Explorer XP

Actively Q-Switched, High-Repetition Laser Systems

User's Manual

This laser product is intended to be sold to a manufacturer of OEM products for use as a component (or replacement thereof) in those products. As such, this product is exempt from performance standards of *United States Code of Federal Regulations*, Title 21, Chapter 1 – Food and Drug Administration, Department of Health and Human Services, Subchapter J – Parts 1040.10 (a), (1) or (2).

Spectra-Physics
A Newport Corporation Brand

3635 Peterson Way
Santa Clara, CA 95054

Part Number D-002-2208, Rev. C
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Preface

This manual contains information for safely installing, operating and servicing your *Explorer XP* actively Q-switched, high-repetition laser system. This manual covers the *Explorer XP-532-5W,* which has an output wavelength at 532 nm. For information on the other *Explorer XP* models, refer to the "Explorer XP Model Description" document.

Chapter 1, "Introduction," contains a brief description of the *Explorer XP* laser systems.

Chapter 2, "Laser Safety," contains essential information for the safe use of these products. The *Explorer XP* is a Class IV laser that emits laser radiation that can permanently damage eyes and skin. This section contains information about these hazards and offers suggestions on how to safeguard against them. To minimize the risk of injury or expensive repairs, be sure to read this chapter—then carefully follow these instructions.

Chapter 3, "Laser Description," contains a more detailed description of the *Explorer XP* laser systems and concludes with system specifications and outline drawings.

Chapter 4, "Controls, Indicators and Connections," describes the *Explorer XP* system components.

Chapter 5, "Installation," contains instructions for installing the system, including hook-up diagrams and lists of required components.

Chapter 6, "Using the L-Win Software," provides instructions for using the custom graphic user interface to operate the *Explorer XP* laser as a standalone system. This chapter also provides further descriptions of the *Explorer XP* models along with some general considerations regarding laser output. A complete listing of the commands available through the *L-Win* interface is provided in Appendix A.

Chapter 7, "Commands and Signals," provides detailed instructions for using serial commands and analog signals to control the laser. This chapter provides examples of different ways of configuring the laser output. A compete listing of the serial command language is provided in Appendix B.

Chapter 8, "Maintenance and Service," is intended as a guide for routine maintenance as well as for troubleshooting the laser to identify the source of possible problems. *Do not attempt repairs yourself while the system is still under warranty.* Instead, report all problems to Spectra-Physics for warranty repair. This chapter concludes with a list of world-wide Spectra-Physics service centers you can call if you need help.

Should you experience any problems with any equipment purchased from Spectra-Physics, or if you are in need of technical information or support, contact Spectra-Physics.

Appendix A is a reference guide for the *L-Win* control software provided with the system. Appendix B is a list and reference for the serial commands that can be used to control the system. Appendix C lists all of the possible status codes that can be returned via system queries.

This product has been tested and found to conform to the provisions of Directive 73/23/EEC, the low-voltage directive governing product safety, and the provisions of EMC Directive 89/336/EEC for electromagnetic compatibility. Refer to the "CE Declaration of Conformity" statement in Chapter 2, "Laser Safety," for a complete list of test specifications. Please note that the *Explorer XP* lasers are OEM systems that are designed to be integrated into a master system that, itself, complies with regulatory requirements.

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.

CE Environmental Specifications

CE Electrical Equipment Requirements

For information regarding the equipment needed to provide the electrical service listed in Table 3-2, please refer to specification EN-60309, "Plug, Outlet and Socket Couplers for Industrial Uses," listed in the official *Journal of the European Communities.*

Environmental Specifications

Explorer XP systems are designed for indoor use. The environmental conditions under which these laser systems will function are:

Operating specifications:

Altitude	0 to 2000 m
Temperature	18°C to 35°C
Max. Baseplate Temperature	45°C
Relative humidity	< 80%, dew point < 20°C
Mains supply voltage	not to exceed ±10% of the nominal voltage
Insulation category	II
Pollution degree	2

Non-operating specifications:

Altitude	0 to 12000 m
Temperature	–20 to 60°C
Maximum relative humidity	< 90%, non-condensing

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.

Laser radiation is present.

Danger! 

Condition or action may present a hazard to personal safety.

 **Danger!** 

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

Warning! 

Condition or action may cause damage to equipment.

Warning!
ESD 

Action may cause electrostatic discharge and cause damage to equipment.

 **Caution!** 

Condition or action may cause poor performance or error.

Note 

Text describes exceptional circumstances or makes a special reference.

Don't
Touch! 

Do not touch.

Eyewear
Required 

Appropriate laser safety eyewear should be worn during this operation.

Refer to the manual before operating or using this device.

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
temperature	Celsius	C
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
AOM	acousto-optic modulator
AR	anti-reflection
CDRH	Center of Devices and Radiological Health
CW	continuous wave
dc	direct current
FPS	first pulse suppression
HR	high reflector
IR	infrared
µs	microsecond or 10^{-6} second
ms	millisecond or 10^{-3} second
ns	nanosecond or 10^{-9} second
OEM	original equipment manufacturer
OC	output coupler
RF	radio frequency
SHG	second harmonic generation
TEC	thermoelectric cooler
TEM	transverse electromagnetic mode
THG	third harmonic generation
UV	ultraviolet
l	wavelength

Unpacking and Inspection

Unpacking the Laser

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

Keep the shipping container. If you file a damage claim, you may need it to demonstrate that the damage occurred as a result of shipping. If you need to return the system for service at a later date, the specially designed container assures adequate protection. **Equipment must be returned in the designated Spectra-Physics shipping container or the laser warranty is void.**

System Components

The *Explorer XP* is an all-in-one laser system that includes the power supply in the same enclosure.

If ordered, an optional custom heatsink with fan and/or a wall-plug autoranging ac/dc converter will also be included with the shipment. Verify that all components are present. The heatsink and the ac/dc converter are shipped in separate containers.

The laser head weighs approximately 3 kg (6.5 lb). It can be handled easily by one person.

Accessory Kit

Included with the laser system is this manual, a packing slip listing all the parts shipped, and an accessory kit containing the following items (Spectra-Physics part numbers are given in parentheses):

- (1) jumper plug for the ANALOG I/O connector
- (2) keys
- (1) heat-conducting foil for mounting the laser head on the heat sink

Chapter 1 Introduction

Figure 1-1: The *Explorer XP* Laser

The Spectra-Physics *Explorer XP-532-5W* (Figure 1-1), is a solid-state, Q-switched OEM laser that produces a superior quality, 532 nm, green output beam at adjustable repetition rates up to 300 kHz. This laser is designed for applications where a high repetition rate, low cost-of-ownership and ease of integration are essential. For other *Explorer XP* models, refer to the "Explorer XP Model Description" document.

All *Explorer XP* models have an internal, single-pulse energy monitor.

Explorer XP lasers provide stable pulse energy through the entire range of repetition rate, as well as precise triggering or gating of pulsed output in response to user-provided signals. Changing the *Explorer XP* pulse energy or pulse repetition rate has little impact on laser beam parameters.

The all-in-one *Explorer XP* laser system offers a variety of methods for controlling laser output: internal or external triggering or gating capability, a unique trigger output that is highly coincident with the laser pulses ("OptoSync"), as well as burst mode and first pulse suppression (FPS). A description of these capabilities is provided in Chapter 3.

Table 1-1: The *Explorer XP* OEM Model

Explorer XP Part Number	Wavelength (nm)	Ave Power (mW)	Max PRF (kHz)
EXPL-XP-532-5W	532	5000	300

For part numbers and output of the other *Explorer XP* models, refer to the "Explorer XP Model Description" document.

Some of the advantages of the *Explorer XP* laser are:

- Actively Q-switched
- Variable repetition rate
- Variable pulse energy
- Excellent mode quality
- High peak power
- Superior pulse-to-pulse stability
- Reliable, rugged design
- Low jitter

The Explorer XP Laser System

The *Explorer XP* laser system was specifically designed for applications requiring a Q-switched, high-quality beam with an adjustable repetition rate, along with good mode quality in a cost-effective package. The *Explorer XP* is a rugged, sealed unit designed for simple hands-free operation. Sufficient cooling for the laser head must be provided by the user. The laser can be air-cooled using the optional Spectra-Physics fan-cooled heat sink (P/N *EXPL-XP-HTSNK-A*), or it can be cooled by conduction through a user-provided heat sink.

All optical components are contained in the laser head. These include the diode laser pump source, the laser crystal and the nonlinear crystals that convert the fundamental infrared light into the output beam. The diode laser pump source is typically operated at a derated power level in order to ensure extended lifetime. The nonlinear crystals are temperature controlled to maintain the phase-matching condition for efficient nonlinear optical conversion. The laser head also contains the Q-switch and its RF driver, as well as the system power supply.

Note

In the context of this manual, the diode laser module is sometimes referred to simply as the "diode," e.g., "the diode current."

The internal power supply provides the low-voltage, high-amperage drive current necessary to power the diode laser. The laser system requires a single 24 Vdc, 6 A power source that complies with the requirements of the European Union for safety, noise and regulation of hazardous component materials. See Chapter 2 for CE certification details. This power supply is to be provided by the user.

System Control

As a component in a master system, the *Explorer XP* system is designed to be controlled via serial commands and queries and/or analog signals provided by the host system. The host connects to the *Explorer XP* through the

serial port. The analog/TTL control signals can either be used alone or in combination with the serial commands. Combining the two methods provides the greatest control over the laser output. Both analog and serial controls are fully described in Chapter 7.

Custom *L-Win* control software for a Windows®-based personal computer is provided for operating the laser as a stand-alone device, for example, when installing or servicing the unit. Operating the *Explorer XP* using the *L-Win* software is described in Chapter 6.

Patents

Explorer XP systems are manufactured under one or more of the following patents:

5,410,559
5,561,547
5,577,060
5,907,570
6,185,235
6,504,858

Windows is a registered trademarks of the Microsoft Corporation.

Chapter 2 Laser Safety

Spectra-Physics *Explorer XP* lasers are *Class IV—High-Power Lasers* whose beams are, by definition, safety and fire hazards. Take precautions to prevent accidental exposure to both direct and reflected beams. Diffuse as well as specular beam reflections can cause severe eye or skin damage. Residual light at 1064 nm and 808 nm wavelengths might also be present.

Note

This is an OEM laser product and, as such, does not conform to the safety specifications and performance standards required of a Class IV laser as defined by the Center for Devices and Radiological Health (CDRH), 21 CFR 1040.

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 that 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 personnel trained in the principles of laser safety.
- Enclose beam paths wherever possible.
- Post prominent warning signs near the laser operating area (Figure 2-1).
- Install the laser so that the beam is either above or below eye level.
- Set up shields to prevent any unnecessary specular reflections or beams from escaping the laser operation area.
- Set up a beam dump to capture the laser beam and prevent accidental exposure (Figure 2-2).

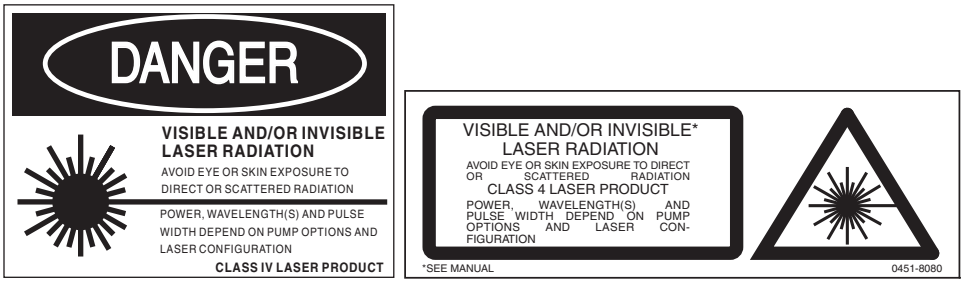


Figure 2-1: These standard safety warning labels are appropriate for use as entry warning signs (EN 60825-1: 2007, ANSI Z136.1, Section 4.7).

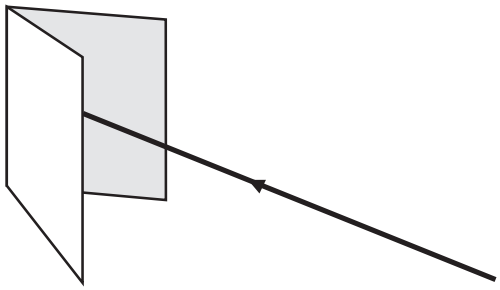


Figure 2-2: Folded Metal Beam Target

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 the laser, avoid unnecessary exposure to laser or collateral radiation[1] 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 the laser.

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

Safety Devices

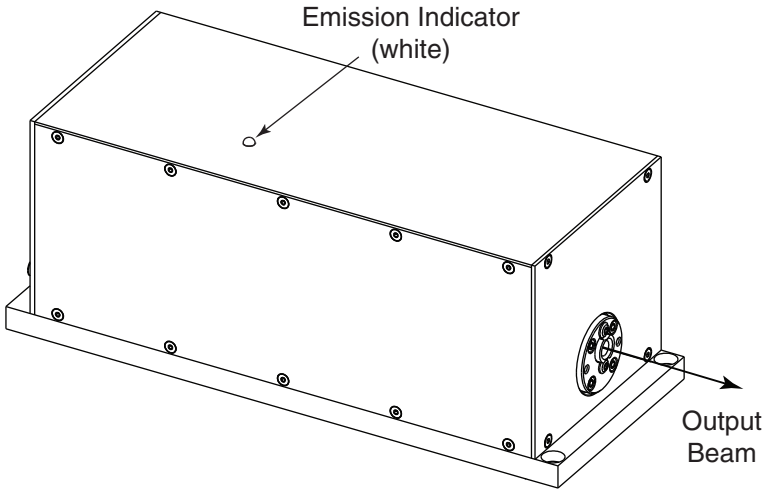


Figure 2-3: Laser Head Emission Indicator

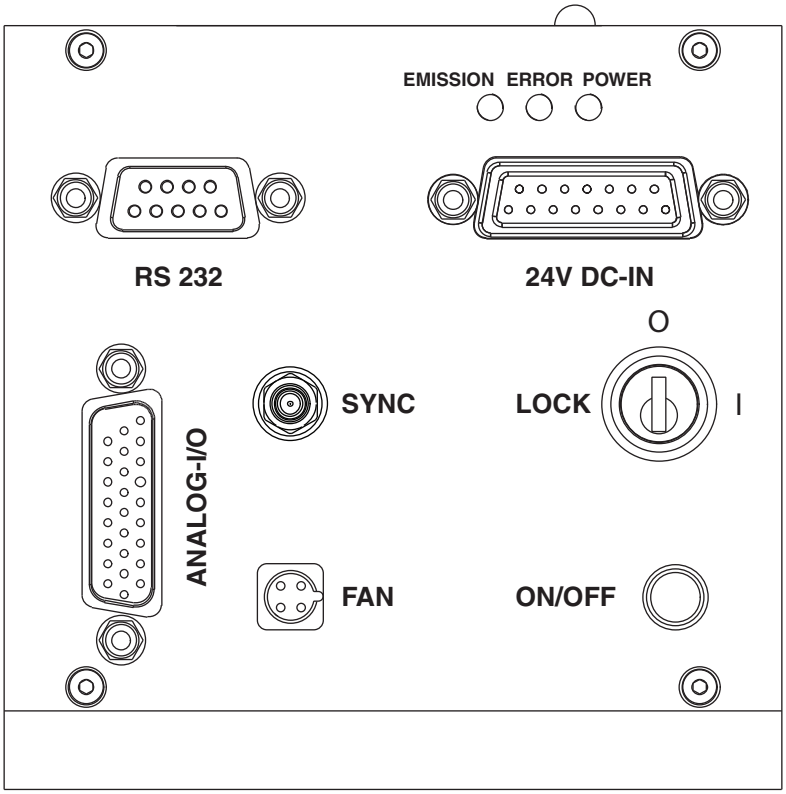


Figure 2-4: Laser Safety Devices, Rear Panel

Emission and Power Indicators

The system provides the following emission and power indicators:

- A white EMISSION indicator on top of the laser head (Figure 2-3) turns on about 3 seconds before actual emission occurs.
- A blue EMISSION indicator (Figure 2-4) turns on about 3 seconds before actual emission occurs.
- A yellow POWER indicator (Figure 2-4) turns on when the power switch is turned on.
- If the *Explorer XP* is operated using the *L-Win* software, an indicator on the *L-Win* Main display turns green when the power switch is turned on, the diode laser keyswitch is set to I, and the proper on command has been issued by the software. This *L-Win* indicator turns on about 3 seconds before actual emission occurs.
- Pin 9 of the ANALOG I/O connector or the relay formed by pins 4 and 5 of the 24V DC-IN power connector can be used to control an external emission indicator. Refer to "Connections" on page 4-3 for more information.

Shutter

The *Explorer XP* lasers are OEM systems that are designed to be integrated into a master system that, itself, complies with regulatory requirements. As such, it provides no internal shutter.

Diode Laser LOCK On/Off Keyswitch

The keyswitch (Figure 2-4) provides power to the diode laser when it is turned on, and it prevents unauthorized use of the laser when it is turned off and the key is removed. Placing this switch in the I position enables the laser to be turned on via serial commands or analog signals.

DC Power ON/OFF Switch

The ON/OFF DC power switch (Figure 2-4) provides electrical power to the laser system when turned on.

Safety Interlocks

External Interlock

Pins 7 and 8 of the ANALOG I/O connector must be shorted together for normal system operation. They can be used in an interlock circuit to terminate laser emission when a normally closed safety switch wired to these pins is opened. Such a switch can be attached to an access point, such as an entry panel, that might be opened unexpectedly. See Chapter 7 for the circuit requirements.

Cover Safety Interlocks

The *Explorer XP* lasers are OEM systems that are designed to be integrated into a master system that, itself, complies with regulatory requirements. As such, the laser head does not have cover safety interlocks. The laser head cover is not to be opened by the user, especially during operation.

Maximum Emission Levels

Table 2-1 lists the maximum emission levels possible for the *Explorer XP* lasers. Use this information for selecting appropriate laser safety eyewear and to implement appropriate safety procedures. These values do not imply actual system power or specifications.

Laser light at longer wavelengths is generated in the production of green emission, and the diode pump laser used in all *Explorer XP* models produces infrared light. These wavelengths are confined to the inside of the laser head.

For the emission levels of the other *Explorer XP* models, refer to the "Explorer XP Model Description" document.

Table 2-1: Maximum Emission Levels from the Laser Head

Emission Wavelength	Max Power, Max Pulse Energy Min Pulse Duration	Leakage Wavelengths
Laser Output: 532 nm	7 W, 0.2 mJ, 4 ns	Diode Laser Emission: 808 nm < 20 mW
		Fundamental Beam: 1064 nm < 20 mW

System Operation Using a User-Provided Control Device

When the *Explorer XP* laser system is controlled by a device provided by the user or by software written by the user, the following criteria must be met in order to comply with recognized safety agency requirements:

- **A keyswitch**—must be employed 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 any similar "key" implementation. The laser must only operate when the "key" is present and in the "on" position.
- **An emission indicator**—must be used to indicate that 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 as long as its function is obvious. Its presence is required on any control panel that affects laser output.

CE Radiation Control Drawings

Refer to "CE Warning Labels" on page 2-7.

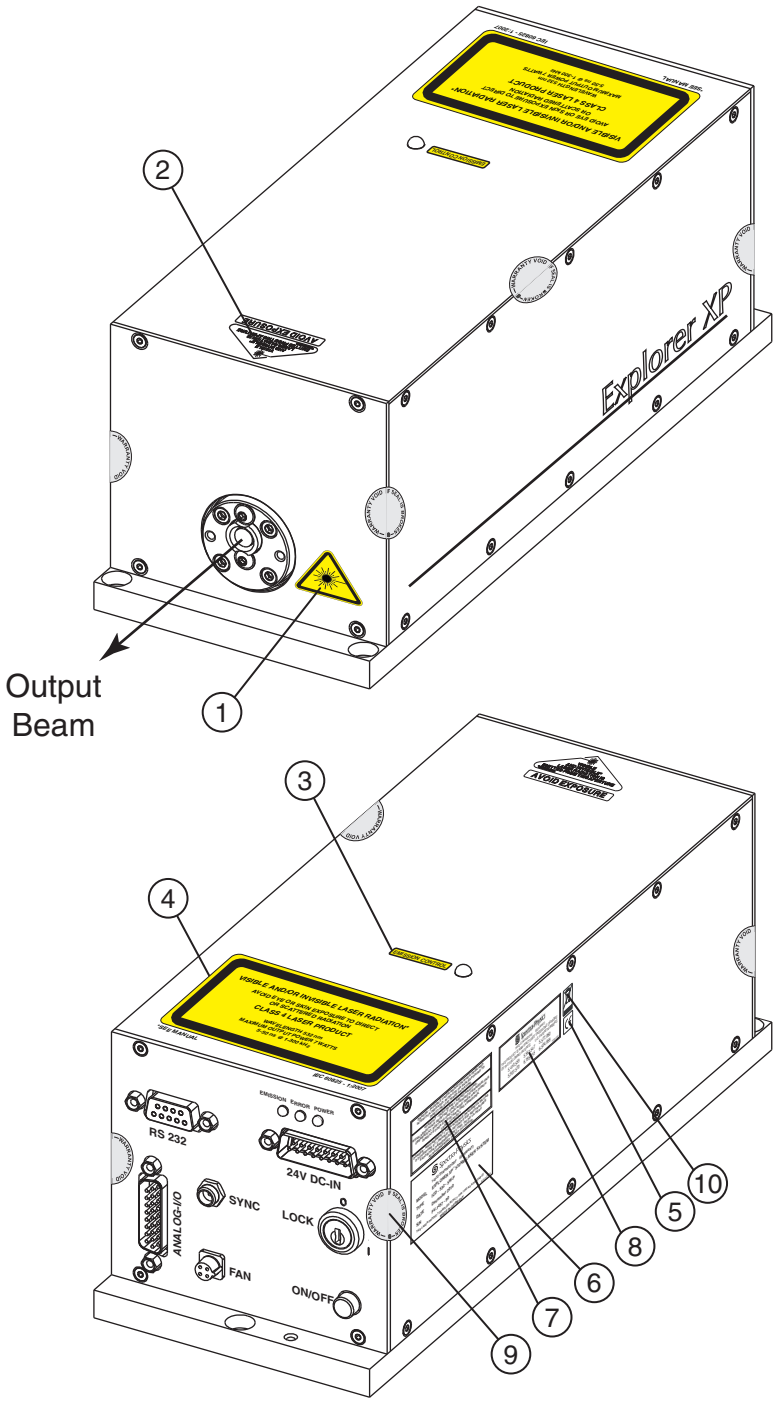


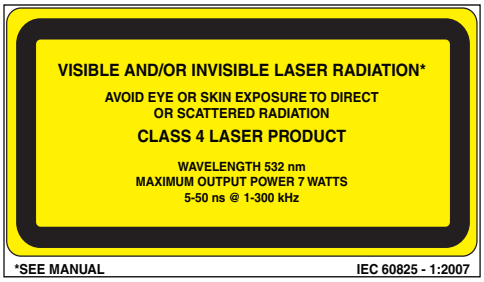
Figure 2-5: *Explorer XP* Radiation Control Drawing

CE Warning Labels

Aperture Symbol
Label (1)

Aperture Warning
Label (2)

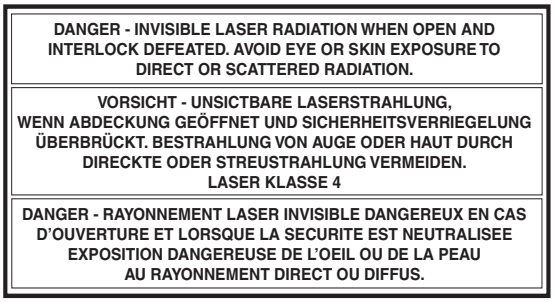
Emission Indicator
Label (3)



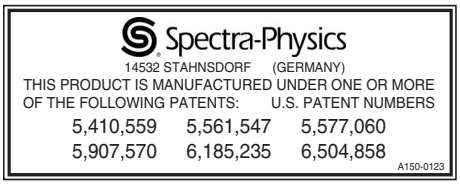
Class 4
CE Warning Label (4)
For the labeling of other Explorer XP models, refer to the “Explorer XP Model Description” document.

CE Approval
Label (5)

Serial Label (6)

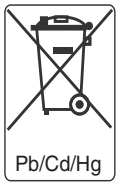


Invisible Radiation
Danger Label (7)



Patent
Label (8)

Warranty
Seal (9)



WEEE
Label (10)

Figure 2-6: *Explorer XP* CE Warning Labels

Label Translations

For safety, the following translations are provided for non-English speaking personnel. The number in parentheses in the first column corresponds to the label number listed on the previous page. For the labels of the other *Explorer XP* models, refer to the "Explorer XP Model Description" document.

Table 2-2: Label Translations

Label No.	French	German	Spanish	Dutch
Aperture Warning Label (2)	Ouverture Laser – Exposition Dangereuse – Un rayonnement laser visible et/ou invisible est émis par cette ouverture.	Austritt von sichtbarer und unsichtbarer Laserstrahlung! Bestrahlung vermeiden!	Por esta abertura se emite radiación láser visible e invisible; evite la exposición.	Vanuit dit apertuur wordt zichtbare en onzichtbare laserstraling geëmitteerd! Vermijd blootstelling!
Emission Indicator Label (3)	Indicateur d'émission	Emissionskontrolle	Control de la emisión	Controle van emissie
Class 4 CE Warning Label (4)	Rayonnement laser visible et/ou invisible. Exposition dangereuse de l'oeil ou de la peau au rayonnement direct ou diffus. Laser de classe 4. 532 nm Puissance maximum moyenne de 7 W. Énergie maximum par impulsion 0,2 mJ. Durée d'impulsion 5–50 ns @ 1–300 kHz.	Sichtbare und/oder unsichtbare Laserstrahlung. Bestrahlung von Auge oder Haut durch direkte oder Streustrahlung vermeiden. Laser Klasse 4. 532 nm Mittlere maximale Leistung 7 W. Maximale Pulsenergie 0,2 mJ. Pulsdauer 5–50 ns @1–300 kHz.	Radiación láser visible y/o invisible. Evitar la exposición directa ó dispersa sobre la piel o los ojos. Producto Láser Clase 4 532 nm Potencia máxima promedio 7 W. Energía máxima del pulso 0,2 mJ. Duración de pulso 5–50 ns @ 1–300 kHz.	Zichtbare en/of onzichtbare* laser straling. Vermijd blootstelling aan ogen of huid door directe of gereflecteerd straling. Klasse 4 laser product 532 nm Maximaal uittredend vermogen 7 W. Maximaal pulsenergie 0,2 mJ. Pulsduur 5–50 ns @ 1–300 kHz.

Waste Electrical and Electronic Equipment (WEEE) Recycling Label

To Our Customers in the European Union:

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

The directive that addresses the reduction, recovery, re-use and recycling of waste electrical and electronic equipment is referred to as WEEE. In accordance with this directive, the accompanying product has been marked with the WEEE symbol. See Label 10 in Figure 2-6.

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

CE Declaration of Conformity

We,

Newport Spectra-Physics GmbH
Ruhlsdorfer Strasse 95
Stahnsdorf, 14532
Germany

declare under sole responsibility that the:

Explorer XP 532-5W Laser System

manufactured after April 27, 2011

meets the intent of the EMC Directive 2004/108/EC for Electromagnetic Compatibility and 2006/95/EC for Low Voltage Directive. Compliance was demonstrated to the following specifications as listed in the official *Journal of the European Communities*:

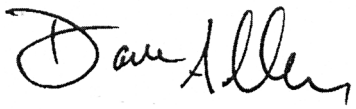
EMC Directive 2004/108/EC

EN 61000-4-2: 2009-03: Part 4: Section 2: Electrostatic discharge immunity test
EN 61000-4-3: 2006-05 + A2: 2008-02: Part 4: Section 3: Testing and measurement techniques—radiated, radio-frequency, electromagnetic field immunity
EN 61000-4-4: 2004-12: Part 4-4: Testing and measurement techniques—electrical fast transient/burst immunity test
EN 61000-4-6: 2009-03: Part 4-6: Testing and measurement techniques—immunity to conducted disturbances induced by radio-frequency fields
EN 61000-6-2: 2005: (EMC) Generic standards—Immunity standard for industrial environments
EN 61000-6-4: 2007: (EMC) Generic standards—Emission standard for industrial environments

Low Voltage Directive 2006/95/EC

EN60950-1: 2006 + A11: 2009 + A2: 2010: Safety of Information Technology Equipment—General Requirements
EN60825-1: 2007: Safety of laser products—Equipment classification, requirements and user's guide

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



Dave Allen
Vice President/General Manager
Spectra-Physics, a Newport Corporation Brand
April 27, 2011

For the CE Declaration of Conformity for the other *Explorer XP* models, refer to the “Explorer XP Model Description” document.

Sources for Additional Information

Laser Safety Standards

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

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

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American Conference of Governmental and
Industrial Hygienists (ACGIH)
1330 Kemper Meadow Drive
Cincinnati, OH 45240
Tel: (513) 742-2020
Web site: http://www.acgih.org/home.htm

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

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Tel: +41 22-919-0211 Fax: +41 22-919-0300
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Chapter 3 The Explorer XP Laser System

An *Explorer XP* laser system consists of an all-in-one *Explorer XP* laser head, which contains the power supply and control system. The following sections briefly describe the design of the laser head. Controls and connections are described in Chapter 4 and the methods of operating the laser are described in Chapters 6 and 7.

The Explorer XP Laser Head

Overview

The *Explorer XP* laser head is designed for maximum reliability with minimum complexity. No adjustments to the laser head are needed for normal operation. In addition to the optical components (see Figure 3-1), the laser head contains microprocessors and memory for storing system parameters (for example, the last operating settings). For the optical layout of other *Explorer XP* models, refer to the "Explorer XP Model Description" document.

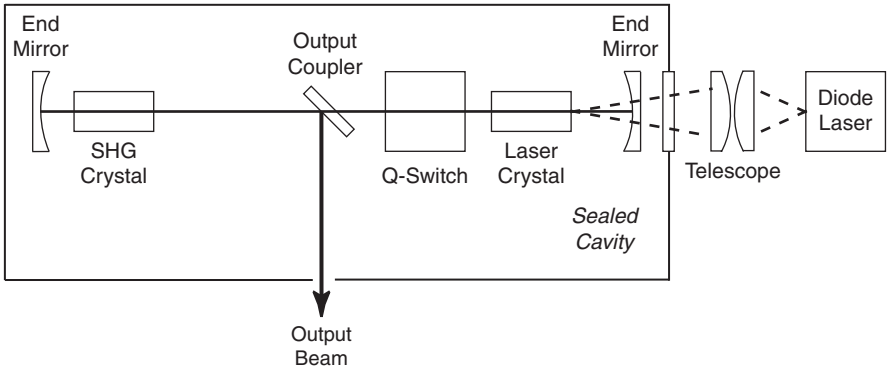


Figure 3-1: Optical Design of the *Explorer XP-532* Laser Head

The *Explorer XP* laser head integrates several key components, including a fiber-coupled, multi-emitter, pump laser diode, as well as the 40 MHz Q-switch driver. The *Explorer XP* models include detection circuitry to measure the energy of individual pulses and measure the average output power of the laser.

Optical Design

The 808 nm output of the diode laser inside the laser head is coupled into the laser crystal by means of a fiber-optic cable. The diode laser itself is

incorporated in a module that is mounted directly on a temperature-regulated cold plate to stabilize its output wavelength. The *Explorer XP L-Win* software allows the diode laser current and temperature to be adjusted if and when necessary.

The output of the fiber is focused into the laser crystal by a beam-shaping telescope. The laser crystal absorbs the 808 nm pump light and is energized to produce a high-quality laser beam at 1064 nm. The energy of this output is concentrated into a series of intense pulses using an acousto-optic Q-switch.

The Q-switched output of the IR laser beam is converted to shorter wavelengths inside the laser head by means of nonlinear optical crystals.

Frequency Doubling and Tripling

Materials with certain crystalline properties will transform a fraction of intense incident laser light into coherent light output at shorter wavelengths. For efficient conversion, care must be taken to keep the incident beam and the converted beam in phase within the crystal. The intense pulses produced by Q-switching are much more efficient than a continuous laser beam at producing the shorter wavelengths obtained through this nonlinear harmonic generation, also referred to as frequency conversion.

Green output at 532 nm is generated by frequency doubling the fundamental IR laser output at 1064 nm in a crystal of lithium triborate (LBO), a process also referred to as second harmonic generation (SHG). The nonlinear wavelength conversion takes place entirely inside the laser head. A specially coated mirror directs the green light out of the laser cavity while confining the infrared wavelength inside. For the configuration of the other *Explorer XP* models, refer to the "Explorer XP Model Description" document.

The LBO crystal must be heated and temperature-stabilized to maintain good conversion efficiency. The *Explorer XP* software and command structure provide the ability to adjust the temperature of the crystal when necessary.

Pulse Energy and Average Power Monitors

A small fraction of the laser output is reflected into a detector (not shown in Figure 3-1) where individual pulse energy is measured. Also measured, but less precise, is average power.

For single-pulse measurement, the detector generates several signals that are evaluated by the microprocessor, including the energy of each pulse. The analog value of this pulse energy is stored by a sample-and-hold circuit, and it becomes the laser output power value until it is replaced by the value of the next measured pulse. This value is available via the RS-232 interface and the ANALOG I/O port.

The pulse energy monitor is an integral part of the *Explorer XP's* advanced control features. These include the *OptoSync* output, Burst mode and First Pulse Suppression (FPS) features. (Burst mode, FPS and *OptoSync* are described in more detail later in this chapter.)

Information about using these features is provided in Chapters 6 and 7, which describe how to operate the *Explorer XP* laser.

Replaceable Output Window

A problem common to all laser systems are the effects caused by intense light on the output window and a dusty environment. With this in mind, the output window on the *Explorer XP* laser head is designed to be replaced in the field, as needed, to ensure the transmission and delivery of the full pulse energy output of the laser to the target. Refer to Chapter 8, "Maintenance and Service," for instructions on when and how to change the window.

The output window on the 532 nm *Explorer XP* should not need to be replaced under normal circumstances. For other *Explorer XP* models, refer to the "Explorer XP Model Description" document.

Laser Head Thermal Management

Thermal management of the *Explorer XP* laser head is key to achieving proper system performance, including cold-start performance. At normal ambient operating temperature (25°C), the *Explorer XP* laser head generates about 90 W of heat (but up to 160 W) that must be dissipated by the heatsink to which the laser head is mounted.

Spectra-Physics offers an optional custom heatsink (P/N *EXPL-XP-HTSNK-A*) that includes a fan for use with the *Explorer XP* laser head (contact your Spectra-Physics representative for more information). The auxiliary fan attached to the heatsink is controlled through the laser. A temperature sensor inside the housing continuously measures the base plate temperature, and its feedback is part of an active servo-loop that is used to set the fan speed. For more information, refer to "Thermal Management" in Chapter 5, and "Controlling the Laser Head Temperature" in Chapter 7.

The laser system provides the drive current for all of the active components inside of the laser head, including the thermoelectric coolers (TEC), the diode laser, the Q-switch driver, the microprocessors and non-volatile memory. It also provides the communication and control interface for the user.

The laser requires a 24 ±2 Vdc, 7 A electrical source. The laser system has been certified to comply with the requirements of the RoHS Directive (the Restriction of Hazardous Substances) of the European Union.

System Control

As a component in a master system, the *Explorer XP* is controlled using either the serial command language or analog signals described in Chapter 7 or a combination of both. The ports for the serial and analog interfaces are located on the rear panel. The most common methods of operating the laser are described in Chapters 6 and 7. The *Explorer XP* can also be operated as a stand-alone system using the custom *L-Win* software provided with the laser.

System Control Hardware

Figure 3-2 is a schematic of the main logic components in the laser.

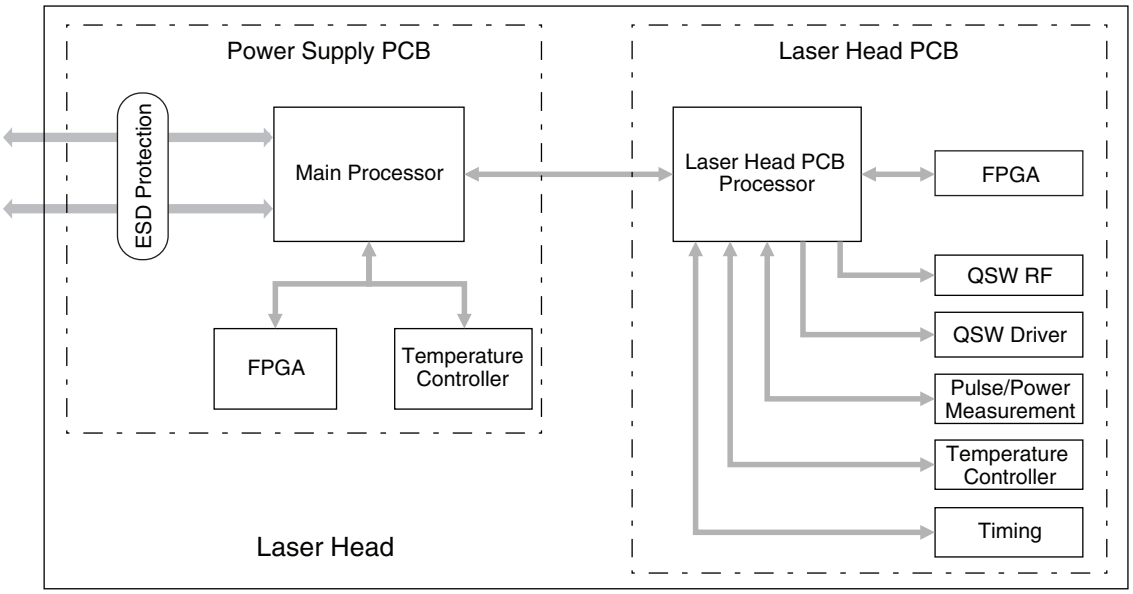


Figure 3-2: *Explorer XP* System Control Hardware

A microprocessor in the laser head controls system functions such as maintaining harmonic crystal temperatures, controlling diode laser current, receiving and storing operating parameters and communicating with the host system.

The versatility of the laser results in part from the use of an FPGA (Field Programmable Gate Array). By setting operating registers through software commands, a variety of triggering schemes can be used without the need for changes to the hardware. Precise timing is realized by locking incoming signals to the microprocessor clock and using counters and registers to minimize jitter.

Note

All inputs are protected from ESD.

Operational settings are stored in non-volatile memory inside the laser head. In case of a sudden power outage, the laser saves important system parameters in this non-volatile memory, thus ensuring that they are secure.

The laser head's permanent memory contains unit-specific identification information and parameters such as maximum diode laser current. The contents of permanent memory cannot be changed in the field.

Laser Performance

Maximum output power and pulse energy will be achieved around 80 kHz for vanadate (as gain medium) when maximum power is applied (see Figure 3-3). For information on the other *Explorer XP* models, refer to the "Explorer XP Model Description" document.

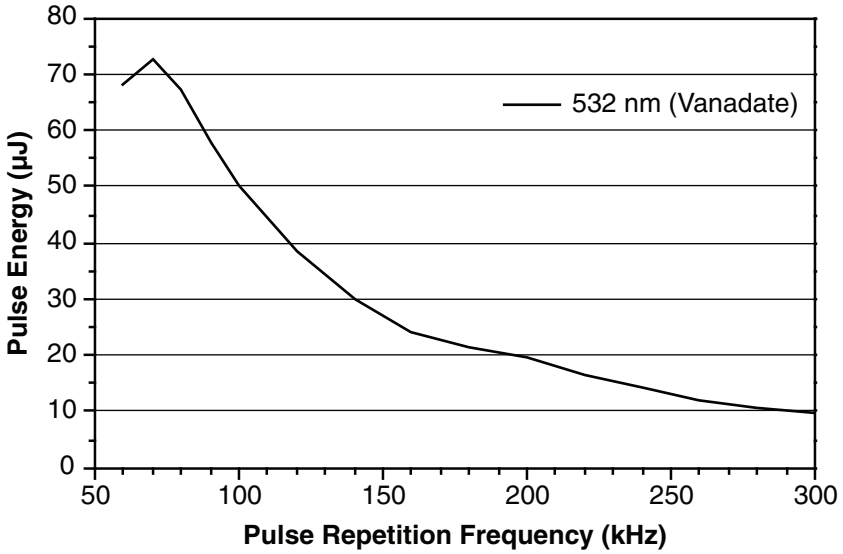


Figure 3-3: Pulse Energy and Pulse Repetition Frequency

At a given diode laser pump current, the individual pulse energy itself will decrease as the repetition rate is increased as shown in Figure 3-3. The lower the diode laser pump current (i.e., the lower the average output power), the less pronounced this effect will be.

Pulse width broadens when the pulse repetition rate is increased (Figure 3-4). The pulse-to-pulse stability stays quite constant over the whole repetition frequency range (Figure 3-5).

Pulse duration is commonly measured at full width, half maximum, or FWHM (see Figure 3-4).

For information on the other *Explorer XP* models, refer to the "Explorer XP Model Description" document.

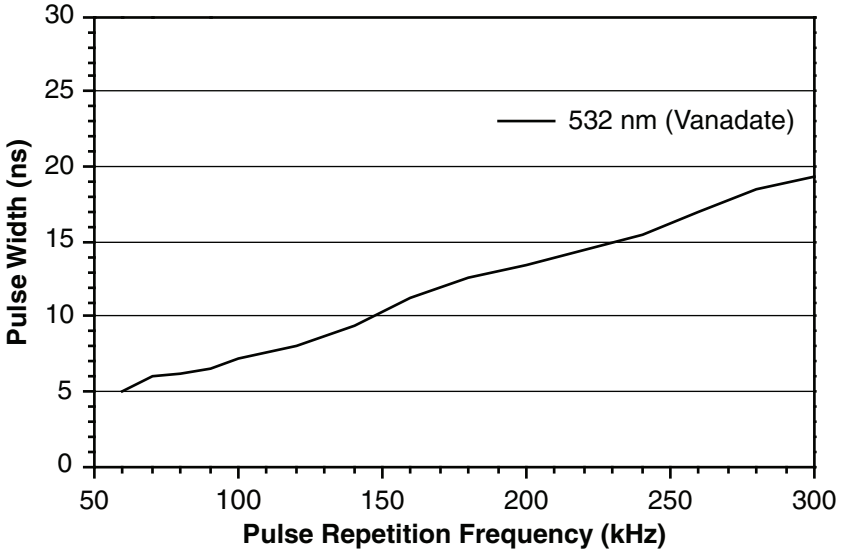


Figure 3-4: Pulse Width vs. Pulse Repetition Frequency

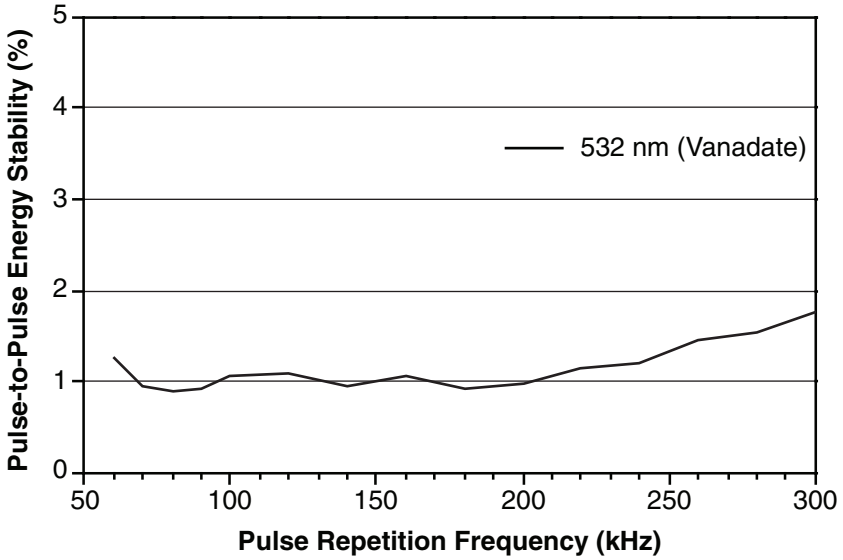


Figure 3-5: Pulse-to-Pulse Stability vs. Pulse Repetition Frequency

Control Features

OptoSync Output

The OptoSync output provides a TTL level signal that is in high coincidence with the production of individual pulses. The OptoSync trigger is provided on Pin 14 of the ANALOG I/O connector.

OptoSync triggering *follows* the laser pulse by about 30 to 100 ns. This delay is almost independent from pulse energy and pulse width, but can vary from system to system. For some applications, this OptoSync delay is unimportant. Other applications may lend themselves to data collection techniques that compensate for this delay.

Refer to “OptoSync” on page 7-22 for more details regarding the use of these trigger outputs.

Burst Mode

Burst mode allows the user to select a desired number of laser pulses to be grouped together as a single packet. The number of pulses allowed in a burst is between 1 and 4095. Burst sequences can be controlled via software commands or TTL signals. The *Explorer XP* system also produces feedback signals for monitoring the status of individual burst sequences. Figure 3-6 shows an example of Burst mode timing.

Refer to “Advanced Control of the Pulsed Output” on page 6-14 and “Control of Pulsed Output” on page 7-12 for examples of how Burst mode can be implemented.

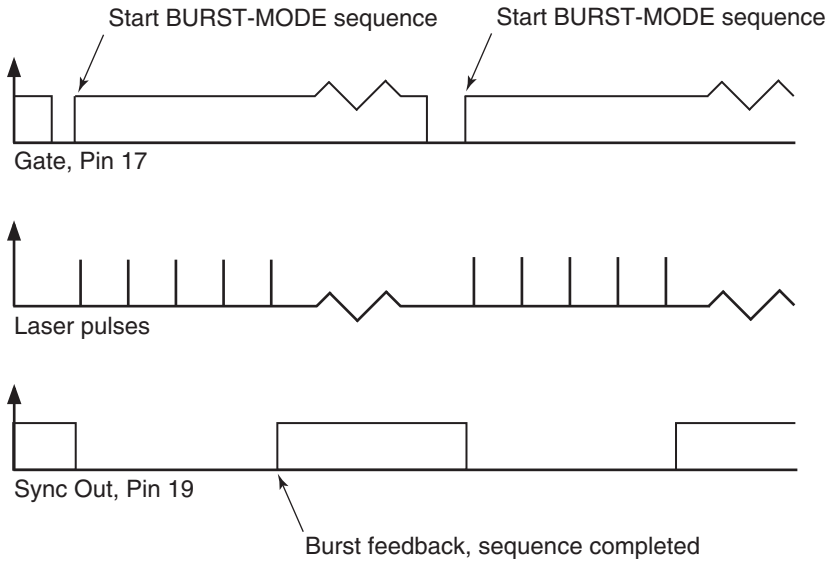


Figure 3-6: Burst Mode Timing Example

First Pulse Suppression

Users who operate high pulse repetition rate lasers (greater than 20 kHz) often have a problem when the first pulse is much greater than the rest. This first pulse anomaly can be avoided by using the *Explorer XP's* First Pulse Suppression (FPS) feature. FPS allows the user to adjust the first pulse in a train so that it has approximately the same energy as the rest of the pulses. FPS reduces the pump energy for the first pulse by reducing the time allowed for light to circulate within the laser resonator before the first pulse is emitted, thereby reducing the disproportionately large amount of energy initially absorbed by the laser crystal.

FPS implementation requires the monitoring and measurement of the energy of individual pulses. This capability is built into the *Explorer XP* laser system.

Refer to "Advanced Control of the Pulsed Output" on page 6-14 and "Control of Pulsed Output" on page 7-12 for examples of how FPS can be implemented.

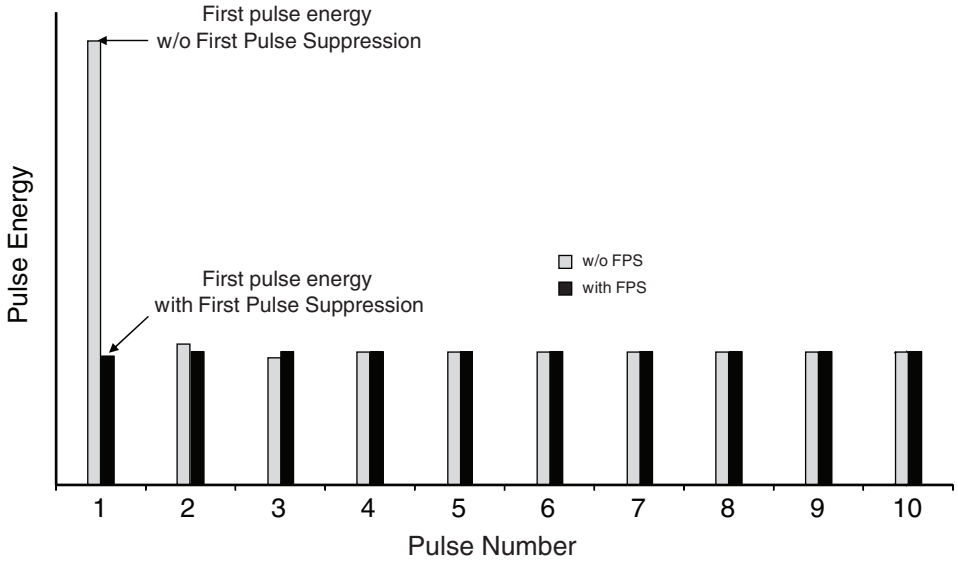


Figure 3-7: The First Pulse Effect at High Repetition Rates

Specifications for the EXPL-532-5W Laser

Environmental specifications for operating and non-operating conditions are listed in “Environmental Specifications” on page -v.

For the specification of the other *Explorer XP* models, refer to the “Explorer XP Model Description” document.

Table 3-1: *Explorer XP* Performance Specifications[1]

Model Part Number	EXPL-532-5W
General Characteristics	
Wavelength	532 nm
Gain Medium	$Nd:YVO_4$
Output power	> 5 W[2]
Pulse width (FWHM)	< 8 ns[3]
Pulse Repetition rate	60–300 kHz
Leakage power @ 1064 nm	< 1 mW
Beam Characteristics	
Spatial mode	TEM_{00}
Beam Quality	M^2 < 1.2
Polarization Ratio	> 100:1 (horizontal)
Beam Waist Diameter[4]	0.19 mm ±15%
Waist Location	(–64.5 ±10) mm
Beam Divergence[5]	<4.5 mrad
Beam Ellipticity[3]	< 1.1
Astigmatism	< 0.2
Stability	
Pulse energy stability	< 3%
Long-term power stability (rms)	< ±2%/2 hr (±1°C)
Warm-up time[6]	< 10 min
Static Alignment Tolerance	
Beam Position	< ± 0.25 mm
Beam Angle	< ± 1 mrad

[1] *Due to our continuous product improvement program, specifications may change without notice.*
[2] *Measured at 80 kHz.*
[3] *Measured at 80 kHz and nominal average power.*
[4] *Specified at the beam waist with beam diameter at 1/e2 points.*
[5] *Diameter at 1/e2, full angle*
[6] *Cold start to > 95% of full power.*

Table 3-2: Electrical and Cooling Specifications

Operating voltage	24 Vdc ±2 V
Power consumption typical maximum	 < 90 W @ 22°C < 160 W
Maximum inrush current	< 9 A
Cooling	Air- and conduction-cooled Optionally water-cooled
Laser thermal heat dissipation	< 160 W
Operating temperature (< 80% relative humidity)	18 to 35°C
Storage temperature (< 90% relative humidity, dew point <20°C)	– 20 to + 60°C

Table 3-3: Dimensions and Weight

***Explorer XP* Laser System**	
Size (L x W x H)	240 x 95 x 94 mm (9.45 x 3.74 x 3.70 in.)
Weight (typical)	3 kg (6.6 lb)

Outline Drawings

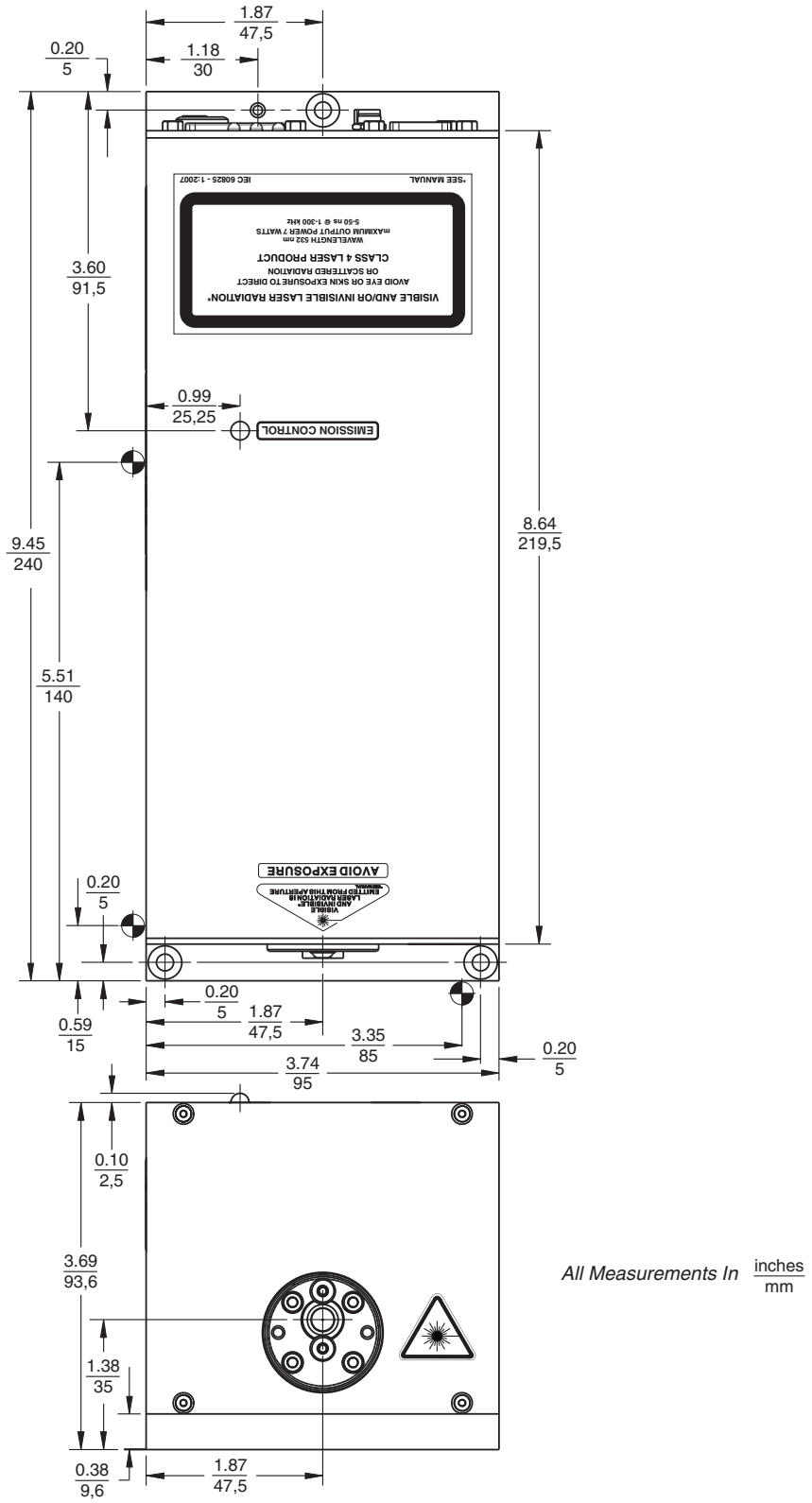


Figure 3-8: Outline Drawing, *Explorer XP* Laser, Top and Front View

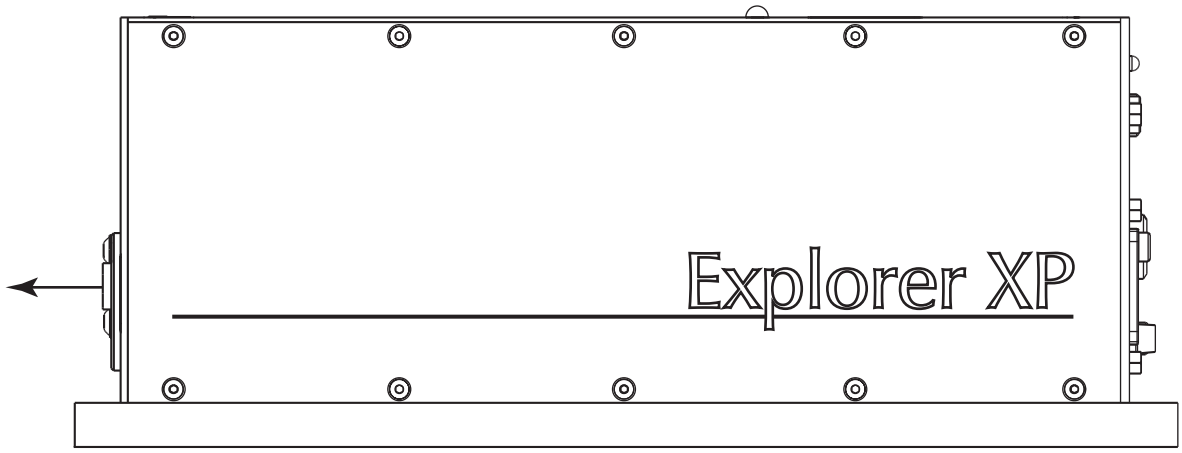


Figure 3-9: Outline Drawing, *Explorer XP* Laser, Side View

The mechanical dimensions and tolerances are identical for all *Explorer XP* models. Only the beam height specification is different for some models. For detailed information, refer to the "Explorer XP Model Description" document.

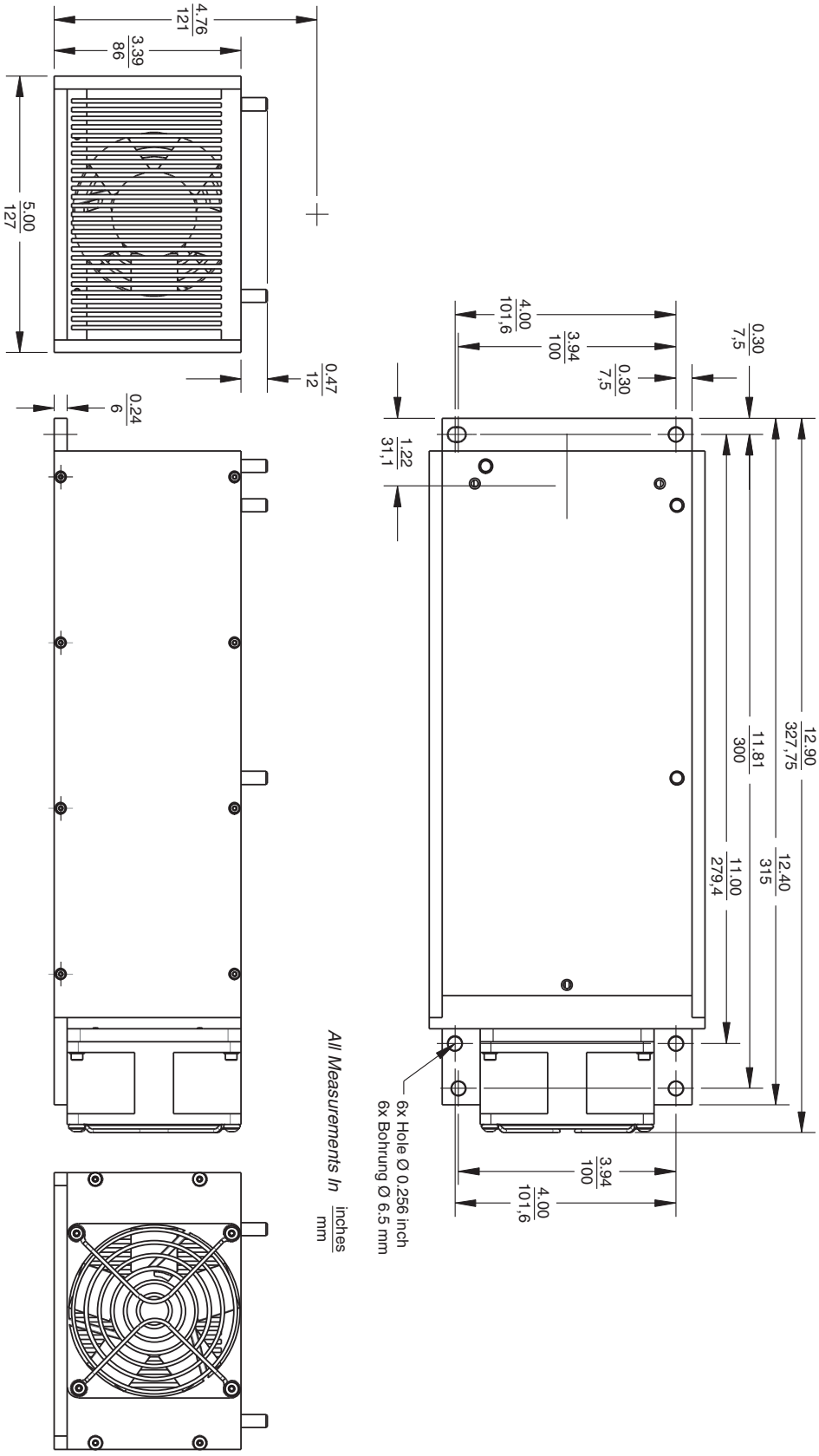


Figure 3-10: Outline Drawing, Optional Heatsink Assembly *EXPL-XP-HTSNK-A*

Interlock Block Diagram

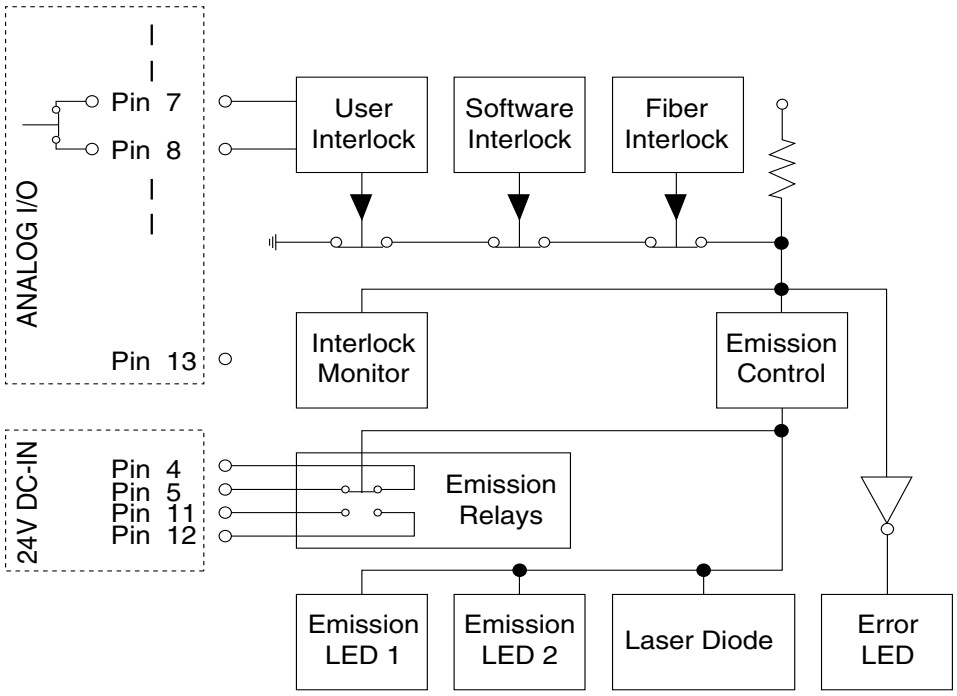


Figure 3-11: Interlock Safety Block Diagram

Chapter 4 Controls, Indicators and Connections

This section describes the user controls, indicators and connections of the *Explorer XP* laser system. Connector types are also listed. For a functional description of the ANALOG I/O connector, refer to Table 7-2.

To control the system via the RS-232 connection using either the *L-Win* control software provided with the laser or the serial commands described in Chapter 7, refer to the operating procedures described in Chapter 6. Likewise, to control the system via the ANALOG I/O connection, refer to these same chapters. The system can also be controlled by using serial commands together with analog commands.

The Explorer XP Laser System

Figure 4-2 shows the rear panel of the laser, which contains all the controls, indicators and connections for this system except the main Emission indicator, which is located on top of the laser.

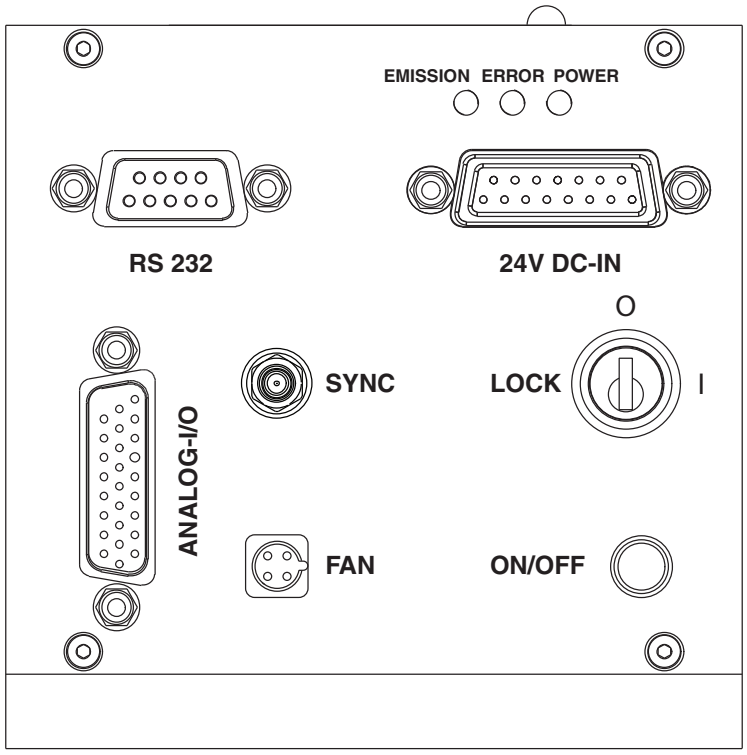


Figure 4-1: *Explorer XP* Laser Rear Panel

Controls

Caution

Note that there is no shutter on the *Explorer XP* laser head. The laser head is designed for integration into a master OEM system that possesses the required safety features.

Power ON/OFF button—provides power to the laser system when pressed.

When this button is pressed, the system is powered on and the red ERROR LED turns on and remains on during the laser boot and warm-up sequence, which takes a few minutes from a cold start.

While the ERROR LED is on, the *Explorer XP* cannot produce laser light. This safety feature prevents possible damage to the internal optical components that might result if intense intracavity laser light is produced before the laser components have achieved proper operating temperature. Once the ERROR LED turns off, the laser can be turned on.

To switch the system off, the ON/OFF button has to be pressed again for about 1 second (soft-off). If the button is pressed for about 3 seconds, the system is switched off by shutting down the supply voltage (hard-off). In the latter case, the system status information will not be stored by the system.

As an alternative, the system can be switched on and off by providing a TTL-level signal on Pin 12 of the ANALOG I/O port (see Table 7-2 on page 7-16 and descriptions starting on page 7-19).

LOCK I/O keyswitch—enables the system to provide power to the diode laser in the laser head when it is set to the "I" position. For safety, when the system is not installed in the master OEM system and/or is not in use, turn the keyswitch to "O" and remove the key to prevent unauthorized use of the laser.

The function of this switch depends upon the software mode setting. Placing this switch in the ON position allows the laser to be turned on via serial commands or analog signals. When the laser is installed in its final configuration, leave this switch in the ON position in order to control the laser remotely.

Indicators

Emission indicator (white lamp on top of the laser)—turns on to indicate that laser emission is present or imminent (Figure 4-2). This happens right after the keyswitch is turned to the "I" position and an appropriate serial *On* command or analog signal is provided indicating that laser emission may be present. The indicator remains on during laser emission and turns off immediately when current to the diode laser is terminated.

POWER indicator (yellow)—turns on when the power switch is turned on, indicating that power is being supplied to the laser head.

EMISSION indicator (blue)—turns on to indicate that laser emission is present or imminent. This happens right after the keyswitch is turned to the

"I" position and an appropriate serial *On* command or analog signal is provided. The indicator remains on during laser emission and turns off immediately when current to the diode laser is terminated.

ERROR indicator (red)—turns on when the software has detected an error condition. It is normal for this indicator to turn on when the power switch is turned on and it will remain on for about 5 minutes during the warm-up sequence from a cold start condition (usually < 1 minute at normal temperatures).

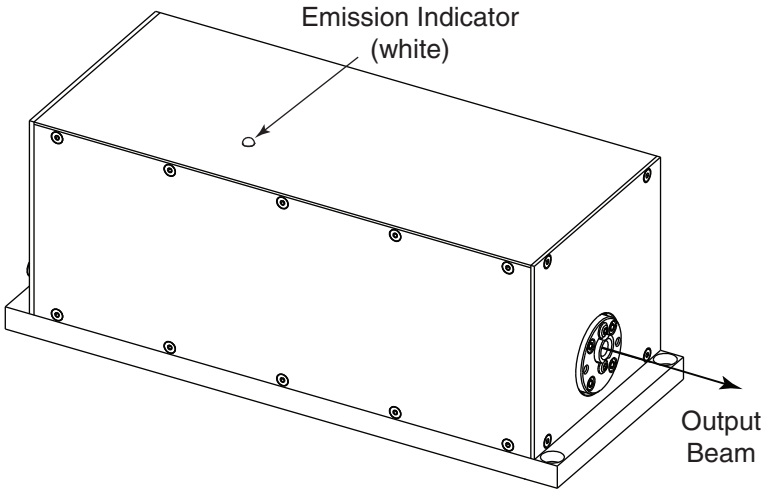


Figure 4-2: *Explorer XP* Laser Emission Indicator

Connections

RS-232 input connector (9-pin, D-sub, female)—provides attachment for a serial cable from a control device, such as a personal computer. Refer to Table 4-1 below for a complete description of these pins, and to "Serial Communication" on page 7-2 for instructions on how to control the laser using this connector.

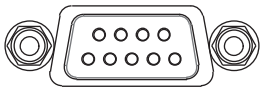


Figure 4-3: The 9-Pin RS-232 Port Connector

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

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

24V DC IN power connector (15-pin, high-current connector, male – Figure 4-4)—provides attachment for the cable from a 24 ±2 Vdc, 7 A electrical source. The power supply should have a current ripple < 100 mV rms. Table 4-2 below describes the pins of this interface. The female mating connector is TYCO/AMP 4-1393483-8 (RoHS-compliant).

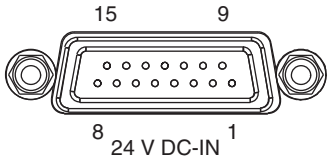


Figure 4-4: 24V DC IN Power Connector

Table 4-2: 24V DC IN Power Connector Pinout

Pin	Signal
1, 2, 3, 9, 10	+24 Vdc
6, 7, 8, 14, 15	Return
4	Emission relay (max 48 Vdc, 1 A)
5	Emission relay return
11	Emission relay (max 48 Vdc, 1 A)
12	Emission relay return

Pins 4 and 5 are connected to a normally open relay that can be used to control an external emission indicator. Pins 11 and 12 are connected to a normally closed relay that can be used to control an external emission indicator. The internal relay switch closes approximately 3 seconds before laser emission occurs and remains closed while laser emission is present.

ANALOG I/O connector (26-pin, D-sub, HD, male)—provides attachment for a control cable to an analog control device.

The female mating connector is TYCO/AMP 1658682-1 (housing, RoHS-compliant), using pins TYCO/AMP 1658686-1 (crimp socket, RoHS-compliant).

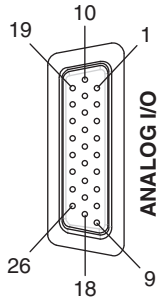


Figure 4-5: ANALOG I/O Connector

Note

In order for the laser to turn on, pins 7 and 8 of this connector must be shorted together, either directly or through a user-supplied, normally-closed interlock switch.

Among its many functions, this connector can be used to provide an interlock to turn off laser emission in the event that a safety switch is opened unexpectedly. This connector also provides a status output that can be used to drive an emission indicator. Refer to Table 7-2 on page 7-16 for a complete description of these pins, and to "The Analog I/O Interface" on page 7-14 for instructions on how to use this connector to control advanced features of the *Explorer XP* laser.

SYNC connector (1-pin SMB)—provides connection to a clock source for synchronizing multiple *Explorer XP* lasers.

FAN connector (4-pin Binder P/N 09-9767-70-04)—provides variable DC power for an auxiliary cooling fan. (Request the Application Notes for details.) The fan voltage and, therefore, fan speed are dependant on the thermal load generated by the *Explorer XP* laser. This connector provides up to 1100 mA at 13 Vdc. If the optional Spectra-Physics *EXPL-XP-HTSNK-A* heatsink is used, connect that unit to this connector.

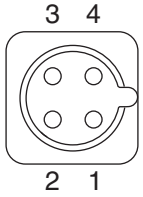


Figure 4-6: The Fan Pinout

Table 4-3: FAN Connector Pinout

Pin	Signal
1	+
2	+
3	–
4	–

Optional Laser Head Heatsink

Spectra-Physics can provide an optional *EXPL-XP-HTSNK-A* heatsink that includes a fan. This heatsink meets the heat dissipation requirement of the *Explorer XP* laser head. The heatsink is pre-drilled and tapped to make mounting the laser head easy, and the control cable plugs directly into the FAN connector on the back of the laser head. Figure 3-10 on page 3-13 is an outline drawing that shows the dimensions and mounting hole positions for this unit.

Chapter 5 Installation

Thermal Management

Proper heat conduction is essential to allowing the *Explorer XP* laser to perform according to specifications. Determine the heat removal capacity of your heatsink mounting before installing the laser head.

At a normal operating temperature of 25°C, the laser head produces about 80 W of waste heat. At the maximum specified operating temperature of 35°C, the heat load that must be removed is about 160 W, worst case. The laser head should be mounted on a heatsink capable of maintaining its baseplate temperature below 45°C but greater than 18°C.

Cooler ambient temperatures makes it easier to dissipate waste heat through the baseplate. Refer to Figure 5-1 for the thermal impedance required for the heatsink. The heatsink surface must be flat to 0.050 mm or better if no heat-conducting material is used (such as the included silicone thermal pad).

Warning

Never use thermal grease when mounting the laser head on the heatsink. Doing so will contaminate the laser package and the output window.

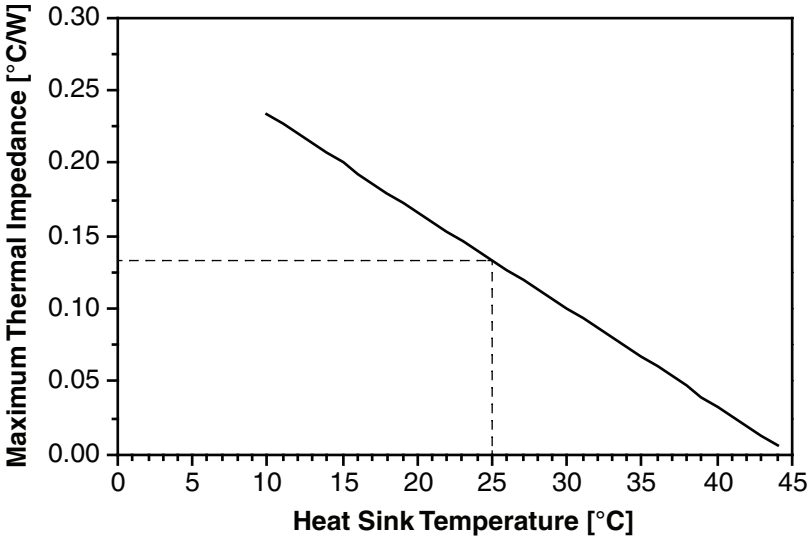


Figure 5-1: Laser Head Heatsink Thermal Impedance Requirement

Spectra-Physics offers an optional heatsink with an auxiliary fan (P/N *EXPL-XP-HTSNK-A*, Figure 5-2) that can be attached to the laser head. Refer to the fan connector description under "Connections" on page 4-3 for details. A temperature sensor located inside the laser head continuously measures base plate temperature and provides feedback for controlling fan speed.

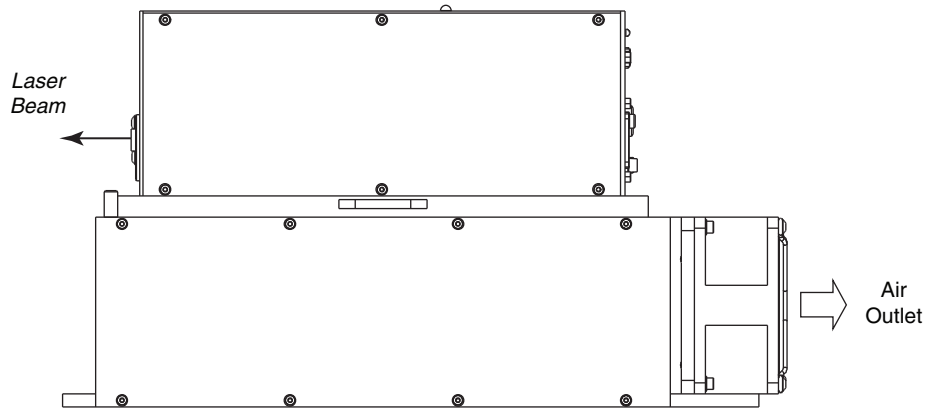


Figure 5-2: Air Flow through the Heatsink

When active, the servo loop maintains a constant laser head temperature at a value set using serial commands. The default laser head temperature is 35°C. The lower the environmental temperature, the lower the fan speed will be. A temperature setting below ambient will result in the fan operating at a constant, maximum speed.

As soon as the head temperature exceeds 40°C (typical), Error Code 39 "Warning Overtemp Laser Head" is issued, but the laser will continue to operate normally. However, exceeding 45°C will cause an emergency shutoff, whereby the laser immediately goes into Sleep mode. Sleep mode can be exited by restarting the laser after the laser head temperature has dropped below 40°C (typical) again. Refer to "System Temperature Management" on page 7-11 for information on setting other temperature limits.

Alternatively, the thermal servo loop can be deactivated via serial command and the fan speed set by the user. This allows the heatsink to be controlled by the operator.

Mounting the Hardware

Following standard practice, mount the laser head on a suitable heatsink such as the Spectra-Physics *EXPL-XP-HTSNK-A* (refer to the preceding section).

Warning

Never use thermal grease when mounting the laser head on the heatsink. This will contaminate the laser package and the output window.

Use three 8-32 (SAE) or M4 (metric) bolts and washers to mount the laser head. Tighten the bolts and torque them to 1 N·m (9 in-lb). Refer to the

"Outline Drawings" on page 3-11 for dimensions and hole locations.

Connecting the System

Connect the *Explorer XP* laser system to the host system using the Interconnect Drawing in Figure 5-3 as a reference.

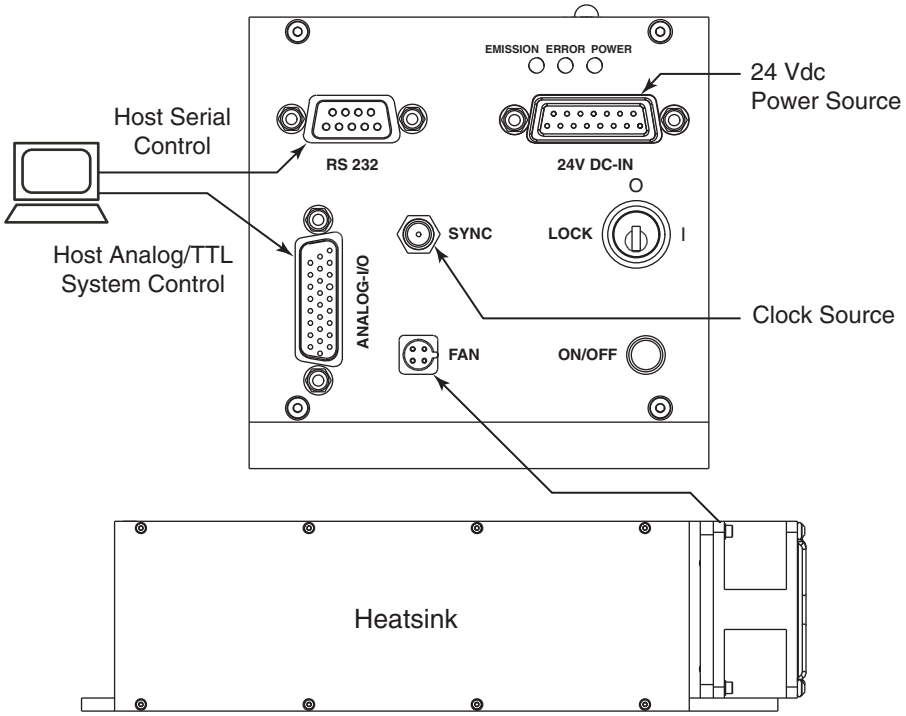


Figure 5-3: System Interconnect Drawing

Note

Note that pins 7 and 8 of the ANALOG I/O connector must be shorted together in order for the laser to operate. A shorting jumper plug is provided for this purpose in case the ANALOG I/O connector is not used. These pins can used in a circuit to shut the laser off if a normally closed emergency switch is opened unexpectedly. The interlock is operated with a 3.5 V signal voltage and cannot be used to drive external devices.

Note also that pin 9 of this connector can be used to control an emission indicator. Figure 7-5 on page 7-20 provides an example circuit.

1. Attach a 2-wire or 4-wire cord (suitable for 7 A) between the 24V DC IN connector and a 24 Vdc, ± 2 V power source. Be sure the off-load voltage does not exceed 30 V.

   We recommended using all +24 Vdc pins and all return pins in order to lighten the current load on any one pin. Refer to Figure 4-4 on page 4-4 and Table 4-2 on page 4-4 for pin descriptions.

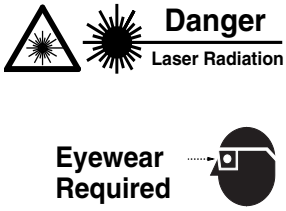
   Pins 4 and 5 of the 24V DC IN connector form a normally open relay that can be used to turn on an emission indicator (the relay closes) when the laser is on. This relay is rated for a maximum 48 Vdc at 1 A.

2. Attach a standard 9-pin M/F serial cable between the RS-232 connector and the serial port on your computer. Do NOT use a null modem cable! Note the computer port number. Refer to Table 4-1 on page 4-3 for a functional description of this connector.
3. If analog signals are to be used to control the laser, attach an analog control cable (not provided) between the analog port of your host controller and the ANALOG I/O connector. Refer to Table 7-2 on page 7-16 for a functional description of each pin.
4. If the optional Spectra-Physics *EXPL-XP-HTSNK-A* heatsink is installed, attach its power cable to the FAN connector on the laser head. If a user-supplied heatsink is used, refer to Figure 4-6 and Table 4-3 on page 4-5 for connector pinout descriptions.

Laser Alignment

No alignment is necessary for the *Explorer XP* laser; there are no controls to adjust nor optics to align. This completes the installation of the laser. Continue with the installation of the *L-Win* software.

Initial Turn On/Turn Off Using the L-Win Software



Spectra-Physics *Explorer XP* lasers are *Class IV—High-Power Lasers* whose beams are, by definition, safety and fire hazards. Take precautions to prevent accidental exposure to both direct and reflected beams. Diffuse as well as specular beam reflections can cause severe eye or skin damage. Residual light at 1064 nm and 808 nm wavelengths might also be present.

When operated as a stand-alone system (for example, as a test before it is installed in a master system), the *Explorer XP* laser can be conveniently controlled using the *L-Win* software provided.

Chapter 6 provides instructions for operating the *Explorer XP* laser using the *L-Win* software, including instructions for monitoring performance, changing the output power and controlling the pulsed output. Appendix A contains a complete description of each of the *L-Win* GUI displays.

Installing the L-Win Software

The *L-Win* software is provided on a CD-ROM shipped in the accessory kit with the system. If an earlier version of the *L-Win* software is installed on the computer, it should be upgraded to the version shipped with the laser system (or to a newer version if software upgrades are provided by Spectra-Physics). Earlier versions may not be compatible with this laser system, or they may not provide full functionality.

1. Insert the CD into the computer to be used to control the system. Use Windows Explorer or My Computer to find the CD drive, then double-click the file “setup.exe” to start the installation.

2. Follow the on-screen instructions to complete the software installation. This procedure installs the *L-Win* software and the *LabView*[1] runtime libraries onto the computer hard drive.

After installation, a new program group will be seen in your Windows Start menu as "Spectra-Physics Laser Control -> L-Win." This manual as well as corrections and addenda will also be copied to your computer and will be accessible via the Windows Start menu.

This completes the installation of the *L-Win* software. The next section describes how to set up communications between the computer and the laser system, how to start the laser for the first time and how to verify that it is operating properly.

Setting Up Initial L-Win Communications

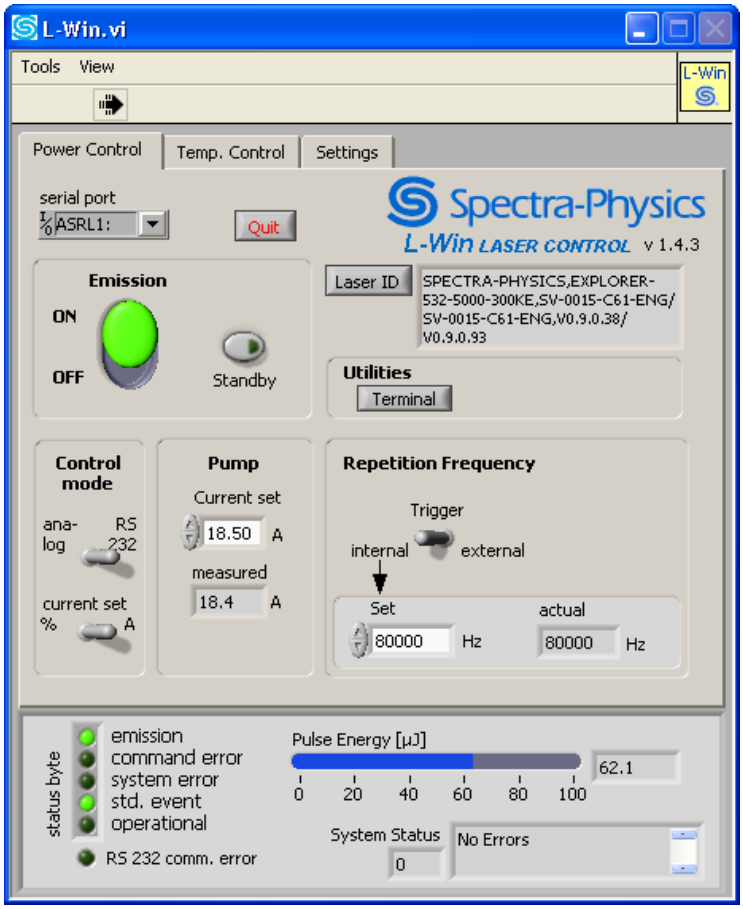


Figure 5-4: The *L-Win* Main Menu and Power Control Tab

1. Turn on power to the laser via the ON/OFF button on the laser head; the POWER indicator will illuminate.
2. Start the *L-Win* control software from your Windows Start menu.

   The software will automatically search for the COM port to which the laser is connected. (Alternatively, you can select the port manually. To

[1] *LabView is a trademark of National Instruments, Inc.*

do this, refer to Appendix A for "port selection" under the Tools menu, which itself is under the Settings tab. See Figure 5-4.) When the laser is found, the Main menu will be displayed.

3. Turn the LOCK keyswitch to I (on).

   The laser will power up at pre-stored factory settings.

4. Wait for the system to finish its initialization and warm-up sequence, which typically takes a few minutes. During this time, the red ERROR indicator remains on. When it turns off, the laser is ready to operate.

5. From the Power Control tab on the *L-Win* Main menu, set Control Mode to "RS 232" and Current to "A" (for "Amps"). Set the Repetition Rate: Trigger toggle switch to "Internal."

6. Verify that the laser beam is properly terminated (e.g., it is pointed into a beam block or power meter), then click on the Emission button to turn on the laser.

   The blue and white EMISSION indicators on the laser head will turn on, indicating that the laser is capable of producing laser light.

7. Following a 3-second safety delay, laser emission will begin. Allow the laser to warm up and achieve stable output (approximately 10 minutes).

8. The *Explorer XP* system comes with a data sheet that details the performance of the laser before it left the factory. Adjust the current and repetition rate to match the listed settings and verify that the laser performs at or close to the listed values. Use a calibrated detector certified for use at the specified wavelength and pulsed output in the 100 kHz range to measure output power.

9. From the *L-Win* Power Control display, click on the Emission button to turn off the laser.

10. Turn the keyswitch to O (off) and press the ON/OFF power switch to turn off power to the laser. Remove the key.

11. Exit the *L-Win* program and turn off the computer.

This completes the installation of the *L-Win* software and the initial test of the laser to verify proper operation. When ready to operate the laser using the *L-Win* GUI, refer to Chapter 6. Otherwise, refer to Chapter 7 for instructions on how to operate the system using commands and signals from a host system.

Chapter 6 Operating Using the L-Win Software

Spectra-Physics *Explorer XP* lasers are *Class IV—High-Power Lasers* whose beams are, by definition, safety and fire hazards. Take precautions to prevent accidental exposure to both direct and reflected beams. Diffuse as well as specular beam reflections can cause severe eye or skin damage. Residual light at 1064 nm and 808 nm wavelengths might also be present.

L-Win is a *LabView*[1]-based graphical user interface (GUI) that provides a simple and direct method of controlling the *Explorer XP* laser as a stand-alone system from a personal computer. For example, it can be used when installing or servicing the laser system.

This chapter provides instructions for using *L-Win* to control the most commonly used features of the laser. For a complete description of each of the *L-Win* menus, refer to Appendix A, "L-Win GUI Reference."

For instructions on operating the *Explorer XP* system using serial commands and/or analog signals, refer to Chapter 7, "Operating with Commands and Signals." The same functions are provided as those in *L-Win*.

Note

The procedures in this chapter assume that the *Explorer XP* laser has been installed according to the instructions in Chapter 5 and that:

- the laser has been installed with proper attention to heat removal,
- the laser and computer have been properly connected and that 24 Vdc power is being supplied to the laser,
- the interlock relay and emission circuits, if installed, have been properly wired, or the interlock jumper plug has been correctly attached to the ANALOG I/O port,
- the *L-Win* software has been installed and appears to be functioning,
- power is turned on, the keyswitch is on and the laser has warmed to operating temperature.

If you are uncertain about the status of the laser, return to Chapter 5 and verify that it has been installed correctly and that *L-Win* is operating properly.

[1] *LabView is a trademark of National Instruments, Inc.*

Basic Operating Control

Note

If the Control Mode toggle switch on the Main/Power Control menu is set to Analog (for external control), the Emission control switch on this menu is disabled. Keep the toggle switch set to RS-232 to operate the laser using the *L-Win* controls.

Turning the Laser On

1. Turn on power to the laser via the ON/OFF button on the laser head; the POWER indicator will illuminate.
2. Start the *L-Win* control software from your Windows Start menu.

   The software will automatically search for the COM port to which the laser is connected. When the laser is found, the Main menu will be displayed (Figure 6-1).

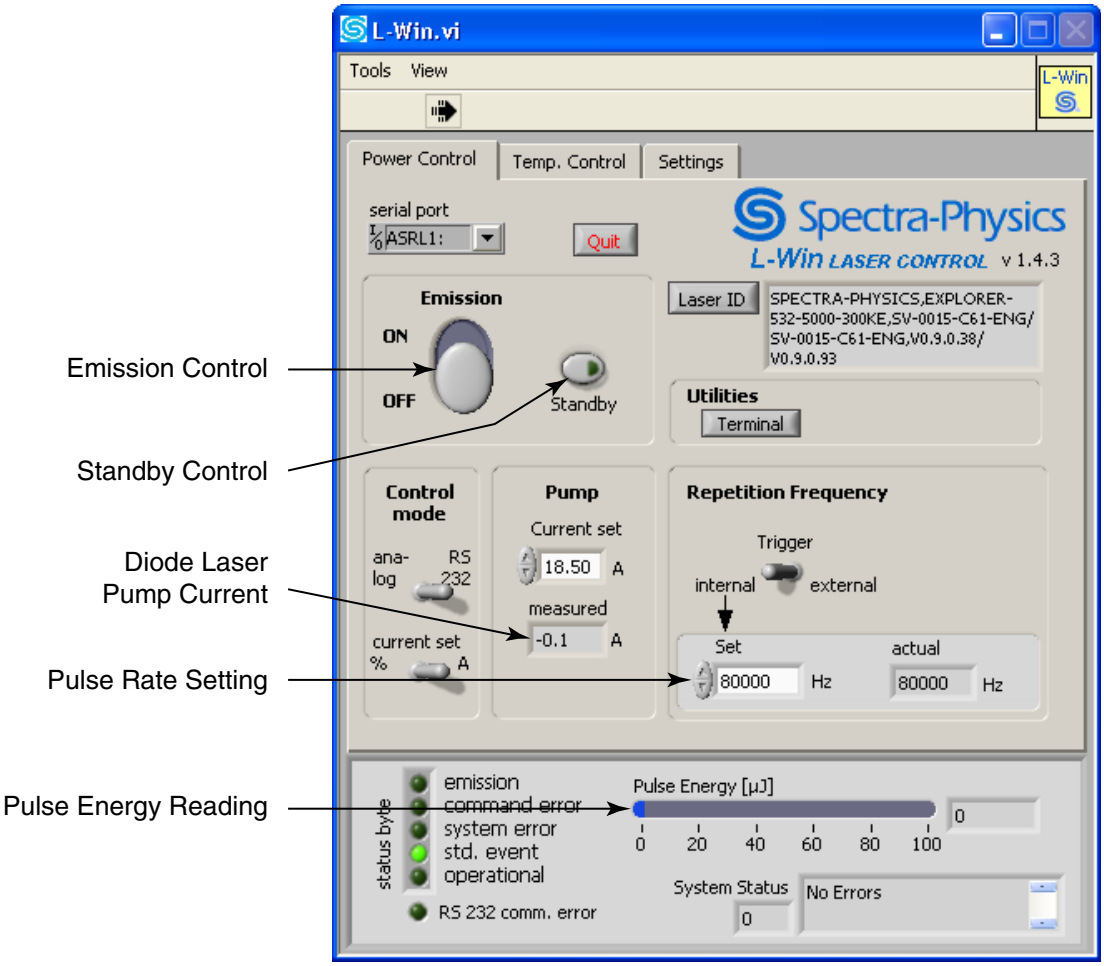


Figure 6-1: The *L-Win* Main Menu

3. Turn the LOCK keyswitch to I (on).

   The laser will either power up at settings set by the user, or if user settings have not be set yet, it will power up at pre-stored factory settings.

   See "Setting the Auto-On Mode" on page 6-7 for a description of how to bypass the keyswitch operation via software.

4. Wait for the system to finish its initialization and warm-up sequence.

   If the laser was turned off using the "Short Term" procedure on page 6-3, the warm-up period with be very short. If the "Long Term" procedure was used, warm-up typically takes a few minutes. While the laser is warming up, the red ERROR indicator remains on. When it turns off, the laser is ready to operate.

5. Verify that the laser beam is properly terminated (e.g., it is pointed at the target or into a beam block or power meter), then click on the Emission button to turn on the laser.

   The EMISSION button will turn green and the blue and white laser head emission indicators will turn on immediately, indicating that the laser is capable of producing laser light., Then, following a 3-second safety delay, a pulsed beam at the displayed pulse repetition rate will be emitted.

6. Allow the laser to warm up and achieve stable output. before using the laser (approximately 10 minutes).

Turning the Laser Off

1. Click on the Emission button to turn the laser off.

   The button will turn gray and the laser will turn off.

If the laser is to be used again in a short while, follow the "short-term" procedure below to leave the crystal ovens on in the laser head (and, thus, reduce the warm-up time). Otherwise, use the "long-term" procedure.

Short-term

2. Leave the keyswitch and power switch in the ON position.

Warning

Since unauthorized personnel may be able to access and operate the laser when the laser is left unattended and the keyswitch is left in the on position or the Auto-On Mode is engaged, it is a violation of CDRH regulations. It may also violate local or state ordinances as well.

3. Exit the *L-Win* program and turn off the computer.

Long-term

1. Click on the Emission button to turn off the laser.

   The button will turn gray and the laser will turn off.

2. Turn off the keyswitch and ON/OFF power switch, and remove the key.
3. Exit the *L-Win* program and turn off the computer.

Adjusting the Pulse Energy and Average Power

To change the pulse energy and, thus, the average power of the laser beam, adjust the diode laser current. The current can be changed by clicking on the up/down arrows to the left of the Current Set field, or a value can be typed directly into the text field. Note that the current can also be varied as a percentage of the maximum pre-set current limit. This is enabled by setting the Current Set toggle switch to "%." The display will then switch from "Amps" to a percentage.

The energy of individual pulses can be read from the pulse monitor on the status panel at the bottom of the Main menu (Figure 6-1). The status panel readings are updated once a second.

Changing the Pulse Repetition Rate

The repetition rate can be varied from 60 to 300 kHz. Please note that there may be a small difference between the set rate and the actual repetition rate (refer to "Changing the Pulse Repetition Frequency" on page 7-4 for more information).

The repetition rate can be set

- by using the *L-Win* program and clicking on the up/down arrows to the left of the Set field of the Repetition Rate section of the menu, or by typing a value directly into the text field.
- via an external trigger. Refer to Appendix A or "External Q-Switch Triggering" on page 7-20 for more information.

Setting the Laser to Standby

Click on the Standby button to set the diode laser to standby current, which is below the threshold for *Explorer XP* lasing. This extends diode laser lifetime when the laser is inactive, but it keeps the laser at operating temperature for immediate use. Clicking this button again will return the system to normal operation. This button turns yellow when Standby mode is active.

Sleep Mode

When the system enters Sleep mode, most commands become inactive. Sleep mode can be activated by using the software command *Mode: Sleep 1*. For safety reasons, this can also happen if one of the temperature controllers fails, for example. The Emission button is deactivated and "Sleep Mode!" is displayed in the Emission control field (see Figure 6-2).

To exit Sleep mode, use the command *Mode:Sleep 0* or turn the laser off then on if the unit was put into Sleep mode by the system itself.

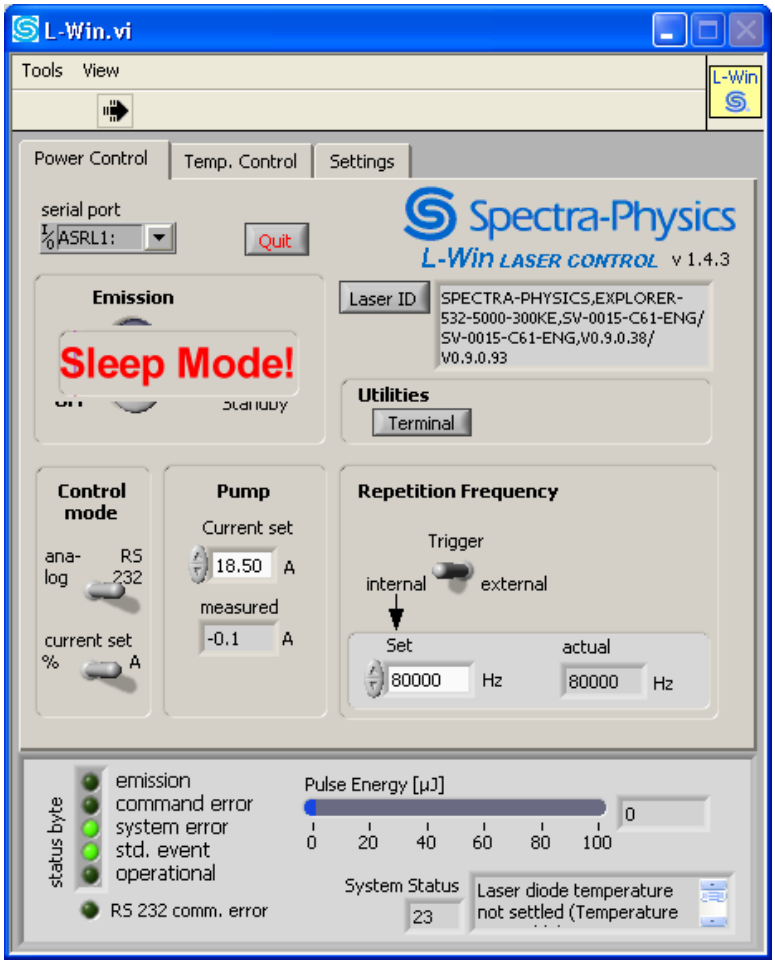


Figure 6-2: Sleep Mode

Saving and Using Pre-Set Operating Parameters

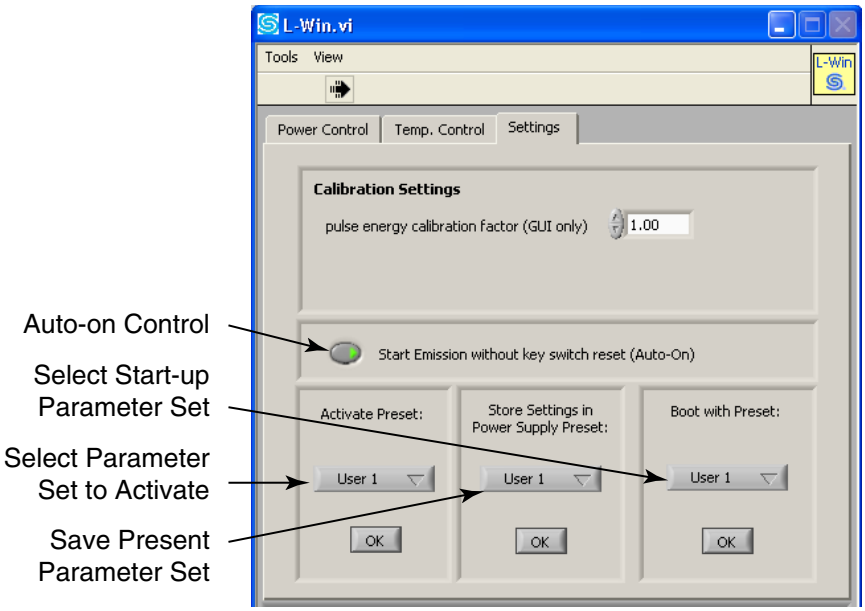


Figure 6-3: Settings Tab—Selecting Operating Parameters

Click on the Settings tab in the Main menu to see the Settings menu (Figure 6-3). Use this menu to enable laser operation using a stored set of parameters: either one of four sets that was previously saved by the user or the one that was pre-set at the factory. To save the current operating parameters, select User 1 through User 4 in the Store Preset section of the menu, then click on OK to save.

Note

The *Explorer XP* system provides 1 set of fixed factory-defined operating parameters and allows the user to save 10 sets user-defined operating parameters. All 11 sets are available via the *Config:Parset:Load n* command where $n = 0$ contains the factory preset parameters and $n = 1$ through 10 are for user-saved parameter sets. The *L-Win* interface allows access to the factory-defined set and four user-defined sets via the Activate Preset panel on the Setup tab.

To use a previously saved set of operating parameters, select User 1 through User 4 or Factory in the Activate Preset section of the menu. Click on OK to operate the laser using the selected set of parameters.

Select a parameter set from the Boot with Preset section and click on OK to designate the parameter set to be activated the next time the system is booted. Save these settings to make this change permanent.

Setting the Auto-On Mode

The Settings menu may also be used to activate the Auto-On feature. Auto-On mode overrides the need to turn the keyswitch off and on. Click on the button labeled Start Emission without key switch reset to enable Auto-On.

Warning

Over-riding the keyswitch does ***NOT*** comply with CDRH regulations!

Monitoring and Adjusting Performance

The performance of the laser can be monitored from the Energy Statistics menu, and the performance can be optimized concurrently on the Main menu. Access the Energy Statistics menu from Tools on the menu bar by selecting Pulse Noise Measurement from the drop-down menu (see Figure 6-4 and Figure 6-5).

The Energy Statistics menu monitors performance in terms of pulse-to-pulse stability by displaying the pulse energy distribution in a histogram as well as other statistical graphical representations. Concurrently, laser performance can be adjusted using the Main menu to change parameters such as diode laser current and pulse repetition rate.

Online Histogram activates/deactivates the data collection, calculation and histogram display. While this function is active, the indicator is on and the displays are automatically updated.

Histo. Intervals sets the resolution of the histogram display in number of intervals to be used.

Statistics calc every x measurements sets the update interval (in number of measurements) for calculating statistics. The number of pulses sampled is shown by the # pulses selection.

The data fields display the max value and min value for the energy values of the sampled pulses, as well as their mean, rms value, and sigma in % values. The Clear button clears all data fields.

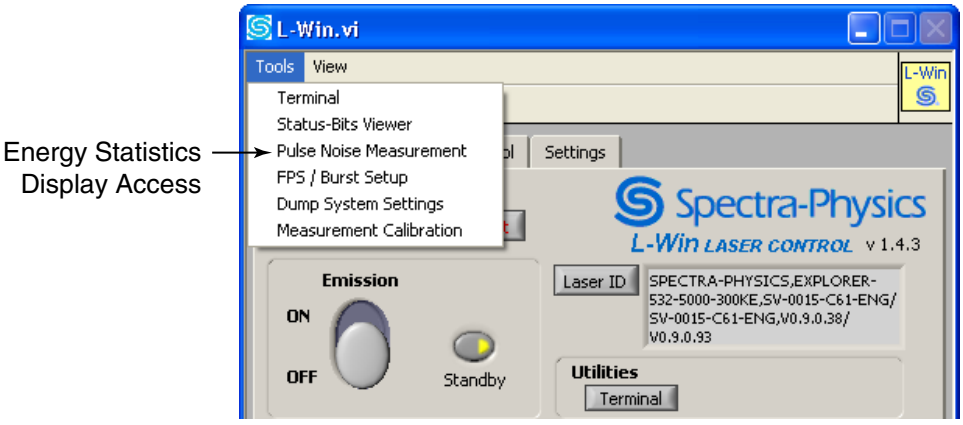


Figure 6-4: Tools Menu—Accessing the Energy Statistics Menu

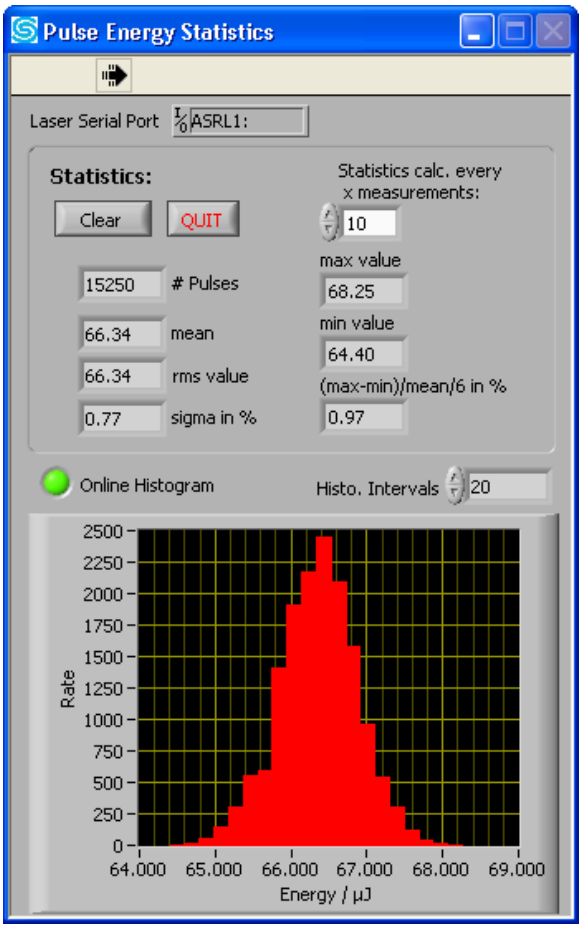


Figure 6-5: Energy Statistics Menu

System Settings

Calibrating the Pulse Energy Monitor Readings or Average Power Monitor Readings

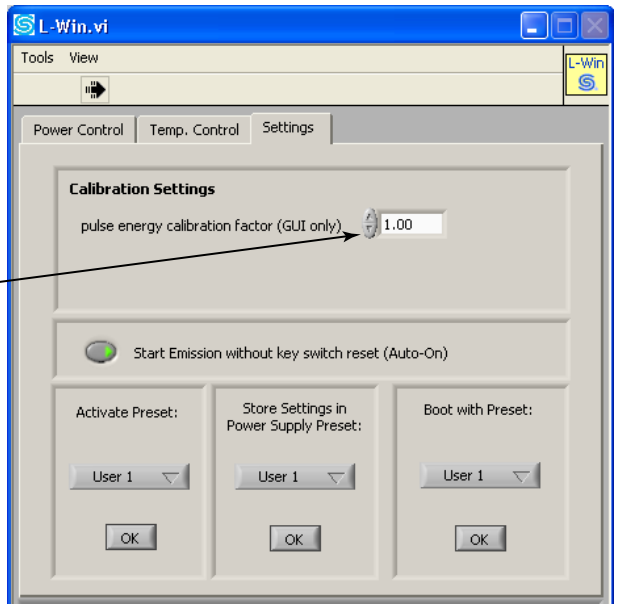


Figure 6-6: Settings Tab/Tools—Pulse Energy Calibration Factor

The Pulse energy calibration factor or Average Power Calibration Factor available under the Settings tab, Tools selection, enables a calibration factor to be set for the internal pulse energy monitor readings. A value of "1" shows the unchanged pulse energy values as reported by the *Explorer XP* laser.

This factor can be changed to correct the displayed values to correspond with an external energy (power) meter. This calibration only adjusts the *L-Win* display readings. It does not calibrate the values reported by the pulse energy monitor itself. To permanently change the internal calibration of the power/pulse energy monitor, see "Energy/Power Measurement Calibration" on page A-12 in Appendix A.

Tracking Operating Hours

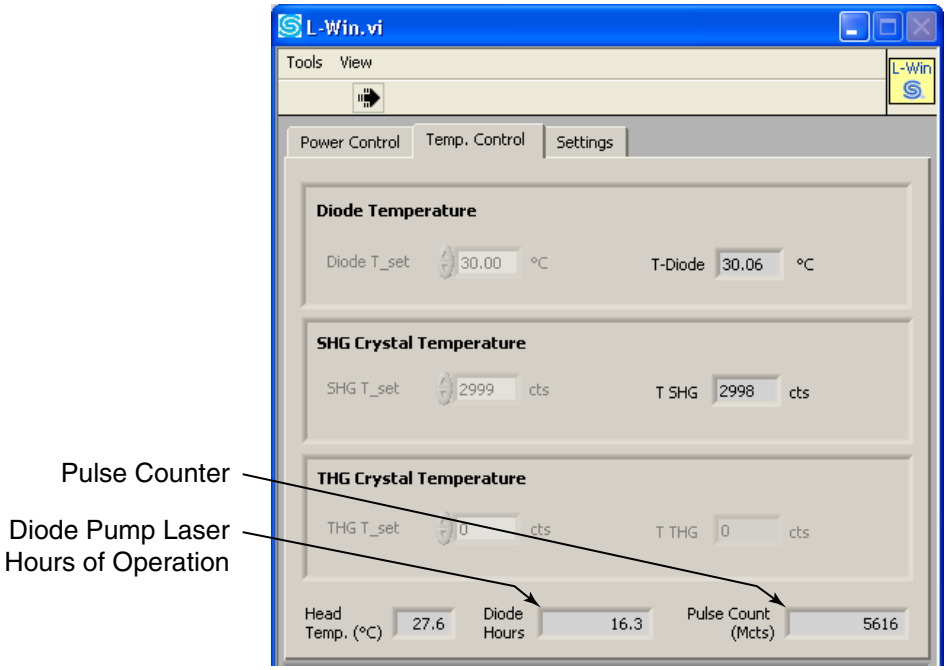


Figure 6-7: Tracking Operating Hours

The Diode Hours field shown on the Temp. Control menu tracks the total number of hours the diode pump laser has been operated. This information is also useful for monitoring the lifetime of the nonlinear crystals in the laser head.

The Pulse Count (Mcts) field displays the total number of pulses (in millions of pulses, or Mcts) that the laser has emitted during its lifetime. The pulse counter is set to "0" prior to shipment.

Selecting Analog Control

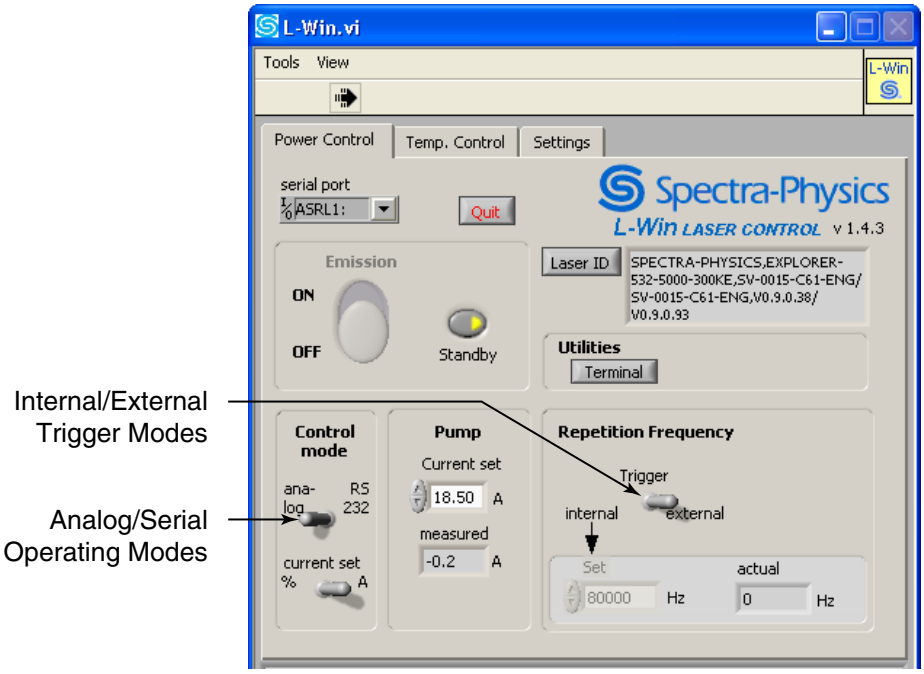


Figure 6-8: Selecting Analog Control or the Q-Switch Trigger Source

Setting the Analog/RS 232 toggle switch to Analog in the Control Mode section under the Power Control tab allows the laser to be controlled via analog voltages applied to the ANALOG I/O connector. While in this mode, the controls for emission on/off are disabled on the *L-Win* menus. Refer to "The Analog I/O Interface" on page 7-14 and "Basic Analog Operation" on page 7-18 in for information about operating the laser using analog signals.

When control mode is set to RS 232, the laser can be controlled via the *L-Win* menus and, likewise, through serial commands. Refer to "Basic Serial Controls" on page 7-3 for information about operating the laser using the RS-232 serial commands. Also refer to Appendix B for a detailed description of the RS-232 commands.

Changing the Q-Switch Trigger Source

To use an external trigger source instead of the *Explorer XP* internal Q-switch trigger, set the Repetition Rate Trigger switch to External. The external trigger signal is input through the ANALOG I/O connector. Refer to "The Analog I/O Interface" on page 7-14 and "Basic Analog Operation" on page 7-18 for information about operating the laser using analog signals.

Component Temperature Adjustment

To function properly, the diode pump laser and the harmonic crystals in the laser head depend strongly on operating at their correct temperatures. The temperatures of these components are controlled and stabilized using closed-loop monitor/driver circuits. The Temp. Control menu provides controls for the pump diode and the second harmonic (SHG) crystal. The temperature is set in °C for the diode laser, and in counts for the crystals.

Warning

Do not change the temperatures of these components unless instructed to do so by an authorized Spectra-Physics service representative.

Setting the Diode Pump Laser Temperature

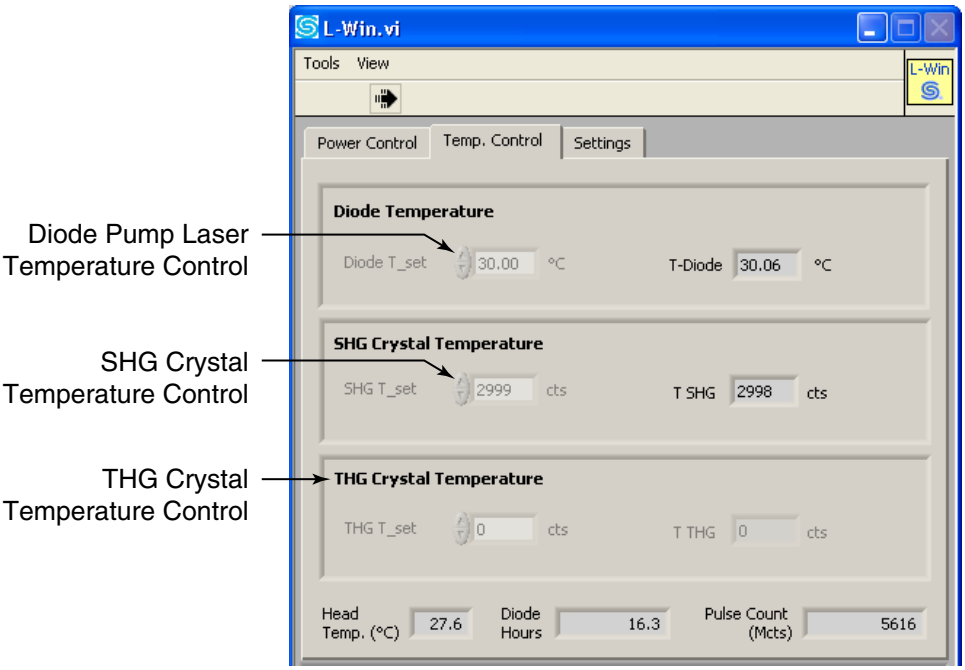


Figure 6-9: Temperature Control Menu

When the *L-Win* software is started, the system enters Standard mode. The set temperature and the measured temperature can be displayed, but it is not possible to change the temperature setting while in this mode. To change the temperature setting, switch to Expert mode by selecting *View/ GUI Mode* from the *L-Win* Main menu (Figure 6-10).

Warning

Do not change the temperatures of these components unless instructed to do so by an authorized Spectra-Physics service representative.

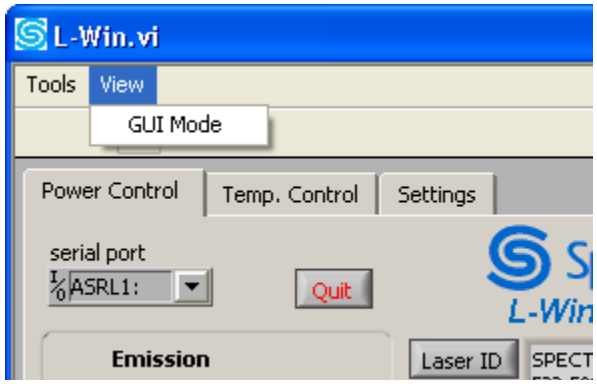


Figure 6-10: Selecting the GUI Mode

Upon selecting "GUI Mode," a dialog box with a warning message appears (Figure 6-11).

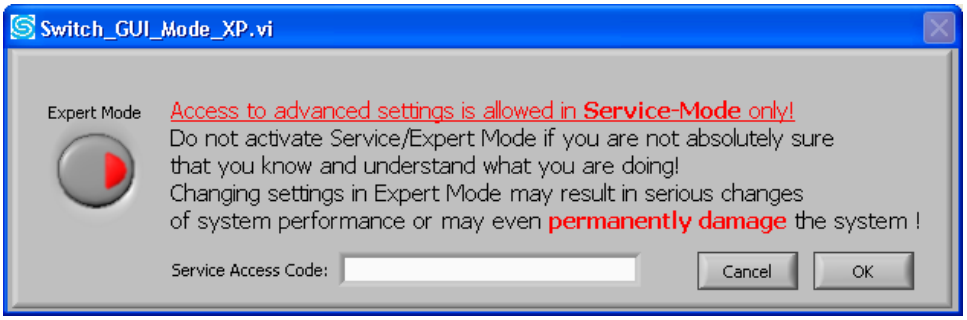


Figure 6-11: Warning—Entering Expert Mode

Changing the temperature settings is only allowed in service mode and only by trained Spectra-Physics Service engineers or trained OEM customers. To enter Expert mode, enter the service access code and press the Expert Mode button (it turns red) and confirm by clicking on OK. The temperature controls are now activated. To return to Standard mode, select *View/GUI Mode* again and press the Expert Mode button once more (it turns black) or power-cycle the laser system.

Since the *Explorer XP-532* does not have a THG crystal, the temperature control fields for the THG are set to "0" and are grayed out as shown in Figure 6-9. For information on the other *Explorer XP* models, refer to the "Explorer XP Model Description" document.

Before changing the diode laser temperature, record the present values for operating current and temperature, as well as the other laser parameters (output power, etc.), in the event that they need to be restored later. To maintain the diode laser wavelength at its optimum value of 808 nm, make small adjustments to the diode laser temperature (in maximum increments of 0.5 °C), then wait a few seconds to see what effect the change has on pulse energy or average power before continuing.

Set the desired temperature of the pump diode using the Diode T_set controls. The T-Diode field displays the measured temperature in °C. If the initial operating parameters are lost, restore the original temperature set points

by activating the preset "Factory" (see "Saving and Using Pre-Set Operating Parameters" on page 6-6).

Setting the SHG Temperature

Note

The *Explorer X*P-532 does not contain a THG crystal. Only the SHG crystal temperature can be adjusted. For models with a THG crystal, corresponding controls are available for adjusting THG crystal temperature.

1. Before making any changes to the crystal temperature, record the starting value for the temperature setting in case you need to return to this setting.
2. Change the SHG crystal setting in small increments, and wait for the laser output to stabilize before making further changes.
3. When optimum output has been achieved, log the new temperature along with the current and energy or power readings. These settings can be saved in one of the user settings. (see "Saving and Using Pre-Set Operating Parameters" on page 6-6).
4. Return to the Main menu to resume laser emission.

Caution

If the SHG temperature setpoint is changed too rapidly, laser emission will be automatically turned off to prevent optical damage to laser components. The laser will remain off until the SHG temperature has reached a stable operating condition.

Return to the Main menu to resume laser emission.

Advanced Control of the Pulsed Output

Burst Control

The *Explorer XP* allows pulses to be grouped in packets that are separated by periods of no laser output. This operation is called Burst mode. Burst mode is selected by choosing FPS/Burst Setup from the Tools menu as shown in Figure 6-12.

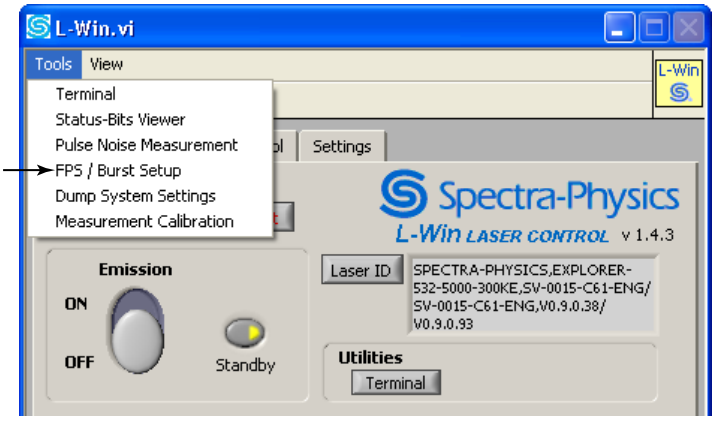


Figure 6-12: Tools Menu

The Burst mode menu will appear as shown in Figure 6-13.

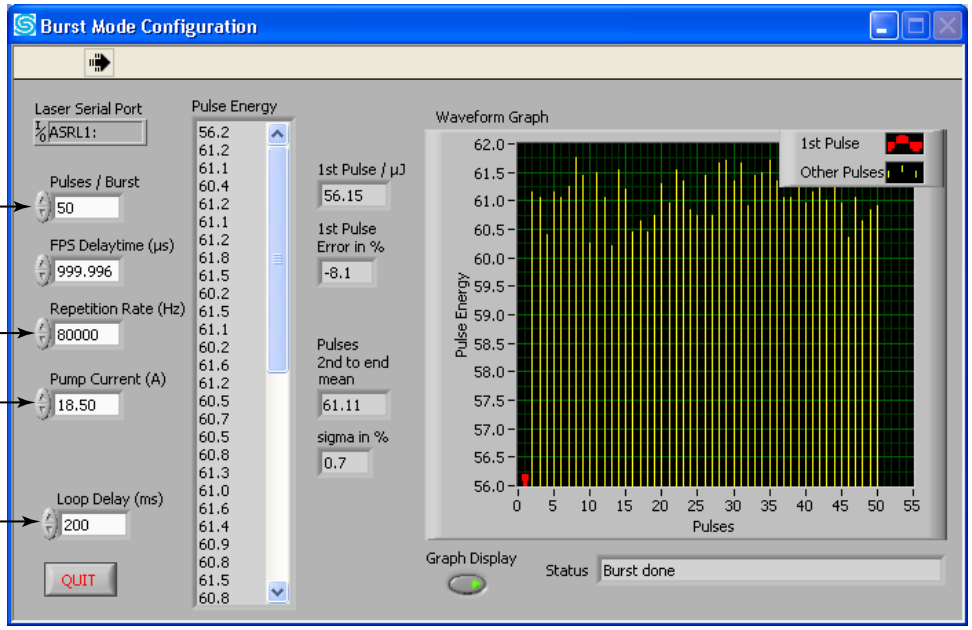


Figure 6-13: The Burst Mode menu showing burst mode settings.

Note that the current and pulse repetition frequency can be changed using this menu. Use this menu to set the laser to operate at the energy level and frequency desired for pulses that will comprise a burst.

To set up Burst mode:

1. Set the number of pulses to be contained in a single burst using the Pulses/Burst field.

   This setting, together with the repetition rate, will determine how long the burst will last. The example shown in Figure 6-13 has 50 pulses (at 50 kHz) per burst, so a burst will span 1 milliseconds.

2. Use the Loop Time field to set (in milliseconds) how often a burst will be emitted. Setting the delay to 200 ms (as shown in Figure 6-13) will result in an interval of 200 ms between bursts (in addition to the time the burst is emitted). (Note: Loop Time is a parameter only available in *L-Win*; it is not supported by *Explorer XP* firmware or serial commands.)

Clicking on the STOP button ends the Burst mode application. Status shows its present status.

Note

If the Burst mode application is exited with a non-zero value set in the Pulses/Burst field, no laser light will be emitted until a new burst command is issued either by serial command or analog signal.

Setting Pulses/Burst to "0" disables the Burst mode application.

FPS Operation

First Pulse Suppression (FPS) is an important feature for operating the laser at high repetition rates in Burst mode or when using external gating (Pin 17 and Pin 15 on the ANALOG I/O port). Without FPS, the first pulse of a burst of high repetition rate pulses will be a "giant" pulse with an energy much larger than the subsequent pulses. With FPS, the first pulse energy can be reduced so that all pulses in a sequence have approximately the same energy. See "First Pulse Suppression" on page 3-8 for a further description of the first pulse effect.

Note

The first pulse suppression feature can be used independently from burst mode, e.g., when using external gating via TTL signals on the ANALOG I/O port. In this case, the burst mode setup tool can be used to setup the correct FPS timing.

Useful operating modes of the *Explorer XP* laser using FPS are "FPS with Gating" and "FPS with Burst mode." Refer to "Control of Pulsed Output" on page 7-12 for more information.

For convenience, both the current and the pulse repetition frequency can be changed using the FPS and Burst mode menu (Figure 6-14).

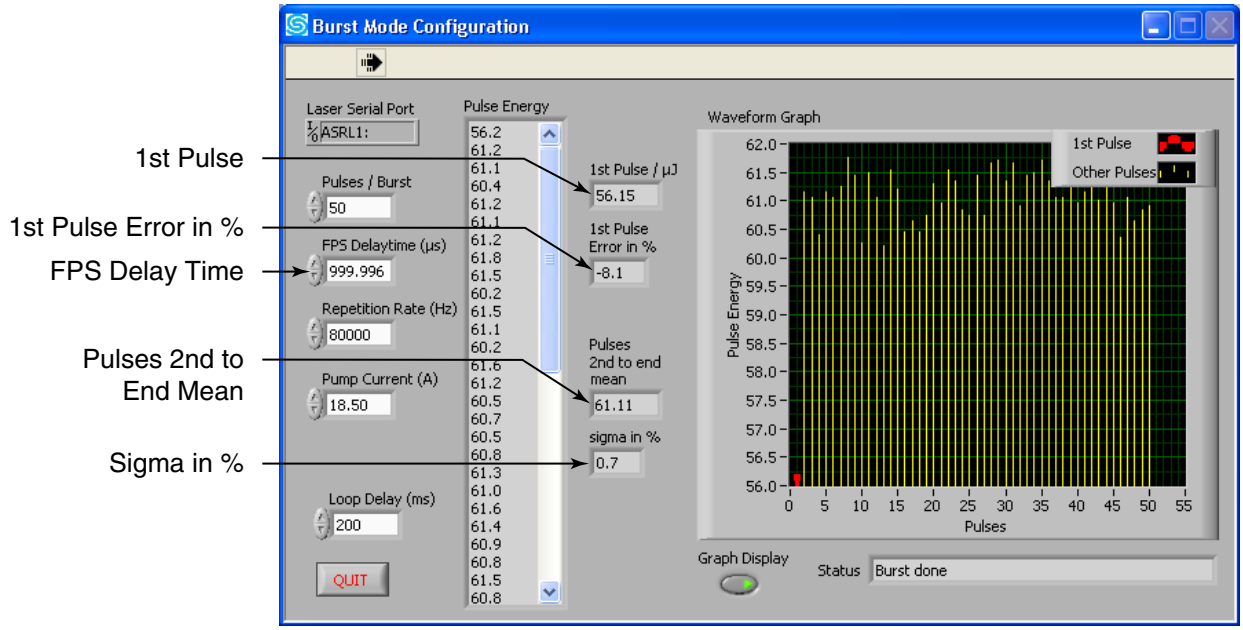


Figure 6-14: The Burst Mode menu showing FPS settings.

FPS Using the Internal Pulse Monitor

To use FPS, set the FPS Delay Time parameter (in microseconds) so that the first pulse has approximately the same energy as subsequent pulses in a burst. The recommended starting value of the FPS delay time is the inverse of the applied pulse repetition frequency. For example, if the pulse repetition frequency is 50 kHz, the recommended FPS starting value is 20 µs.

Iterate the FPS delay time around this starting value to minimize the difference between the first pulse energy and the energy of subsequent pulses in the chain.

The energy of the first pulse can be compared to the remaining pulses using the red bar shown in the waveform graph. Also, the First Pulse Error field displays the discrepancy (as a percentage) between the energy of the first pulse and the mean energy of the remaining burst pulses. Adjust the FPS Delay Time value until the First Pulse Error is close to 0%.

This menu provides additional pulse energy monitoring features as well. The First Pulse field displays the energy of the first pulse of the burst. The Pulse energy field displays the energy of a burst, chronologically. The Pulses 2nd to end mean field displays the calculated average energy of the first 50 pulses in a burst except the first. And the sigma in % field displays the calculated standard deviation of the energy of all pulses in the burst (excluding the first pulse).

The Waveform Graph display shows one vertical bar for each pulse in a burst, showing its energy in relation to other pulses. Use the Graph Display button to display or not display the waveform graph.

Important Notes on Controlling Explorer XP Output

Explorer XP laser output power is controlled by changing the diode laser current. Diode current can be varied as needed, but the maximum diode laser current allowed is pre-set at the factory.

The minimum diode current that can be commanded is the standby current level (5A default) which is below lasing threshold. However no laser light will be emitted if the diode current is lowered below the laser threshold. If the diode current is lowered close to the laser threshold, unstable operation might result.

A Cautionary Note on Changing Power

Changing diode current will change the temperature of the diode laser and, hence, the wavelength of its emission. Failure to maintain the diode emission at the proper wavelength can actually cause a decrease in output power when diode current is increased.

Explorer XP systems are specified and tested for the highest power they can reliably output. The laser must not be operated at power levels higher than this tested and verified level (refer to the Ship Report included with the system).

Caution

Over-driving the system can cause spatial mode degradation and Q-switch hold-off problems, which can cause unstable operation.

Output power levels may be reduced if the application requires lower power. Since diode laser lifetime is strongly a function of current, reducing this current can extend the lifetime of the diode laser. However, reducing

pump power might impact other performance parameters of the laser output. For example, it is common for pulsed, solid-state lasers to change pulse width when the pump power changes. Decreasing pump power will lower optical gain and result in a broadening of the pulse width. This might also result in higher pulse-to-pulse instability.

The Diode Laser Current Limit

To ensure long system lifetime, the *Explorer XP* laser head achieves specified output power using a level of pump power that is lower than the maximum rating of the pump diode laser. To protect the laser, a current limit is imposed that prevents an over-driven situation that could damage the diode laser or even the *Explorer XP* itself. When new, the laser achieves its rated output power using a fraction of the diode current required at its end of life. Higher drive current is necessary later in the system life in order for the laser to achieve its specified output power.

The *Explorer XP* laser system is able to achieve and exceed the specified output power over a wide range and over the available repetition frequencies. At higher repetition frequencies, diode current needs to be increased to achieve this power range.

In case the *Explorer XP* system is operated at lower repetition frequency and maximum diode current at the same time, it is possible to achieve significantly higher output power or pulse energy than specified. Especially for UV models, this can accelerate UV degradation processes that may impact output power and beam quality.

Should the *Explorer XP* system be operated outside the specified power range, a system failure due to degraded (UV) optics will not be covered under warranty.

Chapter 7 Operating with Commands and Signals

Spectra-Physics *Explorer XP* lasers are *Class IV—High-Power Lasers* whose beams are, by definition, safety and fire hazards. Take precautions to prevent accidental exposure to both direct and reflected beams. Diffuse as well as specular beam reflections can cause severe eye or skin damage. Residual light at 1064 nm and 808 nm wavelengths might also be present. For information on the other *Explorer XP* models, refer to the "Explorer XP Model Description" document.

The *Explorer XP* laser must be started initially using either the serial commands outlined in this chapter or the *L-Win* software described in Chapter 6. Once the *Explorer XP* system is turned on, it can also be controlled using signals applied to the ANALOG I/O interface or through a combination of serial commands and analog signals. Maximum control of laser output is provided by combining the flexibility of serial commands with the speed of analog signals.

Note

The procedures in this chapter assume that the *Explorer XP* laser has been installed according to the instructions in Chapter 5. This means that:

- the laser was installed with proper attention to heat removal,
- the laser head and computer were properly connected and that 24 Vdc power is supplied,
- the interlock relay and emission circuits, if installed, are properly wired or the jumper plug is installed on the ANALOG I/O port,
- power has been turned on, the keyswitch is on and the laser is warmed up to operating temperature.

If you are uncertain about the status of the laser, return to Chapter 5 and verify that it has been installed correctly.

Appendix B lists all of the serial commands and analog signals available to the user. This chapter provides instructions and examples on how to use some of these commands and signals to control laser output.

Serial Communication

Connection and Parameters

The *Explorer XP* serial connection is via the RS 232 port on the rear panel. Refer to Table 4-1 on page 4-3 for a functional description of this connector.

Communications Parameters

4,800 – 115,200 baud
No parity
8 data bits
1 stop bit
Hardware handshake: none

Enable: echo local typed characters.

Serial Command/Query Language

The user can issue commands and create programs for operating the *Explorer XP* laser system using the serial command/query language described in Appendix B. The latest version of the command language can always be obtained from Spectra-Physics.

The command terminator is a carriage return: <CR>. All queries and commands reply with a carriage return and line feed: <CR> <LF>. Commands are not case-sensitive.

Serial Communication Through the L-Win GUI

Once installed in the host system, a user-written program run on the system host computer can be used to operate the *Explorer XP,* possibly in combination with analog command signals. Serial commands can also be entered manually through the RS 232 port using a terminal emulation program.

The *L-Win* software provides a convenient method for executing serial commands (refer to Chapter 5, "Installation," for instructions on installing and starting *L-Win*). From the *L-Win* Main menu, select Tools from the menu bar, then Terminal from the pull-down list of options that appears. This will activate a menu that can be used to type in serial commands manually.

Basic Serial Controls

Note

Refer to "Important Notes on Controlling Explorer XP Output" on page 6-17 before making significant changes to laser operation.

Serial vs. Analog Control

Before serial commands can be used to initiate emission, on/off control must first be transferred to the RS 232 serial port.

The following commands enable and disable emission control via the ANALOG I/O interface:

MODE:RMT 1 — puts the system in a mode where emission is controlled by commands sent via the serial port. Any signal at pin 10 of the ANALOG I/O interface is ignored.

Only the control for starting emission and stopping emission (command on/off) is changed between RS 232 and the ANALOG I/O port (pin 10). External trigger, gating, etc., is independent from this setting.

MODE:RMT 0 — puts the system in analog mode where emission is controlled by signals applied to the ANALOG I/O interface in addition to any serial commands.

Use the following query to determine if the laser is in Serial or Analog mode:

MODE:RMT?

1 — the system is in Serial mode.

0 — the system is in Analog mode.

Turning the Laser On and Off

If the power switch and the keyswitch are both on and control has been set to RS 232 remote operation (command = *MODE:REMOTE 1* or, in *L-Win*, set the control mode to RS232) or, turn the laser on and off by entering:

On — the blue and white laser emission indicators on the laser turn on immediately and emission begins after a safety delay of about 3 seconds.

Off — causes laser emission to stop immediately and turns off the emission indicators.

The Watchdog Timer

The laser has a watchdog timer that, if enabled, turns off the laser if it does not receive a communication from the host computer within a user-specified interval. The default setting for the watchdog timer is OFF.

Turn on the timer and set the interval using the following command:

WDOG <n> — where <n> = interval time from 0 to 110 seconds

Turn off the timer using the following command:

WDOG 0 — turns off the watchdog timer.

To query the status of the watchdog timer, enter

WDOG?

25 where “25” is the interval time in seconds

Adjusting the Pulse Energy or Average Power

To read the actual pulse energy in µJ, use the query:

READ:PENER?

To read the actual average power in Watts, use the query:

READ:POW?

To change pulse energy, adjust the diode laser current using the command:

DIOD1:CURR <f> where <f> is a decimal value for current in Amps. Diode current has to be higher than standby current (5 A), otherwise the command is not accepted.

Example:

DIOD1:CURR 18

READ:DIOD1:CURR?

18 diode current = 18 A.

DIOD1:CURR? returns the value last commanded.

The current can also be set as a percentage of its maximum allowed value thus allowing the operator to change the current relative to its present value.

Use the following command to change the current as a percentage of maximum current:

PCUR <f> where <f> is a decimal value for the percent of maximum current.

If necessary, the maximum current value can be found using the query:

DIOD1:MAXC? returns the diode laser current limit in Amps. This diode current limit is set at the factory and cannot be changed.

Changing the Pulse Repetition Frequency

The QSW:PRF command sets the pulse repetition frequency (PRF). In normal operation mode, each model has a low limit for the minimum PRF that can be queried with QSW:PRF:MIN?. Lower values are not accepted by the command QSW:PRF.

To operate at repetition frequencies below this limit, please request the “Explorer XP E-Pulse Mode” application note. Please note that E-Pulse mode is not available for all *Explorer XP* lasers.

For example, to set the pulsed output to 80 kHz, enter the command:

QSW:PRF 80000

To return the last commanded value for the PRF, enter the query:

QSW:PRF?

To return the present value of the PRF, enter the query:

READ:QSW:PRF?

Because of the minimum interval of the timer clock, there is an inaccuracy regarding the frequency adjustment. However, the real frequency f_{real} can be calculated from the adjusted frequency f_{adj} using the following equation:

$$f_{real} = \frac{40.68\ MHz}{round\left(\frac{40.68\ MHz}{f_{adj}}\right)}$$

The command READ:QSW:PRF? returns the real frequency. The maximal difference between the real frequency and the adjusted frequency can be calculated from the equation:

$$\Delta f_{max} = \max\left|f_{real} - f_{adj}\right| = f_{adj} - \left|\frac{40.68\ MHz}{\frac{40.68\ MHz}{f_{adj}} + 0.5}\right|$$

The correction is shown graphically in Figure 7-1.

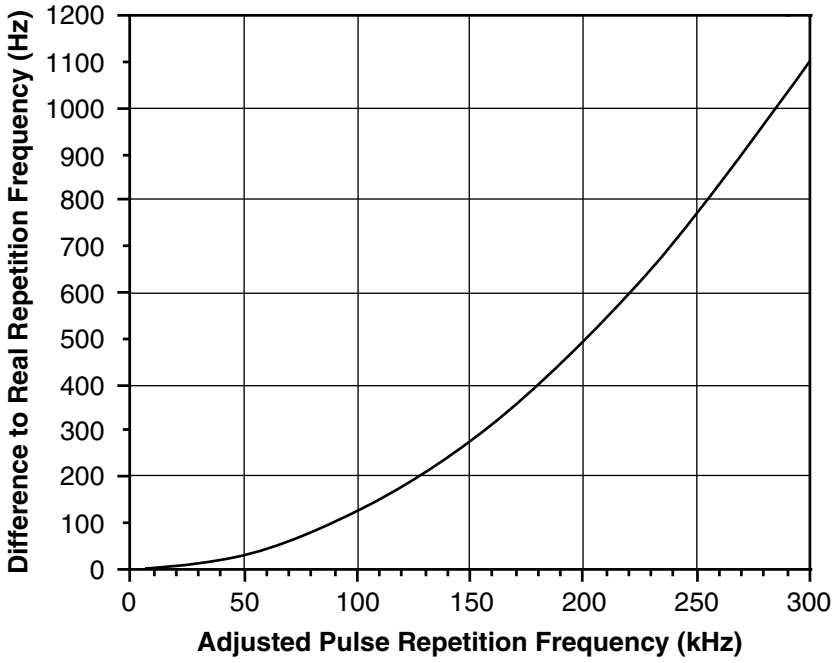


Figure 7-1: Repetition Rate Correction

Changing the Q-Switch Trigger Source

The QSW:PRF command sets the pulse repetition frequency (see "Changing the Pulse Repetition Frequency" on page 7-4). It can also be used to set the Q-switch trigger input to an external source applied to the ANALOG I/O connector. Details for using an external trigger source are provided in "The Analog I/O Interface" starting on page 7-14.

To change to an external Q-switch trigger source, enter the command:

QSW:PRF 0

To return to the internal trigger, enter a number between QSW:PRF:MAX? (the maximum frequency) and the number returned by QSW:PRF:MIN? (the minimum frequency).

Monitoring the System Status Byte

The system status byte returns a summary of important status information about the *Explorer XP* laser. Appendix C describes each of the byte bits.

To monitor the system status byte, enter the query:

*STB?

Example:

*STB?

1 where "1" (bit 0 of the status byte is set) indicates that laser emission is present. Refer to Table C-1 on page C-1 for other responses.

Tracking Diode Laser Operating Hours

The system keeps track of diode laser operating hours, which is useful in tracking the lifetime of the diode laser and harmonic crystal.

To find out the total time the system has operated, enter the query:

READ:DIODE1:HOUR?

Example:

READ:DIODE1:HOUR?

456.2HrsD1 total operation time is returned in hours.

Setting the Laser to Standby or Sleep Mode

There are two Standby modes for the *Explorer XP* laser: Standby and Sleep. The modes differ in the time required for the laser to return to normal operation, and the amount of electric energy used.

Standby Mode

Standby mode lowers the current of the diode laser below the threshold for laser output but keeps the diode laser in a state of readiness. All other *Explorer XP* components are maintained at operating temperature. Use this mode when the laser is to be used again soon.

To enter Standby mode, enter the command:

MODE:STBY 1

To see if the laser is in Standby mode, enter the query:

MODE:STBY?

1 Standby mode is on

0 Standby mode is off

To return from Standby mode, enter:

MODE:STBY 0

Sleep Mode

Sleep mode turns off the diode laser, the Q-switch and temperature control for the diode and crystals. Everything else is still on. This allows the system to be returned to operation via a software command instead of requiring a hardware start using the keyswitch. It saves energy, but it takes longer for the laser to warm up again. Use this mode when the laser is not to be used for quite some time (e.g., over-night).

To enter Sleep mode, enter the command:

MODE:SLEEP 1

To return from Sleep mode, enter:

MODE:SLEEP 0

To see if the laser is in Sleep mode, enter the query:

MODE:SLEEP?

1	Sleep mode is on
0	Sleep mode is off

Note

Sleep can only be activated when laser emission is off.

While in Sleep mode, all commands to the laser, except status queries and MODE:SLEEP 0, are ignored.

Saving and Using Operating Parameters

As a short-cut to activate a desired state of laser operation, the *Explorer XP* system allows the use of stored sets of operating parameters. Ten sets can be saved by the user. The factory settings are stored in a separate parameter set. The parameters are loaded automatically at boot-up or can also be activated after operation has begun. Appendix B lists all system commands.

A user set comprises the parameters listed in Table B-7. In addition to parameters that are specific for one of the four parameter sets, a set of global parameters exists (see Table B-8). These are also stored each time a specific parameter set is stored.

To save the current operating parameters, enter the following command:

CONFIG:PARSET:STOR <n> where:

n = 1 ... 10 for user parameter sets 1 through 10

To load one of the two user-saved sets or one of the read-only factory sets, enter the following command:

CONFIG:PARSET:LOAD <n> where:

n = 1 ... 10 for user parameter sets 1 through 10

To reactivate factory settings enter the following command:

CONFIG:PARSET:LOAD 0.

To find out which set of parameters is presently active, enter the query:
CONFIG:PARSET:ACT?

A value 1 through 10 is returned, which corresponds to one of the user configurable parameter sets.

To designate which parameter set will be used the next time the system is booted, enter the command:
CONFIG:PARSET:BOOT <n> where:

n = 1 ... 10 which corresponds to one of the user configurable parameter sets.

To find out which set of parameters will be activated the next time the system is booted, enter the query:
CONFIG:PARSET:BOOT? where:

n = 1 ... 10 which corresponds to one of the user configurable parameter sets.

Setting the Auto-On Mode

Auto-On mode overrides the need for a keyswitch reset (i.e., having to turn the keyswitch off then back on) to turn the system on using only serial commands. This is the normal mode for operating the laser using remote control.

To enable Auto-On mode, enter the command:
CONT:AUTOON 1

To disable Auto-On mode, enter the command:
CONT:AUTOON 0

To return the status of Auto-On mode, enter the query:
CONT:AUTOON?

Warning! 

Over-riding the keyswitch does *not* comply with CDRH regulations.

With Auto-On enabled and the keyswitch in the I position, the laser can be turned on using software commands without having to switch the keyswitch off and on again. To comply with CDRH regulations, it is highly recommended that the OEM manufacturer provide a security access function on his system.

System Settings

Configuring Analog Control

Serial commands can be used to configure and monitor the individual pins of the ANALOG I/O connector. Refer to "The Analog I/O Interface" starting on page 7-14 for a description of the ANALOG I/O connector. The serial commands and queries act on an 8-bit "Analog Port Status" byte, where each bit corresponds to a particular laser function controlled by an analog signal.

If a bit in the "Analog Port Status" byte is set to "1," the corresponding analog signal is either set to "high" (for a command) or is read as "high" (in response to a query). Appendix B provides more detailed information about the "Analog Port Status" byte.

The query STAT:APORT:SIGNAL? is used to read the status of a function available through the analog interface. If this query returns "64," for example, it means that if bit 5 is active high, the laser is in Standby mode.

The default for the digital pins of the ANALOG I/O connector is either active low or falling edge, but they can be set to active high or rising edge using the command CONFIG:APORT:POLAR. For example, the command CONFIG: APORT:POLAR 96 places a "1" in bit positions 5 and 6, corresponding to Standby and Go functions, which are then set to active high.

The query CONFIG:APORT:POLAR? returns the setting of individual pins. If a "96" was returned, for example, it means that there are 1's in bits 5 and 6, so those functions (Standby mode and Go) will be activated when the pins for them are pulled high.

Component Temperature Adjustment

Warning!

Changing the temperature of the following components can cause serious damage to the laser. Consult Spectra-Physics before making any adjustments to these temperatures.

In order to maintain the highest possible laser output, the diode pump laser and the harmonic crystal depend strongly on operating at the correct temperature. These components are actively cooled or heated via closed-loop control circuits. The laser system also provides the ability to actively control an optional heatsink fan to cool the laser head mounting baseplate (refer to "Optional Laser Head Heatsink" on page 4-5).

Please note that changing the temperature settings (diode and SHG/THG crystal temperature) is only allowed in service mode and by trained Spectra-Physics Service engineers or trained OEM customers. To access service mode, an access code has to be entered. Otherwise the temperature set commands are not accepted (only queries are allowed).

Setting the Diode Pump Laser Temperature

The laser diode operating temperature is specified between 18 – 35°C. If the temperature is properly stabilized, the measured value is constant in a range of ±0.05°C.

To set the temperature of the diode laser (in °C), enter the command:
DIOD1:TEMP <f> where *f* is a decimal number: 18.0 ≤ f ≤ 35.0

Example:
DIOD1:TEMP 29.2

To find the temperature of the diode laser (in °C), enter the query:
READ:DIOD1:TEMP?

To find the diode laser temperature setting (in °C), enter the query:
DIOD1:TEMP?

Setting SHG/THG Crystal Temperatures

Temperatures are set in counts between 100 and 4000 for the crystals.

Warning!

Do not change the temperatures of this component unless instructed to do so by an authorized Spectra-Physics service representative.

Use the command CONT:SHG:TEMP <n> to set the temperature of the SHG crystal in counts. For models with a THG crystal, there are corresponding commands to change the THG crystal temperature. Use Appendix B as a command language reference.

Example:
CONT:SHG:TEMP 1650

Use the query READ:SHG:TEMP? to read the temperature of the SHG crystal in counts.

Example:
READ:SHG:TEMP?
1649

Use the query CONT:SHG:TEMP? to read the last commanded temperature for the SHG crystal in counts.

Example:
CONT:SHG:TEMP?
1650

System Temperature Management

The *Explorer XP* system continuously monitors component temperatures during operation. If a laser head over-temperature condition is detected, the system will perform a safety shut-down by entering Sleep mode in order to prevent any damage. Before the shut-down condition is reached, however, warning codes are issued while the system continues to operate normally.

The temperature conditions of the laser system may be checked using serial commands or the Status Viewer menu in the *L-Win* control program.

The laser head temperature can be checked with the READ:HEAD:BAS:TEMP? query.

Table 7-1: System Response to Over Temperature Conditions

Component	Temperature[1]	Action
Laser head	< 18°C	Issue error #37 (WARNING UNDERTEMP HEATSINK) Laser remains fully operational
Laser head	> 40°C	Issue error #39 (WARNING OVERTEMP HEATSINK) Laser remains fully operational
Laser head	> 45°C	Safety shutdown (Sleep mode is activated) Clear error #38 (WARNING OVERTEMP LASERHEAD) Issue error#34 (ERROR LASER HEAD OVERTEMP)
Laser head	unit returns to < 40°C	Clear error #34 (ERROR LASER HEAD OVERTEMP) User may exit Sleep mode: MODE:SLEEP 0

[1] *All temperatures listed are typical values.*

Controlling the Laser Head Temperature

The control for the optional Spectra-Physics *EXPL-XP-HTSNK-A* heatsink fan has two modes, drive mode and control mode.

In Drive mode, a percentage value of the maximum voltage (13 V) can be set. In this mode, the speed of the fan is independent of the laser head temperature.

In Control mode, the fan speed is dependent on the laser head temperature, which can be set by the user.

To set the fan control mode, enter the command:

HEAD:FANCONT:MODE <n> where drive mode is $n = 0$ and Control mode is n = 1.

To obtain the current fan control mode, enter query:

HEAD:FANCONT:MODE?

To set the fan speed, enter the command:

HEAD:FANCONT:PVOLT <f> where *f* is an integer between 0 and 100.

Example:

HEAD:FANCONT:PVOLT 50

To obtain the current fan speed, enter the query:
HEAD:FANCONT:PVOLT?

To set the laser head temperature (in °C), enter the command:
HEAD:FANCONT:TEMP <f> where *f* is a decimal number: 24.0 ≤ f ≤ 40.0

Example:
HEAD:FANCONT:TEMP 33.5

To obtain the laser head temperature (in °C), enter the query:
READ:HEAD:BAS:TEMP?

Note the laser head temperature can be kept at a constant temperature by the heatsink and fan only when the ambient temperature is about 10° lower than the laser head temperature set point.

Control of Pulsed Output

There are three laser pulsed output control functions:

- Burst control
- First Pulse Suppression (FPS) control
- Automatic energy output control

Burst Control

The BURST command causes the *Explorer XP* laser to emit one burst of pulses.

The number of pulses in a burst is set using the command:
BURST:CNTS <n> where *n* is a decimal number 1 ≤ n ≤ 4000.

The command BURST:CNTS 0 disables Burst mode and returns the laser to normal output (a constant stream of pulses set by the rep rate function).

Burst mode can only be selected using serial commands. However bursts can be started using analog signals applied to the ANALOG I/O port.

To return the number of pulses that will be contained in the next burst (when issued), use the query BURST:CNTS?. If the return value for this query is "0," Burst mode is disabled.

The following script is an example of how to create a burst of laser pulses. Laser emission is assumed to be off. Note: if the laser was booted using pre-set parameters or is already operating at the desired energy level and pulse repetition rate, the first 3 commands should be skipped.

MODE:RMT 1	Place the laser in computer control.
QSW:PRF 60000	Set the pulse repetition rate (In this example, 60 kHz)
DIOD1:CURR 18	Set diode current

BURST:CNTS 100	Select the number of pulses in the burst (In this example, 100 pulses).
ON	Emission is activated (3-sec safety delay) No pulses are emitted, laser emission is at idle.
BURST	Emit a burst of 100 pulses.
BURST	Emit a second burst of 100 pulses.
BURST:CNTS 0	Exit Burst mode and return to normal operation.

The *Explorer XP* laser allows the trigger output, which is available for synchronizing equipment to the laser output, to be extended for the duration of the burst, i.e., pin 19 on the ANALOG I/O port (*External Sync*) is low for the whole duration of the pulse burst as shown in Figure 7-11 on page 7-26.

BURST:SYNC 1 extends the trigger output for the burst duration.

BURST:SYNC 0 causes the trigger output to have its normal duration.

BURST:SYNC? returns the status of this "synchronize-over-burst" setting.

Figure 7-11 shows both trigger options.

FPS Operation

The first pulse of a burst will become anomalously large at high pulse repetition rates. (This effect is discussed in more detail in Chapter 3 and also in Chapter 6.) To reduce the energy in the first pulse, use the First Pulse Suppression (FPS) commands and queries as described below.

The query READ:PENER:HIST? is useful for determining the level of the first pulse energy. It returns the energy values of the first 50 pulses, in counts, after the ON, BURST, or READ:PENER:HIST? command has been sent. (A returned value of "0" means the laser has not emitted a pulse in this session.)

For example, a return might look like this:

955 772 781 776 ..... 776 778 773

Based on this example, the FPS delay time should be set to reduce the first pulse from a value, in counts, of about 950 to about 750.

To optimize laser performance using the FPS feature, the recommended start value is the inverse of the applied pulse repetition frequency plus 10% to 20%. For example, if the PRF is 100 kHz, the recommended FPS starting value is 12000 ns. The FPS delay time has to be entered in nanoseconds. the smallest value is 50 ns. FPS:DELAY 0 disables FPS.

FPS:DELAY <n> sets the FPS delay time, where <n> is an integer value in nanoseconds up to 400000.

Example:

FPS:DELAY 50

FPS:DELAY? reads the value of the FPS delay time.

FPS:DELAY 0 exits FPS mode.

Note: FPS is to be used in combination with burst mode or with external gating (pin 17 and pin 15). Refer to Appendix B for details.

Automatic Pulse Energy or Power Adjustment

The automatic pulse energy setting procedure allows the diode laser current to be automatically adjusted to achieve the desired pulse energy or output power (see Table B-3 for the ranges of automatic energy or power adjustment). Note that maximum output power or pulse energy varies with the pulse repetition rate as shown in Figure 3-4 and Figure 3-5 on page 3-6.

The duration depends on the requested pulse energy. The maximum duration is 50 seconds.

To use this feature:

1. Turn on the laser using either the ON command (computer mode must be activated) or an external signal applied to the EXT_DIODE_ON pin (pin 10) of the ANALOG I/O port. Either internal or external triggering may be used.
2. Wait until the laser system temperature has stabilized before starting the pulse energy adjustment procedure (i.e., wait until operational bit 12 is activated; use the command STAT:COND:OPER? to query this pin).

Start this procedure using the command CONT:PENER <n_1>,<n_2>,<n_3> where <n_1> is the requested pulse energy[1], <n_2> states the desired pulse repetition frequency and <n_3> determines whether the user parameters will be stored after completion.

If this procedure is successful, the requested diode current and repetition rate are set as the new input values (if internal triggering mode is on). These values can be verified by using the command CONT:PENER?, which displays the new diode current and pulse energy settings.

If this procedure fails, the command CONT:PENER? displays a question mark "?". Review the chart in Figure 3-4 on page 3-6 to make sure the laser is capable of delivering the energy requested for the given pulse frequency.

The Analog I/O Interface

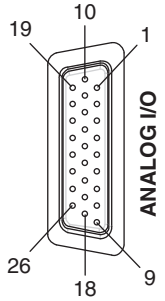


Figure 7-2: The 26-Socket ANALOG I/O Connector

The 26-pin D-sub ANALOG I/O port is used to control the laser system via user-supplied DC voltages and/or TTL-level signals.

[1] *See Table B-3 for the valid n_1 range.*

Caution

Pins 7 and 8 of this connector are system interlock pins. In order for the system to operate, these pins must be shorted together, either directly (using the supplied shorting jumper plug) or through a user-supplied, normally-closed interlock switch.

The ANALOG I/O interface accommodates a variety of control modes and timing requirements, and it is used in conjunction with serial commands that are executed through the RS 232 interface. The ANALOG I/O interface provides the following controls:

- turn laser on and off
- set system to standby mode
- set diode laser current
- safety interlock
- indicate emission output
- ready and fault indicators
- pulse energy monitor
- Q-switch trigger
- pulse gating
- synchronous output trigger signals

To use this interface, communication must first be established between the host system and the *Explorer XP* using either the *L-Win* software or through serial commands from the host system.

Table 7-2 describes the default state of the pins of the ANALOG I/O interface. “Configuring Analog Control” on page 7-9 describes how the functions of some of the pins can be set to a different polarity. Table 7-2 is followed by examples of how to use the ANALOG I/O interface to perform some of the more common laser operations.

The configuration and status of the pins of the ANALOG I/O interface are set and queried using serial commands. This is accomplished by modifying or querying two bytes that encode some of the functions of the ANALOG I/O connector pins: the “Analog Port Polarity Configuration” byte and the “Analog Port Status” byte. Refer to “Configuring Analog Control” on page 7-9 for more information about using these bytes.

Tables of these two bytes are provided at the end of Appendix B.

Table 7-2: ANALOG I/O Pin Description

Pin	Type	Description	Function
1	Output, Analog	*Pulse Energy*	Single Pulse Energy monitor Scale[1]: 0 – 4 V Tolerance: +5%/−10% Maximum load: 2 kΩ
2	Input, Analog	*I_EXT*	External diode current control Active if Pin 18 is pulled low (high)[2] Scale: 0 – 4 V 0%−100% of diode current limit
3	Output, Digital	*Pulse Error*	Pulse Error
4	N/A		Do not connect!
5	Input, Digital	*Pulse Error Reset*	Pulse Error Reset
6	N/A		Do not connect!
7	Output, Power	*USR_ILK*	~+3.5 V line with 470 Ω source impedance. Must be shorted to Pin 8 by a floating contact to complete the interlock return circuit.
8	Input, Power	*USR_ILK_RTN*	Must be shorted to Pin 7 by a floating contact to complete the interlock return circuit. Typical current is 10 mA. The floating contact resistance must be <100 Ω (see Note)
9	Output, Digital	*EMISSION(L)*	Open-Collector (OC) line, pulls low when laser emission is active, TTL level (see Figure 7-5).
10	Input, Digital	*EXT_DIODE_ON*	Internal pull-up[3]. Pull and keep low (high)[4] to trigger the diode laser on. Release high (low)[4] to shut laser emission off. Disabled in remote (computer) mode!
11	Output, Digital	*READY*	Open-Collector (OC) line, pulls low when the laser is operational, TTL level (see Figure 7-5).
12	Input, Digital	*Remote power on/off*	TTL level, 1 s high switches power on and off, respectively; static high (> 4 s) means power off.
13	Output, Digital	*ILK_FAULT*	Open-Collector (OC) line, pulls low when the laser interlock is open, TTL level (see Figure 7-5).
14	Output, Digital	*PULSE_ MONITOR_ OPTO_SYNC*	Pulls low (high)[2] when an optical pulse has been detected. May not appear at <5% maximum specified pulse energy. Source: HCT gate (5 V), 50 Ω series resistor. A 50 Ω cable is recommended in order to maintain the waveform. 50 Ω termination is not necessary. Delay wrt. optical pulse: 45 ns typical Jitter wrt. optical pulse: 1 ns typical
15	Input, Digital	*STANDBY*	Internal pull-up[3]. Pull low (high)[3] to force the laser diode into standby current level, e.g., it blanks laser output. Timing: 2nd order lag: Delay time (50%): 5 µs (typ.) Rise time: 5 µs (+20%−80%, typ.)

Table 7-2: ANALOG I/O Pin Description

Pin	Type	Description	Function
16	N/A		Do not connect!
17	Input, Digital	*EXT_GATE*	Internal pull-up.[3] Pull low (high)[4]to gate the pulse trigger (blanks laser output).
18	Input, Digital	*ILD_SOURCE*	Internal pull-up.[3] Pull low (high)[4] to switch to an external current control (use Pin 2 to set the diode current).
19	Output, Digital	*SYNC_OUT*	TTL-level pulse[2] that is synchronous with the leading edge of the trigger (see Figure 7-8 for timing). Source: HCT gate (5 V), 50 Ω series resistor. A 50 Ω cable is recommended in order to maintain the waveform. 50 Ω termination is not necessary.
20	N/A		Do not connect!
21	Input, Digital	*EXT_TRIG*	Internal pull-up.[3] Generates a single Q-switch pulse,[1] TTL-level. Software must be set to external triggering mode (QSW:PRF 0) to enable this pin.
22	Analog reference	*AGND*	Ground for Pins 1 and 2.
23	N/A		Do not connect!
24	Digital reference	*DGND*	Ground for Pins 9, 10, 11, 12, 13, 14, 15, 17, 18, 19, 21.
25	N/A		Do not connect!
26	Reference	*EARTH*	PS chassis ground. Low impedance DC-path to supply return (power interface).

[1] See Table B-3 for calculating the pulse energy or average power.
[2] The default polarity is "falling edge" but it can be changed to "rising edge" using the serial command CONFIG:APORT:POLAR <n>
[3] Internal pull-up 10.9 kΩ to +5 V (default) or internal pull-down 8.2 kΩ to GND, depending on user-commanded polarity configuration (CONFIG:APORT:POLAR <n>). TTL levels apply.
[4] The default active level is low, but it can be changed to active high using the serial command CONFIG:APORT:POLAR <n>.

Basic Analog Operation

Turning the Laser On and Off

Setting the laser emission control to "Analog Interface" (MODE:RMT 0) through the RS 232 interface allows the *Explorer XP* laser to be turned on and off using a single analog control signal on pin 10 (active-low). The laser uses either the last commanded diode current setpoint or the default preset values after turn-on as the operating parameter.

An example of a simple circuit used to pull one of the *Explorer XP* analog pins low is shown in Figure 7-3. Note that pin 24 is the ground pin on the ANALOG I/O connector. This circuit can be used with pin 10 to turn on the diode laser. It can also be used with other pins that are described later in this section.

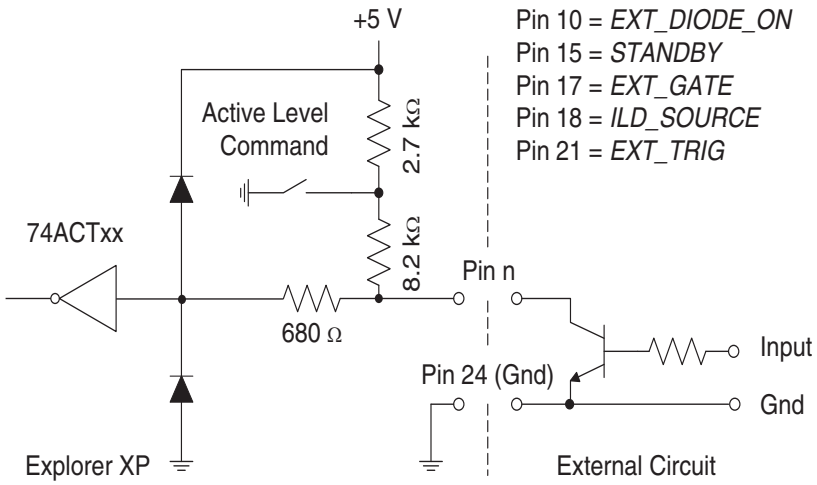


Figure 7-3: Laser Control Circuit Example

The system pulls pin 11 low (Figure 7-5) when the laser has reached a stable operating condition (i.e., the TECs for the nonlinear crystals and the diode laser have reached the default temperature set points). Pin 11 signals that the laser is ready for use.

To turn the laser on, pins 10 and 11 must be low and pin 13 (INTERLOCK active indicator) must be high, otherwise laser emission is inhibited.

Once pin 10 has been pulled low, pin 9 (the EMISSION indicator) reports active-low immediately, and laser emission occurs about 3 seconds after activating pin 10. Pin 9 can be used to control (not drive) an external emission indicator. If pin 9 does not report active-low immediately after activating pin 10, an internal system error may have occurred. Refer to the troubleshooting procedures provided in Chapter 8 for resolution.

Powering up and shutting down the laser system using the ON/OFF button or Pin 12 on the Analog interface

The system is powered up and switched off by:

- pressing the ON/OFF button, or
- by applying a signal on pin 12 of the analog interface.

To be accepted, the button press (or the signal) must have the correct duration as described in Figure 7-4 and Table 7-3. When powering up, the ON LED on the back panel will turn on as soon as the button press is acknowledged. A static high signal keeps or switches the power off. This timing is also valid for manual ON/OFF switch.

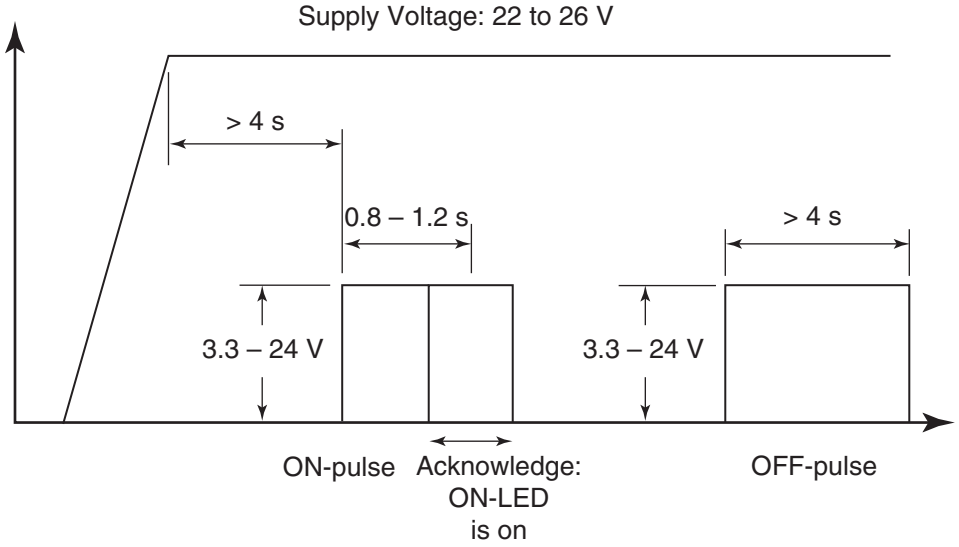


Figure 7-4: Remote Power ON (Analog I/F Pin 12). Recommended Pulse Pattern.

Table 7-3: Remote Power On Signal Meaning[1]

Pulse Length Regime	< 0.2 s	0.2 s < t < 0.8 s	0.8 s < t , 1.2 s	1.2 s < t < 4 s	t > 4 s	Multiple pulses for a total of > 0.2 s
Typical Limits	< 0.5 s	—	0.5 s < t < 1.5 s	—	t > 1.5 s	Multiple Pulses for a total of > 0.5 s
Specified Effect	Ignored	Not Specified (may switch)	Switch toggles on and off.[2]*	Not Specified (may switch)	Switches off or stays off.	Not Specified (may switch)

[1] *Analog I/F Pin 12 is valid > 4 s after the supply voltage settles.*
[2] *During start-up (for ~ 10 s after the ON pulse), the OFF command is ignored. For power OFF during this time, hold the pulse for > 4 s (> 1.5 s typ).*

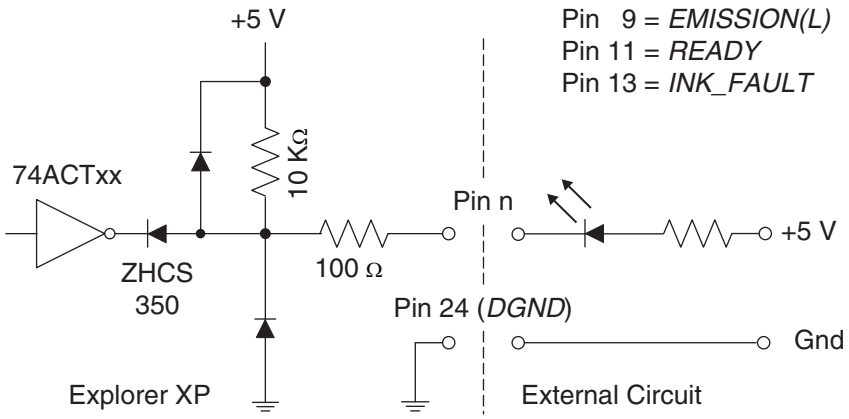


Figure 7-5: Laser Indicator Circuit Example

Adjusting the Pump Diode Current Using Analog Signals

Pin 2 of the ANALOG I/O port can be used to adjust the diode laser current set point. The maximum diode current is set at the factory. A signal voltage of 4.095 V corresponds to 100% of the maximum diode current (which is returned by DIOD1:MAXC?).

To activate analog diode laser control, pin 18 on the ANALOG I/O port must be pulled low prior to enabling laser emission on pin 10. During emission, the mode of operation cannot be changed.

External Q-Switch Triggering

Internal triggering is the default setting for the *Explorer XP* laser. To switch to external triggering, send the serial command QSW:PRF 0, which enables pin 21 of the ANALOG I/O port. Once this command has been sent, no emission will occur until a TTL signal is provided on pin 21 to trigger the laser. Figure 7-3 shows an example of a circuit that can be used to supply the trigger signal.

The external trigger signal applied to pin 21 should be a TTL level, falling edge input (default setting, see Appendix B and Table B-4) 60 kHz to 300 kHz. External trigger frequencies significantly higher than 300 kHz (QSW:PRF:MAX?) will be suppressed.

Note

Explorer XP lasers are designed for pulse repetition rates above a model-specific limit (60 kHz for the *Explorer XP-532-5W*). Lower frequencies can result in unstable laser operation. To avoid instability, decrease the pump diode current or increase the pulse repetition rate.

Setting the Laser to Standby

To place the *Explorer XP* in Standby mode, pull pin 15 low (default setting, see Appendix B and Table B-4). Again, see Figure 7-3 for an example of a circuit that can be used to control this function.

Monitoring Laser Status

Using the Indicator Outputs

Figure 7-5 shows an example of a circuit that can be used to turn one of three *Explorer XP* analog interface indicators on and off. This circuit works for the indicators available on pin 9 (EMISSION indicator), pin 11 (READY indicator), and pin 13 (INTERLOCK active indicator). When the condition corresponding to the pin output is active, the internal transistor connected to the pin will turn on. The LED shown in the figure will then turn on, indicating that the laser condition is active (e.g., pin 9 will indicate that the *Explorer XP* is emitting optical pulses).

Note that pin 24 is the reference ground pin on the ANALOG I/O connector and should be used with pins 9, 11 and 13.

Pulse Energy Monitor

Figure 7-6 shows the circuit for the output signal at pin 1 of the ANALOG I/O port. Pin 1 provides a calibrated feedback signal from the power detector that is integrated into the laser head (see Table B-3). The resolution of the output signal is 12-bit, which corresponds to a maximum signal of 4.095 V. The output is calibrated in a way that a level of 2.0 V corresponds to the nominal output pulse energy of the laser (50 μJ for the *Explorer XP-532-5W*). The output signal gets latched through a sample-and-hold circuit and is refreshed prior to each new laser pulse, thus providing single-pulse energy measurement capability.

Note that pin 22 is the ground pin on the ANALOG I/O connector that should be used with pin 1.

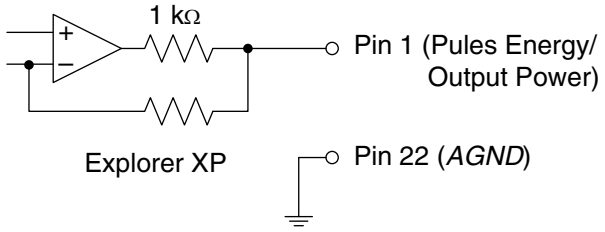


Figure 7-6: *Pulse Energy* Circuit

External Sync

The *External Sync* output on pin 19 is synchronized to the internal Q-Switch trigger and can be used as a trigger pulse for synchronizing measurement equipment to the pulsed laser output. Figure 7-7 shows the circuit for the output signal at pin 19. The timing and jitter of the trigger signals is shown in Figure 7-8.

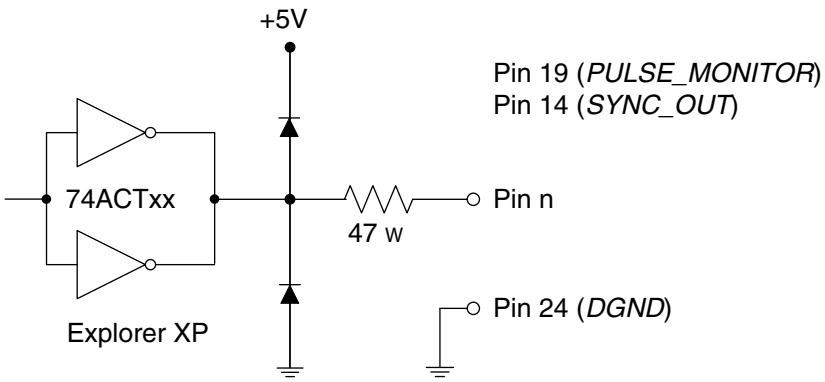


Figure 7-7: *External Sync Out* and *OptoSync* Circuits

OptoSync

The *OptoSync* output on pin 14 of the ANALOG I/O connector (referenced to pin 24) provides a trigger signal for measurement equipment with very low jitter. Figure 7-7 shows the circuit for the output signal at pin 14. Figure 7-8 shows a timing chart. *OptoSync* triggering *follows* the laser pulse by about 30 to 100 ns. More information about *OptoSync* is provided in Chapter 3.

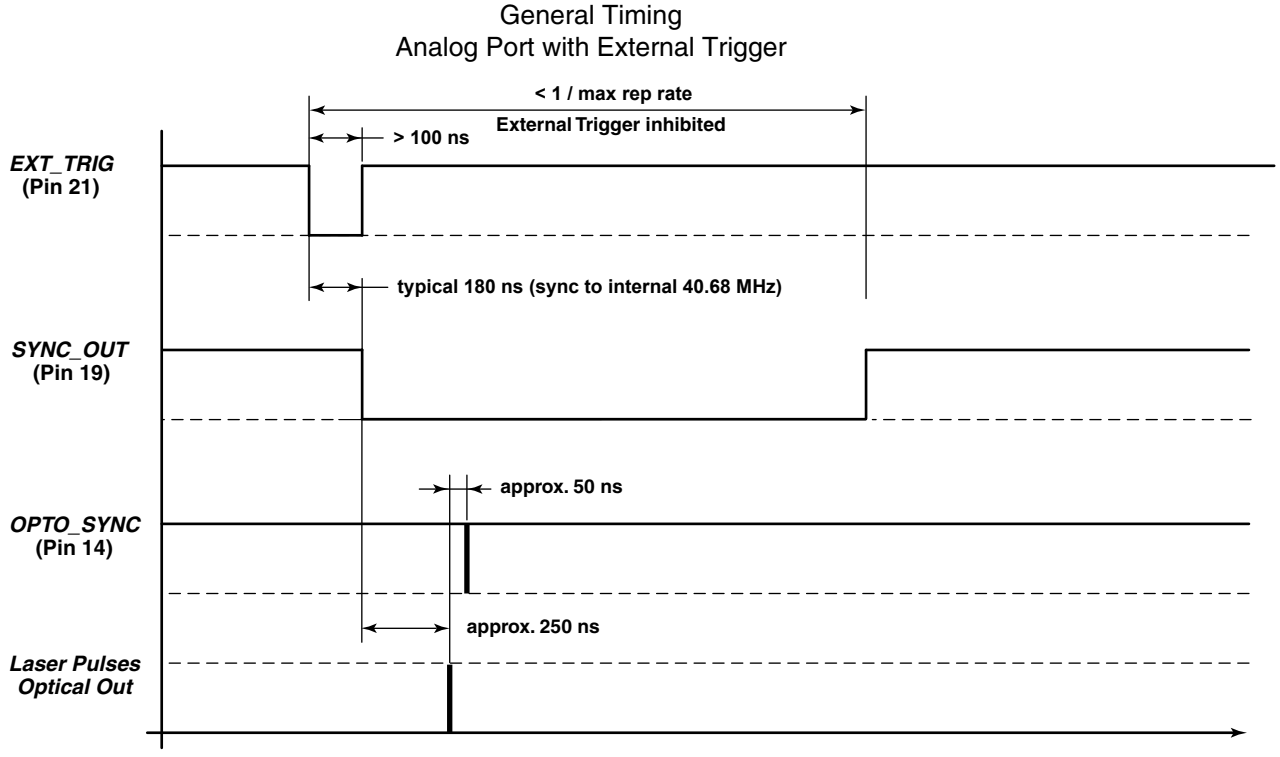


Figure 7-8: *Explorer XP* Trigger Timing

The *OptoSync* output typically will not appear whenever the pulse energy falls below about 5% of specified power.

Explorer XP pulse energy may be at levels that can cause serious skin or eye damage even when below the threshold for *OptoSync* output. *Do not use the OptoSync trigger as a laser safety emission indicator!*

Basic Operating Methods

This section describes two simple methods of operating the laser using analog signals. These methods are used to introduce the more sophisticated methods described later in this chapter.

Table 7-4 summarizes the two operating methods.

Table 7-4: Operating Mode Summary

Method A: Internal pulse trigger, external gating	
Advantage	Safe, fast gating; no optical output power during off time
Disadvantage	Additional user-supplied circuitry required to synchronized gating
Main commands	QSW:PRF <n>, n = repetition rate
Pin used	17

Method B: External pulse trigger, external gating	
Advantage	Easy set up; no optical output power during off time; fast repetition rate changes; optional synchronization
Disadvantage	Pulse clock has to be provided externally
Main commands	QSW:PRF 0 external trigger mode
Pins used	21, 17 (Pin 17 only enables or disables Q-Switch trigger. It has no impact on internal timing.)

Method A

Method A gates the laser output on and off using an external gating TTL level signal applied to pin 17. The Q-switch repetition rate is set internally using the serial command QSW:PRF <n>.

Note that in this example the gate signal and the Q-switch signal have no fixed timing with respect to each other, i.e., the pulse-to-pulse time can vary between the gate open command and the first Q-switch signal. To keep the timing between gate open and the first Q-switch signal constant, use Method B.

Method B

This method is the same as Method A except that the Q-switch is triggered by a TTL signal applied to pin 21. Another option is to use the Q-Switch signal that is available on pin 19 to synchronize laser pulses with the gating signal on pin 17. Using the Q-switch trigger as the output trigger allows laser pulses to be synchronized with the gating signal, which is applied in the same fashion as in Method A (to pin 17).

A timing diagram for Methods A and B is shown in Figure 7-9.

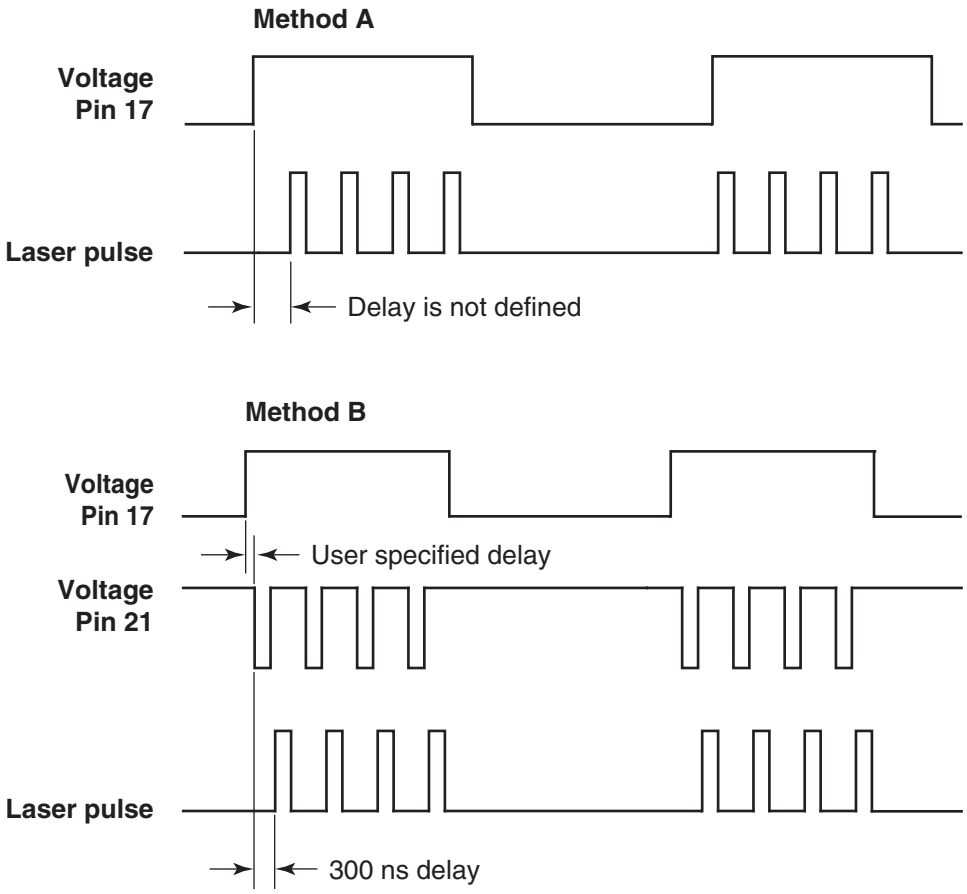


Figure 7-9: Timing Diagrams for Methods A and B

Advanced Control of the Pulsed Output

Figure 7-10 and Figure 7-11 illustrate the timing relationships using either Standby (pin 15) or Gate (pin 17) to control internal triggering. Figure 7-10 shows operation using FPS but not Burst mode, while Figure 7-11 shows operation using both FPS and Burst.

Gating

The laser output pulses can be shut off by pulling pin 17 low. Figure 7-3 shows an example circuit.

The External Gate must provide at least 1 µs prior to the estimated start of the optical pulse until at least 1 µs after the estimated end of the optical pulse.

Burst Output

Burst mode timing is illustrated in Figure 7-11 on page 7-26.

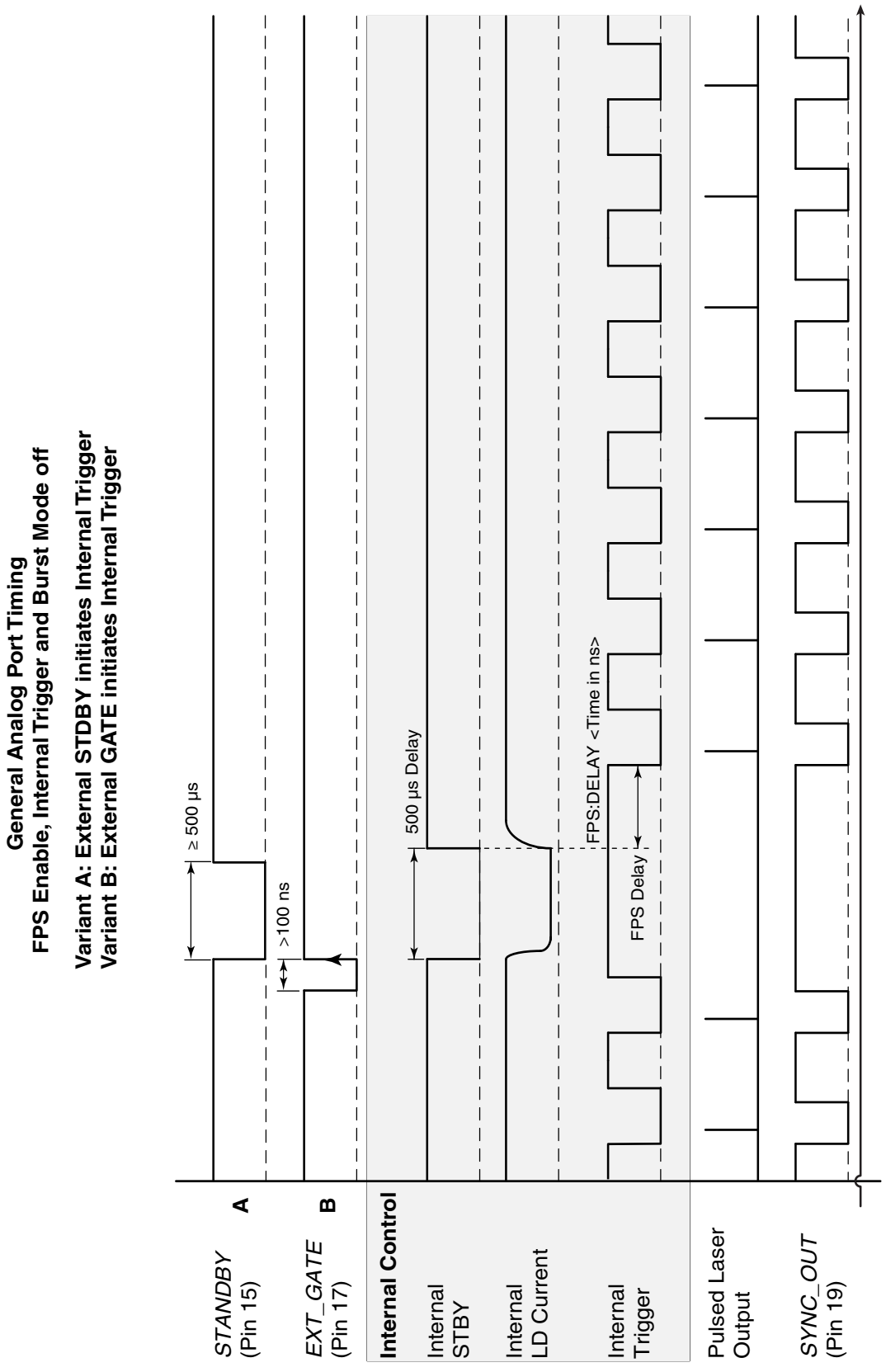


Figure 7-10: External Triggering with FPS and without Burst

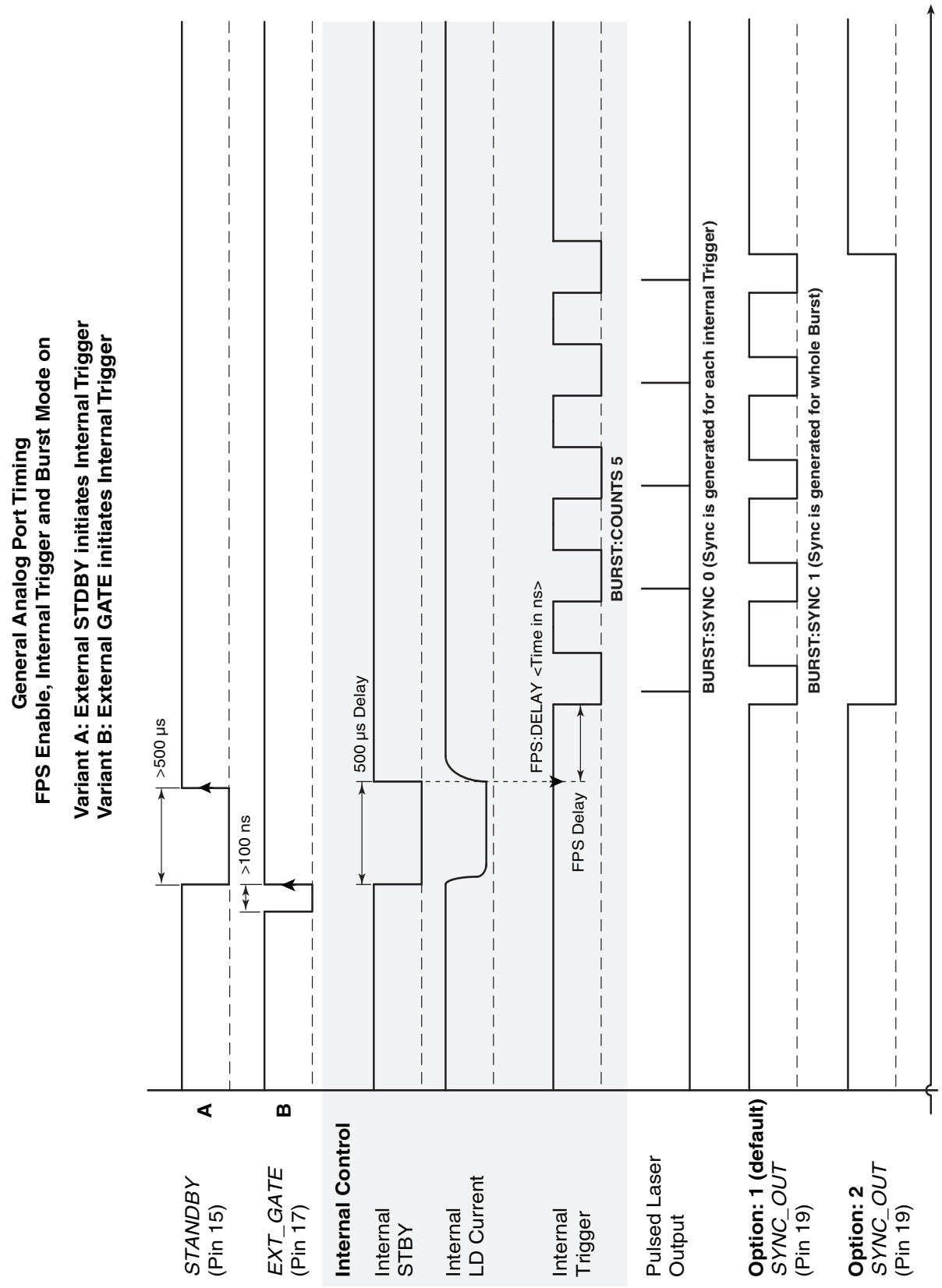


Figure 7-11: External Triggering with FPS and Burst

Chapter 8 Maintenance and Diagnostics

Spectra-Physics *Explorer XP* lasers are *Class IV—High-Power Lasers* whose beams are, by definition, safety and fire hazards. Take precautions to prevent accidental exposure to both direct and reflected beams. Diffuse as well as specular beam reflections can cause severe eye or skin damage. Residual light at 1064 nm and 808 nm wavelengths might also be present.

Warning

Never open the *Explorer XP* laser head. To retain a clean intracavity environment, all components have been cleaned to stringent standards prior to assembly in a clean room and have been permanently aligned at the factory. Removing the laser cover will compromise the cleanliness of the intracavity space and void the warranty. There are no user-serviceable parts inside the laser head—replacement of the diode pump laser or the nonlinear crystals must be performed by a technician authorized by Spectra-Physics to service *Explorer XP* systems.

Troubleshooting

Any error that occurs will cause the ERROR indicator to turn on. This troubleshooting guide is intended to assist in identifying some of the problems that might arise while using the laser. Use the list of symptoms and potential problems on the following pages to troubleshoot the laser system. Procedures for performing the corrective actions for the symptoms listed in the service tables below are provided in the section following the tables.

Note

If a problem with the *Explorer XP* laser cannot be resolved after using this basic troubleshooting section, contact your Spectra-Physics service representative for further assistance. Contact information for service centers is provided at the end of this chapter.

Symptom: No laser beam

Possible Causes	Corrective Action
No ON signal applied to the laser	Review the instructions for operating the laser in Chapters 6 and 7.
Improper DC voltage	Verify that input voltage is 24 Vdc ±2 V.
Loose cable connector	Check that all cables are securely connected.
Burst Mode is active but there is no Burst Mode signal	Either deactivate Burst Mode or supply a proper Burst Mode signal.
Standby or Gate signal is active on the ANALOG I/O Port	Remove the Standby or Gate signal from the ANALOG I/O port.

Symptom: Low power

Possible Causes	Corrective Action
External Trigger mode is active	Switch the system to Internal Trigger mode or provide a trigger signal on ANALOG I/O port, pin 21.
Laser is not warmed up	Allow the laser to warm up for at least 5 minutes.
Dirty output window	Clean or exchange the laser head output window.
Laser head temperature is outside the operating range	Verify that the laser head base plate is properly heatsinked.
Reflected laser light is destabilizing the laser	Ensure that light reflected from any external optical elements does not directed back through the window of the laser head.
Nonlinear crystals require temperature optimization	Refer to “Component Temperature Adjustment” on page 6-12 and page 7-9.
Diode pump laser has reached its end of life	Contact your Spectra-Physics service representative.

Symptom: High optical noise

Possible Causes	Corrective Action
Laser head temperature is outside the operating range	Verify that the laser head base plate is properly heatsinked.
External noise source exists	Check that there are no strong electromagnetic noise sources near the laser.
Laser is operating close to threshold (significantly below specified values)	Increase the diode laser pump current.
Frequency is too low or pump diode current is too high	Increase the frequency or decrease the pump diode current.

Symptom: Bad transverse mode

Possible Causes	Corrective Action
Laser is not warmed up	Allow the laser to warm up for at least 5 minutes.
Output window is dirty	Clean the laser head output window.
Laser head temperature is outside the operating range	Verify that the laser head base plate is properly heatsinked.
Nonlinear crystals require temperature optimization	Refer to “Component Temperature Adjustment” on page 6-12 and page 7-9.
Nonlinear crystals have reached end of life	Contact your Spectra-Physics service representative.

Symptom: Output power is unstable

Possible Causes	Corrective Action
Loose cable connector	Verify that all cables are securely connected.
Laser is not warmed up	Allow the laser to warm up for at least 5 minutes.
Laser head temperature is outside the operating range	Verify that the laser head base plate is properly heatsinked.
Nonlinear crystals require temperature optimization	Refer to "Component Temperature Adjustment" on page 6-12 and page 7-9.
Frequency is too low or pump diode current is too high.	Increase the frequency or decrease the pump diode current.

Corrective Procedures

Removing and Cleaning the Output Window

Before removing the output window, the laser must be off and the *keyswitch removed* in order to prevent the laser from being turned on accidently during the procedure.

If a significant amount of scattered laser light appears around the laser beam, the most likely cause is a contaminated output window. If this is the case, the output window must be removed from the laser head for cleaning. Never try to clean the output window when it is mounted on the laser. There is a second (inner) window behind the replaceable window that permanently seals the laser cavity. Solvents used for cleaning the outer window while it is still on the laser might contaminate the inner window and thus destroy the laser. Always remove the outer window for inspection or cleaning.

Note that the inner window cannot be cleaned. Do not allow any dust or other contaminants to enter the space between the windows.

Tools required

- gloves
- 2 mm Allen key
- tweezers

Warning

Observe the following when removing the output window:

- The output window assembly should only be removed in a clean, dust-free environment. All tools, parts and solvents should be gathered first to minimize the time that the window is removed from the laser.
- Always wear clean room gloves when exchanging or handling the output window. Never touch the window itself, even with gloves on; handle the window assembly only by its rim mount.

Figure 8-1shows the various components of the output window.

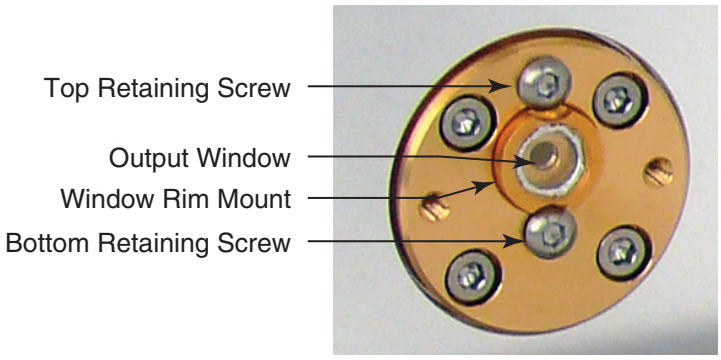


Figure 8-1: The Output Window Assembly

Procedure

1. Loosen the top retaining screw while carefully pressing against the rim mount to hold the window assembly in place (Figure 8-2). Do not remove the screw completely.

Figure 8-2: Loosen the top retaining screw.

2. While still holding the rim mount, carefully loosen the bottom screw until the window assembly is completely free (Figure 8-3).

Figure 8-3: Loosen the bottom retaining screw.

Do not remove either retaining screw completely. Reassembling the window is much easier if the screws (at least the bottom screw) remain in place.

3. The window assembly can now be removed using tweezers (Figure 8-4). Alternatively, the window assembly can be removed using gloved fingers by handling the rim mount—*remember, never touch the window itself!*

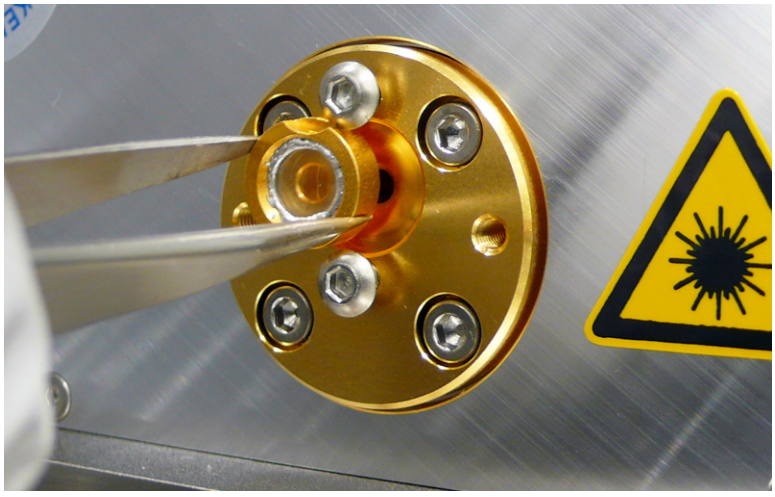


Figure 8-4: Remove the window assembly.

4. Inspect the window surface and clean it if necessary, following standard practice for ultraviolet optics (feel free to consult Spectra-Physics regarding these procedures). If necessary, replace the window assembly with a new assembly.

5. Carefully place the window in the holder and, while holding the window in position, tighten the bottom retaining screw until the screw head gently touches the window mount (Figure 8-5). Make sure that the screw head fits into the clearance in the mount.

Figure 8-5: Replace the window assembly.

6. Tighten the top retaining screw until the screw head touches the mount. Carefully tighten both screws using the minimum torque needed to secure the assembly.

Service Training Programs

The *Explorer XP* diode-pumped, Q-switched laser is designed for hands-off operation. This laser system does not require daily alignment nor routine cleaning of cavity optics. With the exception of the laser output window, servicing components is generally limited to replacing the entire laser head.

Unauthorized repair will void the warranty. Spectra-Physics offers Service Training Programs to train personnel in the diagnosis of problems and repair of the laser. These training programs are tailored to suit the needs of the customer and can be conducted on site or at our factory. For more information or to schedule a training program, contact your sales representative.

For information concerning the repair of your unit by Spectra-Physics, please call your local service representative. A list of world-wide service sites is included at the end of this chapter. Before calling, however, note the serial numbers of the laser.

Replacement Parts

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

Warning

The replacement of internal *Explorer XP* system components must only be performed by personnel trained in these specific procedures by Spectra-Physics. Do not order a field replaceable unit or attempt to replace an internal system component without first receiving proper training.

Table 8-1: Field Replaceable Units

Description	Part Number
Output window, customer exchangeable, 532 nm systems	EXPL-532-OW
Optional Explorer XP Heatsink/Fan	EXPL-XP-HTSNK-A

For information on the other *Explorer XP* models, refer to the "Explorer XP Model Description" document.

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 "Service Centers" on page 8-9.

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 (800) 456-2552** from anywhere else.

Warranty

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

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.

Warning 

Equipment must be returned in the original shipping containers to secure instruments during shipment or the laser warranty is void. If shipping boxes have been lost or destroyed, new ones must be ordered. We can return instruments only in Spectra-Physics containers.

Service Centers

Belgium

Telephone: 0800-11 257
Fax: 0800-11 302
Email: belgium@newport.com

China

Newport Corporation
Beijing Representative Office
Room 2305, Building B, Tri-Tower
No. 66 Zhongguancun East Road
Beijing 100080
P. R. China
Telephone: (86) 10-6267-0065
Fax: (86) 10-6267-2342

France

Micro-Contrôle
Spectra-Physics S.A.
Zone Industrielle
45340 Beaune-la-Rolande
France
Telephone: +33-2-38-40-50-00
E-mail: france@newport-fr.com

Germany and Export Countries[1]

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

Japan (East)

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

Japan (West)

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

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

Netherlands

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

Singapore

Newport Opto-Electronics Technologies (Singapore) Private Ltd
10 Ang Mo Kio Street 65
02-11 TechPoint
Singapore 569059
Telephone: +65-6664-0400
Fax: +65-6664-0401

Taiwan

Newport Corporation
11F, No. 35, Sec. 3, Minquan E. Rd.,
Taipei 10476, Taiwan (ROC)
Telephone: +886-2-2508-4977
Fax: +886-2-2508-0367
E-mail: sales@newport.com.tw

United Kingdom

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

United States and Export Countries[1]

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

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

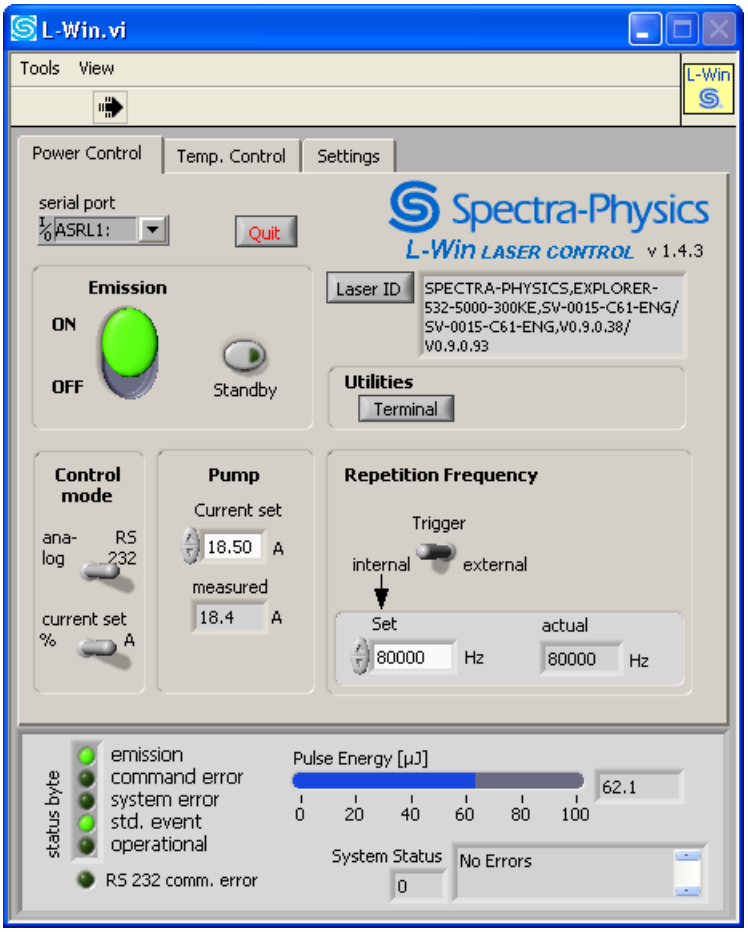
Appendix A L-Win GUI Reference

This appendix contains a screen-by-screen reference for the *L-Win* control software provided with the *Explorer XP* laser. For a description of some common operating procedures using the *L-Win* interface, refer to Chapter 6.

L-Win Main Menu

The *L-Win* Main menu consists of:

- Menu bar (Tools menu)
- Control section (Power Control, Temp. Control and Settings tabs)
- Status panel



Menu Bar

Control Section

Status Panel

Figure A-1: *L-Win* Main Menu

Status Panel

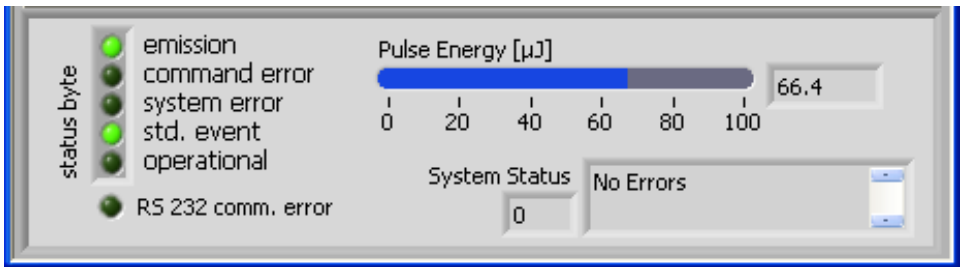


Figure A-2: Status Panel, Pulse Energy

The Status Panel displays system status information. The Status Panel is updated once per second.

Status byte indicators—display bits of the system status byte. (This byte can be also be read with the *STB? serial query. Refer to Table C-1 on page C-1 for a description.)

Emission indicator—turns on when laser emission is present.

Command error indicator—turns on when a command fault is detected, such as an unknown command or invalid parameter.

System error indicator—turns on when a system fault is detected, such as a temperature fault.

Std. event indicator—turns on if a standard event occurs (e.g., interlock active, system boot, watchdog tripped, etc.).

Operational indicator—turns on if certain operational conditions have been met (e.g., the system has successfully entered Standby or Burst mode).

RS 232 comm. error indicator—turns on when an error is detected on the RS 232 communication link (which can be caused, for example, by a missing RS 232 cable or when power to the laser is off).

Pulse Energy bar and number field—displays the internally measured pulse energy in µJ.

System Status numeric and text fields—display the system error status code and its description. These displays are updated once per second. Refer to Table C-3 on page C-9 for status codes.

Control Section

Power Control Menu

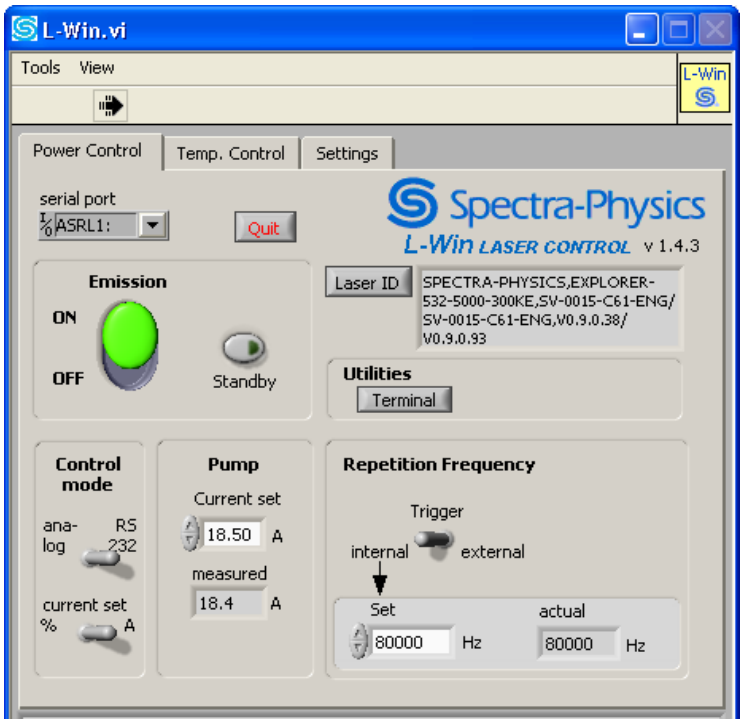


Figure A-3: Power Control Menu

The Power Control menu contains fields for controlling system functions. This menu is updated once per second.

Laser ID field—displays the laser identification string (serial query *IDN?) that is available after initialization.

Serial Port field—provides a pull-down menu for manually selecting the serial port of the control computer to which the laser is connected.

Note

On most computer systems, the serial ports will be named ASRL1:INSTR, ASRL2:INSTR, etc., in the Serial Port field instead of COM1, COM2, etc.

Quit button—exits the program. All program settings (serial port, calibration settings) are stored in the "L-Win.ini" file, which can be found in the program directory.

Emission ON/OFF button—provides a switch to turn the laser on and off. Click on it once to turn on the laser: the Emission indicator turns green if no error is present and actual emission occurs after a 3-second safety delay. Click on it again to turn the laser off immediately.

Standby button—sets the diode laser to standby current (which is below the threshold for lasing) and turns yellow. Clicking this button again will return the laser to normal operation and the button will turn gray.

Control mode: analog/RS 232 control—selects the ANALOG I/O or serial RS-232 port as the control source. When set to analog, switching on emission is controlled by pin 10 of the ANALOG I/O port. In Analog mode, the control for on/off is disabled. When set to RS 232, emission is controlled by the serial commands ON and OFF.

Control mode: current set %/A control—determines whether the pump current is set and displayed in Amperes or as a percentage of the maximum current setting (which is the value returned by DIOD1: MAXC?).

Pump Current fields—provide a means to set the diode laser current and to display the measured current. Both values are displayed either in Amperes or in percent of the maximum current drive setting, depending on Current set switch setting. Current can be set using the up/down arrows or by typing in the desired value in the window.

Repetition Rate: Trigger control—sets the Q-switch trigger mode to internal or external (external = TTL-low on pin 21 of the ANALOG I/O port, internal = TTL-high).

Repetition Rate: Set/Actual fields—sets the pulse repetition frequency and displays the measured frequency when Internal Trigger mode is selected.

Temperature Control Menu

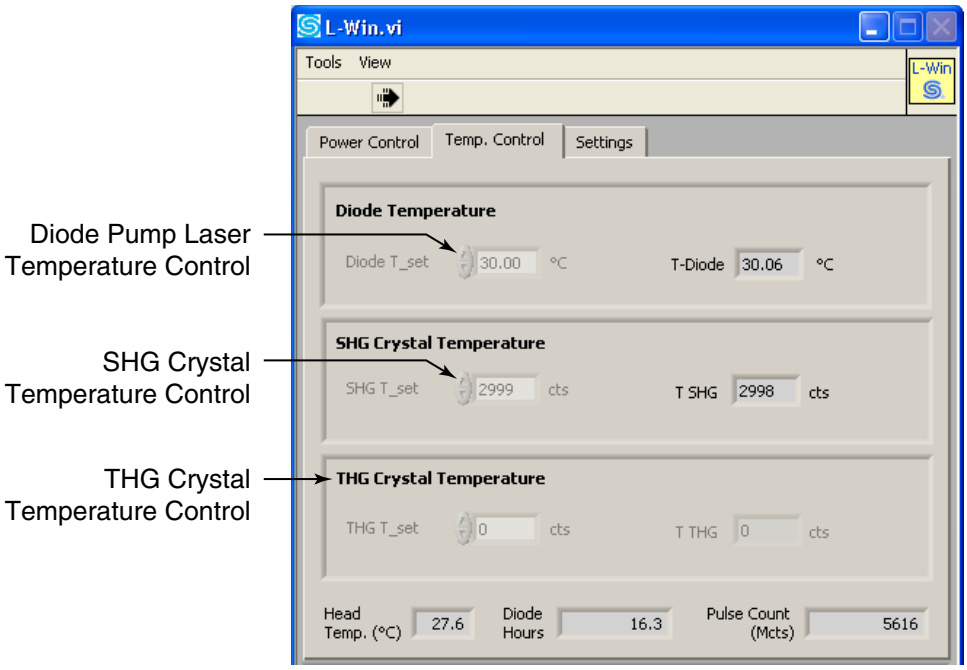


Figure A-4: Temperature Control Menu

The Temp Control menu provides controls for setting the temperature of the pump diode and the second harmonic generator crystal (SHG). The temperatures are set in °C for the diode laser and in "counts" for the SHG crystal. If the temperatures are properly stabilized, the measured values are constantly in a range of ±0.05 °C and ±3 counts, respectively. The same is true for the THG crystal.

Since a THG crystal is not present on the Explorer XP-532, the temperature controls are displayed with "0" and are greyed out as shown in Figure A-4.

Diode temperature fields—provide a means to set the desired temperature of the pump diode and to display the measured temperature (in °C).

SHG temperature fields—provide a means to set the desired temperature of the second harmonic crystal and to display the measured temperature (in "counts").

THG temperature fields—provide a means to set the desired temperature of the third harmonic crystal and to display the measured temperature (in "counts"). This control is only active for models with a THG crystal.

Diode Hours field—displays the total number of hours the diode pump laser has been operated.

Pulse Count (Mcts) field—displays the total number of pulses, in millions of pulses (Mcts), that the laser has emitted during its lifetime. The pulse counter is set to "0" prior to shipment.

Note: Upon GUI start-up, the system enters Standard mode where the set temperatures and the measured temperatures are displayed, but the temperatures cannot be changed. To change temperature settings, switch to Expert mode by selecting *View/GUI Mode* from the *L-Win* Main menu (Figure A-5).

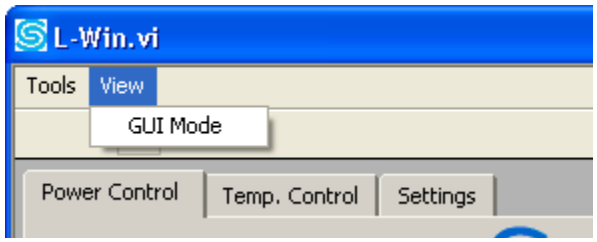


Figure A-5: Selecting the GUI Mode

Upon selecting "GUI Mode," a dialog box with a warning message appears (Figure A-6). Heed its warning!

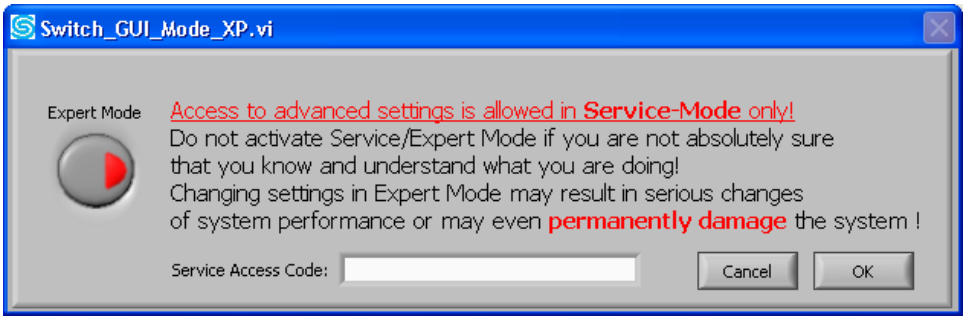


Figure A-6: Warning—Entering Expert Mode

To continue entering Expert mode, click on the EXPERT MODE button on the left (it turns red), type in the service access code and confirm by clicking on OK. The temperature controls are now activated. To return to Standard mode, either select *View/GUI Mode* again and click on the EXPERT MODE button once more (it turns black) or restart the *L-Win* software. See comment on page 6-13 (Figure 6-11) for entering service mode to change temperature settings

Before changing the diode laser temperature, record the present values for operating current and temperature, as well as the other laser parameters (output power, etc.), in the event they need to be restored later. Then set the desired temperature of the pump diode using the Diode T_set controls. The T-Diode field displays the measured temperature in °C. Make small adjustments to the diode laser temperature (in maximum increments of 0.5°C), then wait a few seconds to see what effect the change has on pulse energy before continuing.

If the initial operating parameters are lost, restore the original temperature set points by activating the preset Factory parameters (refer to "Saving and Using Pre-Set Operating Parameters" on page 6-6).

Settings Menu

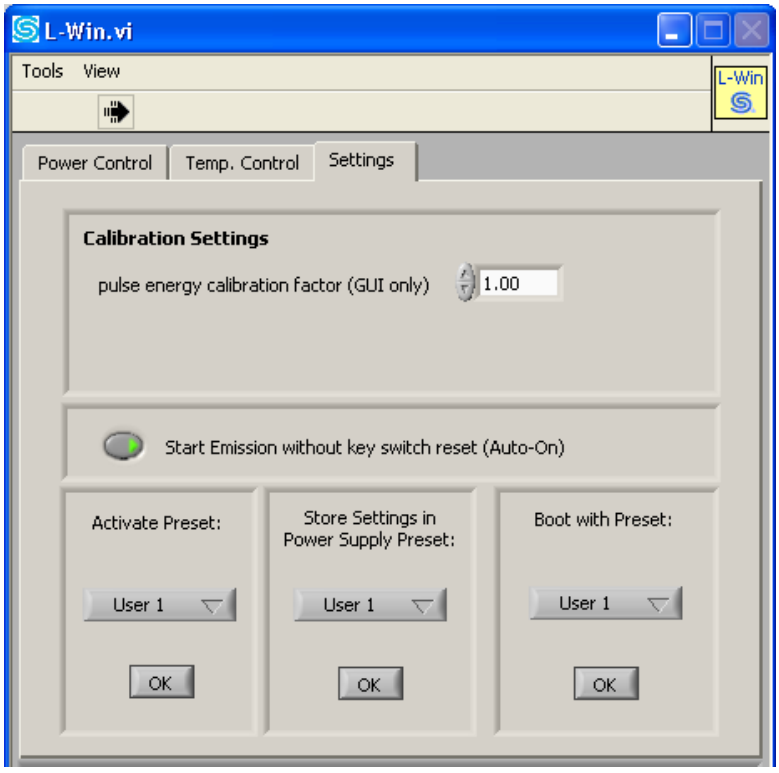


Figure A-7: Settings Menu

The Settings menu has controls for setting, storing and loading system parameter sets, called "presets," that are defined by the user or by the factory. This menu also allows the calibration display factor to be set and the Auto-On mode to be enabled or disabled.

Pulse energy calibration factor field—sets a correction factor for the measured pulse energy displayed in the Status Panel (see Figure A-2 on page A-2). With a value of "1," the display shows the unchanged pulse energy values delivered by the laser in response to the query READ:PENER?. The calibration factor can be changed to correct the displayed values to correspond to your external energy meter.

This factor is used only for the GUI menu. It is not stored in the laser.

Auto-On button—enables or disables the Auto-On mode, which overrides the need for a keyswitch reset (turning the keyswitch off and on) to turn the system on with a serial command.

Note

Note that overriding the keyswitch reset does *NOT* comply with CDRH regulations.

Preset controls—provide a means to store, activate and boot the system with a predefined parameter set. In each panel, click the menu button to select the desired parameter set (User 1 to User 4), then click OK to execute the function.

Note

Activating a preset and storing the actual parameters as a preset are only possible when emission is turned off.

Activate Preset—loads the specified parameter set from memory and activates it.

Store Preset—stores the current actual system values as the specified parameter set (User 1 to User 4).

Boot with Preset—designates the parameter set that will be activated the next time the laser system is turned on.

Menu Bar

Tools Menu

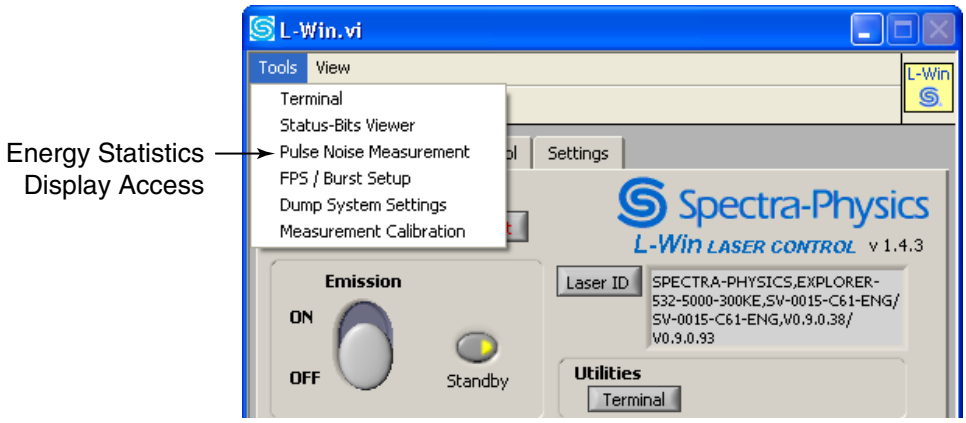


Figure A-8: Tools Menu, Pulse Energy

The Tools pull-down menu provides the following functions:

Terminal—opens a terminal emulation program window (see "Terminal Menu" on page A-9) that can be used to communicate with the laser system via serial commands. Refer to Appendix B for a complete list of serial commands, queries and responses.

Status-Bits Viewer—provides tools for troubleshooting the system by displaying various status and error bits of the system components. Refer to "Status Bits Viewer" on page A-10.

Pulse Noise Measurement—displays performance statistics, such as pulse-to-pulse stability. Refer to "Monitoring and Adjusting Performance" on page 6-7.

FPS/Burst Setup—allows adjustment and performance monitoring of the FPS and Burst mode settings. Refer to "FPS and Burst Control Menu" on page A-13 and "Advanced Control of the Pulsed Output" on page 6-14.

Dump System Settings—stores a snapshot of all relevant settings of the *Explorer XP* system in an external file. Just follow the on-screen instructions. This information can be used for troubleshooting the system by Spectra-Physics service engineers.

Set Output Power/Energy—opens a new window where the pulse average energy can be set. Refer to "Set Output Power/Energy" on page A-11.

Measurement Calibration—opens a new window where the average pulse energy that is displayed on the Main menu can be calibrated against an external source. Refer to "Energy/Power Measurement Calibration" on page A-12.

Terminal Menu

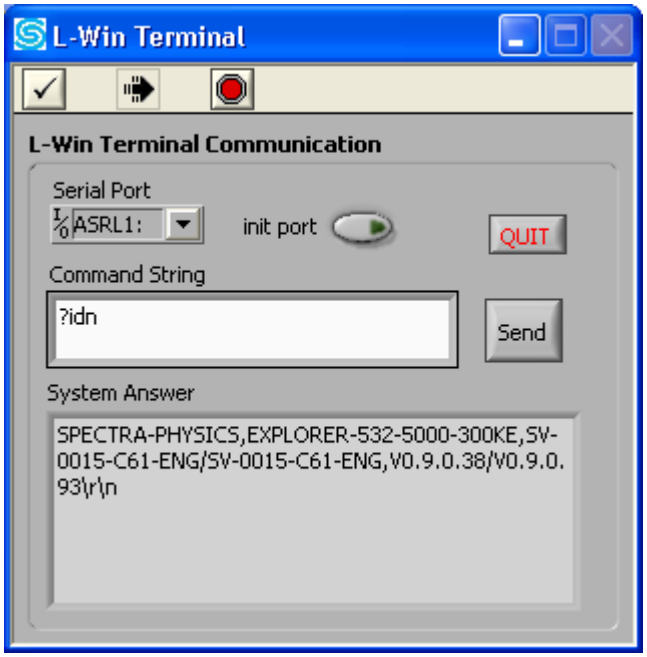


Figure A-9: Terminal Menu

The Terminal menu can be used to communicate with the laser system via serial commands. Refer to Appendix B for a complete list of serial commands, queries and responses.

The termination characters "\r" (carriage return) and "\n" (new line) shown in the **System Answer** box correspond to "<CR>" and "<LF>" respectively as described in "Serial Communication" on page 7-2.

The *L-Win* Main menu remains active while the Terminal window is active, and it is continually updated to reflect any new settings or conditions that result from serial commands sent via the Terminal window.

Serial Port field—provides a pull-down menu for manually selecting the serial port of the control computer to which the laser is connected.

init port button—initializes communication with the laser. The indicator is "on" (red) while the link is active.

QUIT button—exits the terminal emulation program, closes the window and deactivates the serial communication link.

Command String field—allows the operator to enter serial commands and queries.

Send button—sends the entered command or query to the laser.

System Answer field—displays a log of the system responses to the sent commands or queries.

Status Bits Viewer

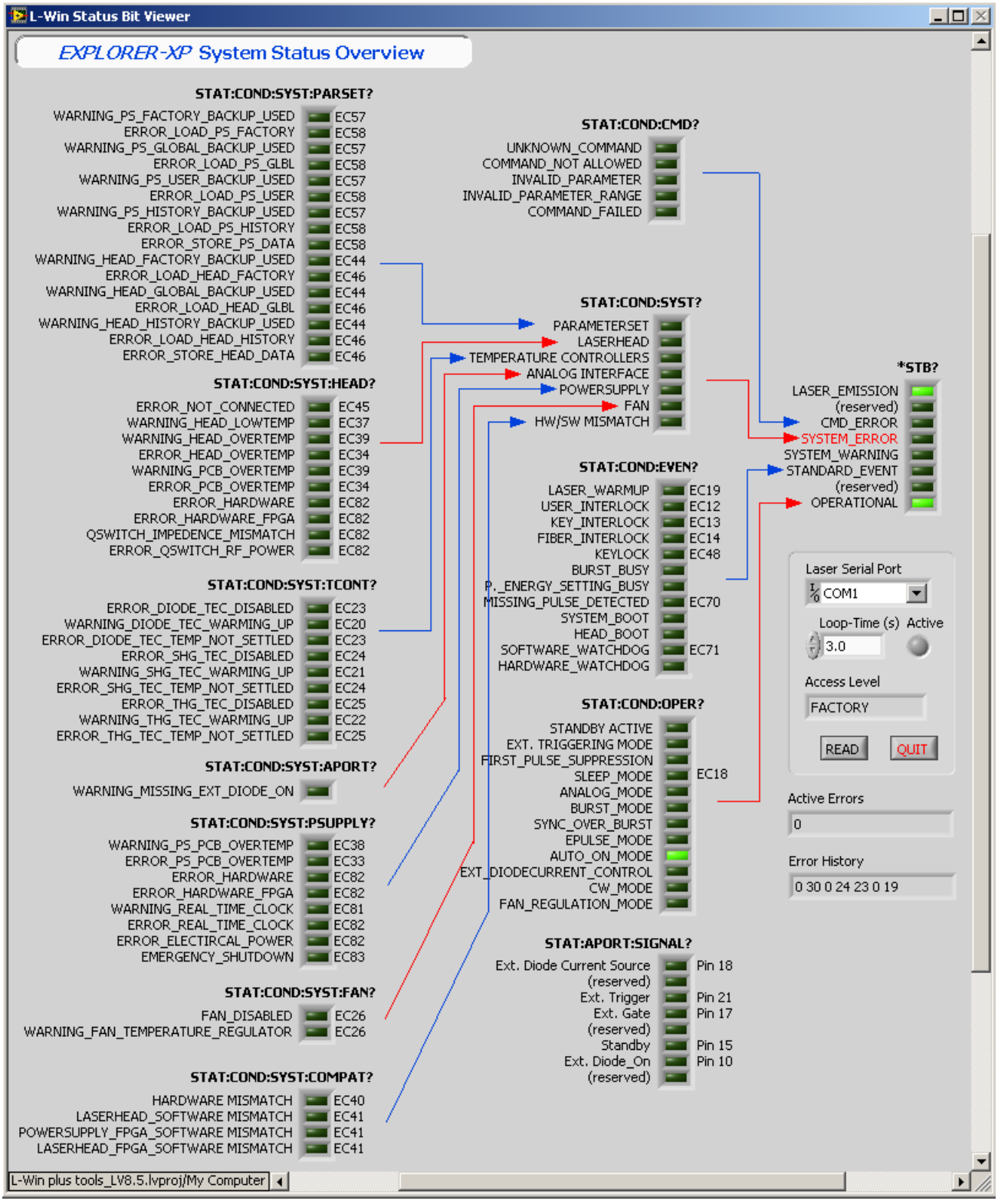


Figure A-10: Status and Error Menu

The Status and Error menu shows all the condition flags in a tree structure, with the system status byte at the root. Active conditions are illuminated. Individual conditions can be checked by branching from right to left to pinpoint the cause of an error. Above each group of elements, the serial command to retrieve the corresponding information is shown.

Laser Serial Port field—shows the active serial port for communication with the system.

Loop Time field—sets the time interval, in seconds, to be used for automatic status inquiries. The default value is 3 seconds.

Access Level field—displays the active access security level.

READ button—issues a new query and updates the indicators.

QUIT button—closes the window.

Set Output Power/Energy

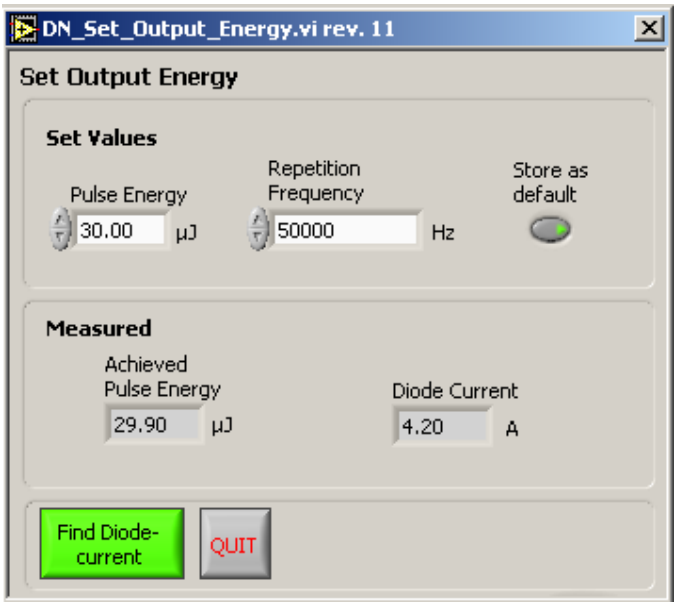


Figure A-11: Set Output Energy Menu

This tool uses the command CONT:PENER <n_1>,<n_2>,<n_3> to set the pulse energy output of the laser. Refer to the command description in Appendix B.

To use this tool:

1. Enter the set points for pulse energy and repetition frequency in the Set Values block.
2. Press the Store as default button if the new diode current setting is to be stored as the default for the first user parameter set, User Set 1.
3. Press the Find Diode Current button to send the command to the laser system. The laser will search for the pump diode current required to achieve the desired output pulse energy. This may take 2 to 5 seconds.

4. The achieved pulse energy and the required diode current will be displayed in the Measured block.

In the event this process was not successful, an error message box will be displayed.

Energy/Power Measurement Calibration

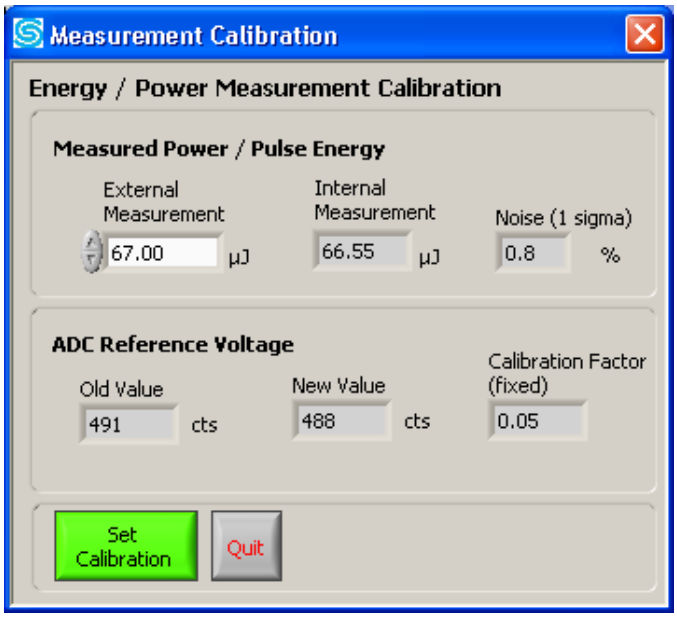


Figure A-12: Energy/Power Measurement Calibration Menu

Use this tool to change the internal system calibration and, therefore, the energy readout via both the RS-232 serial port and the analog port voltage calibration on Pin 1. Do not confuse this tool with the GUI calibration factor on the Settings tab, which only calibrates the GUI power menu.

External Measurement field—allows the user to enter the measured output pulse energy from an external, calibrated meter. After a value has been entered and the Set Calibration button is pressed, a new calibration reference voltage will be calculated (see below).

Internal Measurement field—shows the internally measured pulse energy (averaged over ~100 pulses) using the current calibration factor stored in the laser head.

Noise field—displays the pulse energy noise in a window (1 sigma value). Refer to “Pulse Noise Menu” on page A-15.

ADC Reference voltage

Old Value field—shows the current reference voltage calibration value (in counts).

New Value field—shows the new reference voltage calibration that was calculated after the externally measured pulse energy value was entered.

Calibration Factor (fixed) field—shows the internal calibration factor. This variable is non-changeable for certain systems and is for use only by personnel trained by Spectra-Physics.

Set Calibration button—sets a new reference voltage (the calculated New Value). After pressing this button, the Old Value equals the New Value, and the value displayed as Internal Measurement should be the same as that shown in External Measurement.

Note

The new reference voltage can be permanently stored in one of the user definable parameter sets (User Setting 1 or 2). The energy calibration is a global parameter that is the same for all parameter sets.

Quit button—quits the application and closes the window.

FPS and Burst Control Menu

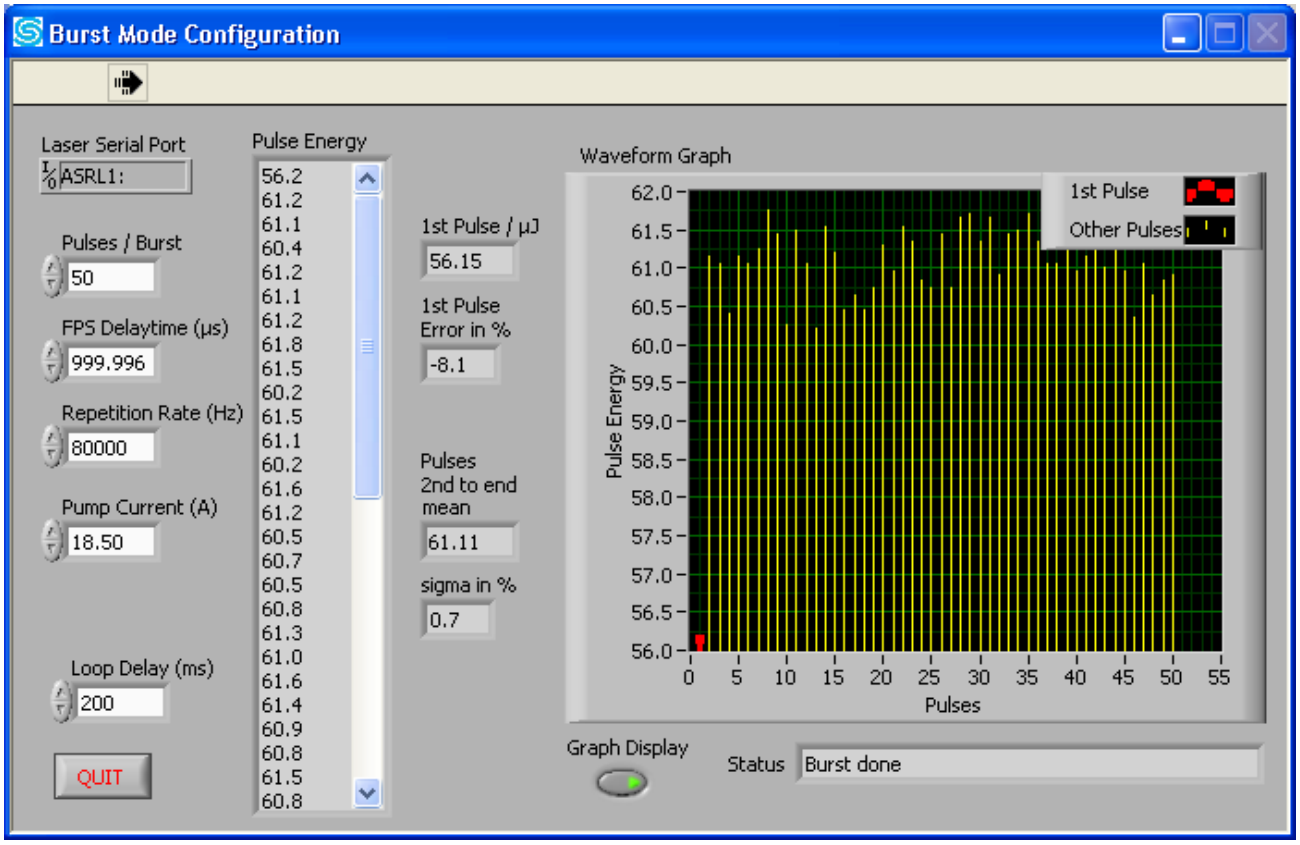


Figure A-13: FPS and Burst Control Menu

The FPS and Burst Control menu is used to adjust the First Pulse Suppression parameter FPS Delay Time in such a way that the first pulse has approximately the same energy as subsequent pulses.

Laser Serial Port field—shows the active serial port for communication with the system.

Pulses/Burst field—sets the number of pulses per burst.

FPS Delay Time field—sets the FPS delay interval (in microseconds). This value can be varied until either the red bar in the Waveform Graph (which represents the first pulse) is approximately the same height as the other bars, or until the First Pulse Error is about 0%.

Repetition Rate field—sets the pulse frequency repetition rate (in Hertz).

Pump Current field—sets the current of the diode pump laser (in Amps).

Status field—displays Burst mode status.

Loop Time field—sets the delay time between the end of one burst and the time the next burst command is sent to the system (in milliseconds).

For example, setting the interval to 200 ms will cause an interval of approximately 200 ms plus (number of pulses per burst times the 1/ pulse repetition frequency) between two bursts. Please note that the interval between two bursts is not very precise because the system status is polled via RS-232 commands. For more precise burst timing, use TTL triggering on the ANALOG I/O port or, with less precision, use the BURST command via RS-232 using a well-defined software timing loop.

STOP button—closes the window.

Pulse energy field—chronologically displays the energy of each pulse in a burst.

1st Pulse field—displays the energy of the first pulse of the burst.

1st Pulse Error in % field—displays the discrepancy, as a percentage, between the energy of the first pulse and the mean energy of the other pulses.

Pulses 2nd to end mean field—displays the calculated mean energy of all pulses except the first.

sigma in % field—displays the value of the standard deviation of all pulses, excluding the first.

Waveform Graph menu—shows one vertical bar for each pulse in a burst, showing its energy in relation to other pulses.

Graph Display button—turns the graphical pulse display on and off.

Pulse Noise Menu

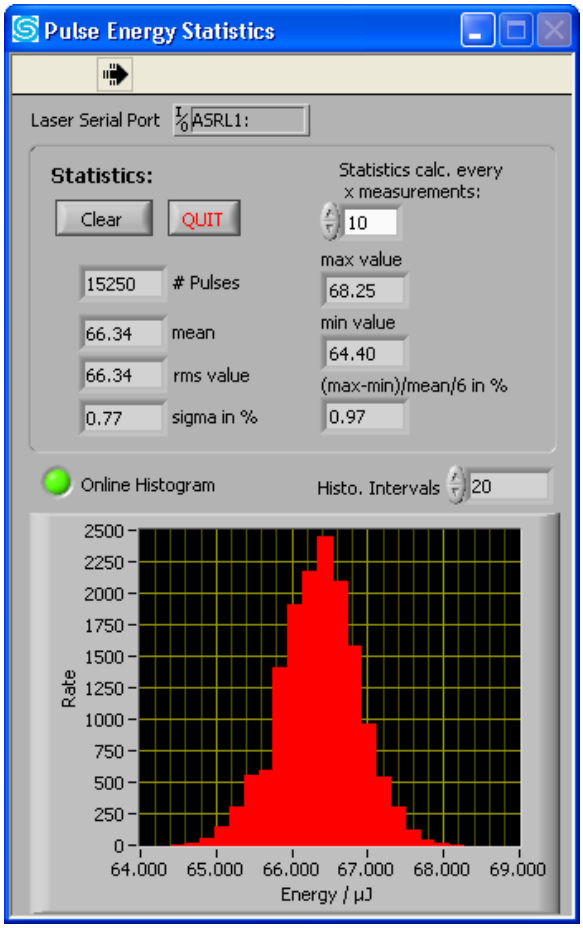


Figure A-14: Pulse Noise Menu

The Pulse Noise menu can be used to monitor performance, in terms of pulse-to-pulse stability, by monitoring the pulse energies and displaying their distribution in a histogram with other statistical data.

The Main menu can be used concurrently with the Pulse Noise menu to improve performance by adjusting operational parameters such as diode laser current and repetition rate.

Laser Serial Port field—shows the active serial port for communication with the system.

Clear button—clears all data fields.

QUIT button—closes the menu.

 # Pulses field—displays the number of pulses sampled.

mean field—displays the calculated mean energy of sampled pulses.

rms value field—displays the "root-mean-square" value of the sampled values, excluding that of the first pulse.

sigma in % field—displays the value of the standard deviation of all pulses, excluding the first.

Statistics calc every x measurements control—sets the update interval for calculating statistics (in number of measurements).

max value field—displays the highest measured energy value of the sampled pulses.

min value field—displays the lowest measured energy value of the sampled pulses.

(max-min)/mean/6 in % field—displays the value, in percent, of the difference between the largest pulse and the smallest, divided by six times the average pulse level.

Online Histogram control—activates/deactivates the data collection, calculation and histogram display. While this function is active, the indicator illuminates and the displays are automatically updated.

Histo. Intervals control—sets the resolution of the histogram display (in number of intervals to be used).

System Settings Summary

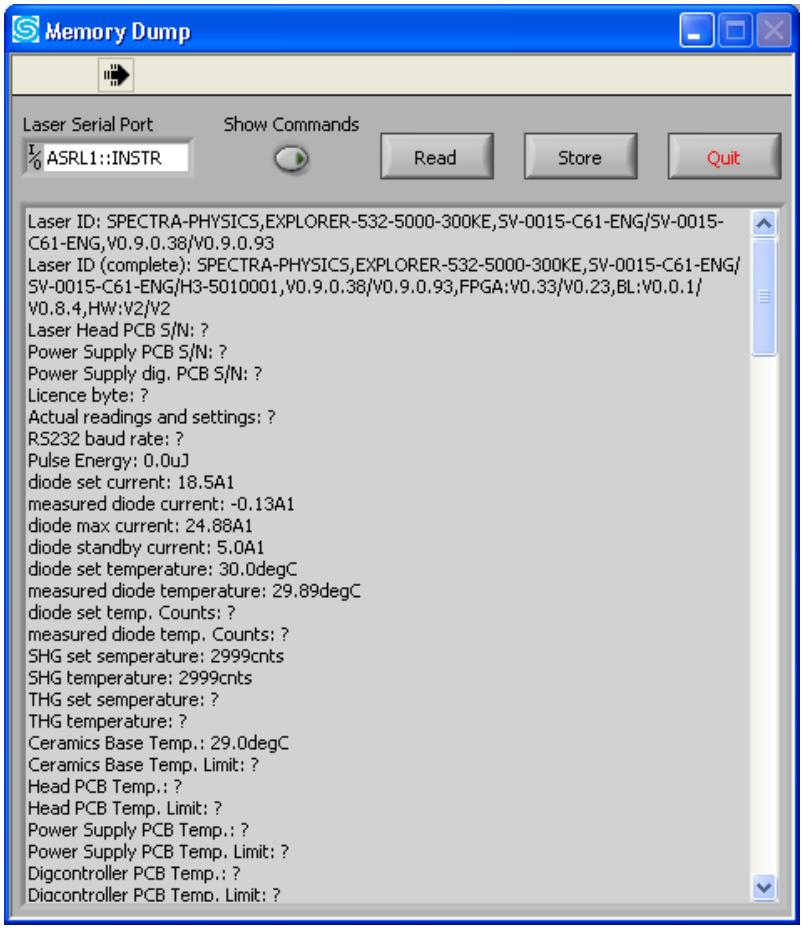


Figure A-15: System Settings Summary

The System Settings Summary menu retrieves the values of all configuration and history parameters by automatically sending the relevant query

commands to the laser system and displays the system responses. The mouse and scroll bar can be used to browse the list.

Laser Serial Port field—provides a pull-down menu for selecting the serial port to be used for the communication link with the laser.

Show Commands button—turns the command/query display on and off.

Read button—retrieves the current list of parameters and settings.

Store button—prompts the user for a path and file name and stores a copy of the list to that file.

Quit button—closes the window.

Note

If the laser is turned on while the Read button is being pressed, the laser will shut off. This behavior is designed to insure that the read captures all parameters. Please note that some queries will be answered by "?" because not all parameters are accessible in user mode.

Appendix B Explorer XP Programming Guide

Serial commands and queries can be used to create programs to allow the master system computer to operate the *Explorer XP* laser.

Each command is acknowledged by a carriage return <CR> and line feed <LF>.

If a command is not successfully executed because it is an unknown command, the command is not allowed or there is an invalid parameter, the system will respond with a question mark "?".

Commands are not case-sensitive.

This appendix contains the following sections:

Programming Conventions for this Guide

← indicates a line of text sent to the *Explorer XP*
→ indicates the *Explorer XP* response
<n> indicates an integer parameter
<f> indicates a floating-point parameter
<s> indicates a string
<CR> is the ASCII Carriage Return character (hex 0x0D)
<LF> is the ASCII Line Feed character (hex 0x0A)

Commands to the *Explorer XP* should be terminated with <CR>. Responses from the *Explorer XP* are always terminated with <CR><LF>.

Command example:

← BAUDRATE <CR>

The *Explorer XP* would consider any of these commands to be equivalent:

← DIOD1:CURR? (all upper case is OK)
← diod1:curr? (all lower case is OK)
← DIOD1:curr? (part is upper case, part lower case is OK)
← Diode1:Curr? (mixture of upper and lower case is OK)

System Identification and General Setup

*IDN?

This query returns the product identification string as a four comma-separated field: manufacturer, model, serial number, firmware version (laser head/power supply). If the laser head controller does not communicate with the power supply controller, the laser head firmware version is replaced by "-999".

Examples:
←*IDN <CR> Send the product identification string.
Typical response:
→SPECTRA-PHYSICS,EXPLORER-532-5000-300KE,SV-1234-B62-ENG,SV-0015-C61-ENG,V0.9.1.37/V0.9.2.94 <CR><LF>

If the laser head communication fails:
→SPECTRA-PHYSICS,EXPLORER-532-5000-300KE,SV-1234-B62-ENG,-999/V0.9.2.94<CR><LF>

```
MODE:RMT  <n>
MODE:RMT?
```

This command enables (n = 1) or disables (n = 0) Computer (remote) mode. When n = 0, the system is in Local (or analog) mode. The query returns the current setting. Computer mode must be enabled in order to turn the laser on or off via the RS232 serial port.

Examples:

←MODE:RMT 1<CR>	Places the system in Computer mode. The laser is turned on by sending the *ON* command.
←MODE:RMT 0<CR>	Places the system in Local (or analog) mode. The laser is turned on by using the EXTERNAL_DIODE_ON line (pin 10) of the ANALOG I/O interface.
←MODE:RMT?<CR>	What mode is the system set to?
→0<CR><LF>	The system is set to Local mode.

```
MODE:AUTOON  <n>
MODE:AUTOON?
```

This command sets the Auto-on feature of the laser system. The query returns the present setting.

n = 1	Enables Auto-on mode. The *ON* command starts laser emission **without** a keyswitch reset (i.e., without turning the key OFF and ON).
n = 0	Disables Auto-on mode. After the system is booted or after a critical error, a keyswitch reset (i.e., turning the key OFF and ON) is necessary in order to start laser emission with the *ON* command. <CR>

Example:

←MODE:AUTOON 1<CR>	Turn the Auto-on feature on.
←MODE:AUTOON?<CR>	Is the Auto-on feature on or off.
→1<CR><LF>	The Auto-on feature is on.

```
SYST:COMM:SER:BAUD  <n>
SYST:COMM:SER:BAUD?
```

This command sets the communication speed (BAUD rate) between the *Explorer XP* and the user's control computer. The query returns the present BAUD rate setting. At startup the system uses the BAUD rate that is stored in the global configuration.

Range n = 4800, 9600, 14400, 19200, 28800, 38400, 57600, 115200 bps (bits per second).

Examples:

←SYST:COMM:SER:BAUD 14400<CR>	Set the BAUD rate to 14,400 bps.
←SYST:COMM:SER:BAUD?<CR>	What is the BAUD rate set to?
→14400bps<CR><LF>	The BAUD rate is set to 14,400 bps.

WDOG <n> WDOG?

This command sets the software watchdog alert time, in seconds. This is the watchdog timer for RS-232 communication between the laser system and the host computer. If the *Explorer XP* has not received commands from the user's computer within the specified time, laser emission will turn off. The query returns the present setting.

Unit: sec
Range <n> where n = 0 to 110, and n = 0 disables the watchdog timer (default). Values of 3 to 10 seconds would be typical.

Examples:

←WDOG 10<CR>	Set the alert time to 10 seconds.
→<CR><LF>	
←WDOG 0<CR>	Disable the software watchdog.
→<CR><LF>	
←WDOG? <CR>	What is the watchdog setting?
→0<CR><LF>	The software watchdog has been disabled.

Laser Operation

These commands are executed only if the laser system has been put into Computer (REMOTE) mode (with the command *MODE:RMT 1* or by using the GUI).

ON

This command turns the diode laser on. The *Explorer XP* laser emission starts after a security delay of 3 seconds (the emission indicator turns on immediately).

Example:
←ON<CR>

OFF

This command turns the diode laser off.

Example:
←OFF<CR>

```
MODE:STBY <n>
MODE:STBY?
```

This command enables/disables the Standby mode for the diode laser (refer to "Setting the Laser to Standby Modes" in Chapter 7 for a description of Standby mode). The query returns the present status.

Range <n> where:

n = 1	enables standby mode
n = 0	disables standby mode and turn laser on again (if previously switched on)

Example:

←MODE:STBY 1<CR>	Enable Standby mode.
←MODE:STBY?<CR>	What is the Standby mode setting?
→1<CR><LF>	The system is currently set to standby mode)

Diode Current

```
DIOD1:CURR  <f>
DIOD1:CURR?
```

This command sets the diode laser current in Amps. The query returns the present diode laser current setting.

Standby current value ≤ f ≤ maximum diode laser current value, in Amps (i.e., the value returned by *DIOD1:MAXC?*), in the form xx.xx. Commands with values outside this range are rejected. The minimum current that can be commanded is the standby current (default is 5 A).

Unit: A1

Examples:

←DIOD1:CURR 24<CR>	Set the diode laser current to 24 Amps.
→<CR><LF>	
←DIOD1:CURR?<CR>	What is the diode laser current setting?
→24A1<CR><LF>	The diode laser current is set to 24 Amps.

```
READ:DIOD1:CURR?
```

This query returns the actual diode laser current in Amps.

Unit: A1

Example:

←READ:DIOD1:CURR?<CR>	What is the actual diode current in Amps?
→23.9A1<CR><LF>	Actual diode current is 23.9 A.

PCUR <f>
PCUR?

This command sets the diode laser current as a percentage of the difference of the maximum current limit (returned by *DIODE1:MAXC?)* and the standby current (returned by *DIOD1:STANDBYC?).* The query returns the present set value for *PCUR*.

Unit: %1

Examples:

←PCUR 34.6<CR>	Set *PCUR* to 34.6%.
→<CR><LF>	
←PCUR?<CR>	What is the value of *PCUR*?
→34.6%1<CR><LF>	The *PCUR* value is set to 34.6%

READ:PCUR? <n>

This query returns the actual diode laser current in % of the difference between the diode current limit and the standby current.

Unit: %1

Example:

←READ:PCUR?<CR>	What is the actual diode laser current in % of the difference between the diode current limit and the standby current?
→67.6%1<CR><LF>	Actual diode laser current is 67.6%.

DIOD1:STANDBYC?

This query returns the diode laser standby current in Amps. The standby current value is set at the factory.

Example:

←DIOD1:STANDBYC?<CR>	What is the diode laser standby current?
→5A1<CR><LF>	Diode laser standby current is 5 A.

DIOD1:MAXC?

This query returns the diode laser current limit in Amps. The diode current limit is set at the factory.

Unit: A1

Example:

←DIOD1:MAXC?<CR>	What is the diode laser current limit setting?
→30A1<CR><LF>	The diode laser current limit setting is 30 A.

Diode and Crystal Temperature Control

```
CONT:SHG:TEMP  <n>
CONT:SHG:TEMP?
CONT:THG:TEMP  <n>
CONT:THG:TEMP?
```

These commands set the SHG or THG temperature in counts and are only available in service mode. These queries are available in user mode and return the SHG or THG temperature setting in counts. If your system has a THG, substitute THG for SHG in the examples below.

Range: $200 \leq n \leq 3900$
Unit: cnts (counts)

Examples:

←CONT:SHG:TEMP 1650<CR>	Set the SHG temperature to 1650 counts.
→<CR><LF>	
←CONT:SHG:TEMP?<CR>>	What is the SHG temperature setting?
→1650cnts<CR><LF>	The SHG temperature setting is 1650 counts.

```
READ:SHG:TEMP?
```

This query retuns the measured SHG temperature in counts.
Unit: cnts (counts)

Example:

←READ:SHG:TEMP?<CR>	What is the actual SHG temperature?
→1649cnts<CR><LF>	The actual SHG temperature is 1649 counts.

```
READ:THG:TEMP?
```

This query retuns the measured THG temperature in counts.
Unit: cnts (counts)

Example:

←READ:THG:TEMP?<CR>	What is the actual THG temperature?
→1649cnts<CR><LF>	The actual THG temperature is 1649 counts.

```
DIOD1:TEMP  <f>
DIOD1:TEMP?
```

This command sets the diode laser temperature in °C. This command is only available in service mode. The query is available in user mode and returns the diode laser temperature setting.

Range: $18.0 \leq f \leq 37.0$
Unit: degC

Examples:

←DIOD1:TEMP 29.2<CR>	Set the diode laser temperature to 29.2°C.
→<CR><LF>	
←DIOD1:TEMP? <CR>	What is the diode laser temperature setting?
→29.2degC<CR><LF>	The diode laser temperature setting is 29.2°C

```
READ:DIOD1:TEMP?
```

This query reads the actual laser diode temperature in degrees C.

Unit: degC

Example:

←READ:DIOD1:TEMP? <CR>	What is the actual temperature of the laser diode?
→29.2degC<CR><LF>	Actual laser diode temperature is 29.2°C.

Q-Switch Repetition Rate

```
QSW:PRF <n>
QSW:PRF?
```

This command sets the Q-switch repetition frequency in Hertz.
The query returns the current value.

Range: 0, minimum pulse repetition frequency ≤ n ≤ maximum pulse repetition frequency (i.e., the value returned by *QSW:PRF:MIN?* and *QSW:PRF:MAX?* respectively).

n = 0 disables internal pulse triggering and allows external triggering.

Note: External triggering mode may not be activated if First Pulse Suppression (FPS) mode is switched on.

Unit: Hz

Table B-1 lists the PRF range for *Explorer XP* models.

Examples:

←QSW:PRF 80000<CR>	Set the pulse frequency to 80000 Hz.
→<CR><LF>	
←QSW:PRF?<CR>	What is the Q-switch repetition frequency?
→80000Hz<CR><LF>	The Q-switch repetition frequency is 80000 Hz.
←QSW:PRF 0<CR>	Set the system to external triggering mode.
→<CR><LF>	

QSW:PRF:MAX?

This query returns the maximum pulse repetition frequency.

Unit: Hz

Table B-1 lists the maximum pulse repetition frequencies for the *Explorer XP* models.

Examples:

←QSW:PRF:MAX?<CR>	What is the maximum pulse repetition frequency?
→300000Hz<CR><LF>	Maximum pulse repetition frequency is 300000 Hz.

QSW:PRF:MIN?

This query reads the minimum pulse repetition frequency.

Unit: Hz
Table B-1 lists the minimum pulse repetition frequencies for the Explorer XP models.

Example:

←QSW:PRF:MIN?<CR>	What is the minimum pulse repetition frequency?
→60000Hz<CR><LF>	The minimum pulse repetition frequency is 6000 Hz.

Pulse Counts and Operating Hours

READ:QSW:CNTS?

This command reads the pulse counter in megacounts.

Unit: Mcnts

Examples:

←READ:QSW.CNTS?<CR>	How many pulses have there been since the last pulse count reset?
→34.4Mcnts<CR><LF>	The system has issued 34,400,000 pulses.

READ:PSUPPLY:HOUR?

This query returns the power supply pc board hours. Power supply pc board hours are incremented every 6 minutes (0.1 hour) that power is supplied to the power supply pc board.
Unit: HrsPS

Example:

←READ:PSUPPLY:HOUR?<CR>	How many hours has the power supply pc board been on?
→478.7HrsPS<CR><LF>	The power supply pc board has been supplied with power for 478.7 hours.

```
READ:DIOD1:HOUR?
```

This query returns the diode laser operating hours. Diode laser operating hours are incremented every 6 minutes (0.1 hour) that the diode laser is turned on (in Emission mode) or in Standby mode.

Unit: HrsD1

Example:

←READ:DIOD1:HOUR?<CR>	How many hours has the laser diode been turned on?
→234.8HrsD1<CR><LF>	The diode laser has been operated for 234.8 hours.

Analog Interface

```
CONFIG:APORT:POLAR <n>
CONFIG:APORT:POLAR?
```

This command sets the polarity of the ANALOG interface lines (refer to Table B-3 to see which pins are affected).

Range <n>: 0 – 511

Individual bit position = 1: line is high active (rising edge)
Individual bit position = 0: line is low active (falling edge) (default)

Examples:

←CONFIG:APORT:POLAR 96<CR>	Set the polarity of pins *EXTERNAL_DIODE_ON* and *STANDBY* to high-active.
→<CR><LF>	
←CONFIG:APORT:POLAR?<CR>	Which pins are set to high-active?
→96<CR><LF>	Pins *EXTERNAL_DIODE_ON* and *STANDBY* are set to high-active.

```
STAT:APORT:SIGNAL?
```

This query returns the status of the ANALOG I/O interface pins. Use this query to find the activity level of the individual signals applied to the ANALOG I/O port (refer to Table B-5).

Individual bit position = 1: signal on pin is active
Individual bit position = 0: signal on pin is not active

Example:

←STAT:APORT:SIGNAL?<CR>	What is the status of the lines of the ANALOG I/O port?
→64<CR><LF>	The Standby line is active.

Pulse Energy

READ:PENER?

This command reads the actual pulse energy in µJ.

Unit: µJ

Example:

←READ:PENER?<CR>	What is the actual pulse energy?
→21µJ<CR><LF>	Actual pulse energy is 21 µJ.

READ:PENER:HIST?

This query returns the energy values of the first 50 pulses after switching on or after the last read-out of the pulse history. The values are given in ADC counts (0 – 1023) and are separated by blank spaces. Pulse energy in µJ may be calculated by multiplying by the numbers returned by the calibration factor (the output of query *PENER:CALF?*)

Examples :

←READ:PENER:HIST?<CR>	What are the energy values, in counts, for the last 50 pulses?
→455 772 781 776 ... 776 778 773<CR><LF>	(These are the energy values for the last 50 pulses.)
←READ:PENER:HIST?<CR>	What are the energy values, in counts, for the last 50 pulses?
→0<CR><LF>	No pulses have been emitted yet.

PENER:CALF?

This query returns the calibration factor that is used to convert the pulse energy ADC counts (0 – 1023) returned by *READ:PENER:HIST?* to the displayed microjoule values. The calibration factor is set at the factory.

Unit: µJ/cnt

Example:

←PENER:CALF?<CR>	What is the conversion factor?
→0.5234µJ/cnt<CR><LF>	The conversion factor is 0.5234 µJ/count.

PENER:REFVOLT:CNTS <n>
PENER:REFVOLT:CNTS?

This command modifies the reference voltage of the pulse energy ADC. It may be used to re-calibrate the displayed pulse energy to match the values read at the user's energy meter. Higher reference voltage counts result in lower pulse energy values.

Range <n>: 200 – 1023
Unit: cnts (counts)

Examples:

←PENER:REFVOLT:CNTS 456<CR>	Change the reference voltage to 456 counts.
→<CR><LF>	
←PENER:REFVOLT:CNTS?<CR>	What is the reference voltage in counts?
→456cnts<CR><LF>	The reference voltage is 456 counts.

CONT:PENER <n_1>,<n_2>,<n_3>

This command starts an automatic pulse energy adjustment. The setting procedure lasts about 10 seconds.

- <n_1> the requested pulse energy, in µJ
- <n_2> pulse repetition rate (PRF) for which the adjustment is to be executed (see Table B-1 for the valid PRF range).
- <n_3> determines if the automatically adjusted parameters are stored or not after completion of the setting procedure.

$n_3 = 0$: The diode laser current is set to the adjusted current but not saved to the internal EEPROM. These settings can be manually stored by the user (*CONFIG:PARSET:STOR <n>*). This requires that the laser emission is disabled.

$n_3 = 1 \ldots 10$: The settings are automatically stored in the user set #1, set#2 etc.

Note 1: The command is rejected if the laser is not switched on. During the adjustment procedure, queries about the diode current, pulse repetition frequency and temperatures are not valid.

Note 2: During the adjustment procedure, the status may be found by using the query *STAT:COND:EVEN?* and then checking if bit 6 ("Pusle Energy Setting Busy") is activated.

CONT:PENER 0	stops a launched adjustment procedure

Examples:

←CONT:PENER 20,80000,1<CR>	Set the pulse energy to 20 µJ @ 50 kHz. After completion, the found parameters (diode current) are stored in the user parameter set #1.
→<CR><LF>	
←CONT:PENER 10,30000,1<CR>	Set the pulse energy to 10 µJ @ 30 kHz
→?<CR><LF>	The request was denied because 30 kHz is outside the valid PRF range.

CONT:PENER?

This query returns the result of an automatic pulse energy adjustment.

The response is two combined values separated by a comma, <f>,<f>, that yields the diode current (in Amps) and adjusted pulse energy (in µJ). If the adjustment procedure fails, the query returns "?;<n>" where <n> contains a number that indicates the reason for the failure:

- n = 1 stopped by user
- n = 2 maximum iteration count exceeded
- n = 3 internal communication fault
- n = 6 measured pulse energy is 0 µJ

Example:

←CONT:PENER?<CR>	What is the result of the automatic pulse energy adjustment?
→14.9A1,20µJ<CR><LF>	Diode laser current is 14.9 A and output energy is 20 µJ.

Laser Power

READ:POW?

This command reads the actual laser power in Watts with one decimal place (e.g., 4.9W<CR><LF>).

Unit: W

Example:

← READ:POW?<CR>	What is the actual laser output power?
→ 5.0W<CR><LF>	Laser output power is 5 W.

POW:PD:CALF <f>
POW:PD:CALF?

This command sets the calibration for average power measurement. The query returns the calibration factor that is used to convert the photodiode voltage to the displayed laser power value (e.g., 2.5W/V).

Unit: W/V (Watts per Volt)

Example:

← POW:PD:CALF 1.23W/V	Set the calibration value to be used to measure power.
←POW:PD:CALF?<CR>	What is the calibration value to be used to measure power?
→1.23W/V<CR><LF>	The calibration value to be used to measure power is 1.23 W/V.

Data Administration

CONFIG:PARSET:STOR <n>

This command stores actual parameters as parameter set #<n> (including the global parameter set) for up to 10 sets. Refer to Table B-5 User Parameters and to Table B-x: Global Parameters.

Range <n>:
n = 1: user parameter set #1
…
n = 10: user parameter set #10

Example:

←CONFIG:PARSET:STOR 1<CR>	Store the current adjusted value set in user set #1.
→<CR><LF>	

CONFIG:PARSET:LOAD <n>

This command loads 1 of 10 actual parameters sets from parameter set #<n> (including the global parameter set). Refer to Table B-5 User Parameters and to Table B-x: Global Parameters.

Range <n>: 0 … 10
n = 0: factory parameter
n = 1: user parameter set #1
…
n = 10: user parameter set #10

Example:

←CONFIG:PARSET:LOAD 1<CR>	Load the parameter set from user set #1.
→<CR><LF>	

CONFIG:PARSET:ACT?

This command reads the active parameter set number (refer to Table B-5 User Parameters).

Range <n>: 1 – 10

Example:

←CONFIG:PARSET:ACT?<CR>	Which parameter set is currently being used?
→1<CR><LF>	Set #1 is currently being used.

CONFIG:PARSET:BOOT <n>
CONFIG:PARSET:BOOT?

This command designates the parameter set, indicated by number, to be loaded at next start-up (refer to Table B-5 User Parameters). The query returns the parameter set to be loaded at next startup.

Range <n>: 1 – 10

Examples:

←CONFIG:PARSET:BOOT 1<CR>	Load parameter set #1 at start-up.
→<CR><LF>	
←CONFIG:PARSET:BOOT? <CR>	Which parameter set will load at start-up?
→1<CR><LF>	Parameter set #1 will load at start-up.

Note: In order to activate this change for the next boot sequence, this global parameter has to be stored as one of the user parameter sets. Otherwise it will be lost after the power cycle, and the system will boot with the old parameter set.

Status and Error Reporting

READ:FAULT?

This query returns the fault code (refer to Table C-3). 0 means there are no errors.

Example:

←READ:FAULT?<CR>	Is there a fault and, if so, what is it?
→12<CR><LF>	The user interlock has been activated.

READ:FAULT:LIST?

This command reads a string of up to 16 status codes which are currently active (refer to Table C-3). Entries are separated by blanks. 0 means there are no errors.

Example:
←READ:FAULT:LIST?<CR>
→12 23 24 25<CR><LF>

READ:FAULT:HIST?

This command reads the history buffer, which consists of up to 16 status codes activated after the most recent startup (refer to Table C-3). Entries are separated by blanks.

Example:
←READ:FAULT:HIST?<CR>
→0 12 24 13 12 23 24 25 12<CR><LF>

*STB?

This command reads the system status byte (refer to Table C-1).

Example:
←*STB?<CR>
→1<CR><LF> Laser emission is present.

STAT:COND:CMD?

This command reads the status of the last command (refer to Table C-2).

Example:
←STAT:COND:CMD?<CR>
→0<CR><LF> The last command was successfully completed.

STAT:COND:SYST?

This command reads the system status (refer to Table C-2).

Example:
←STAT:COND:SYST?<CR>
→2<CR><LF>> There is a laser head fault.

STAT:COND:SYST:PARSET?

This command reads data administration status (refer to Table C-2).

Example:
←STAT:COND:SYST:PARSET?<CR>
→16<CR><LF> An error occurred while loading the user parameter set.

STAT:COND:SYST:PSUPPLY?

This command reads power supply PCB status (refer to Table C-2).

Example:
←STAT:COND:SYST:PSUPPLY?<CR>
→1<CR><LF> There is an overtemp condition on the power supply board.

STAT:COND:SYST:HEAD?

This command reads laser head status (refer to Table C-2).

Example:
←STAT:COND:SYST:HEAD?<CR>
→1<CR><LF> There was a communication error with the laser head.

STAT:COND:SYST:FAN?

This command reads system fan status (refer to Table C-2).

Example:
←STAT:COND:SYST:FAN?<CR>
→2<CR><LF> Diode laser current control error.

STAT:COND:SYST:TCONT?

This command reads temperature controller status (refer to Table C-2).

Example:
←STAT:COND:SYST:FAN?<CR>
→1<CR><LF> PWM controller for diode laser temperature failed.

STAT:COND:SYST:APORT?

This command reads analog interface status (refer to Table C-2).

Example:
←STAT:COND:SYST:APORT?<CR>
→1<CR><LF> Missing EXTERNAL_DIODE_ON signal.

STAT:COND:EVEN?

This command reads system events status (refer to Table C-2).

Example:
←STAT:COND:EVEN?<CR>
→4<CR><LF> Keyswitch is in OFF position.

STAT:COND:OPER?

This command reads system operational status (refer to Table C-2).

Example:
←STAT:COND:OPER?<CR>
→8<CR><LF> System is in Sleep mode.

Power Saving Modes

MODE:SLEEP <n> MODE:SLEEP?

This command activates/deactivates Sleep mode. In Sleep mode, the Q-switch and the TECs for controlling the temperatures of the harmonic crystals and diode laser are turned off.
Range <n>: n = 1: Sleep mode on
n = 0: Sleep mode off

Note: in Sleep mode, all commands besides status queries are rejected.

Examples:

←MODE:SLEEP 1<CR> →<CR><LF>	Activate Sleep mode.
←MODE:SLEEP?<CR> →1<CR><LF>	Sleep mode is activated.

Laser Head Temperature Control

HEAD:BAS:TEMP:MAX?

This indicates the warning level of the laser head base plate temperature in degrees C. An over-temperature warning will be issued if the temperature rises above this maximum, and a safety shutdown occurs if the temperature rises 5°C above the warning level.

Example:
←HEAD:BAS:TEMP:MAX?<CR>
→40<CR><LF>

READ:HEAD:BAS:TEMP?

This command reads the temperature of the laser head base plate in degrees C.
Unit: degC

Example:
←READ:HEAD:BAS:TEMP?<CR>
→34.5<CR><LF>

HEAD:FANCONT:MODE <n>
HEAD:FANCONT:MODE?

This command sets the operation mode of a connected fan either to Control mode, where the base plate temperature is regulated to the adjusted set point (refer to command HEAD:FANCONT:TEMP <f>), or to Drive mode, which provides a constant but adjustable voltage.

Range <n>: n = 1: control mode (default)
n = 0: drive mode

Examples:
←HEAD:FANCONT:MODE 1<CR>
→<CR><LF>

←HEAD:FANCONT:MODE?<CR>
→1<CR><LF>

HEAD:FANCONT:TEMP <f>
HEAD:FANCONT:TEMP?

This command sets the temperature set point for the fan control (the setting has no effect if no fan is connected). The command is rejected if the fan operation mode is set to Drive mode.

Range <f>: 18.0 degC ≤ f ≤ 34.0 degC

Unit: degC

Examples:
←HEAD:FANCONT:TEMP 33.5<CR>
→<CR><LF>

←HEAD:FANCONT:TEMP?<CR>
→33.5degC<CR><LF>

HEAD:FANCONT:PVOLT <f> HEAD:FANCONT:PVOLT?

This command sets the fan voltage in percent of the maximum voltage of 12 V if the fan operation mode is set to Drive mode. The command is rejected if the fan operation mode is set to Control mode.
Unit: %

Range <f>: 0 – 100 %

Examples:

←HEAD:FANCONT:PVOLT 50.0<CR> Set the fan voltage to 50% (6.0 Volt).
→<CR><LF>

←HEAD:FANCONT:PVOLT?<CR>
→50%<CR><LF>

First Pulse Suppression (FPS)

FPS:DELAY <n> FPS:DELAY?

This command sets the FPS delay time to <n> ns. The smallest value is 50 ns. The maximum value is 400000 ns.

Range <n>: $0 \leq n \leq 4000$
n = 0 disables FPS Note : FPS mode may not be activated if External Triggering mode is turned on.

Unit: µsec

Examples:

←FPS:DELAY 67800<CR> Set FPS delay to 67.8 µs.
→<CR><LF>

←FPS:DELAY?<CR> FPS delay is set to 67.8 µs.
→67800<CR><LF>

←FPS:DELAY 0<CR> Disable FPS.
→<CR><LF>>

Burst Mode

BURST:CNTS <n> BURST:CNTS?

This command sets the number of pulses issued at next BURST command using the currently active pulse repetition rate.
Unit: cnts

Range <n>: $0 \leq n \leq 4{,}294{,}967{,}295$
n = 0 disables Burst mode

Examples:

←BURST:CNTS 100<CR>	
→<CR><LF>	Set burst count to 100 counts.
←BURST:CNTS?<CR>	
→100cnts<CR><LF>	
←BURST:CNTS 0<CR>	
→<CR><LF>	Burst mode is disabled.

BURST:SYNC <n> BURST:SYNC?

This command sets synchronize-over-burst mode.

Range <n>: n = 1: span sync pulse over burst duration
n = 0: sync pulse will have standard duration

Examples:

←BURST:SYNC 1<CR>	Span sync pulse over burst duration.
→<CR><LF>	
→BURST:SYNC?<CR>	
←1<CR><LF>	

BURST

This command performs a burst of the specified pulse count. Note: the command is executed only if the laser system is put into Computer (Remote) mode and the laser diode is ON.

Example of how to perform a burst:
1. Set system in remote mode:
   MODE:RMT 1<CR>
2. Select the desired pulse count per burst (e.g., 100):
   BURST:CNTS 100 <CR>
3. Switch laser on: ON<CR>
4. Launch a burst: BURST<CR>
5. Launch next burst: BURST<CR>

External Power Supply

READ:PSUPPLY:CURR:EXT?

This query retuns the current supplied by the external power supply. It may be used to check the proper operation of a customer-supplied power supply

Unit: A (amps)

Example:

←READ:PSUPPLY:CURR:EXT?<CR>	What is the actual current supplied by the external power supply?
→5<CR><LF>	The current supplied by the external power supply is 5.0 A.

READ:PSUPPLY:VOLT:EXT?

This query retuns the voltage supplied by the external power supply. It may be used to check the proper operation of a customer-supplied power supply.

Unit: V (volts)

Example:

←READ:PSUPPLY:VOLT:EXT?<CR>	What is the actual external supply voltage?
→35<CR><LF>	The voltage on the external power supply is 35.0 volts.

Serial Commands and Queries (listed alphabetically)

BURST

This command performs a burst of the specified pulse count. Note: the command is executed only if the laser system is put into Computer (Remote) mode and the laser diode is ON.

Example of how to perform a burst:

1. Set system in remote mode:
   MODE:RMT 1<CR>
2. Select the desired pulse count per burst (e.g., 100):
   BURST:CNTS 100 <CR>
3. Switch laser on: ON<CR>
4. Launch a burst: BURST<CR>
5. Launch next burst: BURST<CR>

BURST:CNTS <n>
BURST:CNTS?

This command sets the number of pulses issued at next BURST command using the currently active pulse repetition rate.
Unit: cnts

Range <n>: $0 \leq n \leq 4{,}294{,}967{,}295$
n = 0 disables Burst mode

Examples:

←BURST:CNTS 100<CR>
→<CR><LF> Set burst count to 100 counts.
←BURST:CNTS?<CR>
→100cnts<CR><LF>

←BURST:CNTS 0<CR>
→<CR><LF> Burst mode is disabled.

BURST:SYNC <n>
BURST:SYNC?

This command sets synchronize-over-burst mode.

Range <n>: n = 1: span sync pulse over burst duration
n = 0: sync pulse will have standard duration

Examples:

←BURST:SYNC 1<CR> Span sync pulse over burst duration.
→<CR><LF>

→BURST:SYNC?<CR>
←1<CR><LF>

CONFIG:APORT:POLAR <n> CONFIG:APORT:POLAR?

This command sets the polarity of the ANALOG interface lines (refer to Table B-3 to see which pins are affected).

Range <n>: 0 – 511

Individual bit position = 1: line is high active (rising edge)
Individual bit position = 0: line is low active (falling edge) (default)

Examples:

←CONFIG:APORT:POLAR 96<CR>	Set the polarity of pins *EXTERNAL_DIODE_ON* and *STANDBY* to high-active.
→<CR><LF>	
←CONFIG:APORT:POLAR?<CR>	Which pins are set to high-active?
→96<CR><LF>	Pins *EXTERNAL_DIODE_ON* and *STANDBY* are set to high-active.

CONFIG:PARSET:ACT?

This command reads the active parameter set number (refer to Table B-5 User Parameters).

Range <n>: 1 – 10

Example:

←CONFIG:PARSET:ACT?<CR>	Which parameter set is currently being used?
→1<CR><LF>	Set #1 is currently being used.

CONFIG:PARSET:BOOT <n> CONFIG:PARSET:BOOT?

This command designates the parameter set, indicated by number, to be loaded at next start-up (refer to Table B-5 User Parameters). The query returns the parameter set to be loaded at next startup.

Range <n>: 1 – 10

Examples:

←CONFIG:PARSET:BOOT 1<CR>	Load parameter set #1 at start-up.
→<CR><LF>	
←CONFIG:PARSET:BOOT? <CR>	Which parameter set will load at start-up?
→1<CR><LF>	Parameter set #1 will load at start-up.

Note: In order to activate this change for the next boot sequence, this global parameter has to be stored as one of the user parameter sets. Otherwise it will be lost after the power cycle, and the system will boot with the old parameter set.

CONFIG:PARSET:LOAD <n>

This command loads 1 of 10 actual parameters sets from parameter set #<n> (including the global parameter set). Refer to Table B-5 User Parameters and to Table B-x: Global Parameters.

Range <n>: 0 … 10
n = 0: factory parameter
n = 1: user parameter set #1
…
n = 10: user parameter set #10

Example:
←CONFIG:PARSET:LOAD 1<CR> Load the parameter set from user set #1.
→<CR><LF>

CONFIG:PARSET:STOR <n>

This command stores actual parameters as parameter set #<n> (including the global parameter set) for up to 10 sets. Refer to Table B-5 User Parameters and to Table B-x: Global Parameters.

Range <n>:
n = 1: user parameter set #1
…
n = 10: user parameter set #10

Example:
←CONFIG:PARSET:STOR 1<CR> Store the current adjusted value set in user set #1.
→<CR><LF>

CONT:AUTOON <n>
CONT:AUTOON?

This command sets the Auto-on feature of the laser system.
n = 1: enables Auto-on mode: The ON command starts laser emission **without** a keyswitch reset (i.e., turning the key OFF and ON).
n = 0: disables Auto-on mode. After the system is booted or after a critical error, a keyswitch reset (i.e., turning the key OFF and ON) is necessary to start laser emission with the ON command.

CONT:PENER <n_1>,<n_2>,<n_3>

This command starts an automatic pulse energy adjustment. The setting procedure lasts about 10 seconds.

<n_1> the requested pulse energy, in µJ

<n_2> pulse repetition rate (PRF) for which the adjustment is to be executed (see Table B-1 for the valid PRF range).

<n_3> determines if the automatically adjusted parameters are stored or not after completion of the setting procedure.

n_3 = 0: The diode laser current is set to the adjusted current but not saved to the internal EEPROM. These settings can be manually stored by the user (*CONFIG:PARSET:STOR <n>*). This requires that the laser emission is disabled.

n_3 = 1 … 10: The settings are automatically stored in the user set #1, set#2 etc.

Note 1: The command is rejected if the laser is not switched on. During the adjustment procedure, queries about the diode current, pulse repetition frequency and temperatures are not valid.

Note 2: During the adjustment procedure, the status may be found by using the query *STAT:COND:EVEN?* and then checking if bit 6 ("Pusle Energy Setting Busy") is activated.

CONT:PENER 0	stops a launched adjustment procedure
Examples:	
←CONT:PENER 20,80000,1<CR>	Set the pulse energy to 20 µJ @ 50 kHz. After completion, the found parameters (diode current) are stored in the user parameter set #1.
→<CR><LF>	
←CONT:PENER 10,30000,1<CR>	Set the pulse energy to 10 µJ @ 30 kHz
→?<CR><LF>	The request was denied because 30 kHz is outside the valid PRF range.

CONT:PENER?

This query returns the result of an automatic pulse energy adjustment.

The response is two combined values separated by a comma, <f>,<f>, that yields the diode current (in Amps) and adjusted pulse energy (in µJ). If the adjustment procedure fails, the query returns "?;<n>" where <n> contains a number that indicates the reason for the failure:

- n = 1 stopped by user
- n = 2 maximum iteration count exceeded
- n = 3 internal communication fault
- n = 6 measured pulse energy is 0 µJ

Example:

←CONT:PENER?<CR>	What is the result of the automatic pulse energy adjustment?
→14.9A1,20µJ<CR><LF>	Diode laser current is 14.9 A and output energy is 20 µJ.

CONT:SHG:TEMP <n>
CONT:SHG:TEMP?
CONT:THG:TEMP <n>
CONT:THG:TEMP?

These commands set the SHG or THG temperature in counts and are only available in service mode. These queries are available in user mode and return the SHG or THG temperature setting in counts. If your system has a THG, substitute THG for SHG in the examples below.

Range: $100 \leq n \leq 4000$
Unit: cnts (counts)

Examples:

←CONT:SHG:TEMP 1650<CR>	Set the SHG temperature to 1650 counts.
→<CR><LF>	
←CONT:SHG:TEMP?<CR>>	What is the SHG temperature setting?
→1650cnts<CR><LF>	The SHG temperature setting is 1650 counts.

DIOD1:CURR <f>
DIOD1:CURR?

This command sets the diode laser current in Amps. The query returns the present diode laser current setting.

Standby current value $\leq f \leq$ maximum diode laser current value, in Amps (i.e., the value returned by *DIOD1:MAXC?*), in the form xx.xx. Commands with values outside this range are rejected. The minimum current that can be commanded is the standby current (default is 5 A).

Unit: A1

Examples:

←DIOD1:CURR 24<CR>	Set the diode laser current to 24 Amps.
→<CR><LF>	
←DIOD1:CURR?<CR>	What is the diode laser current setting?
→24A1<CR><LF>	The diode laser current is set to 24 Amps.

DIOD1:MAXC?

This query returns the diode laser current limit in Amps. The diode current limit is set at the factory.

Unit: A1

Example:

←DIOD1:MAXC?<CR>	What is the diode laser current limit setting?
→30A1<CR><LF>	The diode laser current limit setting is 30 A.

DIOD1:STANDBYC?

This query returns the diode laser standby current in Amps. The standby current value is set at the factory.

Example:

←DIOD1:STANDBYC?<CR>	What is the diode laser standby current?
→5A1<CR><LF>	Diode laser standby current is 5 A.

DIOD1:TEMP <f>
DIOD1:TEMP?

This command sets the diode laser temperature in °C. This command is only available in service mode. The query is available in user mode and returns the diode laser temperature setting.

Range: $18.0 \leq f \leq 38.0$
Unit: degC

Examples:

←DIOD1:TEMP 29.2<CR>	Set the diode laser temperature to 29.2°C.
→<CR><LF>	
←DIOD1:TEMP? <CR>	What is the diode laser temperature setting?
→29.2degC<CR><LF>	The diode laser temperature setting is 29.2°C

FPS:DELAY <n>
FPS:DELAY?

This command sets the FPS delay time to <n> ns. The smallest value is 50 ns. The maximum value is 400000 ns.

Range <n>: $0 \leq n \leq 4000$
n = 0 disables FPS

Note : FPS mode may not be activated if External Triggering mode is turned on.

Unit: µsec

Examples:

←FPS:DELAY 67800<CR>	Set FPS delay to 67.8 µs.
→<CR><LF>	
←FPS:DELAY?<CR>	FPS delay is set to 67.8 µs.
→67800<CR><LF>	
←FPS:DELAY 0<CR>	Disable FPS.
→<CR><LF>>	

HEAD:BAS:TEMP:MAX?

This indicates the warning level of the laser head base plate temperature in degrees C. An over-temperature warning will be issued if the temperature rises above this maximum, and a safety shutdown occurs if the temperature rises 5°C above the warning level.

Example:
←HEAD:BAS:TEMP:MAX?<CR>
→40<CR><LF>

HEAD:FANCONT:MODE <n>
HEAD:FANCONT:MODE?

This command sets the operation mode of a connected fan either to Control mode, where the base plate temperature is regulated to the adjusted set point (refer to command HEAD:FANCONT:TEMP <f>), or to Drive mode, which provides a constant but adjustable voltage.

Range <n>: n = 1: control mode (default)
n = 0: drive mode

Examples:
←HEAD:FANCONT:MODE 1<CR>
→<CR><LF>

←HEAD:FANCONT:MODE?<CR>
→1<CR><LF>

HEAD:FANCONT:PVOLT <f> HEAD:FANCONT:PVOLT?

This command sets the fan voltage in percent of the maximum voltage of 12 V if the fan operation mode is set to Drive mode. The command is rejected if the fan operation mode is set to Control mode.
Range <f>: 0 – 100 %
Unit: %

Examples:
←HEAD:FANCONT:PVOLT 50.0<CR> Set the fan voltage to 50% (6.0 Volt).
→<CR><LF>

←HEAD:FANCONT:PVOLT?<CR>
→50%<CR><LF>

HEAD:FANCONT:TEMP <f> HEAD:FANCONT:TEMP?

This command sets the temperature set point for the fan control (the setting has no effect if no fan is connected). The command is rejected if the fan operation mode is set to Drive mode.

Range <f>: 18.0 degC ≤ f ≤ 34.0 degC
Unit: degC

Examples:
←HEAD:FANCONT:TEMP 33.5<CR>
→<CR><LF>

←HEAD:FANCONT:TEMP?<CR>
→33.5degC<CR><LF>

*IDN?

This query returns the product identification string as a four comma-separated field: manufacturer, model, serial number, firmware version (laser head/power supply). If the laser head controller does not communicate with the power supply controller, the laser head firmware version is replaced by "-999".

Examples:
←*IDN <CR> Send the product identification string.
Typical response:
→SPECTRA-PHYSICS,EXPLORER-532-5000-300KE,SV-1234-B62-ENG,SV-0015-C61-ENG,V0.9.1.37/V0.9.2.94 <CR><LF>

If the laser head communication fails:
→SPECTRA-PHYSICS,EXPLORER-532-5000-300KE,SV-1234-B62-ENG,-999/V0.9.2.94 <CR><LF>

```
MODE:RMT  <n>
MODE:RMT?
```

This command enables (n = 1) or disables (n = 0) Computer (remote) mode. When n = 0, the system is in Local (or analog) mode. The query returns the current setting. Computer mode must be enabled in order to turn the laser on or off via the RS232 serial port.

Examples:

←MODE:RMT 1<CR>	Places the system in Computer mode. The laser is turned on by sending the *ON* command.
←MODE:RMT 0<CR>	Places the system in Local (or analog) mode. The laser is turned on by using the EXTERNAL_DIODE_ON line (pin 10) of the ANALOG I/O interface.
←MODE:RMT?<CR>	What mode is the system set to?
→0<CR><LF>	The system is set to Local mode.

```
MODE:SLEEP <n>
MODE:SLEEP?
```

This command activates/deactivates Sleep mode. In Sleep mode, the Q-switch and the TECs for controlling the temperatures of the harmonic crystals and diode laser are turned off.

Range <n>: n = 1: Sleep mode on
n = 0: Sleep mode off

Note: in Sleep mode, all commands besides status queries are rejected.

Examples:

←MODE:SLEEP 1<CR> →<CR><LF>	Activate Sleep mode.
←MODE:SLEEP?<CR> →1<CR><LF>	Sleep mode is activated.

```
MODE:STBY <n>
MODE:STBY?
```

This command enables/disables the Standby mode for the diode laser (refer to "Setting the Laser to Standby Modes" in Chapter 7 for a description of Standby mode). The query returns the present status.

Range <n> where:

n = 1	enables standby mode
n = 0	disables standby mode and turn laser on again (if previously switched on)

Example:

←MODE:STBY 1<CR>	Enable Standby mode.
←MODE:STBY?<CR>	What is the Standby mode setting?
→1<CR><LF>	The system is currently set to standby mode)

OFF

This command turns the diode laser off.

Example:
←OFF<CR>

ON

This command turns the diode laser on. The *Explorer XP* laser emission starts after a security delay of 3 seconds (the emission indicator turns on immediately).

Example:
←ON<CR>

PCUR <f> PCUR?

This command sets the diode laser current as a percentage of the difference of the maximum current limit (returned by *DIODE1:MAXC?)* and the standby current (returned by *DIOD1:STANDBYC?).* The query returns the present set value for *PCUR*.

Unit: %1

Examples:

←PCUR 34.6<CR>	Set *PCUR* to 34.6%.
→<CR><LF>	
←PCUR?<CR>	What is the value of *PCUR*?
→34.6%1<CR><LF>	The *PCUR* value is set to 34.6%

PENER:CALF?

This query returns the calibration factor that is used to convert the pulse energy ADC counts (0 – 1023) returned by *READ:PENER:HIST?* to the displayed microjoule values. The calibration factor is set at the factory.

Unit: µJ/cnt

Example:

←PENER:CALF?<CR>	What is the conversion factor?
→0.5234µJ/cnt<CR><LF>	The conversion factor is 0.5234 µJ/count.

PENER:REFVOLT:CNTS <n>
PENER:REFVOLT:CNTS?

This command modifies the reference voltage of the pulse energy ADC. It may be used to re-calibrate the displayed pulse energy to match the values read at the user's energy meter. Higher reference voltage counts result in lower pulse energy values.

Range <n>: 200 – 1023
Unit: cnts (counts)

Examples:

←PENER:REFVOLT:CNTS 456<CR>	Change the reference voltage to 456 counts.
→<CR><LF>	
←PENER:REFVOLT:CNTS?<CR>	What is the reference voltage in counts?
→456cnts<CR><LF>	The reference voltage is 456 counts.

POW:PD:CALF <f>
POW:PD:CALF?

This command sets the calibration for average power measurement. The query returns the calibration factor that is used to convert the photodiode voltage to the displayed laser power value (e.g., 2.5W/V).

Unit: W/V (Watts per Volt)

Example:

← POW:PD:CALF 1.23W/V	Set the calibration value to be used to measure power.
←POW:PD:CALF?<CR>	What is the calibration value to be used to measure power?
→1.23W/V<CR><LF>	The calibration value to be used to measure power is 1.23 W/V.

QSW:PRF <n>
QSW:PRF?

This command sets the Q-switch repetition frequency in Hertz.
The query returns the current value.

Range: 0, minimum pulse repetition frequency ≤ n ≤ maximum pulse repetition frequency (i.e., the value returned by *QSW:PRF:MIN?* and *QSW:PRF:MAX?* respectively).

n = 0 disables internal pulse triggering and allows external triggering.

Note: External triggering mode may not be activated if First Pulse Suppression (FPS) mode is switched on.

Unit: Hz

Table B-1 lists the PRF range for *Explorer XP* models.
Examples:

←QSW:PRF 80000<CR>	Set the pulse frequency to 80000 Hz.
→<CR><LF>	
←QSW:PRF?<CR>	What is the Q-switch repetition frequency?
→80000Hz<CR><LF>	The Q-switch repetition frequency is 80000 Hz.
←QSW:PRF 0<CR>	Set the system to external triggering mode.
→<CR><LF>	

QSW:PRF:MAX?

This query returns the maximum pulse repetition frequency.

Unit: Hz

Table B-1 lists the maximum pulse repetition frequencies for the *Explorer XP* models.

Examples:

←QSW:PRF:MAX?<CR>	What is the maximum pulse repetition frequency?
→300000Hz<CR><LF>	Maximum pulse repetition frequency is 300000 Hz.

QSW:PRF:MIN?

This query reads the minimum pulse repetition frequency.

Unit: Hz
Table B-1 lists the minimum pulse repetition frequencies for the Explorer XP models.

Example:

←QSW:PRF:MIN?<CR>	What is the minimum pulse repetition frequency?
→60000Hz<CR><LF>	The minimum pulse repetition frequency is 6000 Hz.

READ:DIOD1:CURR?

This query returns the actual diode laser current in Amps.

Unit: A1

Example:

←READ:DIOD1:CURR?<CR>	What is the actual diode current in Amps?
→23.9A1<CR><LF>	Actual diode current is 23.9 A.

READ:DIOD1:HOUR?

This query returns the diode laser operating hours. Diode laser operating hours are incremented every 6 minutes (0.1 hour) that the diode laser is turned on (in Emission mode) or in Standby mode.

Unit: HrsD1

Example:

←READ:DIOD1:HOUR?<CR>	How many hours has the laser diode been turned on?
→234.8HrsD1<CR><LF>	The diode laser has been operated for 234.8 hours.

READ:DIOD1:TEMP?

This query reads the actual laser diode temperature in degrees C.

Unit: degC

Example:

←READ:DIOD1:TEMP? <CR>	What is the actual temperature of the laser diode?
→29.2degC<CR><LF>	Actual laser diode temperature is 29.2°C.

READ:FAULT?

This query returns the fault code (refer to Table C-3). 0 means there are no errors.

Example:

←READ:FAULT?<CR>	Is there a fault and, if so, what is it?
→12<CR><LF>	The user interlock has been activated.

READ:FAULT:HIST?

This command reads the history buffer, which consists of up to 16 status codes activated after the most recent startup (refer to Table C-3). Entries are separated by blanks.

Example:

←READ:FAULT:HIST?<CR>
→0 12 24 13 12 23 24 25 12<CR><LF>

READ:FAULT:LIST?

This command reads a string of up to 16 status codes which are currently active (refer to Table C-3). Entries are separated by blanks. 0 means there are no errors.

Example:

←READ:FAULT:LIST?<CR>
→12 23 24 25<CR><LF>

READ:HEAD:BAS:TEMP?

This command reads the temperature of the laser head base plate in degrees C.
Unit: degC

Example:
←READ:HEAD:BAS:TEMP?<CR>
→34.5<CR><LF>

READ:PCUR?

This query returns the actual diode laser current in % of the difference between the diode current limit and the standby current.

Unit: %1

Example:

←READ:PCUR?<CR>	What is the actual diode laser current in % of the difference between the diode current limit and the standby current?
→67.6%1<CR><LF>	Actual diode laser current is 67.6%.

READ:PENER?

This command reads the actual pulse energy in µJ.

Unit: µJ

Example:

←READ:PENER?<CR>	What is the actual pulse energy?
→21µJ<CR><LF>	Actual pulse energy is 21 µJ.

READ:PENER:HIST?

This query returns the energy values of the first 50 pulses after switching on or after the last read-out of the pulse history. The values are given in ADC counts (0 – 1023) and are separated by blank spaces. Pulse energy in µJ may be calculated by multiplying by the numbers returned by the calibration factor (the output of query *PENER:CALF?*)

Examples :

←READ:PENER:HIST?<CR>	What are the energy values, in counts, for the last 50 pulses?
→455 772 781 776 … 776 778 773<CR><LF>	(These are the energy values for the last 50 pulses.)
←READ:PENER:HIST?<CR>	What are the energy values, in counts, for the last 50 pulses?
→0<CR><LF>	No pulses have been emitted yet.

READ:POW?

This command reads the actual laser power in Watts with one decimal place (e.g., 4.9W<CR><LF>).

Unit: W

Example:

← READ:POW?<CR>	What is the actual laser output power?
→ 5.0W<CR><LF>	Laser output power is 5 W.

READ:PSUPPLY:CURR:EXT?

This query retuns the current supplied by the external power supply. It may be used to check the proper operation of a customer-supplied power supply

Unit: A (amps)

Example:

←READ:PSUPPLY:CURR:EXT?<CR>	What is the actual current supplied by the external power supply?
→5<CR><LF>	The current supplied by the external power supply is 5.0 A.

READ:PSUPPLY:HOUR?

This query returns the power supply pc board hours. Power supply pc board hours are incremented every 6 minutes (0.1 hour) that power is supplied to the power supply pc board.

Unit: HrsPS

Example:

←READ:PSUPPLY:HOUR?<CR>	How many hours has the power supply pc board been on?
→478.7HrsPS<CR><LF>	The power supply pc board has been supplied with power for 478.7 hours.

READ:PSUPPLY:VOLT:EXT?

This query retuns the voltage supplied by the external power supply. It may be used to check the proper operation of a customer-supplied power supply.

Unit: V (volts)

Example:

←READ:PSUPPLY:VOLT:EXT?<CR>	What is the actual external supply voltage?
→35<CR><LF>	The voltage on the external power supply is 35.0 volts.

READ:QSW:CNTS?

This command reads the pulse counter in megacounts.
Unit: Mcnts

Examples:

←READ:QSW.CNTS?<CR>	How many pulses have there been since the last pulse count reset?
→34.4Mcnts<CR><LF>	The system has issued 34,400,000 pulses.

READ:SHG:TEMP?
READ:THG:TEMP?

These queries retun the measured SHG or THG temperature in counts.
Unit: cnts (counts)

Example:

←READ:SHG:TEMP?<CR>	What is the actual SHG temperature?
→1649cnts<CR><LF>	The actual SGH temperature is 1649 counts.

STAT:APORT:SIGNAL?

This query returns the status of the ANALOG I/O interface pins. Use this query to find the activity level of the individual signals applied to the ANALOG I/O port (refer to Table B-5).

Individual bit position = 1: signal on pin is active
Individual bit position = 0: signal on pin is not active

Example:

←STAT:APORT:SIGNAL?<CR>	What is the status of the lines of the ANALOG I/O port?
→64<CR><LF>	The Standby line is active.

STAT:COND:CMD?

This command reads the status of the last command (refer to Table C-2).

Example:

←STAT:COND:CMD?<CR>	
→0<CR><LF>	The last command was successfully completed.

STAT:COND:EVEN?

This command reads system events status (refer to Table C-2).

Example:

←STAT:COND:EVEN?<CR>	
→4<CR><LF>	Keyswitch is in OFF position.

STAT:COND:OPER?

This command reads system operational status (refer to Table C-2).

Example:
←STAT:COND:OPER?<CR>
→8<CR><LF> System is in Sleep mode.

STAT:COND:SYST?

This command reads the system status (refer to Table C-2).

Example:
←STAT:COND:SYST?<CR>
→2<CR><LF>> There is a laser head fault.

STAT:COND:SYST:APORT?

This command reads analog interface status (refer to Table C-2).

Example:
←STAT:COND:SYST:APORT?<CR>
→1<CR><LF> Missing EXTERNAL_DIODE_ON signal.

STAT:COND:SYST:FAN?

This command reads system fan status (refer to Table C-2).

Example:
←STAT:COND:SYST:FAN?<CR>
→2<CR><LF> Diode laser current control error.

STAT:COND:SYST:HEAD?

This command reads laser head status (refer to Table C-2).

Example:
←STAT:COND:SYST:HEAD?<CR>
→1<CR><LF> There was a communication error with the laser head.

STAT:COND:SYST:PARSET?

This command reads data administration status (refer to Table C-2).

Example:
←STAT:COND:SYST:PARSET?<CR>
→16<CR><LF> An error occurred while loading the user parameter set.

STAT:COND:SYST:PSUPPLY?

This command reads power supply PCB status (refer to Table C-2).

Example:
←STAT:COND:SYST:PSUPPLY?<CR>
→1<CR><LF> There is an overtemp condition on the power supply board.

STAT:COND:SYST:TCONT?

This command reads temperature controller status (refer to Table C-2).

Example:
←STAT:COND:SYST:FAN?<CR>
→1<CR><LF> PWM controller for diode laser temperature failed.

*STB?

This command reads the system status byte (refer to Table C-1).

Example:
←*STB?<CR>
→1<CR><LF> Laser emission is present.

SYST:COMM:SER:BAUD <n> SYST:COMM:SER:BAUD?

This command sets the communication speed (BAUD rate) between the *Explorer XP* and the user's control computer. The query returns the present BAUD rate setting. At startup the system uses the BAUD rate that is stored in the global configuration.

Range n = 4800, 9600, 14400, 19200, 28800, 38400, 57600, 115200 bps (bits per second).

Examples:
←SYST:COMM:SER:BAUD 14400<CR> Set the BAUD rate to 14,400 bps.
←SYST:COMM:SER:BAUD?<CR> What is the BAUD rate set to?
→14400bps<CR><LF> The BAUD rate is set to 14,400 bps.

WDOG <n>
WDOG?

This command sets the software watchdog alert time, in seconds. This is the watchdog timer for RS-232 communication between the laser system and the host computer. If the *Explorer XP* has not received commands from the user's computer within the specified time, laser emission will turn off. The query returns the present setting.

Range <n> where n = 0 to 110, and n = 0 disables the watchdog timer (default). Values of 3 to 10 seconds would be typical. Values of 3 to 10 seconds would be typical.

Unit: sec

←WDOG 10<CR> →<CR><LF>	Set the alert time to 10 seconds.
←WDOG 0<CR> →<CR><LF>	Disable the software watchdog.
←WDOG? <CR> 0<CR><LF>	What is the watchdog setting? The software watchdog has been disabled.

Table B-1: Ranges for Automatic Energy Adjustment[1]

	Min. Pulse Repetition Frequency	Max. Pulse Repetition Frequency	Voltage at Analog Port Pin 1 / Output Power
Explorer XP Model	**[Hz]**	**[Hz]**	
EXPL-XP 532-5W[2]	60000	300000	25 µJ/V

*[1] If the requested combination of pulse energy and pulse repetition frequency is not within the power budget of the system, the command CONT:PENER <n1>,<n2>,<n3> will not be rejected but the diode current seek process will fail. Therefore, the result of the query CONT:PENER? **after** the seek process has stopped (monitor bit 6 of status byte STAT:COND:EVEN?) will be "?".*
[2] For other Explorer XP models, refer to the "Explorer XP Model Description" document.

Table B-2: Status /Error Reporting Commands

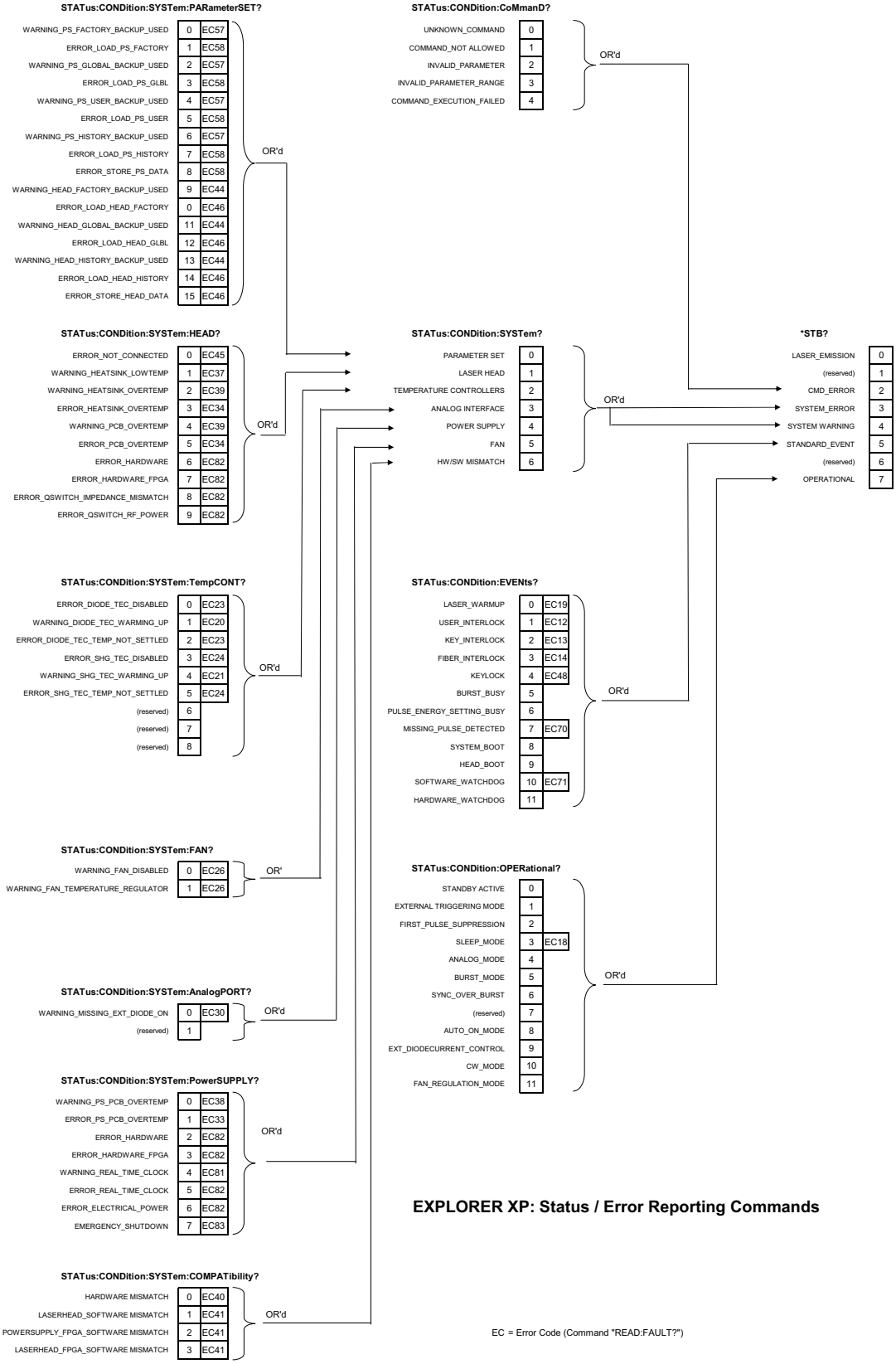


Table B-3: Analog Port Polarity Configuration Bits

Bit	Description / Signal	Default Setting *
0	Sync out	Low-active (falling edge)
1	Pulse monitor	Low-active (falling edge)
2	External trigger	Low-active (falling edge)
3	External gate	Low-active
4	(reserved)	N/A
5	External standby	Low-active
6	External diode on	Low-active (falling edge)
7	(reserved)	N/A
8	External diode current source	Low-active

** Polarity/active level can be changed using the serial command: CONFIG:APORT:POLAR <n>*

Examples:
To set the polarity of the "External trigger" pin to "rising edge" while keeping all other polarities to defaults, the command to change the polarity is CONFIG:APORT:POLAR 4 (bit 2 $\rightarrow 2^2$).

To set both the polarity of the "External trigger" pin and of the "External Gate" pin to "rising edge" while keeping all other polarities to defaults, the command to change the polarity is CONFIG:APORT:POLAR 12 (bit 2 + bit 3 $\rightarrow 2^2 + 2^3 = 4 + 8 = 12$).

Table B-4: Analog Port Signal Status Bits

Bit	Description	Bit is high …
0	External diode current source	if pin 18 (ILD_SOURCE) is active*
1	(reserved)	N/A
2	External trigger	if pin 21 (EXT_TRIG) is active*
3	External gate	if pin 17 (EXT_GATE) is active*
4	(reserved)	N/A
5	External standby	if pin 15 (STANDBY) is active*
6	External diode on	if pin 10 (EXT_DIODE_ON) is active*
7	(reserved)	N/A

** Active low or high depends on ANALOG port polarity configuration*

Table B-5: User Parameters

The parameters in this table comprise a user parameter set. Two different sets can be defined and stored as "User Set #1" and "User Set #2."

Parameter Description	Command to Modify Parameter
SHG temperature	CONT:SHG:TEMP <n>
THG temperature	CONT:THG:TEMP <n>
Diode temperature	CONT:DIOD1:TEMP <f>
Diode current	DIOD1:CURR <f> or PCUR <f>
Pulse repetition frequency	QSW:PRF <n>
Operating mode for fan (heat sink)	HEAD:FANCON:MODE <n>
Set temperature for fan in control mode	HEAD:FANCON:TEMP <f>
Voltage percent for fan in drive mode	HEAD:FANCON:PVOLT <f>
Analog port signal polarity	CONFIG:APORT:POLAR <n>
Burst counts	BURST:CNTS <n>
First-Pulse-Suppression delay time	FPS:DELAY <n>
Alert time for software watchdog	WDOG <n>
Auto-on mode	MODE:AUTOON <n>
Computer (Remote) mode	MODE:RMT <n>
Sync pulse spanned over burst	BURST:SYNC <n>

Table B-6: Global Parameters

Global parameters are stored if a user set is stored (with the command CONFIG:STOR <n>).

Parameter Description	Command to Modify Parameter
Pulse energy reference voltage counts	PENER:REFVOLT:CNTS <n>*
Average power reference voltage counts	POW:REFVOLT:CNTS <n>*
Baud rate for serial communication	SYST:COMM:SER:BAUD <n>
User parameter set # that is active at system start-up	CONFIG:PARSET:BOOT <n>

**All XP models have both independent measurements, which have to be calibrated separately using the above commands.*

Table B-7: Serial Commands: Command Access Restrictions

		Analog Mode (Local Mode)	Laser Switching on	Laser Emission	Laser OFF	Laser Standby	External Standby On	SLEEP Mode	BURST Mode	BURST BUSY	BURST Mode disabled	FPS enabled	Constant Energy Mode	Constant Energy Mode disabled	INTERNAL triggering mode	EXTERNAL triggering mode	External Diode Current Mode	Pulse Energy Setting busy	Laser Warm-up	Laserhead Not Connected	Hardware / Software Incompat.	Critical Error
System Identification																						
*IDN?	read system identification string	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Serial Communication: Baudrate																						
SYST:COMM:SER:BAUD <n>	set baudrate for user communication via RS232	✓	✗	✗	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓
SYST:COMM:SER:BAUD?	read baudrate for user communication via RS232	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓
Remote (Computer) or Analog Interface Mode																						
MODE:RMT <n>	place system in remote (computer) or analog interface mode	✓	✗	✗	✓	✓	✓	✗	✓	✗	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓	✗	✓
MODE:RMT?	read actual remote mode setting	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓
Laser Diode Current																						
DIOD1:CURR <f>	Set diode current	✓	✓	✓	✓	✓	✓	✗	✓	✗	✓	✓	✓	✓	✓	✓	✗	✗	✓	✓	✗	✓
DIOD1:CURR?	return the last commanded diode current	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✓	✓	✗	✓
READ:DIOD1:CURR?	return the actual diode current	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓	✗	✓
PCUR <f>	set diode current to <f> % of maximum current	✓	✓	✓	✓	✓	✓	✗	✓	✗	✓	✓	✓	✓	✓	✓	✗	✗	✓	✓	✗	✓
PCUR?	return the last commanded diode current in % of the maximum current	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✓	✓	✗	✓
READ:PCUR?	return the actual diode current in % of the maximum current	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓	✗	✓
DIOD1:MAXC?	return adjusted diode maximum current	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓
DIOD1:STANDBYC?	return adjusted diode standby current	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓
Pulse Repetition Rate / Q-Switch Timing																						
QSW:PRF <n>	set pulse repetition frequency, in Hz	✓	✓	✓	✓	✓	✓	✗	✓	✗	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓	✗	✓
QSW:PRF 0	set external trigger mode	✓	✓	✓	✓	✓	✓	✗	✗	✗	✓	✓	✗	✓	✓	✓	✓	✗	✓	✓	✗	✓
QSW:PRF 1000000	set CW mode	✓	✓	✓	✓	✓	✓	✗	✗	✗	✓	✓	✗	✓	✓	✓	✓	✗	✓	✓	✗	✓
QSW:PRF?	read last commanded pulse repetition frequency	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓
READ:QSW:PRF?	read programmed (timer) pulse repetition frequency	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓
QSW:PRF:MIN?	return actual lower pulse repetition frequency limit	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓
QSW:PRF:MAX?	return actual pulse repetition frequency limit	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓
Diode / Xtal Temperatures																						
CONT:SHG:TEMP?	read last commanded SHG crystal temperature in DAC counts	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓
CONT:THG:TEMP?	read last commanded THG crystal temperature in DAC counts	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓
READ:SHG:TEMP?	read actual SHG crystal temperature (control loop), in ADC counts	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓
READ:THG:TEMP?	read actual THG crystal temperature (control loop), in ADC counts	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓
DIOD1:TEMP?	read last commanded diode temperature	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓
READ:DIOD1:TEMP?	read actual diode temperature (control loop), in deg C)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓
Head Baseplate Temperature / PCB Temperatures																						
READ:HEAD:BAS:TEMP?	read actual laserhead housing temperature	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✓
HEAD:BAS:TEMP:MAX?	read laserhead baseplate temperature limit, in °C (unit:degC)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✓

		Analog Mode (Local Mode)	Laser Switching on	Laser Emission	Laser OFF	Laser Standby	External Standby On	SLEEP Mode	BURST Mode	BURST BUSY	BURST Mode disabled	FPS enabled	Constant Energy Mode	Constant Energy Mode disabled	INTERNAL triggering mode	EXTERNAL triggering mode	External Diode Current Mode	Pulse Energy Setting busy	Laser Warm-up	Laserhead Not Connected	Hardware / Software Incompat.	Critical Error
Laserhead Fan Controller																						
HEAD:FANCONT:TEMP?	return actual set temperature for fan control	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓
HEAD:FANCONT:TEMP <f>	set temperature for fancontrol	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓	×	✓
HEAD:FANCONT:MODE <n>	set operation mode for fan control: control or drive mode (constant voltage)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓	×	✓
HEAD:FANCONT:MODE?	return operation mode for fan control: control or drive mode (constant voltage)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓
HEAD:FANCONT:PVOLT <f>	set fan control voltage (in drive mode) in % (of 12V)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓	×	✓
HEAD:FANCONT:PVOLT?	return fan control voltage (in drive mode) in % (12V = 100%)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓
Pulse Energy																						
READ:PENER?	read actual output pulse energy, in µJ	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓
PENER:CALF?	return the actual pulse energy calibration factor	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓
READ:PENER:HIST?	return a list of pulse energies (50 pulses), in uJ	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓
PENER:REFVOLT:CNTS?	return reference voltage (in counts) for pulseenergy measurement	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓
PENER:REFVOLT:CNTS <n>	set reference voltage (in counts) for pulseenergy measurement	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	×	×	✓
Average Power																						✓
READ:POW?	read actual average pow er, in W	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓
POW:CALF?	return the pow er calibration factor in mW/cnt	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓
POW:PD:CALF <f>	set calibration factor for average pow er (using the photodiode) (in W/v)	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	×	×	✓
POW:PD:CALF?	return calibration factor for average pow er (using the photodiode) (in W/v)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓
POW:REFVOLT:CNTS?	return reference voltage (in counts) for pow er measurement	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓
POW:REFVOLT:CNTS <n>	set reference voltage (in counts) for pow er measurement	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	×	×	✓
Status / Errors																						
READ:FAULT?	read actual error code	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
READ:FAULT:HIST?	read error code history (FIFO list of 16 entries)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
READ:FAULT:LIST?	return list of all active error codes (max. 16)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
*STB?	read status byte	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
STAT:COND:CMD?	read serial command status	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
STAT:COND:SYST?	read system status	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
STAT:COND:EVEN?	read events status	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
STAT:COND:OPER?	read operational condition status	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
STAT:COND:SYST:PARSET?	read parameter set status (load/storage)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
STAT:COND:SYST:PSUPPLY?	read pow ersupply status	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
STAT:COND:SYST:HEAD?	read laserhead system condition	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
STAT:COND:SYST:TCONT?	read temperature controller condition	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
STAT:COND:SYST:APORT?	read analog port condition	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
STAT:COND:SYST:COMPAT?	return hardw are/softw are compatibility status	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
STAT:COND:SYST:FAN?	return fan status	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
History: Pulse Counts, Operating Hours																						
READ:PSUPPLY:HOUR?	read pow er supply ON time	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
READ:QSW:CNTS?	read actual pulse counter	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓
READ:DIOD1:HOUR?	read diode operating hours	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓
Auto-On Feature																						
MODE:AUTOON <n>	set AUTO-ON feature on/off	✓	×	×	✓	✓	✓	×	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓
MODE:AUTOON?	read the AUTO-ON setting	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓

		Analog Mode (Local Mode)	Laser Switching on	Laser Emission	Laser OFF	Laser Standby	External Standby On	SLEEP Mode	BURST Mode	BURST BUSY	BURST Mode disabled	FPS enabled	Constant Energy Mode	Constant Energy Mode disabled	INTERNAL triggering mode	EXTERNAL triggering mode	External Diode Current Mode	Pulse Energy Setting busy	Laser Warm-up	Laserhead Not Connected	Hardware / Software Incompat.	Critical Error
Configuration / Parameter Sets																						
CONFIG:PARSET:BOOT <n>	set user parameter set number to be loaded at start-up	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓
CONFIG:PARSET:BOOT?	return actual boot user parameter set number	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓
CONFIG:PARSET:STOR <n>	store actual parameters as parameter set #<n>	✓	✗	✗	✓	✓	✓	✗	✓	✗	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓	✗	✓
CONFIG:PARSET:LOAD <n>	load parameter set #<n>	✓	✗	✗	✓	✓	✓	✗	✗	✗	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓	✗	✓
CONFIG:PARSET:ACT?	return current parameter user set number	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓
Laser On / Off / Standby																						
ON	turn the laser diode on at the last commanded current	✗	✗	✗	✓	✓	✓	✗	✓	✗	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗	✗
OFF	turn diode off	✗	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓
MODE:STBY <n>	place diode in STANDBY mode	✗	✗	✓	✓	✓	✓	✗	✗	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓
MODE:STBY?	return (computer) standby mode	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓
First Pulse Suppression																						
FPS:DELAY <n>	set the delay time of first pulse suppression to <n> µsecs	✓	✓	✓	✓	✓	✓	✗	✓	✗	✓	✓	✗	✓	✓	✓	✓	✗	✓	✗	✗	✓
FPS:DELAY 0	disable first-pulse-suppression mode	✓	✓	✓	✓	✓	✓	✗	✓	✗	✓	✓	✗	✗	✓	✓	✓	✗	✓	✗	✗	✓
FPS:DELAY?	return delay time of first pulse suppression	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✓
Burst Mode																						
BURST:CNTS <n>	set number of pulses to be issued on next "burst" command / enables/disables burst mode	✗	✓	✓	✓	✓	✓	✗	✓	✗	✓	✓	✗	✓	✓	✗	✓	✗	✓	✗	✗	✓
BURST:CNTS?	return number of set pulses in burst mode	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✓
BURST	perform burst	✗	✗	✓	✗	✗	✗	✗	✓	✗	✓	✓	✓	✓	✓	✗	✓	✗	✓	✗	✗	✗
BURST:SYNC <n>	enable/disable SYNC signal over burst	✗	✓	✓	✓	✓	✓	✗	✓	✗	✓	✓	✓	✓	✓	✗	✓	✓	✓	✗	✗	✓
BURST:SYNC?	return SYNC signal over burst setting	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✓
Analog Interface																						
CONFIG:APORT:POLAR?	return analog port polarity configuration byte	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓
CONFIG:APORT:POLAR <n>	set analog port polarity configuration	✓	✗	✗	✓	✓	✓	✗	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓
STAT:APORT:SIGNAL?	return analog port pin status byte	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓

		Analog Mode (Local Mode)	Laser Switching on	Laser Emission	Laser OFF	Laser Standby	External Standby On	SLEEP Mode	BURST Mode	BURST BUSY	BURST Mode disabled	FPS enabled	Constant Energy Mode	Constant Energy Mode disabled	INTERNAL triggering mode	EXTERNAL triggering mode	External Diode Current Mode	Pulse Energy Setting busy	Laser Warm-up	Laserhead Not Connected	Hardware / Software Incompat.	Critical Error
Software Watchdog																						
WDOG <n>	set the software watchdog alert time <n>=0 disables SW watchdog	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓
WDOG?	return the software watchdog alert time (in seconds)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓
Power-Saving Mode																						
MODE:SLEEP <n>	switch on/off q-switch + TECs	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓	×	✓
MODE:SLEEP?	return sleep status	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓
Pulse Energy Setting																						
CONT:PENER <n>,<n>,<n>	start pulse energy setting procedure (lasts approx. 5 secs)	✓	×	✓	×	×	×	×	✓	×	✓	✓	×	✓	✓	✓	×	×	×	×	×	✓
CONT:PENER 0	stop pulse energy setting procedure (old PRF and diode current are recovered)	✓	×	✓	×	×	×	×	✓	×	✓	✓	×	✓	✓	✓	×	✓	×	×	×	✓
CONT:PENER?	return the result of the pulse energy setting procedure	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	×	×	✓
Real-Time Clock (RTC)																						
SYST:RTC:DTIME?	return adjusted date and time (+ timezone info)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓
SYST:RTCDTIME <s>	set date and time (+ timezone info)	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓
Electrical Power																						
POW:OFF	switch laser system electrically off	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
External Power Supply																						
READ:PSUPPLY:VOLT:EXT?	return external power supply voltage	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
READ:PSUPPLY:CURR:EXT?	return total power supply input current	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		✓		Command is allowed																		
		×		Command is not allowed (a "?" will be returned)																		

Appendix C Operating Status Codes

This appendix contains the following tables:

The query *STB? returns an 8-bit byte that yields the following information about the system status.

Table C-1: System Status Byte

Bit	Description	Bit is activated …
0	Laser emission	if the diode laser is on or is in Standby mode.
1	(reserved)	N/A
2	Command error	if a serial command could not be executed correctly.
3	System error	if a system error is present. (e.g., temperature control, configuration)
4	System Warning	if a system warning is present. (e.g., temperature too low, RTC failure)
5	Event summary	if one or more events have taken place. (e.g., interlocks, system boot, software watchdog)
6	(reserved)	N/A
7	Operational	if one or more system conditions are enabled. (e.g., Standby, external triggering mode, Burst mode)

Table C-2: Operating Status and Error Bits

Bit Active	Description	Condition	Action Required
		Serial Commands Register (Query STAT:COND:CMD?)	
0	UNKNOWN_CMD	Unknown command	Use allowed command from list.
1	CMD_NOT_ALLOWED	Command is not allowed, e.g., *BURST* when Burst mode is not activated.	Prepare system to accept the command (refer to Table B-7).
2	INVALID_PAR	Command was sent using invalid parameter(s): e.g., *DIOD1:CURRENT AB3*.	Make sure valid parameters are used.
3	CMD_FAILED	A communication error with the laser head or an internal bus error occurred.	If the problem persists, contact Spectra-Physics service.
4	INVALID_PAR_RANGE	Command was sent using parameter(s) that are beyond the allowed range: e.g., DIOD1:CURR 32.3, when the maximum diode current is set to 25.0 A.	Make sure valid parameters are used.
		System Condition Register (Query STAT:COND:SYST?)	
0	PAR_SET	There is a problem with the configuration set(s) (communication error, invalid checksums).	Retrieve detailed information by querying the individual configuration set conditions.
1	LASER_HEAD	There is a problem with the laser head (communication error, temperature, etc.).	Retrieve detailed information to pinpoint the cause of the problem.
2	TEMP_CONTROLLER	Temperature controller failure (crystal and/or diode laser)	Query temperature controller conditions.
3	ANALOG_INTERFACE	There is a problem with the analog port pins.	Query analog port conditions.
4	POWER_SUPPLY	There is a problem with the power supply PCB.	Query power supply conditions.
5	FAN	There is a problem with the fan.	Query fan conditions.
6	HARDWARE_SOFTWARE_ MISMATCH	The updated software does not match the hardware found.	Contact Spectra-Physics service.
		System Events Condition Register (Query STAT:COND:EVEN?)	
0	LASER_WARMUP	Laser system is warming up.	No action is required. The laser cannot be switched on.
1	USER_INTERLOCK	The user interlock is activated.	Check the cause of the activated interlock. Reset the keyswitch (if Auto-On mode is disabled).
2	KEY_INTERLOCK	The keyswitch is OFF.	Turn keyswitch to ON position.

Table C-2: Operating Status and Error Bits (Continued)

Bit Active	Description	Condition	Action Required
3	FIBER_INTERLOCK	The laser diode fiber is broken.	Contact Spectra-Physics service.
4	KEY_LOCK	A keyswitch reset is necessary (this condition can only occur if Auto-On mode is disabled).	Reset the keyswitch (turn the key to the OFF position and then to the ON position again).
5	BURST_BUSY	Burst mode is activated and a burst is being carried out.	No action is required. (Check this bit before sending a new BURST command.)
3	SYSTEM_BOOT	Notification: the laser system has been booted.	No action is required by the user (the bit is cleared automatically after a reading).
6	PULSE_ENERGY_SETTING	An automatic pulse energy adjustment is taking place.	No action is required. (Check this bit before sending a new command.)
7	MISSING_PULSE_DETECTED	Notification: a trigger signal did not launch an optical pulse.	No action is required.
8	SYSTEM_BOOT	Notification: the laser system has been booted.	No action is required by the user (the bit is cleared automatically after a reading).
9	HEAD_BOOT	Notification: the laser system has been booted.	No action is required by the user (the bit is cleared automatically after a reading).
10	SOFTWARE_WATCHDOG	The software watchdog for communication between the laser system and the host computer is tripped.	Check the serial communication between your PC software and the power supply PCB. Lengthen the watchdog alert time or disable the software watchdog.
11	HARDWARE_WATCHDOG	The system has rebooted because the hardware watchdog was activated.	Contact Spectra-Physics service.
	System Operational Condition Register (Query STAT:COND:OPER?)		
0	STANDBY	Standby mode is active (was activated by software or by an external analog signal).	No action is required.
1	EXTERNAL_TRIGGER	External triggering mode is activated	Apply a suitable trigger signal to Pin 21 of the ANALOG port.
2	FIRST_PULSE_SUPPRESSION	FPS mode is activated.	No action is required.
3	SLEEP_MODE	Sleep mode is activated (the Q-switch and TECs are switched off). All serial commands besides status queries will be rejected.	To re-enable normal operation, use the *MODE:SLEEP 0* command.
4	ANALOG_MODE	Analog (local) mode is enabled.	To re-enable computer mode, use the *MODE:RMT 1* command.

Table C-2: Operating Status and Error Bits (Continued)

Bit Active	Description	Condition	Action Required
5	BURST_MODE	Burst mode is enabled, i.e., burst count is set to <n> counts.	To perform a burst, enter the BURST command. To disable the burst mode, set the burst mode count to 0.
6	SYNC_OVER_BURST	The SYNC pulse duration is extended to include the whole burst sequence	No action is required.
7	(reserved)		
8	AUTO-ON_MODE	Auto-on mode is enabled (overrides the need for a key-switch reset).	No action is required.
9	EXTERNAL_DIODE_CURRENT_CONTROL	The laser diode current is controlled by a voltage signal applied to Pin 2 of the ANALOG I/O port. To activate analog diode laser control, Pin 18 must be pulled low.	No action is required.
10	(reserved)		
11	FAN_REGULATION_MODE	The supplied fan is operated in Control mode.	No action is required.
	System Condition "Parameter Set" Register (Query STAT:COND:SYST:PARSET?)		
0	WARNING_PS_FACTORY_BACKUP_USED	An error occurred while retrieving the factory-set data from the power supply PCB EEPROM. A backup data set is used.	If the problem persists, contact Spectra-Physics service.
1	ERROR_LOAD_PS_USER	An error occurred while retrieving the actual user parameter set from the power supply PCB EEPROM.	Contact Spectra-Physics service.
2	WARNING_PS_GLOBAL_BACKUP_USED	An error occurred while retrieving the global data from the power supply PCB EEPROM. A backup data set is used.	If the problem persists, contact Spectra-Physics service.
3	ERROR_LOAD_PS_GLOBAL	An error occurred while retrieving the global data from the power supply PCB EEPROM.	Contact Spectra-Physics service.
4	WARNING_PS_USER_BACKUP_USED	An error occurred while retrieving the user data set from the power supply PCB EEPROM. A backup data set is used.	If the problem persists, contact Spectra-Physics service.
5	ERROR_LOAD_PS_USER	An error occurred while retrieving the user data set from the power supply PCB EEPROM.	Contact Spectra-Physics service.

Table C-2: Operating Status and Error Bits (Continued)

Bit Active	Description	Condition	Action Required
6	WARNING_PS_HISTORY_ BACKUP_USED	An error occurred while retrieving the (accumulated) seconds that the power supply PCB has been supplied with power and the laser diode emission seconds. A backup data set is used.	Contact Spectra-Physics service.
7	ERROR_LOAD_PS_HISTORY	An error occurred when retrieving the (accumulated) seconds that the power supply PCB has been supplied with power and the laser diode emission seconds.	Contact Spectra-Physics service.
8	ERROR_STORE_PS_DATA	An error occurred while storing power supply data to the PCB EEPROM.	Contact Spectra-Physics service.
9	WARNING_HEAD_FACTORY_ BACKUP_USED	An error occurred while retrieving the factory-set data from the laser head PCB EEPROM. A backup data set is used.	If the problem persists, contact Spectra-Physics service.
10	ERROR_LOAD_HEAD_ FACTORY	An error occurred while retrieving the factory-set data from the laser head PCB EEPROM.	Contact Spectra-Physics service.
11	WARNING_HEAD_GLOBAL_ BACKUP_USED	An error occurred while retrieving the global data from the laser head PCB EEPROM. A backup data set is used.	If the problem persists, contact Spectra-Physics service.
12	ERROR_LOAD_HEAD_ GLOBAL	An error occurred when retrieving the global data from the laser head EEPROM.	Contact Spectra-Physics service.
13	WARNING_HEAD_HISTORY_ BACKUP_USED	An error occurred while retrieving the (accumulated) pulse counts from the laser head PCB EEPROM. A backup data set is used.	If the problem persists, contact Spectra-Physics service.
14	ERROR_LOAD_HEAD_ HISTORY	An error occurred while retrieving the (accumulated) pulse counts from the laser head PCB EEPROM.	Contact Spectra-Physics service.
15	ERROR_STORE_HEAD_DATA	An error occurred while storing the pulse counts to the laser head EEPROM.	Contact Spectra-Physics service.
System Condition "HEAD" Register (Query STAT:COND:SYST:HEAD?)			
0	ERROR_NOT_CONNECTED	The laser head was not detected by the software.	Contact Spectra-Physics service.

Table C-2: Operating Status and Error Bits (Continued)

Bit Active	Description	Condition	Action Required
1	WARNING_HEATSINK_ LOW_TEMP	The heat sink temperature is below the minimum of 18°C (typical). The laser system remains fully operational.	No action is required.
2	WARNING_HEATSINK_OVERT EMP	The heat sink temperature is above the warning level of 40 °C (typical). The laser system remains fully operational.	Make sure the laser system is properly heatsinked.
3	ERROR_HEATSINK_ OVERTEMP	The laser turned off because the maximum heat sink temperature was exceeded.	Make sure the laser system is properly heatsinked.
4	WARNING_PCB_ OVERTEMP	The temperature of the printed circuit board is above the adjusted warning level. The laser system remains fully operational.	Make sure the laser system is properly heatsinked.
5	ERROR_PCB_OVERTEMP	The laser turned off because the maximum printed-circuit board temperature was exceeded.	Make sure the laser head is properly heatsinked. If the problem persists, contact Spectra-Physics service
6	ERROR_HARDWARE	because a hardware problem was detected (invalid voltage, safety failure etc.)	Contact Spectra-Physics service.
7	ERROR_HARDWARE_FPGA	The laser turned off because a problem with the logic module was detected.	Contact Spectra-Physics service.
8	ERROR_QSWITCH_ IMPEDANCE_MISMATCH	because a problem with the Q-Switch was detected.	Contact Spectra-Physics service.
9	ERROR_QSWITCH_RF_ POWER	The laser turned off because the Q-Switch driver was switched off. This is intentionally done if SLEEP mode is activated.	The error should be cleared if SLEEP mode is disabled using the command MODE:SLEEP 0. Otherwise, contact Spectra-Physics service.
10	(Reserved)		
11	WARNING_HEAD_USER_ CONFIG	1. An error occurred while retrieving the user-set data from the laser head PCB EEPROM. A backup data set was used. 2. An error occurred during storage of the user-set data on the laser head PCB EEPROM.	If the problem persists, contact Spectra-Physics service.
12	ERROR: HEAD_USER_CONFIG	An error occurred while retrieving the user-set data from the laser head PCB EEPROM.	Contact Spectra-Physics service.

Table C-2: Operating Status and Error Bits (Continued)

Bit Active	Description	Condition	Action Required
13	ERROR_EMERGENCY_SHUT DOWN	The laser turned off because a severe hardware failure occurred in the laser head. The system was placed in SLEEP mode and cannot be awaken.	Contact Spectra-Physics service.
System Condition "POWER SUPPLY" Register (Query STAT:COND:SYST:PSUPPLY?)			
0	WARNING_PS_PCB_ OVERTEMP	The temperature of the printed circuit board is above the adjusted warning level. The laser system remains fully operational.	Make sure the laser system is properly heatsinked.
1	ERROR_PS_PCB_OVERTEMP	The laser turned off because the maximum pc board temperature was exceeded.	Make sure the laser system is properly heatsinked. If the problem persists, contact Spectra-Physics service.
2	ERROR_HARDWARE	The laser turned off because a hardware problem was detected (invalid voltage, safety failure etc.)	Contact Spectra-Physics service.
3	ERROR_HARDWARE_FPGA	The laser turned off because a problem with the logic module was detected.	Contact Spectra-Physics service.
4	WARNING_REAL_TIME_ CLOCK	A problem with the Real-Time-Clock was detected. The laser remains fully operational.	No action required.
5	ERROR_REAL_TIME_CLOCK	The laser turned off because of a Real-Time-Clock failure.	Contact Spectra-Physics service.
6	(reserved)		
7	EMERGENCY_SHUTDOWN	The laser turned off because a severe hardware failure condition occurred. The system was placed in SLEEP mode and cannot be awaken.	Contact Spectra-Physics service.
System Condition "TEMPERATURE CONTROLLER" Register (Query STAT:COND:SYST:TCONT?)			
0	ERROR_DIODE_TEC_ DISABLED	The TEC controller of the laser diode was not switched on at start-up.	Contact Spectra-Physics service.
1	WARNING_DIODE_TEC_ WARMING_UP	The TEC controller of the laser diode is busy to reach the setpoint temperature after start-up.	No action required.
2	ERROR_DIODE_TEC_ TEMP_NOT_SETTLED	The TEC controller of the laser diode is busy to reach the setpoint temperature.	If this error is not cleared after a few seconds, contact Spectra-Physics service.

Table C-2: Operating Status and Error Bits (Continued)

Bit Active	Description	Condition	Action Required
3	ERROR_SHG_TEC_DISABLED	The TEC controller of the SHG crystal was not switched on at start-up.	Contact Spectra-Physics service.
4	WARNING_SHG_TEC_ WARMING_UP	The TEC controller of the SHG crystal is busy to reach the setpoint temperature after start-up.	No action required.
5	ERROR_SHG_TEC_ TEMP_NOT_SETTLED	The TEC controller of the SHG crystal is busy to reach the setpoint temperature.	If this error is not cleared after a few seconds, contact Spectra-Physics service.
6	ERROR_THG_TEC_DISABLED	The TEC controller of the THG crystal was not switched on at start-up.	Contact Spectra-Physics service.
7	WARNING_THG_TEC_WARM-ING_UP	The TEC controller of the THG crystal is busy to reach the setpoint temperature after start-up.	No action required.
8	ERROR_THG_TEC_TEMP_ NOT_SETTLED	The TEC controller of the THG crystal is busy to reach the setpoint temperature.	If this error is not cleared after a few seconds, contact Spectra-Physics service.
	System Condition "FAN" Register (Query STAT:COND:SYST:FAN?)		
0	WARNING_FAN_DISABLED	The supplied fan is operating in Drive Mode, the voltage is set below 18% of maximum voltage.	Enhance the fan voltage using the command HEAD:FAN-CONT:PVOLT <n>.
1	WARNING_FAN_TEMP_ REGULATOR	operating in Control Mode, the fan setpoint temperature has not been adjusted by the fan control loop.	No action required.
	System Condition "ANALOG PORT" Register (Query STAT:COND:SYST:APORT?)		
0	MISSING_EXT_DIODE_ON	The laser is in Analog mode. To start laser emission, a signal must be applied to pin 10 of the ANALOG I/O port.	Apply an appropriate signal to pin 10.
	System Condition "COMPATIBILITY" Register (Query STAT:COND:SYST:COMPAT?)		
0	HARDWARE_MISMATCH	The versions of power supply PCB and laser head control PCB do not match.	Contact Spectra-Physics service.
1	LASERHEAD_SOFTWARE_MIS MATCH	The power supply software does not match the laser head software version.	Contact Spectra-Physics service.
2	POWERSUPPLY_FPGA_ SOFTWARE_MISMATCH	The power supply software does not match the logic module software version.	Contact Spectra-Physics service.
3	LASERHEAD_FPGA_ SOFTWARE_MISMATCH	The laser head software does not match the logic module software version.	Contact Spectra-Physics service.

Table C-3: Fault Codes

Code	Description
0	No errors present
12	User interlock open
13	Keyswitch interlock open
14	Fiber interlock open
18	Sleep mode is active
19	Warning Laser system is warming up (system not ready)
20	Warning Laser diode temperature (system not ready)
21	Warning SHG temperature (system not ready)
22	Warning THG temperature (system not ready)
23	Error diode laser temperature
24	Error SHG temperature
25	Error THG temperature
33	Power supply temperature limit exceeded
34	Laser head temperature limit exceeded
35	Hardware mismatch
36	Software mismatch
45	Laser head not connected
46	Laser head EEPROM malfunction
48	Keyswitch reset required (Turn the keyswitch off then back on again)
58	Bad configuration (EEPROM error)
71	Software watchdog
82	Hardware error
83	Emergency shutdown

Table C-4: Non-Critical Fault Codes[1]

Code	Description
26	Warning Fan
30	Waiting for external diode ON signal
37	Warning under temp heatsink
38	Warning over temp power supply
39	Warning over temp laser head
44	Warning laser head bad configuration (EEPROM error)
57	Warning power supply bad configuration (EEPROM error)
81	Warning Real-Time-Clock

[1] *These are notifications; the laser is fully functional.*

Table C-5: Laser Emission Shutdown Conditions

Laser Emission Shutdown Condition	Cause	Indication
Diode temperature error (#23)	Diode temperature not stabilized (significant offset from set temperature) or temperature controller not working properly.	Error LED is lit. Fault list contains error #23. (READ:FAULT:LIST?)
SHG xtal temperature error (#24)	SHG crystal temperature not stabilized (significant offset from set temperature) or temperature controller not working properly.	Error LED is lit. Fault list contains error #24. (READ:FAULT:LIST?)
THG xtal temperature error (#25)	THG crystal temperature not stabilized (significant offset from set temperature) or temperature controller not working properly.	Error LED is lit. Fault list contains error #25. (READ:FAULT:LIST?)
Power supply PCB over temperature (#33)	Temperature in the power supply PCB housing exceeded the safety shutdown temperature limit.	Error LED is lit. Fault list contains error #37. (READ:FAULT:LIST?)
Laser head over temperature (#34)	Either the heatsink temperature or the controller PCB temperature in the laser head exceeded the safety shutdown temperature limit.	Error LED is lit. Fault list contains error #34. (READ:FAULT:LIST?)
Software watchdog triggered	The software watchdog is activated. No serial command was sent to the Explorer XP within the adjusted alert time.	Bit #10 of the event status word is set. (STAT:COND:EVEN?).
Hardware watchdog triggered	Unexpected behavior of the control software (e.g., infinite loop).	After start-up, bit #11 of the event status word is set. (STAT:COND:EVEN?)
User interlock activated (#12)	The user interlock was triggered by an external wiring loop or by removing the analog plug.	Error LED is lit. Fault list contains error #12. (READ:FAULT:LIST?)
Keyswitch interlock activated (#13)	The keyswitch was turned off.	Error LED is lit. Fault list contains error #13. (READ:FAULT:LIST?)
Fiber interlock activated (#14)	The fiber has a light leak.	Error LED is lit. Fault list contains error #14. (READ:FAULT:LIST?)
Hardware error (#82)	A hardware error occurred (e.g., voltage or safety failures).	Error LED is lit. Fault list contains error #82. (READ:FAULT:LIST?)
Emergency shutdown (#83)	To protect the laser the system was shut down.	Error LED is lit. Fault list contains error #83. (READ:FAULT:LIST?)

Notes/Logs

Report Form for Problems and Solutions

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

Send all instrument related questions to:

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

Send all manual related questions to:

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

Thank you.

From:

Name _____

Company or Institution _____

Department _____

Address _____

_____

Instrument Model Number _____ Serial Number _____

Problem: _____

_____

_____

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_____

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_____

Suggested Solution(s): _____

_____

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