DisQ-Mark

Diode-Pumped Thin-Disk Laser

User's Manual

This laser product is intended to be sold to a manufacturer of electronic products for use as a component (or replacement thereof) in those electronic products. As such, this product is exempt from the DHHS performance standard for laser products in accordance with paragraph 1040.10(a), (1) or (2).

OEM
or
This product is otherwise intended
for
EXPORT

Spectra-Physics
Lasers & Photonics
1335 Terra Bella Avenue
Mountain View, CA 94043

Part Number 0000-323A, Rev. A
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Preface

This manual contains information required in order to safely install and operate the *DisQ-Mark* diode-pumped thin-disk laser system. This system comprises either the *DisQ-Mark* standard laser head or the *DisQ-Mark* laser head with the beam expanding telescope and aiming laser, along with the *DisQ-Mark* power supply. The laser head provides output at 1064 nm.

Chapter 1, "Introduction", contains a brief description of the *DisQ-Mark* system and its intended uses.

Chapter 2, "Laser Safety", contains information about laser hazards and offers suggestions on how to safeguard against them. The *DisQ-Mark* is a Class IV laser and, as such, emits laser radiation that can permanently damage eyes and skin. Be sure to read this entire chapter and, to minimize the risk of injury or equipment damage, follow the instructions carefully.

Chapter 3, "Laser Description", contains a short section on laser theory that is followed by a detailed description of the *DisQ-Mark* laser system, including specifications and outline drawings.

Chapter 4, "Handling Fiber Optics", gives detailed instructions for unpacking, handling, installing and cleaning the fiber-optic cable.

Chapter 5, "Controls, Indicators and Connections", describes the hardware controls, indicators and connections of the *DisQ-Mark* system.

Chapter 6, "Installation", provides detailed instructions for the initial planning and setup of the *DisQ-Mark* laser system.

Chapter 7, "Operation", gives detailed information about start-up, shut-down, operation and control of the *DisQ-Mark* laser system. System control is provided via two sources. Analog voltage signals can be applied at the parallel INTERFACE port on the power supply to provide direct control of system functions. Alternatively, a user-supplied control source (typically a Windows®-based personal computer) can be connected to the RS-232 serial port to control the system (CW only) via user-written software. Both control methods are described in detail in this chapter.

Chapter 8, "Maintenance and Troubleshooting", provides instructions for the care of your *DisQ-Mark* system and procedures to correct any faults that might occur.

Chapter 9, "Customer Service", provides contact information and procedures for obtaining service and repairs for your Spectra-Physics equipment.

Do not attempt repairs yourself while the unit is still under warranty; instead, report all problems to Spectra-Physics for warranty repair.

Every effort has been made to ensure that the information in this manual is accurate. All information in this document is subject to change without notice. Spectra-Physics makes no representation or warranty, either express or implied, with respect to this document. In no event will Spectra-Physics be liable for any direct, indirect, special, incidental or consequential damages resulting from any defects in this documentation.

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

Thank you for your purchase of Spectra-Physics instruments.

Environmental Specifications

CE Electrical Equipment Requirements

Electrical service requirements are listed in Table 3-3 on page 12. For information regarding the equipment needed to provide this service, please refer to specification EN-309, "Plug, Outlet and Socket Couplers for Industrial Uses," listed in the official *Journal of the European Communities.*

Environmental Specifications

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

Indoor use

Temperatures:	+15°C to +40°C
Maximum relative humidity:	≤ 80% non-condensing, up to 30°C ≤ 50% non-condensing, up to 40°C
Mains supply voltage:	not to exceed ±10% of the nominal voltage
Pollution degree:	2

FCC Regulations

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

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

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Warning Conventions

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

Danger! Laser Radiation	Laser radiation is present.
Danger!	Condition or action may present a hazard to personal safety.
Danger!	Condition or action may present an electrical hazard to personal safety.
Warning!	Condition or action may cause damage to equipment.
Warning! ESD	Action may cause electrostatic discharge and cause damage to equipment.
Caution!	Condition or action may cause poor performance or error.
Note	Text describes exceptional circumstances or makes a special reference.
Don't Touch!	Do not touch.
Eyewear Required	Appropriate laser safety eyewear should be worn during this operation.
	Refer to the enclosed documents and manual before operating or using this device.

Standard Units

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

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

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

Abbreviations

The following is a list of abbreviations used in this manual:

ac	alternating current
ACGIH	American Conference of Governmental Industrial Hygienists
ANSI	American National Standards Institute
AOM	acousto-optic modulator
AR	antireflection
CDRH	Center of Devices and Radiological Health
CE	European Community Compliance Symbol
CW	continuous wave
dc	direct current
E/O	electro-optic
IEC	International Engineering Consortium
FHG	fourth harmonic generation
FWHM	full-width at half-maximum
HR	high reflector
IR	infrared
LBO	lithium triborate
Nd:YAG	neodymium-doped yttrium aluminum garnet
Nd:YLF	neodymium-doped yttrium lithium fluoride
Nd:YVO_4	neodymium-doped Vanadate
OC	output coupler
RF	radio frequency
SCFH	standard cubic feet per hour
SHG	second harmonic generation
TEM	transverse electromagnetic mode
THG	third harmonic generation
UV	ultraviolet
λ	wavelength

Unpacking and Inspection

Unpacking the Laser

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

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

Warning!

Prior to opening the packaging, verify the device has normalized to ambient temperature to avoid condensation. This will take about 6 hours.

System Components

The following components comprise the *DisQ-Mark* laser system:

- *DisQ-Mark* standard laser head, or *DisQ-Mark* laser head with beam expander and aiming laser
- Power supply
- Umbilical

Verify that all the components you purchased are present. Included with the laser system is this manual, the product shipping report, a packing slip listing all the parts shipped, system software on a CD, and accessory kits.

Accessory Kits

Accessory kits are included for the installation of the *DisQ-Mark* components:

Laser Head

- Hex key 3 mm
- Hex key 2.5 mm

Power Supply

- (2) keys for the power supply
- EU power cord
- US power cord

- RS-232 null-modem cable
- Analog plug with interlock jumper

Storage, Transport and Shipment

For storage, or for later transport or relocation of the system, use only the original transport boxes and packaging and maintain the following requirements:

- Minimum temperature –25°C
- Maximum temperature +70°C
- Relative humidity (no condensation)
  ≤ 80% up to +40°C
  ≤ 50% from +41°C to +70°C
- Ensure careful transportation avoiding shocks, jolts and fall (< 50 g).
- Do not stack the system components.
- Disconnect cables between system components.

Chapter 1 Introduction

The *DisQ-Mark* Thin-Disk Laser for Industrial Marking Applications

Figure 1-1: The *DisQ-Mark* Laser System

The Spectra-Physics *DisQ-Mark*™ is an innovative, cost-effective laser that produces 1064 nm output for surface marking and precision machining applications. This highly reliable, diode-pumped, thin-disk Nd:YAG system performs in either CW or Q-switched operation. As a CW laser, the *DisQ-Mark* generates up to 8 watts of output, while Q-switched operation allows pulse repetition rates from 5 kHz to 50 kHz. The beam maintains an M^2 value less than 4, even when the CW power is varied from 2 W to 8 W.

The Q-switched, near-infrared output enables this laser to create surface marks on many organic materials, including most plastics, as well as on a wide variety of metals, including aluminum and anodized aluminum. It can be used for all types of surface marking including color changing, engraving and annealing. Additionally, the *DisQ-Mark* is well-suited for uninterrupted, 24-hour operation in precision machining applications.

DisQ-Mark's innovative design employs thin-disk laser technology, a novel approach to the problems of thermal management of solid state laser materials. The use of thin-disk technology results in an air-cooled architecture that is simpler, easier to integrate, more efficient, lower cost and more rugged than conventional diode-pumped lasers.

The DisQ-Mark Laser Head

The *DisQ-Mark* laser head was specifically designed to meet the requirements of applications requiring a highly reliable Q-switched laser with good beam quality, excellent stability and compact packaging for ease of use and integration. The laser head is available in its standard model or with a 5x beam expander and aiming laser.

The DisQ-Mark Power Supply

The *DisQ-Mark* system houses the diode laser module used for pumping the laser head in the separate power supply, and couples the diode pump output into the laser head through a fiber-optic cable. This facilitates system maintenance and eliminates the need for optical realignment after diode pump replacement. These factors result in a lower cost of ownership and make the *DisQ-Mark* an attractive alternative to lamp-pumped lasers.

System Control

The system supports two control interfaces. The standard control method is by means of analog volatage signals issued over the parallel port, described in Chapter 6. A user-supplied control source (typically a personal computer) can be connected to the *DisQ-Mark* serial port to control the system via user-written software, based on the command and control language, also described in Chapter 6. Software control of the *DisQ-Mark* is intended mainly for CW operation.

Intended Use

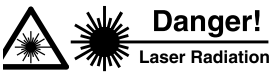
The *DisQ-Mark* thin-disk laser system (a Class IV laser device) is designed for industrial OEM applications. The *DisQ-Mark* laser system itself must be integrated into a master system, for which the owner/operator must ensure compliance with the regulations for Class 1 laser devices and provide appropriate interlock circuits, as well as an external laser emission indicator.

Patents

The *DisQ-Mark* laser system is manufactured under one or more of the following patents:

EP 0 632 551	EP 0 869 591
EP 0 911 920	EP 0 869 592
EP 1 103 090	
US 5 553 088	US 6 577 666
WO 99/08728	JP 2002 524839
DE 5 940 7111	DE 5 990 1655

Chapter 2 Laser Safety



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

The 1064 nm infrared beam, as well as the infrared beam from the diode laser module, is invisible and therefore especially dangerous. Infrared radiation passes easily through the cornea of the eye, which, when focused on the retina, can cause instantaneous and permanent 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 suppliers listed in the *Laser Focus World*, *Lasers and Optronics*, and *Photonics Spectra* buyer's guides. Consult the ANSI and ACGIH standards listed at the end of this section for guidance.
- Maintain a high ambient light level in the laser operation area so the eye's pupil remains constricted, reducing the possibility of damage.
- Avoid looking at the output beam; even diffuse reflections are hazardous.
- Avoid blocking the output beam or its reflections with any part of the body.
- Establish a controlled access area for laser operation. Limit access to those trained in the principles of laser safety.
- Enclose beam paths wherever possible.
- Post prominent warning signs near the laser operating area (Figure 2-1).
- Set up experiments so the beam is either above or below eye level.
- Set up shields to prevent any unnecessary specular reflections or beams from escaping the laser operation area.
- Set up a beam dump to capture the laser beam and prevent accidental exposure (Figure 2-2).
- Keep objects away from the laser area that do not conform to the intended use of the device.
- If the device should fail to perform to the specified working conditions, immediately discontinue using it. Remove the key from the keyswitch and contact Technical Service.
- Prior to the use of any accessories, make sure that they have been tested for safe operation and approved by the manufacturer.

- Never expose the laser beam to explosive, flammable or combustible material.

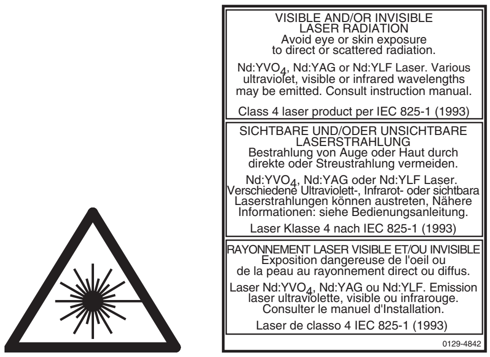


Figure 2-1: These standard safety warning labels would be appropriate for use as entry warning signs (EN 60825-1, ANSI 4.3.10.1).

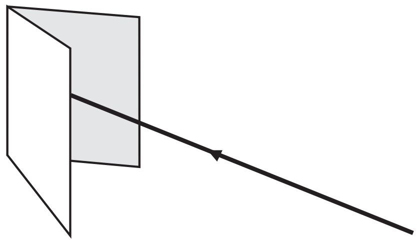


Figure 2-2: Folded Metal Beam Target

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

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

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

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

Safety Devices of the *DisQ-Mark* System

Power Supply Safety Features

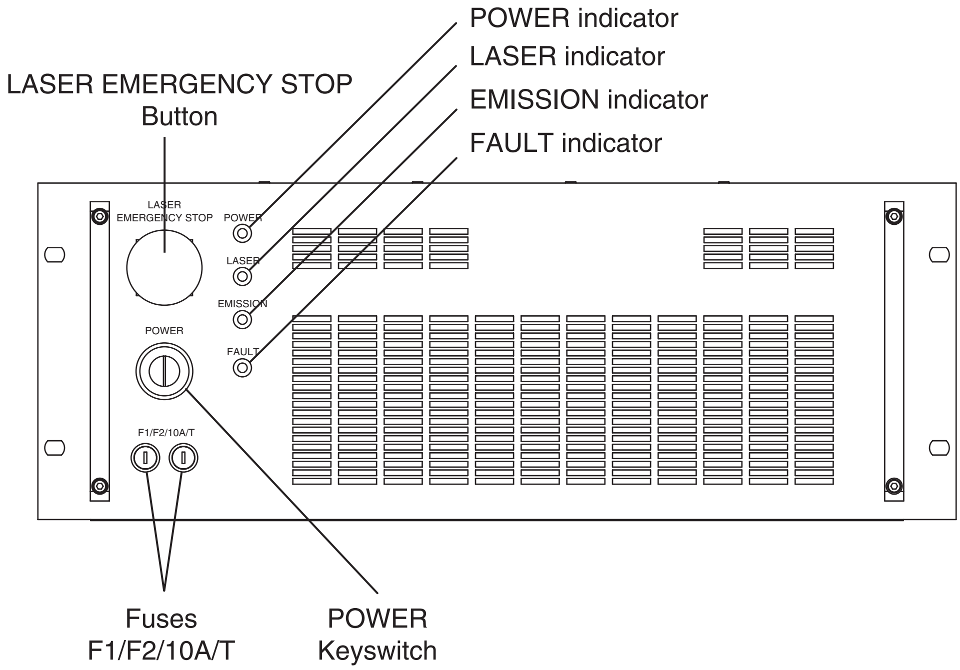


Figure 2-3: Safety Features, Power Supply Front Panel

LASER EMERGENCY STOP Button

Pressing the EMERGENCY STOP button immediately interrupts the line voltage to the *DisQ-Mark* laser and stops laser emission. After pressing the EMERGENCY STOP button, it must be unlocked (reset) by turning it counter-clockwise before the system can be started again.

When the *DisQ-Mark* laser head is integrated into a host system, the operator must install a stop device that will cut off power to the *DisQ-Mark* as well as the overall system. The system must be in a defined OFF state after the button is pressed, and all control signals must be set to ground (“Earth”) level.

Keyswitch

The keyswitch on the front panel of the power supply acts as both a system power switch and safety interlock. Once the key is inserted and turned to the ON position, line voltage is provided to the system and the diode laser module inside of the power supply can be energized. The key can only be removed when it is turned to the OFF position. Removing the key prevents unauthorized use.

POWER Indicator

The green POWER indicator glows when the keyswitch is set to ON and electrical power is available to the system.

LASER Indicator

The yellow LASER indicator glows when the diode pump laser module in the power supply has been turned on, either by serial command or by analog signals applied to the parallel INTERFACE port. After a safety delay of about 3 seconds, the *DisQ-Mark* laser head is capable of emitting radiation.

EMISSION Indicator

The yellow EMISSION indicator is identical in function to the LASER indicator. This redundancy provides a measure of safety in the event that one of these indicators fails.

FAULT Indicator

The yellow FAULT indicator glows whenever a system fault has been detected.

Fuses

DisQ-Mark incorporates two double-pole neutral fuses for 100 to 240 Vac operation. The fuses are located on the front panel and can be accessed using a standard screwdriver. Replacement fuses must be of the same type.

Table 2-1: Fuse Ratings for F1, F2 of the *DisQ-Mark* Power Supply

Supply Voltage	Rating	Type
100–240V~	10 A	T 10 A, 250 V

User Interlock

Pins 8 and 15 of the parallel INTERFACE port on the back of the power supply provide a remote safety interlock. When wired to an external, normally closed safety switch, this circuit will turn off the laser when the switch is opened.

Laser Head Safety Features

Emission Indicator

The yellow EMISSION indicator (Figure 2-4) glows when the diode pump laser module in the power supply is turned on. After a delay of about 3 seconds, the laser head is capable of emitting laser light.

Shutter

The laser head shutter is opened by an electro-magnet that is activated by the 24 V interlock circuit. When the safety circuit is opened (i.e., when power to the electromagnet is interrupted), a spring returns the shutter to the closed (default) position.

Controlling the shutter and monitoring actual (as opposed to nominal) shutter position is done through a combination of software commands and internal signals. Control of the shutter via the serial port is explained in "Shutter Safety Functions" on page 7-4, while instructions for use of the parallel INTERFACE connector are described in "Interlock Control" on page 7-10.

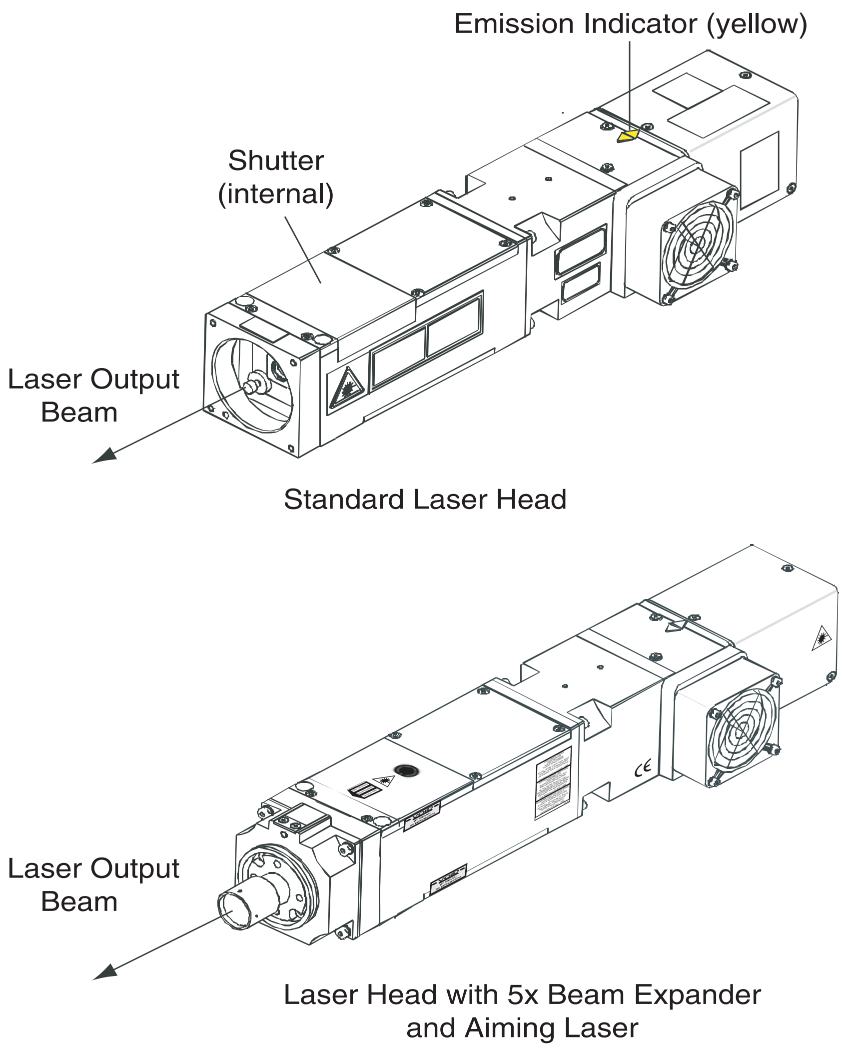


Figure 2-4: Safety Features, *DisQ-Mark* Laser Head

Cover Safety Interlocks

Laser Head

Because there are no user-serviceable parts inside the laser head and no internal adjustments that can be made by the user, the laser head requires no cover safety interlocks.

Power Supply

The power supply cover is not interlocked. Except when changing the diode laser module, the power supply should not be opened by the user, and then only by a technician trained by Spectra-Physics in this specific procedure. When the system requires a diode module change, the entire system is to be turned off during the installation. Following diode laser replacement, the power supply cover is to be installed before power is turned on again. The power supply is not intended to be run with the cover removed.

Requirements for Operation in Compliance with Standards and Regulations

Laser Class and Protection Class: This device is a Class 4 laser device and classified in Protection Class 1. It meets the requirements of safety and protection standards EN 60825-1 (IEC 60825-1) and EN 61010-1.

Operation of this device should be in accordance with any relevant local safety regulations for the operation of laser devices, such as the American National Standard for Safe Use of Lasers (ANSI Z136.1-2000) or the German Regulations on the Prevention of Accidents (BGV B2).

Enclosure Protection: This device is classified to comply with Enclosure Protection IP 20 in compliance with EN 60529.

Noise: This device satisfies the requirements of EN 55011 (radio noise suppression) and EN 61000-6-2 (industrial immunity standard).

ISO Compliance: This device has the following certifications:

QUALITY MANAGEMENT
Certificate
Voluntary participation in regular monitoring according to ISO 9001

ENVIRONMENTAL MANAGEMENT
Certificate
Voluntary participation in regular monitoring according to ISO 14001

FCC Compliance

The *DisQ-Mark* system has been certified as compliant with the Class A limits of the FCC (Federal Communications Commission) Radio Frequency Devices Rules (FCC Part 15 Subpart B—revised as of October 1 1998).

Maximum Emission Levels

Table 2-2 lists the maximum emission levels possible for the *DisQ-Mark* laser. Use this information for selecting appropriate laser safety eyewear and implementing appropriate safety procedures. These values do not imply actual system power or specifications.

Table 2-2: Maximum Emission Levels

Emission Wavelength	Maximum Power
Fiber-Optic Emission: 808 nm	40 W, CW
Laser Head Emission: 1064 nm	
CW	10 W
Q-switched (70 ns pulses at 5 kHz rep rate)	10 kW

Requirements for Safely Operating the DisQ-Mark Laser System with a User-Provided Control Device

When the *DisQ-Mark* laser system is controlled by a device provided by user or software written by the user, for safety the following must be provided by the user:

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

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

Since the *DisQ-Mark* laser is intended for use as an OEM component in a system that is itself subject to regulatory approval, the laser has not been submitted for approval by the Center for Devices and Radiological Health (CDRH). Nonetheless, it is prudent to observe the schedule of maintenance for the safety features of the laser in accordance with CDRH regulations.

Once a year, or any time the product may have been subjected to adverse environmental conditions (e.g., fire, flood, mechanical shock, spilled solvent, etc.), verify all features of the product identified on the CE/IEC Radiation Control Drawings (found later in this chapter) function properly. Also, make sure that all warning labels remain firmly attached.

1. Verify the laser can only be turned on when the keyswitch is in the ON position, and that the key can only be removed when the switch is in the OFF position.
2. Verify the emission indicator provides a visible signal when the accessible laser emission exceeds the level for laser radiation Class I.
3. Verify the time delay between turn-on of the emission indicator and starting of the laser gives enough warning to allow action to avoid exposure to laser radiation.
4. Verify the shutter closes and actually blocks laser radiation emission when the interlock loop is opened.

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

(*0.39 µW for CW operation where output is limited to the 400 to 1400 nm range*).

CE/IEC Radiation Control Drawings

Numbers in the following drawings refer to the warning labels in Figure 2-7.

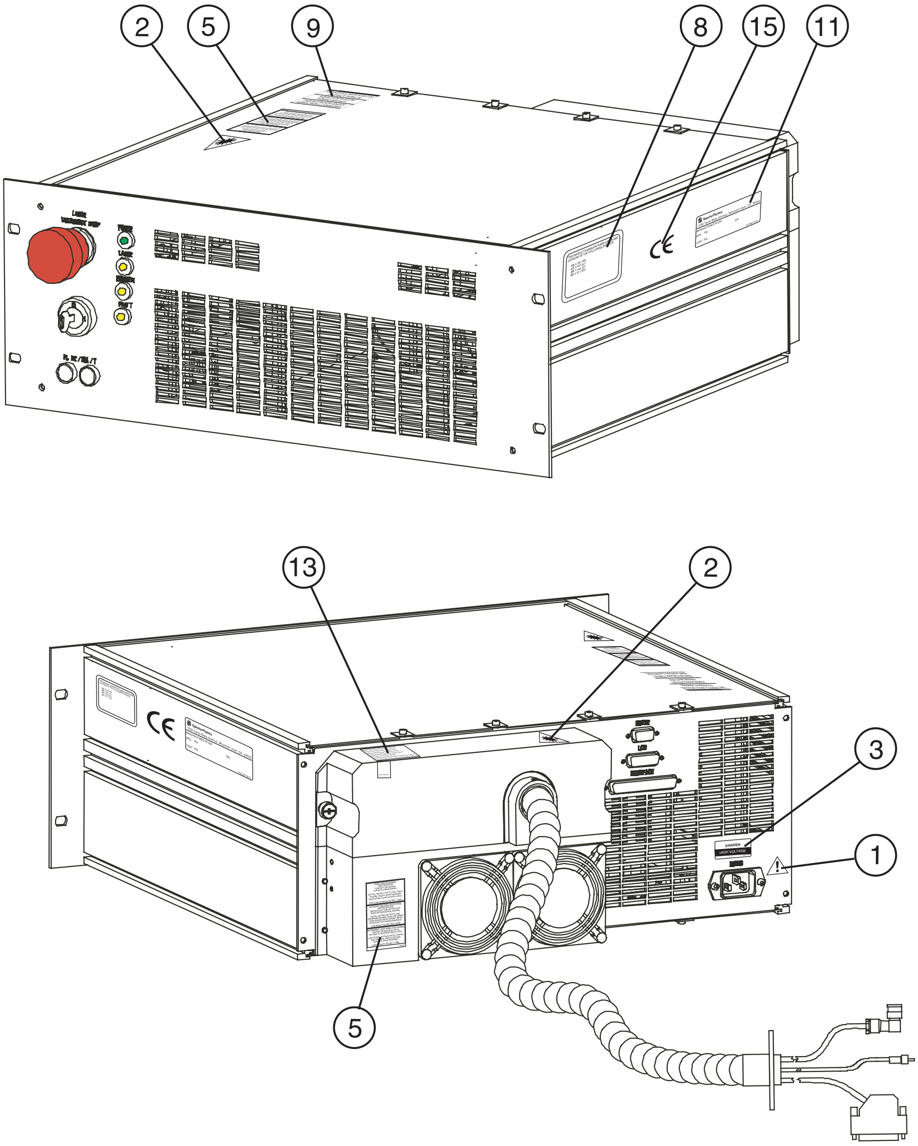


Figure 2-5: *DisQ-Mark* Power Supply CE/IEC Radiation Control Drawing.

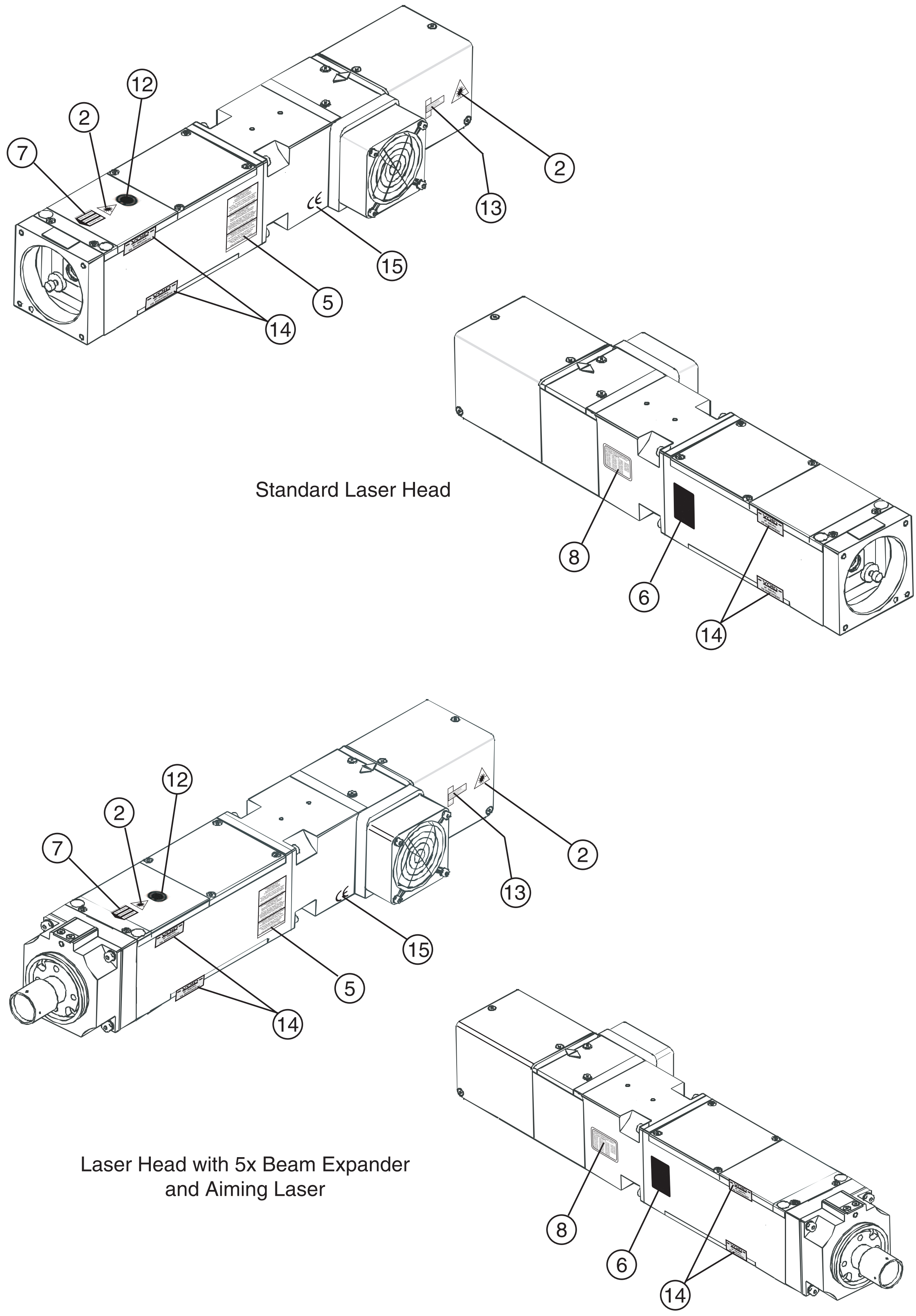


Figure 2-6: *DisQ-Mark* Laser Head CE/IEC Radiation Control Drawing.

CE/IEC Warning Labels

Note Removing any seals or the serial number label will void the warranty.

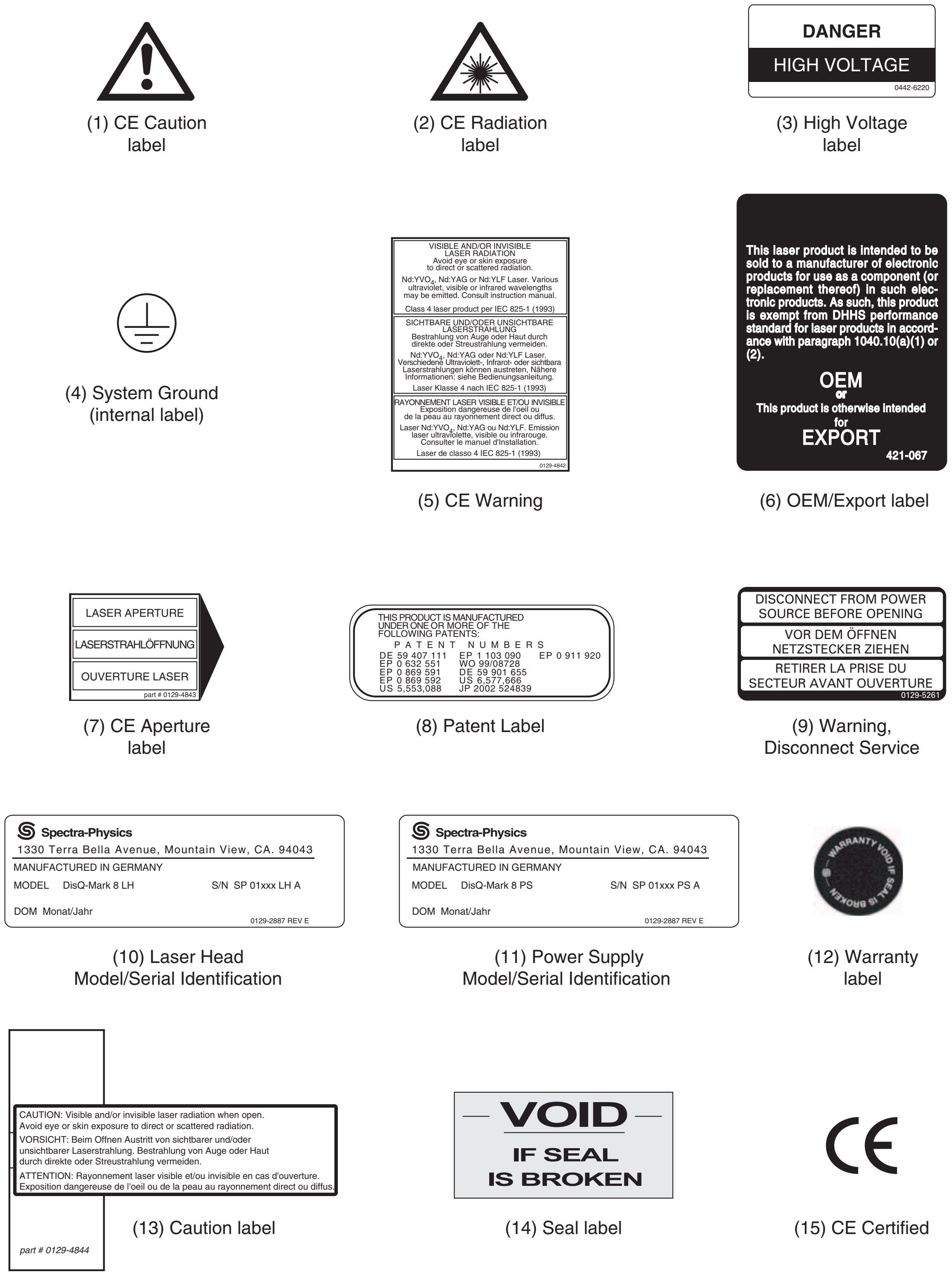


Figure 2-7: *DisQ-Mark* CE/IEC Warning Labels

CE Declaration of Conformity

We,

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

declare under sole responsibility that the

DisQ-Mark power supply and any variation of DisQ-Mark laser head, Manufactured after January 1, 2002,

meets the intent of EMC Directive 89/336/EEC: 1989, Annex 1, for electromagnetic compatibility and 73/23/EEC: 1973, for low voltage directives. Compliance was demonstrated to the following specifications as listed in the official *Journal of the European Communities*:

EMC Directive 89/336/EEC: 1989

EN 50081-2: 1993 (Emissions)

EN 55011: 1998, CISPR 11: 1997, Class A radiated and conducted emissions

EN 50082-2: 1995 (Immunity)

EN 61000-6-2: 2000, Noise immunity.

Low Voltage Directive 73/23/EEC: 1973

EN 61010-1: 1994, Safety requirements for electrical equipment for measurement, control, and laboratory use, Part 1: General Requirements

EN 60825-1: 2001 (IEC 60825-1), Safety of laser products- Part 1 Equipment classification, requirements, and users guide

EN 31252: 1994, Lasers and laser related equipment, Laser device, Minimum requirements for documentation

EN 31253: 1994, Lasers and laser related equipment, Laser device, Mechanical interfaces

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

Bruce Craig
Vice President and General Manager

Spectra-Physics
Lasers & Photonics

March 10, 2004

Sources for Additional Information

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

Laser Safety Standards

Safe Use of Lasers (Z136.1: 1993)
American National Standards Institute (ANSI)
11 West 42nd Street
New York, NY 10036
Tel: (212) 642-4900

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

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

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

Compliance Engineering
70 Codman Hill Road
Boxborough, MA 01719
Tel: (978) 635-8580

International Electrotechnical Commission
Journal of the European Communities
EN60825-1 TR3 Ed.1.0—Laser Safety Measurement and Instrumentation
IEC-309—Plug, Outlet and Socket Coupler for Industrial Uses
Tel: +41 22-919-0211
Fax: +41 22-919-0300
Internet: http://ftp.iec.c.h/

Cenelec
European Committee for Electrotechnical Standardization
Central Secretariat
rue de Stassart 35
B-1050 Brussels

Document Center
1504 Industrial Way, Unit 9
Belmont, CA 94002-4044
Tel: (415) 591-7600

Equipment and Training

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

Laser Focus World Buyer's Guide
Laser Focus World
Penwell 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 Drive
P.O. Box 650
Morris Plains, NJ 07950-0650
Tel: (973) 292-5100

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

Chapter 3 Laser Description

A Brief Review of Laser Theory

Emission and Absorption of Light[1]

Laser is an acronym derived from Light Amplification by Stimulated Emission of Radiation. Unlike thermal radiators, which emit light in all directions, the laser is an amplifier of light, and because its output comprises photons that are identical in phase and direction, its output beam is singularly directional, monochromatic, and coherent.

Radiant emission and absorption take place within the atomic or molecular structure of materials. Each electron occupies a distinct orbital that represents the probability of finding the electron at a given position relative to the nucleus. The energy of an electron is determined by the orbital that it occupies, and the over-all energy of an atom—its energy level—depends on the distribution of its electrons. The level with the lowest possible energy is called the ground state, and higher energy levels are called excited states. If an atom is in its ground state, it will stay there until it is excited by external forces.

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

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

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

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

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

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

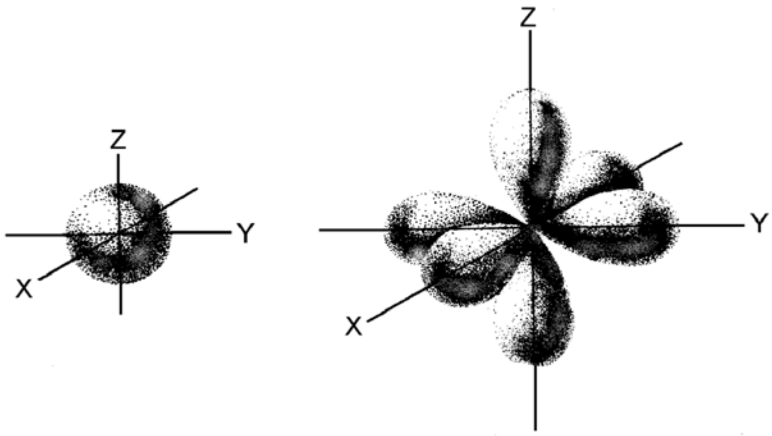


Figure 3-1: Electrons occupy distinct orbitals that are defined as the probability of finding an electron at a given position. The shape of the orbital is determined by the radial and angular dependence of this probability.

An atom excited to E_2 can also be stimulated to decay to E_1 by interacting with a photon of frequency ν, emitting energy in the form of a pair of photons that are identical to the incident one in phase, frequency, and direction. This is known as stimulated emission. By contrast, spontaneous emission produces photons that have no directional or phase relationship with one another.

A laser is designed to take advantage of absorption, and both spontaneous and stimulated emission phenomena, using them to create conditions favorable to light amplification.

Population Inversion

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

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

If enough light of frequency ν is supplied, the populations can be shifted until $N_1 = N_2$. Under these conditions the rates of absorption and stimulated emission are equal, and the absorption coefficient at frequency ν is zero. If the transition scheme is limited to two energy levels, N_2 can never exceed N_1 because every upward transition is matched by one in the opposite direction.

However, if three or more energy levels are employed, and if their relationship satisfies certain requirements described below, additional excitation can create a population inversion where $N_2 > N_1$.

A model four-level laser transition scheme is depicted in Figure 3-2. A photon of frequency ν_1 excites—or "pumps"—an atom from E_1 to E_4. If the E_4 to E_3 transition probability is greater than that of E_4 to E_1, and if the lifetime of an atom at E_4 is short, the atom will decay almost immediately to E_3. If E_3 is metastable, i.e., atoms that occupy it have a relatively long lifetime, the population will grow rapidly as excited atoms cascade from above.

The E_3 atom will eventually decay to E_2, emitting a photon of frequency ν_2. Finally, if E_2 is unstable, its atoms will rapidly return to the ground state, E_1, keeping the population of E_2 small and reducing the rate of absorption of ν_2. In this way the population of E_3 is kept large and that of E_2 remains low, thus establishing a population inversion between E_3 and E_2. Under these conditions, the absorption coefficient at ν_2 becomes negative. Light is amplified as it passes through the material, which is now called an "active medium." The greater the population inversion, the greater the gain.

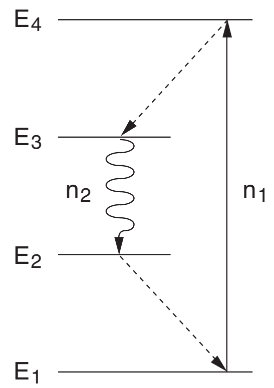


Figure 3-2: A Typical Four-level Transition Scheme

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

Resonant Optical Cavity

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

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

The laser oscillates within a narrow range of frequencies (or wavelengths) around the transition frequency of the laser material.

Nd^{3+} as a Laser Medium

The source of excitation energy for the gain medium is usually optical or electrical. Arc lamps are often employed to pump high-powered solid-state lasers. The *DisQ-Mark* uses the output from a diode laser to pump Nd^{3+} ions doped in a yttrium\crystalline matrix (Nd:YAG).

The properties of neodymium-doped matrices are the most widely studied and best understood of all solid-state laser media. The four-level Nd^{3+} ion scheme is shown in Figure 3-3. The active medium is triply ionized neodymium, which has principle absorption bands in the red and near infrared. Excited electrons quickly drop to the $^4F_{3/2}$ level, the upper level of the lasing transition, where they remain for a relatively long time.

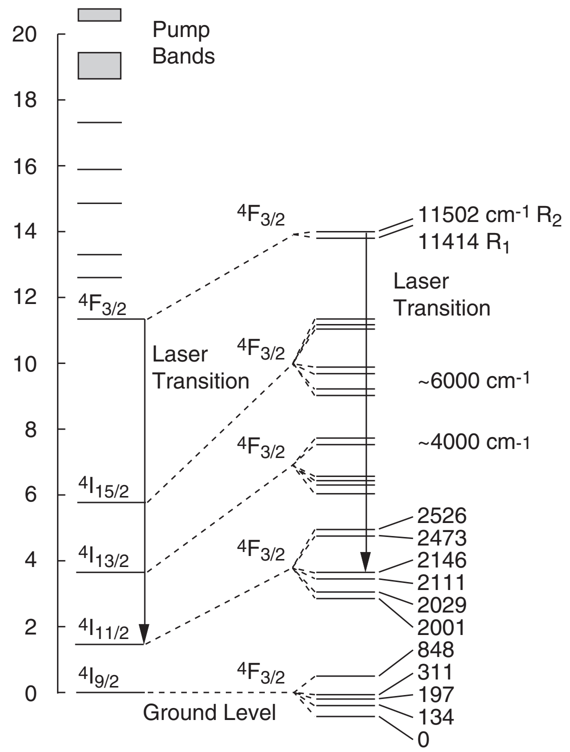


Figure 3-3: Energy Level Scheme for the Nd^{3+} Ion

The most probable lasing transition is to the $^4I_{1/2}$ state, where a photon at 1064 nm is emitted. Because electrons in that state quickly relax to the ground state, its population remains low. Hence, it is easy to build a population inversion. At room temperature the emission cross section of this transition is high, so its lasing threshold is low.

Diode-pumped Laser Design

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

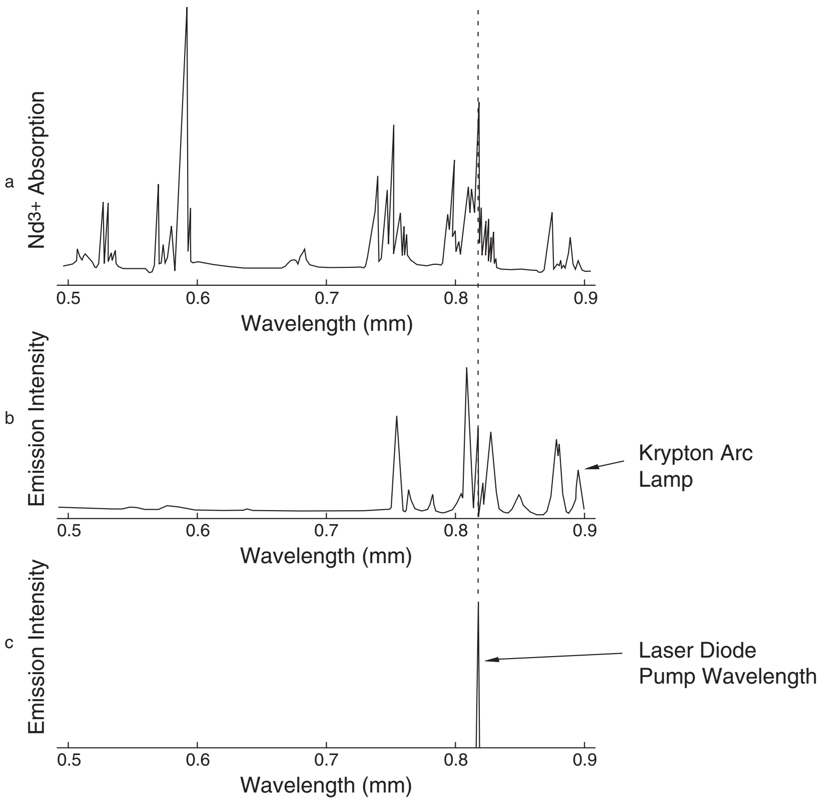


Figure 3-4: Nd^{3+} absorption spectra (a) compared to the emission of a Krypton Arc Lamp (b) and a Diode Laser Pump (c).

One of the key elements in optimizing the efficiency of a solid-state laser is maximizing the overlap of the regions of the active medium excited by the pumping source and the active medium occupied by the laser mode. A consideration in this design is the absorption depth in Nd:YAG of the diode laser wavelength.

Spectra-Physics uses as a pump laser a diode laser that has numerous emitters at 808 nm in a monolithic bar. These bars are ideal as high power pump sources. They have the same high efficiency as discrete diode laser devices, yet allow for the manufacture of simple and reliable high-power pump laser sources. The active emission area for these new devices is a virtual "ribbon of light."

Thin-Disk Laser Technology

Conventional diode-pumped solid-state lasers typically employ their gain medium in a rod geometry, either in a cylindrical or a rectangular shape. The major drawback to achieving both high peak output power and good beam quality from these types of lasers is the formation of a temperature gradient perpendicular to the rod axis.

Above a threshold of pump power, this temperature gradient leads to a refractive index gradient (a "thermal lens") that focuses the laser beam itself and intensifies the thermal lens effect even further. This ultimately limits the output power and beam quality, and in extreme cases may even cause damage to the laser rod.

The thin-disk laser was developed to overcome these difficulties. In this innovative design, the laser crystal is formed as a disk only a fraction of a millimeter in thickness. This disk receives a coating on one face that is highly reflective at both the laser wavelength and the pump laser wavelength as well. This coated surface is then bonded to a heatsink. Because the disk is so thin, excellent cooling efficiency and uniformity can be achieved at high levels of pump energy density, avoiding thermal lensing and even enabling the use of air-cooled designs for high-powered Nd:YAG lasers.

In order to achieve a sufficient degree of absorption of the pump light in the thin disk, the diode laser pump beam light is reflected multiple times through the disk. The output surface of the disk has an anti-reflection coating. A mirror that is partially transmitting at the laser wavelength reflects the output wavelength back into the thin-disk gain medium in order to extract all of the available gain.

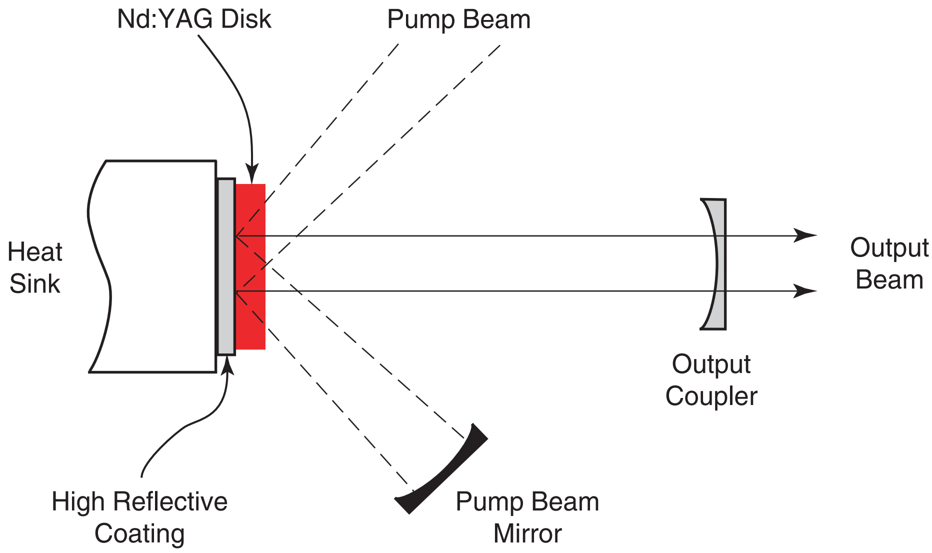


Figure 3-5: Thin-Disk Laser Cavity

Thin-disk laser technology enables high-power, diode-pumped, solid-state laser designs of compact size that are exceptionally robust and stable.

The DisQ-Mark Laser System

A *DisQ-Mark* laser system consists of the following basic components:

- the *DisQ-Mark* laser head, either the standard model
  or the laser head with a 5x beam expander and aiming laser
- the *DisQ-Mark* power supply
- the umbilical cable

The DisQ-Mark Laser Head

DisQ-Mark uses a high-power, thermally-stabilized diode laser module in the power supply that provides 808 nm pump power to the laser cavity via a fiber-optic cable. This cable attaches to the laser head by a connector that maintains the alignment of the output from the fiber to the components inside the laser head.

The fiber output is imaged onto the face of the thin disk of the Nd:YAG crystal, where a portion of it is absorbed through excitation of the upper laser state. Since the laser crystal is so thin, however, a substantial percentage of the pump light passes through the crystal to the high reflector coating on the bonded side of the disk where it gets reflected back through the disk and onto the second pump mirror. The pump mirrors reflect this pump light multiple times through the disk, where more is absorbed with each pass. The small fraction that remains passes out of the disk. However, virtually all of the pump light delivered by the fiber-optic cable is absorbed by the Nd:YAG crystal.

The Nd:YAG crystal converts the pump energy into 1064 nm infrared intracavity light. The high reflector coating on the back surface of the crystal, together with an output coupler mirror define the resonant cavity. The output coupler allows a portion of the light to pass out of the cavity. The *DisQ-Mark* laser cavity is designed for maximum reliability with minimum complexity, producing operation that is so stable that no alignment is required in the course of normal operation.

To generate high-energy pulses, the *DisQ-Mark* uses an acousto-optic modulator (AOM). The AOM functions as a Q-switch, an optical switch that is placed inside of the laser cavity to momentarily prevent the laser beam from circulating inside the Nd:YAG crystal. This allows the laser gain in the Nd:YAG crystal to build to an elevated value, as the stimulated emission that saturates the gain is interrupted. The Nd:YAG crystal can then provide all of its available energy as individual pulses when the AOM is returned to its fully transparent state. Since the pulses are on the order of one hundred nanoseconds, this results in (combined with the duty cycle) an instantaneous peak power about 1000 times greater than the CW power.

A common AOM design uses a simple transparent block of quartz, to which is bonded a piezo-electric transducer (PZT). The AOM performs its switching function when the PZT, driven by an RF signal, impresses a standing acoustic wave within the quartz block. This produces a diffraction grating that results in the switch-like function that extinguishes the intracavity beam. The AOM allows the repetition rate for the Q-switched pulses to be set by the user in a range between 5 kHz to 50 kHz. When the laser is operated in CW mode, the AOM remains off and acts simply as a transparent window.

General Operating Considerations

The *DisQ-Mark* is specified for the highest power it can reliably deliver. The laser must not be operated at power levels higher than its maximum specified level (refer to the final test report included with the laser system).

Caution!

Over-driving the system can cause spatial mode degradation and Q-switch hold-off problems, and it will shorten the lifetime of the diode laser pump module.

Output power should be reduced, however, if the application accepts lower power levels. Since the lifetime of a diode laser depends on the operating current and the optical power density at the output facets, reducing these two factors can extend the lifetime of the diode laser pump module.

It should be noted, however, that changes in the pump power and in the circulating laser intensity result in other changes to the laser output in addition to changing output power. These types of effects are common to all solid-state lasers, regardless of their pumping mechanism. For diode-pumped lasers, while most of the optical power absorbed by the laser crystal is used to excite the laser transition, the high levels of pump energy nevertheless result in some of this pump energy heating the laser crystal.

The laser crystal in turn behaves as a "variable lens" with characteristics that depend on its temperature. As a result, the laser modes that resonate in the cavity will change as the pump level changes. You might notice, then, that beam size and divergence, pulse width, and pulse-to-pulse stability may vary when pump power is changed. The *DisQ-Mark* laser cavity is designed to minimize this thermal lensing, resulting in optical output that remains significantly higher in quality than competing laser systems.

System Control

The *DisQ-Mark* system can be controlled in two ways:

- by using the parallel interface (the default method), as described in "Controlling the System Through the Parallel Interface" on page 5
- by using the serial interface with user-written software, as described in "Controlling the System Through the Serial Interface" on page 11.

Both methods allow complete control of basic system functions, including power level, shutter position, pulse repetition rate, and the monitoring of important system temperatures. Serial control is intended primarily for CW operation. The parallel interface provides control of the first Q-switched pulses that are emitted when the *DisQ-Mark* is initially turned on. It is a characteristic of solid-state Q-switched lasers that these initial pulses might have unpredictable behavior. Thus, this "first pulse suppression" avoids potential problems that might result from these pulses in applications where a high degree of consistency in energy is required for all pulses.

The *DisQ-Mark* laser head is also available with a 5x beam expander and aiming laser to simplify control of the beam direction through the optical path of certain master systems.

The DisQ-Mark Power Supply

Pump power is provided to the Nd:YAG crystal in the laser head by a diode laser module in the power supply via a fiber-optic cable. The cable encases and protects the optical fiber, which is less than 1 mm in diameter. The laser light from each emitter of a diode laser bar is brought together and focused into the optical fiber. The waveguide properties of fiber transport allow the astigmatic light from the diode laser bar to be converted into a beam of exceptional brightness that is shaped to match the requirements for pumping the disk volume of the Nd:YAG laser crystal.

The delivery fiber-optic cable allows the diode laser module to be located in the power supply, thereby removing its heat load from the laser head and, thus, providing better laser head stability. In practice, the diode laser module is significantly derated from its rated power in order to ensure a long lifetime for the diode laser emitters comprising the bar.

This design facilitates the replacement of the diode laser module in the field without requiring a realignment of the laser cavity. As an extra benefit, because the laser head remains sealed, it is not exposed to possible contamination that could compromise its operation.

The power supply includes these assemblies:

- fiber-coupled diode laser module
- microprocessor-controlled operating system for controlling and monitoring diode laser power, current and cooling temperature
- logic and analog dc power supplies
- RF Q-switch power supply
- RS-232 and analog/TTL inputs to control the system
- diode module cooling system

The power supply provides the control interface(s) for the system and contains the laser diode laser module that pumps the Nd:YAG crystal in the laser head. A 10 W RF driver supplies power to drive the Q-switch in the laser head.

The front panel of the power supply has a power on/off keyswitch and interlock. For safety, when the system is turned off, remove the key to prevent unauthorized operation of the system. Two fuses provide over-load protection. Refer to Table 2-1 on page 4 for fuse size and type.

When the keyswitch is turned on, the POWER indicator turns on to show that power is applied to the system. When the diode laser module is turned on, the EMISSION indicator and the LASER indicator turn on to warn that emission from the diode laser pump and the laser head is present or imminent. Any system faults will cause the FAULT indicator to glow. Errors can be monitored remotely by the control source through the parallel or serial interface.

Connections are provided on the rear panel for ac input power and control signals to and from the laser head. The power supply is air-cooled. Allow 3 inches of clearance at the front and rear panels for proper ventilation. The power supply is designed to be mounted in a 19 inch or equivalent rack and requires 100–240 Vac, 47–63 Hz, 15 A single-phase power.

Intended Use

The *DisQ-Mark* thin-disk laser system (a Class IV laser device) is designed for industrial OEM applications. The *DisQ-Mark* laser system itself must be integrated into a master system, for which the owner/operator must ensure compliance with the regulations for Class I laser devices and provide appropriate interlock circuits, as well as an external laser emission indicator.

The diode laser module in the power supply operates in CW mode. The system is to be operated only up to its maximum output power of 8 W. The maximum operating voltage specified on the Test Certificate that is shipped with the *DisQ-Mark* system *must not be exceeded*.

The diode pump module of the power supply is subject to degradation during its service life. To counteract the effects of degradation, higher current settings can be used. However, variation of the voltage setting is permissible only after consultation with Spectra-Physics.

The *DisQ-Mark* thin-disk laser system was not designed for and should not be employed for the following applications:

- Operation in rooms with an explosive atmosphere
  (it does not comply with the requirements of Directive 94/9/EC)
- Medical or therapeutic applications
  (it does not comply with the requirements of Medical Device Directive 93/42/EC)
- Irradiation of living beings, flammable and combustible material, substances that are dangerous to health, dangerous gases, dusts and chemicals.

Danger!
Laser Radiation

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

Specifications

Table 3-1: *DisQ-Mark* Performance Specifications[1]

General Characteristics		
Wavelength	1064 nm	
Noise emission	57 dB (A)	
Mode	Low order mode	
CW Operation		
Output power	8 W	
M^2	< 4	
RMS stability	2%	
Polarization	random polarization	
Beam diameter	1.8 mm	
Beam divergence	< 3.5 mrad	
Beam location (refer to the Outline Drawing on page 3-13)	±0.5 mm from nominal optical axis Angular error: ±5 mrad	
Q-switch Mode	**5 kHz**	**10 kHz**
Repetition rate	5 kHz to 50 kHz	
Pulse energy	> 0.6 mJ	> 0.4 mJ
Peak power	> 6 kW	> 3 kW
Average power	> 3 W	> 4 W
Pulse duration	< 125 ns	< 150 ns
Peak-to-peak stability	< 2%	< 4%
Pumping Light (CW mode)		
Wavelength	808 nm	
Output power	24 W (typical)	
Aiming Laser		
Wavelength	650 nm	
Output power	< 1 mW	
Laser class	2	

[1] *Due to our continuous product improvement program, specifications may change without notice.*

Table 3-2: Environmental Specifications

Operating Conditions	
Temperature range	+15°C to +40°C
Relative humidity	≤ 80% (non-condensing) up to 30°C, ≤ 50% (non-condensing) to 40°C
Permissible vibrations	Sinusoidal excitation of 20 Hz to 500 MHz, sliding frequency
Permissible load	0.15 mm / 2 g
Permissible shocks, laser head	Semi-sinusoidal, max. 30 g / 6 ms
Permissible shocks, power supply	Semi-sinusoidal, max. 15 g / 11 ms
Storage and Transport Conditions	
Temperature range	-25°C to +70°C
Relative humidity	≤ 80% (non-condensing) up to 40°C, decreasing linearly to ≤ 50% from 41°C to 70°C
General	
Overvoltage category	2
Pollution degree	2

Table 3-3: *DisQ-Mark* Electrical and Physical Specifications

Electrical Requirements	100−230 Vac, 50/60 Hz
Power Input	800 Watts max (400 Watts typical at 22°C)
Cooling	Air-cooled
Weights (approximate)	
Standard laser head	4.0 kg (8.8 lb)
Laser head with 5x expander, etc.	4.35 kg (9.6 lb)
Power supply	20.0 kg (44.0 lb)
Dimensions (approximate)	
Standard laser head (L x W x H)	393 x 126 x 70 mm (15.5 x 5.0 x 2.8 in.)
Head with 5x expander (L x W x H)	464 x 126 x 77 mm (18.3 x 5.0 x 3.0 in.)
Power supply (W x H x D)	483 mm x 4 HU x 500 mm (19 in. x 4 HU x 19.7 in.)
Optical Fiber Length	4.8 m (16 ft)
Electromagnetic Compatibility	
Radio noise suppression	EN 55011
Noise immunity	EN 61000-6-2
Safety Standard Compliance	EN 61010-1
Enclosure Protection	IP 20 as per EN 60529
Protection Class	1

Outline Drawings

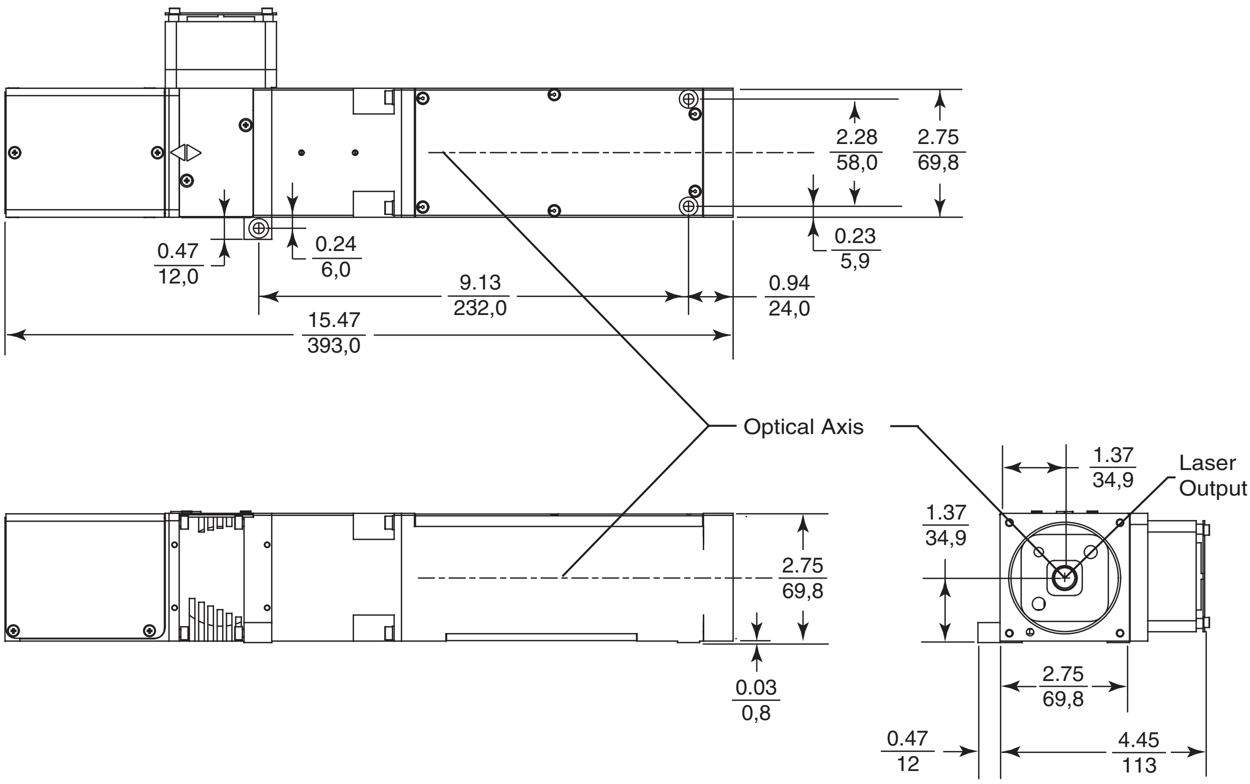


Figure 3-6: Outline Drawing, Standard Laser Head

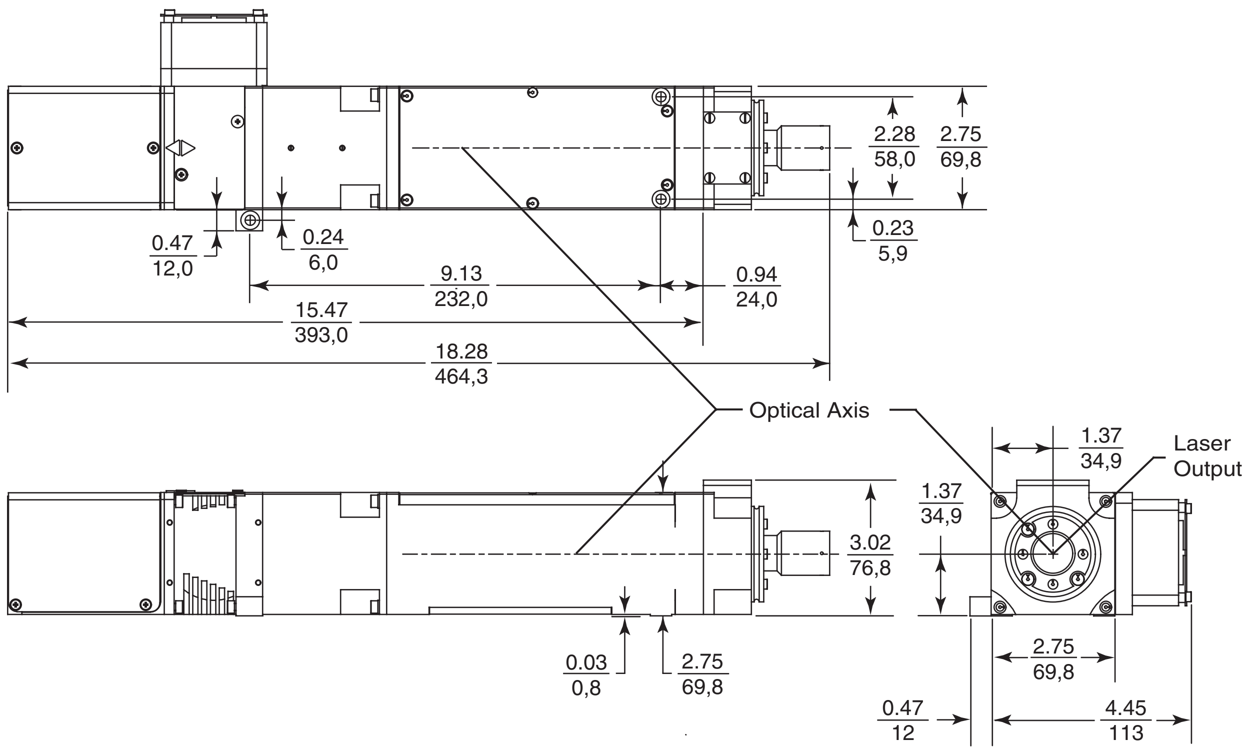


Figure 3-7: Outline Drawing, Laser Head with 5x Beam Expander and Aiming Laser

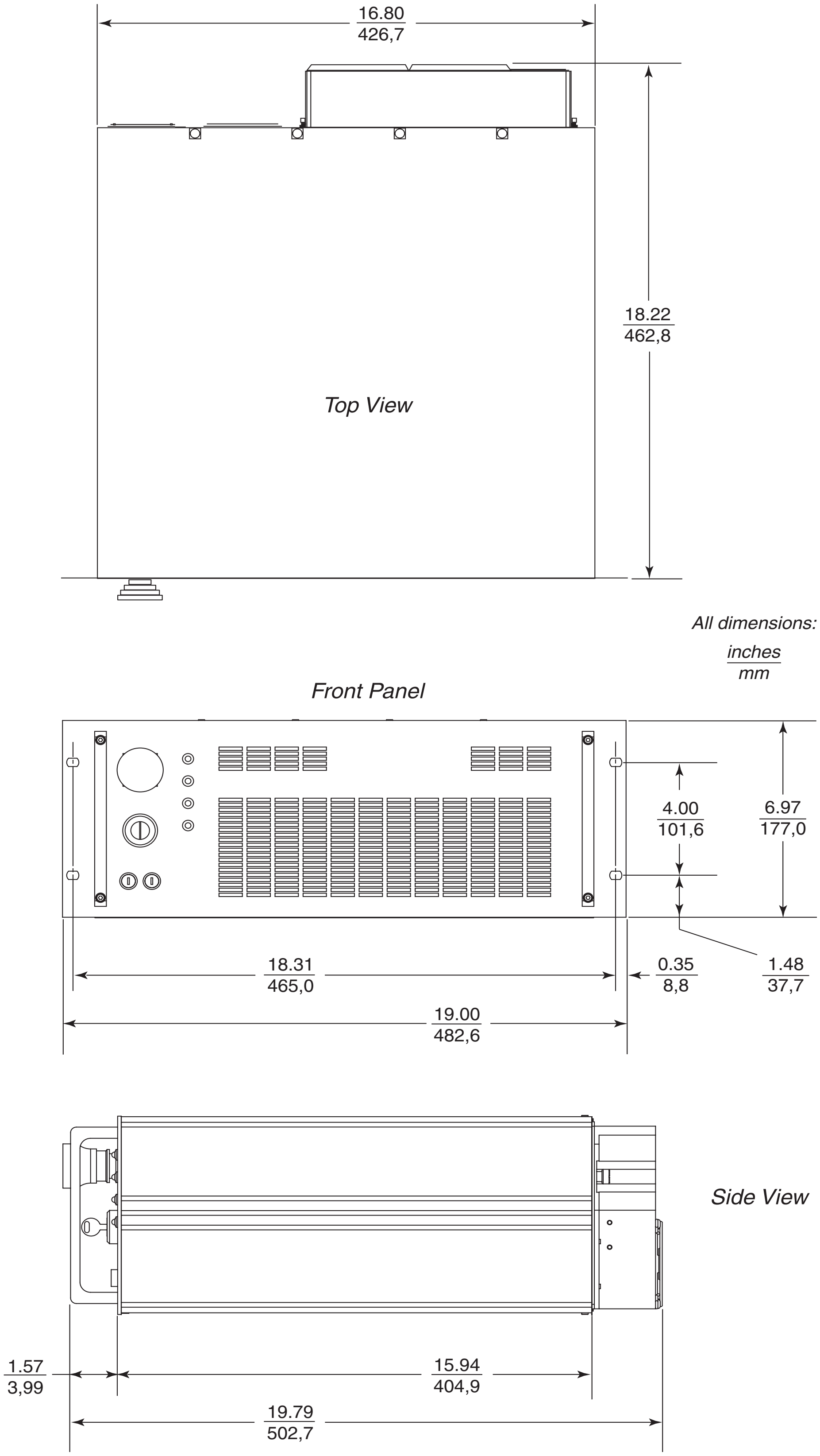


Figure 3-8: Outline Drawing, *DisQ-Mark* Power Supply

Block Diagrams

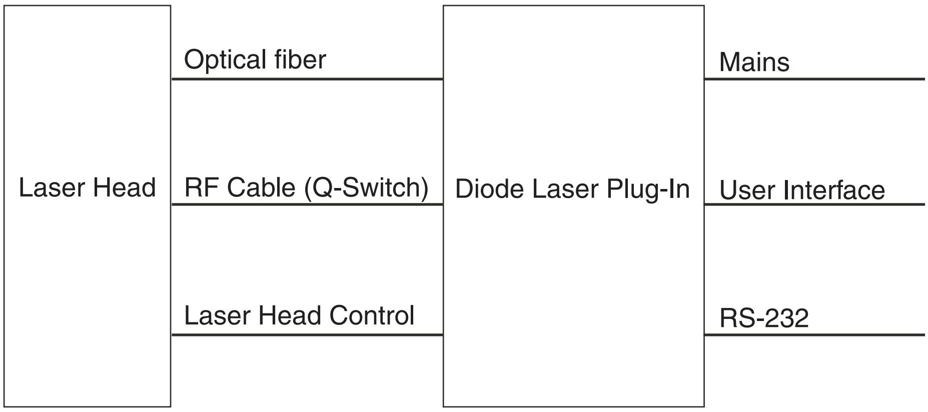


Figure 3-9: ***DisQ-Mark*** **Connections**

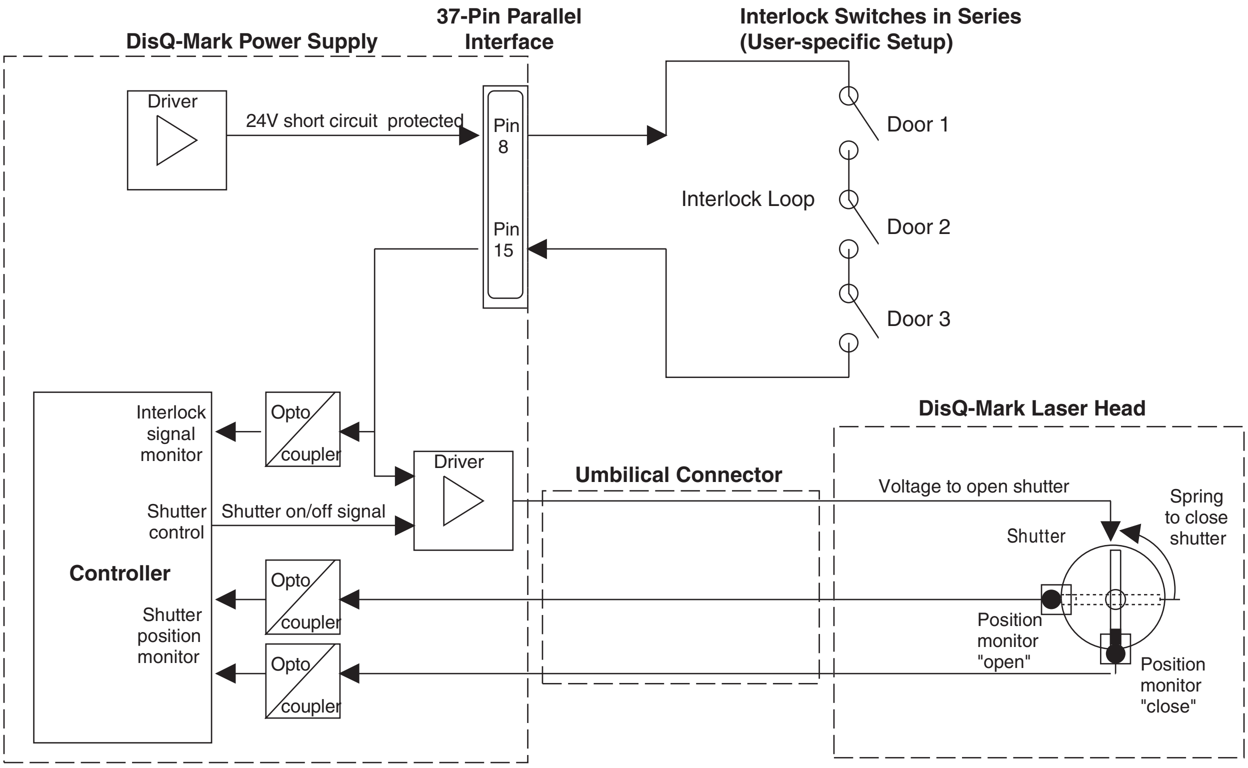


Figure 3-10: Safety Interlock Block Diagram

Chapter 4 Handling Fiber Optics

This chapter contains important information pertaining to the safe use and handling of the fiber-optic cable. Please read this section carefully before installing or operating this laser system.

The fiber in the *DisQ-Mark* fiber-optic cable is less than 1 millimeter in diameter and must be handled with care. The cable is located inside the umbilical (along with the control and RF cables), which provides limited protection for the optical fiber.

Excessive stress on the optical fiber can also alter the characteristics of beam delivery and can possibly lead to damage to the fiber. Stress comes in three forms:

- tensile stress (occurs when the fiber is pulled)
- torsional stress (occurs when the fiber is twisted)
- bending stress (occurs when the fiber is bent to a small radius)

Unpacking and Uncoiling

The *DisQ-Mark* power supply was shipped with the umbilical rolled and secured. Support the umbilical when unpacking and uncoiling it. Do not allow the umbilical to “spring” out.

Do not remove the protective end caps from the fiber-optic cable until ready to connect the cable to the laser head or power supply.

General Handling

Caution!

The minimum fiber-optic bend radius is 6 cm (2.5 in.), and then only for short-term, such as when installing or servicing the laser.

The minimum long-term fiber-optic bend radius is 30 cm (12 in.).

Avoid twisting the umbilical.

A strain relief may be used to support the umbilical, provided that the strain relief itself does not violate these guidelines. Do not allow the strain relief to crimp the umbilical.

Never pull on the fiber-optic cable. Excessive pulling forces may lead to fiber and/or connector damage. Avoid walking on or rolling equipment over the umbilical. Keep it out of water, oils and other contaminants.

Cleaning and Inspection

Danger! Laser Radiation

The Spectra-Physics *DisQ-Mark* is a Class IV—High Power laser system. The output beam from the fiber-optic cable is, by definition, a safety hazard. Turn off and unplug the power supply before inspecting the fiber-optic cable.

As with most optical components used in lasers, contamination of the optical surfaces can lead to performance degradation and possible catastrophic failure. Contaminants on the end of the fiber-optic cable can cause localized heating and damage to the anti-reflective coating. Contaminants can come from handling the fiber or from mounting the fiber output too close to a power meter or beam dump. In severe cases, charring may occur at the output end, which requires replacement of the entire diode laser module assembly.

To prevent costly damage of the fiber-optic cable, always be extremely careful when handling the output end. Before use or anytime the presence of contaminants is suspected, inspect the output end of the cable and, if necessary, clean it (refer to “Cleaning Methods” starting on page 4-3).

Materials Required

- Powder-free finger cots or gloves
- Lint-free lens tissue
- Clean forceps or hemostats
- Water-free, spectroscopic-grade methanol (methyl alcohol)
- Clean dropper or droplet dispensing unit for the methanol
- Fiber holding fixture for inspection (optional, but very helpful)
- Inspection video microscope, 40–80 x magnification, for indirect viewing of the fiber-optic cable. Example: *Optispec ME2500* Fiber-Optic Illuminated Inspection Video Microscope, available from *Micro Enterprises*, Norcross, Georgia, U.S.A. Fiber Bundle Viewer with SMA Adapter Cap, available from Noyes Incorporated, P/N OFS 300-200B.

Warning!

Unplug the power supply during inspection!

Prior to insertion, inspect the end of the fiber for damaged or burned areas and clean only as needed. For safety, we recommend indirect viewing of the fiber-optic cable using a microscope and CCD camera, such as the one listed above. Inspection of the coating should reveal a uniform, bluish, smooth and shiny surface with few scratches, inclusions, or dust particles.

Listed below are some of the types of damage that might be present.

Inspection Criteria

Blemishes—minor blemishes are unavoidable. In small numbers, they will not adversely affect laser system performance.

Scratches—a minor scratch should have a width of less than 5 µm and should not penetrate the coating.

Digs—a minor dig should have a maximum diameter of less than 30 µm and no cracks propagating from the dig.

Burns—a minor burn should have a maximum diameter of less than 30 µm. Debris should be cleaned away with methanol to prevent further damage.

Figure 4-1 shows examples of acceptable and unacceptable fiber-optic faces.

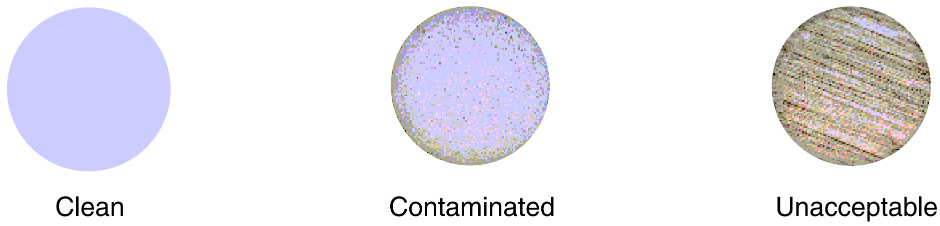


Figure 4-1: Clean Fiber Optic Face

Rejection Criteria

Broken—a broken fiber is a safety hazard; replace the umbilical assembly.

Blemishes—if a fiber-optic cable exceeds the limit of 6 minor blemishes, the cable should be replaced.

Cleaning Methods

If contaminants are visible, clean the fiber ends using one or both of the following two methods, as required, to achieve acceptable results.

Method A

Use the "drop and drag" method to remove contaminants that are not tightly bound to the coated surfaces. Use one tissue per wipe to prevent removed contaminants from being redeposited on the surface.

1. Place a single drop of the cleaning solvent near the center of a small piece of lens tissue.
2. Contact the fiber end and draw slowly and steadily, moving the fiber across the tissue surface until no more liquid remains at the point of contact between the fibers and tissue.

When finished, reinspect the results of the fiber cleaning process and repeat the procedure if necessary.

Method B

1. Fold the lens tissue to form a small wiper, approximately 3 – 4 mm wide, and held in forceps.
2. Apply 2 – 3 drops of cleaning solvent on the end of this wiper and gently draw it across the fiber end surfaces.

Use this method to remove more tightly bound contaminants, but be careful. If done too roughly or too often, it can damage the coatings.

When finished, reinspect the fiber and repeat the procedure if necessary.

Connections and General Operation

Never operate the system with the protective cap installed on the fiber-optic cable (Figure 4-2). Make the connection to the laser head first; make all optical and interface connections prior to connecting the ac power cable.

The fiber cable uses a SMA standard connector designed for precision alignment (see Figure 4-3). Avoid damaging the barrel and optical surface when mating the fiber cable to the laser head. It may be helpful to tip the barrel upward at a slight angle to make the insertion. Do not scrape it around hunting for insertion. Align the connector to achieve full and proper seating, then push it in and hand-tighten the fiber connector. Do not use a tool to tighten the connector.

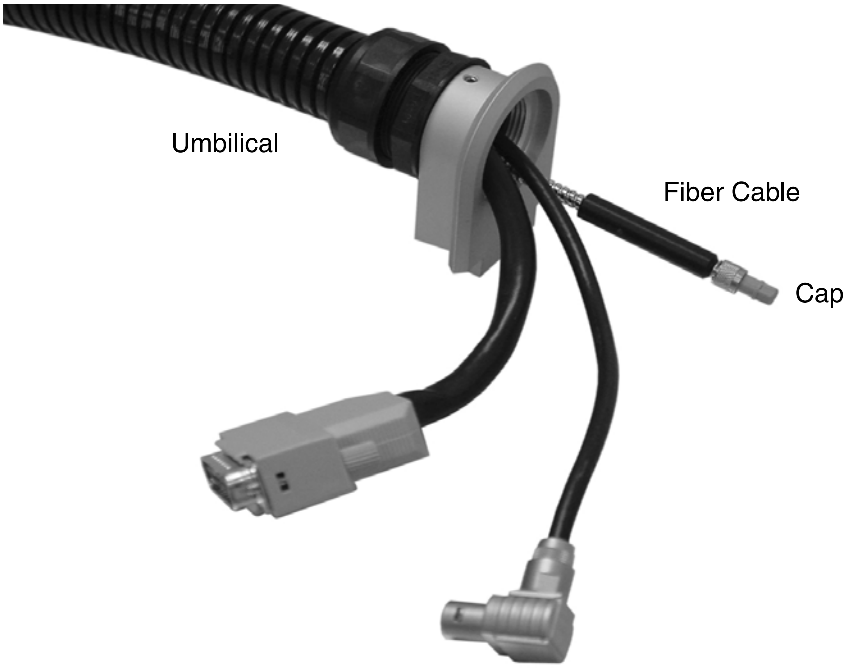


Figure 4-2: Fiber-Optic Cable with Connector and Cap

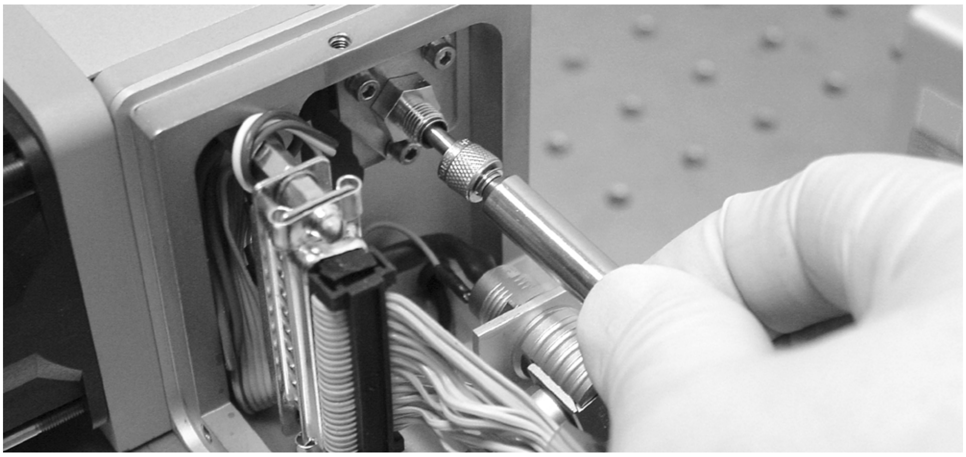


Figure 4-3: Fiber Connection to Laser Head

Figure 4-4: Fiber Connection to Power Supply

Measuring Fiber Output Power

If it becomes necessary to measure the fiber output power, follow these precautions to insure the safety of both personnel and equipment.

- Turn off the power supply.
- Disconnect the fiber cable from the laser head.
- Inspect the fiber-optic cable and clean it as described in "Cleaning Methods" on page 4-3.
- Carefully secure the output end near an optical power meter capable of reading 50 W, such as the *Gentec* 310/330. Maintain a distance of approximately 2 cm from the fiber tip to the detector surface. Never allow the optical surface to touch the detector surface.
- Prevent vapors and contaminants from foreign surfaces from being deposited on the tip of the fiber. This can cause rapid and permanent damage to the optical surface.
- Never attempt to move the fiber output connector when the diode laser is energized.

Danger!

Eyewear Required

Only authorized operators and/or personnel that have received laser safety training are allowed to perform this operation.

Chapter 5 Controls, Indicators and Connections

This section describes the hardware controls, indicators and connections of the *DisQ-Mark* system.

DisQ-Mark Laser Head

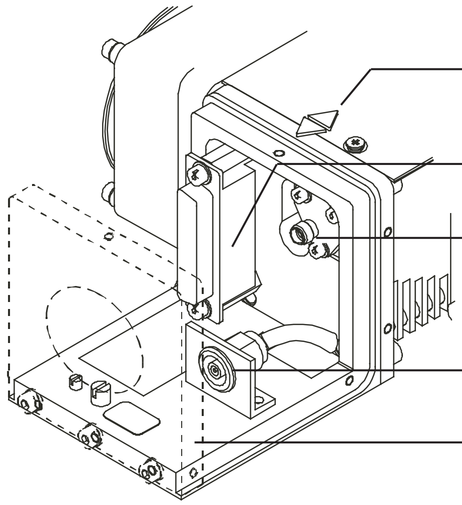


Figure 5-1: Laser Head, Rear View with U-Shaped Cover Removed

Indicators and Connectors

EMISSION indicator (yellow)—illuminates when diode power is supplied to the laser head and laser emission is present or imminent. This indicator illuminates when the diode laser is first turned on; diode laser emission is transmitted to the *DisQ-Mark* laser head about 3 seconds later.

Control connector (25 pin D-sub)—provides attachment for the control cable from the power supply.

Optical fiber connector—provides attachment for the optical fiber cable carrying pump laser output from the power supply.

RF (Q-switch) cable connector—provides attachment for the RF cable from the power supply.

Mounting

The *DisQ-Mark* laser head can be mounted either directly onto a table or other plane surface, or onto a mounting plate that is then mounted onto a plane surface. For the locations of screw holes, refer to Figure 6-1 and Figure 6-2 in Chapter 6.

DisQ-Mark Power Supply

Front Panel

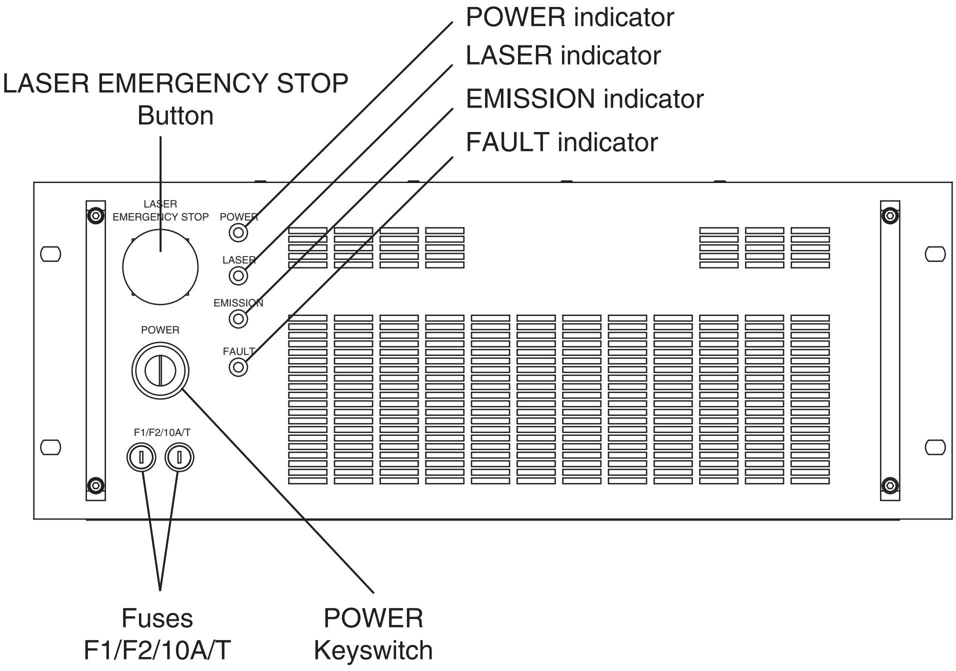


Figure 5-2: Power Supply, Front View

LASER EMERGENCY STOP button—pressing this button immediately disconnects the *DisQ-Mark* laser from the line power and causes laser emission to stop. This button must be unlocked by turning it counter-clockwise prior to restarting the system.

POWER indicator (green)— illuminates when the keyswitch is turned on and ac power is available.

LASER indicator (yellow)—illuminates when the laser head is capable of emitting laser light (i.e., it is being pumped by the diode laser module). This indicator illuminates when the diode laser is turned on by software command or analog voltage signal.

EMISSION indicator (yellow)— duplicates the function of the LASER indicator as a redundant safety display.

FAULT indicator (yellow) —illuminates when a fault has been detected. To determine the source of the fault, refer to “Troubleshooting” on page 8-2.

F1/F2/10A/T fuses—are accessible using a standard screwdriver. Refer to Table 2-1 in Chapter 2 for fuse values.

POWER keyswitch—is used to activate the system. The key must be inserted and turned to the ON position in order to allow the diode laser module to be energized. Emission from the laser head will begin about 3 to 5 seconds later if the shutter is open. The key can only be removed when it is turned to the OFF position. Removing the key prevents unauthorized system use.

Rear Panel

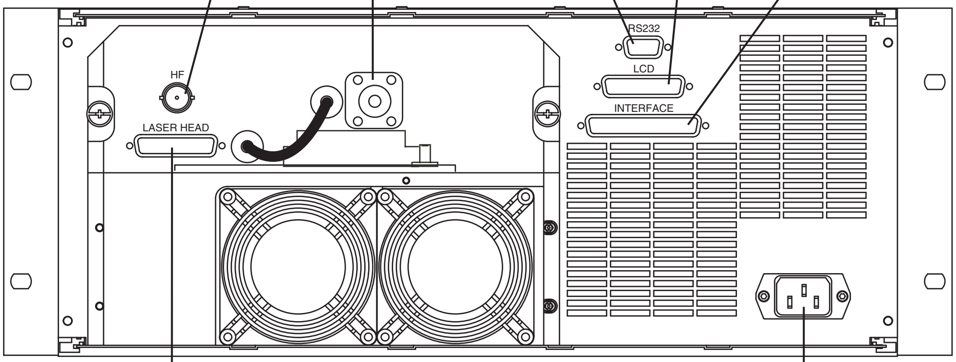


Figure 5-3: Power Supply, Rear View

HF (Q-switch) connector (BNC)—provides attachment for the RF cable to the laser head (referred to as "RF" in this manual).

LASER HEAD connector (25-pin D-sub)—provides attachment for an IEC power cable to provide ac power to the *DisQ-Mark* power supply.

Optical fiber connector (SMA)—provides attachment for the optical fiber that delivers pump laser power to the laser head.

RS-232 connector (9-pin D-sub)—provides attachment for a 9-pin RS-232 serial interface cable from the control computer. For a complete discussion of the serial port and how to control the system using it, refer to "Controlling the System Through the Serial Interface" on page 7-11.

LCD connector—provides attachment for the cable from a diagnostic or service computer. This connection is for use *only* by the factory or by authorized service personnel.

Parallel INTERFACE connector (37-pin D-sub)—provides attachment for the parallel interface cable from the control computer. For a complete discussion of the parallel port and how to control the system through it, refer to "Controlling the System Through the Parallel Interface" on page 7-5.

AC power connector—provides attachment for the ac power cable.

Mounting

The *DisQ-Mark* power supply is designed to be mounted on slide rails in a standard 19 inch or similar rack.

Chapter 6 Installation

This section provides detailed instructions for the initial planning and setup of the *DisQ-Mark* laser system. If you have not set up the laser before, or if you are moving the laser system to a new location, please review this section in its entirety.

Be sure to follow all safety precautions for laser use while handling or storing the laser system, and install all laser safety devices before using the system. Refer to Chapter 2, “Laser Safety” for more information.

Installation Considerations

Danger!

Interaction of laser radiation with material can generate aerosols, gases and/or dust dangerous to health. Provide adequate exhaust and filtering of exhaust air appropriate for your application. The owner/operator of the master system must ensure compliance under conditions of the maximum possible concentrations of the air-borne contaminants.

Location: Install the *DisQ-Mark* system in a site that is free of dust, grease, oil and aerosols. Easy access to the laser system will simplify maintenance. The device must be mounted on a low-vibration surface.

Heat accumulation: Allow for clear ventilation of the fans on the power supply and the laser head. Keep a minimum clear distance of about 10 cm (4 in.) for the fan and exhaust of the laser head. Keep a minimum clear distance of 0.5 m between the rear panel of the power supply and the wall or any other surface.

Additional optical systems such as beam expanding telescopes, scanning systems, etc. should be positioned directly in front of the beam exit. Failure to do so will result in power losses due to the laser beam divergence.

Dust protection: Dirt on the beam exit window will result in a decrease of laser power, and burnt-in dirt will void the warranty. Use a dust-protective cover for the optical path following this window.

Umbilical length: The length of the umbilical between the laser head and power supply is approximately 4.8 m. The umbilical can not be used in a drag-chain, i.e. do not connect the umbilical to a moving platform.

Bench space required is approximately 1 m^2.

A power cable with grounding and a safety plug is required.

Laser Head Mounting Considerations

The *DisQ-Mark* laser head can be mounted either directly onto a table or other plane surface, or onto a mounting plate that is then mounted onto a plane surface. In either case, the underside of the laser head **does not** rest flat on the mounting plate or table. Instead, it is supported by three screws with washers, according to DIN 125-A5.3 (three-point support).

Caution! Do not attempt to press the underside of the laser head flat to the mounting surface.

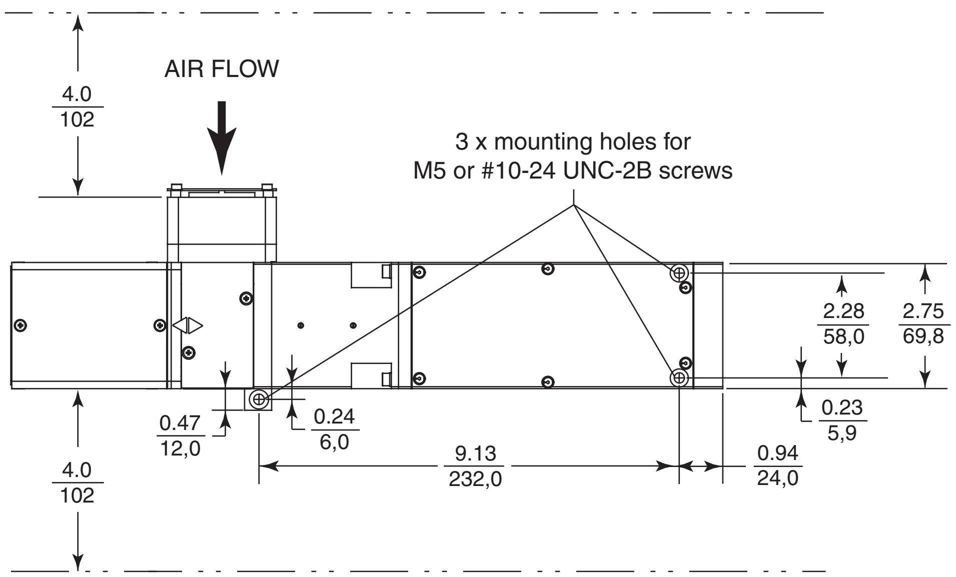


Figure 6-1: Bore holes for mounting the standard laser head

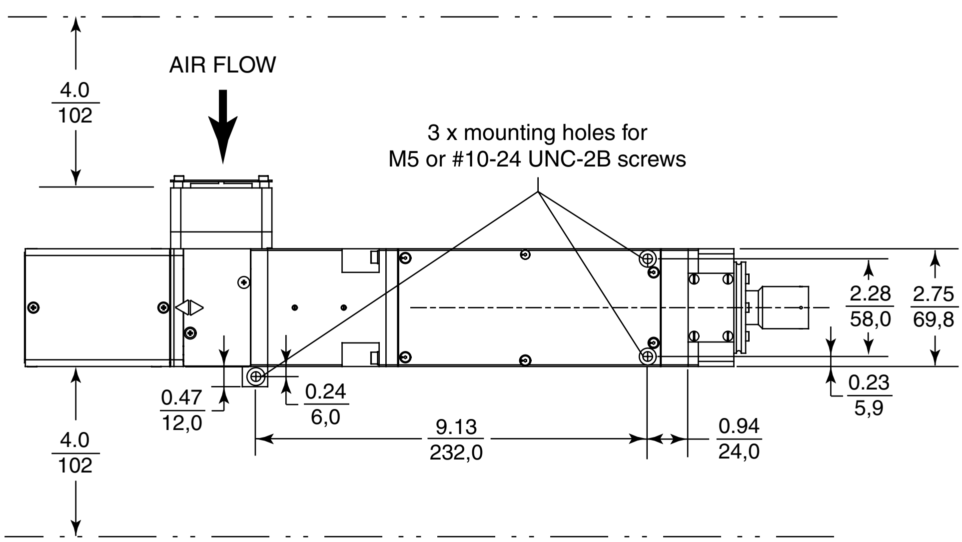


Figure 6-2: Bore holes for mounting laser head with beam expander

Installation Procedure

When required, the system can be disassembled by following these procedures in the reverse order.

Caution!

Please read both Chapter 2, “Laser Safety”, and Chapter 4, “Handling Fiber Optics”, before beginning this installation.

Danger! Laser Radiation

Prior to installation, verify the keyswitch has been turned to OFF, the key has been removed and the power cable is disconnected to prevent the system from being powered up. **Do not** connect the power cable to the power outlet until all installation steps have been completed.

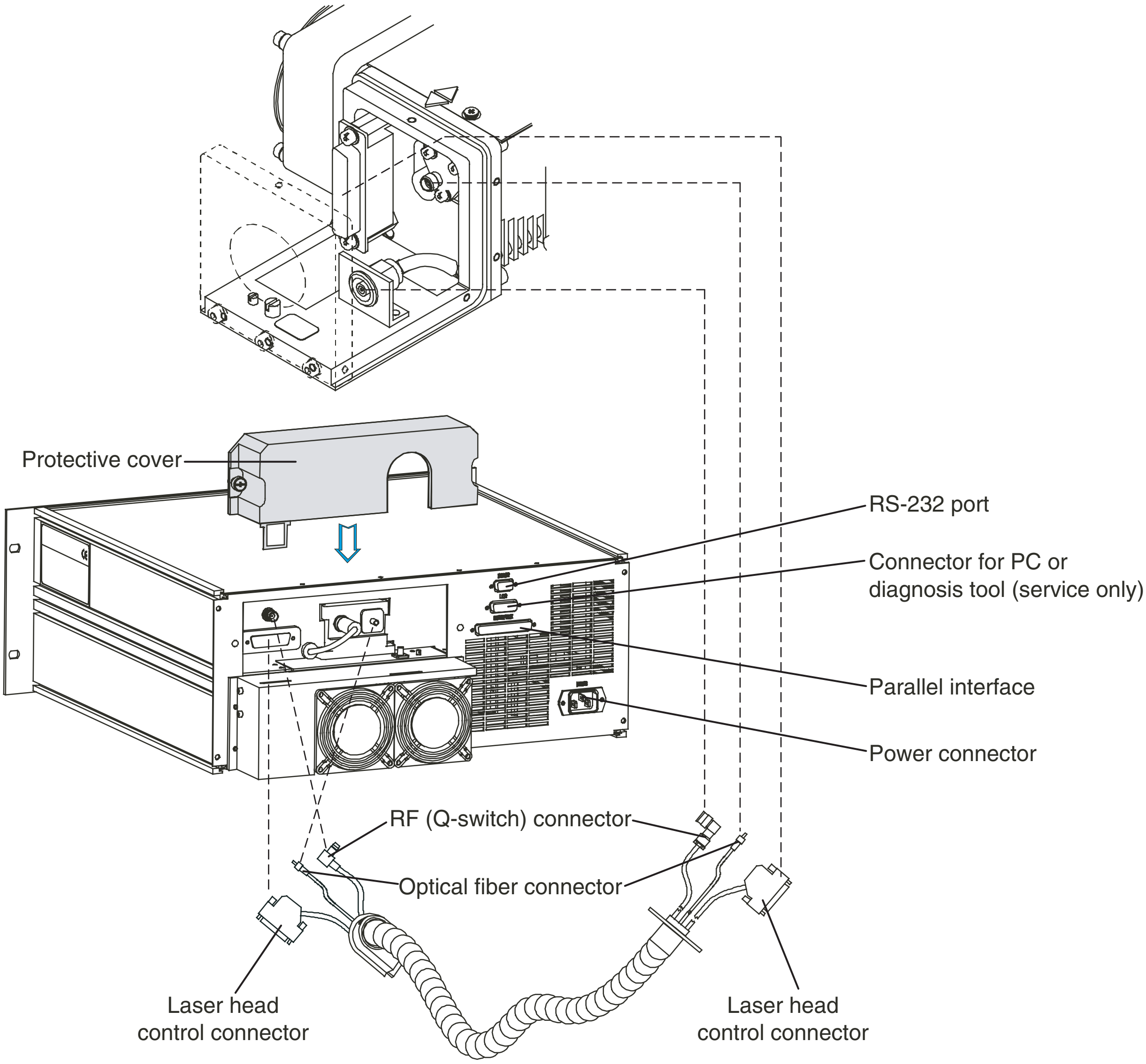


Figure 6-3: Connections between the laser head and the power supply

Power Supply Connections

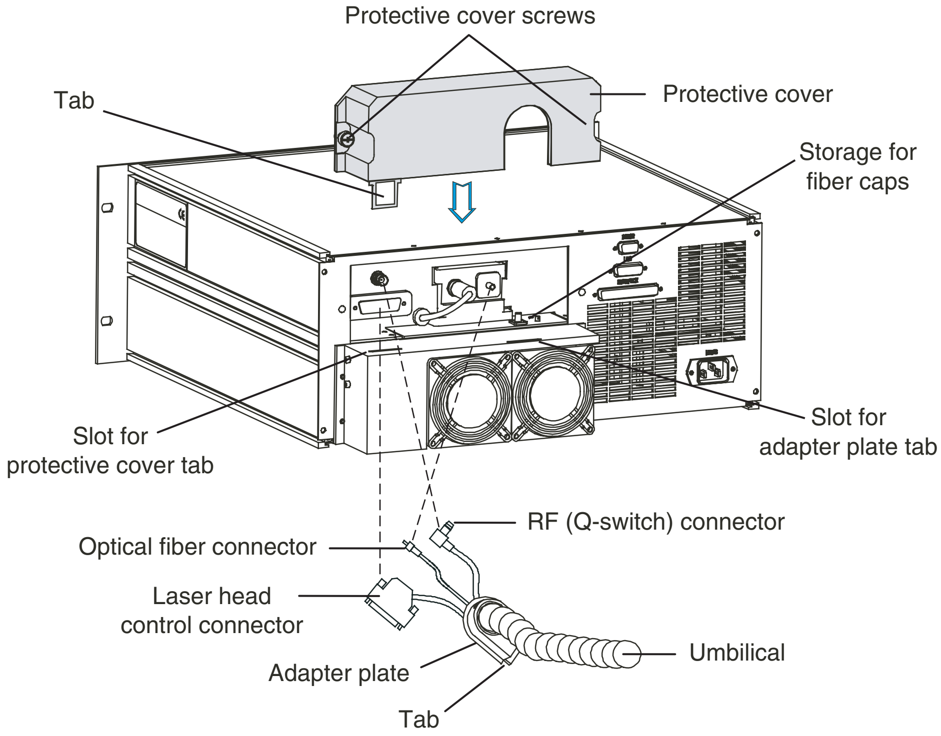


Figure 6-4: Cover and umbilical connections on the power supply

The *DisQ-Mark* power supply is designed to be placed on slide rails in a standard 19 inch or similar rack, and mounted from the front. The weight of the power supply must be borne by the rails, not by the front panel. The front panel screws are only meant to secure the power supply to rack.

Leave a minimum clearance of 0.5 meters (about 1.5 ft) from the rear panel to allow room for the connectors, the bending radii of the cables and for proper ventilation.

1. Loosen the two screws on the protective cover and lift off the cover (refer to Figure 6-4).
2. Remove the protective cap from the fiber connector of the power supply. Then remove the protective cap from the fiber and store the caps on the pins provided inside the power supply.
3. Inspect and carefully clean the end of the fiber-optic cable, following the procedures in Chapter 4.
4. Immediately connect the optical fiber (Figure 4-2). Only hand-tighten the fiber connector.
5. Connect the D-sub control cable to the 25-pin connector labeled LASER HEAD on the rear of the power supply (Figure 6-3).
6. Connect the Q-switch cable to the HF connector on back of the power supply (Figure 6-3).
7. Slide the tab of the umbilical adapter plate into the slot provided on the power supply.
8. Fasten the adapter plate with the screw.
9. Reattach the protective cover from the top so that its tab slides into the appropriate slot and the adapter plate of the umbilical fits into the cut-out. Fasten the protective cover with the two screws.

10. If the device is to be controlled using the parallel port, connect the external control system to the parallel interface connector. Refer to "Controlling the System Through the Parallel Interface" on page 7-5.
11. If the device is to be controlled using serial commands, use a shielded, null-modem cable to connect the host system to the RS-232 port. Refer to "Controlling the System Through the Serial Interface" on page 7-11.
12. To protect all connections against contamination, lock the connectors or screw them down tightly.

Laser Head Connections

1. Loosen the 6 recessed screws from the U-shaped cover on the rear of the laser head and remove the cover. Refer to Figure 6-5.

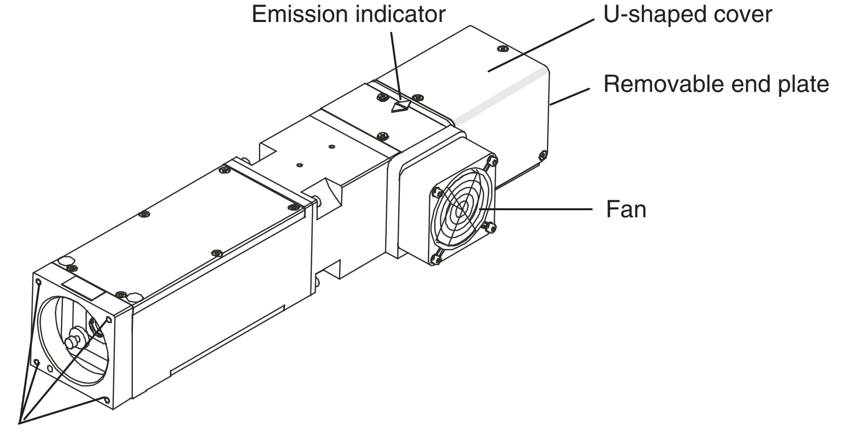


Figure 6-5: ***DisQ-Mark*** **Laser Head, Standard**

2. Remove the protective shipping plate shown in Figure 6-6 by removing the three fastening screws. Save this plate—the screws will be used in Step 8.

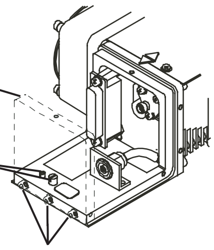


Figure 6-6: U-Shaped Cover Removed

3. Attach the Q-switch cable connector.
4. Attach the 25-pin D-sub connector for the control cable.
5. Remove the protective cap from the fiber connector on the laser head. A pin is provided on the laser head to store this cap (see Figure 6-6).
6. Inspect and carefully clean the end of the fiber-optic cable following the procedures in Chapter 4.

7. Immediately attach the optical fiber to the connector, referring again to Chapter 4, and remember to only hand-tighten the fiber connector.
8. Firmly attach the plate located at the end of the umbilical to the laser head (see Figure 6-3).
9. Reattach the U-shaped cover.
10. Loosen the four hexagonal socket screws on the laser head (Figure 6-5) and remove the protective plate from the exit aperture.

This completes the installation of the *DisQ-Mark* laser system. Connect the power cable to the power outlet.

Warning! Verify the ac line voltage matches the operating voltage specified on the power supply label.

Initial Startup

Refer to the next chapter for instructions on starting and controlling the *DisQ-Mark* system.

The default control system is via analog voltage signals using the parallel port. Refer to Chapter 7, "Operation", for a complete description of this control method.

The system can also be commanded via the RS-232 port using serial commands designed specifically for the *DisQ-Mark* system. To do this, attach the control device (typically a Windows®-based personal computer) to the system, and employ a user-generated command sequence (a program written by the user). This control method is primarily for CW operation. Again, refer to Chapter 7, "Operation."

Chapter 7 Operation

Overview

Please read this entire chapter and Chapter 2, "Laser Safety", before using the *DisQ-Mark* laser for the first time.

Danger!
Laser Radiation

The Spectra-Physics *DisQ-Mark* laser is a *Class IV—High Power Laser* whose beam is, by definition, a safety and fire hazard. Take precautions to prevent accidental exposure to both direct and reflected beams. Diffuse as well as specular beam reflections can cause severe eye or skin damage. *The infrared output from the fiber-optic cable and the 1064 nm infrared output from the laser head are invisible and, therefore, especially dangerous!*

This chapter assumes that the system has already been connected as described in Chapter 6, "Installation", and that you are ready to turn the system on and operate it.

The *DisQ-Mark* system can be controlled in two ways:

- by using the parallel INTERFACE port, as described in "Controlling the System Through the Parallel Interface" on page 7-5.
- by using the RS-232 serial interface and running a user-written software program based on the *DisQ-Mark* command language described in "Controlling the System Through the Serial Interface" on page 7-11.

The default method of controlling the *DisQ-Mark* is via analog voltage signals through the parallel INTERFACE port. Software control is designed primarily for CW operation; it does not allow for first-pulse suppression. However, to use serial commands, connect a serial control device (typically a Windows®-based personal computer) to the RS-232 port on the power supply, and run a user-generated command sequence.

Turn on the laser system by turning the power supply keyswitch to the ON position. If the *DisQ-Mark* is integrated into a host laser system, setting the keyswitch to ON will allow the device to be switched on and off via the host system's master power switch.

The following section, "Start-up and Shut-down," is a summary for operators already familiar with the control of the *DisQ-Mark* system and its safety features. If you are using the system for the first time, return to this section after reading the sections of this chapter relevant to your mode of use.

Start-up and Shut-down

Start-up Via the Parallel Interface

1. Pins 12, 16, and 18 must be at 0 Volts with pins 9, 17 and 30 connected to GROUND (pin 2).
2. Place pins 8 and 15 of the interlock current loop in the desired state (typically shorted; an "open" will prevent the laser from starting).
3. Close the shutter; set pin 34 is to 0 Volts.
4. Set the power supply keyswitch to ON. The system will begin initialization and the green POWER LED will illuminate. (The yellow FAULT LED will glow continuously if a fault is detected. See Figure 5-2.) Pin 28 will rise from 0 to 24 V in a couple of seconds as the system initializes. When it has reached 24 V, the diode module in the power supply has reached operating temperature and the laser can be turned on.
5. If open, close the interlock circuit by connecting pin 8 to pin 15.
6. Switch pin 12 and pin 18 from 0 V to 24 V. The LASER and EMISSION indicators on the power supply will illuminate, as well as the EMISSION indicator on the laser head. 1 Amp is applied to the diode laser module, which heats the diode laser module, but is not enough to produce emission).

   After approximately a 3-second delay, the diode laser is capable of providing pump light to the laser head.
7. Apply 24 V to pin 34 to open the shutter, and verify pin 10 is at 24 V to confirm the shutter is actually open. Note that if the interlock circuit is open, the shutter cannot be opened.
8. Apply 5 V voltage to pin 16 to turn on diode laser current. This sets output power to mid-level. The laser head will begin emission. Adjust the voltage on pin 16 from 0 to 10 V for the desired laser output level.

Shut-down Via the Parallel Interface

Warning!

Emergency shut-down: In case of emergency, press the EMERGENCY STOP button on the power supply! If the laser system is embedded in a host system, the laser system must be installed in such a way that an "Emergency Stop" function (switch) is present that can cut off power to the *DisQ-Mark* laser along with that of the host system.

Prior to continuing operation, connect pins 12, 16 and 34 to GROUND (pin 2) before unlocking the EMERGENCY STOP button on the power supply or before resetting the "Emergency Stop" function of the host system.

1. Open the interlock loop to turn off the laser (open pins 8 and 15).
2. Apply 0 V to pin 34 to close the shutter. Verify that pin 10 is at 0 V to confirm the shutter is closed.
3. Apply 0 V to pins 12, 18, and 16. The LASER and EMISSION indicator LEDs on the power supply and the emission inidcator on the laser head will turn off.
4. Turn off the power supply keyswitch and remove the key.

Start-up Via the RS-232 Serial Interface

Warning!

Never connect devices or peripheral equipment to the RS-232 port that do not meet the requirements listed in EN 60950.

1. Use a shielded null-modem cable to connect the RS-232 port on the power supply to the serial port of your control computer.
2. Place pins 8 and 15 of the interlock current loop in the desired state (typically shorted; an "open" will prevent the laser from starting).
3. Set the power supply keyswitch to ON. The system will begin initialization and the green POWER LED will illuminate. (The yellow FAULT LED will glow continuously if a fault is detected. See Figure 5-2.)
4. Issue the *Request Status* command. System initialization is complete when the Status returned = 16). If necessary, repeat this process until initialization has been fully completed. When it is, the diode laser module in the power supply will be set for the proper operating temperature.
5. If open, close the interlock circuit by connecting pin 8 to pin 15.
6. Issue the *Control Command* with control parameter = 001 (start laser). The LASER and EMISSION indicator LEDs will illuminate on the power supply, as well as the Emission indicator on the laser head. 1 Amp is applied to the diode laser module, which heats the diode laser module, but is not enough to produce emission.

   After approximately a 3-second delay, the diode laser is capable of providing pump light to the laser head.
7. Issue the *Control Command* with control parameter = 009 (start laser, open shutter).
8. Issue the *Request Status* command and verify that the Status = 009. (If the interlock circuit is open, the shutter cannot be opened.)
9. Issue the command *Control Current* = 20 A. The laser will begin emission. Use this same command to adjust the current for the desired laser output from 0 to 20 A (or max current).

Shut-down Via the RS-232 Serial Interface

Warning!

Emergency shut-down: In case of emergency, press the EMERGENCY STOP button on the power supply! If the laser system is embedded in a host system, the laser system must be installed in such a way that an "Emergency Stop" function (switch) is present that can cut off power to the *DisQ-Mark* laser along with that of the host system.

Prior to continuing operation, connect pins 12, 16 and 34 to GROUND (pin 2) before unlocking the EMERGENCY STOP button on the power supply or before negating the Emergency Stop function of the host system.

1. Open the interlock loop to turn off the laser (open pins 8 and 15).
2. Issue the *Request Status* command and verify the status = 017 (laser is on, interlock loop is open).

3. Issue the *Control Command* with control parameter = 002 (stop laser, close shutter). The LASER and EMISSION indicator LEDs will turn off.
4. Turn off the power supply keyswitch and remove the key.

Shutter Safety Functions

The following *DisQ-Mark* laser safety features are discussed below:

- Software-independent shutter closing when the interlock circuit (Interlock 1 and Interlock 2) is opened
- Continuous internal monitoring of the shutter position
- Monitoring the shutter position via the user interface

Software-Independent Closing of the Shutter

The interlock circuit provides the 24 volts required to drive the electromagnet that opens the shutter. A spring integrated into the shutter causes it to return to the closed (default) position when this circuit is opened.

Continuous Internal Monitoring of the Shutter Position

Actual shutter position is internally monitored and compared to the commanded position:

Table 7-1: Shutter Monitoring Signals

Commanded Signal	Actual State	System Status
OPEN	OPEN	OK
OPEN	CLOSED	ERROR
CLOSED	CLOSED	OK
CLOSED	OPEN	ERROR

This monitoring circuit protects against the unlikely possibility that the shutter spring breaks or the shutter itself becomes stuck.

After a debounce time of approximately 600 ms, if the actual shutter state differs from the commanded state, the system will turn off and an error signal will be generated (refer to the sections on commands in this chapter for explanations of the error returned).

Monitoring the Shutter Position Via the Serial Interface

The user can monitor the shutter position with the *Request Status* query and respond in the event that there is a difference between requested and actual shutter position. Consider time delays of approximately 100 ms between a commanded signal and the response from the monitoring signal.

Warning!

The *DisQ-Mark* laser is designed as an OEM device for use *only* as part of a master system. The shutter therefore operates independently of the laser output. For example, if the diode output is turned off with the shutter open, the shutter will still be open if the diode is turned on again and the *DisQ-Mark* head will emit laser light immediately.

Note that the shutter does close automatically when the power supply is turned off.

Controlling the System Through the Parallel Interface

The pin inputs of the parallel INTERFACE port are coupled to the laser system microprocessor via opto-isolators. Only the RF driver is directly connected. The laser is controlled by 24 V signals, with dc voltage supplied by the user or internally from the *DisQ-Mark* system (pin 1). This control device is compatible with alpha-numeric control systems.

The Q-switch device is an acousto-optical modulator (AOM) inside the laser head, and it, too, can be controlled through the parallel INTERFACE port.

Table 7-2 lists the function of each of the 36 pins of the INTERFACE port. Pins not accounted for are not used.

Note All pins not specified in Table 7-2 must not be connected.

Table 7-2: Pin Assignments for Laser Control

Pin	Name	In/Out	Connection if controlled through user interface
1	*24 V*		Internal Voltage Supply • Provides 24 V supply voltage if none is available on the user side. • Maximum current is 1 A.
2	*GND*		Ground • Connect to pins 9, 17 and 30
4	*External Error 1*	In	System Monitor #1 • Shuts off the laser if an error occurs in the laser system. • Active signal required: 24 V. • The laser switches into “error state” if 24 V is not present (laser off, warning light on). • Connect to 24 V (pin 1) if not used.
5	*External Error 2*	In	System Monitor #2 • Shuts off the laser if an error occurs in the laser system. • Active signal required: 24 V. • The laser switches into “error state” if 24 V is not present (laser off, warning light on). • Connect to 24 V (pin 1) if not used.
6	*External Error 3*	In	System Monitor #3 • Shuts off the laser if an error occurs in the laser system. • Active signal required: 24 V. • The laser switches into “error state” if 24 V is not present (laser off, warning light on). • Connect to 24 V (pin 1) if not used.
7	*AOMF*	In	Q-Switch Frequency Control • Connected to the internal voltage-to-frequency converter. • Range is from 0 V (approximately 100 Hz) to 10 V (approximately 50 kHz). • Active only when pin 29 = 24 V.
8	*Interlock +*		Interlock Circuit Contact 1 • Connect to all laser system interlock switches (doors, panels, etc.). • Complete circuit to pin 15. • Connect directly to pin 15 if the interlock circuit is not used. • The laser shutter will close when the interlock circuit is opened.

Table 7-2: Pin Assignments for Laser Control

Pin	Name	In/Out	Connection if controlled through user interface
9	*GND*		Ground • Connect to pin 2.
10	*Shutter State*	Out	Shutter Status • Provides 24 V (relative to pin 2) if the shutter is closed. • Provides 0 V if the shutter is open.
11	*Warning*	Out	Warning Indicator • Provides 24 V (relative to pin 2) if operator attention is required (e.g., diode temperature is rising). • The laser will not switch off immediately (in order to finish the current task). • The laser will switch to an error state (laser off, warning light on) if the problem worsens. • Can be used for an external system warning indicator.
12	*Start Laser 1*	In	Laser Emission Control 1 • Laser emission starts when the voltage level (relative to pin 9) on pins 12 and 18 switches from 0 V to 24 V. • Laser emission stops when the voltage on either pin 12 or pin 18 drops to 0. • Both pins 12 and 18 have to be reset to 0 V to re-start the laser.
13	*Start Pilot*	In	Pilot (Aiming) Laser Control • The aiming (pilot) laser is activated when the voltage level on this pin (relative to pin 9) is switched from 0 to 24 V. • The aiming laser is deactivated when the voltage level on this pin is set to 0 V.
15	*Interlock –*		Interlock Circuit Contact 1 • Connect to all laser system interlock switches (doors, panels, etc.). • Complete the circuit to pin 8. • Connect directly to pin 8 if the interlock circuit is not used. • The laser shutter will close when the interlock circuit is opened.
16	*Diode Current On*		Diode Current Control • Input voltage from 0 V to 10 V corresponds to a diode current range from 0 A to 50 A. • NOTE: maximum diode current is specific for each installation and is limited to a safe, factory-defined level.
17	*GND Diode Current*	In	Ground Diode Current Control • Connect to pin 2.
18	*Start Laser 2*	In	Laser Emission Control 2 • Laser emission starts when the voltage level on both pins 12 and 18 (relative to pin 9) is switched from 0 V to 24 V. • Laser emission ends when the voltage on either pin 12 or pin 18 drops to 0 V. • Both pins 12 and 18 have to be reset to 0 V to re-start the laser.
26	*RF Reflection*	Out	RF Reflection Monitor • This pin monitors the reflected RF power (VSWR) from the AOM. • Output is set to 24 V if excessive reflected power is detected (for example, if the RF cable should break). • The laser switches to error mode (laser OFF, warning ON).
27	*Temperature AOM*	Out	AOM Temperature Monitor • Monitors the temperature of the AOM. • Output is set to 24 V if the AOM is over-temperature.

Table 7-2: Pin Assignments for Laser Control

Pin	Name	In/Out	Connection if controlled through user interface
28	*Laser State*	Out	Laser Status Monitor • Is set to 24 V (relative to pin 2) when the laser is on. • Is set to 0 V if the laser is in error mode.
29	*AOM Intern*	In	AOM Mode Control • Controls whether the Q-switch is controlled by the internal frequency generator or by an external pulse generator (for example, to synchronize the scanner to a marking system). • 24 V applied to this pin activates the internal frequency generator (pin 32 is deactivated). The AOM frequency is then controlled via pin 7 (0 to 10 V). • 0 V on this pin activates external frequency control via pin 32. • Pin 35 must be connected to 5 V relative to pin 31, GND. • CW mode (AOM is completely open): pin 29 = GND pin 32 = GND • Block mode (AOM is completely closed): pin 29 = GND pin 32 = 5 V relative to pin 31 (AOM GND) pin 35 = 5 V relative to pin 31 (AOM GND)
30	*GND*		Ground • Connect to pin 2.
31	*GND AOM*		Ground AOM • Connect to the ground of an external pulse generator (e.g., a scanner control card).
32	*RF-Pulse*	In	RF Pulse Signal • Connect to the TTL signal of an external pulse generator (e.g., a scanner control card).
33	*FPS*	In	First Pulse Suppression • A drop in the TTL signal (5 V to 0 V) activates the internal “First Pulse Suppression” routine. • The signal must be switched off (switched from 0 to 5 V) after a maximum of four pulses. • Different suppression modes can be programmed. • The laser can be configured to activate either pin 33 or pin 35.
34	*Open Shutter*	In	Shutter Control • Applying 24 V (relative to pin 9) opens the shutter.
35	*AOM Analog In*	In	AOM Analog Control • Use an analog signal (from 0 to 5 V, relative to pin 31) to control the amplitude of the AOM RF driver. • The AOM can be adjusted from completely open (0 V) to completely closed (5 V) and to states in between. • This can be used for grayscale marking. • Input impedance: approx. 700 ohms. • The laser can be configured to activate either pin 33 or pin 35.
36	*AOM 5 V*		Internal Supply Voltage • Provides a supply voltage of 5 V if it is not provided by the user. • Maximum current is 1 A.

RF Driver Control

The RF (Q-switch) driver can be programmed for two operating modes:

- Analog mode (factory default)
- FPS (first pulse suppression) mode

The operating mode must be chosen prior to turning on the laser.

Danger! Laser Radiation

The RF driver mode can be re-programmed only while the laser is off and there is no laser emission.

Analog Mode

The RF driver is controlled by the two signals *RF-Pulse* (pin 32) and *AOM Analog In* (pin 35). *RF-Pulse* is used to switch the RF signal completely on and off. *AOM Analog In* allows linear modulation of the RF signal.

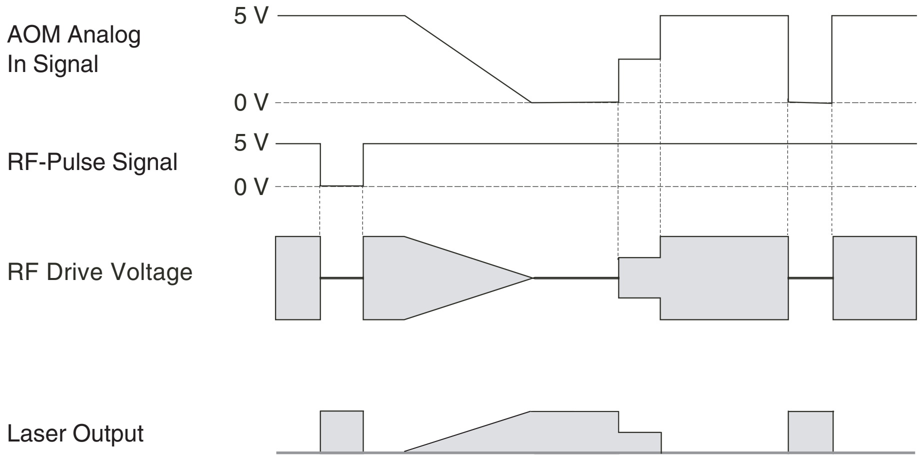


Figure 7-1: Example of RF Driver Control in Analog Mode

FPS (First Pulse Suppression) Mode

In this mode, the RF driver is controlled by the signals *RF-Pulse* (pin 32) and *FPS* (pin 33). When the *FPS* signal is passive (set to 5 V), RF power is switched on and off via the *RF-Pulse* signal only. When the *FPS* signal is active (0 V), pre-defined levels of the RF drive voltage are set for a maximum of four pulses (at *RF-Pulse*).

The number of pulses suppressed can be varied between 1 and 4 by controlling the duration of the applied *FPS* signal. See Figure 7-2 and Figure 7-3 for examples of FPS Mode.

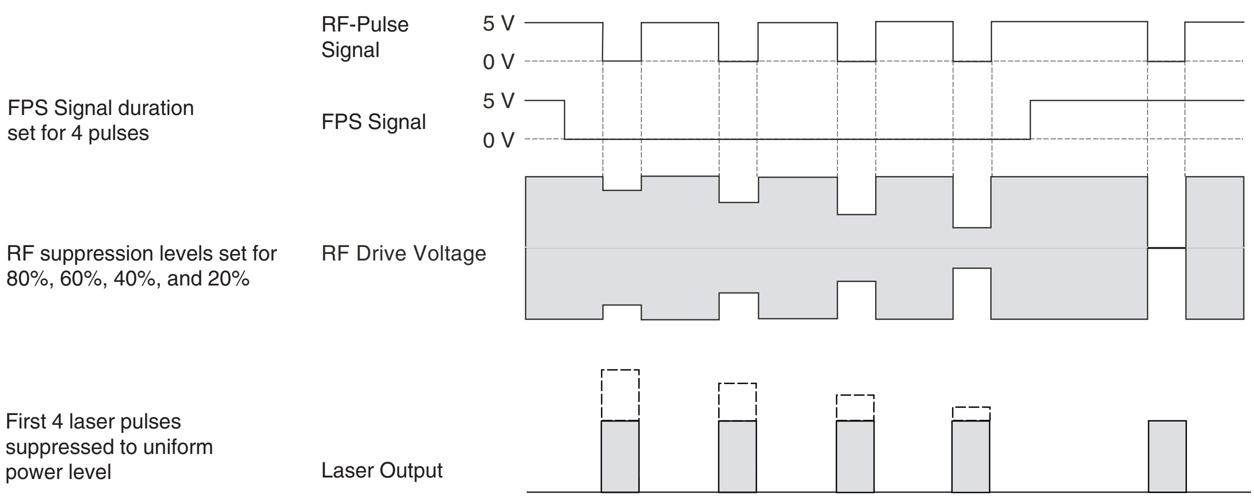


Figure 7-2: Example 1 of FPS Mode Using RF Driver Control

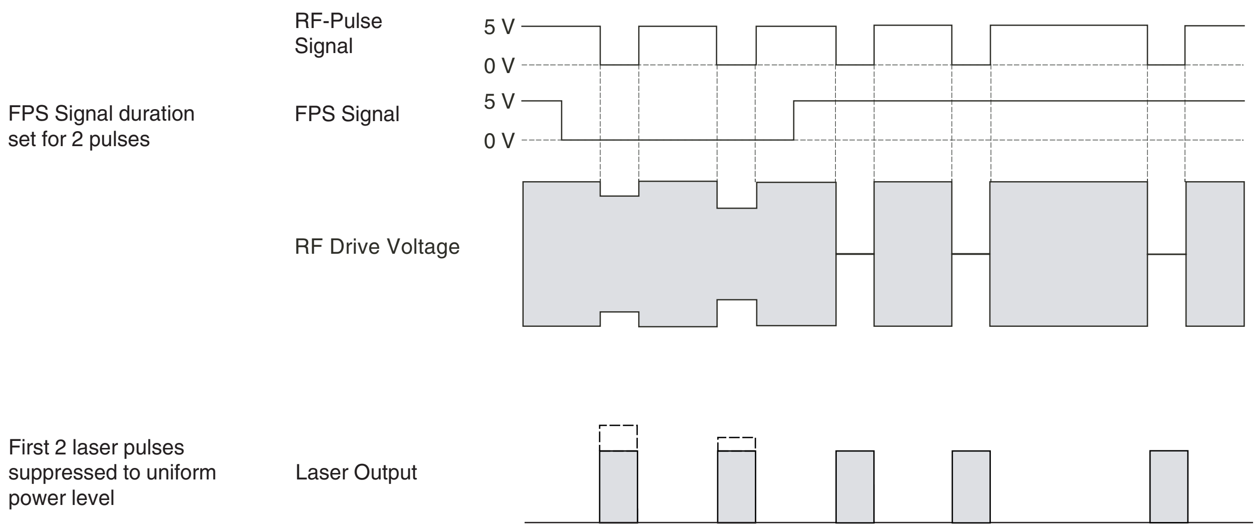


Figure 7-3: Example 2 of FPS Mode Using RF Driver Control

External Error Inputs

Pins 4, 5 and 6 can be used to monitor external errors, for example, the presence of scanner voltage. If any of these pins becomes disconnected from 24 V, laser emission will stop. When this happens, the *Laser State* signal at pin 28 switches to GND, the corresponding bit in *Error Block 2* is set, and the sum error bit in the Status field is set. To resume laser operation, the fault must be removed and the *Start Laser 1* signal must then be reset. For more information, refer to “Controlling the System Through the Serial Interface” on page 7-11.

Interlock Control

Pins 8 and 15 provide a means for the user to include a protective interlock to turn off the system in the event a safety violation is possible. For example, these pins can be wired to a normally-closed switch. Before laser emission is possible, the switch must be closed (pins 8 and 15 must be shorted). Opening the switch immediately closes the shutter.

Caution!

Do not apply voltage to pins 8 and 15. They are part of a 24 V, current-sensing loop. They can only be open or shorted together.

Start Laser Control

If the voltage level at both pins 12 and 18 changes from 0 V to 24 V, the laser will perform a soft start independent of the sequence of switching operations. After the start, the current will ramp up to the adjusted nominal value (approximately 10 A/s). 0 V applied to pin 12 or pin 18 results in the laser diode current being shut off.

After an internal laser fault occurs, the error register is reset by resending the *Start Laser* signal (apply 0 V to pin 12). For more information, refer to "Controlling the System Through the Serial Interface" on page 7-11.

Shutter Open Control

Applying 24 V (relative to GND) to pin 34 and closing the interlock circuit (shorting pins 8 and 15) will open the shutter. Disconnecting pin 34 from 24 V or opening the interlock circuit closes the shutter.

Laser State Monitor

When a command is given to turn on the laser, the laser state monitor (pin 28) rises over 1 to 3 seconds to 24 V as the system initializes and the diode laser warms up. When 24 V is reached, the laser is ready for operation.

The device state can be requested in greater detail via the serial RS-232 port. For more information, refer to "Controlling the System Through the Serial Interface" on page 7-11.

Current Control

Laser current is set by applying an external control voltage of 0 to 10 V (5 A/1 V). Pin 17 must be connected to pin 9 (GND).

Shutter Monitor

Shutter position is output at pin 10.

24 V = shutter is closed
0 V = shutter is open.

Controlling the System Through the Serial Interface

Control through the RS-232 port requires the serial port be set to:

Baud rate: 9600
Data bits: 8
Stop bits: 1
Parity: none

Each command consists of an ASCII character string beginning with STX (^B) and ending with ETX (^C). Commands are classified as control or request commands.

Control command structure: **^B|C-byte1|C-byte2|x|x|x|.|y|y|^C**

Request command structure: **^B|R|C-byte2|^C**

where:

all characters are ASCII bytes	
^B:	start of text
^C:	end of text
C-bytes:	command codes
xxx.yy:	parameter field

The *Start Laser* command has a code of SS and parameter of 001:

^BSS001.00^C

The parameter field (indicated as **ccc**, **sss**, **jjj** or **eee** in Table 7-3) is coded as a 3-digit decimal number in the range of 000 ... 255. The decimal value is determined from an 8-bit binary number formed according to the following scheme:

$$b0 \times 2^0 + b1 \times 2^1 + b2 \times 2^2 + \ldots + b7 \times 2^7$$

Depending on the value of Bits 0 … 7 (1 or 0), the resulting number is between 0 and 255.

Examples:

- Simultaneously start the laser and open the shutter:
  In the control command (see table below), b_0 and b_3 are set to “1”, and the remaining bits are set to “0”. Thus, the 3-digit control byte reads as follows:
  $$1 \times 2^0 + 0 \times 2^1 + 0 \times 2^2 + 1 \times 2^3 + 0 \times 2^4 + 0 \times 2^5 = 009$$
- For status requests, decoding of individual states uses the inverse process:
  $$b_0 \times 2^0 + b_1 \times 2^1 + \ldots$$
- The response “129” for *Request Error Block 1* is decoded as follows:
  $$129 = 1 \times 2^0 + 0 \times 2^1 + \ldots + 0 \times 2^6 + 1 \times 2^7$$
  $$129 = 1 + 0 + \ldots + 0 + 128$$
  Bit 0 and Bit 7 are set.

Note

The Q-switch can be controlled only through the parallel INTERFACE port. See “Controlling the System Through the Parallel Interface” on page 7-5.

Table 7-3 gives a summary list of the commands and their syntax.
Table 7-4 gives additional details and usage notes about each command.

Table 7-3: Command Summary

Command[1]	Structure[2]			Response	Timeout
Control Command	^B	SSccc.00	^C	^B VSsss.00 ^C	100 ms
Control Current	^B	SJjjj.jj	^C	^B VIjjj.jj^C	100 ms
Request Status	^B	RS	^C	^B VSsss.00 ^C	100 ms
Request Error Block 1	^B	E1	^C	^B V1eee.00 ^C	100 ms
Request Error Block 2	^B	E2	^C	^B V2eee.00 ^C	100 ms
Request for 1st Occurring Fault	^B	R1	^C	ee	100 ms
Request Current Limit	^B	Nb	^C	iiiii	
Request Actual current	^B	Nd	^C	iiiii	
Request Warning	^B	RW	^C	^B VWwww.00 ^C	
Error Reset	^B	UL	^C		
Request Set Current RS-232	^B	Um	^C	iiiii	
Request Set Current Analog	^B	Un	^C	iiiii	
Request Nominal Diode Laser Temperature	^B	Ca	^C	ttttt	
Request Actual Diode Laser Temperature	^B	Cb	^C	ttttt	
Request Ambient Temperature	^B	cn	^C	ttttt	
Request Turn Off Current	^B	Nc	^C	iiiii	
Request Heatsink Temperature	^B	p0	^C	ttttt	
Request Upper Temperature Limit	^B	Eb076.00	^C	ttttt	
Request Lower Temperature Limit	^B	Eb082.00	^C	ttttt	
Request Standby Temperature Window	^B	Eb088.00	^C	ttttt	
Request Version	^B	VE	^C		
AOM K1-Analog	^B	AB032.00	^C	16	
AOM K1-FPS	^B	AB164.00	^C	16	
Request of AOM K1	^B	Ab	^C	xxxxx	
AOM K2-Analog	^B	AC004.00	^C	16	
AOM K2-FPS	^B	AC136.00	^C	16	
Request of AOM K2	^B	Ac	^C	xxxxx	
AOM P1 … 4	^B	AFxxx.yy (xxx = ‰ RF power for pulse # yy)	^C	16	
Request of AOM P1 … 4	^B	Afyyy.00 (yyy = No. of requested pulse)	^C	xxxxx	

[1] *See Table 7-4 for further details on most commands.*
[2] *The actual command structure does not include any spaces. Spaces are used in this table to separate the control characters from the rest of the string for ease of reading.*

Table 7-4: Command Usage Notes

Command	Notes			
Control Command parameter **ccc**	b0	Start Laser	1: Start pulse	0: No response
	b1	Stop Laser	1: Stop pulse	0: No response
	b2	System Reset	1: Reset pulse	0: No response
	b3	Shutter	1: Open	0: Close
	b4	Aiming Laser	1: Open	0: Close
examples:	^BSS002.00^C (Stop Laser and Close Shutter)			
	^BSS009.00^C (Start Laser and Open Shutter)			
Control Current example	^BSJ015.00^C--> ^BVI015.00^C (Set diode laser current to 15 A)			
Request Status parameter **sss**	b0	Laser On/Off		1: Laser started
	b1	System Initialization		1: Nominal temperature is being adjusted.
	b2	Sum Error		1: Active
	b3	Shutter Open/Closed		1: Open
	b4	Interlock Circuit		1: Open
	b5	Case Cover		1: Open
examples:	^BRS^B of SPS (Request of current system state)			
	^BVS001.00^C (Response from laser: laser is running; shutter closed; no errors; ...)			
Request Error Block 1 parameter **eee**	b0	Maximal Current		The device-specific maximal current has been reached.
1: active, applies to all errors	b1	Power Supply Power		
	b2	Excess Temperature of Laser Electronics		Temperature of heatsink in power supply is too high.
	b4	Line Break		The actually flowing current is too low (e.g., caused by line power failure or undervoltage, or internal contact faults)
	b6	Shutter Error		Shutter end position does not agree with nominal position
	b7	Short-Circuit Load		Short-circuit load or ESD safety relay does not open.
Request Error Block 2 parameter **eee** 1: active, applies to all errors	b0	External Error 1		
	b1	External Error 2		
	b2	External Error 3		
	b6	AOM error		
	b7	Excess Temperature of Diode Laser		

Table 7-4: Command Usage Notes

Command	Notes	
Request for 1st Occurring Fault decimal value of response:	0	No Error
	1	Maximum Current
	2	Power Supply Power
	3	Excess Temperature of Laser Electronics
	5	Line Break
	8	Short-Circuit Load
	10	Excess Temperature of Diode Laser
	12	Shutter
	13	Case Cover
	14	VSWR Error or AOM Driver Temperature
	15	External Error 1
	16	External Error 2
	17	External Error 3
Request Current Limit	Response iiiii corresponds to the latest current limit in Amperes.	
Request Actual Current	Response iiiii corresponds to the current actual current, scaled in mA.	
Request Warning parameter **www**	b0	Diode Laser Temperature
	b1	Ambient Temperature
	b2-b7	(not used)
Request Set Current RS-232	Parameter iiiii corresponds to the current setting, scaled in A.	
Request Set Current Analog	Parameter iiiii corresponds to the current setting, scaled in A.	
Request Nominal Diode Laser Temperature	Parameter ttttt corresponds to the current nominal temperature, scaled in 0.01°C.	
Request Actual Diode Laser Temperature	Parameter ttttt corresponds to current actual temperature, scaled in 0.01°C.	
Request Ambient Temperature	Parameter ttttt corresponds to current temperature in power supply, scaled in 0.1°C.	
Request Heatsink Temperature	Parameter ttttt corresponds to current heatsink temperature of diode laser, scaled in 0.01°C.	
Request Upper Temperature Limit	Parameter ttttt corresponds to current upper temperature limit, scaled in 0.1°C.	
Request Lower Temperature Limit	Parameter ttttt corresponds to current lower temperature limit, scaled in 0.1°C.	
Request Standby Temperature Window	Parameter ttttt corresponds to the current Standby temperature window, scaled in 0.1°C.	
Request Turn Off Current	Response iiiii corresponds to the currently defined turn-off current in Amperes.	
AOM K1-Analog	Program the AOM K1 register for analog mode: "16" must be displayed as an acknowledgement. Any other code indicates faulty data transmission. Repeat the command until "16" is displayed.	
AOM K1-FPS	Program the AOM K1-FPS register for FPS mode: "16" must be displayed as an acknowledgement. Any other code indicates faulty data transmission. Repeat the command until "16" is displayed.	
Request of AOM K1	xxxxx = 32 for analog mode; 164 for FPS mode	

Table 7-4: Command Usage Notes

Command	Notes
AOM K2-Analog	Program the AOM K2 register for analog mode: “16” must be displayed as an acknowledgement. Any other code indicates faulty data transmission. Repeat the command until “16” is displayed.
AOM K2-FPS	Programming of the AOM K2-FPS register for the FPS mode: “16” must be displayed as an acknowledgement. Any other code indicates faulty data transmission. Repeat the command until “16” is displayed.
Request of AOM K2	xxxxx = 4 for analog mode: 130 for FPS mode
AOM P1 … 4	Parameter xxx corresponds to the percentage of the maximum RF driver power for the pulse #yy. “16” must be displayed as an acknowledgement. Any other code indicates faulty data transmission. Repeat the command until “16” is displayed.
example:	50% RF power for pulse #2: ^BAF500.02^C
Request of AOM P1 ... 4	Parameter xxxxx corresponds to the adjusted RF power for pulse yyy (in 0.1%).
example:	^BAf002.00^C 500 (corresponds to 50% of the maximum RF power)

Chapter 8 Maintenance and Troubleshooting

Maintenance

Danger!

Prior to beginning any service or maintenance, verify the keyswitch on the power supply is turned to OFF and that both the key and the power cord have been removed.

There are no controls or adjustable components inside the laser head.

The *DisQ-Mark* laser head and power supply have been mated together at the factory for optimum performance. Do not interchange the components between different *DisQ-Mark* systems, i.e., do not separate the original power supply and laser head. This may result in a reduction of performance. When replacing a laser head or power supply, arrange to have the new component optimized for the system by a technician trained by Spectra-Physics.

Refer to the Test Certificate for identification of the system components. Do not use any cables other than those provided with the system.

This product was produced under clean room conditions in a controlled atmosphere. It is sensitive to moisture. For this reason, you may only open the U-shaped casing lid on the laser head and the lid on the power supply to connect the cables and optical fiber. (See Figure 6-5 on page 6-5.)

Protect the laser against grease and oils, as well as dust and aerosols in the room atmosphere. Do not allow moisture to condense on the unit or corrosive gases to enter the casing. The laser head casing is dust-proof; it must remain intact.

It is forbidden to mechanically modify any components of the laser system. Do not loosen any screws other than when following the procedures in this manual. Loose screws can cause damage to the equipment.

Replacing Fuses

Use an appropriate screwdriver to unscrew and remove the fuse holder from the power supply. Replace the defective fuse, then re-insert the fuse holder and screw it in again. Refer to Table 2-1 on page 2-4 for fuse ratings and Figure 5-2 on page 5-2 for the location of the fuses.

Danger!

Do not bypass or short-circuit any fuses.

Cleaning the Front Window

The front window on the laser exit aperture can be cleaned using optical cleaning tissue moistened with ethanol (reagent-grade, purity class: 99.8%). If the front window is badly contaminated and shows burnt-in dirt, the window must be replaced by a new one from Spectra-Physics.

Note

Burnt-in dirt is a direct consequence of coarse contamination and is not covered by the warranty. Keep the window clean.

Cleaning the Casing

The casing can be cleaned using a cloth moistened with a commercial, non-abrasive and non-corrosive detergent.

Troubleshooting

- After a fault has occurred, the Fault LED illuminates yellow (Refer to Figure 5-2 on page 5-2.)
- The fault can be identified from information given in "Request for 1st Occurring Fault" on page 14.
- For information on clearing the fault, refer to the table below.

Table 8-1: Fault Correction Summary

State / Fault	Cause	Corrective Action
Maximum current	Preset current is higher than the device-specific maximum current.	Check limit settings.
Power supply fault	Power supply defectively.	Contact Spectra-Physics.
Excess temperature, laser electronics	Internal temperature in module is too high.	Check ambient temperature and cooling or fan function. Contact Spectra-Physics, if necessary.
Line break	Fault in power supply	Contact Spectra-Physics, if necessary.
Short circuit in load circuit	Short circuit in laser system	Contact Spectra-Physics.
Temperature fault on diode laser	Operating temperature is too low or too high.	Check ambient temperature and cooling or fan function. Contact Spectra-Physics, if necessary.
Shutter	Shutter position undefined	Contact Spectra-Physics.
Case cover		Attach cover at rear side of module correctly and lock it.
VSWR	Poor RF transmission.	Check contacts and plug-and-socket connection of RF cable.
External error 1	24 V failure at Pin 4 of user interface	Check contacts and signal sources.
External error 2	24 V failure at Pin 5 of user interface	Check contacts and signal sources.
External error 3	24 V failure at Pin 6 of user interface	Check contacts and signal sources.

Chapter 9 Customer Service

Customer Service

At Spectra-Physics, we take great pride in the reliability of our products. Considerable emphasis has been placed on controlled manufacturing methods and quality control throughout the manufacturing process. Nevertheless, even the finest precision instruments will need occasional service. We feel our instruments have excellent service records compared to competitive products, and 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 get your instrument repaired and back to you as soon as possible.

Spectra-Physics maintains major service centers in the United States, Europe, and Japan. Additionally, there are field service offices in major United States cities. When calling for service inside the United States, dial our toll free number: **1 (800) 456-2552**. To phone for service in other countries, refer to the "Service Centers" listing located at the end of this section.

Order replacement parts directly from Spectra-Physics. For ordering or shipping instructions, or for assistance of any kind, contact your nearest sales office or service center. You will need your 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) 961-2550** 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.

Unless otherwise specified, all parts and assemblies manufactured by Spectra-Physics are unconditionally warranted to be free of defects in workmanship and materials for a period of one year following delivery of the equipment to the F.O.B. point.

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

This warranty does not apply to any instrument or component not manufactured by Spectra-Physics. When products manufactured by others are included in Spectra-Physics equipment, the original manufacturer's warranty is extended to Spectra-Physics customers. When products manufactured by others are used in conjunction with Spectra-Physics equipment, this warranty is extended only to the equipment manufactured by Spectra-Physics.

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

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

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

Notice

This laser product is intended to be sold to a manufacturer of electronic products for use as a component (or replacement thereof) in such electronic products. As such, this product is exempt from DHHS performance standards for laser products in accordance with paragraph 1040.10(a)(1) or (2).

Return of the Instrument for Repair

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

Use the original packing boxes to secure instruments during shipment. If shipping boxes have been lost or destroyed, you should order new ones. We can return instruments only in Spectra-Physics containers.

Service Centers

Benelux

Telephone: (31) 40 265 99 59

France

Telephone: (33) 1-69 18 63 10

Germany and Export Countries*

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

Japan (East)

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

Japan (West)

Spectra-Physics KK
West Regional Office
Nishi-honmachi Solar Building
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Telephone: (44) 1442-258100

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(800) SPL-LASER (Sales) or
(800) 775-5273 (Sales) or
(650) 961-2550 (Operator)
Fax: (650) 964-3584
e-mail: service@splasers.com
sales@splasers.com
Internet: www.spectra-physics.com

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

Notes

Report Form for Problems and Solutions

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

Thank you.

From:

Name ______________________________

Company or Institution ______________________________

Department ______________________________

Address ______________________________

____

Instrument Model Number ______________ Serial Number ______________

Problem: ______________________________

____

____

____

____

Suggested Solution(s): ______________________________

____

____

Mail To:

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

E-mail: sales@splasers.com
www.spectra-physics.com

FAX to:

Attention: SSL Quality Manager
(650) 961-7101