User Manual

Gigashot™ Laser
GS-320-QMI
GS-150-QMG
GS-100-QMU

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Original

NORTHROP GRUMMAN

Worldwide Technical Support and Product Information

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Important Information

Warranty Summary

Northrop Grumman Cutting Edge Optronics (NG CEO) warrants that the products that it manufactures and sells will be free from defects in materials and workmanship for a period of one year from the date of shipment from an NG CEO distributor. If a product proves defective within the respective period, NG CEO will provide repair or replacement as described in the complete warranty statement.

To arrange for service or obtain a copy of the complete warranty statement, please contact your nearest NG CEO sales and service office.

EXCEPT AS PROVIDED IN THIS SUMMARY OR THE APPLICABLE WARRANTY STATEMENT, NG CEO MAKES NO WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PUPOSE. IN NO EVENT SHALL NG CEO BE LIABLE FOR INDIRECT, SPECIAL, OR CONSEQUENTIAL DAMAGES.

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Patents

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Safety Information

Product End-of-Life Handling

NG CEO is committed to protecting the environment. In accordance with the Waste Electrical and Electronic Equipment directive (WEEE) and Restriction of Hazardous Substances in the European Union (RoHS EU) directives, NG CEO accepts the return of our products for disposal. When you are ready to reclaim the instrument, you must properly transfer it according to local regulations concerning WEEE equipment. Contact NG CEO or your local distributor for shipping instructions. Please package the products as directed for a return for repair.

ROC ROHS Declaration

In accordance with the Clause 6.2 of Marking for Control of Pollution Caused by Electronic Information Products (SJ/T11364:2006) for Measures for the Administration on Pollution Control of Electronic Information Products No. 39, Order of the Ministry of Information Industry of the Peoples Republic of China, NG CEO includes the following translation about our laser modules.

中华人民共和国，电子讯息产品管理办法：自我声明

生产商　Northrop Grumman Cutting Edge Optronics
生产商地址　20 Pointe West Blvd St. Charles, MO 63301 USA
产品名称 / 编号　GS-XXX-XXX

有毒有害物质或元素标识表

部件编号	部件名称	有毒有害物质或元素					
		铅 (Pb)	汞 (Hg)	镉 (Cd)	六价铬 (CrVI)	多溴联苯 (PBB)	多溴二苯醚 (PBDE)
第一组	外壳	O	O	O	O	O	O
第二组	电线/ 连接插头	X	O	X	X	X	X
第三组	安装组件	O	O	O	X	O	O
第四组	开关组件	O	O	O	X	X	X
第五组	电路板/ 开关组件	X	O	O	O	X	X
第六组	阵列前端次模组	O	O	O	O	O	O
第七组	接触板	X	O	O	O	X	X
第八组	热交换组件	O	O	O	O	O	O
第九组	16 进制硬件	O	O	X	O	O	O
第十组	焊锡	X	O	X	O	O	O
第十一组	电线/ 连接插头	X	O	O	O	X	X
第十二组	基部/ 端帽	X	O	O	X	O	O
第十三组	硬件/ 装配	O	O	O	X	O	O
第十四组	时计组件	X	O	O	X	X	X
第十五组	包装物料	O	O	O	O	O	O

O：表示该有毒有害物质在该部件所有均质材料中的含量均在 SJ/T 11363-2006 规定的限量要求以下

X：表示该有毒有害物质至少在该部件的某一均质材料中的含量超出 SJ/T 11363-2006 规定的限量要求

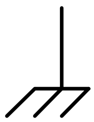
Conventions

The following conventions appear in this manual:

	This icon denotes a caution or a warning, which advise you of precautions to take to avoid injury, data loss, or a system crash.
Initial Capped	The first letter in uppercase refers to menu options, e.g., **Phase Delay**, **Pulse Width**.
CAPS	Front-panel buttons, knobs, and connectors appear in all uppercase letters, e.g., **MENU, CURRENT**.
▸	The ▸ symbol separates a sequence of button pushes, e.g., **MENU** ▸ **CHANNEL SETUP** ▸ **PULSE WIDTH** means that you push the **MENU** button, then push the **CHANNEL SETUP** soft key, and then push the **PULSE WIDTH** soft key.
italic	Italic text denotes references to other resources that may be helpful to you or to bring attention to important information.
	This icon denotes a note, which alerts you to important information.
I **O**	Power Switch Position Symbols I = On O = Off

The following conventions may appear on the product:

DANGER	An injury hazard immediately accessible as you read the marking.
WARNING	A hazard not immediately accessible as you read the marking.
CAUTION	A hazard to property including the product.
	ESD: Handle Appropriately

	Laser Emission: Use caution.
	Shock Hazard: Use caution.
	Caution: Risk of danger. Refer to manual.
	Chassis Ground

General Safety Summary

The Gigashot™ Laser System emits laser radiation that can permanently damage eyes and skin, ignite fires, and vaporize materials. *Chapter 2: Laser Safety* contains information and guidance about these hazards. To minimize the risk of injury or expensive repairs, carefully follow these instructions.

Do not attempt to operate the laser system before carefully reading this complete operation manual. If you have any questions on the product that have not been discussed sufficiently in this manual, contact the manufacturer for complete instructions. **Failure to heed this warning may result in the destruction or serious damage to the device, and will void the product warranty.**

The *Service* and *Troubleshooting* sections are intended to help guide you to the source of problems. Do not attempt repairs while the unit is under warranty; instead, report all problems to NG CEO for warranty repair.

Use the form in *Appendix A: Customer Service* to describe issues with the laser. We also suggest that you record information about the laser such as power, settings, time and date.

About This Manual

This manual describes the installation, operation, and service of the Gigashot™ Laser System with the eDrive Nitro Laser Controller. The manual consists of the following chapters:

- *Chapter 1: Introduction* provides a theory of laser operation and a description of the Gigashot™ laser.
- *Chapter 2: Laser Safety* describes proper safety procedures you should understand before operating the Gigashot™ laser.
- *Chapter 3: System Details* provides information about components of a laser system and proper environmental conditions for operation.
- *Chapter 4: Installation and Operation* discusses how to unpack, setup, and powering on your system for the first time.
- *Chapter 5: Maintenance* provides information on proper maintenance of your laser system.
- *Chapter 6: Service* provides resources to help fix problems with the Gigashot™ laser.
- *Chapter 7: Troubleshooting* provides possible solutions to the most commonly reported issues with the Gigashot™ laser.
- *Appendix A: Customer Service* provides information to expedite any service request before contacting NG CEO.
- *Appendix B: System International Units* identifies commonly used units of measurement found in this manual.
- *Appendix C: Acronyms* provides a list of commonly used abbreviations and their descriptions used throughout this manual.

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List of Figures and Tables

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Chapter 1: Introduction

This introduction provides the following information:

- Theory of Operation
- Warm Up Laser System
- Laser Internal Environment Control
- System Description
- Specifications

Theory of Operation

Gigashot™ DPSS laser is the next generation of high energy, short pulse diode-pumped solid-state (DPSS) Nd:YAG laser systems. High efficiency and ultra-long life quasi-continuous-wave (QCW) pump diodes allow the Gigashot™ laser to operate for many billions of shots. A homogenous pumping structure, dual gain modules with depolarization compensation give the laser excellent beam quality and stability at high (≥ 100 Hz) repetition rates. The unstable optical resonator uses a graded reflectivity mirror (GRM) as the output coupler, which provides the best way to extract diffraction-limited energy from a large-volume, high gain Nd:YAG rod. The standard Gigashot™ laser is designed for frequency ≥ 100Hz. BBO Pockels cell is used to handle high average power. Three carbon fiber rod structures are selected for the best thermal stability of the laser cavity.

REA QCW Gain Module

Northrop Grumman Cutting Edge Optronics (NG CEO) diode pumped gain modules use temperature-tuned GaAlAs laser diodes. These diodes replace flash arc lamps light sources as the optical pump source. The principal advantages of this approach include:

- Longer lifetime
- More compact size
- More efficient operation

The REA QCW-Series module uses pulsed arrays of solid-state laser diodes to optically pump a neodymium-doped yttrium aluminum garnet (Nd:YAG) lasing medium. The diode optical output power is radially coupled into the laser rod. The Nd:YAG laser rod has an anti-reflection coating chosen for the highest gain wavelength of this material, 1064 nm. The REA-Series module is constructed within a durable and rigid structure. Exterior components and connections are shown as an example in Figure 1-1.

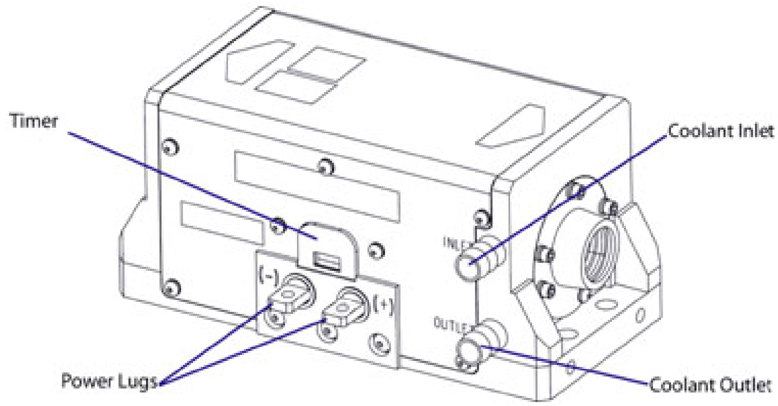

Figure 1-1 Exterior Components and Connections with Barb Fittings

Temperature Tuning of Laser Diodes

The laser diodes are located within the REA QCW-Series module and tuned, wavelength matched, via the closed loop chiller. For maximum efficiency, the diode output wavelength must match the laser medium absorption characteristics (see Figure 1-2). The output spectrum of a conventional pump source for Nd:YAG operation, the xenon arc lamp, and an 808 nm diode array is also shown.

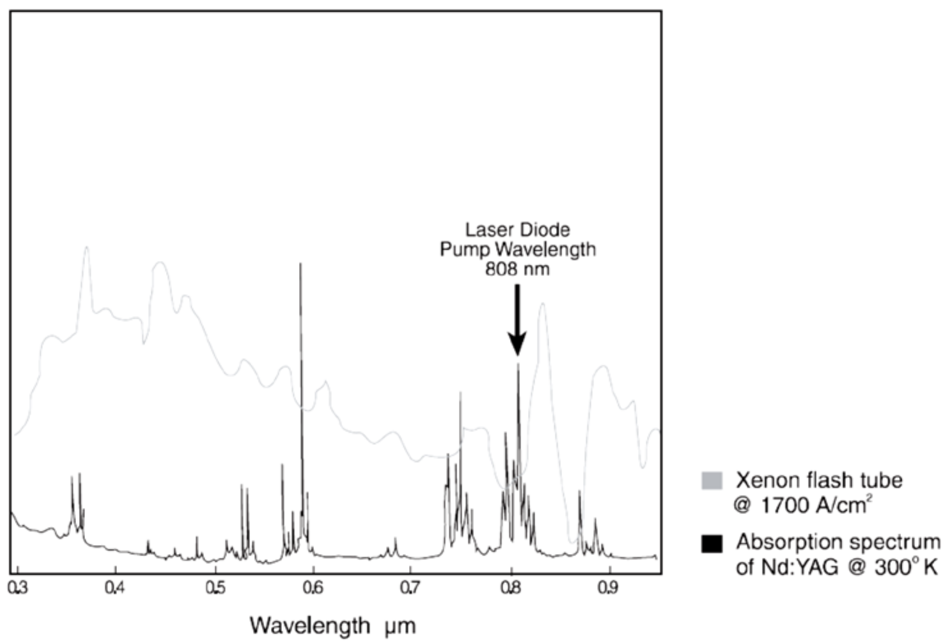

Figure 1-2 Nd:YAG Absorption Characteristics

A single GaAlAs laser diode bar has a 2 nm full width at half maximum (FWHM) distribution of output wavelengths. However, the process used in the manufacture of GaAlAs laser diodes results in a peak output wavelength for each diode that fits within a 10 nm distribution of wavelengths from 800-810 nm. To match the diode output to an absorption peak of the laser medium, diodes are selected with similar peak output wavelengths within the manufacturing range. Temperature tuning is possible because GaAlAs diode characteristics are such that 0.25 nm of wavelength shift occurs for every $1^{o}C$ change in temperature of the diode junction. Cooling shortens the wavelength, and heating lengthens it.

Figure 1-3 shows the percentage of pump light of different wavelengths absorbed by two passes through a 6.35 mm thick Nd:YAG rod. In NG CEO modules, the laser diode center wavelength, under normal operating conditions, is near the absorption peak of the laser medium. The operating temperature of closed loop chiller is carefully chosen to shift the diode temperature, so that the wavelength matches the absorption peak. The final test report, included with each module, indicates the optimum operation temperature for that module.

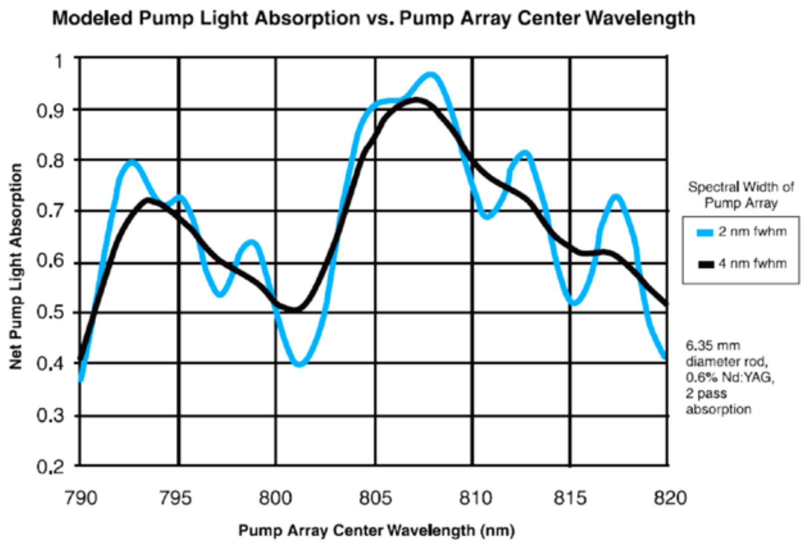

Figure 1-3 Pump Light Absorption vs. Pump Array Center Wavelength

REA QCW-Series Description

The REA-Series module utilizes a radial longitudinal pump geometry to excite the solid-state laser medium (see Figure 1-4). This pump geometry results in excellent gain uniformity (see Figure 1-5) and lensing performance. The reflector directs the divergent diode light back to the laser medium, which is kept in a flow tube for coolant circulation. The laser medium is a rod of neodymium-doped yttrium aluminum garnet (Nd:YAG). Both ends of the rod are optically polished and include anti reflection coatings at the lasing wavelength. The ends of the rod may be curved to compensate for thermal lensing, depending on module configuration.

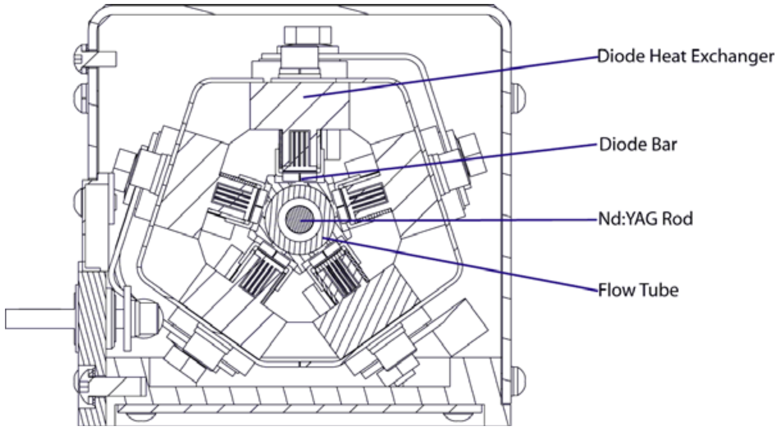

Figure 1-4 Example of Radial Pump Geometry

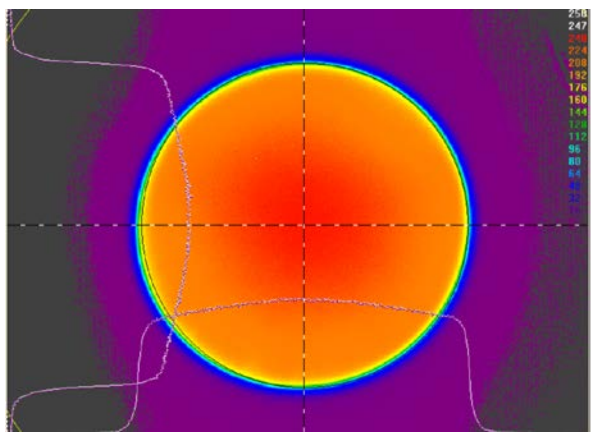

Figure 1-5 Pumping Uniformity of REA QCW Module

EO Q-Switch and Driver

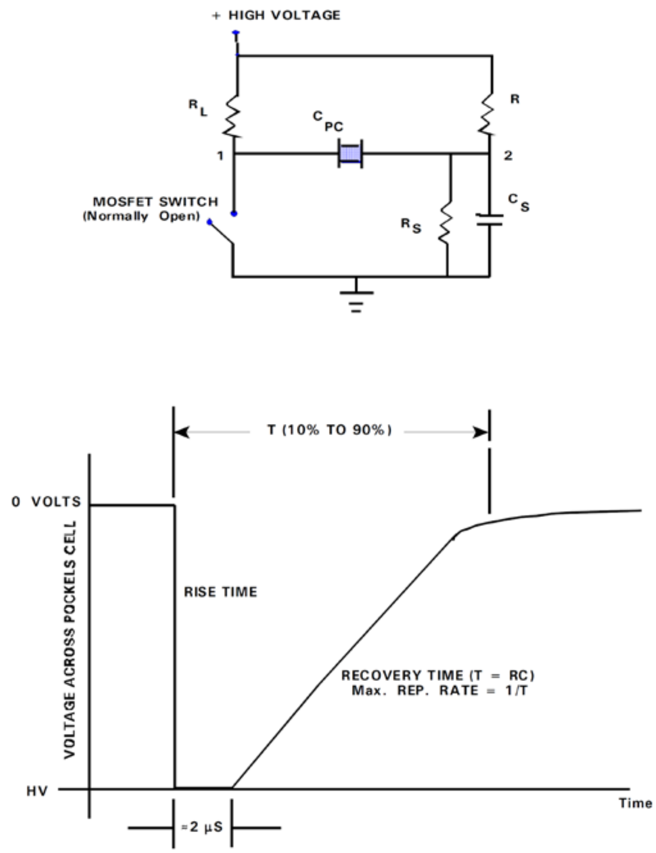

Figure 1-6 Typical H.V. Output of Q-Switch Driver

The Gigashot™ laser uses an electro-optic (EO) Q-switch. The Q-switch comprises a polarizer, a quarter-wave plate, and a Pockels cell. Applying high voltage to the Pockels cell crystal changes its polarization retardation characteristics, which determine whether the Q-switch is open (low loss) or closed (high loss).

Figure 1-6 indicates output pulse of the Q-switch driver with balanced output. The “ON” time of 2 µs is a function of RC time constants - where R is the internal switching circuit resistance and C is the sum of Pockels cell, circuit and cable capacitance. Static voltage across Pockels cell is zero volts when output is not triggered. When output is triggered, voltage across cell switches to the high voltage set point. The advantage of this circuit is the absence of a net DC voltage across the EO Q-switch. Continued long term application of DC high voltage may cause ion migration within the crystal resulting in fogged optical surfaces and ultimate degradation of the device. The balanced output configuration provides for the zero voltage condition needed for continuous, long term operation.

The Nd:YAG laser amplifier is capable of storing a considerable amount of energy due to the long upper state lifetime of the Nd ion when the Q-switch is closed. The EO Q-switch prevents the buildup of optical power in the oscillator cavity by introducing a loss greater than the available gain allowing energy to accumulate in the gain medium.

When the Q-switch is suddenly opened by applying high voltage to the Pockels cell, the loss of Q-switch is removed allowing the laser power to increase exponentially with each round trip of the oscillator cavity until much of the stored energy is exhausted and the gain once again falls below the loss. The resultant pulse width is <10 ns and the peak optical power is tens of megawatts.

The high peak power achieved in this manner is also essential to achieving an adequate wavelength conversion through several nonlinear processes, e.g., frequency doubling, frequency mixing, optical parametric chirped-pulse amplification (OPCPA) and other applications. A short pulse provides excellent temporal resolution of fast phenomena like rapid chemical reactions or high-speed motion.

Unstable Laser Cavity

Unstable resonators provide the best way to extract diffraction-limited energy from large volume, high gain laser media. The design of an unstable-resonator cavity is a more complicated procedure than for a stable resonator because of the interdependence of cavity length, output coupling and mirror radii of curvature. The requirement to avoid focal points in the cavity, and the desire to have a collimated output beam, dictate the choice of positive-branch confocal unstable resonator.

A Gaussian mirror, also known as VRM (variable reflecting mirror), is characterized by a degree of reflection that slopes from the center of the optic in a Gaussian distribution. Such mirror is used as the output coupler in unstable resonator where it helps produce high quality laser beams with low beam divergence at high pulse energies.

Unlike Gaussian beam profiles generated by low-gain stable oscillators, the unstable-resonator mode is not described by a simple analytical expression. There are annular rings that modulate the beam intensity even though a Gaussian mirror as the output coupler is carefully selected. Actually these concentric circular fringes are the result of Fresnel diffraction of light from the edge of the Nd:YAG rod.

The thermal lensing and birefringence of the Nd:YAG rod have to be considered during design the unstable laser cavity. Any solid laser material operating in either the CW or QCW mode of operation must dissipate an appreciable amount of heat. The heat arises from the non-radiation transitions in the material, i.e., the energy differential from pump to fluorescent bands, and the quantum efficiency less than one. In the cylindrical geometries generally used, the heat is removed on the circumferential surface of the cylinder, thereby generating a radial thermal gradient. The change in temperature within a laser rod causes a thermal distortion of the laser beam due to a temperature and stress dependent variation of the refractive index. In addition, the generated stresses and strain induce birefringence.

The birefringence in the laser will cause depolarization loss in the laser and impact the beam profile. If birefringence becomes a significant issue, it can be compensated with dual identical pump gain modules using a polarization rotator between them.. Because of birefringence effects, the Gigashot™ is designed to contain one or two modules, depending upon the desired output power.

The thermal lensing of the Nd:YAG rod will impact the laser beam diameter and divergence angle. At optimum operating parameters, the output beam from the unstable cavity will be collimated. There is little room for adjustment of the operating current, duty cycle, frequency and temperature of coolant, These parameters determine the average heat load on the Nd:YAG rod(s) and are fixed by design.

The Gigashot™ laser has very high power density inside the laser. Improper adjustment of operating parameters may lead to a decrease in beam diameter and will result in optical damage. For this reason, all parameters are well-controlled through the user interface. Please contact the factory if the laser must be operated outside specified operation parameters.

Timing Unit

The timing unit provides three key functions for the laser system.

1. The timing unit provides the trigger signal to the eDrive Nitro at a fixed frequency so the laser diodes will pump the Nd:YAG rod at a stable average power. It is very important to have the correct thermal lensing in order to make an unstable laser work properly.
2. The timing unit provides the trigger signal to the Q-switch driver. When the Nd:YAG rod is excited by the pumping light, it takes time for the population inversion to build up. The delay between pumping light and Q-switching can be varied precisely by the timing unit. The output pulse energy can be adjusted by changing the delay. The optimal delay time results in maximum output energy with minimal jitter. Because of the high flexibility of the timing unit, the trigger frequency to the Q-switch driver can either be the same as the frequency of pumping light or can be reduced by a factor of N where N is an integer.
3. The timing unit provides synchronized trigger signals for other device(s). The synchronized trigger signal can be configured to match the trigger signal to the eDrive Nitro or to the Q-switch driver.

Harmonic Generation

The harmonic generation (HG) device is a lithium triborate (LBO) crystal cut at a special angle. For instance, in a second harmonic generation crystal, this special angle provides phase matching between the fundamental waves in the beam and the waves generated (at 532 nm at room temperature). Phase matching and efficient conversion is sensitive to the angle of the unidirectional beam. It is also sensitive to the temperature of the HG crystal. As a result, it is necessary to provide a stable mechanical and thermal environment for the HG crystal.

Phase matching conditions can be met by mechanical angular adjustment of the HG crystal or by varying the temperature of the HG crystal electrically. Stability and reliability considerations lead to a mechanically fixed HG crystal with fine tuning accomplished electrically.

The temperature of the HG crystal is controlled with the thermal electric cooler (TEC), The performance parameters are optimized with a crystal temperature between 20 ºC and 50 ºC. Once this temperature is identified and fixed, the temperature of the crystal can be stabilized to within ± 0.1 ºC with the TEC controller.

Warm Up Laser System

The thermal load on the laser head and the chiller varies when the operating current is changed. It takes several minutes for the chiller to stabilize the temperature of the coolant. The laser head needs approximately one half hour to reach the thermal equilibrium from the cool-state due to its high thermal resistance.

For the high power Nd:YAG laser, there is a thermal response or relaxation time for the laser crystal and also the HG crystal. Any large transient operating current change has an impact on the energy storage in the laser crystal as well as thermal properties on both crystals. Both the laser crystal and the HG crystal may need several minutes to reach thermal equilibrium.

Laser Internal Environment Control

Gigashot™ lasers need a clean, dry environment to prevent failure. The Gigashot™ laser is not hermetically sealed: there is potential for molecular water vaporization through the o-ring seal. The humidity inside of the laser enclosure is controlled with a desiccant, which should be replaced before it is expired.

It is very important to keep the laser head dry and free of water condensation at all times. The lithium triborate crystal is a key component for the laser. Lithium triborate is a slightly hygroscopic material. Condensation on any optical surface will cause laser damage.

As discussed in *Chapter 3: System Details*, the relative humidity is related to the ambient temperature. The relative humidity is high when the laser is cool and it decreases as the laser is warmed up. When the relative humidity exceeds the threshold, the eDrive Nitro alerts the user with a beeping sound to replace the desiccant.

System Description

The Gigashot™ laser consists of four interconnected subsystems. The optics subsystem contains the laser oscillator, the control electronic subsystem provides power, timing and control for the laser transmitter, the chiller provides thermal control, and a computer provides the graphic user interface (GUI) to control the laser. The user must supply prime power and cooling to the optics subsystem. The interface relationships among these subsystems are illustrated in Figure 1-7.

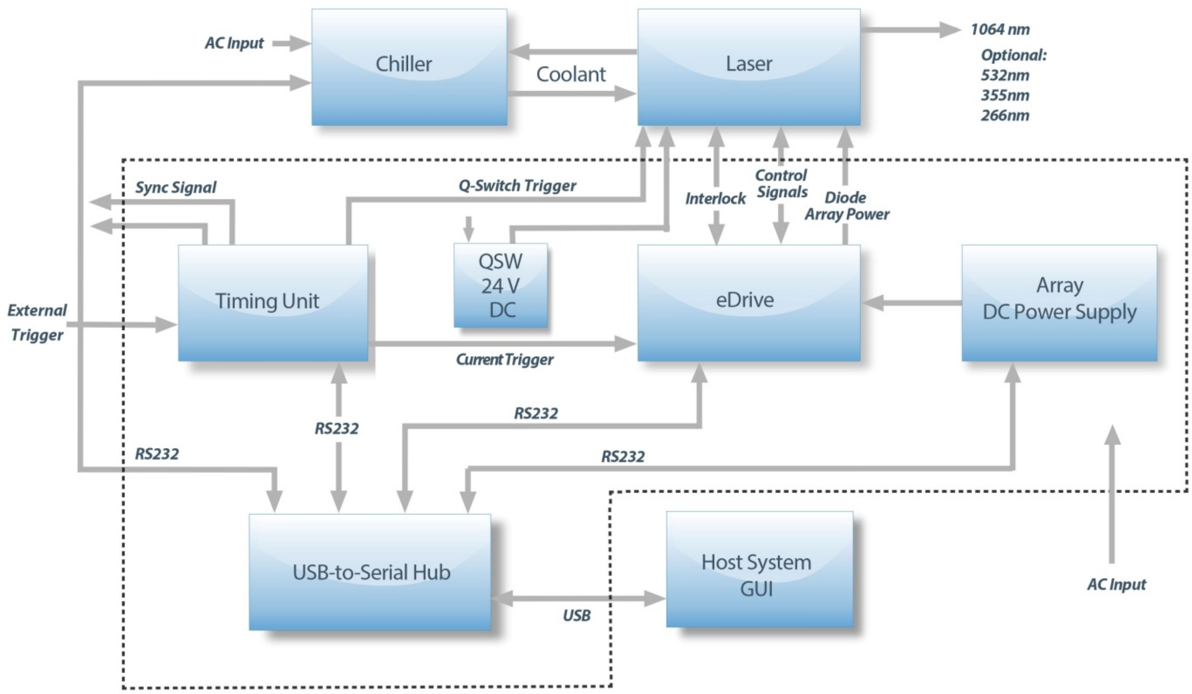

Figure 1-7 Typical System Block Diagram (Controller Subsystem Inside Dotted Line)

Specifications

For performance specifications, please refer to the NG CEO website for standard lasers or the agreed upon specifications noted in your contract.

Table 1-1 Typical Specifications Table

Parameter	Performance
Electrical Inputs	240 VAC, 10 A, 1 phase
Cooling	Closed Loop Re-circulating Chiller[1]
Coolant	Opti-Shield Plus
Operating Temperature	18-30 °C
Laser head size	44.05" L x 8.68" H x 14.9" W
Controller Size	27" H x 23.5" W x 30" D

[1] Chiller must be able to circulate a minimum of 1.5 gpm of coolant at the approximately 60 psi. See the ATP Test Report Data Summary sheet supplied with the laser for the exact flow rate required.

Optics Subsystem

The optics subsystem consists of an optical assembly on a NG CEO industrial laser optics bench. The optical assembly is kinematically mounted to the housing.

Controller Subsystem

There are five components total in the controller subsystem. These components are mounted in an equipment rack. The equipment rack is demarcated by a dotted line in the system block diagram shown in Figure 1-7, above.

Timing Unit

The timing unit sets the timing for the whole laser system. It provides the trigger signals to the eDrive Nitro and Q-switch driver at a fixed frequency. It also provides the synchronization output TTL signals for reference. If the whole laser is triggered externally, it must be at the designed fixed frequency.

Q-Switch Power Supply

The Q-switch driver is located inside the laser head. It requires 24V DC power and the trigger signal to drive the Pockels cell.

eDrive Nitro

The eDrive Nitro controls the peak pumping current and the pumping pulse duration. The frequency is controlled by the timing unit. Your laser shipment includes the final ATP Test Report Data Summary that provides the values necessary to achieve the full power conditions.

The temperature of the harmonic generation (HG) crystal for phase matching is crucial to determining the performance of the Gigashot™ laser. It is set and controlled by an internal TEC controller.

Diode Array Power Supply

The DC power supply for the Gigashot™ laser provides the power to the eDrive Nitro. Please refer the ATP Test Report Data Summary for the proper voltage and current settings.

USB-To-Series Hub

The hub is powered through the USB connector by the computer. The status and parameters of each subsystem must be monitored and set properly before the laser is started. The hub is the hardware interface for the communication between the computer and each subsystem.

Thermal Control Subsystem

Thermal control and heat removal from the laser transmitter is accomplished by the chiller. The laser's integral flow switch will interrupt drive current to the amplifier module should the flow rate fall below 1.0 gpm (4 lpm). Flow direction is labeled on the laser optics housing below the coupler ports. Please observe the flow direction at all times.

The thermal control system must be capable of maintaining the temperature set point to ±0.1 ºC with a flow rate of >1.5 gpm (~6 lpm). An input pressure of approximately 49 psi is required at the laser housing. Chiller pressure may be several psi higher if additional filtering, flow metering, fittings, and long runs of coolant tubing are used.

Coolant used in the system must be compatible with the materials used in the internal coolant lines of the laser. Tap or de-ionized water must be avoided because of corrosion and mineral deposits. NG CEO can supply an approved coolant for this application.

2

Chapter 2: Laser Safety

Please read this chapter carefully before installing or operating your laser. An NG CEO trained service engineer should perform all service and repair operations. If you plan to service your laser, please follow the procedures in *Chapter 5: Maintenance*.

Sections in this chapter include:

- Safety Overview
- Precautions for Safe Operation
- Center for Devices and Radiological Health Compliance

Safety Overview

Safe operation of any laser should be reviewed prior to any new installation of the Gigashot™ laser.

CAUTION. The Gigashot™ laser is a Class IV, high power laser whose beam is, by definition, a safety hazard. Avoid eye or skin exposure to direct or scattered laser radiation. Avoid direct viewing of the beam or its specular reflection.

Follow the instructions contained in this manual for proper installation and safe operation of your laser. We recommend the use of protective eyewear at all times (the type of eyewear depends on the energy and wavelength of the laser beam and operating conditions). Consult ANSI, ACGIH, or OSHA standards for guidance.

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

WARNING. At all times during installation, operation, maintenance, or service of your laser, avoid exposure to laser or collateral radiation exceeding the accessible emission limits listed in “Performance Standards for Laser Products,” U.S. Code of Federal Regulations, 21 CFR 1040 10(d).

Precautions for Safe Operation

- Avoid looking directly into the laser beam or at specular reflection, even with protective eyewear on.
- Wear laser safety eyewear that is optically dense at the wavelengths of operation (798-816 nm pump light, 1064 nm fundamental, 532 nm second harmonic, 355 nm third harmonic and 266 nm fourth harmonic).
- Provide a controlled access area for laser operation and limit access to those trained in laser safety principles.
- Post warning signs in prominent locations near the laser operation area.
- Use safety interlocks on all entryways. All NG CEO system control electronics are supplied with interlock inputs that can be used to preclude operation with an open safety door.
- Enclose beam paths wherever possible. And set up energy absorbing target to capture the laser beam, preventing unnecessary reflections or scattering.
- Set up experiments so the laser beam is below eye level.
- Work in an area that is well lighted to avoid dilation of pupils.

- Set up a target for the beam.
- Set up shields to prevent reflected beams from escaping the laser operation area.
- View an infrared laser beam with a protected image converter at an oblique angle reflecting from a diffuse surface.
- Ensure that all electrical connections are made in a safe manner.
- Position equipment so that electrical connections are shielded from accidental touch.
- Focused back reflections of even a small percentage of the output energy of the Gigashot™ laser can destroy its optical components. To illustrate, consider an uncoated convex lens, which reflects about 4% of the energy incident on each of its surfaces. While the reflection off the first surface diverges harmlessly, the reflection off the second focuses, and the power density at the point of focus is high enough to destroy the Q-switch, Nd:YAG rod, and output coupler of the laser. Even antireflection coated optics can reflect enough energy to damage optical components of the laser. The high peak power density laser beam can also ablate other materials in the laser. The ablation will generate the contamination which results in expensive optical damage.
- Do not smoke, eat, or drink in laser areas.
- Avoid leaving an operating laser unattended.

Center for Devices and Radiological Health Compliance

This laser product complies with Title 21 of the U.S. Code of Federal Regulations, Chapter 1, Subchapter J, Part 1040.10 and 1040.11, as applicable. To maintain compliance with these regulations, once a year or whenever the product has been subject to adverse environmental conditions (e.g. fire, flood, mechanical shock, spilled solvent), verify that the radiation controls such as shutter, laser on light, and audible warning are functioning properly. All warning labels should remain fully attached. (See Figure 2-1.)

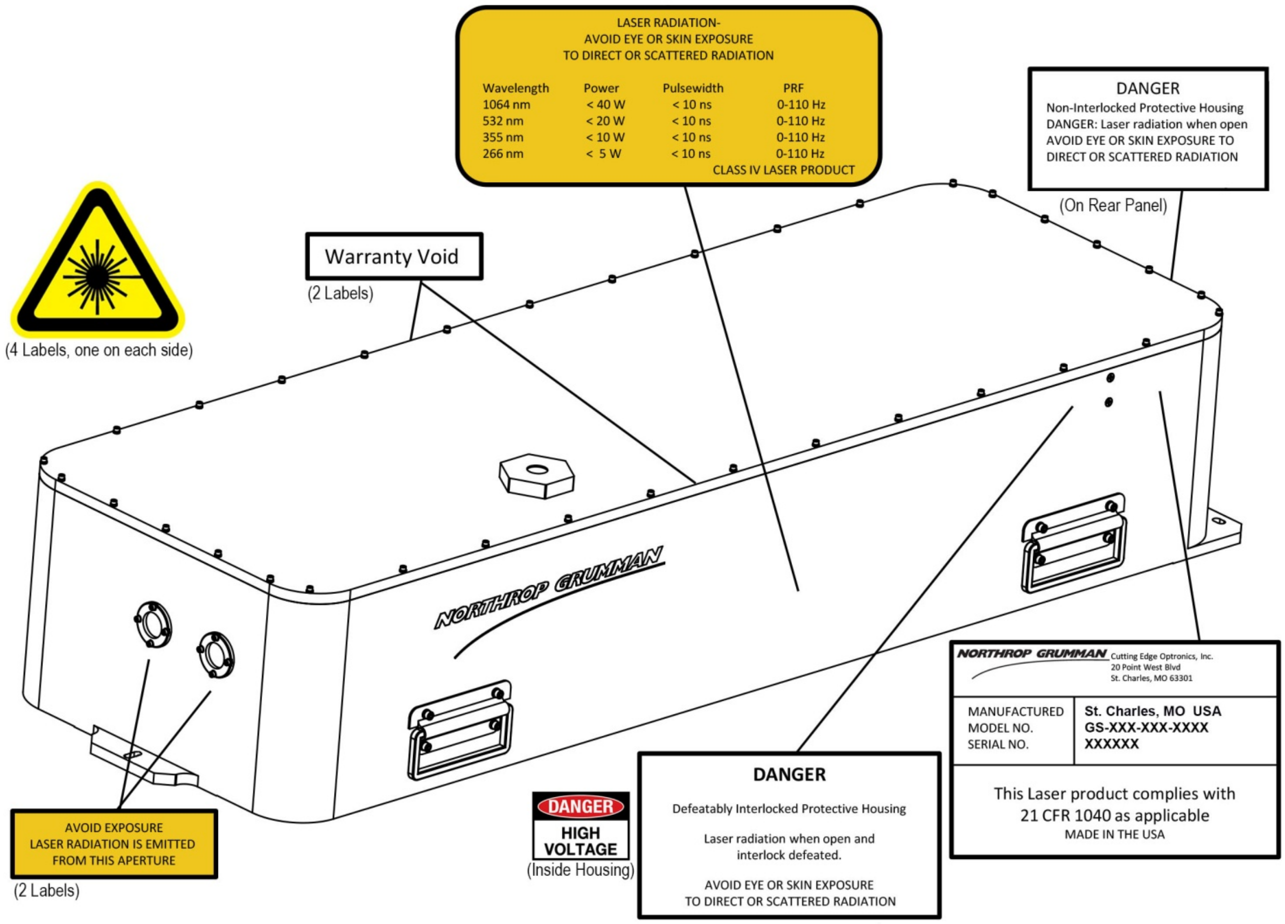

Figure 2-1 Example of Radiation Control Drawing

3

Chapter 3: System Details

This chapter discusses the operation of the Gigashot™ laser:

- Gigashot™ Laser
- Closed Loop Chiller
- Gigashot™ Controller

Gigashot™ Laser

Please see the envelope drawing supplied for your particular model of Gigashot™ laser for beam output location. The Gigashot™ laser head measures 44.05 inches (111.89 cm) by 14.9 inches (37.85 cm) by 8.68 inches (22.05 cm) (not including the connectors at the rear of the laser or the optional beam dump).

The rear panel of the Gigashot™ laser has connectors for the cable connection to the electronic subsystem. The **COOLANT IN** and **COOLANT OUT** ports are also found on the back panel.

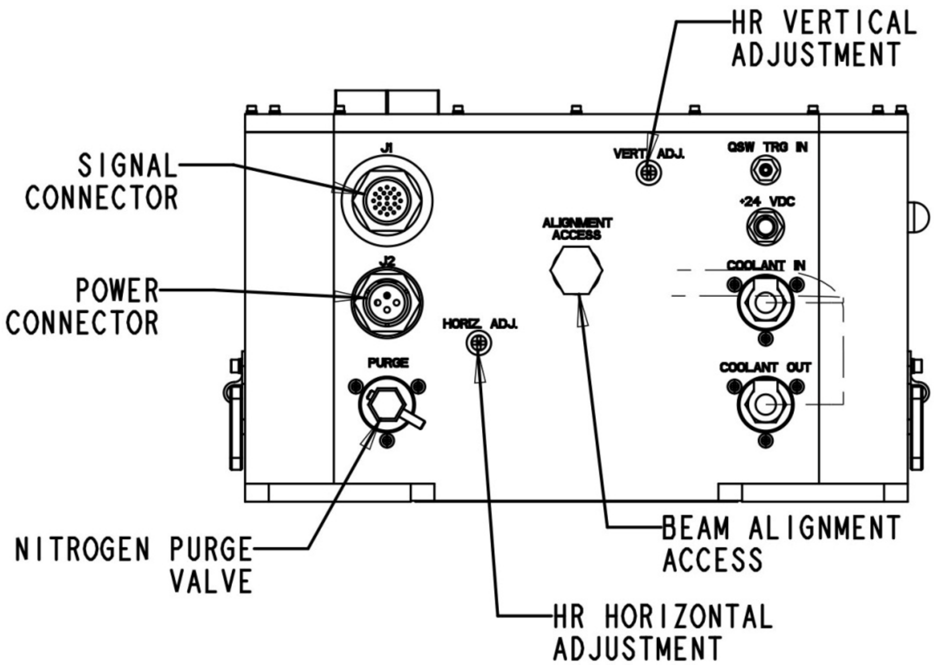

Figure 3-1 Gigashot™ Rear View

The alignment opening is located on the back panel. It is sealed by a screw to prevent beam emission during normal operation. The service technician can remove the screw and use a HeNe laser to aid alignment.

WARNING. The screw filling the alignment hole is considered a non-interlocked cover. If the screw is not replaced and the Gigashot™ laser is running, the opening will function as an aperture. It can allow an output beam of up to 3 W at the same rep rate and pulse width as the main beam. This beam could cause eye or skin damage from direct exposure or specular reflection of the beam. Always replace the screw in the alignment hole.

WARNING. Additional adjustment holes in the back panel of the laser housing provide access to the HR cavity mirror. The access holes should be always covered unless an alignment is being performed. Dust particles can cause damage to the mirrors and crystals inside the laser. All holes on the laser enclosure should be sealed all times to prevent moisture penetration. Moisture in the enclosure can degrade the lifetime of HG crystal. Moisture can also damage the coatings on all optical components.

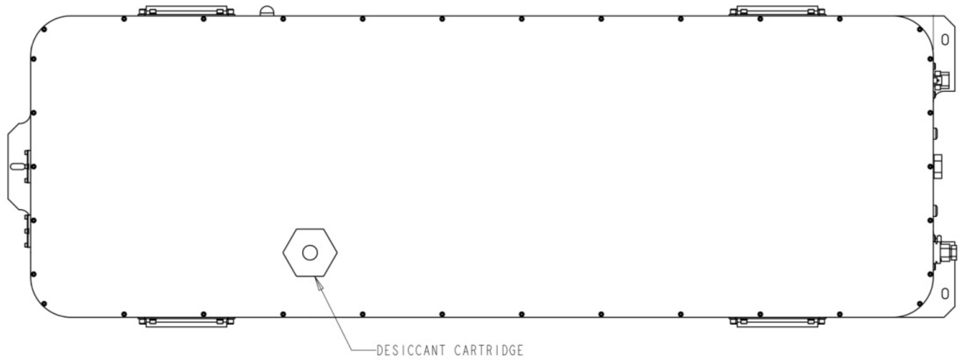

Figure 3-2 Gigashot™Top View

Closed Loop Chiller

The single most common cause of a laser returned for repair involves customer damage. More than one third of laser damage results from cooling problems. Coolant problems almost always require the replacement of the diode arrays - the single most expensive component in NG CEO lasers. This section describes how to avoid damaging arrays.

WARNING. Do not operate laser without cooling. Inadequate heat dissipation will seriously damage the laser diodes and **will void warranty**.

Table 3-1 Cooling System Requirements

Chiller and Cooling System Requirements
Capable of recommended flow rate at 60 psi[1]
Optishield Plus™ mixed with distilled water (90% distilled water, 10% Optishield Plus™)
Filter connected between chiller and inlet on laser[3]
Chiller Heat Capacity > Laser Power Consumption (750W)
Flow sensor (installed internally on Gigashot™ lasers)[4]
Replace coolant and filter monthly

[1] The actual operating pressure should be lower than 70 psi. It is acceptable if your chiller can achieve the required minimum flow rate through the laser with a lower water pressure (typically around 55 psi).

[2] Clean coolant keeps coolant lines from clogging. Untreated tap water may cause damage. Suitable coolants include: Optishield™ Plus from Opti Temp Inc, Traverse City, Mich., (231)946-2931. If Optishield Plus™ is not allowed due to local regulations, use Optishield™.

[3] The filter should be capable of removing particles 5 µm or larger. The filter and coolant should be replaced each month or more frequently if the pH drops below 8 or the filter or coolant show any discoloration.

[4] When not using NG CEO drive electronics, verify that flow sensor interrupts current to diodes less than 1s after a low flow condition occurs.

Table 3-2 Avoid with Chillers

Avoid with Chillers
De-ionized water[1]
Iron or aluminum parts in plumbing loop
Operation below air condensation temperature[2]

[1] The Gigashot™ laser has exposed bare copper inside the coolant loop. For this reason, NG CEO does not recommend using untreated de-ionized (DI) water. If DI water is used as the coolant, it is important to maintain the water resistivity between 300 and 700 K ohms and to keep the water slightly basic (i.e., keep the water above 8.0 pH).

[2] The Gigashot™ laser is environmentally sealed, but not hermetically sealed. Atmospheric conditions near the exterior of the laser will mimic conditions inside laser head.

Operating the Chiller

WARNING. Do not operate laser without cooling. Inadequate heat dissipation will seriously damage the laser diodes and will void warranty. If you notice coolant in the immediate vicinity of the laser, shut the laser system down immediately. Check to see if the coolant is coming from the laser head. If so, return the laser for repair. If not, repair the source of the leak and allow the unit to dry thoroughly before resuming operation.

The laser system has a coolant loop to prevent thermal damage to the laser diodes. The diodes should be kept at approximately 20 °C to 35 °C. See the ATP Test Report Data Summary included with your laser for optimum temperature and flow rate settings.

Operating the laser diodes without coolant for even a short period of time (even 1 second) will cause permanent damage. To help prevent this, all NG CEO drive electronics are equipped with a coolant interlock. This interlock interrupts drive current to the diodes when coolant flow rate drops below a set point. When setting up the laser system for the first time, NG CEO recommends testing the flow interlock before firing. Turn the controller on without current applied to the laser, and then turn the chiller off. A fault should be reported. By testing the interlock with no current to the laser, there is no risk of damaging the laser.

NOTE: The chiller must run continuously to prevent biological growth or corrosion. If the laser system is to be shut down for more than 1 week, the chiller should either be left running or drained and the coolant loop purged with oil-free, dry filtered air or (N_2) per the "Prepare for Shipment" section of this manual.

WARNING. Do not operate the coolant system below the air condensation temperature (dew point) at the laser head. Condensation on the diode arrays can seriously damage the laser head and will void the warranty. Consult NG CEO technical service if you have any questions.

Air Condensation Temperature

The air condensation temperature (or dew point) is the highest surface temperature that allows water to form from the ambient water vapor. The dew point is dependent on the surrounding air temperature and relative humidity. If a surface (such as a laser diode) is cooled to (or below) the condensation temperature, water may collect on that surface. A formula for calculating dew point is as follows, along with a calculated table, shown if Figure 3-3. All temperatures are given in Celsius.

Condensation Temperature
$T_d = \frac{237.7 \times \alpha(T,RH)}{17.27 - \alpha(T,RH)}$ where $\alpha(T,RH) = \frac{17.27 \times T}{237.7 + T} + \ln\left(\frac{RH}{100}\right)$
T is the ambient air temperature in degrees Celsius (0 < T < 60)
RH is the relative humidity in percent (1% < RH < 100%)
T_d is the air condensation temperature

For example, suppose your chiller is running at 22 °C and the ambient air temperature near the laser is 28 °C (82 °F). Referring to Figure 3-3 and Table 3-3, find the intersection of the 28 °C air temperature and the curve for the 22 °C diode temperature. At a relative humidity of 70 percent or greater, condensation will form on the laser diodes.

Controlling the humidity level inside the laser is important to extend the lifetime of the HG crystal. The desiccant cartridge on the top cover can help to remove excess moisture from inside the laser head.

WARNING. Do not operate the laser without a functional desiccant cartridge. Condensation on the diode arrays can seriously damage the laser and may void warranty.

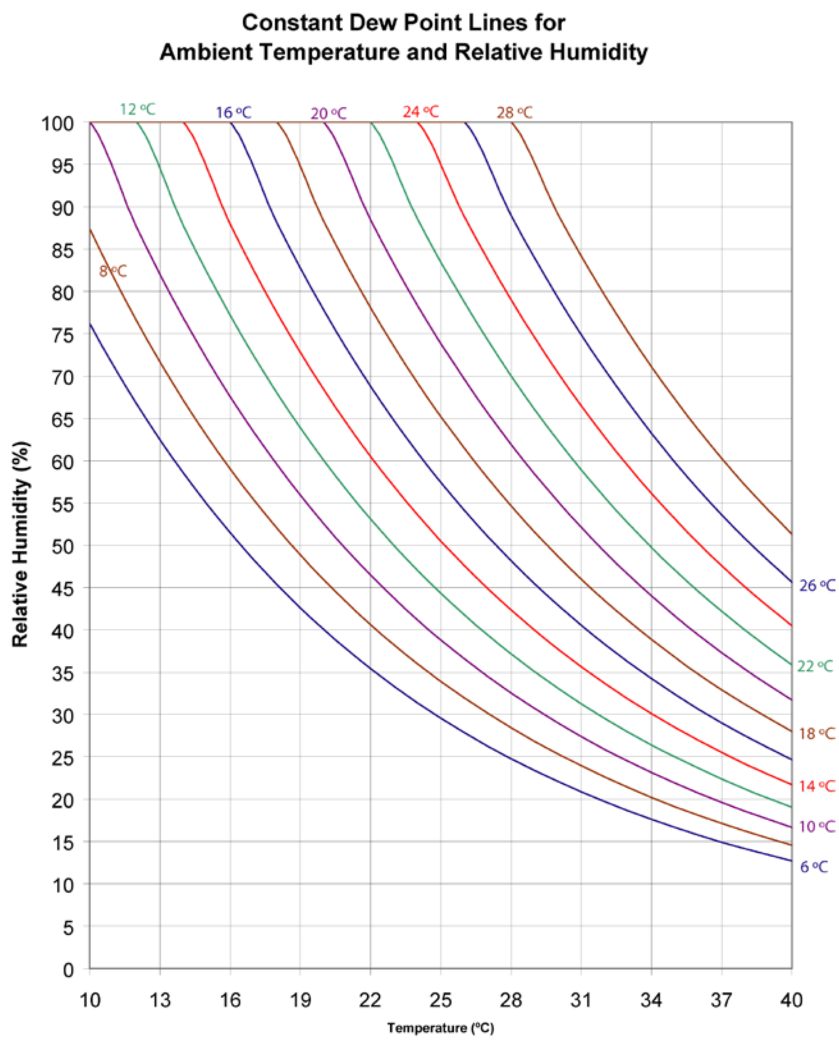

Figure 3-3 Constant Dew Point Lines for Ambient Temperature and Relative Humidity

Table 3-3 Table of Air Condensation Temperature at Given Ambient Air Temperature (Celsius) and Relative Humidity (percent)

	Relative Humidity										
Air Temperature °C	1%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
10	-43.9	-20.2	-11.9	-6.8	-3.0	0.1	2.6	4.8	6.7	8.4	10.0
12	-42.6	-18.7	-10.3	-5.0	-1.2	1.9	4.5	6.7	8.7	10.4	12.0
14	-41.4	-17.1	-8.6	-3.3	0.6	3.7	6.4	8.6	10.6	12.4	14.0
16	-40.2	-15.6	-7.0	-1.6	2.4	5.6	8.2	10.5	12.5	14.4	16.0
18	-39.0	-14.1	-5.3	0.2	4.2	7.4	10.1	12.4	14.5	16.3	18.0
20	-37.8	-12.5	-3.6	1.9	6.0	9.3	12.0	14.4	16.4	18.3	20.0
22	-36.6	-11.0	-2.0	3.6	7.8	11.1	13.9	16.3	18.4	20.3	22.0
24	-35.4	-9.5	-0.4	5.3	9.6	12.9	15.7	18.2	20.3	22.3	24.0
26	-34.2	-8.0	1.3	7.1	11.3	14.8	17.6	20.1	22.3	24.2	26.0
28	-33.0	-6.5	2.9	8.8	13.1	16.6	19.5	22.0	24.2	26.2	28.0
30	-31.8	-4.9	4.6	10.5	14.9	18.4	21.4	23.9	26.2	28.2	30.0
32	-30.6	-3.4	6.2	12.2	16.7	20.3	23.2	25.8	28.1	30.1	32.0
34	-29.5	-1.9	7.8	13.9	18.5	22.1	25.1	27.7	30.0	32.1	34.0
36	-28.3	-0.4	9.5	15.7	20.2	23.9	27.0	29.6	32.0	34.1	36.0
38	-27.1	1.1	11.1	17.4	22.0	25.7	28.9	31.6	33.9	36.1	38.0
40	-26.0	2.6	12.7	19.1	23.8	27.6	30.7	33.5	35.9	38.0	40.0

If required to operate a laser in conditions near the condensation temperature, take precautions to keep the laser dry. The laser should be operated inside an area that is purged with nitrogen (N_2) or encased in a sealed enclosure with a desiccant.

Gigashot™ Controller

The controller front panel provides an emergency stop button to halt laser output.

WARNING: The emergency stop should only be used in an emergency situation. For normal operation, use the shutter or emission buttons to halt laser output.

Additional information about the eDrive Nitro can be found in the eDrive Nitro User Manual.

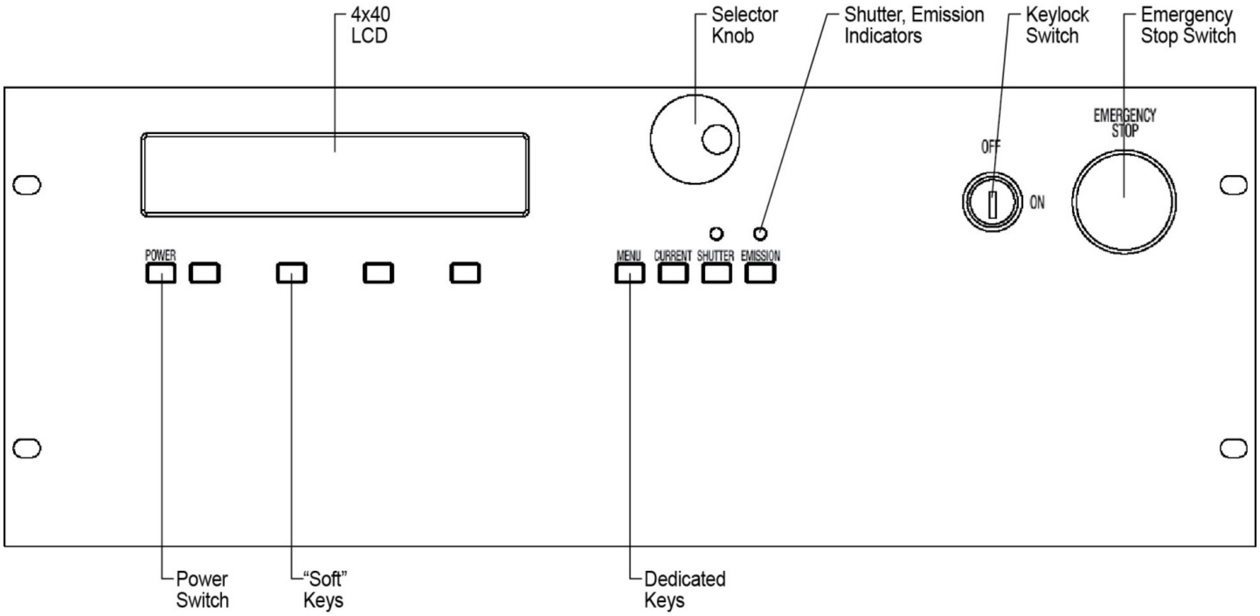

Figure 3-4 eDrive Nitro Control Panel

The parameters of the eDrive, DC power supply and the timing unit are controlled by the graphic user interface (GUI) supplied with the Gigashot™ system. None the front panel controls should be used except for the keylock switch and the emergency stop switch.

An external power supply is integrated to drive the laser diodes for Gigashot™ laser. The external DC power supply is connected to the 4U eDrive. Current and voltage are regulated through the eDrive Nitro and controlled by the external computer.

WARNING: Read the owner's manual supplied with the DC Power supply for safety information.

Figure 3-5 Controller Front Panel

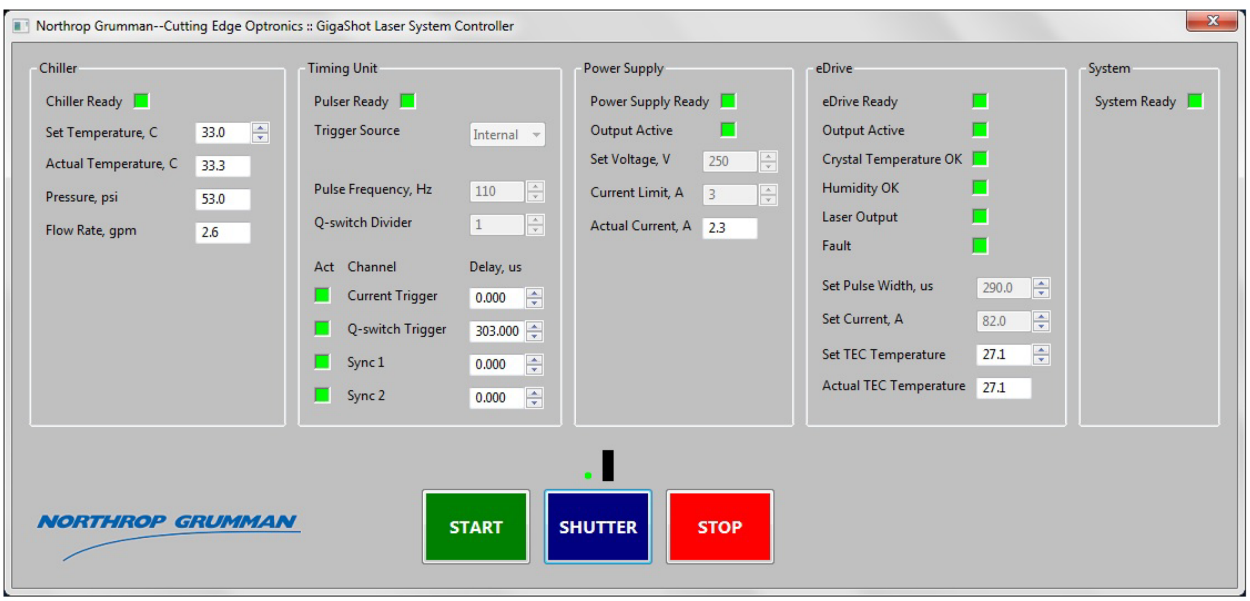

Figure 3-6 Graphic User Interface

The graphic user interface (GUI) is designed to control the laser system. The user friendly communications software requires no prior programming experience for operation. See Table 3-4 for details regarding the graphic user interface.

The sections of the GUI include parameter settings and status feedback for the Chiller, the Timing Unit, DC Power Supply, eDrive, and overall System status. The indicator box at the top of each section should display a green light in each of the “Ready” status boxes which means that each device is powered on, and communication is established. A yellow light in any of the first four "Ready" fields indicates the system is not communicating with the device, and the laser will not operate.

There are four field types:

a. Status – Indicates the readiness and status of each device.
b. Input – Generally, the input parameters are set before operation of the laser according to the ATP Test Report Data Summary. The user may change some of the settings, even when the laser is in operation. While the laser is in operation, some input parameters cannot be changed. These (locked) parameters will show as gray instead of black text on the GUI.
c. Readout – These fields indicate the current operating conditions.
d. Command Buttons - **START**, **SHUTTER** and **STOP**.
    - The "**START**" button initiates the following sequence: the DC power supply mode is switched from standby to output; the eDrive Nitro mode is switched from standby to emission, allowing the current pulses to flow to the laser module(s); the eDrive Nitro is triggered at the pulse frequency; and the laser is powered on. The user will hear multiple audible warnings as the sequence occurs.
    - When "**SHUTTER**" button is used to open the shutter, the shutter opens and after a short (~one second) delay the Q-switch is triggered, and the laser begins operating. When the shutter button is used to close the shutter, the Q-switch triggering stops, and the shutter closes immediately. The shutter status indicator displays the shutter position. Figure 3-6 shows the shutter status indicator in the open position.
    - The "**STOP**" button switches eDrive Nitro mode from emission to standby, and the DC power supply mode from output to standby.

The initial optimal chiller temperature should be set per the ATP Test Report Data Summary, in the "Set Temperature" field in the chiller section. The user is allowed to adjust the temperature of the chiller as needed for optimization, even when the laser is in operation. The range of temperature setting has predetermined limits, and should be set for optimal performance. The GUI will display the actual temperature, pressure, and flow rate in the fields below.

The timing unit section of the GUI allows the user to set the Trigger source. The timing unit frequency is the diode current pumping frequency, which should be fixed per the ATP Test Report Data Summary. Some of the triggers must be preset before laser operation. The Q-switch divider setting allows the user to change the output pulse frequency (PF). The output PF is determined by dividing the Pulse Frequency (in Hz) by the integral Q-switch divider setting.

$$\text{Output Pulse Frequency} = \text{Pulse Frequency} / \text{Q-switch Divider}$$

The Timing Unit section of the GUI allows the user to set the delays between the pulsed pumping current and the Q-switch. Varying the delay will change the output pulse energy. Typically, the delay (in μs) will be fixed for optimal pulse energy.

The TEC controller is used to control the temperature of the HG crystal.

The System Status section of the GUI contains a “Show Log” button, which when selected will show the status of the entire laser system.

Table 3-4 Graphic User Interface Descriptions

	Field Name	Description	Setting
Chiller	Set Temperature, C	Use the up and down arrows to toggle to the optimal temperature setting of the chiller, or enter the value	Set for optimal performance
	Actual Temperature, C	Automatic display of actual temperature (in Celsius units)	Read out
	Pressure, psi	Automatic display of pressure in psi	Read out
	Flow Rate, gpm	Automatic display of flow rate in gpm	Read out
Timing Unit	Trigger Source	Choose the source of the timing unit using the arrows	Chose Internal or External
	Pulse Frequency, Hz	Choose the pulse frequency using the arrows, or enter the value	Set for optimal performance (according to ATP Test Report Data Summary)
	Q-switch Divider	Factor which determines the Pulse Rate Frequency along with the Pulse Frequency (in Hz)	Set for optimal performance (according to ATP Test Report Data Summary)
	Current Trigger	These may be set to delay the Current or Q-switch (in µs)	Set for optimal pulse energy
	Q-switch Trigger		Set for optimal pulse energy
	Current Trig Monitor	Output synchronization signal (in µs)	Set with respect to the Current Trigger
	Q-switch Trig Monitor	Output synchronization signal (in µs)	Set with respect to the Q-switch Trigger
DC Power Supply	Set Voltage, V	Choose the voltage using the arrows, or enter the value	Set for optimal performance (according to available power supply)
	Current Limit, A	Choose the current limit using the arrows, or enter the value	Set for optimal performance (according to ATP Test Report Data Summary)
	Actual Current, A	Automatic display of current (in amperes)	Read out
eDrive	Set Pulse Width, µs	These may be set to (in µs)	Set for optimal pulse energy
	Set Current, A	Choose the set current using the arrows, or enter the value (in amperes)	Set for optimal pulse energy
	Set TEC Temperature	Set the temperature using the arrows, or enter the value	Set for optimal performance (according to ATP Test Report Data Summary)
	Actual TEC Temperature	Automatic display of temperature	Read out

4

Chapter 4: Installation and Operation

Gigashot™ is a high energy and high peak power laser. It is dangerous to handle. Please read all safety instruction as well as other notes, cautions and warnings in the manuals. To ensure safe operation of the Gigashot™ laser system, please be familiar with the Chiller User Manual, the DC Power Supply manual, eDrive user manual and timing unit manual before beginning a laser procedure.

NOTE: Focused back reflections of even a small percentage of the output energy of the Gigashot™ laser can destroy its optical components. To illustrate, consider an uncoated convex lens, which reflects about 4% of the energy incident on each of its surfaces. While the reflection off the first surface diverges harmlessly, the reflection off the second focuses, and the power density at the point of focus is high enough to destroy the Q-switch, Nd:YAG rod, and output coupler of the laser. Even antireflection coated optics can reflect enough energy to damage optical components of the laser. The high peak power density laser beam can also ablate any materials in the laser. The ablation will generate the contamination which results in expensive optical damage.

WARNING. The Gigashot™ warranty does not cover damage caused by focused back reflections. To avoid damage to your laser, minimize back reflections of its output beam, and where they are unavoidable, direct them away from the optical axis. The back reflection beams can be checked out at pulse energy level.

WARNING. The peak power generated by a Gigashot™ laser will damage any power meter. To measure high average or high peak power, meter the beam reflected by a calibrated beam splitter. Be sure to safely dump the main beam.

NOTE: Only those trained and authorized by NG CEO should attempt installation and alignment of the Gigashot™ laser. Improper alignment can cause catastrophic damage to optical elements within the cavity.

DANGER: HIGH VOLTAGE AND CURRENT. The laser head and power supply contain electrical circuits operating at lethal levels. Turn off the system and open the power line circuit breaker before opening the laser housing. If you must open the laser housing while the laser is on, avoid contact with high voltage components. When the laser is off, residual high voltage is dangerous. Only those trained in the safe repair of high voltage circuits should attempt any electrical service. Call NG CEO Technical Service: (636) 916-4900 for assistance.

4

Chapter 4: Installation and Operation

This chapter covers:

- Laser System Components
- Unpacking the Laser System
- Laser Head Setup
- Controller Setup
- Chiller Setup
- Connecting the Chiller
- PolyScience 6000 Series Power-Up Procedure
- First Time Laser Power-Up Procedure
- Daily Operation
- Adjusting the Laser System

The purchaser is responsible for any loss or injury during installation and use of the laser system. NG CEO recommends that a qualified service technician install and maintain the laser. If you intend to service the laser yourself, please comply with the following procedures.

Laser System Components

Before installing, be familiar with the components of the laser system (see Figure 4-1).

Figure 4-1 Components for the Gigashot™ Laser

Unpacking the Laser System

Your NG CEO Gigashot™ laser was carefully packed for shipment. If its carton appears to have been damaged in transit, have the shipper's agent present when you unpack.

Inspect the unit as you unpack it, looking for dents, scratches, or other evidence of damage. If you discover any damage, immediately file a claim against the carrier and notify NG CEO technical service. NG CEO will arrange for repair without waiting for settlement of your claim.

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 unit for service, the specially designed carton assures adequate protection.

A standard Gigashot™ laser system consists of:

Item	Description
Laser Head	Model Numbers: GS-320-QMI, GS-150-QMG, GS-100-QMU
Controller	eDrive
	DC Power supply
	Timing Unit
	Computer (optional)
Chiller	60 Hz Chiller or 50 Hz Chiller
Laser Signal Cable	P/N 85-151-11
Power Cables	Determined by electric system available
Q-switch Trigger Cable	50 Ohm SMA Coaxial Cable
Q-switch Power Cable	50 Ohm BNC Coaxial Cable
Power Cord for Chiller	Determined by electric system available
Power Cord for Power Supply and Controller	Determined by electric system available
Desiccant Cartridge	40g P/N 42-228
(2) Desiccant Refills	P/N 643665
Desiccant Refill Tool	P/N 980412
Plumbing Kit	P/N PK-PA-EDX-0012
Manual and Software CD	CEO-UMAN-0067 CD

Please check the contents against the packing list and the sales order.

Laser Head Setup

The laser head should be mounted on an optical table or equivalent strong, flat surface. Three mounting holes are provided to secure the laser. The laser should be installed in a clean environment.

A power meter, with the ability to handle the maximum power of the laser, should be installed approximately 0.5 meter away from the laser in the direction of the laser output beam. To protect the power meter, a negative lens (f=-100 mm) with an anti-reflective (AR) coating at output wavelength should be installed in front of the power meter as shown in Figure 4-2 below. If a negative lens is not available, only a small portion of the laser power should be measured by a beam sample, so that the power density is below the damage threshold of the power meter. The power should be calibrated in this way. A pulse detector should be positioned as shown in Figure 4-2 to verify the pulse characteristics of the laser.

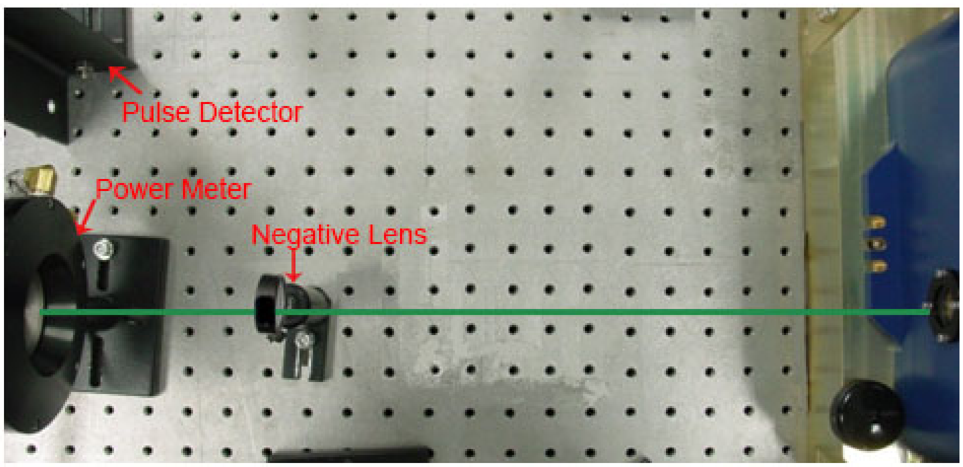

Figure 4-2 Basic Setup for the Laser Power Test

Controller Setup

Ac Input Power

Before you can use the controller, you must provide the proper AC input power requirements. The controller is shipped with a kit of connector and strain relief parts to assemble using the procedures in the section.

CAUTION. Obstructing the air inlets and/or exhaust may cause fire and irreversible damage to the components inside the cabinet.

Table 4-1 AC Requirements for Controller

AC Input		Frequency	Fuse Ratings
240V ±10%	10A	50/60 Hz	T 10A 250V
Fuse Dimensions: 0.25 x 1.25 inches			

Clearance

You must allow at least 1U (1.75”, 4.45 cm) clearance for cooling air to reach the ventilation inlets on the controller cabinet. You must also allow sufficient space for unobstructed airflow on each side and rear so that the operating ambient temperature stays within the specifications. The controller may be placed under the optical table.

Chiller Setup

Ambient Temperature and Relative Humidity

The chiller is designed for indoor installation in ambient temperatures between 5 °C and 30 °C (41 °F and 86 °F). Relative humidity should not exceed 80 percent (non-condensing).

Location

The Chiller should be installed on a strong, level surface. Position the chiller close to the laser as possible. Do not installer the chiller any closer than 4 feet (1.4 meters) from a heat generating source, such as heating pipes or boilers. If possible, the chiller should be located near a suitable drain to prevent flooding in the event of leaks. Do not place it where corrosive fumes, excessive moisture, dust, or high room temperatures are present.

For ease of positioning and maneuverability, the chiller is supplied with casters. The front wheels can be locked to keep the chiller in place while in use. To help prevent voltage drops, position the chiller as close as possible to the power distribution panel. Avoid voltage drops by using a properly grounded power outlet wired with 14 gauge (or larger diameter) wire. The use of an extension cord is not recommended.

NOTE: The chiller may be located at a level below that of the equipment being cooled. As long as the process remains closed, overflow will not occur when adding cooling fluid to the chiller reservoir.

Oxygen Depletion Risk

In the event of a refrigerant leak, refrigerant gas may displace oxygen that could result in suffocation and death. Never place the chiller in a room that is smaller than the minimum room volume requirement as defined below. If the room is ventilated, the air distribution system must be analyzed to determine the worst case distribution of leaked refrigerant. A leak detector alarm device is always required in a ventilated room that does not meet the minimum room volume given below. Assure adequate and sufficient room volume and ventilation before placing a chiller that contains refrigerant in a room. Contact Polyscience at 800-229-7569 if you have any concerns or questions.

Pounds of refrigerant charge can be read directly from the nameplate on your chiller. Remember to include in your calculation any refrigerant that may be stored in any other containers.

Minimum Room Volume = Pounds of refrigerant x 110 cubic feet

Example: Two chillers are placed in a room, each containing 6 pounds of refrigerant. The minimum room volume shall be 12 x 110 cubic feet, or 1,320 cubic feet.

Clearance

Adequate clearance should be allowed on the front, sides, and rear of the chiller for access to connections and components. The cabinet of the chiller is designed to vent air. Maintain free space equal to the height of the chiller for flow of air on the condenser side of the chiller (opposite to where the coolant lines connect). The two sides and the top must have an equal amount of free space. When air flow becomes impeded, cooling capacity decreases and electrical efficiency drops as motor load increases.

Electrical Power

For 60 Hz Polyscience chillers with less than 1.5 horsepower, the supplied power cord will be for connection to a NEMA 6-20 (North America) receptacle, in accordance with local electrical codes. A Euro cord will be supplied with 50Hz models.

CAUTION. The chiller has been set 208-230 Volts at the factory for 60-Hertz single phase or 200 volts for 50-Hertz single phase. High voltages out of the specified range could damage the chiller.

WARNING. DO NOT plug the Chiller into the electrical outlet until the unit is ready for Startup.

Chiller Cleaning Procedures

Please follow the proper procedures to clean the chiller before it is connected to the laser head. Refer to section “Clean and Maintain Chiller” in *Chapter 5: Maintenance* for details. Chiller maintenance procedures are also available through the NG CEO Knowledge Center.

WARNING. Make sure that the chiller will not contaminate the laser head.

Connecting the Chiller

Coolant Hoses and Filter Connections

The required coolant hoses, filters, and fittings are included in the plumbing kit that was shipped with your laser. They should be connected as illustrated in Figure 4-3. The correct coolant flow path starts with the supply port of the chiller ▸ filter ▸ coolant in port of laser head ▸ laser head ▸ coolant out port of laser head ▸ return port of the chiller. Please be aware of the flow direction of the filter.

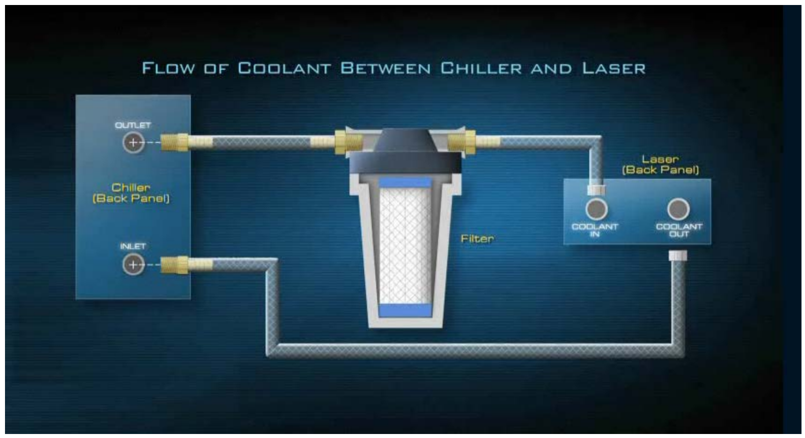

Figure 4-3 Example of Coolant Hose and Filter Connections

The filter may be attached to the back of the chiller, customer's equipment or a wall using the provided L-bracket.

NOTE: Threaded hose barbs and adapters should be wrapped 3-4 times with Teflon tape around the threads.

Figure 4-4 depicts the chiller with connected coolant hoses.

Figure 4-4 Chiller Assembled with Coolant Hoses and Filter

Connections on Laser Head

Figure 4-5 depicts the connectors on the rear panel of the Gigashot™ laser. All of the connectors are clearly labeled.

Figure 4-5 Connectors on the Rear Panel of the Gigashot™ Laser

Figure 4-5 shows all of the connectors on the back panel of the Gigashot™ laser. All of the connectors are clearly labeled. The steps for installation follow.

1. **Plumbing Connection**: Push the barb fittings of water hoses connectors gently into the **COOLANT IN** and **COOLANT OUT** ports by following the flow patch direction. Wetting the o-rings of the quick disconnect fittings and receptacles can prevent the o-ring from being cut by the mating piece during insertion. Make sure that the quick disconnect fittings are locked. A click is heard once it is locked.
2. **Laser Signal Connection**: Align the female connector of the laser signal cable to the **J1** connector on the laser head. Once it is aligned, the connector can be pushed in. Turn the locking ring of the connector in the clockwise direction until it is locked.
3. **Q-switch Trigger Connection**: Connect the Q-switch trigger cable to the SMA connector **QSW TRG IN** on the laser head accordingly. The cable should be threaded on to the connector by turning it clockwise until hand tight.
4. **Q-switch Power Connection**: Connect the Q-switch power cable to the BNC connector **+24 VDC** on the laser head accordingly. The connector should be locked as well by turning it clockwise until it stops.
5. **Laser Power Connection**: Connect the female connector of the diode power cable to the **J2** connector on the laser head.

Figure 4-6 Gigashot™ Laser Connections

Connections on Controller

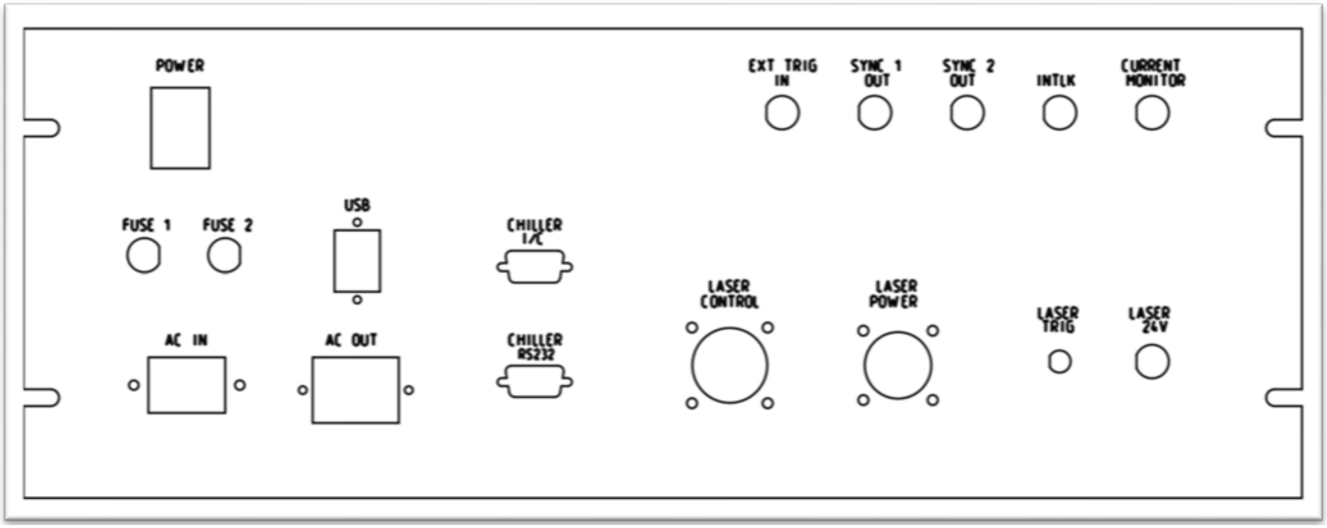

Figure 4-7 Controller Rear Panel Schematic

Table 4-4 Controller Rear Panel Information

Item	Description
POWER	Powers on all components of the controller
FUSE 1	10A, 250V, 0.25 x 1.25 inches
FUSE 2	10A, 250V, 0.25 x 1.25 inches
AC IN	208 - 240 V, 10 A, 50/60 Hz, single phase AC input connector
AC OUT	Computer
USB	Connects to communicate with the computer.
CHILLER I/C	Chiller Interlock- DB9 connector.
CHILLER RS232	Provides communication with the chiller, DB9 connector.
LASER CONTROL	Laser Controller –signal cable, connects to J1 on rear panel of laser.
LASER POWER	Power cable, connects to J2 on rear panel of laser.
LASER TRIG	SMA connector, provides Q-switch trigger, connects to QSW TRG IN on rear panel of laser.
LASER 24V	BNC connector, provides 24V DC to Q-switch, connects to +24 VDC on rear panel of laser.
EXT TRIG IN	BNC connector, allows an external host system to trigger the laser at specified frequency.

Item	Description
SYNC 1 OUT	BNC connector, provides current trigger monitor for initial installation, synchronization with other systems, or diagnostic purposes.
SYNC 2 OUT	BNC connector, provides Q-switch trigger monitor for initial installation, synchronization with other systems, or diagnostic purposes.
INTLK	BNC connector, used for the laser safety interlock.
CURRENT MONITOR	BNC connector, connect to an oscilloscope to monitor the current pulse width and amplitude for initial installation or diagnostic purposes (See the eDrive Nitro user manual for current monitor scaling factor)

1. **Laser Signal Connection**: Connect the male connector of laser signal cable to the receptacle labeled **LASER CONTROL** on the back of the controller. Once it is aligned, the connector can be pushed in. Turn the locking ring of the connector in the clockwise direction until it is locked.
2. **Laser Power Connection**: Connect the male connector of laser power cable to the receptacle labeled **LASER POWER** on the back of the controller. Once it is aligned, the connector can be pushed in. Turn the locking ring of the connector in the clockwise direction until it is locked.
3. **Q-switch Trigger Connection**: Connect the male SMA connector of the Q-switch trigger cable to the receptacle labeled **LASER TRIG** on the back of the controller. The cable should be threaded on to the connector by turning it clockwise until hand tight.
4. **Q-switch Power Connection**: Connect the male BNC connector of the Q-switch power cable to the receptacle labeled **LASER 24V** on the back of the controller. The connector should be locked as well by turning it clockwise until it stops.
5. **Chiller Interlock Connection**: Connect the DB9 chiller interlock shorting connector to the receptacle labeled **CHILLER I/C**.
6. **Chiller Communication Connection**: Connect the DB9 RS232 chiller communication cable from the chiller to the receptacle labeled **CHILLER RS232**.
7. **Interlock BNC Connection**: Connect from door interlock to the receptacle labeled **INTLK** for laser safety. If not used, the shorting BNC should be used instead.
8. **USB Connection:** Connect the USB cable from the GUI computer to the receptacle labeled **USB.**
9. **AC IN Connection:** Connect the AC power cable from the wall plug to the receptacle labeled **AC IN**.
10. **AC OUT Connection:** An optional AC power port for the computer.

PolyScience 6000 Series Power-Up Procedure

NG CEO routinely supplies a chiller with each laser system. If a customer purchases the chiller separately, the chiller must be cleaned properly per manufacturer's instructions before it is connected to the laser head.

Assuming the coolant hose, filter and laser head are properly connected, the following steps indicate how to turn on the cleaned PolyScience 6000 series for the first time.

1. Fill the reservoir. Remove the filler cap from the reservoir and, using a funnel, fill the reservoir with a mixture of 10% Optishield Plus™ and distilled water until it reaches the MAX line on the reservoir's fluid level gauge. When full, remove the funnel, but do not replace the cap at this time.

WARNING. Do not use untreated de-ionized water in the system as it is aggressive in nature and can attack and corrode the metals in the laser head.

2. Connect the electrical power. Plug the chiller's power cord into an appropriate electrical outlet. Place the **Circuit Breaker/Power Switch** on the rear of the instrument enclosure to the **On** position. Three decimal points appear on the temperature display; two decimal points appear on the pressure/flow rate display.
3. Start process fluid flow. Press the **Power** button on the front panel. The system startup sequence begins. The pump turns on and fluid begins circulating through the system. The set point temperature appears briefly on the temperature display. After a few seconds, it will be replaced by the actual fluid temperature. The compressor will begin operating 15 to 20 seconds after power up.
4. Check for leaks. Once the pump is turned on, check all of the connectors to see if there is any leakage. If leakage is observed, turn off the pump immediately and fix the leak. The reservoir's fluid level will drop as the process and/or process cooling lines fill with fluid. Slowly add fluid to the reservoir until the liquid level remains stable.
5. Replace reservoir cap.

First Time Laser Power-Up Procedure

Remove the cap that protects laser output window and make sure the window is clean. Gently clean the laser output window with a lens tissue and methanol, as needed. Make sure all communications and power cables and the computer with the GUI are connected.

WARNING. Never allow the reflected laser beams to re-enter the laser, as optical damage may occur, and thereby void the warranty.

Verify Chiller Settings

1. Turn on the chiller.
2. Check the temperature setting of the chiller. Refer to the ATP Test Report Data Summary included in your Gigashot™ laser shipment for the coolant operational temperature. The chiller's temperature setting should be the same as in the report. If it is set to a different temperature, change it to match the setting on the report.
3. The minimum flow rate for Gigashot™ laser is 1.5 gpm. Typically it is 1.8 gpm using the NG CEO supplied chiller and standard plumbing kit. If the flow rate is not ≥ 1.5 gpm, adjust the bypass valve inside the chiller . When adjusting and setting the flow rate, do not allow the coolant pressure to exceed 70 psi.

NOTE. Chiller flow rate calibration may be required. Please refer to the chiller user manual for instructions on calibration.

4. Run the chiller for approximately ½ hour to allow the coolant temperature to stabilize at the set point.

Turn on Controller

1. Flip the power switch on the rear panel of the controller to the **ON** or **I** position.
2. Make sure that the red **EMERGENCY STOP** button of the eDrive Nitro is released. Turn the key switch to the **ON** position. If the key switch is in the **OFF** position, a fault will occur.
3. Flip the power switch on the front panel of the DC power supply to the **ON** or **I** position.
4. Launch the Gigashot™ Laser System Controller GUI from the computer. Ensure that the ready signals at the top of each section of the GUI are green, indicating that communication is established.
5. Verify the GUI parameter settings are set correctly according to the ATP Test Report Data Summary.

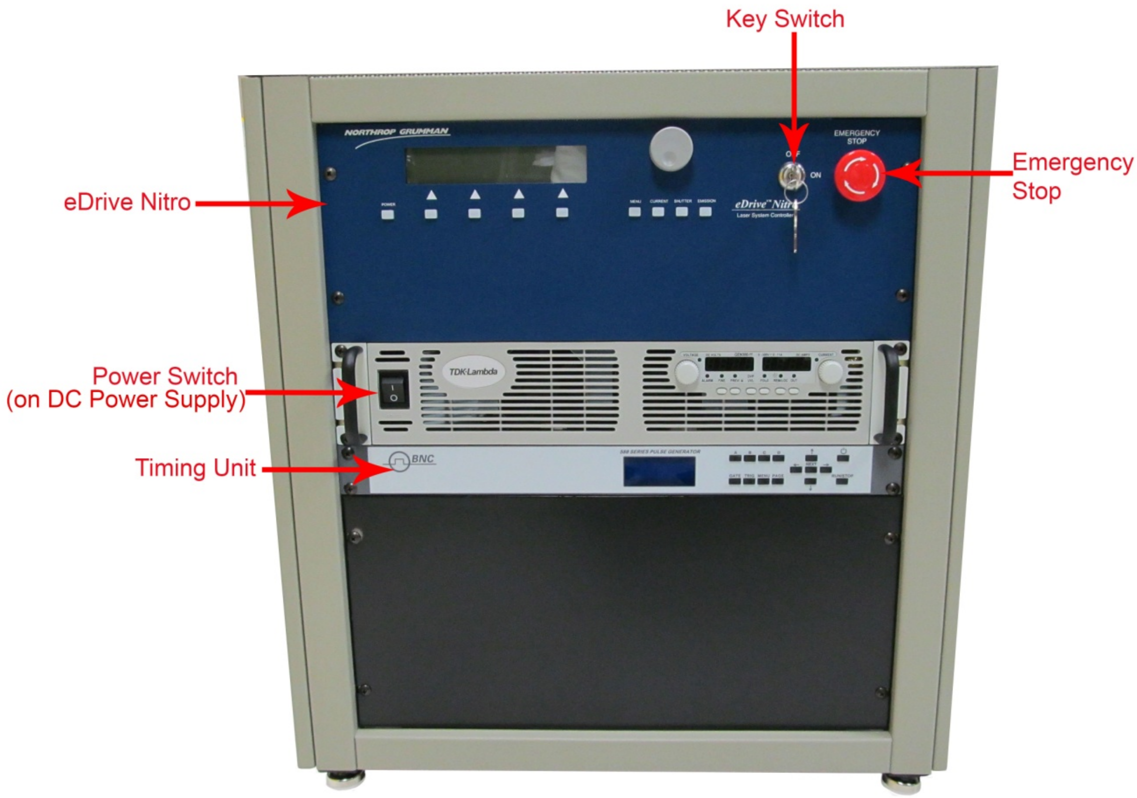

Figure 4-8 Front Panel of Controller

Set Up Test Equipment

1. Verify that there are no objects in the laser beam path except for the negative lens and power meter.
2. Connect **SYNC 1 OUT** from the rear controller panel to channel 1 of the 4 channel oscilloscope. Connect **SYNC 2 OUT** from the rear controller panel to channel 2. Connect **CURRENT MONITOR** from the rear controller panel to channel 3.
3. Connect photo detector to channel 4 of the oscilloscope.
4. Use channel 1 as the trigger source. Figure 4-10 shows a screenshot of all 4 signals when the laser is running.

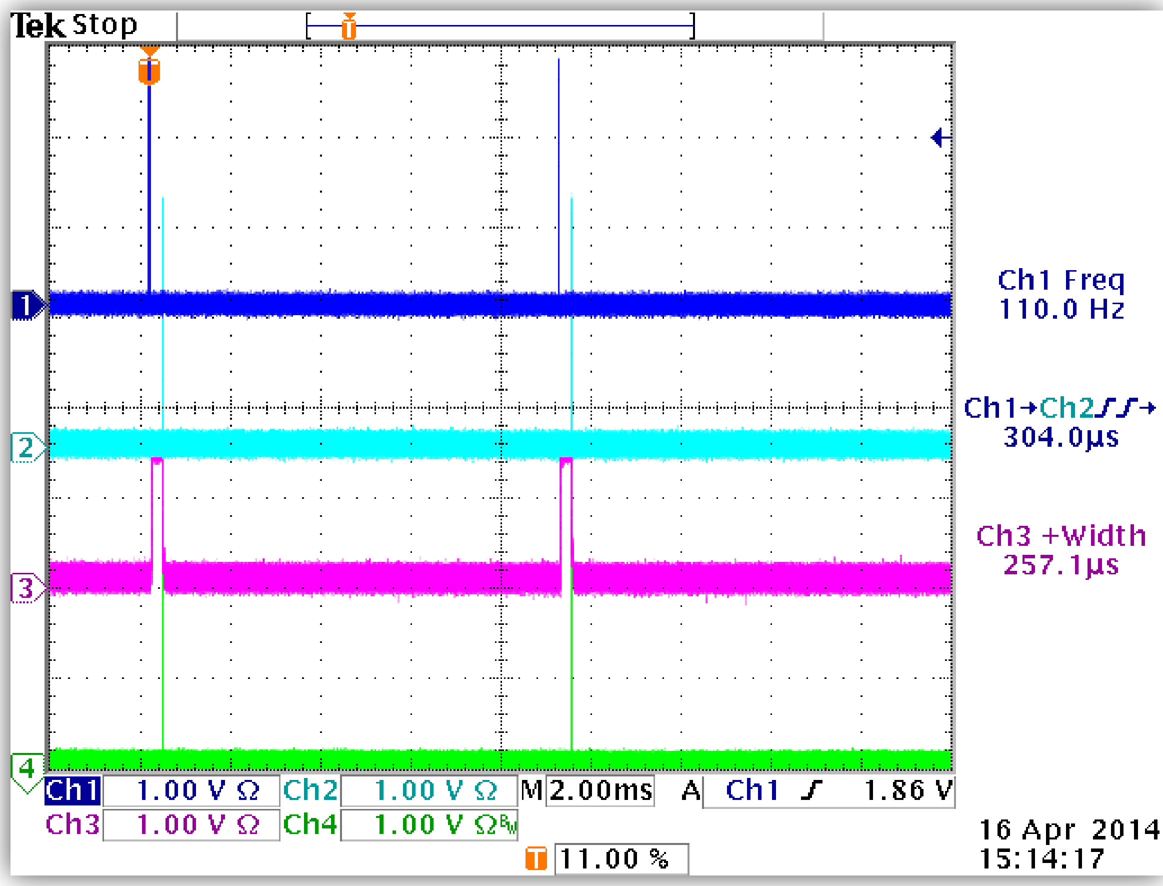

Figure 4-9 Four Channel Oscilloscope Screenshot

Laser Emission

WARNING. Wear proper laser safety eyewear to protect your eyes.

ELECTRICAL WARNING. The voltages in this system can be harmful or even lethal. Whenever handling or servicing the laser, always disconnect the power cord to the power supplies and drivers. Allow at least five (5) minutes for all electronics to discharge before touching or grounding of electrical connections.

1. Once temperatures are stabilized, set the Q-switch trigger delay to 170µs. Single click the **START** button on the GUI. An audible warning will be heard and the emission light on the eDrive Nitro will flash. The indicators for “Output Active” in the Power Supply and eDrive sections will be green.
2. Measure the frequency of channel 1. Confirm the frequency with the GUI after the laser is powered on.
3. Measure the pumping current pulse width on channel 3 of the oscilloscope. Confirm that the value is 245 to 255µs.

4. Allow the laser system to run for at least 20 minutes in order to achieve thermal stabilization.
5. Single click the **SHUTTER** button on the GUI to open the laser shutter and begin laser output. Gradually increase the Q-switch trigger delay to just above the threshold. Move the negative lens and power meter so that the beam is going through the center of the lens and hitting the center of the power meter.
6. Once the TEC and chiller temperatures have stabilized, gradually increase the Q-switch delay to the value specified in the ATP Test Report Data Summary. Don't touch any part of the laser, and wait for the laser to stabilize for 1 hour (the laser typically takes around 20 minutes to reach 95% of the maximum power). Verify that the power measurement approximates that reported on the ATP Test Report Data Summary.
7. Optimize the laser by making slight adjustments to the HR to minimize the delay between the Q-switch trigger signal and the laser pulse, to maximize output power.
8. Slightly change the Q-switch trigger delay for best pulse-to-pulse stability.
9. Optimize TEC temperature for harmonic power,
10. Usually the laser needs optimization for the first installation due to the slight differences of environments, chiller settings and vibration of the transportation. If so, please follow the laser performances optimization procedures in *Chapter 5: Maintenance.*

Daily Operation

Output energy and repetition rate of the Gigashot™ laser system can be adjusted within a specified range. Operating protocols must be observed to assure operation without risking internal damage to optical components. Contact NG CEO Customer Service if the laser must be operated outside the specified range.

CAUTION. The output beam of this system is a safety hazard. Avoid viewing the beam directly.

Turn On Procedure

1. Switch the chiller to the **ON** position. Verify correct flow rate and temperature setting to value specified on laser ATP Test Report Data Summary. Wait until the chiller has achieved proper temperature, which may take 5 to 10 minutes.
2. Flip the power switch on the rear panel of the controller to the **ON** or **I** position.
3. Make sure that the red **EMERGENCY** button of the eDrive Nitro is released. Turn the key switch to the **ON** position (if not in the **ON** position already).
4. Flip the power switch on the front panel of the DC power supply to the **ON** or **I** position (if not in the **ON** position already).

5. Launch the Gigashot™ Laser System Controller GUI from the computer. Ensure the ready signals at the top of each section of the GUI show green, indicating that communication is established. If there are any faults, clear them at this time.
6. Verify the GUI parameter settings match the last known optimal values.
7. After the TEC temperature has stabilized, single click the **START** button to fire the laser diode. The indicators for "Output Active" in the Power Supply and eDrive sections will be green.
8. Measure the frequency of channel 1. Confirm the frequency with the GUI after the laser is powered on.
9. Allow the laser system to run for at least 20 minutes in order to achieve thermal stabilization.
10. Single click the **SHUTTER** button on the GUI to open the laser shutter and begin laser output. The "Laser Output" indicator in the eDrive section of the GUI will turn green. The laser will automatically ramp to the Q-switch delay specified in the GUI. Wait for about 20 minutes to stabilize the laser.

Manual Interrupt Procedure

1. Single click the **SHUTTER** button on the GUI to close the laser shutter and stop laser output. The icon on the GUI will display a horizontal bar (with a green dot).
2. Resume operation by single clicking the **SHUTTER** button on the GUI. A vertical black bar (with a green dot to the left) will display above the **SHUTTER** button on the GUI.

NOTE: The laser diodes are still operating at a set frequency and full operating current when the shutter is closed. The Q-switch trigger signal is disabled.

Interlock Interrupt

A safety interlock BNC connector is located on the back panel of the controller. If the continuity of the interlock is broken, the controller will be powered off and the laser will stop lasing. The chiller will continue to run. Once the continuity of the interlock is satisfied, the fault in the controller must be cleared, and the system must reset to restart the laser. For other interlock configurations, please contact NG CEO.

CAUTION. Never look at the laser beam path even if the laser is off, as the laser beam could be powered automatically.

Shut Down Procedure

1. It is not necessary to use any buttons (or the key switch) on the front panel of the controller in order to turn off the laser.

2. Single click the **SHUTTER** button on the GUI to stop lasing. The “Laser Output” indicator in the eDrive section of the GUI will turn black.
3. Single click the **STOP** on the GUI to cease diode emission. The controller will be inactive after this step. The indicators for “Output Active” in the Power Supply and eDrive sections will be black.
4. Let Chiller run for 2 minutes.
5. Close the GUI.
6. Turn off the controller with the power switch on the rear panel.
7. Turn off the chiller.

Adjusting the Laser System

WARNING. Any parameter change while the laser is operational may damage the laser. Operating outside the specified ranges given in the ATP Test Report Data Summary may damage the laser.

Change the Parameter Settings

There are two types of parameter settings. Some settings may be changed during laser operation, such as chiller Set Temperature, Set TEC temperature, and Q-switch trigger delay. Some settings may be locked to prevent laser damage. These settings will appear as gray text when the laser is running. See *Chapter 3: System Details*. In order to change settings that are locked, perform the following steps:

1. Single click the **SHUTTER** button on the GUI to stop lasing.
2. Single click the **STOP** button on the GUI to cease diode emission.
3. Change the desired parameter using the GUI. See the ATP Test Report Data Summary for reference.
4. Resume operation by single clicking the **START** button on the GUI and then single clicking the **SHUTTER** button on the GUI. The laser will resume operation with audible warning and the indicator lights will display green.
5. Warm up for one hour (not necessary if laser has been operating).
6. Optimize laser per the Optimize Laser Performance section in *Chapter 5: Maintenace*
   - Fine Tune TEC temperature
   - Fine Tune Cavity Mirrors

NOTE: For lasers exceeding 200 million shots usage, cooling fluid temperature may need to be optimized. Increasing the diode current or pulse width may be needed as well.

5

Chapter 5: Maintenance

The chapter contains information in these sections:

- Prepare for Shipment
- Purge Housing
- Replace Desiccant Cartridge
- Clean and Maintain Chiller
- Check Hold Off
- Extend Lifetime of Laser Diodes
- Optimize Laser Performance

Prepare for Shipment

It is anticipated that in most applications the Gigashot™ laser will be installed in another system that will be shipped internationally. The Gigashot™ optical assembly must be properly prepared for shipment if internal damage is to be avoided due to possible freezing of coolant trapped in the lines. This procedure follows:

1. Ready a dry gas source in preparation for draining the system. Oil-free, dry filtered air or (N_2) is recommended.
2. Remove coolant connections from back of laser housing.
3. Connect a dry gas line to the **COOLANT OUT** connector on the housing. Coolant lines must be purged in the proper direction or trapped water may remain in the lines inside the laser. If this trapped water freezes it can cause lines to leak coolant when operation is resumed.
4. Connect a drain hose with a proper quick disconnect fitting to the **COOLANT IN** connector on the housing.
5. Purge the lines with for at least ½ hour at 5 psi.
6. Remove purge lines.

After the laser is dry, place it in a sealed ESD bag with a desiccant. Package the laser securely in its original shipping container.

You will need to remove all coolant from the chiller prior to shipment. Refer to the chiller manufacturer's instructions. Do not reconnect chiller lines to laser prior to shipment. After shipment, if antifreeze was used, drain and clean the chiller. Add a new filter and clean Optishield Plus™ coolant before reconnecting the chiller to the laser.

Purge Housing

The Gigashot™ optics assembly must be kept at low humidity to protect the HG crystal, which is slightly hygroscopic, and to prevent the possibility of condensation on the laser diode arrays. The Gigashot™ housing provides a level of protection from entry of ambient humidity, but it is not hermetically sealed. When operating in a high ambient humidity, precautions need to be taken to keep the interior of the housing dry. The lid of the housing has a port for a desiccant cartridge, which should be changed when the cartridge indicator is no longer blue. Also, the housing interior can be purged with clean, dry air using the valve on the rear of the housing. The inlet line is the stemmed valve and is opened and closed by rotating the knob on the valve end. Please contact NG CEO before attempting this procedure.

CAUTION. The clean dry air input line must be on a pressure regulator and the line must be filtered.

Replace Desiccant Cartridge

The desiccant cartridge removes excess moisture from inside the laser head. It is located on the lid of the Gigashot™ laser head. The desiccant cartridge must be replaced regularly, so it should be checked at least weekly for exhaustion.

Exhaustion is indicated by a change in the color of the indicator paper in the top of the cartridge. While any sector of the indicator paper in the cartridge top remains blue, the cartridge can still absorb water. When all sectors of the indicator paper turn completely white or light pink, the cartridge has absorbed all the water it can and must be replaced. Replacement frequency varies with the humidity in your operating environment and if the laser head is opened.

WARNING Waiting to replace desiccant until all sectors on desiccant cartridge have turned white will result in optical damage.

If the desiccant cartridges are exhausted in a short time frame (e.g., two weeks) without the laser head having been opened, contact NG CEO technical service.

A second desiccant cartridge is recommended to reduce the time the desiccant cartridge is removed from the Gigashot™ laser cover during service. Any spare desiccators should be stored in a cool dry area. A nitrogen purged dry box is recommended for storage.

40 Gram Desiccant Cartridge

The 40 Gram Desiccant Cartridge (Figures 5-3 and 5-4) is used on Gigashot™ lasers.

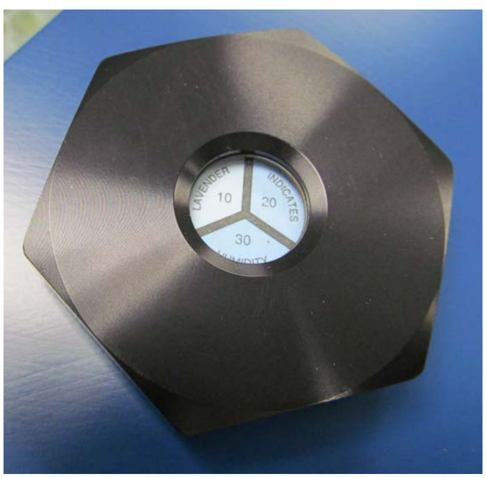

Figure 5-1 40 Gram Desiccant Cartridge Top

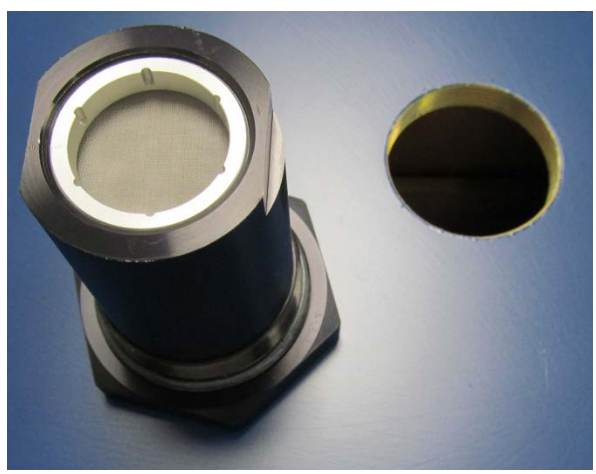

Figure 5-2 40 Gram Desiccant Cartridge Bottom

To service the desiccant, the following supplies are required. Desiccant supplies can be purchased from NG CEO, or directly from AGM Container Controls, Inc. telephone number 800-995-5590.

- Desiccant cartridge NG CEO part no. 42-228
- Refill part number 643665
- Refill tool 980412

Remove the desiccant cartridge from the top cover of the laser housing. Use the refill tool to remove the retainer ring, and exchange the desiccant. The refill package contains 50 grams of desiccant. Fill the cartridge to the counter-bore surface where the filter is mounted. Do not overfill. Fill as shown in Figure 5-5.

Make sure that there are no desiccant beads on the surface where the filter is mounted. Install the paper filter, then the screen, then the retainer ring. Hand-tighten the retainer ring with the refill tool. Replace the desiccant cartridge immediately to minimize the amount of time that the desiccant cartridge is removed from the laser housing.

Tighten the desiccant cartridge by hand. DO NOT OVERTIGHTEN.

Figure 5-3 50 Gram Refill and Refill Tool

WARNING. Do not operate the laser without a functional desiccant cartridge. Condensation on the diode arrays or other optics can seriously damage the laser and may void warranty.

Clean and Maintain Chiller

The 5 µm filter and coolant in the chiller should be replaced at least monthly. Comply with your chiller manufacturer's recommendation if more frequent. The color of the filter and coolant hose are good indicators of the coolant quality. The coolant hose should be clear and the filter white. If not, the chiller needs maintenance. Drain and re-fill the chiller per the chiller and coolant manufacturer's instructions.

Chemicals and Supplies Needed

- 3% Hydrogen Peroxide solution sufficient to fill the system.
- Optishield Plus™ and distilled water solution (10% Optishield Plus™, 90% distilled water).
- Distilled water, sufficient to fill the system.
- Two replacement particle filters (NG CEO P/N 37023165).

NOTE: The chiller must run continuously to prevent biological growth or corrosion. If the chiller is to be shut down for more than 1 week, the coolant loop should be drained, flushed with 3% hydrogen peroxide solution and purged with oil-free, dry filtered air or nitrogen (N_2).

Cleaning Procedure

1. Drain chiller and clean any residue or contamination in the reservoir with the use of a bottle brush or alcohol wipes.
2. Using a filter housing wrench, dismantle the particle filter housing. Empty the coolant trapped in the filter housing into a container for later disposal.
3. Dispose of the expired particle filter and clean any residue or contamination from the inside of the filter housing. Install a new filter in the housing.
4. Refill with distilled water and circulate for 5 minutes.
5. Drain system completely as detailed in steps 1 and 2.
6. Fill the chiller with a 3% solution of Hydrogen Peroxide. Care should be taken to ensure that the mixture completely fills to the top of the reservoir to ensure all wetted surface areas of the chillers are cleaned. Cycle the chiller on and off. Top off the reservoir as necessary to ensure it is full of the cleaning solution. Ensure that the cap of the chiller reservoir is loose or remove it completely to allow gas to escape from the system.
7. Circulate the cleaning solution through the system including the laser module for 40 minutes.
8. Drain the cleaning solution mixture from the chiller as detailed in steps 1 and 2.
9. Refill and circulate distilled water for 5 minutes and drain. Ensure that the cap of the chiller reservoir is loose, or remove it completely to allow gas to escape from the system.

10. Drain the chiller and dispose of the filter.
11. Disconnect the chiller from the laser module and blow out water from the laser module coolant loop prior to refilling the chiller coolant reservoir.
12. Reconnect the laser module coolant loop.
13. Install new 5 micron filter into housing.
14. Record cleaning date on sticker with a one-month reminder to drain & clean the system. Affix sticker to chiller (or cabinet).
15. Refill the chiller reservoir with Optishield Plus™ and distilled water coolant following the manufacturer's directions. Run for 30 minutes with the cap loose to allow gas to escape from the system.
16. Secure the reservoir cap.
17. The chiller is now ready to use.

Check Hold Off

Checking hold off is a technique needed to verify proper operation of the laser. To check hold off, perform the following steps:

1. Turn on the laser and run for at least 20 minutes.
2. Lower the current to 10A.
3. Power off the Q-switch driver by disconnecting the 24V DC on the back of laser enclosure. Gradually increase the current to the full operation current level.
4. Observe the beam output on the power meter. Hold off condition is met when no output light is observed.
5. If output light is observed, the laser does not hold off and may need internal repair or adjustment.
6. Reduce the current to 10A.
7. Power up the Q-switch driver with connection of 24V DC on the back of laser enclosure.
8. Gradually increase the current to the operation current.

Extend Lifetime of Laser Diodes

The specification for laser system optical output is provided in the ATP Test Report Data Summary delivered with the system. During its early lifetime, the laser diodes will deliver this specified power at or below the preset current limit. As the diodes age, an increase in current or pumping duration may be required to maintain power and beam quality so the diodes can continue to be used. Once the maximum peak current of 175A is reached, consider replacing diodes or upgrade the laser. Please contact NG CEO for detailed information.

Optimize Laser Performance

Optimization of the laser may be required when the laser is initially installed or the laser performance has degraded due to aging laser diodes.

For this procedure, light should be emitting from the laser. In the absence of any output, please review *Chapter 7: Troubleshooting* or contact NG CEO for assistance. To obtain the best performance, small adjustments may optimize the laser. To optimize the laser, follow these steps:

1. Wait for the laser reach thermal stabilization.

Both the laser bench temperature and environmental temperature significantly impact the laser power. Wait for the laser to be thermally stabilized before attempting any adjustment.

2. Check the settings of the controller and chiller.

Check the performance with all items set to the values on the laser ATP Test Report Data Summary. Verify that all of the Controller and GUI settings are correct.

The coolant flow rate and coolant temperature have a significant impact on the laser performance. Make sure that the flow rate and the temperature of the chiller match results from the original ATP Test Report Data Summary.

3. Peak up the laser power by tuning the temperature of the TEC controller (if the TEC is equipped on your laser model).

The phase matching of the harmonic generation (HG) crystal is crucial for the Gigashot™ laser. This is achieved by setting the proper temperature on the HG crystal, which is controlled by the TEC controller.

Figure 5-4 illustrates an example of the dependencies of power of the laser to the HG crystal temperature. As shown in the example, the mid-point of the temperature band is around 25 °C.

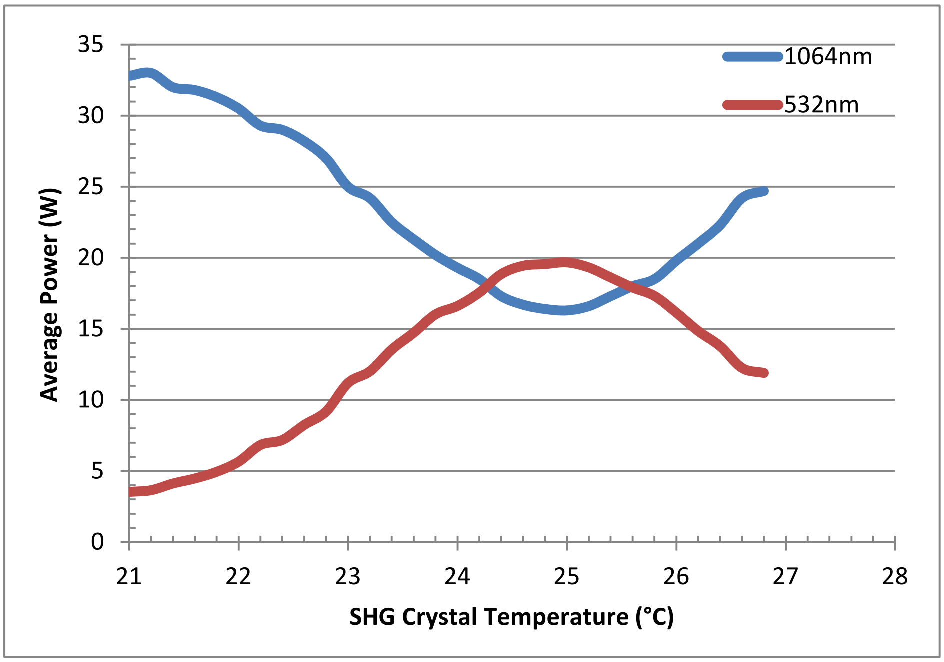

Figure 5-4 Example of Power Dependence of the laser to SHG Crystal Temperature

4. Peak the laser power by adjustment of chiller temperature.

The laser diode wavelength will slowly drift as the laser diodes age. In order to match the diode wavelength to the absorption wavelength of Nd:YAG crystal, the chiller temperature has to be adjusted. Chiller temperature adjustment should be stopped when the temperature may cause condensation inside the laser.

5. Increase the pulse energy by changing the current or pumping pulse width.

The laser diodes have an aging rate less than 2% over 200 million shots, which means the laser would be considered normal if the power is maintained over 200 million shots by increasing the operating current or pumping pulse width by 2%.

The slight difference between the actual operating current and the ATP Test Report Data Summary value may be due to the performance difference of the chillers. An increase in the operating current or a change in chiller temperature can compensate for the aging of the Gigashot™ laser diodes. In order to protect the laser, eDrive Nitro and DC power supply currents have been limited. These limits need to be increased as the laser diodes age.

6. Peak up the laser with adjustment of the HR mirror.

WARNING. Making mirror adjustments can be non-reversible. Perform this step only when all the steps above have been completed and the laser does not meet the specifications with the correct settings.

a. Reduce the pulse energy to 10mJ by adjusting the Q-switch trigger delay to avoid optical damage.

b. Locate the access holes for high-reflection (HR). Notice the positions of horizontal and vertical adjustment access holes for the HR mirror as shown in Figure 5-5.

c. Remove screws from access holes in the back panel only in a dust free environment.

d. Use a 1/8 inch ball driver to make adjustments. Adjustments should be made in very small increments, of 1 degree (or less) rotation.

e. Always make sure that the TEC temperature is stabilized.

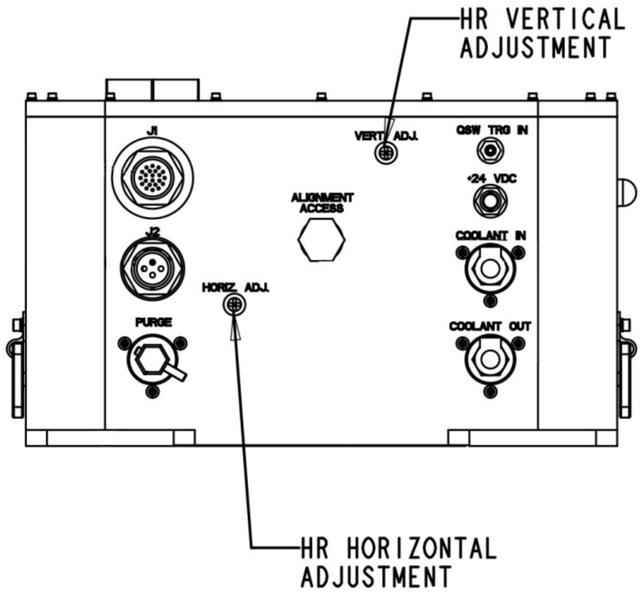

Figure 5-5 HR Mirror Adjustment

f. Optimize power:

- Make small adjustments to the horizontal angle of HR mirror and observe the output power.
- Once a maximum is found, adjust the vertical control of HR mirror to maximize power.

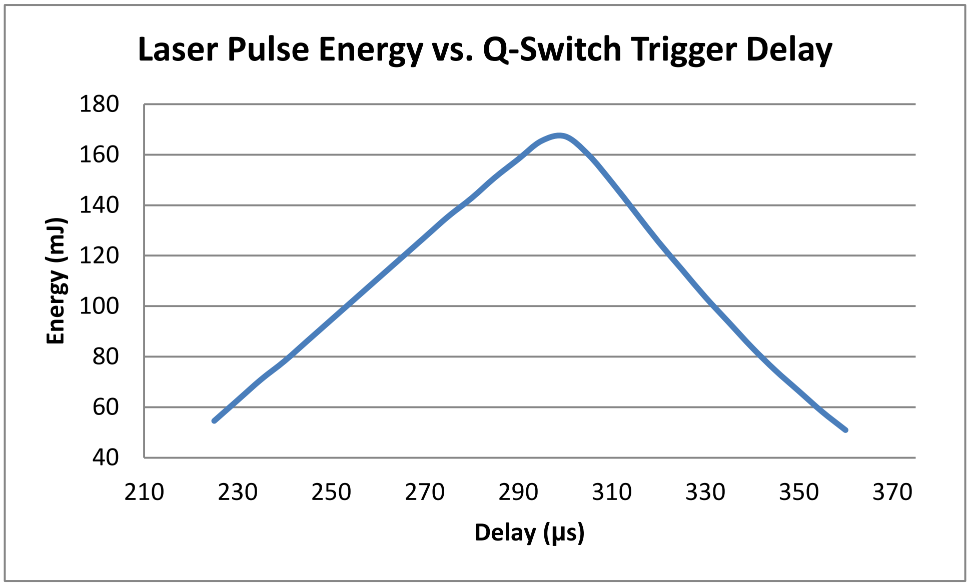

Figure 5-6 Example of Laser Pulse Energy Dependence on the Q-Switch Trigger Delay

7. Peak the laser pulse energy with Q-switch trigger delay. Figure 5-6 shows an example of the relationship between Q-switch trigger delay and pulse energy.
8. Repeat the optimization steps with until there is no significant performance improvement.
9. Once the laser is optimized, the laser should have the best power, display a round beam, and have good pulse-to-pulse stability. .

6

Chapter 6: Service

At Northrop Grumman Cutting Edge Optronics, we are proud of the durability of our products. Our manufacturing and quality control processes emphasize consistency, ruggedness, and high performance. Nevertheless, even the finest instruments break down occasionally. We believe that the reliability record of our instruments compares favorably with that of our competition, and we hope to demonstrate our superior service by providing dependable instruments and, if the need arises, service facilities that can restore your instrument to peak performance without delay.

When calling for service in the U.S., dial (636) 916-4900 (follow prompts for department directory). To phone for service in other countries, contact your sales agent.

This chapter provides reference to types of customer service needs:

- Contacting Customer Service
- Laser Module Replacement
- Return the Instrument for Repair

Contacting Customer Service

To expedite your service needs, please complete the questionnaire in *Appendix A: Customer Service* ***before*** you contact NG CEO Technical Service. Complete the questionnaire with as much detail as possible and retain a copy for your records.

E-mail or fax the form to NG CEO (refer to the second page of this manual for contact information) and notify your customer service representative that it has been sent.

Laser Module Replacement

The laser module can be replaced by a trained service engineer. Contact NG CEO for Laser Level 2 training, and access to Level 2 maintenance instructions.

Return the Instrument for Repair

A return merchandise authorization (RMA) *is required* prior to shipping any instruments to NG CEO. Contact NG CEO or your local distributor for RMA and shipping instructions.

CAUTION. Failure to obtain proper shipping instructions may result in damage to the instrument.

Use the packing boxes supplied by NG CEO to ship your instruments. If shipping boxes have been lost or destroyed, replacements are available for a nominal charge from NG CEO.

Remove all coolant from laser prior to packaging for shipment (see *Chapter 5: Maintenance* for details). Place a desiccant in a sealed ESD bag with the laser and secure the laser in the shipping container.

WARNING. Damage from residual coolant due to condensation or expansion can be catastrophic to the diode arrays or laser rod if not dealt with properly. Such damage is excluded from warranty coverage.

7

Chapter 7: Troubleshooting

This chapter is intended to provide possible solutions to common problems encountered with the Gigashot™ laser during normal use.

WARNING. Do not attempt repairs while the unit is under warranty. Complete the form in Appendix A and report problems to NG CEO for repair.

The following sections can be found in this chapter:

- Initial Checklist
- Laser Output Power
- Controller Operation

Initial Checklist

Before adjusting or attempting troubleshooting procedures, verify the following. Additional information is available in the troubleshooting guide that was supplied with your laser:

- Verify the eDrive is operating at the correct peak current, pumping pulse width, pumping frequency, and other settings match the ATP Test Report Data Summary supplied with the laser. This can be verified through the current monitor port.
- Verify that the delay between the eDrive and Q-switch trigger matches the ATP Test Report Data Summary. This can be verified with two synchronization monitor outputs.
- Verify that the TEC is set to the temperature specified on the ATP Test Report Data Summary supplied with the laser.
- Verify the chiller temperature and flow rate are correct.
- Operate the laser and for at least 20 minutes to reach full power and stability before making any adjustments.

NOTE. Only after verifying these conditions should you attempt to make adjustments to the laser system.

Laser Output Power

Low Output Power (0.01W -full)

Delay is not optimized: Check the setting of the Q-switch delay in the settings.

Problem with power meter: Use another power meter to verify the measurement.

Low operating current or pumping duration: Check the set current and pumping duration.

Coolant flow rate/temperature incorrect: Verify the chiller is set to provide the correct coolant flow rate and temperature to the laser head.

Phase matching condition of HG crystal is not met: Check the temperature of TEC (if equipped) controller and make sure it works properly.

Pulse repetition frequency incorrect: Check the pulse rate frequencies of the pumping current and Q-switching.

Laser is misaligned: Perform the laser power optimization procedures as described in the *Optimize Laser Performance* section in *Chapter 5: Maintenance* to bring the power back.

Internal optical damage to the laser, contaminated rod, or aging diodes: If the laser power cannot be restored after optimization, contact NG CEO for service.

No Output Power

- Verify the operating current is set at the operation point.
- Verify the Q-switch is triggered at preset PULSE FREQUENCY with an internal or external triggering source.
- Verify that the shutter light on the front panel of the eDrive is turned on, or a vertical black bar (with a green dot to the left) is displayed above the **SHUTTER** button on the GUI, indicating that the laser shutter is open.
- Verify there are no interlock warning messages on the eDrive and that the eDrive Nitro is supplying the correct current.

Laser Flicker

When the external perturbations are applied to the laser system, the laser exhibits flickering.

- Verify the laser performance is optimized.
- Verify there is no strong vibration force applied to the laser head.
- Verify that the flow rate to the laser head matches the flow rate reported in the ATP Test Report Data Summary and the coolant flow is constant.
- Verify the laser has good output power. A laser with high modulation loss or low operating current is sensitive to perturbations.
- Verify the operating current is stable.
- Verify the Q-switch hold off is good.

Controller Operation

The following issues may occur in relation to the Gigashot™ laser.

The eDrive Nitro has built-in diagnostics to alert the user of fault conditions. Common error reports and suggested remedies follow. Consult the eDrive Nitro User Manual for more details.

Chiller Fault Detected / Flow Interlock Fault

- Check chiller for operation and low coolant level.

Hardware Fault Detected

- Check that the Emergency Stop button is not depressed.
- Check **INTERLOCK** input on back panel for open condition.

Cover Interlock Fault Detected

- Verify that the cover is secure on the laser.
- Check cable connections to laser.

Channel Over Temperature Fault

- Verify the eDrive Nitro fans are operational.
- Verify that the airflow through the driver is not obstructed.

A

Appendix A: Customer Service

This form has been provided to encourage you to tell us about any difficulties you may have experienced while using your NG CEO instruments or user manuals. Call or write our customer service department to bring attention to problems that you may not have personally experienced. We are always interested in improving our products and manuals, and we appreciate all suggestions.

Date:	
Name:	
Company or Institution:	
Department:	
Address:	
Laser Model Number:	Serial Number:
Chiller Model Number:	Serial Number:
eDrive Model Number:	Serial Number:
Laser Manufacture Date:	Total Laser Lifetime (shots):

Questions

What is the coolant flow rate (GPM)?

What is the set temperature on the chiller (^{o}C)?

What is the coolant pressure on chiller (PSI)?

What are the temperature set and actual reading from TEC controller (^{o}C)?

What are the set current and actual current from eDrive (A)?

Is Q-switch enabled (yes/no)?

Is Q-switch triggered internally or externally?

What is the pulse repetition frequency (Hz)?

Is the output power measured directly from the laser (yes/no)?

What is the measured power (W)?

When did the problem happen?

Have you changed any settings recently (yes/no)?

Have you adjusted the laser to try to fix the problem (yes/no)?

What are the changes made recently to the system?

Please describe the problem or laser behavior as detailed as possible:

Suggestions

Email or fax to:

Northrop Grumman
Cutting Edge Optronics, Inc.
20 Point West Boulevard
Saint Charles, MO 63301 USA
Phone: (636) 916-4900
Fax: (636) 916-4994
Email: ngceoservice@ngc.com

B

Appendix B: System International Units

The following System International (SI) units, abbreviations, and prefixes are used throughout NG CEO user manuals:

Quantity	Unit	Symbol
mass	gram	g
length	meter	m
time	second	s
frequency	Hertz	Hz
force	Newton	N
energy	Joule	J
power	Watt	W
electric current	Ampere	A
electric charge	Coulomb	C
electric potential	Volt	V
resistance	ohm	Ω
inductance	Henry	H
magnetic flux	Weber	Wb
magnetic flux density	Tesla	T
luminous intensity	candela	cd
temperature	Kelvin	K

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

Appendix C: Acronyms

Acronym	Description
ACGIH	American Conference of Governmental Industrial Hygienists
ANSI	American National Standards Institute
AO	Acusto-Optical (type of Q-switch)
AR	Anti-Reflective
ASM	Array Sub-Module
CDRH	Center for Devices and Radiological Health - U.S. Food and Drug Administration
CEO	Cutting Edge Optronics, Incorporated
CFR	Code of Federal Regulations
CW	Continuous Wave
DC	Direct Current
DPSS	Diode-Pumped Solid-State
EO	Electro-Optical (type of Q-switch)
ESD	Electro-Static Discharge
FET	Field Effect Transistor
FDA	U.S. Food and Drug Administration
FPS	First Pulse Suppression
FWHM	Full Width at Half Maximum
GaAlAs	Gallium Aluminum Arsenide
GPM	Gallons Per Minute
HeNe	Helium Neon
HG	Harmonic Generator
HM	Harmonic Mirror
HR	High Reflector
HV	High Voltage
IEC	International Electrotechnical Commission
IR	Infrared
KTP	Potassium Titanyl Phosphate

Acronym	Description
LPM	Liters per Minute
LBO	Lithium Triborate
MCC	Meters Concave
N_2	Nitrogen
Nd:YAG	Neodymium-doped Yttrium Aluminum Garnet
Nd:YLF	Neodymium-doped Yttrium Lithium Fluoride
NG	Northrop Grumman
NIR	Near Infrared
OC	Output Coupler
OSHA	Occupational Safety and Health Administration
PULSE FREQUENCY	Pulse Repetition Frequency
psi	Pounds per Square Inch
QCW	Quasi-Continuous Wave
QSW	Q-switch
RF	Radio Frequency
RH	Relative Humidity
RMS	Root Mean Square
TEC	Thermal Electric Cooler
TEM	Transverse Electromagnetic Mode
TTL	Transistor - Transistor Logic
UV	Ultra Violet
VAC	Volts, Alternating Current

Index

T

W