


CDRH Aperture Label (1)

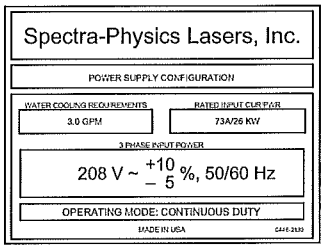
CE Aperture Label (2)



Danger Label (3)



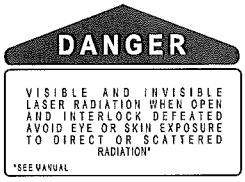
Identification/Certification Label (4)



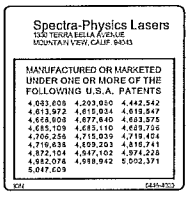
Configuration Label (5)



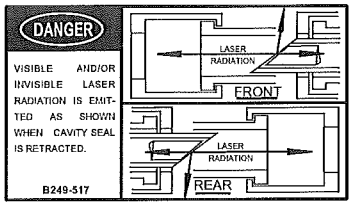
CE Certification Label (6)



Cover Interlock Label (7)



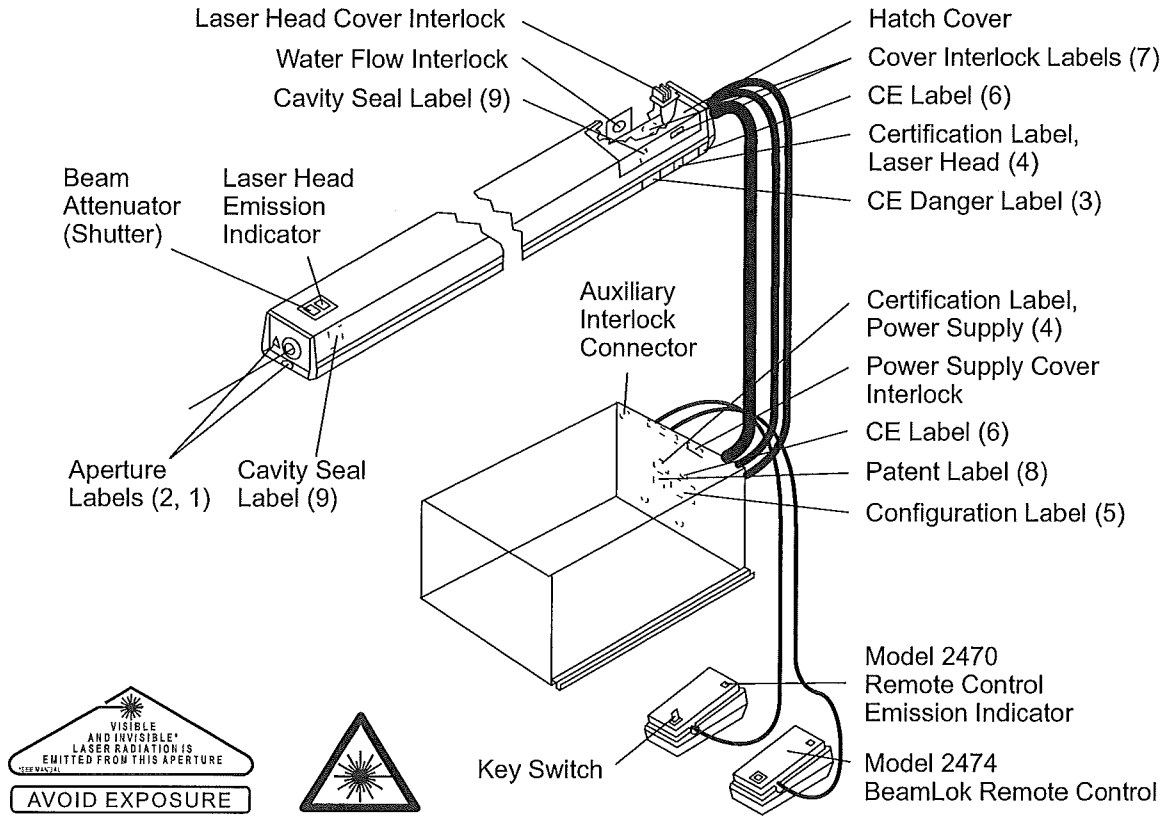
Patent Label (8)



Cavity Seal Label (9)

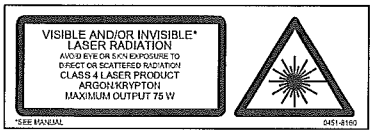
Figure 2-6: BeamLok 2060/65 Radiation Control Drawing

CE/CDRH BeamLok 2080 Radiation Control Drawing

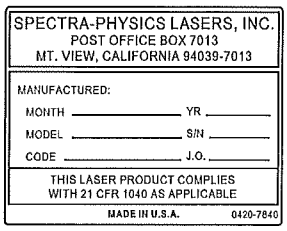


CDRH Aperture Label (1)

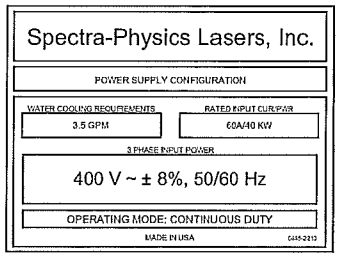
CE Aperture Label (2)



Danger Label (3)



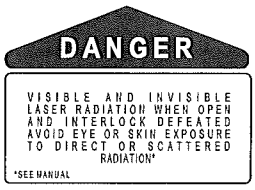
Identification/Certification Label (4)



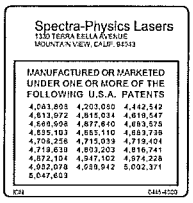
Configuration Label (5)



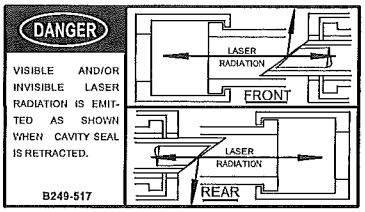
CE Certification Label (6)



Cover Interlock Label (7)



Patent Label (8)



Cavity Seal Label (9)

Figure 2-7: BeamLok 2080/85 Radiation Control Drawing

EC Declaration of Conformity

We,

Spectra-Physics Lasers, Inc.
Scientific and Industrial Systems
1330 Terra Bella Avenue
P.O. Box 7013
Mountain View, CA. 94039-7013
United States of America

declare under sole responsibility that the:

BeamLok 2060/2080 Ion Laser Systems with 2580 power supply, Model 2470 Laser Remote and Model 2474 BeamLok Remote,

Manufactured after December 31, 1995

meet the intent of "Directive 89/336/EEC for Electromagnetic Compatibility."

Compliance was demonstrated (Class A) to the following specifications as listed in the official *Journal of the European Communities*:

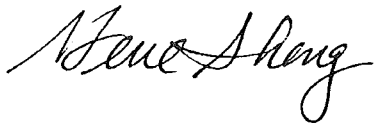
EN 50081-2:1993 Emissions:

EN55011 Class A Radiated
EN55011 Class A Conducted

EN 50082-1:1992 Immunity:

IEC 801-2 Electrostatic Discharge
IEC 801-3 RF Radiated
IEC 801-4 Fast Transients

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



Steve Sheng
Vice President and General Manager
Spectra-Physics Lasers, Inc.
Scientific and Industrial Systems
December 31, 1995

Sources for Additional Information

The following are some sources for additional information on laser safety standards and safety equipment and training.

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) 219-8151

A Guide for Control of Laser Hazards
American Conference of Governmental and
Industrial Hygienists (ACGIH)
1330 Kemper Meadow Drive
Cincinnati, OH 45240
Tel: (513) 742-2020

Laser Safety Guide
Laser Institute of America
12424 Research Pkwy., Suite 125
Orlando, FL 32826
Tel: (407) 380 1553

Compliance Engineering
One Tech Drive
Andover, MA 01810-2452
Tel: (508) 681-6600 or (508) 681-6673

Equipment and Training

Laser Focus World Buyer's Guide
Laser Focus World
Pennwell Publishing
10 Tara Blvd., 5th Floor
Nashua, NH 03062
Tel: (603) 891-0123

Lasers and Optronics Buyer's Guide
Lasers and Optronics
Gordon Publications
301 Gibraltar Dr.
P.O. Box 650
Morris Plains, NJ 07950-0650
Tel: (201) 292-5100

Photonics Spectra Buyer's Guide
Photonics Spectra
Laurin Publications
Berkshire Common
P.O. Box 4949
Pittsfield, MA 01202-4949
Tel: (413) 499-0514

Chapter 3 Installation

This chapter consists of two parts: the one immediately below which describes the controls, indicators and connections on the power supply and laser head, and the installation procedure. Be sure to read this entire section to familiarize yourself with the system prior to installing it.

Power Supply Connectors and Indicators

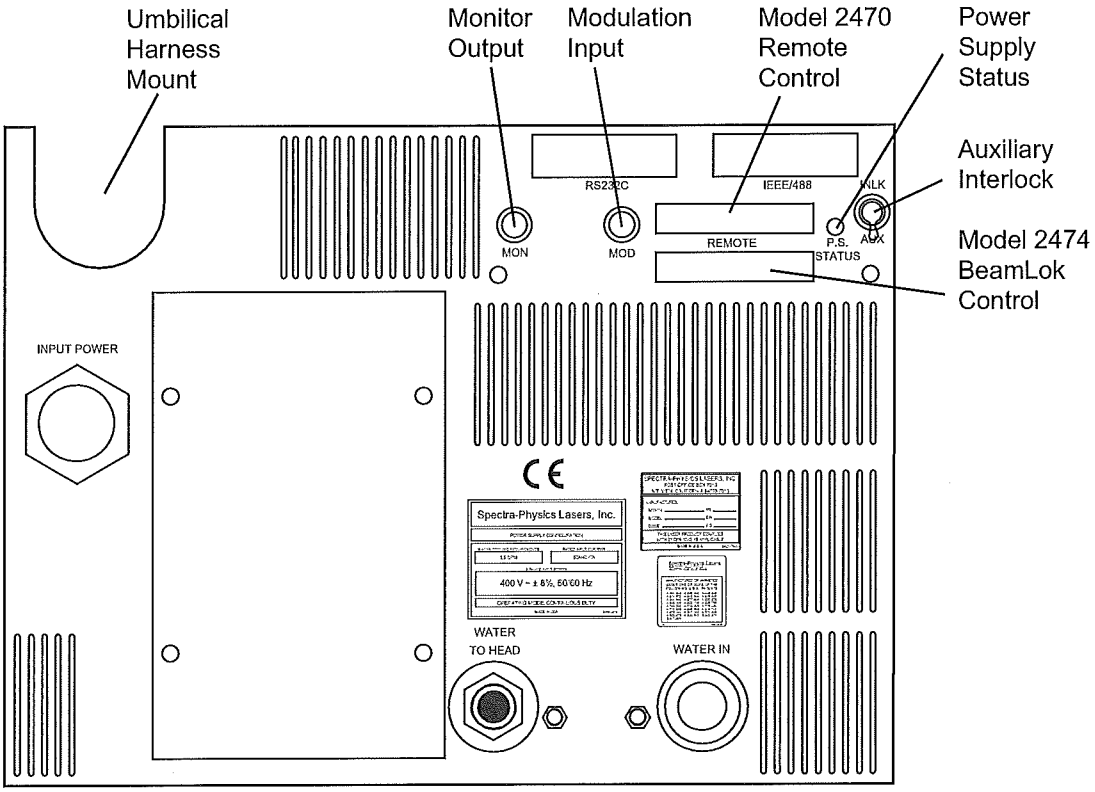


Figure 3-1: Model 2580 Power Supply Connector Panel

Umbilical harness mount—provides a fasten point on the power supply for the laser head umbilical. The plate (permanently attached to the umbilical) connects to the outside of the power supply with four (4) screws.

MONitor jack (BNC)—provides a 0 to 5 V_{dc} signal corresponding to the active function on the remote control module as follows:

Active Function	Range Selected	0–5 V (dc) Represents
AMPS	N/A	0–100 A
VOLTS	N/A	0–316 V
WATTS	100 W	0–100.0 W
WATTS	30 W	0–31.6 W
WATTS	10 W	0–10 W
WATTS	3.0 W	0–3.16 W
WATTS	1.0 W	0–1 W
WATTS	0.3 W	0–0.316 W

MODulation jack (BNC)—a 0 to ±5 V signal input at this connector affects the output as follows:

MODE Switch	RANGE Switch	Modulation Sensitivity
Current	N/A	20 A/V
Power	100 W	20.0 W/V
Power	30 W	6.32 W/V
Power	10 W	2.0 W/V
Power	3.0 W	0.63 W/V
Power	1.0 W	0.2 W/V
Power	0.3 W	0.06 W/V

The command signal to the power supply is the sum of the signal from the modulation connector and the signal from the active control knob (current or power). To illustrate, with the system in current mode and the current control knob set to 40 A, a ±0.5 V signal will vary the operating current from 30 to 50 A.

Modulation Specifications:	
Frequency Range	0 to 100 Hz
Input Impedance	20 kΩ
Input Voltage Range	±5 V
Slew Rate	+250 A/sec, −150 A/sec

Model 2470 REMOTE receptacle—connects the Model 2470 remote control module to the power supply.

P.S. STATUS indicator—glows when the low-voltage control power supply is operating correctly.

AUX INTLK—contacts must be shorted together before the laser will operate. A defeating, shorting jumper plug is installed at the factory. It can be replaced by a similar non-shorting connector wired to auxiliary safety equipment (such as a door switch) to shut off the laser when actuated (opened). Such a switch must have a minimum rating of 100 mA @ 12 V.

Model 2474 REMOTE receptacle—connects the Model 2474 BeamLok remote control module to the power supply.

Laser Head Controls and Indicators

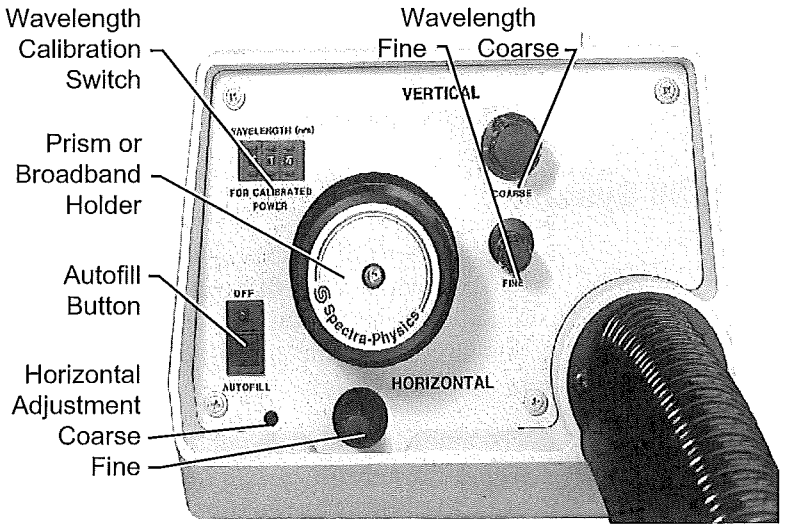


Figure 3-2: BeamLok 2060 and 2080 Laser Head Control Panel

COARSE VERTICAL adjustment—changes the vertical alignment of the high reflector. When a prism is installed, this adjustment selects the operating wavelength within the bandwidth of the cavity.

FINE VERTICAL adjustment—changes the vertical alignment of the high reflector at a rate $^{1}/_{30}$ th of the coarse adjustment.

COARSE horizontal adjustment—changes the horizontal alignment of the high reflector. This adjustment is accessible with a hex driver through a hole in the panel. There is no indicator.

FINE horizontal adjustment—changes the horizontal alignment of the high reflector at a rate $^{1}/_{30}$ th of the coarse adjustment. There is no indicator. If the adjustment is moved out of its range, it is necessary to turn the adjustment fully clockwise until it stops. Then turn the adjustment four revolutions counterclockwise to restore it to midrange.

WAVELENGTH CALIBRATION switch—calibrates the light pick-off assembly so the power meter reading remains accurate at different wavelengths. Pressing the upper button increases the count; the lower button decreases the count. When operating single line, set the switch to the active wavelength. When using broadband visible optics, set the switch to "500." When using broadband uv optics, set the switch to "350." For wavelengths between 1000 and 1090 nm, ignore the "1." For example, the setting for 1090 nm is "090."

The power meter readings are accurate within the following ranges:

275–799 nm	single line	±10% maximum ±5% typical
275–799 nm	broadband	±15% maximum
800–1090 nm	single line	±20% maximum ±15% typical

Gas Autofill System

The gas autofill system continuously monitors plasma tube voltage and current, which directly relate to gas pressure. When the laser is first turned on, autofill is also turned on. If tube pressure drops below a preset safety threshold when the autofill circuit is on, the system restores tube pressure to the safety level.

The autofill disable switch located on the laser head rear panel is used to toggle the autofill system on and off. Disabling the system causes the indicator to glow as a reminder. When the laser is turned off (with the key switch), the autofill disable indicator continues to glow as a warning. The autofill disable function is useful when long-term experiments require interruption-free operation.

Intracavity Shutter

Use the intracavity shutter to safely interrupt the intracavity beam to stop lasing. Its operating lever is located on top of the laser head, in front of the aperture wheel (Figure 3-3). Setting the lever to "Ø" closes the shutter. Always switch the power supply to *current* mode before closing the shutter.

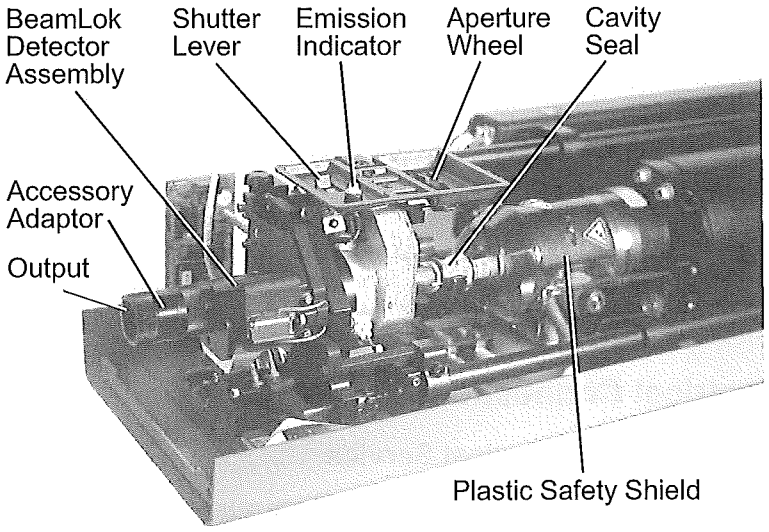


Figure 3-3: Laser Head Interior (Output End)

Warning!

Closing the shutter while still in *power* mode will cause the power control circuit to increase plasma current to maximum. Prolonged operation at maximum current may reduce plasma tube life.

Laser Head Hatch

The laser head is equipped with a hinged hatch cover to allow access to the intracavity space at the high reflector end. Lifting this hatch cover, or the cover itself, opens the laser head cover interlock and shuts off the laser. To operate the laser with either cover open, install the plastic "T"-shaped interlock defeat key into the switch and turn it clockwise to lock it in place (Figure 2-3). The key must be removed before the cover(s) can be replaced or closed.

Danger!
Laser Radiation

Defeating the safety interlock allows access to dangerous laser radiation. Allow only those trained in the principles of laser safety to operate the laser.

Caution! 

The following installation procedures are provided for reference only; they are not intended as guides to the initial installation and set-up of your laser. Please call your Spectra-Physics Lasers service representative to arrange an installation appointment, which is part of your purchase agreement. Allow only those qualified and authorized by Spectra-Physics Lasers to install and set up your laser. You will be charged for repair of any damage incurred if you attempt to install the laser yourself, and such action may void your warranty.

Electrical Connections

Connecting to Electrical Service

For a BeamLok 2060 system, you need to provide three-phase, 208 V_{ac} (+10/– 5 %) electrical service. The system draws a maximum of 60 A.

For a BeamLok 2080 system, you need to provide three-phase, 480 V_{ac} (+8/– 5 %) electrical service. The system draws a maximum of 73 A.

The service box should be less than 3.6 m (12 ft) from the power supply. Connect the green lead of the power cable to *earth ground*, not neutral. Connect the remaining three leads to the legs of the three-phase service; the sequence is not important.

Warning! 

Do not exceed the specified input voltage. If the service voltage does not fall within the specified range, use a transformer to bring it to within this range. Contact your Spectra-Physics Lasers service representative for details.

Connecting the Laser Head Umbilical to the Power Supply

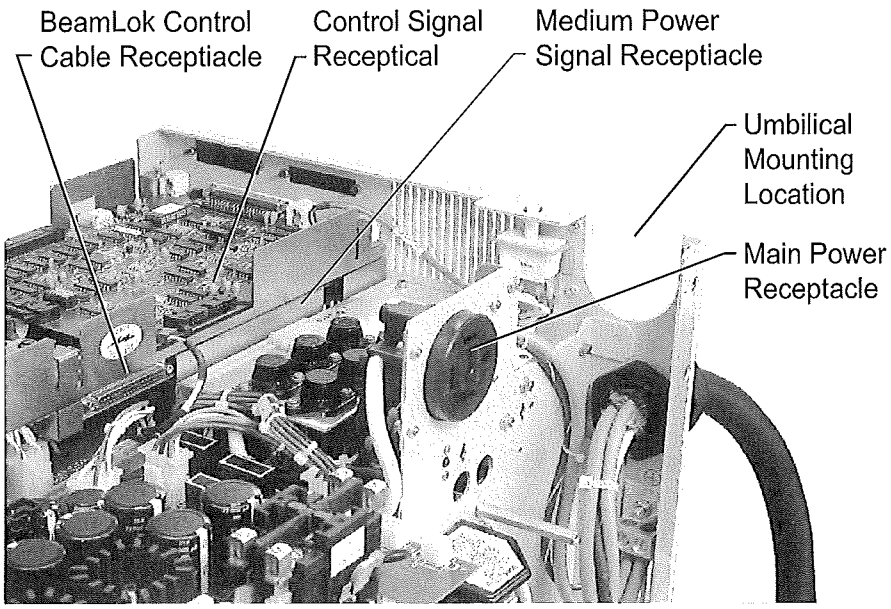


Figure 3-1: Model 2580 Power Supply and Electrical Connections

1. Place both the laser head and power supply in their operating positions; the power supply must be less than 3.6 m (12 ft) from the laser head, the length of the umbilical cable.

   Remove the power supply cover (10 screws).
2. Secure the metal flange of the umbilical to the rear panel of the power supply (4 screws).
3. Plug the large, four-prong, plasma current plug into the socket in the power supply.
4. Connect the control signal cable, the BeamLok signal cable, and the medium-power cable to their matching receptacles.

Operation in Deep UV (275 – 306 nm)— BeamLok 2080 ONLY

Because deep uv wavelengths are especially susceptible to absorption by intracavity ozone, a nitrogen purge of the intracavity spaces is required. The purge nitrogen must be free of water, particulates, and organic contaminants. A high purity (99.99%) or better grade of nitrogen gas is recommended.

An optional purge kit is available for when operating in deep uv. Refer to "Table 9-2: Replacement Parts List," for its part number.

Control Connections

Before the laser can be operated, a control module must be installed. This is usually the Model 2470 remote control module. If the Model 2680 computer interface board (CIB) was ordered at the time of purchase, it will already be installed, and either the remote control or a computer or terminal can be used to control the laser. Refer to chapter 7, "Computer Interface Board," for information on its use and its dip switch settings.

If a user-supplied controller is to be used, it is connected to the Model 2580 power supply in the same manner as the Model 2470 remote control. Specifications for the REMOTE connector signals are given in Table 5-2. CDRH requirements for the user-supplied controller are listed in chapter 2, "Laser Safety: CDRH Requirements for a Custom Remote Control or for Operation with the Model 2680 Computer Interface Board."

Installing the Model 2470 Remote Control Module

1. Attach the cable from the remote control module to the connector marked REMOTE on the control panel of the Model 2580 power supply (Figure 4-1).

   This cable terminates in a polarized connector: it can only go in one way. Push it in until it seats, then tighten the screws (2) to keep the cable from pulling loose during use.

2. Connect the perimeter laser safety switch if you intend to use it.

   If a laser safety switch is used as part of the laser interlock system (a door switch for example), remove the jumper plug from the auxiliary interlock connector (AUX INTLK) on the back of the remote control, and replace it with a BNC cable to the safety switch. This switch must be wired so it is closed during laser operation. The laser must shut off if the switch opens.

   If no safety switch is used, verify that the jumper plug is secure in the auxiliary interlock connector. The system will not start or run without it.

3. Refer to chapter 5, "Model 2470 Remote Control Module," for information on its controls and functions, and to chapter 4, "Operation," for information on how to use it to operate the laser.

Installing the Computer Interface Cable

A computer or terminal may be connected to either the RS-232-C serial interface or the IEEE 488 parallel interface on the power supply connector panel when the optional Model 2680 computer interface (CI) is installed. Refer to your computer or terminal manual for information on the type of interface it requires.

RS-232-C Interface

1. Connect the computer or terminal to the laser system.

Connect a serial cable between the RS-232-C connector on the the power supply and the mating connector on the back of the computer or terminal.

Note: IBM-PCs and compatibles use a 25- or 9-pin connector with **pins** (not sockets) for serial ports. The other 25-pin connector with **sockets** is a modified, Centronics parallel printer port. *Do not connect to this port.* Refer to chapter 7, "Model 2680 Computer Interface Board: RS-232-C Interface, Operation," for a description of the RS-232-C serial interface and how it is used. Figure 7-4 shows the connector pinout for both the IBM-PC 25-pin and IBM-PC AT 9-pin connectors. Use this as a guide for buying or wiring your connecting cable.

Manufacturers of terminals alternatively switch between connectors with pins and sockets for their RS-232-C interface. Most do not use 25 wires even if a 25-pin connector is used. Refer to the terminal manual for the connector configuration and the port to use to connect to the Model 2580.

2. Push the connectors in until they seat, then tighten the screws (two on each connector) to keep the cable from pulling loose.
3. Refer to chapter 7, "Model 2680 Computer Interface: RS-232-C Interface," for information on how to set the CI dip switches for baud rate, parity, etc.

IEEE 488 Interface

Many computers from Hewlett-Packard, and engineering test and measurement equipment from vendors such as Hewlett-Packard, Keithly, and Fluke, incorporate the IEEE 488 parallel bus into their products. This makes the job of running and monitoring otherwise tedious tests easier for the manufacturing or test engineer. Because of its popularity, this bus is provided as an alternative control interface on the CI.

The IEEE 488 connector is a 24-pin, polarized shell with metric fasteners. Up to 32 IEEE 488-compatible devices can be daisy-chained together in either a serial or star network, with one master controller and various "talkers" and "listeners" for drivers, monitors, and measuring devices. Refer to chapter 7, "Model 2680 Computer Interface: IEEE 488 Interface," for a description of the interface and the CI commands, for information on how to set the dip switches on the CI, and for information on programming. Refer to your computer manual or your IEEE 488 controller manual for information on how to use their IEEE 488 interface product.

1. Connect the IEEE 488 parallel cable (available from your computer or controller vendor) between the IEEE 488 connector on the the power supply and the IEEE 488 connector on the back of your computer, terminal, or controller.

   Unlike the RS-232-C interface, the IEEE 488 cable is standardized: there are no wires to modify. Simply plug it in.

2. Push the connectors in until they seat, then tighten the screws (two on each connector) to keep the cable from pulling loose.

   The screws are metric and will not screw into a similar, but non-IEEE 488-compatible connector.

Water Connections

Cooling water may be supplied from an open-loop system consisting of a tap water source and a drain connection. Refer to Table 3-1 for flow, pressure, and thermal ratings, and for requirements for water quality. The diameter of the incoming water service line should be at least 15.9 mm ($^5/_8$ in.). All hose connections are U.S. garden hose variety.

Table 3-1: BeamLok 2060 and 2080 Cooling Water Requirements

	BeamLok 2060	BeamLok 2080
Flow Rate (min)	11.3 l/min (3.0 gal/min)	18.9 l/min (5.0 gal/min)
Inlet Temperature (max)	35°C (95°F)	35°C (95°F)
Differential Pressure (min)[1]	172 kPa (25 lb/in.^{2})	414 kPa (60 lb/in.^{2})
Inlet Pressure (max)	517 kPa (75 lb/in.^{2})	517 kPa (75 lb/in.^{2})
Hardness (max)	<100 ppm calcium	<100 ppm calcium
pH Level	7.0 to 8.5	7.0 to 8.5
Particulate Size (max)[2]	<200 µ dia.	<200 µ dia.
Heat Load	21 kW (1224 Btu/min)	57 kW (3244 Btu/min)

[1] *Defined as the difference between the exit back pressure and the input pressure.*

[2] *A 25 µ filter is provided with the laser.*

The laser head must be mounted horizontally for proper water cooling.

1. Install the water filter in the water supply line; the direction of flow is marked on the filter case.
2. Connect the filtered water supply to the WATER IN fitting on the rear panel of the power supply.
3 Connect the hose from the laser head umbilical that matches the WATER TO HEAD fitting on the power supply.
4. Connect the remaining umbilical hose to the water drain line. Make sure the water hoses are not kinked or restricted at the laser head or power supply.

Closed-Loop Cooling Systems

Because local tap water can be expensive and varies in pressure and temperature throughout the day, or because it might be "hard" (high dissolved solids content), a closed-loop cooling system (such as the Spectra-Physics Lasers Model 315A water conditioner) can be used to regulate the pressure, temperature, and flow rate of the cooling water, and to avoid the build up of scale on the plasma tube. A closed-loop cooling system can enhance the stability of the laser, improve its performance, and prevent premature tube failure due to reduced cooling efficiency. Any such system must meet or exceed the cooling requirements listed in Table 3-1.

Laser Head Inspection

Great care was taken in preparing your laser for shipping. Remove the laser head cover and inspect the interior.

1. Inspect the cavity seal on each end of the plasma tube. If the seal was dislodged during shipping, the plasma tube window will have to be cleaned; refer to chapter 8, "Maintenance: Cleaning the Plasma Tube Windows," for details.
2. Inspect the shutter and aperture (Figure 4-3). Both should operate easily, and the shutter should open fully. "12" on the aperture wheel is the open position. "○" is the open position on the shutter switch.

Adjusting the Height of the Laser Head

The laser head rests on four adjustable feet. The head can be raised or lowered by loosening the threaded retaining ring under the bottom cover and screwing the feet in or out using an Allen wrench from inside the laser head. The feet should all be the same height, especially from side to side, and their heights must be within 0.3 cm ($^1/_8$ in.) of one another. Tighten the retaining rings when the adjustments are complete.

Water Testing the System

The following procedure should be performed before operating the laser for the first time.

1. Slowly open the water supply valve until you hear the water begin to flow.
2. Check for leaks at both ends of the magnet/plasma tube assembly, at all plumbing connections within the laser head, and around the umbilical connection at the rear of the power supply. Check for water drops beneath the power supply.
3. If leaks are present, check the O-ring seals and hose washers at the locations mentioned above for proper seating. If leaks persist, shut off the water supply, drain the cooling system, and call your Spectra-Physics Lasers service representative.
4. Install the laser head and power supply covers. Verify the covers actuates the cover interlock switch.

Chapter 4 Operation

For descriptions of the laser head and power supply controls, please refer to chapter 3, "Installation."

Starting the Laser



The output beam of this laser is a safety and fire hazard. Avoid directly viewing the beam and its reflection or blocking it with clothing or parts of the body.

First Time Start-Up

1. Verify that the green lead of the power cable is connected to *earth ground.*
2. Check for proper power line voltage.

   For a BeamLok 2060 input voltage should be 208 V, +10/–5 %; for a BeamLok 2080 it should be 480 V, +8/–5 %. Extended operation near the limits of these ranges is not recommended.
3. Place a beam block or power meter in the beam path, clear the beam path of reflective objects, and open the shutter.
4. Turn on the main power.

   The P.S. STATUS indicator on the power supply should be glowing, indicating power is available.
5. Test the flow switch.

   Turn on the cooling water supply. The FLOW indicator should turn off within a few seconds. Turn off the water supply. The FLOW indicator should turn on again. If not, contact your Spectra-Physics Lasers service representative.
6. Turn on the cooling water supply.
7. Select CURRENT mode on the remote module, and turn the current control to its minimum setting, fully counterclockwise.
8. Verify BeamLok is off.
9. Turn on the key switch.

   The emission indicator turns on, and after about a 15 second delay, the plasma discharge starts and the laser beam emerges. If there is no emission, refer to chapter 9, "Service and Repair: Troubleshooting."

Note

To reduce stress on the plasma tube during turn on, a current limiter circuit engages when the main power and key switch are turned on, and tube current is ramped up at 1 A/sec until it reaches the preset set point value.

10. Allow the system to warm up 15 minutes.
11. Adjust the high reflector for maximum optical output power.
12. Turn on BeamLok.

Daily Start-Up Procedure

1. Place a beam block or power meter in the beam path, clear the beam path of reflective objects, and open the shutter.
2. Turn on the cooling water supply.
3. Turn on the main power.

   The P.S. STATUS indicator on the power supply should turn on.
4. Turn on the key switch.

   The emission indicator turns on, and after a 15 second delay, the plasma discharge starts and the laser beam emerges. If there is no emission, refer to chapter 9, "Service and Repair: Troubleshooting."

   During routine start-up, start the system with BeamLok enabled. This keeps the output beam aligned while the laser is warming up. Refer to chapter 6, "BeamLok," for information on using BeamLok.

Adjusting for Maximum Output Power

Note

The following procedure is only applicable when BeamLok is off. When on, BeamLok automatically compensates for minor day to day misalignment.

Assuming the laser has been allowed to warm up properly (approximately 15 minutes), high reflector misalignment is the most likely cause of low output power. The beam must be normal to the mirror for optimum performance. If the mirror is misaligned, either horizontally or vertically or both, laser output power will suffer. The mirror mount is designed to permit each plane to be independently adjusted.

Use the vertical and horizontal fine adjustments on the high reflector to adjust for maximum optical output power.

1. Select CURRENT mode on the remote module.
2. Turn BeamLok off.
3. Adjust for maximum optical output power.

Turn one fine adjust control while observing the change in output power. If power increases, continue to turn the control in the same direction. If power declines, turn the control in the opposite direction.

Achieve maximum power with one control before moving to the other. These controls interact with each other, so iterate between controls, first with one control, then with the other, until the highest possible output power is achieved.

Note



If the unit stops lasing while you are turning one of the controls, turn it in the opposite direction until lasing is restored. Leave the other control alone until you get the unit lasing again.

Adjust only the high reflector to achieve maximum power. The curved output coupler should remain stationary under normal operating conditions. If disturbed, realignment may be time-consuming and tedious. If the output performance remains below specification after adjusting the high reflector, clean the mirrors and plasma tube windows. (Refer to chapter 8, "Maintenance," for information on cleaning optics. If cleaning fails to restore power, the output coupler or plasma tube may be misaligned. Refer to chapter 9, "Service and Repair" for troubleshooting and alignment details.

4. Once power is satisfactory, turn BeamLok on.

Wavelength Selection

Prism

For single-line operation, use the prism assembly. It contains both a prism and a high reflector. The prism disperses the laser beam, bending individual lines according to their wavelength. A line will oscillate if its angle of refraction through the prism matches the vertical rotation angle of the prism. As you adjust the high reflector vertically, the angle at which the beam strikes the prism changes, and with it the wavelength of the oscillating line.

The wavelength indicator on the laser head displays the approximate wavelength in nanometers (NO TAG). The lines can also be identified by their relative power. Power for each line is listed in the BeamLok specifications table in chapter 1. Positive identification of weaker lines requires a spectroscope.

Wavelength-Selective Mirrors

Wavelength-selective mirrors (WSMs) are an alternative to using the prism assembly for single-line operation. In this case, the cavity comprises a broadband high reflector and a wavelength-selective output coupler coated to favor a single line. Together, they provide both power and length stability while maximizing power.

Note

To ensure correct power readings, the wavelength calibration switch must be set to the appropriate wavelength range. When BeamLok is on, changing the wavelength may cause misalignment of the beam position detector. Refer to chapter 6, "BeamLok: Aligning the BeamLok Position Detector."

Adjusting the Aperture for TEM_{00} Output

Well-defined variations in the spatial distribution of the electromagnetic field perpendicular to the direction of travel of the beam are called transverse electromagnetic modes (TEM). These variations determine, in part, the power distribution across the beam.

Many laser applications require a TEM_{00} beam, which appears as a round spot that is brighter in the center than on its edges (Figure 4-1). Other modes have different irradiance contours and are identified by the number of nulls in the irradiance distribution. The mode pattern for a given laser is a function of wavelength, and can be affected by laser alignment, the size of the aperture, scratches on the mirrors, or dust on the optical surfaces.

The aperture control allows adjustment for true single-mode (TEM_{00}) output over a wide range of wavelengths. The aperture may also be used to reduce output power or, if TEM_{00} performance is not required, to increase it. The aperture selection to achieve TEM_{00} may change as the plasma tube ages.

You may find it difficult to identify the mode of a beam by direct observation. Even lenses are not enough since diffraction patterns confuse the mode pattern in the near field. Please refer to the paper by S. Guggenheimer and D. Wright, "Laser Beam Diagnostics," volume 1414, January 1991, a SPIE proceedings reprint.

Danger!

The BeamLok 2060 and 2080 are Class IV lasers whose beams are, by definition, a safety hazard. Even reflected beams can be dangerous. Use a neutral density attenuator for mode observations and adjustments. Make sure the beam only strikes low-reflectance surfaces.

In power mode, the range of control is from about $1/20$ of the power meter full-scale setting up to the maximum of the full-scale setting. The power supply provides effective regulation from about 50 mW up to full output power, although best signal-to-noise ratios are at settings $>1/3$ of power meter full scale. Note, however, that certain high-gain lines (such as 488 nm) will not drop as low as 50 mW before discharge ceases. An external attenuator is recommended where stable output of less than 50 mW is required with these lines.

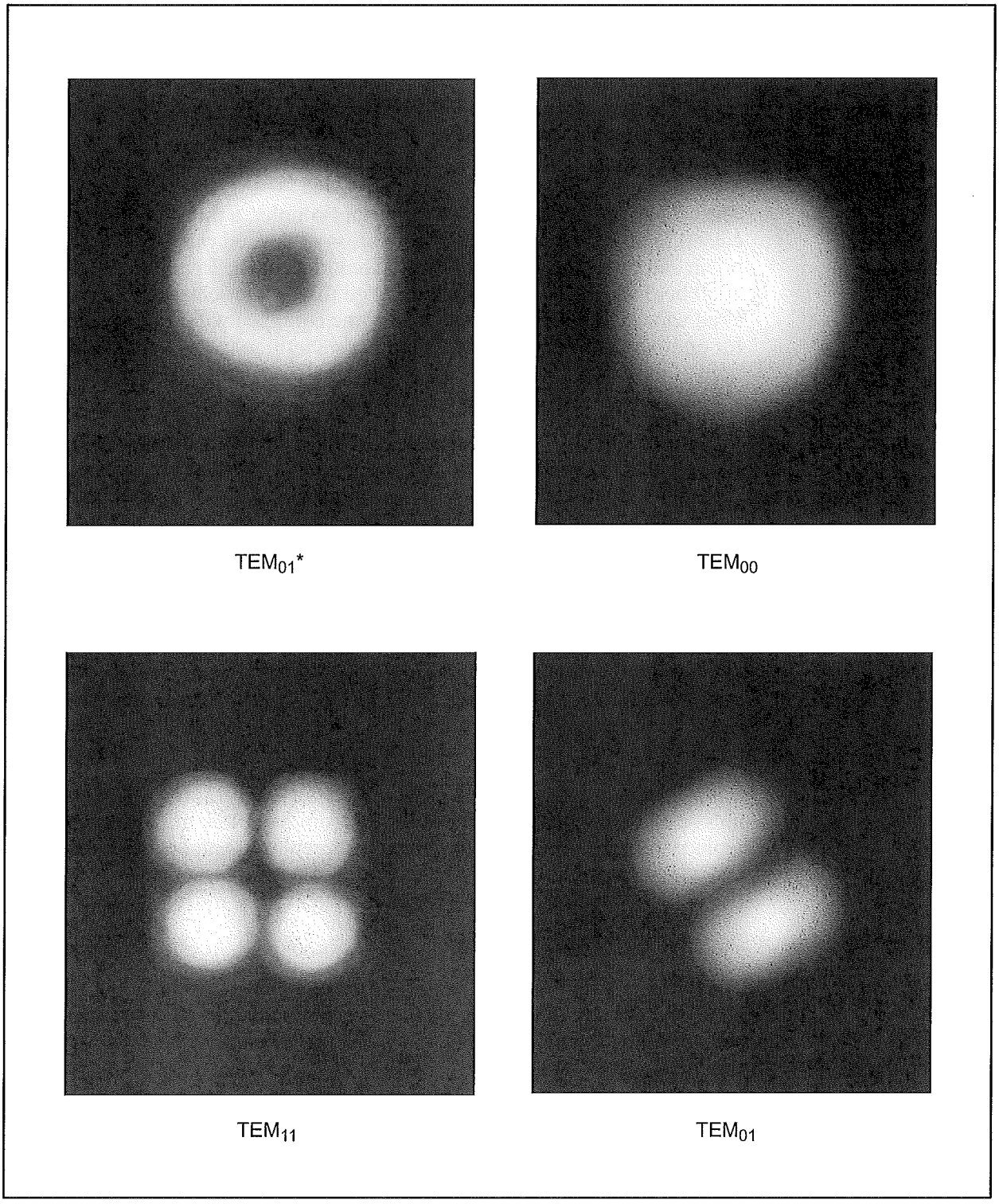


Figure 4-1: Transverse Modes

Changing Optics

Warning! 

The optics are fragile and can be damaged if dropped. Work over a clean, dust-free, soft surface.

The output-end assembly holds the output coupler, a thin-film mirror coated to allow a few percent transmission of desired wavelengths. The prism and broadband high reflector assemblies of the BeamLok 2060 and 2080 hold slightly *convex* mirrors coated for high reflectance of the desired wavelengths. These lasers also come equipped with a set of mirrors for optimum performance within the wavelength range specified at the time of purchase. Optics sets for other wavelength ranges are also available. Refer to "BeamLok Optics" at the end of chapter 1.

The mirror mounts feature bayonet-style mirror holders to provide quick access and precise seating without undue readjustment of the mirrors. Simply twist the holder counterclockwise 30° and it will snap loose. Once loose, pull it straight out. To replace, push the holder into the receiver and turn it clockwise. At only one point will the holder enter all the way and seat against the stop. To lock it, turn the holder 30° clockwise until it clicks.

If a mirror appears tilted in its holder, its alignment lock is disengaged. Try turning the mirror and its spring-loaded retaining cup until the locking mechanism snaps back in place. You will not be able to turn the mirror and cup any further. If the mirrors are clean and locked in alignment, but the output power remains low, refer to chapter 9, "Service and Repair."

Before changing optics sets, always align your laser for maximum output power, close the shutter to stop lasing, and turn BeamLok off. Remove and replace the optics one at a time. After each replacement, open the shutter and adjust the high reflector for maximum power. If a significant power loss occurs, try removing, cleaning, and installing the mirror again.

Changing the Output Coupler and High Reflector

The output coupler mounts inside the BeamLok beam position detector. To access the output coupler, unfasten the bail clamp on the right-hand side of the BeamLok assembly and swing the assembly out of the way (Figure 4-2).

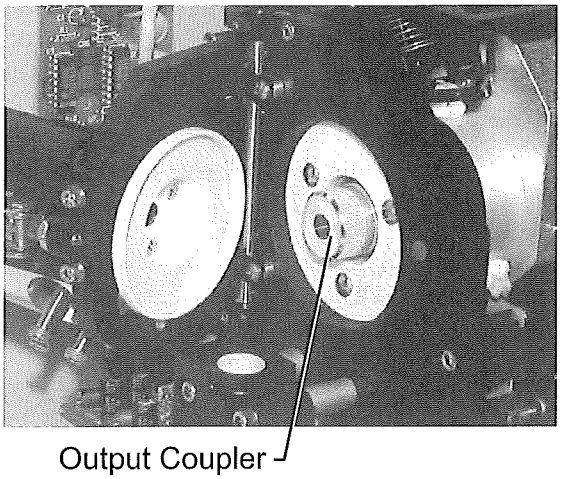


Figure 4-2: Removing the Output Coupler

Remove the output coupler holder and hold it vertical with the mirror on top. Use clean finger cots to protect the mirror during removal and replacement. Slide the mirror gently out of its retaining cup. Every mirror has a Spectra-Physics Lasers part number and an arrow printed on its barrel. The arrow points to the coated surface which faces the laser cavity. Insert the new mirror in the retaining cup with the coated surface on top, then insert the holder in the laser. Available optics are listed in tables in "BeamLok Optics" at the end of chapter 1.

Changing the high reflector is just like changing the output coupler except nothing is in the way.

After changing optics, your laser will usually operate at full power, requiring only fine vertical and horizontal adjustments of the high reflector. Make these adjustments with BeamLok off. Avoid tampering with output coupler controls unless you are certain it is misaligned. Realignment can be time consuming and tedious.

Note



The beam position detector should be checked for alignment after changing optics. Turn off BeamLok and note the power level. Turn on BeamLok again and verify that the power level does not drop by more than 3%. If it does, refer to chapter 6, "BeamLok: Aligning the BeamLok Position Detector."

Changing to a Prism

When changing from the broadband mirror to the prism, or vice versa, follow this simple procedure to minimize loss of alignment and to increase the chance of lasing with minimal readjustment.

Before changing from the broadband mirror to the prism, optimize laser output by adjusting the high reflector. This essentially optimizes it for its strongest line at 488 nm. Then, when you change to the prism, you should be very close to alignment at 488 nm. When returning to the broadband mirror, do just the opposite. First, adjust the prism for maximum power at 488 nm, then remove the prism and install the broadband mirror.

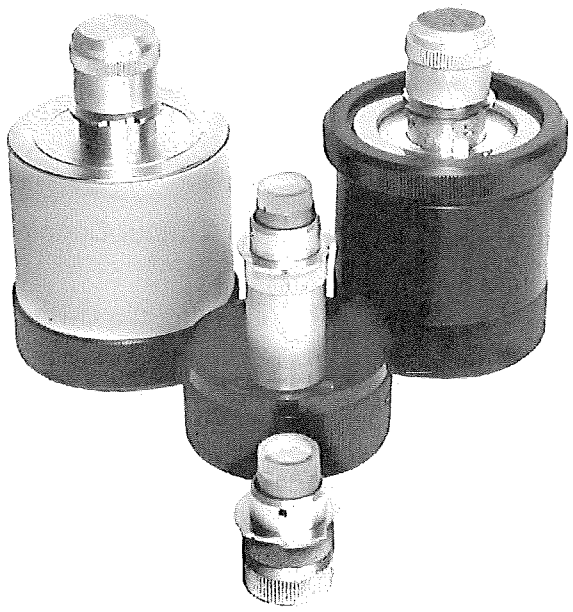


Figure 4-3: BeamLok 2060 and 2080 Optics Assemblies

Etalons

The Spectra-Physics Lasers Model 587 temperature-stabilized etalon allows single-frequency operation. Refer to the Model 587 manual for details or call your Spectra-Physics Lasers service representative.

Shutdown Procedure

1. Turn off the key switch.
2. Remove the key.

   Do not leave the laser accessible to people who are untrained in laser safety or operation.

Note

If you leave the main power on, the laser will return to the operating condition it was in before shutdown.

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3. After allowing the unit to cool down for 15 minutes, turn off the water.
4. If the unit is not to be used for some time, turn off the main power.

Chapter 5 Model 2470 Remote Control Module

The Model 2580 power supply is typically operated from the Model 2470 remote control module (Figure 5-1). The module connects to the power supply through the REMOTE connector, located on the connector panel of the power supply. This connector provides analog and TTL logic signals that control the power supply and laser head and monitor their status.

The module allows you to turn the laser on and off, select the power supply operating mode (*current* or *power*), and adjust the operation set point for tube current or optical output power. It also provides readouts of the interlock, emission, and fill status, and gives a digital display of current, power, or voltage.



Figure 5-1: Model 2470 Remote Control Module

Model 2470 Remote Control Module Controls and Indicators

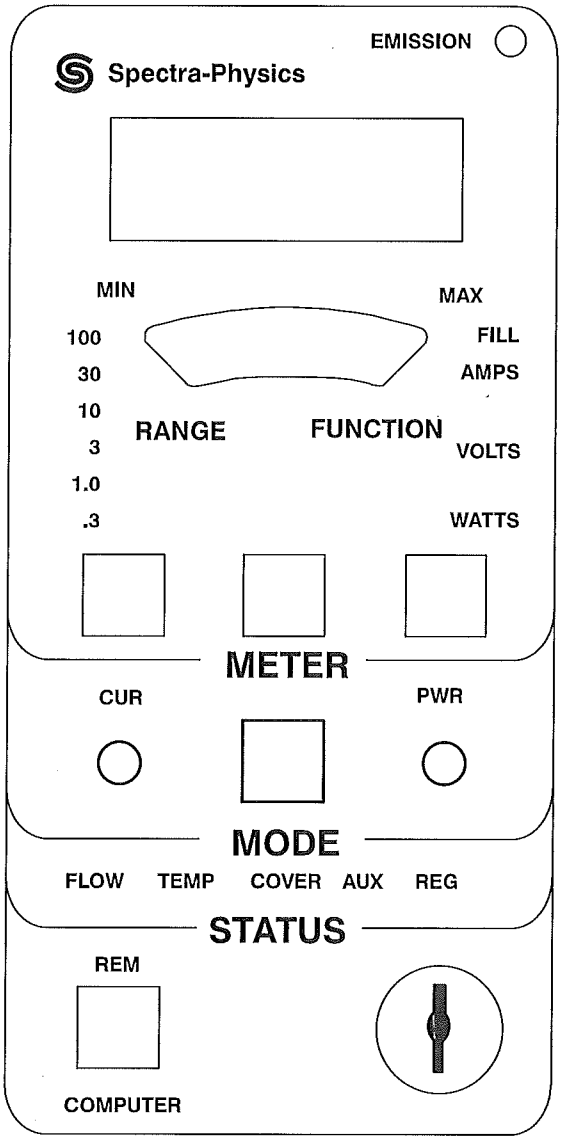


Figure 5-2: Model 2470 Remote Control Indicators and Ranges

Interlock STATUS Indicators

The following indicators show which fault has occurred and are visible only when the interlock is open and the power supply has turned off.

FLOW indicator—glows when the water flow rate through the laser head is less than:

BeamLok 2060 — 11.3 l/min (3.0 gal/min)

BeamLok 2080 — 19.0 l/min (5.0 gal/min).

TEMP indicator—glows when the temperature of the water exiting the laser head exceeds 78°C (172°F).

COVER indicator—glows when the cover interlock switch in the laser head or power supply is open.

AUX INTLK indicator—glows when the auxiliary interlock circuit is open. The auxiliary interlock connector (AUX INTLK) is located on the connector panel of the power supply.

REG indicator—glows when the system regulator monitor shuts off the power supply due to:

- tube current exceeding the maximum safe operating limit:

BeamLok 2060:	55 A
BeamLok 2060-10-SA:	59 A
BeamLok 2080:	65 A

- a fault detected in the power supply,
- the plasma tube either running out of gas or cannot be filled. Low tube pressure makes the laser unsafe to operate. The FILL indicator blinks on and off in this condition.

Warning! 

Whenever the REG indicator comes on, call your Spectra-Physics Lasers service representative.

FILL Indicator

The FILL indicator glows when the fill system is filling the tube. If the AUTOFILL indicator is off (located on the AUTOFILL defeat switch on the laser head rear panel), the fill system fills the tube whenever tube voltage drops below the primary fill threshold.

If AUTOFILL is disabled (the AUTOFILL indicator is glowing) and the tube voltage drops below the secondary safety fill level, the fill system fills the tube to the primary safety fill level.

Warning! 

If the fill system is unable to raise the tube voltage to either the primary or secondary fill threshold level within 15 minutes, the power supply will turn off and the FILL indicator will flash. If this condition occurs, call your Spectra-Physics Lasers service representative.

EMISSION Indicator

This indicator glows when the key switch is turned on and the laser head is capable of emitting laser radiation. All interlocks must be closed before the laser can be turned on.

Key and REMOTE/COMPUTER Switches

Key switch—turns the laser on and off. Turning the key switch one-quarter turn clockwise to the "on" position turns on the emission indicators located on the remote control module and laser head. After a 15 second safety delay, laser emission starts.

REMOTE/COMPUTER switch—selects either the remote control module or the computer interface as the power supply control source. When REMOTE glows, the Model 2470 remote control module (or custom module) is the control source for the power supply.

When COMPUTER glows, the control source is a computer or terminal connected through the optional Model 2680 computer interface. Under computer control, the power range switches and the current and power control knobs on the remote module are disabled; however, the range and mode indicators and the digital and analog meters continue to monitor the status of the system.

As a safety precaution the REMOTE/COMPUTER switch can be disabled so that either one or the other is always active. Refer to "Internal DIP Switch Settings" below.

METER Function Switch

The METER function switch selects either the WATTS, VOLTS, or AMPS function for display on both the digital and analog meter readouts. The full scale value of the meters is determined by the function selected.

- When AMPS is selected, the meters display plasma tube current.
- When VOLTS is selected, the meters display plasma tube voltage:

  BeamLok 2060 full scale — 316 V

  BeamLok 2080 full scale — 1000 V
- When WATTS is selected, the meters display optical output power. Full scale is determined by the selected power range.

MODE Switch and Control Knobs

MODE switch—selects current (CUR) or power (PWR) mode, and the indicator shows which mode is active. The MODE switch is disabled when the system operates under computer control.

- In current control mode, plasma tube current is held constant at the level set by the current control knob.
- In power control mode, plasma tube current is regulated to hold optical output power constant at the level set by the power control knob.

Note



Changing control mode does not change the meter function (see "METER Function Switch" and "RANGE Switch"). You can be in current control mode with the meter showing output power level. The meter range selection, however, does affect output power when set to WATTS (see "Power control knob").

Current control knob—sets the plasma tube current when current mode is selected.

Power control knob—sets the optical output power within the selected power range when the system is in power mode.

RANGE Switch

The RANGE switch allows you to step up or down to select the system power range. One of five indicators glows to display the active range and full scale reading.

Indicator	Meter Full Scale (W)
100	100.0
30	31.6
10	10.0
3.0	3.16
1.0	1.0
0.3	0.316

Danger!



Changing the power range when the system is in power mode will result in a change in the output power of the laser. For example, if the laser is operating at $^2/_3$ full scale in power mode, changing the power range will cause the output power to rise to $^2/_3$ of the new full scale setting.

After the main power is turned on, the temperature-regulated photocell must warm up for 5 minutes before power readings can be considered accurate. The circuit remains stabilized as long as the main power is on. The key switch does not affect power to this circuit.

Internal DIP Switch Settings

The six-position DIP switch (SW_1) inside the remote control module sets the default start-up configuration. Refer to Table 5-1.

Table 5-1: SW_1 DIP Switch Function Settings

Function		DIP Switch 1	2	3	4	5	6
Range	0.3 W	On	Off	Off			
	1.0 W	Off	On	Off			
	3.0 W	On	On	Off			
	10 W	Off	Off	On			
	30 W	On	Off	On			
	100 W	On	On	Off			
Mode	Power				Off		
	Current				On		
Control Source	Remote					Off	
	Computer					On	
Remote/ Computer Switch	Disabled						Off
	Enabled						On
Factory Setting		On	Off	Off	On	Off	Off

Setting SW_1 Defaults

The selected factory settings are: 0.3 W range for safety (output power remains low until deliberately increased), CURrent mode, REMote control source, and the REMOTE/COMPUTER switch disabled. To change the default configuration, set the switches according to Table 5-1.

Note

The REMOTE/COMPUTER switch is disabled at the factory, with REMOTE always selected.

If you plan to operate the system under computer control and need to switch between remote and computer control, enable the REMOTE/COMPUTER switch by setting position 6 of SW_1 to ON.

Note



If the REMOTE/COMPUTER switch is enabled and you attempt to change the control source from remote to computer, the laser will shut off unless a computer is connected to the power supply and the Model 2680 computer interface has been initialized. Refer to chapter 7, "Model 2680 Computer Interface," for information on computer control.

If you plan to operate under computer control only, set position 5 of SW_1 to ON, and position 6 to OFF to set the default to computer control with the REMOTE/COMPUTER switch disabled.

Table 5-2 describes the function of each pin of the REMOTE connector. All logic inputs are optically coupled and require driving logic that can sink 10 mA with a "logic low" voltage of less than 0.8 V.

Changing the Settings on SW1

1. Turn off the main power.
2. Remove the screws (2) on the back side of the remote control module.
3. Grasp the control knobs and lift the controller assembly about 5 cm (2 in.) out of the base enclosure to expose SW_1.
4. Set the switch positions on SW1 according to Table 5-1 then reassemble the module.

Table 5-2: Remote Connector Pin Assignments

Pin	Name	Type	Description
1	GND	Output	Model 2580 power supply digital ground.
2	GND	Output	Model 2580 power supply digital ground.
3	Remote/	Input	Selects control source. When pulled low, control Computer signals on input pins 4, 5, 6, 7, 8, 19, and 36 are enabled. When inactive (high), the signals on the above pins are ignored, and control inputs are taken from a computer connected to the power supply through the RS-232-C or IEEE 488 interfaces. The computer-interface is an optional accessory.
4	Pre0	Input	One of three inputs used to select power range. Input signals on pins 4, 5, and 7 together select the power range according to the following table:
5	Pre1	Input	One of the three inputs used to select power range (see pin 4 description).
6	Control	Input	Selects feedback mode. When pulled low, power mode is selected; when inactive (high), current mode is selected.
7	Pre2	Input	One of three inputs used to select power range (see pin 4 description).
8	Plasma	Input	The main laser on/off control. When pulled low the power , On/Off contactor closes and the tube cathode begins to warm up. The laser will light after about 15 sec.
9	AUX Inter-lock Open	Output	When the interlock is open, the output is inactive (high); if closed, the output is pulled low.
10	High Water Temp	Output	When the head outlet water temperature exceeds 78°C (172°F), the output is inactive (high); otherwise, the output is pulled low.
11	Head Cover Interlock Open	Output	When the cover interlock switch in the head is open, output is inactive (high); if closed, output is pulled low.
12	Low Water Flow	Output	When water flow through the head is below specifications, the output is inactive (high); otherwise, the output is pulled low.

Pre2 (Pin 7)	Pre1 (Pin 5)	Pre0 (Pin 4)	Power Range
Low	Low	Low	0.3 W
Low	Low	High	0.3 W
Low	High	Low	1.0 W
Low	High	High	3.0 W
High	Low	Low	10 W
High	Low	High	30 W
High	High	Low	100 W
High	High	High	0.3 W

<table>
<tr><th>Pin</th><th>Name</th><th>Type</th><th>Description</th></tr>
<tr><td>13</td><td>Regulator Fault</td><td>Output</td><td>Under normal operating conditions, output is pulled low. However, when the laser cannot be turned on because of faulty head or power supply operation, the output is inactive (high). Possible fault conditions are: plasma tube current exceeds the maximum safe operating limit; the plasma tube has run out of gas and cannot be filled; the power supply is defective.</td></tr>
<tr><td>14</td><td>Voltage Monitor</td><td>Output</td><td>This 0 to 5 V analog signal represents plasma tube voltage:
• 0 to 316 V for 2060
• 0 to 1000 V for 2080.</td></tr>
<tr><td>15</td><td>Current Monitor</td><td>Output</td><td>This 0 to 5 V analog signal represents 0 to 100 A plasma tube current.</td></tr>
<tr><td>16</td><td>Power Monitor</td><td>Output</td><td>This 0 to 5 V analog signal represents optical output from 0 W to a full-scale value determined by the active power range.
Power Monitor (0 to 5 V) — Power Range
0 to 0.316 W — 0.3 W
0 to 1.0 W — 1.0 W
0 to 3.16 W — 3.0 W
0 to 10.0 W — 10 W
0 to 31.6 W — 30 W
0 to 100.0 W — 100 W</td></tr>
<tr><td>17</td><td>Buffered +5 V REF</td><td>Output</td><td>+5 V reference (10 mA maximum)</td></tr>
<tr><td>18</td><td>GND</td><td>Output</td><td>Model 2580 power supply digital ground</td></tr>
<tr><td>19</td><td>Current Control</td><td>Input</td><td>This 0 to +5 V full-scale command signal selects the desired plasma tube current when the laser is operated in current mode (pin 6 inactive) and under remote control (pin 3 low). It may be used to manually select the current set point when connected to the wiper arm of a 10 kW potentiometer. Connect the other two terminals of the potentiometer to Buffered +5 V REF (pin 17) and CMD CMN (pin 37). Full-scale value of the command signal represents 100 A plasma tube current.</td></tr>
<tr><td>20</td><td>Premon0</td><td>Output</td><td>One of three outputs that monitor power range selection. Output signals on pins 20, 21, and 26 together indicate the power range according to the following table:
Premon2 (Pin 26) — Premon1 (Pin 21) — Premon0 (Pin 20) — Power Range
Low — Low — High — 0.3 W
Low — High — Low — 1.0 W
Low — High — High — 3.0 W
High — Low — Low — 10 W
High — Low — High — 30 W
High — High — Low — 100 W</td></tr>
<tr><td>21</td><td>Premon1</td><td>Output</td><td>One of three outputs that monitor power range selection (see pin 20 description).</td></tr>
</table>

Pin	Name	Type	Description
22	Digital Input Common	Input	Current sources for optically coupled logic input signals on pins 3, 4, 5, 6, 7, and 8. Requires a +5 V pull-up at 50 mA, which may be taken from pins 23, 24, or 27.
23	+5 V	Output	+5 V dc at 500 mA (maximum current available to combined output pins 23, 24, and 27).
24	+5 V	Output	See pin 23 description.
25			Not used
26	Premon2	Output	One of three outputs that monitor power range selection (see pin 20 description).
27	+5 V	Output	See pin 23 description.
28	+12 V	Output	+12 V dc at 50 mA (max).
29	–12 V	Output	–12 V dc at 50 mA (max).
30	Tube Fill Status	Output	When inactive (high), low gas pressure is indicated and the, plasma tube is in need of a fill. If AUTOFILL is on, or if gas pressure is lower than the safety level, the system will fill the tube. When repeatedly pulled high and low (1 Hz square wave), an empty gas reservoir is indicated and the tube can no longer be operated. When held constantly low, gas pressure is sufficient.
31	Remote Emission Indicator	Output	When pulled low, the laser is turned on and, following an initial 15 sec warm-up delay, is capable of emitting light. If inactive (high), the laser is turned off.
32	P.S. Type	Output	Reserved
33	Modemon	Output	Monitors the control mode selection.When pulled low, power mode is selected. If inactive (high), current mode is selected.
34	Monitor Jack	Input	Signal input to the monitor jack located on the Model 2580 power supply connector panel.
35	REF GND	Output	Common reference return line for output signals Voltage Monitor (pin 14), Current Monitor (pin 15), Power Monitor (pin 16), Buffered +5 V REF (pin 17), and for Monitor Jack (pin 34).

<table>
<tr><th>Pin</th><th>Name</th><th>Type</th><th>Description</th></tr>
<tr><td>36</td><td>Power Control</td><td>Input</td><td>This 0 to +5 V full-scale command signal selects the desired optical output when the laser is operated in the power mode (pin 6 low) and under remote control (pin 3 low). It may be used to manually select the power set point when connected to the wiper arm of a 10 kΩ potentiometer. Connect the other two terminals of the potentiometer to Buffered +5 V REF (pin 17) and CMD CMN (pin 37). Full-scale value of the command signal is determined by active power range as follows:

Power Control (0 to 5 V) — Power Range
0 to 0.316 W — 0.3 W
0 to 1.0 W — 1.0 W
0 to 3.16 W — 3.0 W
0 to 10.0 W — 10 W
0 to 31.6 W — 30 W
0 to 100.0 W — 100 W</td></tr>
<tr><td>37</td><td>CMD CMN</td><td>Input</td><td>Common reference return line for command signals Current Control (pin 19) and Power Control (pin 36).</td></tr>
</table>

Chapter 7 Model 2680 Computer Interface

Functional Overview

The Model 2580 power supply may optionally include the Model 2680 computer interface (CI) which is designed especially for interfacing Spectra-Physics lasers to computers through either an RS-232-C or IEEE 488 interface. When installed, these interfaces are available on the connector panel of the power supply (Figure 7-1).

To use the computer interface while the Model 2470 remote control module is connected to the power supply, the REMOTE/COMPUTER switch on the remote control must be set to COMPUTER. The remote control meter readings and status indicators will continue to monitor operation while operating under computer control.

Note

If all power range indicators on the remote control module are off after setting the REMOTE/COMPUTER switch to COMPUTER, the Model 2680 computer interface has not been initialized. Refer to "Interface Initialization" in this chapter for instructions.

Computer Control and Diagnostic Functions

The following control and diagnostic functions are available when the power supply is operated under computer control:

Control functions

- turn the plasma current on and off
- select either *current* or *power* mode
- select power range:
  - 0.3 W
  - 1.0 W
  - 3.0 W
  - 10.0 W
  - 30.0 W
  - 100.0 W
- regulate plasma current or optical output
- turn the autofill system on or off
- enable/disable BeamLok active beam position control

Diagnostic functions

- monitor tube voltage, current, and optical output
- monitor interlock, regulator, and tube fill status
- monitor power range selection, autofill board DIP switch status, and +5 V_{dc} reference signal
- monitor BeamLok beam position or actuator range

Power Supply Connectors

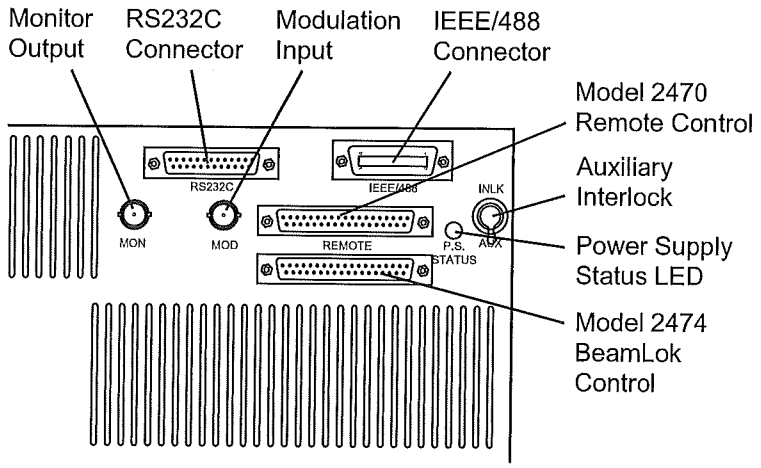


Figure 7-1: Model 2580 Power Supply Connector Panel

RS-232-C receptacle—accepts an RS-232-C connector for computer or terminal-controlled operation (Figure 7-1).

IEEE 488 receptacle—accepts an IEEE 488 connector for computer-controlled operation (Figure 7-1).

Commands

Only five commands are needed for the CI to perform all control and monitoring functions in the power supply:

- **CONFIGURE**—used to initialize the CI for computer use.
- **WRITE**—turns plasma current on or off, selects *current* or *power* mode, selects the power range, enables autofill, and turns BeamLok on.
- **READ**—monitors the tube gas pressure, the interlocks, and the overcurrent status lines.
- **SET**—sets the current or light output level.
- **SAMPLE**—measures tube voltage and current, optical output, BeamLok position and range, and the +5 V_{dc} reference.

The following sections explain how to use these commands to query system status and control system functions.

Command Set Summary

The following CI commands are used to execute control or measurement functions in the Model 2580 power supply.

CONFIGURE 6, OUT, NON	Initialize system, part 1
CONFIGURE 7, OUT, NON	Initialize system, part 2
READ 4	Monitor interlock status (key switch, cover, flow, temperature)
READ 5	Monitor interlock status (auxiliary, regulator fault) and autofill switch setting
SAMPLE 1	Measure tube voltage
SAMPLE 2	Measure tube current
SAMPLE 3	Measure optical output power
SAMPLE 4	Measure +5 V reference
SAMPLE 5	Monitor tube fill
SAMPLE 6	Measure beam position or actuator x-axis range
SAMPLE 7	Measure beam position or actuator y-axis range
SAMPLE 8	Multiplexed data byte
SET 1, n (n = 0 to 250)	Set current
SET 2, n (n = 0 to 250)	Set power
WRITE 6, 8	Select current mode
WRITE 6, 1	Select power mode, 0.3 W range
WRITE 6, 2	Select power mode, 1.0 W range
WRITE 6, 3	Select power mode, 3.0 W range
WRITE 6, 4	Select power mode, 10 W range
WRITE 6, 5	Select power mode, 30 W range
WRITE 6, 6	Select power mode, 100 W range
WRITE 7, 7	Turn laser off
WRITE 7, 6	Turn laser on (with autofill enabled)
WRITE 7, 14	Turn laser on (with autofill disabled)
WRITE 7, 4, WRITE 7, 0	Toggle BeamLok on or off (with plasma on and autofill enabled)

Sample Program Listings

Appendix A contains two sample program listings written in generic GW BASIC. The first, "EXAMPLES.BAS," contains uncommented routines for running specified tasks. The second, "LASER.BAS," is offered as a demonstration/tutorial, complete with introduction and commented code listing. Both programs may be used, modified or unmodified, to run your BeamLok 2060 or 2080 laser. They are available on 5 1/4 in. IBM-formatted floppy disks from Spectra-Physics Lasers, part number 0446-3560.

Status Commands

SAMPLE a

The "SAMPLE a" command, where a is a value of 1 to 8, queries eight system monitors. The value returned will be a decimal number from 0 to 250. Use the following equation to determine the value of the system function measured:

$$V = \frac{\text{response x multiplier}}{250}$$

where V is the actual value of the system function measured, response is the value returned by the "SAMPLE a" command, and multiplier is the value from Table 7-1 for the system function polled.

"SAMPLE 3"—returns a value dependant on the Power Range previously set (see "Control Commands: WRITE p, n" below).

"SAMPLE 5"—returns a value that is a converted logic signal. A value greater than "128" indicates a fill is required. A value less than "100" indicates normal operation: no fill required. When this signal toggles continuously (1 Hz square wave), an empty gas reservoir or mechanical malfunction is indicated.

Warning! 

If the signal is toggling, the tube is well below its normal operating pressure and may destroy itself. If there is a mechanical malfunction, e.g., someone disconnected the fill solenoid, the tube will be needlessly destroyed. Turn off the system and call Spectra-Physics Lasers.

"SAMPLE 6" along with "SAMPLE 7" returns decimal values that indicate the X and Y-axis position of the beam through the aperture when BeamLok is off (unlocked). When it is on (locked), these values indicate the X and Y-axis position of the mirror positioning actuator. Refer to Table 7-2.

Table 7-1: SAMPLE a

Command	System Monitor	Range	Multiplier
SAMPLE 1	2060 Tube Voltage	0 to 316 V dc	316
	2080 Tube Voltage	0 to 1000 V dc	1000
SAMPLE 2	Tube current	0 to 100 A	100
SAMPLE 3	Output power	0 to 0.316 W or 0 to 1.0 W or 0 to 3.16 W or 0 to 10 W or 0 to 31.6 W or 0 to 100 W	.316 1 3.16 10 31.6 100
SAMPLE 4	+5 V dc reference	0 to 5 V dc	5
SAMPLE 5	Tube fill status	0 < 128 < 250	250
SAMPLE 6	BeamLok X-position, range	0 to 253	250
SAMPLE 7	BeamLok Y-position, range	0 to 253	250
SAMPLE 8	8-bit status byte	see Table 7-3	250

Table 7-2: BeamLok Display

Response Value	X-Axis Position/Range	Y-Axis Position/Range
250	Right Most	Top Most
148	Center	Center
45	Left Most	Bottom Most
0	Lost Signal	

The value returned for the "SAMPLE 8" command is a decimal status byte for the power range and BeamLok (on or off) setting. Use Table 7-3 below to interpret the status of these two functions.

Table 7-3: "SAMPLE 8" Decimal to Power Range and BeamLok Status Conversion

Response Value	Power Range (Watts)	BeamLok
32	0.3	Off
40	0.3	On
64	1.0	Off
72	1.0	On
96	3.0	Off
104	3.0	On
128	10	Off
136	10	On
160	30	Off
168	30	On
192	100	Off
200	100	On

READ a

The "READ a" command, where a is 4 or 5, queries the status of the eight system functions shown in Table 7-4 and Table 7-5. A decimal number from 0 to 15 is returned, representing a four-bit binary pattern.

Table 7-4: READ 4

Response Value	Water Temperature	Water Flow	Head Cover	Key Switch
0	Hot	Low	Open	Off
1	Hot	Low	Open	On
2	Hot	Low	Closed	Off
3	Hot	Low	Closed	On
4	Hot	Ok	Open	Off
5	Hot	Ok	Open	On
6	Hot	Ok	Closed	Off
7	Hot	Ok	Closed	On
8	Ok	Low	Open	Off
9	Ok	Low	Open	On
10	Ok	Low	Closed	Off
11	Ok	Low	Closed	On
12	Ok	Ok	Open	Off
13	Ok	Ok	Open	On
14	Ok	Ok	Closed	Off
15	Ok	Ok	Closed	On

Table 7-5: READ 5

Response Value	Fill SW 2	Fill SW 1	Regulator	Auxiliary Inlk.
0	Closed	Closed	Bad	Open
1	Closed	Closed	Bad	Closed
2	Closed	Closed	Ok	Open
3	Closed	Closed	Ok	Closed
4	Closed	Open	Bad	Open
5	Closed	Open	Bad	Closed
6	Closed	Open	Ok	Open
7	Closed	Open	Ok	Closed
8	Open	Closed	Bad	Open
9	Open	Closed	Bad	Closed
10	Open	Closed	Ok	Open
11	Open	Closed	Ok	Closed
12	Open	Open	Bad	Open
13	Open	Open	Bad	Closed
14	Open	Open	Ok	Open
15	Open	Open	Ok	Closed

Control Commands

SET p, n

The "SET p, n" command, where p is 1 or 2 and n is a decimal number from 0 to 250, sets either the tube current (p = 1) or the desired optical output (p = 2; refer to Table 7-6). Prior to sending this command the control mode (current or power) and power range (if p = 2) must be selected (see "WRITE p, n" and Table 7-7 below).

To set the current level:

SET 1, 0 = 0 A
SET 1, 125 = 50 A
SET 1, 250 = 100 A

Table 7-6: SET 2, n

		Range (Watts)					
		.316	1.0	3.16	10	31.6	100
SET 2, 0	(min)	0	0	0	0	0	0
SET 2, 50		0.06	0.2	0.63	2.0	6.32	20
SET 2, 100		0.13	0.4	1.26	4.0	12.64	40
SET 2, 150		0.19	0.6	1.90	6.0	18.96	60
SET 2, 200		0.25	0.8	2.53	8.0	25.28	80
SET 2, 250	(max)	0.32	1.0	3.16	10.0	31.60	100

WRITE p, n

The "WRITE p, n" command, where p is 6 or 7 and n is a decimal or binary number listed in Table 7-7 or Table 7-8, controls five system functions. "WRITE 6, n" sets the power range and control mode. "WRITE 7, n" enables or disables the autofill system, and turns BeamLok and the laser itself on or off. n may be specified as a decimal number from 0 to 14.

Table 7-7: WRITE 6, n

	Power Range	Control Mode
WRITE 6, 1	0.3 W	Power
WRITE 6, 2	1.0 W	Power
WRITE 6, 3	3.0 W	Power
WRITE 6, 4	10 W	Power
WRITE 6, 5	30 W	Power
WRITE 6, 6	100 W	Power
WRITE 6, 9	0.3 W	Current
WRITE 6, 10	1.0 W	Current
WRITE 6, 11	3.0 W	Current
WRITE 6, 12	10 W	Current
WRITE 6, 13	30 W	Current
WRITE 6, 14	100 W	Current

Table 7-8: WRITE 7, n

	Fill System	BeamLok	Plasma
WRITE 7,0	Enabled	0	On
WRITE 7,1	Enabled	0	Off
WRITE 7,4	Enabled	1	On
WRITE 7,5	Enabled	1	Off
WRITE 7,8	Disabled	0	On
WRITE 7,9	Disabled	0	Off
WRITE 7,12	Disabled	1	On
WRITE 7,13	Disabled	1	Off

Note



The BeamLok setting is a toggled function. It must be toggled from "0" to "1" to turn BeamLok **either on or off**, then toggled back to "0" before it is ready for the next toggle operation (if any). For example, if the fill system is enabled, with plasma current on and BeamLok off, and you want to turn BeamLok on, send the command "WRITE 7, 0" followed immediately by "WRITE 7, 4," "WRITE 7, 0." If BeamLok was already on, this procedure would turn it off.

Power Supply "On" Default Condition

When a Model 2580 power supply is first turned on, it defaults to the REMOTE connector as its primary interface, even if the power supply contains a CI. Therefore, either the Model 2470 remote control or a custom control device attached to this connector has primary control and CI controls are disabled.

To use the CI:

1. The REMOTE/COMPUTER switch on the Model 2470 remote control module must be set to COMPUTER.
2. If a custom control device is used, pin 3 of the REMOTE connector must be set to 5 V_{dc} (logic level high) or be allowed to float (open or tri-stated).
3. The CI must then be initialized.

Initializing the Interface

The CONFIGURE command is unique. It is only used at system start-up to initialize the CI. Two CONFIGURE commands are sent followed by two WRITE statements (refer to "Control Commands") to perform the initialization and to disable the REMOTE connector. Once initialized, only a computer or terminal connected through one of the CI interfaces can control the power supply.

These must be the first six lines of code:

```
PRINT #1, "CONFIGURE 6, OUTPUT, NONCLOCKED"
PRINT #1, "CONFIGURE 7, OUTPUT, NONCLOCKED"
PRINT #1, "WRITE 6, 9"
PRINT #1, "WRITE 7, 1"
```

The CI is now initialized to these settings:

Initialization Settings

Interface	Computer
Plasma Control	Off
Mode	Current
Power Range	0.3 W

Refer to your IEEE 488 controller manual for specific hardware set-up information and to your BASIC manual for information on BASIC command statements. Other programming languages may also be used.

IEEE 488 Interface

Operation

The IEEE 488 interface conforms to the ANSI/IEEE standard 488-1978 and comprises a user-supplied bus controller and from 1 to 32 I/O devices that are defined and addressed by the controller as *talkers*, *listeners*, or *talker-listeners*.

Talkers are input devices that can only monitor events and send data to the controller, e.g., digital voltmeters. They "talk" to the controller. Conversely, listeners are output devices that "listen" to the controller and send signals from it to the real world, e.g., digital to analog converters (DACs). Talker-listeners operate in both directions. The CI is just such a device. When the CI is properly programmed, the controller will execute data transfers to and from it via the IEEE 488 bus.

Command strings sent from the controller to the CI need to be terminated by a comma (,) or line feed (<LF>). Unlike some IEEE 488 interfaces, the CI does not require the END command to terminate messages to it (refer to "Message Formats" below).

Nevertheless, to conform with controllers programmed to recognize the END command, the CI sends it to terminate all data transfers from the CI.

Remote Reset

The CI can be reset to the power-on default state any time by sending it either a Device Clear (DCL) or Select Device Clear (SDC) bus message, or Interface Clear (IFC) bus reset. Refer to "Power supply 'On' Default Condition" above and to your controller's user manual for details.

Note

After receiving a DCL or SDC command, or IFC signal, the CI takes about 0.5 sec to reinitialize. Therefore, the controller must not send messages to the CI during this time. Programs will require a delay routine immediately following any reset command.

Serial Poll Status Byte

The CI responds to the IEEE 488 controller's Serial Poll Enable (SPE) message by returning a status byte indicating (a) the execution status of the last command received, and (b) the version number of the CI firmware (used for factory diagnostic purposes). Figure 7-2 shows the composition of the status byte. This status byte is provided primarily to facilitate error masking and recovery. This feature is standard on all IEEE 488 controllers.

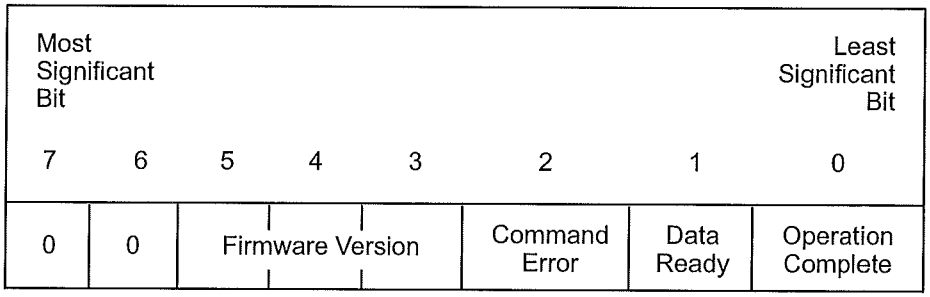


Figure 7-2: Diagram of the serial poll status byte indicating the function of each bit.

Bit 0 is set (1) when the CI finishes executing a command. It is reset (0) during the execution of a command.

Bit 1 is set when the CI has finished executing the SAMPLE or READ command, and response data is ready for output to the controller. It is reset when the CI has finished sending the response to the controller. (The SAMPLE and READ commands are defined in the "Commands" section above.)

Bit 2 is set when an error is detected in the command line, and the CI has aborted the command.

Bits 3, 4, and 5 indicate the firmware version as a three-bit binary number. Bit 5 is the most significant bit.

Bits 6 and 7 are always zero.

The IEEE 488 controller performs a serial poll of the CI by executing an SPE command. The CI will automatically respond by sending back the status byte.

Note



Each IEEE 488 controller manufacturer has its own way of querying the input device for the serial status byte. Refer to your IEEE 488 controller hardware manual for samples of BASIC statements to be used.

The following is a BASIC statement used by the *IO-Tech Personal 488 GPIB Controller Card*:

```
.
.
Print #1, "SPOLL"
Input #2, A$
.
```

Print in the above example is a BASIC output statement. The controller attached to the CI has been designated device #1 for output. "SPOLL" is the SPE command that causes its controller to request a status byte. Refer to your IEEE 488 controller manual for specific I/O device setup information and command language.

Input in the above example is a BASIC input statement. The controller attached to the CI has been designated device #2 for input, even though only one controller card is likely to be used for both input and output. The requested status byte is read into the IEEE 488 controller as BASIC variable "A$."

SW_2 DIP Switch Setting

The CI IEEE 488 hardware interface is easy to configure. Simply select a device address that is different from that of all other devices attached to the same bus. DIP switch SW_2 on the CI pc board sets the address from 0 to 31. The factory setting is 25. Table 7-9 lists the possible switch settings. Figure 7-3 shows the location of DIP switch SW_2 on the CI pc board.

Table 7-9: SW_2 DIP Switch Settings for Selecting Device Address

Switch Number	1	2	3	4	5
Bit Weight	16	8	4	2	1
Factory Setting (25)	On (16)	On (8)	Off	Off	On (1)

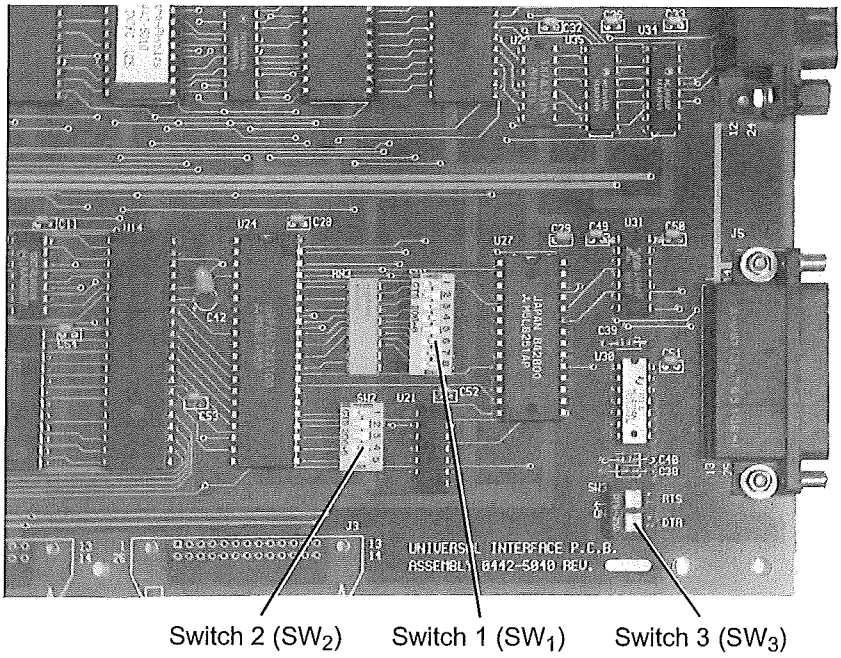


Figure 7-3: Model 2680 Computer Interface PC Board

RS-232-C Interface

Operation

The RS-232-C interface standard classifies serial I/O devices as either Data Terminal Equipment (DTE) or Data Communications Equipment (DCE). The standard further identifies a serial connector as a 25 pin, D-sub type, and defines its 25 pins as various data and control lines. However, the standard does not narrowly define each of these signals and, unfortunately, manufacturers of serial I/O devices have provided incompatible definitions. As a result there is no guarantee that any two devices will communicate with each other until all hardware and data format settings have been configured to match the requirements of the mating device.

The serial interface of the CI is an RS-232-C compatible interface configured to emulate DCE equipment. Signal inputs and outputs of the serial interface are likely to be compatible with most computers and terminals configured as DTE equipment. If the CI is connected to another DCE device, an interface cable adapter that switches the data signal lines, pin 2 with pin 3, and control signal lines, pin 4 with pin 5, is usually all that is needed to make the devices compatible.

The following diagram shows the interface signals and interconnections used by the CI. The data link signals are named relative to the DTE.

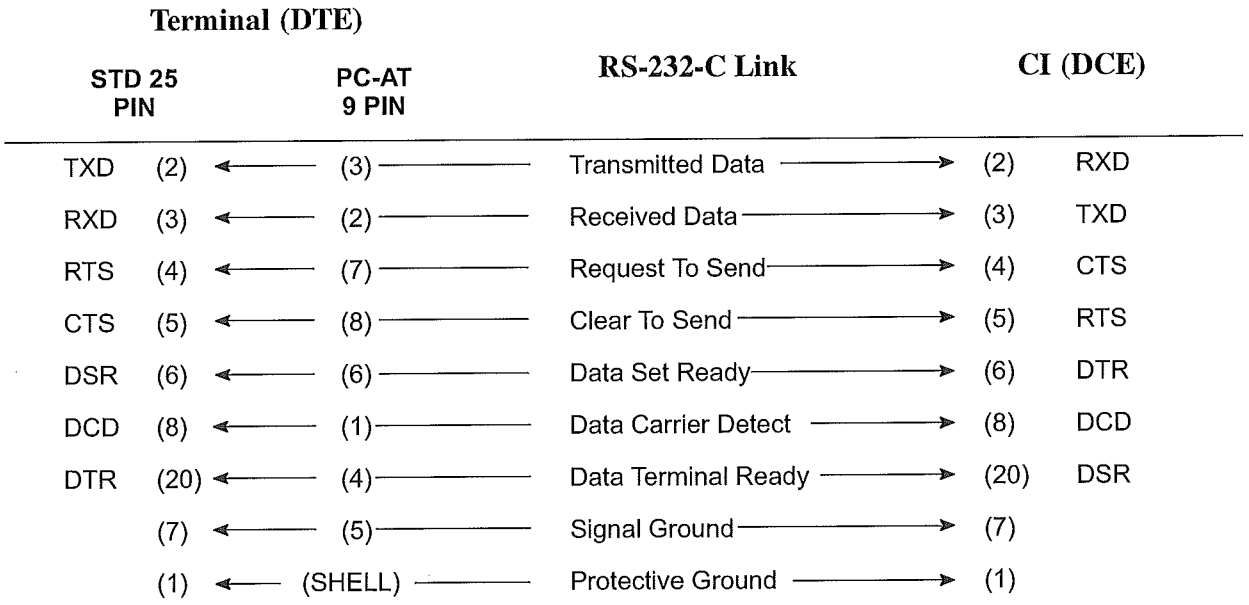


Figure 7-4: Standard RS-232-C Interconnections

Data Transfer and Handshaking

The RS-232-C serial interface operates in the full duplex mode: data may be sent and received simultaneously. To synchronize data transmissions with the RS-232-C controller, the CI implements a simple hardware handshaking protocol, monitoring and controlling the interface signals in the manner described below. Interface signals are named relative to the data terminal device (DTE).

DATA TERMINAL READY *and* REQUEST TO SEND—the CI checks both of these lines when it has response data to send. It sends data only when both signals are high (1).

DATA SET READY, CLEAR TO SEND *and* DATA CARRIER DETECT—the CI keeps these lines high at all times; thus, it is always ready to receive commands from the RS-232-C controller.

SW_1 DIP Switch Setting

Both the CI and the RS-232-C controller must be configured to send and receive data at the same rate. Positions five through eight of DIP switch SW_1 on the CI pc board (Table 7-10) set the bit transmission (BAUD) rate for the CI. Match the controller baud rate to the chosen CI rate. The factory setting for the CI is 4800 baud.

Table 7-10: SW_1 Baud Rate Settings

Switch Number	Switch Position*								
5	Off	Off	Off	Off	Off	Off	Off	Off	On
6	Off	Off	Off	Off	On	On	On	On	Off
7	Off	Off	On	On	Off	Off	On	On	Off
8	Off	On	Off	On	Off	On	Off	On	Off
Baud Rate	75	110	150	300	600	1200	2400	4800	9600

** On = closed, Off = open*

There are also three data format settings on the two communications devices that must match: character length, parity, and stop bit(s) (Table 7-11). SW_1 also sets these parameters. The factory setting is eight-bit character length, parity disabled (odd/even is ignored), and two stop bits.

Table 7-11: SW_1 Mode Select Settings

Switch	Switch Position	Condition	Switch Position	Condition
1	Off*	Parity Disabled	On	Parity Enabled
2	Off*	Odd Parity	On	Even Parity
3	Off	One Stop Bit	On*	Two Stops Bits
4	Off	Seven Bits per Character	On*	Eight Bits per Character

** Default factory setting*

SW_3 DIP Switch Setting

DIP switch SW_3 on the CI (Figure 7-3) is used to force the Data Terminal Ready (DTR) and Request To Send (RTS) signals high (1). This may be necessary because some computers or terminals ignore one or both signals. If so, the appropriate signal(s) must be set high to enable communications between the two devices. To force these lines high, set the appropriate switch(s) on SW_3 to the "on" (or closed) position.

Message Formats

Command Format

Information in this section applies for both the IEEE 488 and RS-232-C interfaces.

Commands are strings of ASCII characters the computer or terminal sends to the CI. The string consists of the command word plus one or two data elements:

<command word><data><LF>

<command word><data>,<data><LF>

For each command word, the CI expects to find appropriate data or keyword elements following it. Data is always in **integer** form, and must be in the range from 0 to 255 (refer to "Commands" earlier in this chapter).

Commands and keywords are reserved words that have unique meaning to the CI and can only be used for narrowly defined purposes.

A command string also includes the comma (,) and line feed (<LF>) delimiter characters to separate command elements and to terminate each command. These delimiters may be used interchangeably. Typically, the comma is used between elements of a command with <LF> used to terminate the command. The delimiter between the command word and the element(s) following may be omitted.

Command words and keywords may contain either upper or lower case alpha characters. Spaces and all nonprintable characters, except <LF>, are ignored by the CI. Consecutive delimiters are interpreted as a single delimiter; all but the first are ignored.

Examples:

SET 1, 127<LF>

SET,2,250<LF>

WRITE4,9,WRITE5,6<LF>

The use of delimiters permits simple message formatting, allowing entry from either a terminal or computer program.

When entered from a terminal, they may take the following form:

SET 1, 127 <CR><LF>

If executed from a program, they may look like this:

```
10 A$ = "SET"
20 B = 1
30 C = 127
40 OUTPUT A$,B,C
```

Command words and keywords may be abbreviated (Table 7-12), but they must include at least the first three characters. Whether spelled out or abbreviated, they must be spelled correctly or they will be aborted.

Table 7-12: CI Command Abbreviations

Command Word	Shortest Abbreviated Form Acceptable
CONFIGURE	CON
READ	REA
SAMPLE	SAM
SET	SET
WRITE	WRI
Keywords used with the CONFIGURE Command	
OUTPUT	OUT
NONCLOCKED	NON

An input error occurs if any part of the command is invalid, e.g., a misspelled command word or keyword, a data value out of range, or an incorrect number of elements in the command. When an input error is detected, the CI aborts and waits for a new command. Bit 2 of the IEEE 488 interface status byte register is set (1). Refer to "IEEE 488 Interface: Serial Poll Status Byte," in this chapter.

Response Format

After executing a SAMPLE or READ command, the CI sends the requested data to the computer followed by a carriage return and line feed:

<response> <CR> <LF>

The CI also sends the END message to terminate transmission if the IEEE 488 interface is used.

Chapter 8 Maintenance

The condition of the laboratory environment and the amount of time the laser is used will affect your periodic maintenance schedule. Do not allow smoking in the laboratory; the optics will stay clean much longer. Condensation due to excessive humidity can also contaminate the optical surfaces. The cleaner the environment, the slower the rate of contamination.

Notes on the Cleaning of Laser Optics

Ion lasers are oscillators that operate with gain margins of a few percent. Losses due to unclean optics, which might be negligible in ordinary optical systems, can disable a laser. Dust on mirror surfaces can reduce output power or cause total failure. Cleanliness is, therefore, essential. The maintenance techniques used with laser optics must be applied with extreme care and with attention to detail.

"Clean" is a relative description; nothing is ever perfectly clean, and no cleaning operation ever completely removes contaminants. Cleaning is a process of reducing objectionable materials to acceptable levels.

Since cleaning simply dilutes contamination to the limit set by solvent impurities, solvents must be as pure as possible. Leave as little solvent on the surface as possible. As any solvent evaporates, it leaves impurities behind in proportion to its volume. Avoid rewiping a surface with the same lens tissue; a used tissue and solvent will redistribute contamination, they won't remove it.

Always use fresh solvent. Both methanol and acetone collect moisture during prolonged exposure to air. Avoid storage in bottles where a large volume of air is trapped above the solvent. Instead, store solvents in small glass bottles where either the solvents are used up quickly or the bottles are filled frequently from a fresh, uncontaminated source.

Laser optics are made by vacuum depositing microthin layers of materials of varying indices of refraction on glass substrates. If the surface is scratched to a depth as shallow as 0.01 mm, the operating efficiency of the optical coating will be reduced significantly.

Because an intracavity passive catalyst is used in the BeamLok laser, there should be little requirement for optical cleaning if the cavity is left closed and undisturbed. However, because optics are exchanged from time to time, there will be occasions when cleaning is necessary.

Stick to the following principles whenever you clean any optical surface.

- Remove and clean one optic at a time. If all of the optics are removed and replaced as a group, all reference points will be lost, making realignment extremely difficult.
- Work in a clean environment, over an area covered by a soft cloth or pad, if possible.
- Wash your hands thoroughly with liquid detergent. Body oils and contaminants can render otherwise fastidious cleaning practices useless.
- Use dry nitrogen, canned air, or a rubber squeeze bulb to blow dust and lint from the optic surface before cleaning it with solvent. Permanent damage may occur if dust scratches the glass or mirror coating.
- Use spectroscopic-grade solvents. Don't try to remove contamination with a cleaning solvent that may leave other impurities behind.
- Use powder-free, clean latex cloves or finger cots.
- Use Kodak Lens Cleaning Paper™ or equivalent to clean optics and plasma tube windows. Use each piece only once: dirty tissue merely redistributes contamination, it does not remove it.

Warning! 

Do not use lens tissue designated for cleaning eye glasses. Such tissue contains silicones. These molecules bind themselves to the mirror coatings and window quartz and can cause permanent damage. Also, do not use cotton swabs, e.g. Q-Tips™. Solvents dissolve the glue used to fasten the cotton to the stick, resulting in contaminated window coatings. Only use photographic lens tissue to clean optical components.

Equipment Required

Some of the following are supplied in the accessory kit.

- dry nitrogen, canned air, or rubber squeeze bulb
- plastic hemostat
- $^1/_{16}$ in. hex driver
- clean (new) finger cots or powder-free latex gloves
- Kodak Lens Cleaning Paper,™ or equivalent

Danger! 

Do not use a metal hemostat or forceps for cleaning optics or windows. There is danger of electrocution when using these instruments inside the laser head. Use the plastic hemostat provided.

Cleaning Solutions Required

- spectroscopic-grade acetone or methanol

Methanol tends to clean better but may deposit a water-based film on the surface being cleaned if not fresh. If this occurs, follow the methanol wipe with an acetone wipe to remove the film. As always, use fresh solvent from a bottle with little air in it.

General Procedures for Cleaning Optics

The laser should be on and stable. Remove, clean, and replace one optic at a time, maximizing laser output power after each optic is cleaned. Use clean finger cots to protect all intracavity components, including the coated mirror surface.

Do not allow the cavity to remain open for very long. The intracavity passive catalyst that reduces O_3 in the cavity will become contaminated, and therefore ineffective. Keep the output coupler and high reflector (or prism) locked in place, and make sure the tubular cavity seals are in place. Following these simple rules will guaranty long life of the catalyst.

The high reflector, the prism (when present), and the routing mirror in the BeamLok assembly can be left in its holder for cleaning. However, the output coupler (OC) and the beam splitter must be removed from their holders to clean the second surface.

1. Use a squeeze bulb, dry nitrogen, or canned air to clean away any dust or grit before cleaning optics with solvent.
2. Whenever possible, clean the optic using the "drop and drag" method (Figure 8-1).

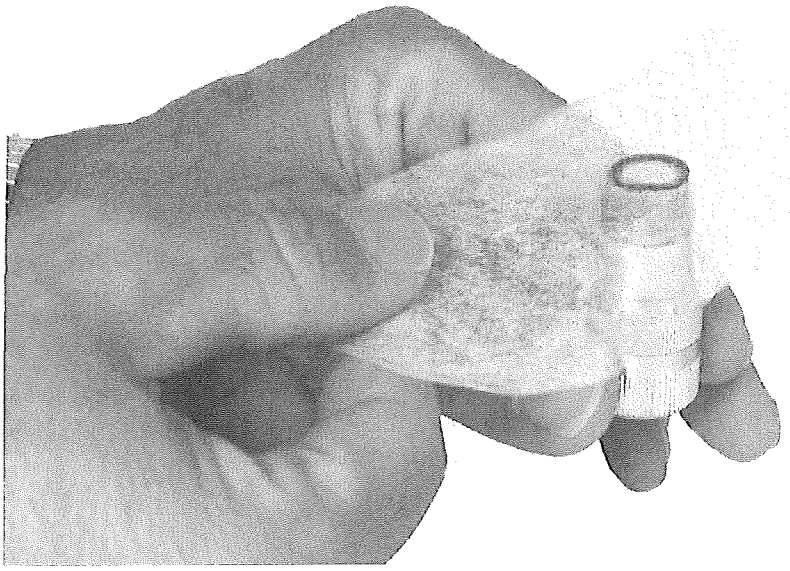


Figure 8-1: Cleaning the Mirror Surface

a. Hold the optic horizontal with its coated surface up. Place a sheet of lens tissue over it, and squeeze a drop or two of acetone or methanol onto it.

b. Slowly draw the tissue across the surface to remove dissolved contaminants and to dry the surface.

   Pull the tissue slow enough so the solvent evaporation front follows the tissue, i.e., the solvent dries only after leaving the optic surface.

3. For stubborn contaminants and to access hard-to-reach places, use a tissue in a hemostat to clean the optic.

   a. Fold a piece of tissue in half repeatedly until you have a pad about 1 cm (0.5 in.) square, and clamp it in a plastic hemostat (Figure 8-2).

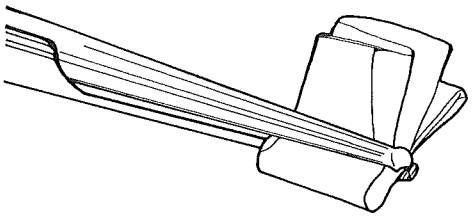


Figure 8-2: Lens Tissue Folded for Cleaning

Caution! 

While folding, *do not touch* the surface of the tissue that will contact the optic, or you will contaminate the solvent.

   b. If required, cut the paper with a solvent-cleaned tool to allow access to the optic.

   c. Saturate the tissue with acetone or methanol, shake off the excess, resaturate, and shake again.

   d. Wipe the surface in a single motion.

      Be careful that the hemostat does not touch the optic surface or the coating may be scratched.

4. After placing the optic you just cleaned in the beam, inspect it to verify the optic actually got cleaner, i.e., you did not replace one contaminant with another.

Cleaning Mirrors

During the following procedure, we will refer to acetone when cleaning, but methanol can be used as well.

1. Close the shutter.
2. Remove the high reflector holder (non-prism holder).
3. Clean the coated surface following the procedure under "General Procedures for Cleaning Optics," steps 1 and 2, above.
4. Install the mirror holder.
5. Open the shutter.
6. Adjust the mirror mounts for maximum optical output power.
7. Close the shutter.
8. Remove the output coupler.

   Because the output coupler mounts between the BeamLok beam position detector and its actuator, the BeamLok assembly must be opened to access the output coupler. Unfasten the bail clamp and swing the assembly out of the way.
9. Remove the optic from its holder (simply pull it out), and clean the output surface following the procedure under "General Procedures for Cleaning Optics," steps 1 and 2, above.
10. Place the optic back into its holder.

    The arrow on the side of the optic points to the coated side which must face the cavity.
11. Clean the cavity surface in the same manner.
12. Install the mirror holder.
13. Close the BeamLok assembly and latch the bail.
14. Open the shutter.
15. Adjust the mirror mounts for maximum optical output power.

This completes the procedure for cleaning the mirrors.

Cleaning the Prism Assembly

The laser should be on and stable.

1. Close the shutter.
2. Remove the prism assembly from the laser.
3. Remove the protective housing cap.

   There are two prism systems available for the BeamLok laser. One is a low-expansion prism and its protective cap is white (P/N 0447-9940); the other is the standard prism and its cap is black (P/N 0428-6086).

a. If yours is white, unscrew the single captive screw in the center of the protective cap until it is loose.

b. If yours is black, unscrew the knurled retaining ring on the input end of the protective cap.

c. Grasp the locking cam and pull the prism assembly from the cap.

4. Remove the high reflector.

   The white unit has a clip holding the high reflector in place from the rear (Figure 8-3). It can be moved out of the way by hand. The black unit has a small screw holding a mirror-retaining spring in place. Loosen the screw using a hex driver, then push the spring to the side of the mirror. Invert the assembly and drop the mirror onto a soft surface. *Do not touch the optic or its holder with your fingers; wear clean finger cots or powder-free latex gloves.*

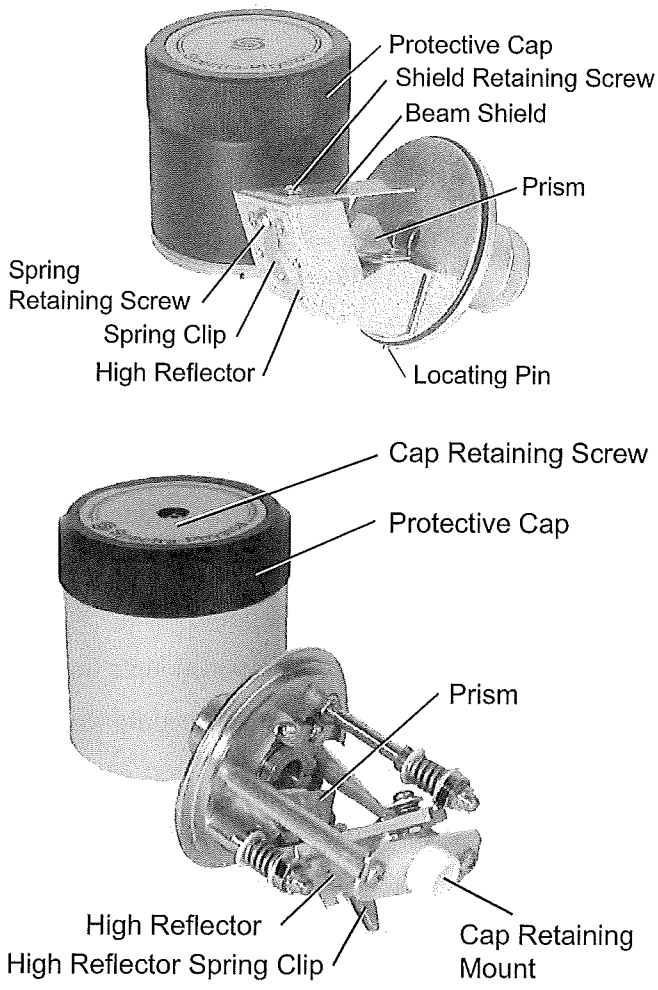


Figure 8-3: BeamLok Single-line Prism Assemblies

5. Clean the high reflector.

   Clean the coated intracavity surface following the procedure under "General Procedures for Cleaning Optics," steps 1 and 2, above.

6. Install the high reflector in its holder.

   The arrow on the barrel of the optic points to the coated surface and should face the cavity. Once the mirror is in the holder, slide the retaining spring back into place. Tighten the screw if you have a black unit.

7. Expose the prism.

   Both white and black units have a screw holding the prism shield in place. Loosen the screw and rotate the shield out of the way. Do not remove the prism: it can be cleaned in its mount.

8. Install the prism assembly in the laser.

Danger!
Laser Radiation

When the prism assembly is installed with its cover off and shield displaced, be aware that a portion of the intracavity beam is reflected upward from each face of the prism (Figure 8-4). Avoid eye contact with these beams.

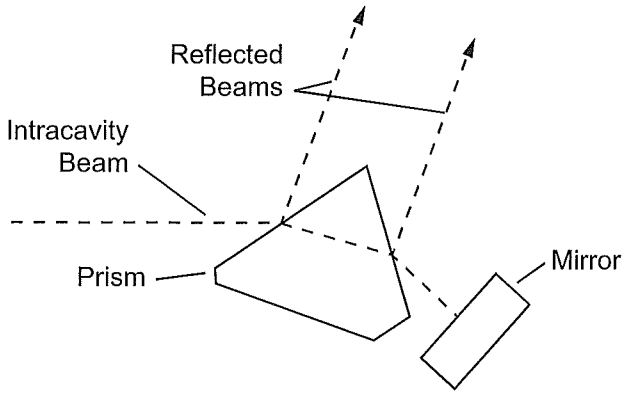


Figure 8-4: A portion of the intracavity beam is reflected upward from each face of the prism.

9. Open the shutter.

10. Clean the prism surfaces.

    Clean the coated surfaces following the procedure under "General Procedures for Cleaning Optics," steps 1 and 3, above.

    a. Wipe one surface—bottom to top—in a single motion. Be careful that the tip of the hemostat does not scratch the surface.

    b. Repeat, *with a fresh tissue,* on the second prism surface.

A clean prism surface will scatter little or no light when the laser is operating.

11. Close the shutter.
12. Remove the prism assembly from the laser.
13. Return the prism shield to its normal position and tighten the screw to secure it.
14. Install the prism assembly into its protective cap.
    a. Slide the prism assembly into its cap, mating the notch on the edge of the cap with the pin on the underside of the prism assembly.
    b. If you have a white unit, secure the cap in place by tightening the captive screw in the center of the cap. Do not over-tighten.
    c. If you have a black unit, secure the cap in place by installing the retaining ring and screwing it onto the assembly. *Be careful not to cross-thread the ring.* To be safe, turn the ring ccw until you hear a click—the alignment of the screw threads, then turn it cw until tight. Do not over-tighten.
15. Install the prism assembly in the laser.
16. Open the shutter.
17. Adjust the high reflector vertically and horizontally for maximum optical output power.

This completes the procedure for cleaning the prism assembly optics.

Cleaning Plasma Tube Windows

Danger! 

The following procedure requires removal of the laser head cover and defeating its safety interlock. Dangerous laser radiation is accessible when cavity seals are pulled back; therefore, permit only trained personnel to service and repair your laser system.

Warning! 

If specified power cannot be achieved after an acetone or methanol/acetone cleaning of all optical components, stop. Further scrubbing may damage the surface. Call your Spectra-Physics Lasers service representative.

Warning!

Perform the following procedure only if, after the mirrors have been cleaned and the output power maximized, the laser still does not meet specified power.

1. Turn off the laser.
2. Expose the windows.

Caution!

Do not touch the interior of any intracavity components with your fingers, including the endbell shroud. Contaminants left on these surfaces will migrate to the windows later. Always wear clean, powder-free latex gloves or finger cots.

Slide the cavity seals toward the plasma tube until the windows are totally exposed. Remove the dust tube if you need to by unscrewing it from the mirror mount.

3. Clean the windows.

   Clean the coated surfaces following the procedure under "General Procedures for Cleaning Optics," steps 1 and 3, above. Wipe windows—bottom to top—in a single motion. Be careful that the tip of the hemostat does not scratch the surface.

   Do not let solvent wick between the window and the shroud (Figure 8-5).

4. Check output power level.

   Restart the laser and allow it to warm up. If the laser meets specified power, stop—you are done. If it does not meet specified power, call your service representative.

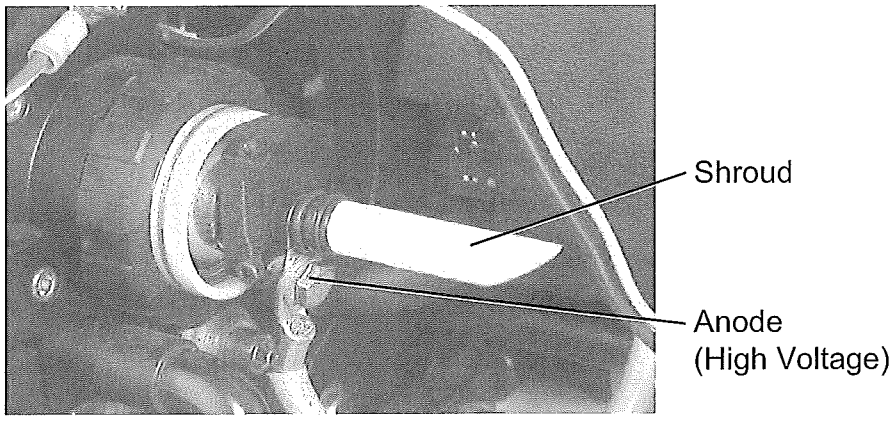


Figure 8-5: Plasma Tube Endbell Showing Shroud

Cleaning the BeamLok Beam Splitter and Routing Mirror

1. Unscrew the optics adapter from the front of the beam splitter housing (Figure 8-6).
2. Remove the plastic shroud (3 screws).
3. Remove the beam splitter to gain access to the BeamLok routing mirror.

   Remove the beam splitter bezel using the beam splitter removal tool found in the accessory kit. (Fit the "T"-shaped tool into the two notches in the bezel and turn ccw.)

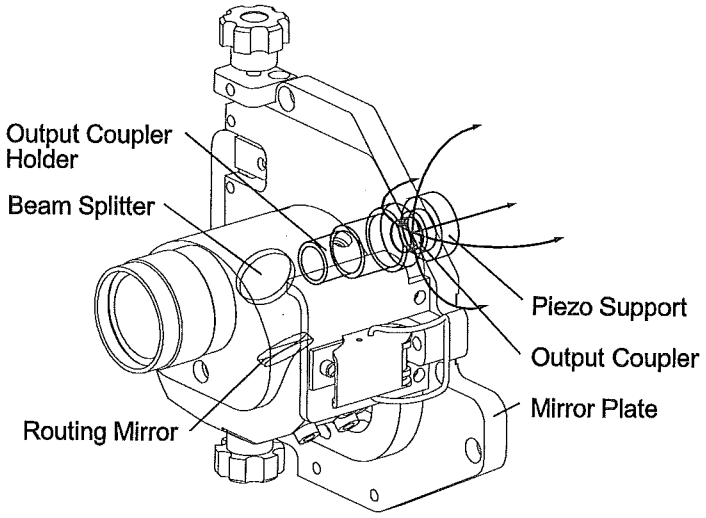


Figure 8-6: BeamLok Module.

4. Clean the routing mirror in place (located inside the housing) following the procedure under "General Procedures for Cleaning Optics," steps 1 and 3, above.

   Wipe the optic—bottom to top—in a single motion. Be careful that the tip of the hemostat does not scratch the surface.
5. Clean both sides of the beam splitter.
6. Install the beam splitter.
7. Install the plastic shroud.
8. Install the optics adaptor.
9. Align BeamLok as outlined in chapter 6.

This completes the procedure for cleaning the BeamLok beam splitter and routing mirror.

Replacing the Water Filter

The water filter is located in an in-line filter assembly that is usually hard plumbed into the source water supply line. The filter housing originally supplied with your laser is light blue with a black cover.

1. Shut off the water supply.

   Shut off the return line as well if you are using a closed-loop cooling system.

2. Place a bucket or container under the filter to catch any spilled water.
3. Press the button on top of the filter cover to release internal pressure.
4. Unscrew the lower blue filter housing from the assembly.
5. Remove the used, filament-wound filter.
6. Make sure the O-ring in the cover is clean and is seated evenly in its groove.
7. Insert a new filter into the housing. Verify the new filter is a 25 µ filter. Use a Spectra-Physics Lasers filter (P/N 2604-0070) or equivalent.
8. Screw the housing into the cover.
9. Open the return line, then slowly turn on the water while checking for leaks.

Cleaning the Power Supply Water Filter Screen

Clean the filter in the power supply female hose fitting frequently. It is a small, round, mesh screen.

1. Shut off the water supply.

   Shut off the return line as well if you are using a closed-loop cooling system.

2. Remove the inlet hose from the female fitting on the power supply.
3. Using a pair of tweezers or forceps, grasp the edge of the screen and pull it out. Grasp the edge only; if the tool punctures the mesh screen, the filter will no longer be effective.
4. Invert the filter and hold it under a forceful water stream to remove trapped debris. Then run water on both sides of the screen.
5. Carefully slip the screen back into place with your finger, being careful not to push against the screen. Make sure it is securely seated.
6. Install the inlet hose.
7. Open the return line, then slowly turn on the water while checking for leaks.

Chapter 9 Service and Repair

Danger!

The following procedures require removal of the laser head cover and defeat of its safety interlock. Dangerous laser radiation is accessible when cavity seals are pulled back; therefore, permit only trained personnel to service and repair your laser system.

The BeamLok 2060/2080 resonators are designed so the center of the aperture and the centers of both mirror mounts lie on the same line—the resonator axis. In order for the laser to provide optimum performance, three conditions must be met:

- the line defined by the plasma tube bore must be centered on the resonator axis;
- the flat high reflector must be normal to the resonator axis;
- the center of curvature of the output coupler must be on the resonator axis.

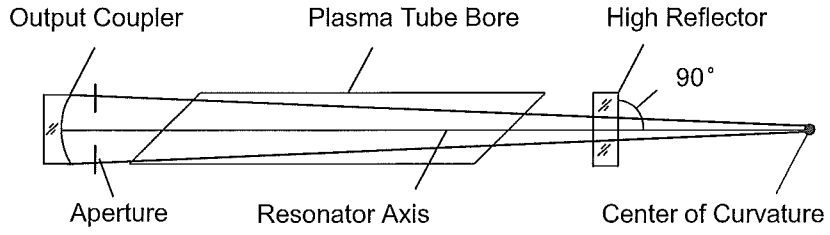


Figure 9-1: Schematic Representation of Ideal Resonator Alignment

Your laser is factory aligned and, under normal operating conditions, should only require the preventive practices described in chapter 8, "Maintenance," to meet its performance specifications. If you discover a significant drop in power that can't be restored by mirror or window cleaning, the source of the problem is probably one of the following:

- misaligned optics,
- misaligned plasma tube.

The procedures in this section allow you to solve these problems, thereby returning your laser to optimum performance. They are listed in the order you should perform them. The most probable cause of poor performance is contaminated optics; they should be cleaned before you try anything else. If the problem persists after cleaning the mirrors, clean the plasma tube windows. Then align the optics, if necessary. Finally, if all else fails, align the plasma tube.

Caution! 

The BeamLok position detector should only be realigned when necessary, and then only after any other alignment being performed. Refer to chapter 6, "BeamLok: Aligning the BeamLok Position Detector."

If the laser has been cleaned and aligned and you are sure that it is producing maximum power, but its performance remains below specification, call your Spectra-Physics Lasers service representative.

Vertical Search Alignment Procedure

If your instrument fails to lase, the most likely source of the problem is a severely misaligned high reflector. The following technique allows you to readily restore lasing.

1. Shut off the laser.
2. Remove the top cover from the laser head, and install the interlock defeat key.
3. Open the shutter.
4. Open the aperture fully ("12" on the scale).
5. Verify that BeamLok is disengaged (off).
6. Restart the laser and allow it a few minutes to warm up again.
7. Turn the coarse vertical adjustment two turns counterclockwise.
8. Perform vertical search alignment (Figure 9-2).
    a. Grasp the high reflector mirror mount near the coarse vertical adjustment and rock the mirror plate rapidly back and forth; simultaneously, turn the coarse horizontal adjustment very slowly to scan the high reflector horizontally.
    b. Keep rocking and scanning until you observe a bright flash of laser light.

       When the beam flashes, stop turning the horizontal control; then turn the vertical adjustment clockwise until you establish sustained lasing.
    c. Adjust the high reflector for maximum power.
    d. If you turn the horizontal adjustment so far that you are convinced that you will never achieve lasing, turn it in the other direction. Keep rocking the mirror plate as you turn the control.

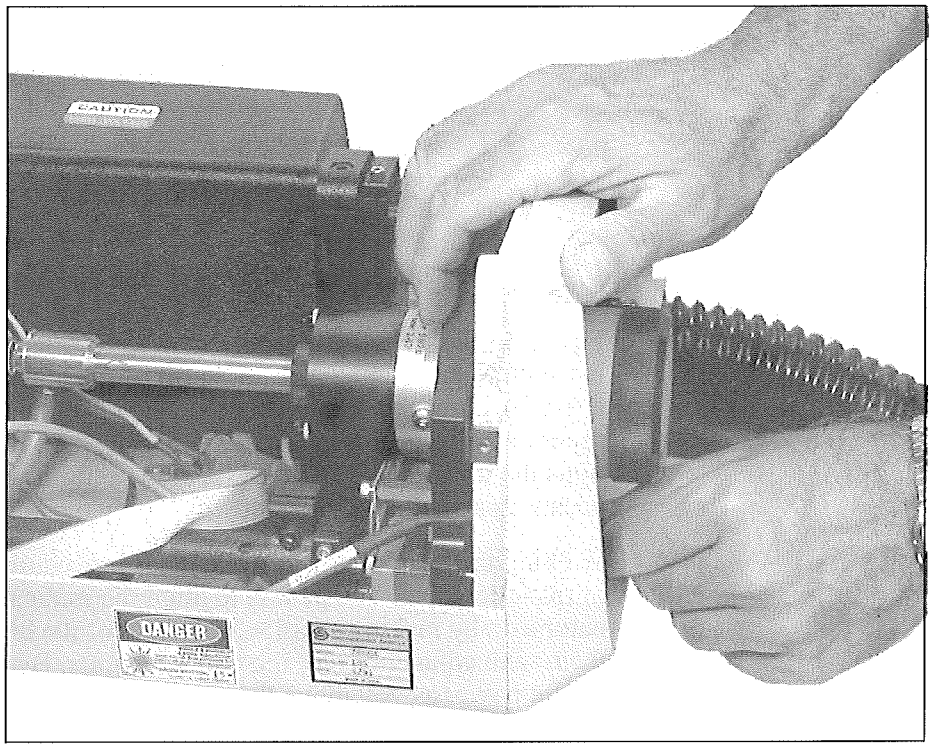


Figure 9-2: Vertical Search Technique

Mirror Alignment

Patience and attention to detail are required to assure proper alignment. First, verify that BeamLok is disengaged. Then adjust the laser for apparent maximum power. Finally, "walk" the beam along the parallel mirrors until you have satisfied yourself, by trial and error, that no additional power can be coaxed from the unit.

Adjusting the Mirrors for Apparent Maximum Power

1. Insert a hex driver in the coarse horizontal adjustment of the high reflector.
2. Monitor output power while you turn the control. Turn it back and forth until output power is as high as possible.
3. Similarly, adjust the vertical coarse control.
4. Repeat these adjustments, first turning one control, then the other, back and forth until the power reaches its maximum.
5. Repeat this procedure using the fine mirror adjustments. Note the output power.

"Walking the Mirrors" to Assure Maximum Power

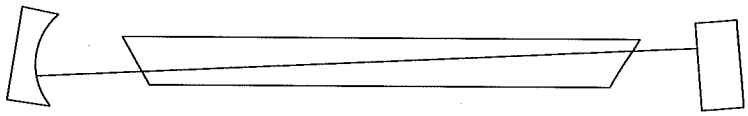


Figure 9-3: Misaligned Mirrors Allow Lasing at Reduced Power

Figure 9-3 illustrates an arrangement of cavity mirrors that will allow lasing, but with reduced output. A slight tilt of the high reflector compensates for a similar tilt of the output coupler. The resulting beam is skewed with respect to the resonator axis and the plasma tube bore. Under these conditions the laser can be "peaked," but the output will be less than optimum because part of the beam is obstructed by the bore walls.

Walking the mirrors is a trial and error procedure that assures optimum mirror alignment. The goal is to align the intracavity beam with the resonator axis by making small adjustments of the high reflector and matching them with adjustments of the output coupler. By observing the change in output power as you move the mirrors, you will find the optimal alignment positions.

1. Once the high reflector has been adjusted for maximum power, use the vertical coarse control to detune the output to 30% – 60% of its maximum value. Move to the other end of the laser and turn the vertical output coupler control in the opposite direction, i.e., if the high reflector control was turned clockwise, turn the output coupler control counter-clockwise.

   Be careful! Only adjust one set of controls at a time. If the laser stops lasing, reverse the direction of mirror movement until lasing is restored.
2. Observe the change in output power as you turn the output coupler control.
   a. If the output maximum exceeds the original value, walk the mirrors in the same direction again. Repeat until the power reaches its maximum.
   b. If output fails to reach the original value, walk the mirrors in the opposite direction.
3. Adjust the high reflector for maximum power.
4. Repeat this procedure using the horizontal coarse controls.

   Always find the maximum power with one set of controls before moving to the other set, i.e., finish with the vertical controls before you move the horizontal controls. Always adjust the high reflector for maximum power before changing from one set of controls to the other.
5. Repeat this procedure using the horizontal coarse controls.

Plasma Tube Alignment

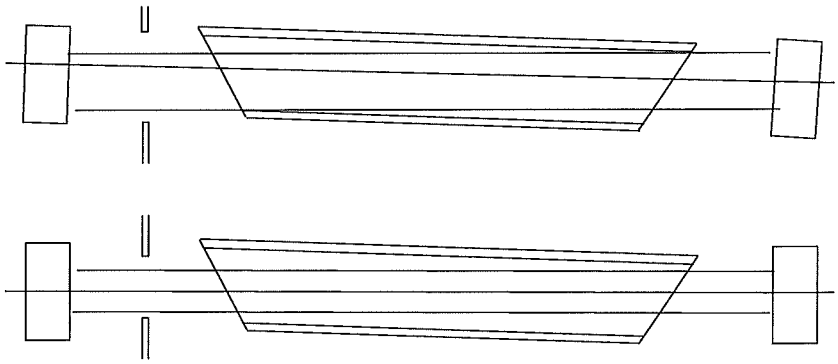


Figure 9-4: Misaligned Plasma Tube Allows Lasing at Reduced Power

Figure 9-4 illustrates two arrangements where the plasma tube is misaligned with respect to the resonator axis. In the first, the tube is skewed and the mirrors have been aligned to compensate. In the second, the cavity mirrors are aligned for optimum output but the tube is skewed. Both problems cause a power loss, the first because the beam does not travel through the center of the aperture. Closing the aperture will cause a significant loss as the aperture wheel partially obstructs the beam. The second causes a power loss because the beam is partially obstructed by the bore walls.

The following procedures center the plasma tube bore on the resonator axis, thereby enabling the laser to produce maximum output power. Use an external power meter to monitor the alignment of the plasma tube.

These procedures assume the unit is lasing. If not, refer to "Vertical Search Alignment Procedure" earlier in this chapter.

Bore Alignment

Danger!



The locking screws described below lie dangerously close to the anode and cathode terminals, and their voltage and current levels are lethal. Be sure to shut off the system before attempting to loosen the magnet mounting screws.

1. Carefully pull back the cavity seals at both ends of the tube.
2. Tighten the eight adjustment screws, 4 vertical, 4 horizontal, against the magnet carriage just until you feel resistance, then loosen the two locking screws at each end of the carriage.

   Figure 9-5 shows the lock–down screw and adjustment screws for the cathode end. The same adjustments are similarly located on the anode end.

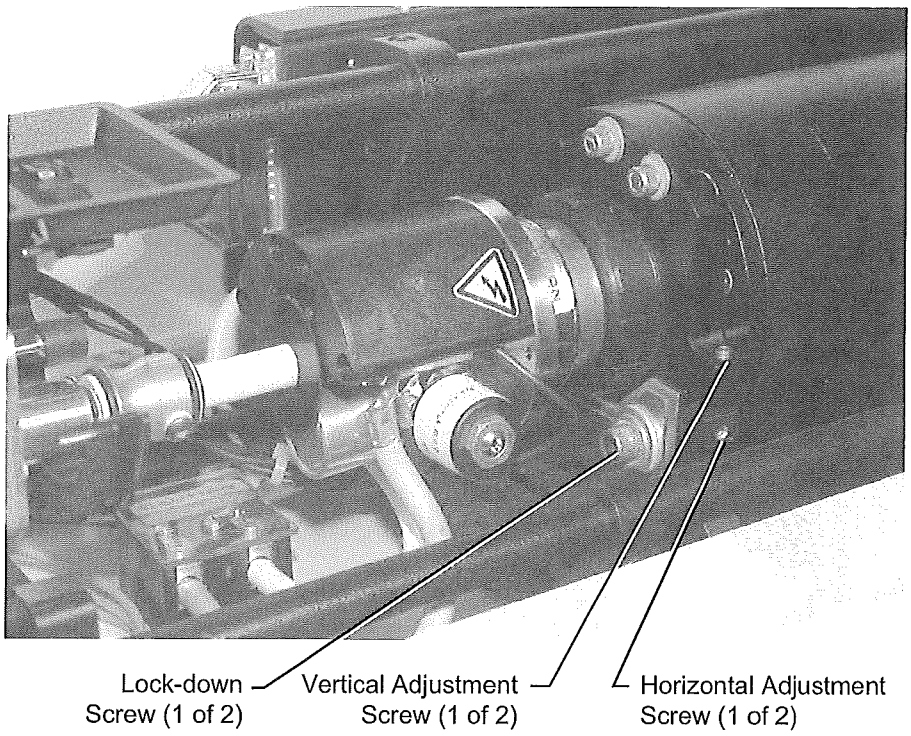


Figure 9-5: Plasma Tube Alignment Adjustments—Cathode End

3. Start the laser and allow it to warm up.
4. Set the aperture wheel to "12."
5. Adjust the horizontal position of the plasma tube at the cathode end. Loosen one adjusting screw $^1/_2$ turn, then tighten the opposite one $^1/_2$ turn, etc., until you achieve maximum output power.
6. Move to the anode end and repeat, adjusting the horizontal position of the plasma tube on that end.
7. Adjust the vertical position of the anode end for maximum power, raising or lowering both adjustment screws $^1/_2$ turn at a time.
8. Move to the cathode end and repeat.
9. Repeat the adjustment sequence until no further increase in power occurs: the plasma tube alignment is "peaked."
10. Reduce the current to the lowest value that will still allow lasing, and observe the position of the beam on the high reflector. If the beam is not centered, move the beam by walking the mirrors.
    a. Determine the axis, either horizontal or vertical, along which the beam must travel and adjust the appropriate controls.
    b. Monitor the output power as you walk the beam toward the center of the mirror. If the power drops significantly, adjust the tube position to maximize output power.

11. Tube and mirror adjustments interact with one another, so you will probably find it necessary to repeat the sequences several times, first walking the mirrors, then moving the tube, then walking the mirrors again, etc. After several iterations you will reach a point where the last possible milliwatt has been coaxed from the laser.
12. Slide the cavity seals back over the windows.

Aligning on the Aperture

This procedure assures that the intracavity beam is centered on the aperture. If the beam is off-center for the aperture, it will suffer unacceptable power loss as the aperture size is reduced.

1. Set the laser in current mode at 55 A, and select 514.5 nm wavelength.
2. Verify that the cavity seals are closed, and set the aperture to "4."
3. Walk both mirrors to maximize output power.

   Refer to "Mirror Alignment: Walking the Mirrors ...," earlier in this chapter.
4. Open the aperture to "11," and align the plasma tube bore for maximum power.

   Refer to the previous section, "Bore Alignment," starting at step 5. Do not adjust the mirrors.
5. Close the aperture to "4," and use the fine control of the high reflector to adjust for maximum power.
6. Open the aperture to "11," and once again align the plasma tube bore for maximum power.
7. Repeat steps 4 through 6 until maximum power is achieved.
8. With the aperture set at "11," adjust the high reflector vertically and horizontally to maximize output power. Note the power level.
9. Close the aperture to "4," and adjust the high reflector vertically and horizontally to maximize output power.
10. Open the aperture to "11." Power should be similar to that noted in step 8. If not, repeat this procedure, starting at step 4.
11. Open the aperture to "12," and adjust the high reflector vertically and horizontally for maximum power. Note the power.
12. Close the aperture to "11." Power loss should be minimal compared to that noted in step 11.
13. The position of the four magnet vertical adjustment screws should appear approximately the same with respect to the holder surface.

Locking Down the Magnet

Once the plasma tube and mirrors are aligned, the magnet/tube assembly can be locked into its final position. Check the power once more before beginning the locking sequence.

Danger! 

The locking screws lie dangerously close to the anode and cathode terminals, whose voltage and current levels are lethal. Be sure to shut down the system before approaching these screws.

1. Tighten the four lockdown screws using a figure-eight pattern so all screws apply equal pressure at all times.
2. Verify alignment of the aperture, refer to "Alignment on Aperture," steps 11 and 12. If the power reading deviates by more than 5%, loosen the magnet, adjust the tube for maximum power, and repeat the lockdown sequence.
3. As soon as you have locked down the magnet, loosen its horizontal and vertical adjusting screws about two full turns. This completes the kinematic isolation of the plasma tube.

Troubleshooting

The troubleshooting guide is provided to assist in isolating some of the problems that might arise in the power supply or laser head. A complete repair procedure is beyond the scope of this manual. For information concerning repair by Spectra-Physics Lasers, see chapter 10, "Customer Service."

Danger! 

The laser head and power supply contain electrical circuits operating at high voltages. Whenever access to the interior of the laser head or power supply is necessary and laser operation is required, exercise extreme caution to avoid contact with high voltages. These high voltages are lethal.

Table 9-1: Troubleshooting

Symptom	Things to Check
Low output power	Dirty optics or plasma tube windows. See corresponding sections in chapter 8, "Maintenance."
	Incorrect optics. Check that the optics in the laser are coated for the wavelength you are using.
	Error in setting. Check for correct current setting, and make sure that the aperture and shutter are both open. Be sure you are tuned to a strong line and that the power range setting is not limiting the power output if you are in power control mode.
	Plasma tube or mirrors misaligned. See "Mirror Alignment" or "Plasma Tube Alignment."
Maximum current too low	Possible high tube pressure. Check the tube voltage on the remote control module. If the voltage is over 275 V for 2060, or over 600 V for 2080, contact your Spectra-Physics Lasers service representative.
	Possible low line voltage. If the line voltage is below 198 V for 2060, or below 442 V for 2080, maximum current may not be available.
Laser fails to start or plasma discharge ceases	Possible open interlock. Check the water flow, water pressure and water temperature. Also check laser head and power supply interlocks.
Low signal indicator is flashing on the remote control module	System is not lasing. Check that the shutter is open. Check for correct mirrors.
	Optics are misaligned. Realign optics, starting with the high reflector coarse adjustments.
	Current level is too low (especially in uv). Turn current up.

Table 9-2: Replacement Parts

Description	Part Number
Water filter	2604-0070
BeamLok purge filter	2602-0310
Fuse, 2 A, 250 V, S.B.	5100-3024
Fuse, 15 A, 250 V, S.B.	5101-0760
Fuse, 8 A, 250 V, S.B.	5101-1020
Fuse, 1 A, 250 V, ceramic dual element	5101-1430
Fuse, 80 A, 600 V ac	5101-1880
Fuse, 20 A, 600 V, F.B.	5101-1600
Fuse, 1 A, 500 V, S.B. dual element	5101-1640
Fuse, 1.5 A, 500 V, S.B. dual element	5101-1840
Deep uv purge kit—2080 only	DUV-1

Chapter 10 Customer Service

At Spectra-Physics Lasers, we take pride in the durability 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. We feel that our instruments have favorable service records compared to competitive products. We hope to demonstrate, in the long run, that we provide excellent service to our customers in two ways. First, by providing the best equipment for the money, and second, by offering service facilities that restore your instrument to working condition as soon as possible.

Spectra-Physics Lasers 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 Lasers. For ordering or shipping instructions, or for assistance of any kind, contact your nearest sales office or service center. You will need your instrument 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) 961-2552** from anywhere else.

Warranty

This warranty supplements the warranty contained in the specific sales order. In the event of a conflict between documents, the terms and conditions of the sales order shall prevail.

The BeamLok 2060 and 2080 systems are protected by an 18-month/2000 hour warranty. All mechanical, electronic, and optical parts and assemblies, including plasma tubes, are unconditionally warranted to be free of defects in workmanship and material for the warranty period.

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 Lasers. Warranty

repairs or replacement equipment is warranted only for the remaining unexpired 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 Lasers. When products manufactured by others are included in Spectra-Physics Lasers equipment, the original manufacturer's warranty is extended to Spectra-Physics Lasers customers. When products manufactured by others are used in conjunction with Spectra-Physics Lasers equipment, this warranty is extended only to the equipment manufactured by Spectra-Physics Lasers.

Spectra-Physics Lasers will provide at its expense all parts and labor and one way return shipping of the defective part or instrument (if required).

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

The above warranty is valid for units purchased and used in the United States only. Products with foreign destinations are subject to a warranty surcharge.

Warranty extensions for incremental 6-month/750 hour periods can be purchased before the expiration date of any prior warranty.

Warranty Return Procedure

Contact your nearest Spectra-Physics Lasers 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 Lasers.

We encourage you to use the special Spectra-Physics Lasers packing boxes to secure instruments during shipment. If shipping boxes have been lost or destroyed, we recommend that you order new ones. Spectra-Physics Lasers will only return instruments in Spectra-Physics Lasers' containers.

Warning! 

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

See the list of Service Centers on the following pages.

Service Centers

Australia

Spectra-Physics Pty. Ltd.
25 Research Drive
Croydon, Victoria 3136
Telephone: (03) 761-5200
Fax: (03) 761-5600

Benelux

Spectra-Physics B.V.
Prof. Dr. Dorgelolaan 20
5613 AM Eindhoven
The Netherlands
Telephone: (40) 2 65 99 59
Fax: (40) 2 43 99 22

France

Spectra-Physics SARL
Z.A. de Courtaboeuf
Avenue de Scandinavie
91941 Les Ulis Cedex
Telephone: (01) 1 69 18 63 10
Fax: (01) 1 69 07 60 93

Germany and Export Countries*

Spectra-Physics GmbH
Siemensstrasse 20
D-64289 Darmstadt-Kranicshstein
Telephone: 06151 7080
Fax: 06151 79102

Japan

Spectra-Physics K.K.
East Regional Office
Daiwa-Nakameguro Building
4-6-1 Nakameguro
Meguro-ku, Tokyo 153
Telephone: (03) 3794 5511
Fax: (03) 3794 5510

** All European and Middle Eastern countries in this region not included elsewhere on this list.*

Service Centers (cont.)

United Kingdom

Spectra-Physics Ltd.
Boundary Way
Hemel Hempstead
Herts, HP2 7SH
Telephone: (01442) 25 81 00
Fax: (01442) 68 538

United States and Export Countries**

Spectra-Physics Lasers
1335 Terra Bella Avenue
Post Office Box 7013
Mountain View, CA 94039-7013
Telephone: 1 (800) 456-2552 (Service)
1 (800) SPL-LASER (Sales) or
1 (800) 775-5273 (Sales), or
1 (650) 961-2550 (Operator)
Fax: 1 (650) 964-3584

** *All countries in this region not included elsewhere on this list.*

Appendix A Sample BASIC Programs

The following two program listings are written in generic GW BASIC for IBM-compatible computers. The first, "Examples.bas," contains uncommented routines for running specified tasks. The second, "Laser.bas," has an introduction, is fully commented, and will run your BeamLok™ 2060 or 2080 laser unmodified. However, our intention is to offer it as a demonstration/tutorial with routines you could modify in blocks to suit your requirements. These two programs are available on 5 1/4 inch, IBM-formatted floppy disks from Spectra-Physics Lasers (part number 0446-3560).

Examples.bas

```
10 '*************************************************************************
20 'EXAMPLES.BAS                                                      07/17/91
30 '
40 'PROGRAMMING EXAMPLES FOR THE BEAMLOK 2060 and 2080 LASERS
50 '*************************************************************************
60 '
70 '-------------------------------------------------------------------------
80 'INITIALIZE THE SERIAL INTERFACE OF THIS COMPUTER
90 '-------------------------------------------------------------------------
100 '
110 OPEN "COM1:4800,N,8,2,LF" AS 1
120 '
130 '-------------------------------------------------------------------------
140 'INITIALIZE THE COMPUTER INTERFACE OF THE LASER POWER SUPPLY
150 '-------------------------------------------------------------------------
160 '
170 PRINT #1,","
180 PRINT #1,"write 6,8"
190 PRINT #1,"write 7,1"
200 PRINT #1,"configure 6,out,non"
210 PRINT #1,"configure 7,out,non"
220 PRINT #1,"set 1,0,set 2,0"
230 '
240 '-------------------------------------------------------------------------
250 'CHECK SYSTEM INTERLOCKS
260 '-------------------------------------------------------------------------
270 '
280 PRINT #1,"read 4"
```

```
290 INPUT #1,PORT4
300 LF$=INPUT$(1,#1)
310 PRINT #1,"read 5"
320 INPUT #1,PORT5
330 LF$=INPUT$(1,#1)
340 IF (PORT4 AND 8) = 0 THEN PRINT "Water Temperature Fault"
350 IF (PORT4 AND 4) = 0 THEN PRINT "Water Flow Low"
360 IF (PORT4 AND 2) = 0 THEN PRINT "Head or P.S. Cover Open"
370 IF (PORT4 AND 1) = 0 THEN PRINT "Key Switch Open"
380 IF (PORT5 AND 2) = 0 THEN PRINT "Regulator Fault"
390 IF (PORT5 AND 1) = 0 THEN PRINT "Auxiliary Interlock Open"
400 '
410 '-------------------------------------------------------------------------
420 'TURN LASER ON
430 '-------------------------------------------------------------------------
440 '
450 PRINT #1,"write 6,8"              'Select current loop mode of operation
460 PRINT #1,"set 1,125"              'Set plasma current control = 50 Amps
470 PRINT #1,"write 7,0"              'Turn laser ON with fill system enabled
480 '
490 '-------------------------------------------------------------------------
500 'MONITOR POWER RANGE STATUS
510 '-------------------------------------------------------------------------
520 '
530 PRINT #1, "sam8"
540 INPUT #1,MUXDDATA
550 LF$ = INPUT$(1,#1)
560 RANGE = 0
570 IF MUXDDATA AND 128 <> 0 THEN RANGE = RANGE + 4
580 IF MUXDDATA AND  64 <> 0 THEN RANGE = RANGE + 2
590 IF MUXDDATA AND  32 <> 0 THEN RANGE = RANGE + 1
600 IF RANGE = 0 THEN PRINT "Power Range is ***"
610 IF RANGE = 1 THEN PRINT "Power Range is .3 Watt"
620 IF RANGE = 2 THEN PRINT "Power Range is  1 Watt"
630 IF RANGE = 3 THEN PRINT "Power Range is  3 Watt"
640 IF RANGE = 4 THEN PRINT "Power Range is 10 Watt"
650 IF RANGE = 5 THEN PRINT "Power Range is 30 Watt"
660 IF RANGE = 6 THEN PRINT "Power Range is 100 Watt"
670 IF RANGE = 7 THEN PRINT "Power Range is ***"
680 '
690 '-------------------------------------------------------------------------
700 'MONITOR OPTICAL OUTPUT POWER
710 '-------------------------------------------------------------------------
720 '
730 IF RANGE = 0 THEN RANGE = 1          'Invalid range
740 IF RANGE = 6 THEN RANGE = 1          'Invalid range
750 IF RANGE = 7 THEN RANGE = 1          'Invalid range
760 IF RANGE = 1 THEN FULLSCALE = .316
770 IF RANGE = 2 THEN FULLSCALE =    1
```

```
780 IF RANGE = 3 THEN FULLSCALE = 3.16
790 IF RANGE = 4 THEN FULLSCALE =   10
800 IF RANGE = 5 THEN FULLSCALE = 31.6
805 IF RANGE = 6 THEN FULLSCALE =  100
810 PRINT #1, "sam3"
820 INPUT #1,POWERMON
830 LF$ = INPUT$(1,#1)
840 WATTS = FULLSCALE * POWERMON / 250   'Calculate output power (watts)
850 '
860 '------------------------------------------------------------------------
870 'MONITOR TUBE CURRENT
880 '------------------------------------------------------------------------
890 '
900 PRINT #1, "sam2"
910 INPUT #1,CURRENTMON
920 LF$ = INPUT$(1,#1)
930 AMPS = 100 * CURRENTMON / 250       'Calculate tube current (amperes)
940 '
950 '------------------------------------------------------------------------
960 'OTHER CONTROL OPERATIONS
970 '------------------------------------------------------------------------
980 '
990 PRINT #1, "write 6,8"            'Select current control mode
1000 '
1010 PRINT #1, "set 1,125"           'Set tube current to 50 amps
1020 '
1030 PRINT #1, "write 6,2"           'Select power control mode and 1W range
1040 '
1050 PRINT #1, "set 2,125"           'Set output power to one-half full scale
1060                                 '(e.g. .5W on the 1W range)
1070 '
1080 PRINT #1, "write 7,1"           'Turn laser off
1090 '
```

Laser.bas

```
10 '*************************************************************************
20 'LASER.BAS                                                        07/17/91
30 '
40 'CONTROL PROGRAM FOR BEAMLOK 2060 AND 2080 LASERS
50 '
60 'Part Number: 0446-3560 Rev. A                        Written by: Tom Bertka
70 '*************************************************************************
80 '
90 ' This program is available on diskette from Spectra-Physics Lasers,
100 '1330 Terra Bella Avenue, Mountain View, CA 94042.
110 '
120 'Program description:
130 '
140 '     This program performs system initialization and laser startup
150 '     operations, and it continuously monitors the laser status while it
160 '     executes basic laser control functions.  The program demonstrates
170 '     the recommended method for initializing and turning on the laser.
180 '     The program also demonstrates how to send, receive, and interpret
190 '     commands and data.  All five commands of the computer interface
200 '     command set are utilized.  Program structure is linear.  Execution
210 '     begins at the lowest line number and ends at the highest line
220 '     number.  The program is written in the GW BASIC language.  It will
230 '     run an any IBM PC-compatible computer.
240 '
250 'Laser power supply preliminary setup requirements:
260 '
270 '   - Model 2680 computer interface board installed in the laser power
280 '     supply.
290 '   - Standard 9-wire RS232 cable connected between the laser power
300 '     supply's computer interface board and the computer's COMM1 port.
310 '   - Dipswitch SW1 of the laser power supply's computer interface board
320 '     set to the factory default setting for selection of these optional
330 '     operating parameters of the RS232 interface:
340 '     Character format ..... eight-bit character length, parity odd
350 '     and disabled, two stop bits;
360 '     Data transfer rate ..... 4800 BAUD (bits per second).
370 '   - Laser power supply turned on.
380 '   - COMPUTER indicator illuminated on the 2470 remote control module.
390 '     Note: Pressing the computer/remote pushbutton switch on the remote
400 '     control module will illuminate the COMPUTER indicator and enable
410 '     computer control of the laser.  If the COMPUTER indicator will not
420 '     turn on, a dipswitch inside the remote control module needs to be
430 '     set to enable selection of computer control.
440 '
450 'Special note regarding message termination characters and GW BASIC INPUT
460 'statements:
470 '
```

```
480 '     All data responses from the laser power supply are terminated by
490 '     both a carriage return and a line feed character.  Care must be
500 '     taken to assure that both termination characters are read in by this
510 '     program.  The GW BASIC INPUT# statement terminates when it sees a
520 '     carriage return character.  Consequently, it does not see the line
530 '     feed character that follows the carriage return.  Therefore, every
540 '     INPUT# statement in this program is followed by an INPUT$ statement
550 '     to read in the line feed character, thus assuring that this computer's
560 '     communications input buffer is completely empty of all data before
570 '     the next data acquisition is attempted.  Failure to clear the
580 '     communications input buffer in this manner will result in erroneous
590 '     data readings when the INPUT# statement is again executed.
600 '
610 '
620 '*************************************************************************
630 '***************   INITIALIZATION AND STARTUP SEGMENT   ******************
640 '*************************************************************************
650 '
660 KEY ON
670 COLOR 7,0,0                     'Normal video
680 CLS
690 PRINT
700 PRINT "CONTROL PROGRAM FOR THE 2040E/2060/2070/2080 LASERS"
710 PRINT
720 PRINT
730 '-------------------------------------------------------------------------
740 'ENABLE COMPUTER CONTROL
750 '-------------------------------------------------------------------------
760 '
770 PRINT "Press the COMPUTER/REMOTE switch on the remote control module."
780 PRINT "The COMPUTER indicator should be on."
790 PRINT
800 PRINT "Press any key to continue"
810 PRINT
820 '
830 K$="":WHILE K$="":K$=INKEY$:WEND        'Monitor keyboard for key press
840 '
850 '-------------------------------------------------------------------------
860 'INITIALIZE THE SERIAL INTERFACE OF THIS COMPUTER
870 '-------------------------------------------------------------------------
880 '
890 OPEN "COM1:4800,N,8,2,LF" AS 1
900 '
910 '-------------------------------------------------------------------------
920 'INITIALIZE THE COMPUTER INTERFACE BOARD (CIB) IN POWER SUPPLY
930 '-------------------------------------------------------------------------
940 '
950 PRINT #1,",,"                    'Send termination character to clear
960                                  'the serial data input buffer of the CIB
```

```
970 '
980 PRINT #1,"write 6,8"              'Initialize the digital ports of the CIB
990 PRINT #1,"write 7,1"
1000 PRINT #1,"configure 6,out,non"
1010 PRINT #1,"configure 7,out,non"
1020 PRINT #1,"set 1,0,set 2,0"       'Set current and power controls to minimum
1030 '
1040 '-------------------------------------------------------------------------
1050 'TEST THE SEND/RECEIVE SERIAL COMMUNICATIONS LINK
1060 '-------------------------------------------------------------------------
1070 '
1080 COMMSTATUS  = 1                  'Initialize communications status flag
1090                                  '(1 = communications link okay)
1100 RESPONSE = 0
1110 LF$ = ""
1120 '
1130 PRINT #1,"sample 4"              'Send command to sample reference voltage
1140 INPUT #1,RESPONSE                'Receive numeric data response
1150 LF$ = INPUT$(1,#1)                     'Receive the line feed termination
character
1160                                  'and empty the communications input buffer
1170 '
1180 IF RESPONSE = 0 THEN COMMSTATUS = 0      'Test for any received data
1190 IF ASC(LF$) <> 10 THEN COMMSTATUS = 0    'Test for line feed character
1200 IF EOF(1) = 0 THEN COMMSTATUS = 0        'Test for empty comm input buffer
1210 '
1220 WHILE  COMMSTATUS = 0
1230   PRINT "Communications error"
1240   PRINT
1250   PRINT "Program terminated"
1260   END                          'Terminate program
1270 WEND
1280 '
1290 PRINT "Communications link okay"
1300 PRINT
1310 '
1320 '-------------------------------------------------------------------------
1330 'CHECK SYSTEM INTERLOCK STATUS
1340 '-------------------------------------------------------------------------
1350 '
1360 INTERLOCKS = 1                   'Initialize interlock status flag
1370                                  '(1 = all safety interlocks closed)
1380 '
1390 PRINT #1,"read 4"                'Read CIB status port 4
1400 INPUT #1,PORT4
1410 LF$=INPUT$(1,#1)
1420 '
1430 PRINT #1,"read 5"                'Read CIB status port 5
1440 INPUT #1,PORT5
```

```
1450 LF$=INPUT$(1,#1)
1460 '
1470 IF PORT4 <> 15 THEN INTERLOCKS = 0          'Test water temp, water flow
1480                                             'head cover, and keyswitch
1490                                             'interlock status bits
1500 '
1510 IF (PORT5 AND 3) <> 3 THEN INTERLOCKS = 0 'Test regulator and auxiliary
1520                                             'interlock status bits
1530 '
1540 WHILE INTERLOCKS = 0           'Terminate program if any interlock open
1550   PRINT "Interlock(s) open..."
1560   PRINT
1570   IF (PORT4 AND 8) = 0 THEN PRINT "    Water Temperature"
1580   IF (PORT4 AND 4) = 0 THEN PRINT "    Water Flow"
1590   IF (PORT4 AND 2) = 0 THEN PRINT "    Head or P.S. Cover"
1600   IF (PORT4 AND 1) = 0 THEN PRINT "    Key Switch"
1610   IF (PORT5 AND 2) = 0 THEN PRINT "    Regulator Fault"
1620   IF (PORT5 AND 1) = 0 THEN PRINT "    Auxiliary (BNC Connector)"
1630   PRINT
1640   PRINT "Program terminated"
1650   END                           'Terminate program
1660 WEND
1670 '
1680 PRINT "System interlocks okay"
1690 PRINT
1700 '
1710 '-------------------------------------------------------------------------
1720 'BEGIN LASER TURN ON SEQUENCE
1730 '-------------------------------------------------------------------------
1740 '
1750 PRINT
1760 PRINT "************************"
1770 PRINT "PREPARE TO TURN ON LASER!
1780 PRINT "************************"
1790 PRINT
1800 PRINT "************************"
1810 PRINT "MAKE SELECTION:"
1820 PRINT
1830 PRINT "  1 ... TURN LASER ON"
1840 PRINT "  0 ... Terminate Program"
1850 PRINT "************************"
1860 PRINT
1870 '
1880 GOFLAG = 0
1890 WHILE GOFLAG = 0
1900   K$="$":WHILE K$<>"":K$=INKEY$:WEND   'Empty keyboard input buffer
1910   PRINT "Enter 1 or 0: ";
1920   K$="":WHILE K$="":K$=INKEY$:WEND     'Monitor keyboard for key press
1930   PRINT K$
```

```
1940    IF K$ = "1" THEN GOFLAG = 1
1950    WHILE K$ = "0"
1960      PRINT
1970      PRINT "Program terminated"
1980      END                                   'Terminate program
1990    WEND
2000  WEND
2010  '
2020  '-------------------------------------------------------------------------
2030  'TURN ON THE LASER
2040  '-------------------------------------------------------------------------
2050  '
2060  PRINT #1,"write 6,8"            'Select current loop mode of operation
2070  PRINT #1,"set 1,125"            'Set plasma current control = 50 Amps
2080  PRINT #1,"write 7,0"            'Turn laser ON
2090                                  'and enable automatic fill system
2100  CLS
2110  PRINT
2120  PRINT "********************"
2130  PRINT "LASER IS TURNED ON!"
2140  PRINT "********************"
2150  PRINT
2160  PRINT "Delay sequence in progress"
2170  PRINT
2180  PRINT "prepare for EMISSION"
2190  PRINT
2200  PRINT
2210  PRINT "Press ANY KEY to turn LASER OFF"
2220  PRINT "      -------          ---------"
2230  PRINT
2240  '
2250  '-------------------------------------------------------------------------
2260  'WAIT 30 SECONDS FOR TUBE TO START LASING
2270  '-------------------------------------------------------------------------
2280  '
2290  'The purpose of the 30 second wait is to suspend communications
2300  'while the laser start delay is in progress.  The laser will start
2310  '15 to 20 seconds following the start command.  Voltage transients
2320  'sometimes occur when the start circuit in the laser head fires.
2330  'These transients may induce noise into the RS232 cable and interface
2340  'circuits.  Any data transmissions occurring at this time may be
2350  'corrupted.  For this reason it is recommended that no communications
2360  'take place while the laser is starting.  It is also recommended
2370  'that a null command message be sent immediately after the laser has
2380  'started to clear the power supply's communications input buffer.
2390  '
2400  T0 = TIMER                      'Store start time
2410  T1 = TIMER
2420  K$ = ""                         'Store null string
```

```
2430 '
2440 WHILE T1-T0<30 AND K$=""       'Loop for 30 sec or until key press
2450   K$ = INKEY$                  'Monitor keyboard for any key press
2460   T1OLD = T1
2470   T1 = TIMER                   'Update current time
2480   IF INT(T1) <> INT(T1OLD) THEN PRINT ".";
2490   IF T1-T0<0 THEN T0=TIMER     'Restart 30 sec delay if midnight occurs
2500 WEND
2510 '
2520 PRINT #1,",,"                  'Send termination character (null command)
2530                                'the serial data input buffer of the CIB
2540                                'after every tube start
2550 '
2560 WHILE K$<>""                   'Turn laser off if key has been pressed
2570   PRINT #1,"write 7,1"         'Send laser off command
2580   PRINT:PRINT
2590   PRINT "LASER TURNED OFF"
2600   PRINT
2610   PRINT "Program terminated"
2620   END                          'Terminate program
2630 WEND
2640 '
2650 '-----------------------------------------------------------------------
2660 'VERIFY EMISSION
2670 '-----------------------------------------------------------------------
2680 '
2690 ONSTATUS = 0
2700 PRINT #1, "sample 2"           'Input tube current monitor
2710 INPUT #1,ONSTATUS
2720 LF$ = INPUT$(1,#1)
2730 '
2740 WHILE ONSTATUS < 50            'Assume no emission if current < 10 amps
2750   PRINT #1, "write 7,1"        'Turn laser off
2760   PRINT:PRINT
2770   PRINT "EMISSION NOT DETECTED"
2780   PRINT
2790   PRINT "LASER TURNED OFF"
2800   PRINT
2810   PRINT "Program terminated"
2820   END                          'Terminate program
2830 WEND
2840 '
2850 '***********************************************************************
2860 '*******************  MONITOR AND CONTROL SEGMENT  *********************
2870 '***********************************************************************
2880 '
2890 '-----------------------------------------------------------------------
2900 'INITIALIZE SYSTEM STATUSES
2910 '-----------------------------------------------------------------------
```

```
2920 '
2930 'SYSTEM STATUS VARIABLE DEFINITIONS:
2940 '
2950 'MODE$         Indicates the active control mode (CUR or PWR)
2960 'RANGEMON$     Indicates the active power range (.3, 1, 3, 10, or 30)
2970 'FULLSCALE     Stores full scale range value (.316, 1, 3.16, 10, 31.6)
2980 'MUXDDATA      Stores sampled multiplexed data signal (power range status)

2990 'POWERMON      Stores sampled power monitor count value (0 to 250)
3000 'WATTSMON      Stores sampled power monitor value as units (watts)
3010 'CURRENTMON    Stores sampled current monitor count value (0 to 250)
3020 'AMPSMON       Stores sampled current monitor value as units (amperes)
3030 'POWERCMD      Stores the power command count value (0 to 250)
3040 'CURRENTCMD    Stores the current command count value (0 to 250)
3050 '
3060 MODE$      = " CUR"            'Initialize system statuses
3070 RANGEMON$  = ".3W"
3080 FULLSCALE  = .316
3090 MUXDDATA   = 0
3100 POWERMON   = 0
3110 WATTSMON   = 0
3120 CURRENTMON = 0
3130 AMPSMON    = 0
3140 POWERCMD   = 0
3150 CURRENTCMD = 125
3160 '
3170 '-------------------------------------------------------------------------
3180 'INITIALIZE SYSTEM STATUS DISPLAY (LINE 25 OF SCREEN)
3190 '-------------------------------------------------------------------------
3200 '
3210 CLS
3220 KEY OFF
3230 LOCATE 25,1:PRINT "MODE";
3240 LOCATE 25,11:PRINT "RANGE";
3250 LOCATE 25,21:PRINT "WATTS";
3260 LOCATE 25,38:PRINT "AMPS";
3270 COLOR 0,7,0                    'Inverse video
3280 LOCATE 25,54:PRINT "FILL ENABLED";
3290 LOCATE 25,68:PRINT " LASER IS ON ";
3300 COLOR 7,0,0                    'Normal video
3310 LOCATE 1,1
3320 '
3330 '-------------------------------------------------------------------------
3340 'BEGIN CONTINUOUS MONITOR AND CONTROL OF LASER
3350 '-------------------------------------------------------------------------
3360 '
3370 WHILE 1                        'LOOP FOREVER
3380   '
3390   '-----------------------------------------------------------------------
```

```
3400   'INITIALIZE CONTROL OPTIONS DISPLAY MENU
3410   '-----------------------------------------------------------------------
3420   '




3430   PRINT
3440   PRINT "             ************************************************
3450   PRINT "                              CONTROL OPTIONS MENU
3460   PRINT "             ************************************************
3470   PRINT
3480   PRINT "                1                 Current control
3490   PRINT "                2                 Power control/Power range
3500   PRINT "                3                 Set current
3510   PRINT "                4                 Set power
3520   PRINT "                5                 Increment current or power
3530   PRINT "                6                 Decrement current or power
3540   PRINT
3550   PRINT "                                  ---------
3560   PRINT "                0 or SPACE BAR    LASER OFF
3570   PRINT "                                  ---------
3580   PRINT "             ************************************************
3590   PRINT
3600   PRINT "Make selection: ";
3610   PRINT:PRINT:PRINT:PRINT:PRINT:PRINT
3620   '
3630   SELECTION$ = ""             'Initialize null selection (no key press)
3640   '
3650   WHILE SELECTION$ = ""       'LOOP UNTIL KEY PRESS
3660     '
3670     '-----------------------------------------------------------------------
3680     'MONITOR KEYBOARD
3690     '-----------------------------------------------------------------------
3700     '
3710     SELECTION$ = INKEY$       'Monitor keyboard for any key press
3720     '
3730     '-----------------------------------------------------------------------
3740     'ACQUIRE DATA
3750     '-----------------------------------------------------------------------
3760     '
3770     PRINT #1, "sam8"          'Input multiplexed data signal
3780     INPUT #1,MUXDDATA
3790     LF$ = INPUT$(1,#1)
3800     '
3810     PRINT #1, "sam3"          'Input power monitor
3820     INPUT #1,POWERMON
```

```
3830     LF$ = INPUT$(1,#1)
3840     '
3850     PRINT #1, "sam2"          'Input current monitor
3860     INPUT #1,CURRENTMON
3870     LF$ = INPUT$(1,#1)
3880     '



3890     '-----------------------------------------------------------------------
3900     'UPDATE SYSTEM STATUSES
3910     '-----------------------------------------------------------------------
3920     '
3930                               'Combine range bits
3940     RANGEMON = 0
3950     IF (MUXDDATA AND 128) <> 0 THEN RANGEMON = RANGEMON + 4
3960     IF (MUXDDATA AND  64) <> 0 THEN RANGEMON = RANGEMON + 2
3970     IF (MUXDDATA AND  32) <> 0 THEN RANGEMON = RANGEMON + 1
3980     '
3990                               'Compute power range
4000     '
4010     IF RANGEMON = 0 THEN RANGEMON$ = "***"    'Invalid range
4020     IF RANGEMON = 6 THEN RANGEMON$ = "***"    'Invalid range
4030     IF RANGEMON = 7 THEN RANGEMON$ = "***"    'Invalid range
4040     '
4050     IF RANGEMON = 1 THEN RANGEMON$ = ".3W"
4060     IF RANGEMON = 2 THEN RANGEMON$ = " 1W"
4070     IF RANGEMON = 3 THEN RANGEMON$ = " 3W"
4080     IF RANGEMON = 4 THEN RANGEMON$ = "10W"
4090     IF RANGEMON = 5 THEN RANGEMON$ = "30W"
4100     '
4110                               'Compute range factor
4120     '
4130     IF RANGEMON = 0 THEN RANGEMON = 1         'Invalid range
4140     IF RANGEMON = 6 THEN RANGEMON = 1         'Invalid range
4150     IF RANGEMON = 7 THEN RANGEMON = 1         'Invalid range
4160     '
4170     FULLSCALE = .316
4180     IF RANGEMON = 1 THEN FULLSCALE = .316
4190     IF RANGEMON = 2 THEN FULLSCALE = 1!
4200     IF RANGEMON = 3 THEN FULLSCALE = 3.16
4210     IF RANGEMON = 4 THEN FULLSCALE = 10!
4220     IF RANGEMON = 5 THEN FULLSCALE = 31.6
4230     '
4240     WATTSMON = FULLSCALE * POWERMON / 250          'Compute power
4250     IF WATTSMON > FULLSCALE THEN WATTSMON = 99.999  'Overrange
4260     '
4270     AMPSMON = 100 * CURRENTMON / 250               'Compute current
4280     '
```

```
4290    '-----------------------------------------------------------------
4300    'DISPLAY SYSTEM STATUSES
4310    '-----------------------------------------------------------------
4320    '
4330    COLOR 0,7,0                'Inverse video
4340    LOCATE 25,5:PRINT MODE$;
4350    LOCATE 25,16:PRINT RANGEMON$;
4360    LOCATE 25,26:PRINT USING "##.###";WATTSMON;
4370    LOCATE 25,42:PRINT USING "###.#";AMPSMON;
4380    COLOR 7,0,0                'Normal video
4390    LOCATE 25,33:PRINT USING "###";POWERMON;
4400    LOCATE 25,48:PRINT USING "###";CURRENTMON;
4410    '
4420  WEND                         'END LOOP UNTIL KEY PRESS
4430  '
4440  '
4450  '*****************************************************************
4460  '***************  CONTROL OPTIONS PROCESSING SEGMENT  ***************
4470  '*****************************************************************
4480  '
4490  '-----------------------------------------------------------------
4500  'TURN LASER OFF
4510  '-----------------------------------------------------------------
4520  '
4530  WHILE SELECTION$ = "0" OR ASC(SELECTION$) = 32
4540    PRINT #1, "write 7,1"      'Send laser off command
4550    LOCATE 20,1
4560    PRINT "Laser turned off"
4570    PRINT
4580    PRINT "Program terminated"
4590    END                        'Terminate program
4600    SELECTION$ = "done"
4610  WEND
4620  '
4630  '-----------------------------------------------------------------
4640  'SELECT CURRENT CONTROL MODE
4650  '-----------------------------------------------------------------
4660  '
4670  WHILE SELECTION$ = "1"
4680    PORT6 = RANGEMON + 8         'Select cur mode; retain power range
4690    PRINT #1, "write 6,",PORT6   'Send current mode command
4700    MODE$ = " CUR"               'Update system status
4710    SELECTION$ = "done"
4720  WEND
4730  '
4740  '-----------------------------------------------------------------
4750  'SELECT POWER CONTROL MODE
4760  '-----------------------------------------------------------------
4770  '
```

```
4780   WHILE SELECTION$ = "2"
4790     LOCATE 20,1
4800     PRINT "    SELECT POWER RANGE:"
4810     PRINT
4820     PRINT "       1      .3 WATT"
4830     PRINT "       2       1 WATT"
4840     PRINT "       3       3 WATT"
4850     PRINT "       4      10 WATT"
4860     PRINT "       5      30 WATT"
4870     PRINT
4880     RANGECMD = 0
4890     WHILE RANGECMD = 0
4900       PRINT "    Enter 1,2,3,4, or 5: ";
4910       K$ = "":WHILE K$="":K$=INKEY$:WEND
4920       PRINT K$
4930       IF K$ = "1" THEN RANGECMD = 1      '.3 W range
4940       IF K$ = "2" THEN RANGECMD = 2      ' 1 W range
4950       IF K$ = "3" THEN RANGECMD = 3      ' 3 W range
4960       IF K$ = "4" THEN RANGECMD = 4      '10 W range
4970       IF K$ = "5" THEN RANGECMD = 5      '30 W range
4980     WEND
4990     PRINT #1,"write 6,";RANGECMD         'Send power mode/range command
5000     MODE$ = " PWR"                       'Update system status
5010     SELECTION$ = "done"
5020   WEND
5030   '
5040   '-------------------------------------------------------------------
5050   'SET CURRENT
5060   '-------------------------------------------------------------------
5070   '
5080   WHILE SELECTION$ = "3"
5090     LOCATE 20,1
5100     PRINT "    SELECT ENTRY OPTION:"
5110     PRINT
5120     PRINT "       1     Enter current in amperes"
5130     PRINT "       2     Enter current as a count"
5140     PRINT
5150     ENTRY$ = ""
5160     WHILE ENTRY$ = ""
5170       PRINT "    Enter 1 or 2: ";
5180       K$="":WHILE K$="":K$=INKEY$:WEND
5190       PRINT K$
5200       IF K$ = "1" THEN ENTRY$ = "1"
5210       IF K$ = "2" THEN ENTRY$ = "2"
5220     WEND
5230     '
5240     WHILE ENTRY$ = "1"
5250       UNITS$ = ""
5260       WHILE UNITS$ = ""
```

```
5270        PRINT "    Enter current in amperes (1 to 100.0): ";
5280        INPUT UNITS$
5290        IF VAL(UNITS$) < 1 OR VAL(UNITS$) > 100 THEN UNITS$ = ""
5300      WEND
5310      CURRENTCMD = 250 * VAL(UNITS$) / 100
5320      ENTRY$ = "done"
5330    WEND
5340    '
5350    WHILE ENTRY$ = "2"
5360      COUNT$ = ""
5370      WHILE COUNT$ = ""
5380        PRINT "    Enter current as a count (0 to 250): ";
5390        INPUT COUNT$
5400        IF VAL(COUNT$) < 0 OR VAL(COUNT$) > 250 THEN COUNT$ = ""
5410      WEND
5420      CURRENTCMD = VAL(COUNT$)
5430      ENTRY$ = "done"
5440    WEND
5450    '
5460    PRINT #1, "set 1,",CURRENTCMD              'Send current command
5470    SELECTION$ = "done"
5480  WEND
5490  '
5500  '-------------------------------------------------------------------------
5510  'SET POWER
5520  '-------------------------------------------------------------------------
5530  '
5540  WHILE SELECTION$ = "4"
5550    LOCATE 20,1
5560    PRINT "    SELECT ENTRY OPTION:"
5570    PRINT
5580    PRINT "       1     Enter power in watts"
5590    PRINT "       2     Enter power as a count"
5600    PRINT
5610    ENTRY$ = ""
5620    WHILE ENTRY$ = ""
5630      PRINT "    Enter 1 or 2: ";
5640      K$="":WHILE K$="":K$=INKEY$:WEND
5650      PRINT K$
5660      IF K$ = "1" THEN ENTRY$ = "1"
5670      IF K$ = "2" THEN ENTRY$ = "2"
5680    WEND
5690    '
5700    WHILE ENTRY$ = "1"
5710      UNITS$ = ""
5720      WHILE UNITS$ = ""
5730        PRINT "    Enter power in watts (.001 to Full Scale)";
5740        INPUT UNITS$
5750        IF VAL(UNITS$) < .0001 OR VAL(UNITS$) > FULLSCALE THEN UNITS$ = ""
```

```
5760        WEND
5770        POWERCMD = 250 * VAL(UNITS$) / FULLSCALE
5780        IF POWERCMD < 1 THEN POWERCMD = 0
5790        POWERCMD = INT(POWERCMD)
5800        ENTRY$ = "done"
5810      WEND
5820      '
5830      WHILE ENTRY$ = "2"
5840        COUNT$ = ""
5850        WHILE COUNT$ = ""
5860          PRINT "     Enter power as a count (0 to 250): ";
5870          INPUT COUNT$
5880          IF VAL(COUNT$) < 0 OR VAL(COUNT$) > 250 THEN COUNT$ = ""
5890        WEND
5900        POWERCMD = VAL(COUNT$)
5910        ENTRY$ = "done"
5920      WEND
5930      '
5940      PRINT #1, "set 2,",POWERCMD                'Send power command
5950      SELECTION$ = "done"
5960    WEND
5970    '
5980    '-------------------------------------------------------------------------
5990    'INCREMENT CURRENT OR POWER
6000    '-------------------------------------------------------------------------
6010    '
6020    WHILE SELECTION$ = "5"
6030      IF MODE$ = " CUR" THEN CASE = 1
6040      IF MODE$ = " PWR" THEN CASE = 2
6050      WHILE CASE = 1
6060        CURRENTCMD = CURRENTCMD + 1
6070        IF CURRENTCMD > 250 THEN CURRENTCMD = 250
6080        PRINT #1, "set 1,",CURRENTCMD            'Send current command
6090        CASE = 0
6100      WEND
6110      WHILE CASE = 2
6120        POWERCMD = POWERCMD + 1
6130        IF POWERCMD > 250 THEN POWERCMD = 250
6140        PRINT #1, "set 2,",POWERCMD              'Send power command
6150        CASE = 0
6160      WEND
6170      SELECTION$ = "done"
6180    WEND
6190    '
6200    '-------------------------------------------------------------------------
6210    'DECREMENT CURRENT OR POWER
6220    '-------------------------------------------------------------------------
6230    '
6240    WHILE SELECTION$ = "6"
```

```
6250     IF MODE$ = " CUR" THEN CASE = 1
6260     IF MODE$ = " PWR" THEN CASE = 2
6270     WHILE CASE = 1
6280       CURRENTCMD = CURRENTCMD - 1
6290       IF CURRENTCMD < 0 THEN CURRENTCMD = 0
6300       PRINT #1, "set 1,",CURRENTCMD          'Send current command
6310       CASE = 0
6320     WEND
6330     WHILE CASE = 2
6340       POWERCMD = POWERCMD - 1
6350       IF POWERCMD < 0 THEN POWERCMD = 0
6360       PRINT #1, "set 2,",POWERCMD            'Send power command
6370       CASE = 0
6380     WEND
6390     SELECTION$ = "done"
6400   WEND
6410   '
6420   '-------------------------------------------------------------------
6430   'END CONTROL OPTIONS PROCESSING
6440   '-------------------------------------------------------------------
6450   '
6460   WHILE SELECTION$ <> "done"
6470     LOCATE 20,1
6480     PRINT "Selection invalid"
6490     SELECTION$ = "done"
6500   WEND
6510   '
6520 WEND                          'END FOREVER LOOP
6530 '
6540 END                           'End of program LASER.BAS
```

Spectra-Physics Lasers User's Manual–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 Lasers 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.

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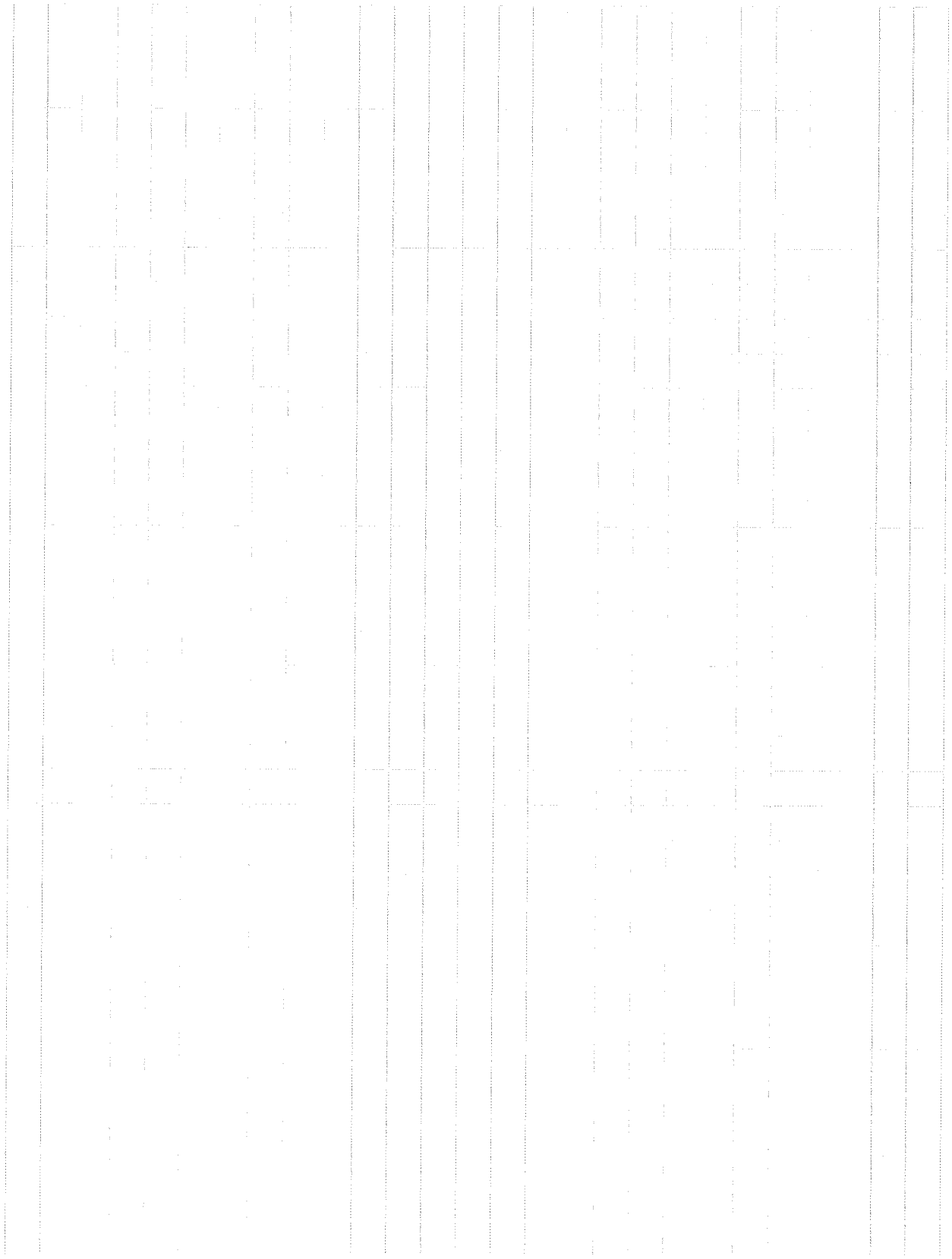
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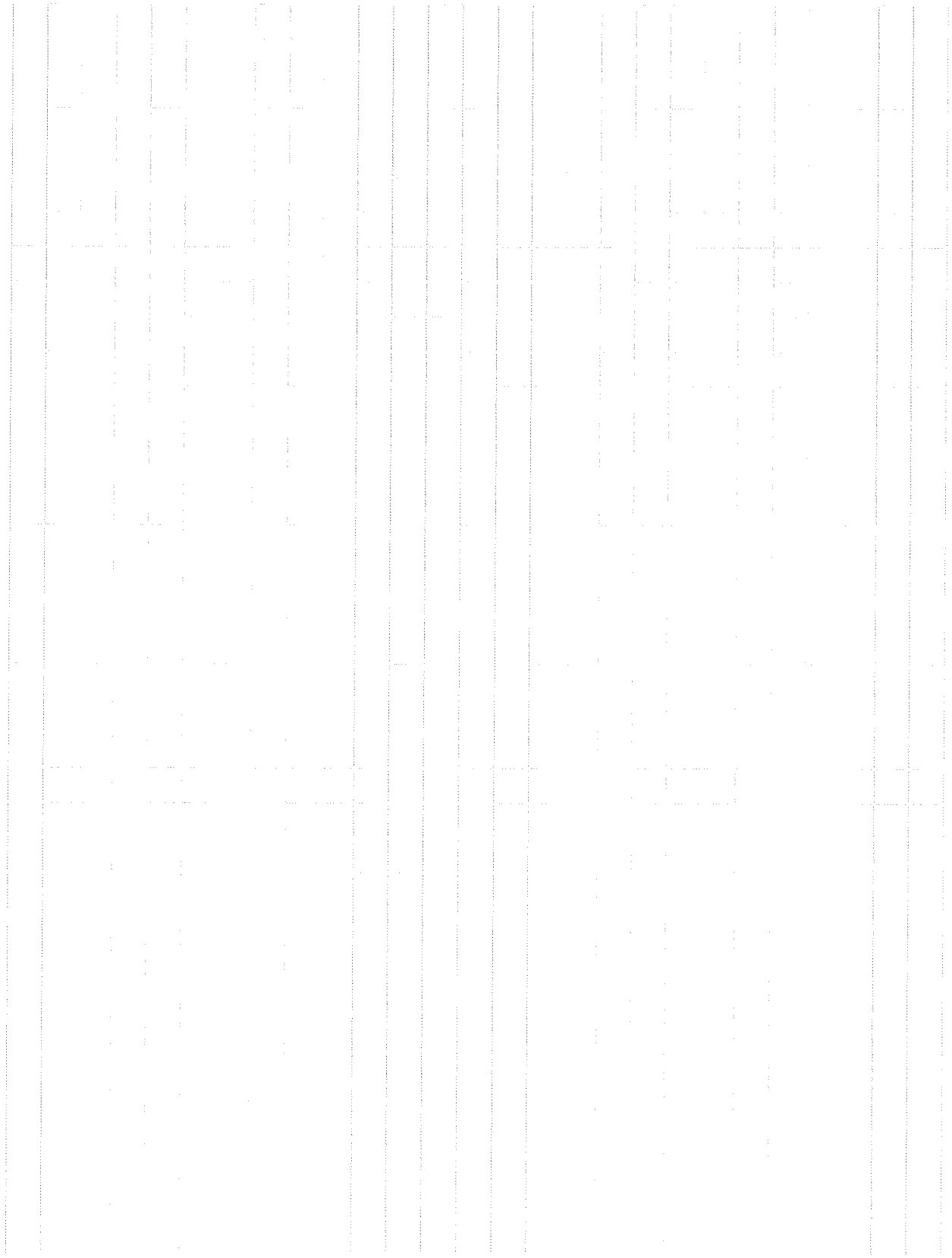
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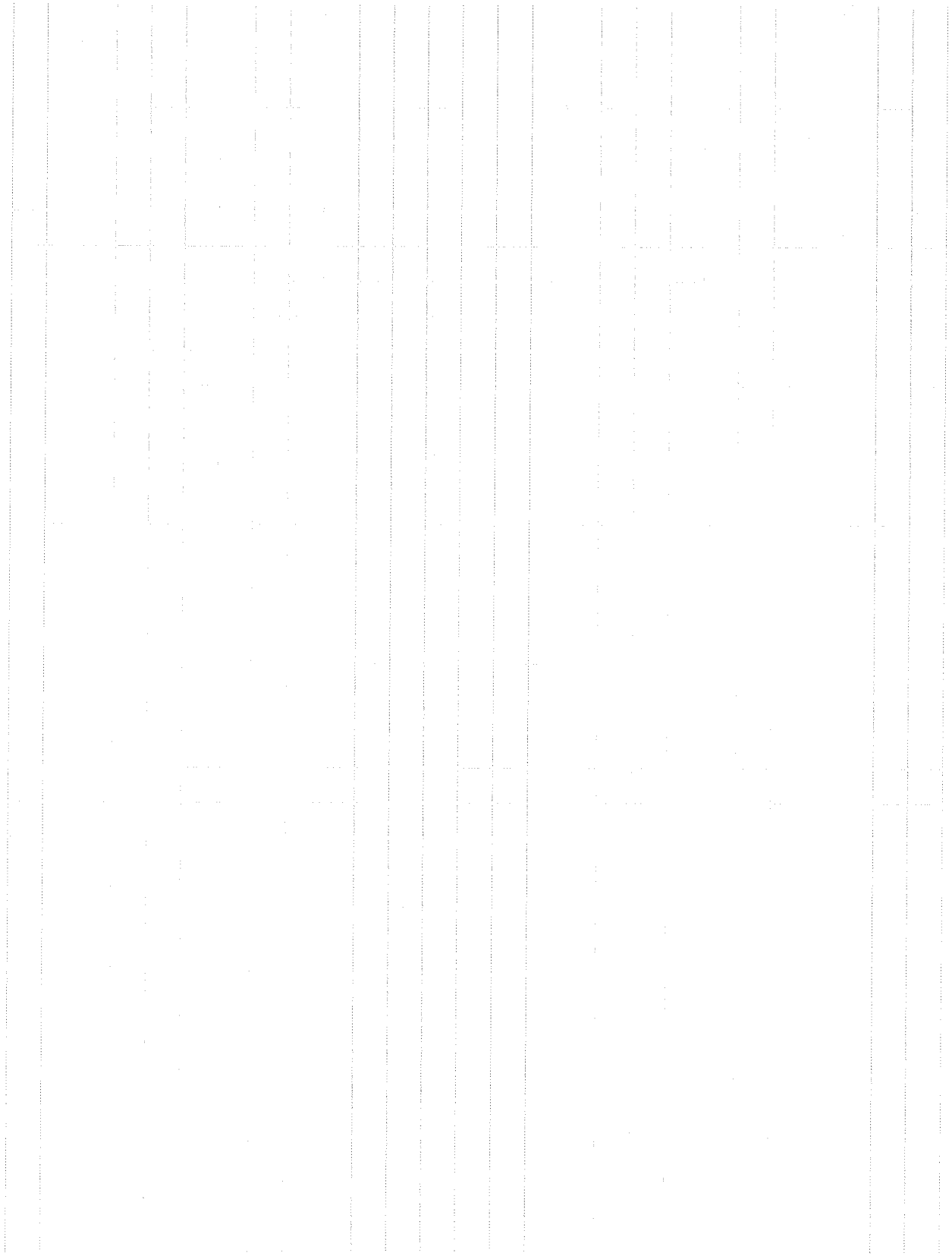
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