

User Manual

- Patara Laser
Model PA-016-QTGP
Gen I and II



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Technical Support: (636) 916-4900 (follow prompts for department directory)

Email: [ngceoservice @ngc.com](mailto:ngceoservice@ngc.com)

Cutting Edge Optronics Headquarters

20 Point West Blvd. St. Charles, MO 63301 USA

Sales Support: (636) 916-4900 (follow prompts for department directory)

*After office hours, please leave a voice mail message. Outside North America, contact a Cutting Edge Optronics sales office or distributor; see the Cutting Edge Optronics website for a list of offices.

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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 Point West Blvd, St. Charles MO 63301 USA
 产品名称 / 编号 Patara Laser Model PA-016-QTGP

有毒有害物质或元素标认表

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	○	○	○	○	○	○
第二组	电线/ 连接插头	X	○	X	X	X	X
第三组	安装组件	○	○	○	X	○	○
第四组	开关组件	○	○	○	X	X	X
第五组	电路板/ 开关组件	X	○	○	○	X	X
第六组	阵列前端次模组	○	○	○	○	○	○
第七组	接触板	X	○	○	○	X	X
第八组	热交换组件	○	○	○	○	○	○
第九组	16 进制硬件	○	○	X	○	○	○
第十组	焊锡	X	○	X	○	○	○
第十一组	电线/ 连接插头	X	○	○	○	X	X
第十二组	基部/ 端帽	X	○	○	X	○	○
第十三组	硬件/ 装配	○	○	○	X	○	○
第十四组	時計组件	X	○	○	X	X	X
第十五组	包装物料	○	○	○	○	○	○

○: 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 pushing 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 or to bring attention to important information.



This icon denotes a note, which indicates important information.

I Power Switch Position Symbols
O I = On O = Off

The following conventions may appear on the product:

DANGER An injury hazard immediately accessible as the marking is read.

WARNING A hazard not immediately accessible as the marking is read.

CAUTION A hazard to property including the product.



ESD: Handle Appropriately



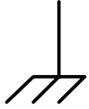
Laser Emission: Use caution.



Shock Hazard: Use caution.



Caution: Risk of danger. Refer to manual.



Chassis Ground

General Safety Summary

The Patara 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. For 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 trouble shooting section is intended to help guide the user to the source of problems. Do not attempt repairs while the unit is under warranty; instead, report all problems to Northrop Grumman for warranty repair.

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

About This Manual

This manual describes the installation, operation, and service of the Patara 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 Patara laser.
- *Chapter 2: Laser Safety* describes proper safety procedures that should be understood before operating the Patara 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 the system for the first time.
- *Chapter 5: Maintenance* provides information on proper maintenance of the laser system.
- *Chapter 6: Customer Service* provides resources to help fix problems with the Patara laser.
- *Chapter 7: Troubleshooting* provides possible solutions to the most commonly reported issues with the Patara laser.
- *Appendix A: Customer Service* provides information to expedite any service request before contacting Northrop Grumman.
- *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.
- *Index* provides page references for subjects within the manual.

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Chapter 1: Introduction

This introduction provides the following information:

- Theory of operation
- System description

Theory of Operation

Patara Laser is a Q-switched, intra-cavity, frequency doubled, laser oscillator. The output consists of pulses of light at 532 nm wavelength and 60 ns to 100 ns pulse duration at repetition frequencies of 4,000 Hz to 10,000 Hz. It is a transverse electromagnetic mode (TEM₀₀) laser and therefore has very high brightness. The continuous wave (CW) pumped neodymium-doped yttrium aluminum garnet (Nd:YAG) rod module in the oscillator is optically excited using arrays of laser diode bars operating at wavelengths around 806 nm.

A laser oscillator consists of an optical amplifier in an optical cavity which forms a laser optical mode that can oscillate when the gain of the amplifier is sufficient to overcome the losses in the optical cavity. One such loss is the amount that escapes the oscillator cavity through one of its mirrors resulting in its useful output. This basic approach suffices unless the output beam at a desired wavelength differs from the fundamental wavelength (1064 nm) of the laser amplifier medium (Nd:YAG).

Various nonlinear optic techniques can serve to convert this beam to another wavelength, but usually with considerable loss of power or with a residue of unconverted fundamental power. This occurs when the fundamental radiation is allowed to leave the oscillator cavity and the beam is converted outside the cavity. However, if the nonlinear conversion is completed inside the oscillator cavity the leftover fundamental simply returns to the oscillator and is conserved, amplified, and returned to the nonlinear frequency converter. As a result nearly all the power which could have been optimally coupled out of the cavity by a semi-transparent mirror, is now converted to another wavelength (provided that the semi-transparent mirror is replaced by one that is fully reflective at the fundamental wavelength). Patara uses this intra-cavity technique to double the laser frequency to a wavelength of 532 nm.

The frequency doubling device is a crystal of lithium triborate (LBO) cut at a special angle providing phase matching between the fundamental waves in the beam and the waves generated at 532 nm at around room temperature. Phase matching and efficient conversion is sensitive to the angle to the unidirectional intra-cavity beam and to the temperature of the LBO crystal. As a result, it is necessary to provide a stable mechanical and thermal environment for the doubling crystal.

A phase matching condition can be met by either the angular adjustment of the doubling crystal mechanically or by the varying the temperature of the crystal electrically. Stability and reliability considerations lead to a mechanically fixed doubling crystal with fine tuning accomplished electrically.

With the doubling crystal mounted in a cell on the top of the thermal electric cooler (TEC), the temperature of the doubling crystal can be controlled. The performance parameters are optimized with a crystal temperature between 20 °C

to 50°C. Once this temperature is identified and fixed, the temperature of the crystal can be stabilized to ± 0.1 °C with the TEC controller.

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. The Patara laser uses an acousto-optic (AO) Q-switch to prevent 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. The Q-switch then suddenly removes the loss 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 (it takes light only a few nanoseconds to transit the laser cavity and results in releasing stored energy in a short duration pulse.) The high peak power achieved in this manner is also essential to achieving an adequate fraction of conversion to 532 nm. The conversion process is dependent on the intensity of the circulating 1064 nm power.

The laser beam that circulates inside the oscillator cavity is determined by a process of self-consistency. The beam characteristics at any given location in the cavity are repeated after the beam completes a round trip back to that location. Oscillator beams are composed of transverse modes of simple structure related to a fundamental Gaussian intensity profile mode, which is of the smallest lateral extent and divergence in the set.

The aperture in the oscillator path limits the laser beam's transverse spatial extent. To achieve maximum power and efficiency, this aperture should coincide with the aperture of the amplifier medium so that the oscillating beam fills the gain medium to the maximum extent. Laser beam quality will degrade if the diameter of the fundamental mode is much smaller than the limiting aperture, causing higher order modes to oscillate with a larger transverse extent and a higher divergence than the fundamental mode.

Beam quality is dependent upon the product of the diameter of the beam and its angular divergence as it propagates into the far distance. This product is conserved with propagation and transformation by optical elements such as lenses and mirrors. Beam quality can also be rated by the reduction of spot size achieved by simple focusing with higher quality beams providing spots with smaller diameters and higher intensities.

This factor also impacts the amount of achievable harmonic conversion and favors restricting laser operation to its fundamental Gaussian mode, such as is used in the Patara laser. The design of the laser cavity for fundamental mode operation involves the selection of cavity length and the characteristics of the pumped amplifier medium's diameter and focal power.

Once the design parameters are selected for optimum fundamental mode operation, they cannot be altered without disrupting the fundamental mode size in the amplifier leading to unacceptable changes in performance. This is particularly important to the intensity of amplifier excitation, pump power, or drive current

since these also determine focal power. Consequently, the amplifier drive current must be kept within a close tolerance of the design point.

In applications that require the laser output power be lowered to reduce gain without sacrificing beam characteristics and focal power, the Patara laser achieves a corresponding reduction of power by increasing the loss of the optical cavity while maintaining the gain at a constant level. This added functionality of accepting and executing power level commands is built into the accompanying eDrive electronic system.

System Description

The Patara laser consists of three interconnected subsystems. The optics subsystem contains the laser oscillator, the eDrive electronic subsystem provides power and control for the laser transmitter, and the chiller provides thermal control. The user must supply prime power and cooling to the optics subsystem. The interface relationships among these subsystems are illustrated in **Figure 1-1**.

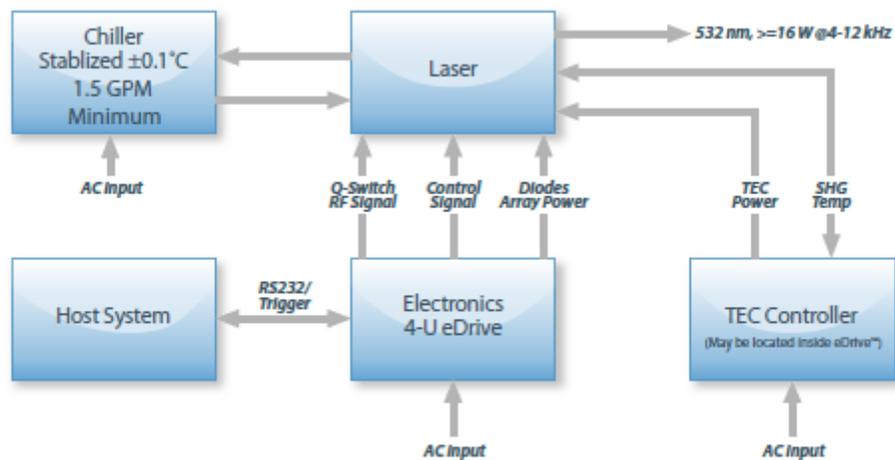


Figure 1-1. System Block Diagram



NOTE: Figure 1-1 shows an external TEC Controller, which is not standard. Typically the TEC Controller is located inside the eDrive (for -0150 and later configurations).

Table 1-1 Typical Performance of the Patara Laser

Parameter	Units
Laser Model	PA-016-QTG
Laser Type	DPSS Nd:YAG
Wavelength	532 nm
Repetition Rate	4 to 10 kHz
Output Power @ 9 kHz	16 W
Spatial Mode	TEM00
Beam Diameter @ 9 kHz	0.9 mm
Beam Quality (M2) @ 9 kHz	< 1.3
Beam Divergence (FWHM) @ 9 kHz	1.7 mrad
Pulse Width (FWHM) @ 9 kHz	< 80 ns
Pulse-to-Pulse Stability @ 9 kHz	< 1.5 % rms
Output Stability (Over 8 hours) @ 9 kHz	< 3 % rms

Table 1-2 – Other Specifications Table

Parameter	Performance
Electrical Inputs	Auto-ranging: 100-250 VAC @ 47-63 Hz Drawing 7A
Cooling	Closed Loop Recirculating Chiller ¹
Coolant	Opti-Shield Plus
Operating Temperature	18-30°C
Laser head size	24" L x 6" H x 8" W
eDrive Nitro Size	7" H x 19" W x 17" D

¹ Chiller must be able to circulate water at the approximately 60 psi required in CEO lasers, see final test report for each laser specific required pressure.

² Drain the chiller, and replace the coolant and filter monthly. This may be required more often if the system shows signs of contamination.

Optics Subsystem

The optical subsystem consists of an optical assembly on a Northrop Grumman industrial laser optics bench.

Electronic Subsystem

The electronic subsystem consists of a 4U sized eDrive with an internal TEC controller (see *eDrive User Manual* [CEO-UMAN-0001] for details). Refer to *Chapter 4: Installation and Operation* to setup and operate the eDrive with the Patara laser. Contact a Northrop Grumman service engineer for assistance.

Operation at reduced power requires that two settings be adjusted in the eDrive: the Q-switch power, and Iset, the drive current level. The laser shipment includes the ATP Test Report Data Summary that provides the values necessary to achieve the full, 9 W, 5 W, and 2 W power conditions.

The temperature of the second harmonic generation (SHG) crystal for phase matching is crucial to determining the performance of the Patara laser. It is set and controlled by a TEC controller inside the eDrive. Refer to the *Check the eDrive* section of this manual in *Chapter 4: Installation and Operation* for TEC Controller settings.

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 and power to the Q-switch should the flow rate fall below 1 gpm (3.8 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 °C with a flow rate of 1.5 gpm (5.7 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 deionized water must be avoided because of corrosion and mineral deposits. Northrop Grumman can supply an approved coolant for this application.

Chapter 2: Laser Safety

Please read this chapter carefully before installing or operating the laser. A Northrop Grumman trained service engineer should perform all service and repair operations. If planning to service the laser, please follow the procedures in *Chapter 5: Maintenance*.

Sections included in this chapter include:

- Safety Overview
- Precautions for Safe Operation
- CDRH Compliance

Safety Overview

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



CAUTION. The Patara 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 the 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 the 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).

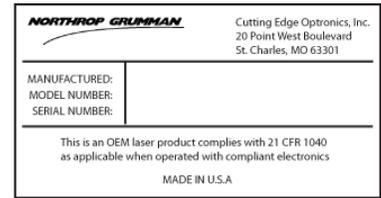
Precautions for Safe Operation

- 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).
- 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 Northrop Grumman 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.
- 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.
- Do not smoke, eat, or drink in laser areas.
- Avoid leaving an operating laser unattended.

Center for Devices and Radiological Health Compliance

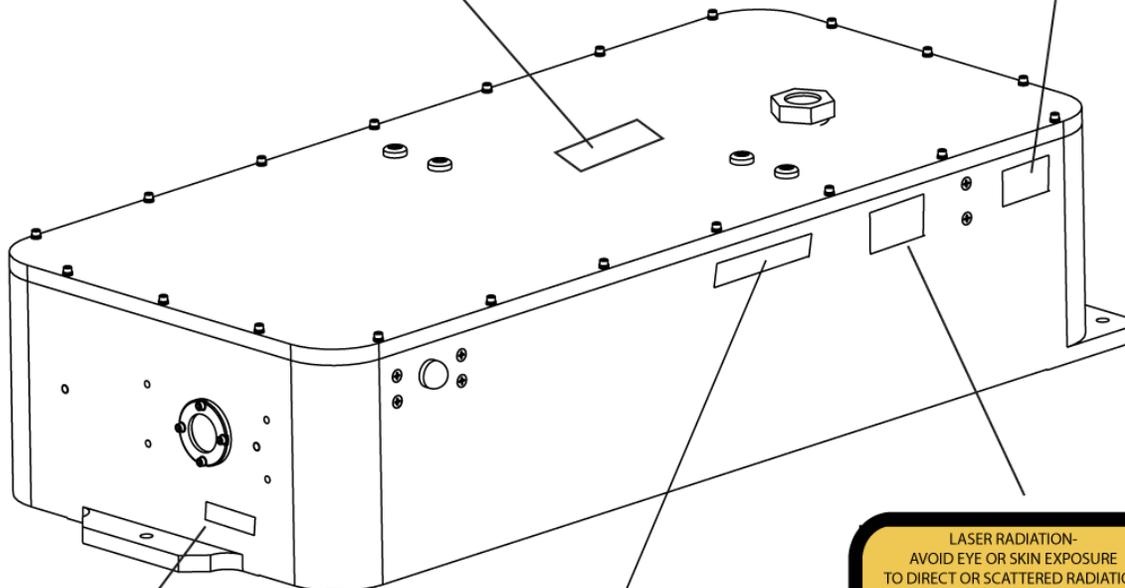
This laser product complies with Title 21 of the U.S. Code of Federal Regulations, Chapter 1, Subchapter J, Part 1040.10 and 1040.11, as applicable. To maintain compliance with these regulations, once a year or whenever the product has been subject to adverse environmental conditions (e.g. fire, flood,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



Certification and Identification Label

DANGER
Non-Interlocked Protective Housing
DANGER: Laser radiation when open.
AVOID EYE OR SKIN EXPOSURE TO
DIRECT OR SCATTERED RADIATION

Non-Interlocked Housing Label



**LASER RADIATION-
AVOID EYE OR SKIN EXPOSURE
TO DIRECT OR SCATTERED RADIATION**

Wavelength	Power	Pulsewidth	PFR
800-810 nm	< 0.1W	CW	CW
1064 nm	<0.5 W	65 - 200 ns	0 - 50 kHz
532 nm	15W	65 - 200 ns	0 - 50 kHz

CLASS IV LASER PRODUCT

Class IV Danger Label

AVOID EXPOSURE
LASER RADIATION IS EMITTED
FROM THIS APERTURE

Avoid Exposure Label

Defeatably Interlocked Protective Housing
DANGER: Laser radiation when open and interlock defeated-
AVOID EYE OR SKIN EXPOSURE TO DIRECT OR
SCATTERED RADIATION

Defeatable Interlocked Housing Label

Figure 2-1. Radiation Labels and Location

Chapter 3: System Details

This chapter discusses the operation of the Patara laser:

- Patara laser
- Closed loop chiller
- eDrive Nitro

Patara Laser

The Patara laser head measures 24" x 8" x 6" (not including the connectors at the rear of the laser). The laser emission indicator is located on the side of the unit. The output window is positioned 76.2 mm (3") from the bottom of the Patara laser and 99.7 mm (3.93") from the side with the emission indicator.

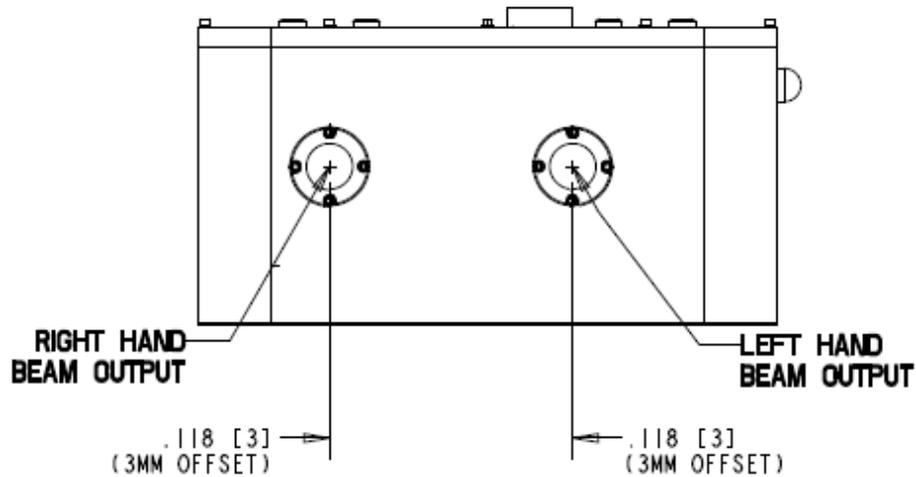


Figure 3-1. Patara Front View

The rear panel of the Patara laser has connectors for the cable connection to the eDrive Nitro. The coolant in and coolant out ports are also found on the back panel.

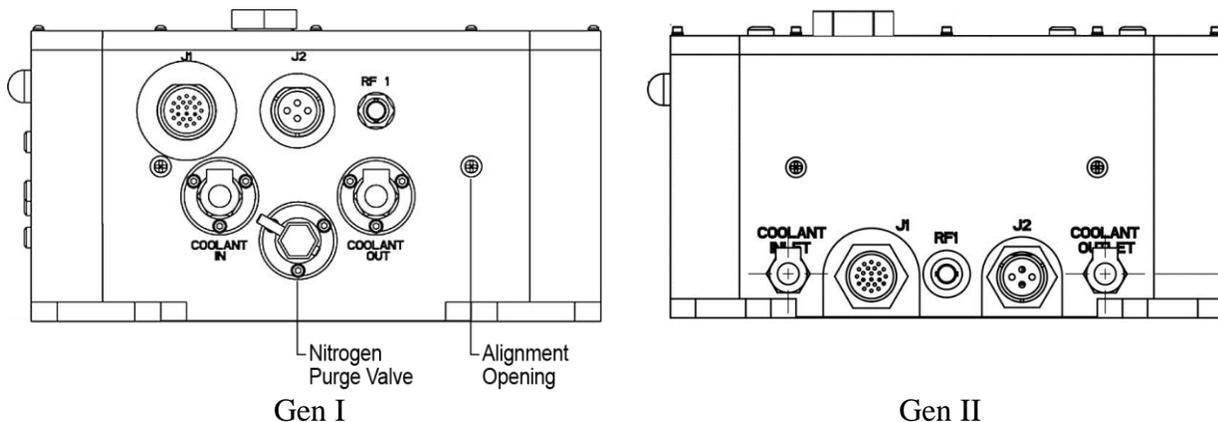


Figure 3-2. Patara Rear View

The alignment openings are located on both front and back panels and are sealed by screws to prevent emission during normal operation. The service technician can remove the screws and use a HeNe laser to aid alignment.



WARNING. The screws filling the alignment hole are considered non-interlocked covers. If the screws are not replaced and the Patara II 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 would be capable of causing eye or skin damage from direct exposure or specular reflection of the beam. Always replace the screws in the alignment holes.



WARNING. Additional adjustment holes in the top cover of the laser housing provide access to the HR cavity mirror and HM 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 the holes on the laser enclosure should be sealed all times to prevent moisture penetration. Moisture in the enclosure can degrade the lifetime of SHG crystal as well as the coatings on all optical components.

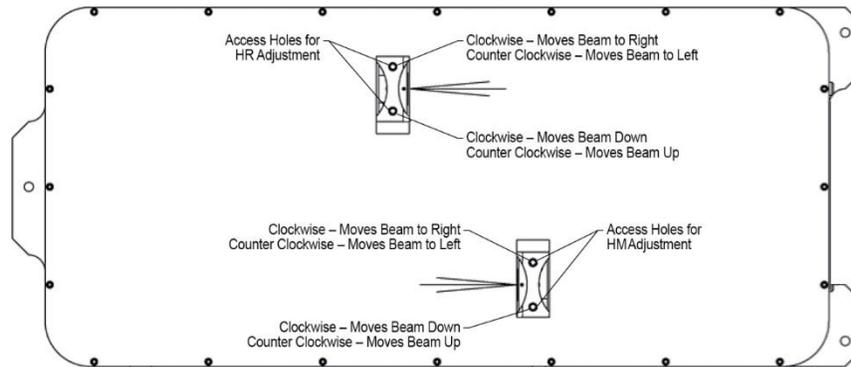


Figure 3-3. Patara II Top View

Closed Loop Chiller

The single most common cause of a laser returned for repair involves customer damage. More than one third of these damaged lasers result from cooling problems. Coolant problems almost always require the replacement of the diode arrays—the single most expensive component in Northrop Grumman 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. Heat Capacity and Minimum Flow Rate

Model	Heat Capacity ¹	Minimum Flow Rate
PA-016-QTG	800 W	1.5 gpm (5.7 lpm)

¹ Heat capacity should be greater than the laser's power consumption.

Table 3-2. Cooling System Requirements

Chiller and Cooling System Requirements
Capable of recommended flow rate at 60 psi ¹
Optishield Plus mixed with distilled water per manufacturer's instructions
Filter connected between chiller and inlet on laser ³
Chiller Heat Capacity > Laser Power Consumption
Flow sensor (installed internally on Patara lasers) ⁴
Replace coolant and filter monthly
<p>¹ The actual operating pressure should be lower than 60 psi. It is acceptable if the chiller can achieve the required minimum flow rate through the laser with a lower water pressure (typically around 55 psi).</p> <p>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.</p> <p>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 9 or the filter or coolant show any discoloration.</p> <p>⁴ When not using Northrop Grumman drive electronics, verify that flow sensor interrupts current to diodes less than 500 ms after a low flow condition occurs.</p>

Table 3-3. Avoid with Chillers

Avoid with Chillers
Deionized water ¹
Iron or aluminum parts in plumbing loop
Operation below air condensation temperature ²
<p>¹ The Patara laser has exposed bare copper inside the coolant loop. For this reason, Northrop Grumman does not recommend using untreated deionized (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).</p> <p>² The Patara laser is environmentally sealed, but not hermetically sealed. Atmospheric conditions near the exterior of the laser will mimic conditions inside laser head.</p>

Operating the Chiller



WARNING. Do not operate laser without cooling. Inadequate heat dissipation will seriously damage the laser diodes and will void warranty. If water is noticed in the immediate vicinity of the laser, shut the laser system down immediately. Check to see if the water 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 final ATP Test Report Data Summary included with the laser for optimum temperature and flow rate settings.

Operating the laser diodes for even a short period of time (even a few seconds) without coolant will cause permanent damage. To help prevent this, all Northrop Grumman 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, Northrop Grumman recommends testing the flow interlock before firing. Turn the eDrive on without current applied to the laser, and then turn the chiller off. A coolant interlock fault should appear on the screen. By testing the interlock with no current to the laser, there is no risk of damaging the laser.



WARNING. Do not operate the coolant system below 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 a Northrop Grumman field service engineer with 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 at or below the condensation temperature, water may collect on that surface. A formula for calculating dew point is given below, along with a calculated table. All temperatures are given in Celsius.

Condensation Temperature

$$T_d = \frac{237.7 \times \alpha(T, RH)}{17.27 - \alpha(T, RH)} \quad \text{where} \quad \alpha(T, RH) = \frac{17.27 \times T}{237.7 + T} + \ln\left(\frac{RH}{100}\right)$$

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 the chiller is running at 22 °C and the ambient air temperature near the laser is 28 °C (82 °F). Referring to **Figure 3-4** and **Table 3-4**, find the intersection of the 28 °C air temperature and the curve for the 22 °C diode temperature. At a relative humidity of 70% or greater, condensation will form on the laser diodes.

Controlling the humidity level inside the laser is important to extend the lifetime of the SHG 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.

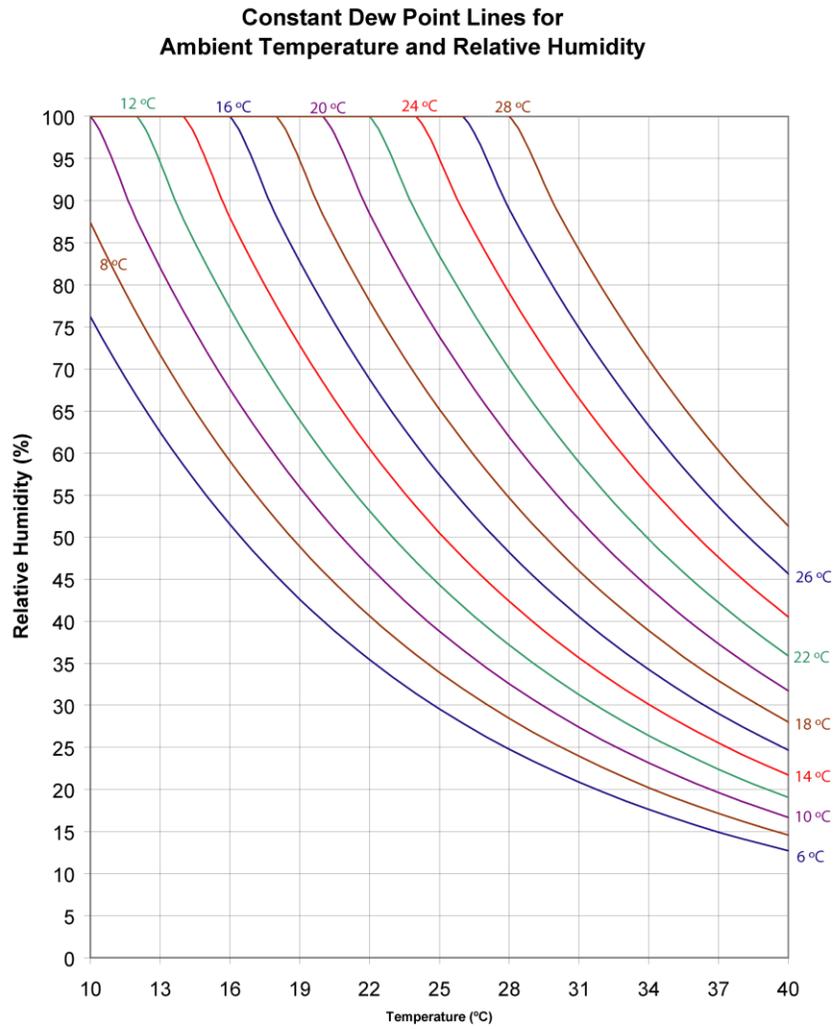


Figure 3-4. Constant Dew Point Lines for Ambient Temp and Relative Humidity

Table 3-4. Air Condensation Temp
at Given Ambient Air Temp (°C) and Relative Humidity (%)

Relative Humidity											
	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 to the condensation temperature, take precautions to keep the laser dry. The laser should be operated inside an area that is purged with nitrogen (N₂) or encased in a sealed enclosure with desiccant.

eDrive Nitro

The eDrive Nitro is a menu driven diode driver and laser controller. The eDrive Nitro regulates the diode drive current, controls the acousto-optic (AO) Q-switch pulses, controls the temperature of the SHG crystal, and monitors the various interlocks. The 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 User Manual* (CEO-UMAN-0001).

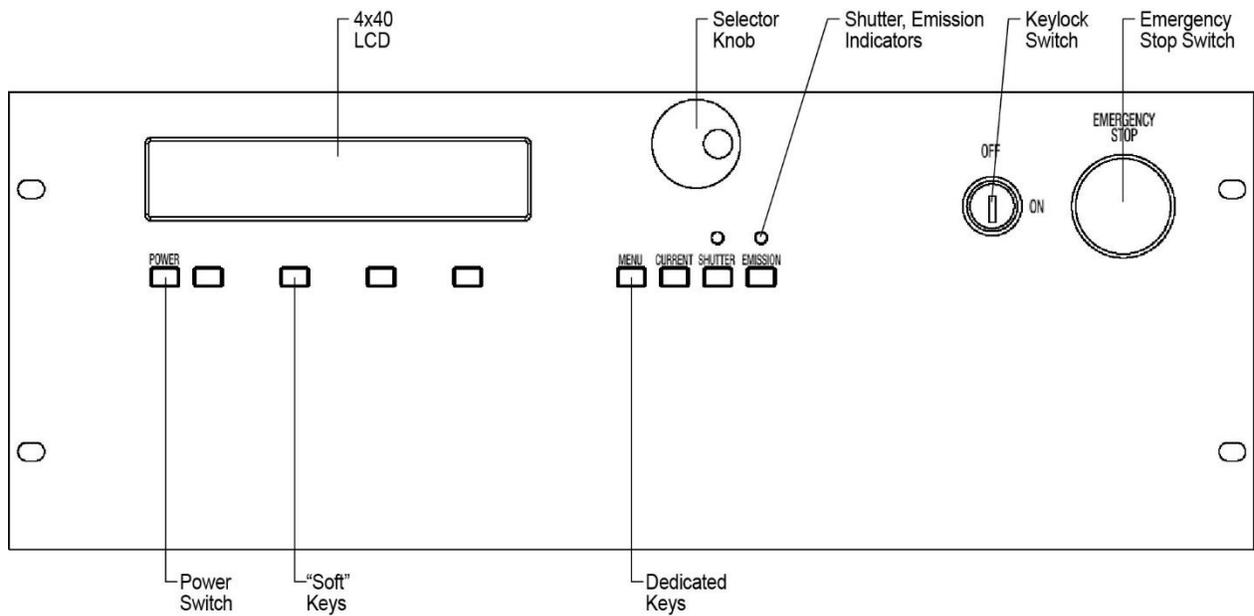


Figure 3-5. eDrive Nitro Control Panel

Chapter 4: Installation and Operation

To ensure safe operation of the Patara laser system, refer to the Chiller User Manual, and *Chapter 3: Operating Basics* of the *eDrive User Manual* (CEO-UMAN-0001). This chapter covers:

- Laser system components
- Unpacking the laser system
- Laser head setup
- eDrive setup
- Chiller setup
- Connecting the chiller
- PolyScience 6000 power-up procedure
- First Time Laser Power-up procedure
- Daily operation
- Output power control
- External triggering and FPS

The purchaser is responsible for any loss and injury during installation and use of the laser system. Northrop Grumman recommends that a qualified service technician install and maintain the laser. If intending to service the laser personally, please follow the following procedures.

Laser System Components

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



Figure 4-1. Components for the Patara Laser

Unpacking the Laser System

The Northrop Grumman Patara laser has been carefully packed for shipment. If the carton appears to have been damaged in transit, have the shipper's agent present when the unit is unpacked.

Inspect the unit as it is unpacked, looking for dents, scratches, or other evidence of damage. If damage is discovered, immediately file a claim against the carrier and notify NG representative. NG will arrange for repair without waiting for settlement of the claim.

Keep the shipping container. If filing a damage claim, it may be needed to demonstrate that the damage occurred as a result of shipping. If returning the unit for service, the specially designed carton assures adequate protection.

A Patara laser system consists of:

- Laser head
- eDrive
- Laser signal cable
- Diode power cable
- Hoses and filter for chiller
- Filter wrench
- Power cord for chiller (United States or European standard as specified in contract)
- Power cords for eDrive (United States or European standard as specified in contract)
- Chiller

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 a minimum of 30 W, should be installed approximately 1.5 feet 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 532 nm should be installed in front of the power meter as shown in **Figure 4-2** below. If a negative lens is not available, the power meter should be at least 2 m away from the laser so that the beam size is larger and the power density is below the damage threshold of the power meter. A pulse detector should be positioned as shown in **Figure 4-2** to verify the pulse characteristics of the laser.

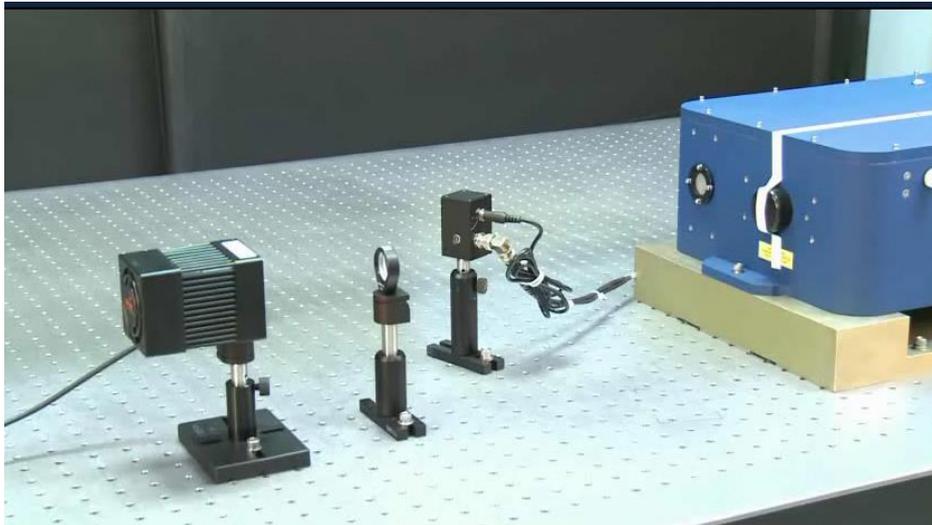


Figure 4-2. Basic setup for the laser power test

eDrive Setup

Input Power

Use only power cords suitable for the driver. Use a power source that delivers voltage in the range of 90 VAC (RMS) to 240 VAC (RMS) and 47 Hz to 63 Hz. Power switching is performed automatically (i.e., there are no configuration switches to set for high or low voltage ranging). **Table 4-4** provides recommended fuse selection for each voltage range.

Table 4-4. Recommended Fuse Ratings

AC Input	Frequency	Fuse Ratings (F1, F2)
120 V / 15 A	47-63 Hz	15 A
240 V / 7 A	47-63 Hz	8 A

Mounting

The front panel of the eDrive is designed with four holes to mount into an EIA-310D-compliant rack. If this option is used, the eDrive's weight requires extra side supports. If the eDrive is to be used on a desktop or table top, it is recommended that the eDrive be equipped with feet to prevent the driver from marring the surface when it is moved. The eDrive must be secured.

Clearance

Adequate clearance should be allowed on the front, sides, and rear of the eDrive for access to connections and components. The front and rear vents of the eDrive must be a minimum of 24 inches (61 cm) away from walls or vertical surfaces so air flow is not restricted.

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% (non-condensing).

Location

The Chiller should be installed on a strong, level surface and be located as close to possible to the laser. It should not be installed closer than 4 feet (1.4 meters) to 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 the chiller where corrosive fumes, excessive moisture or 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.

Clearance

Adequate clearance should be allowed on the front, sides, and rear of the chiller for access to connections and components. The front and rear vents of the chiller must be a minimum of 24" (61 cm) away from walls or vertical surfaces so air flow is not restricted.

Electrical Power

An IEC power cord is provided with the chiller. It should be attached to the receptacle on the rear of the enclosure. Ensure that the power outlet used for the chiller is properly grounded and matches the voltage and frequency indicated on the label on the back of the chiller.

The use of an extension cord is not recommended. However, if one is necessary, it must be properly grounded and capable of handling the total wattage of the unit. The extension cord must not cause more than a 10 percent drop in voltage to 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. These procedures are listed on the CD (compact disc) shipped with the unit. They are also available through Northrop Grumman customer service.



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

Connecting the Chiller

Water Hoses and Filter Connections

The required water hoses, filters, and fittings are included in the plumbing kit that was shipped with the laser. They should be connected as illustrated in **Figure 4-3**. The correct water 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. Water Hoses 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 have threads wrapped 3-4 times with Teflon tape.

Figure 4-4 depicts the chiller with connected water hoses on a Patara II laser.

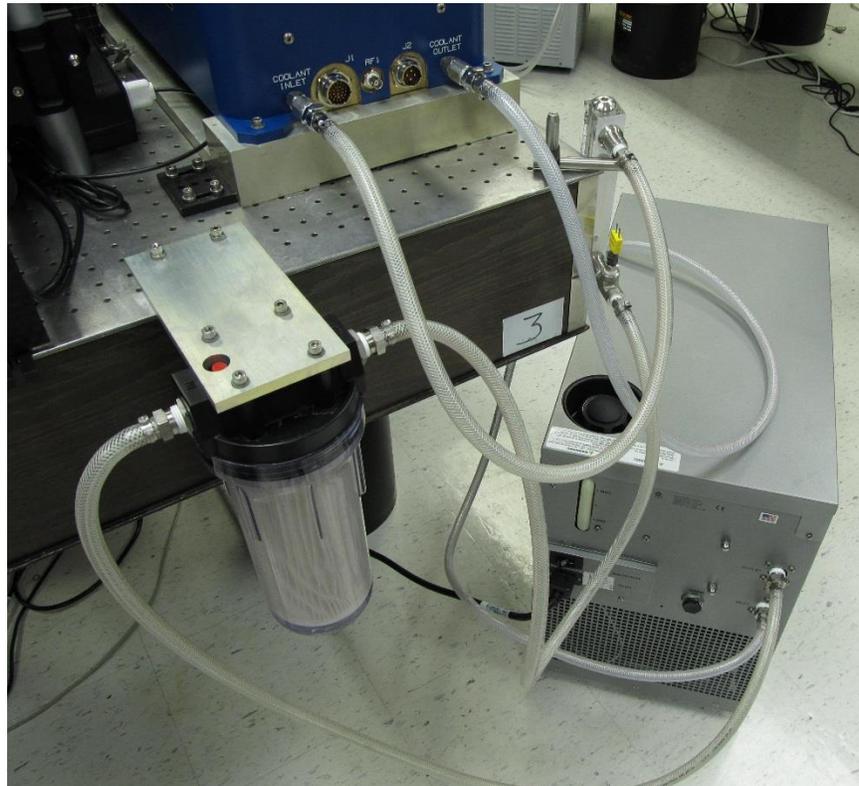


Figure 4-4. Chiller Assembled with Water Hoses and Filter

Connections to the Laser Head

Figure 4-5 depicts the connectors on the rear panel of the Patara Laser. All of the connectors are clearly labeled.



Gen I



Gen II

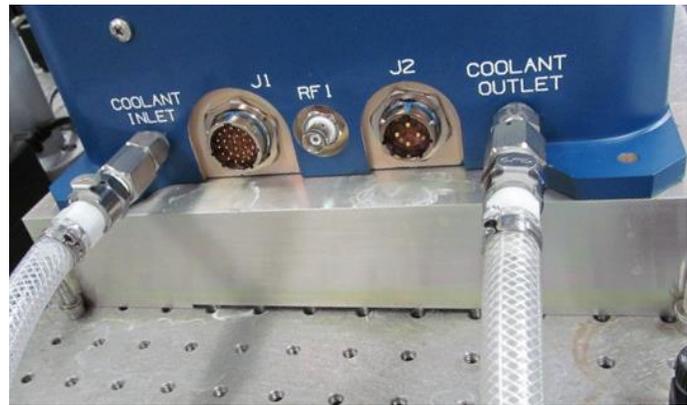
Figure 4-5. Connectors on the Rear Panel of the Patara Laser

Follow these steps to connect the laser head:

1. Connect plumbing. As shown in **Figure 4-6**, push the barb fittings of water hose connectors gently into the coolant in and coolant out ports by following the flow path direction. Wetting the o-rings of the quick disconnect fittings and receptacles can prevent the o-ring from being damaged. Make sure that the quick disconnect fittings are locked by listening for a clicking sound.



Gen I



Gen II

Figure 4-6. Plumbing Connection

2. Connect RF Cable: Connect the Q-switch RF cable to the BNC connector on the laser head (see **Figure 4-7**). 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.



Gen I



Gen II

Figure 4-7. RF Connection

3. Connect diode power. Remove the end cap and connect the female connector of the diode power cable to the **J2** connector on the laser head (see **Figure 4-8**). 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.



Gen I



Gen II

Figure 4-8. Diode Power Connection

4. Connect laser signal. 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 as shown in **Figure 4-9**.

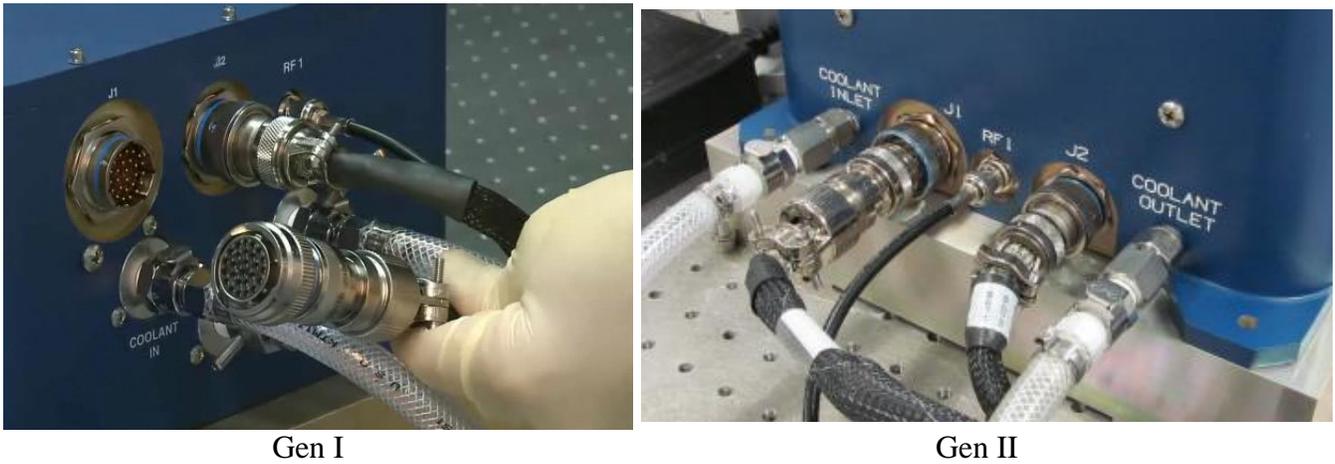


Figure 4-9. Signal Connection

Connections on eDrive

Figure 4-10 depicts the rear panel of the eDrive.



Figure 4-10. Rear Panel of the eDrive

1. Connect RF cable. Connect the QS RF cable to the **RF OUT 1** connector as shown in **Figure 4-11**.



Figure 4-11. RF Connection

2. Connect diode power. Connect the diode power cable to the receptacle **ARRAY POWER** as shown in **Figure 4-12**. 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.



Figure 4-12. Diode Power Connection

3. Connect laser signal. Connect the male connector of laser signal cable to the receptacle labeled laser interface on the back of eDrive (see **Figure 4-13**). 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.



Figure 4-13. Signal Connection

4. Connect the power cords for eDrive.
5. Verify that everything is connected properly and locked. Check that all of the interlocks (three BNC: **TRIGGER/GATE IN**, **QWS THERM INTLK**, **INTERLOCK**; one black **CHILLER**; and one white **INTERLOCK** shorting connectors) are in place on the back of the eDrive (see **Figure 4-10**). The black and white connectors are not in place during shipment and will need to be connected by the user.
6. Lay out all of the cables and water hoses. Mount the water filter securely.

PolyScience 6000 Power-Up Procedure

The following steps indicate how to turn on the PolyScience 6000 series for the first time.

1. Fill the reservoir. Remove the filler cap from the reservoir and, using a funnel, add 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 deionized 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. Add fluid as follows:
 - Closed systems: Slowly add fluid to the reservoir until the liquid level remains stable.
 - Open bath systems: Adjust the restriction (pinch) valve until the liquid level in both the bath and the reservoir remain stable. Add fluid as needed to bring liquid levels in the bath and reservoir up to the desired level. Make sure the fluid level in the bath is above the opening on the chiller's inlet hose.
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. If not, gently clean it with a lens tissue and methanol.

Turn on the chiller and verify its settings:

1. Check the temperature setting of the chiller. Refer to the ATP Test Report Data Summary included in the Patara laser shipment for the coolant operational temperature. The chiller's temperature setting should match the report's. If set to a different temperature, change it to match the setting on the report.
2. The minimum flow rate for Patara laser is 1.5 gpm. Ensure the flow rate meets the requirement. If it does not, open the valve inside the chiller until it matches the flow rate recorded in the test report.
3. Run the chiller for approximately half an hour to allow it to stabilize at the set temperature.



WARNING. Do not operate coolant system below air condensation temperature (dew point) at the laser head. Condensation on the diode arrays can seriously damage the laser head.



WARNING. Do not set the temperature of SHG below air condensation temperature (dew point) at laser head. Condensation on the SHG crystal can seriously damage the crystal.

Check the eDrive

1. Flip the power switch on the back panel of the eDrive to the **ON** or - position
2. Make sure that the red **EMERGENCY** button is released. Turn on the eDrive by turning the key to **ON** position and pressing the **POWER** button to power up the eDrive.
3. Check all the laser parameters in the eDrive Nitro. The menu designations will help locate the settings. Use the following values for the Patara laser:

Menu 1	Menu 2	Menu 3	Parameter	Setting or Value
Channel Setup			Internal Trigger	Enabled
Channel Setup	Q-Switch		Q Switch (QS)	Enabled
			Set Frequency	refer to test report
			Set Window Width	5 μ s
			Set Q-Switch Power	100%
Channel Setup	Q-Switch	Set FPS Settings	FPS	Enabled
			FPS Mode	Standard
			FPS Delay	250 μ s
			Start Power	refer to test report
			FPS Window Length	refer to test report
			FPS Modulation Type	Exponential
			PPK Open Offset	0
PPK Closed Offset	0			
Channel Setup	Channel 1		Channel 1	Enabled
			Set Current	refer to test report
			Set Standby Current	0.0 A
			Set Slew Rate	5 A/S
			Slew Control	Enabled
			Set Current Limit	30 A
Channel Setup	Channel 1	Fault Setup	Set Voltage Dropout	20 V
			Set Current Tolerance	Enabled
			Set Current Tolerance	4 A

Menu 1	Menu 2	Menu 3	Parameter	Setting or Value
Comm Setup	Channel 0 Setup	Set Function	Function	Oven TEC
Channel Setup	Comm 0*		Set Temp	See Test Report
			Set Tolerance Range	+1.5C
			Set output voltage	5.00 V
			Set Min Temp	+22.0C
			Set Max Temp	+45.0C
			Set P Const.	4.0C
			Set I Const	2.00 rep/min
			Set D Const	0.00 cycles/min
			Set Control Function	H-BRIDGE
			Set Heat Mult.	1.000
			Set Cool Mult	1.000
			Sensor Type	TS67
			Sensor Offset	0
TEC Enabled (Note: must be done last)	Enabled			
Interface Setup	Set Trig Out Mode		Trig out mode	QSW Active High
Interface Setup	Shutter Setup		Shutter FPS	Enabled
			Shutter Speed	5 ms
			Closed to Standby	Disabled
Interface Setup	Marking Mode Setup		LM Active	Low
			Gate Active	High
			FPS Active	High
Utility Functions			Manual Lockout	Disabled
Utility Functions	Humidity Options		Measured Current Humidity	(reads out measured humidity)
			Adjust Humidity Threshold	29.5

- Verify that there are no objects in the laser beam path except for the negative lens and power meter.



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

- Once all the parameters are set correctly, and temperatures of TEC Controller and chiller are stabilized, set the current at 10 A and press the **EMISSION** button.
- Press the **SHUTTER** button to open the laser shutter. Gradually increase the current until the laser is firing at very low power. Move the negative lens and

power meter so that the beam passes through the center of the lens and hits the center of the power meter.

7. Gradually increase the current set point to the operating current specified in the ATP Test Report Data Summary. Do not touch any part of the laser. Wait for the laser to stabilize for one hour (usually the laser takes about 20 minutes to reach 95% of the maximum power). Then check if the power is close to the result on the test report.

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 *Chapter 5: Maintenance*.

Daily Operation

Output energy and repetition rate of the Patara laser system are adjustable over a wide range. However, operating protocols must be observed to assure operation without risking internal damage to optical components. **Table 1-1** summarizes laser performance.

Turn On Procedure

1. Switch the chiller to the **ON** position. Verify correct flow rate and temperature setting to value specified on laser test report. Wait until chiller has achieved proper temperature, which may take five to ten minutes.
2. Turn the eDrive power enable key switch to **ON** position.
3. Press the eDrive **POWER** switch. LCD panel illuminates.
4. Press **MENU** to verify the current and Q-switch settings.
5. Press **EMISSION** to fire the laser diode after the TEC temperature is stabilized within the tolerance range.



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

6. Press **SHUTTER** to begin laser output.

Wait for about 20 minutes to reach 95% of nominal output power.

Manual Interrupt Procedure

1. Press **SHUTTER** button on the eDrive front panel. The **EMISSION** and **LASER ON** indicators will begin to blink. The laser diode current will default to standby current level while the shutter is closed.

2. Resume operation by pressing **SHUTTER** again. The laser will resume operation with no audible warning. The **EMISSION** and **LASER ON** indicators will become steady. The laser will automatically ramp the current to the set point with the preset slew rate.

Shut Down Procedure

1. Press **SHUTTER** key to stop lasing.
2. Press **EMISSION** on the eDrive. The laser diodes cease emission.
3. Press **POWER** on the eDrive and hold for 5 seconds until display turns dark.
4. Turn the eDrive power enable key switch to **OFF**. Let chiller run for 1 to 2 minutes.
5. Turn off chiller.

Please refer to the separate Operation and Maintenance Manual for the eDrive for detailed operating instructions.

Output Power Control

Every laser application requires specific laser power settings for the best results. In some cases, the output power has to be changed at different stages even in the same laser process. Typically, the output power of a laser can be varied by changing the operating current. However, the active laser crystals can exhibit strong thermal lensing, which is related to the operating current. Variation of the operating current results in the change of the thermal lensing. Therefore, the position of the focal point moves as the pump current is varied. This is not desirable for most laser applications especially laser micro-machining.

The output power of Patara laser can be changed either by changing the operating current or by changing the Q-switch power. This unique, patented technology allows users to adjust the laser output power continuously without changing the operating current. The focal point is kept at the same position regardless of the power level. This feature is very useful for precision micro-machining requiring different power levels to complete the process.

External Triggering and FPS

The laser may be externally triggered using a TTL signal of 300 ns to 500 ns duration. The signal may be input via the BNC connector labeled **EXTERNAL TRIGGER** on the back of the eDrive controller.

Figure 4-14 illustrates the RF signal output to the Q-switch without first pulse suppression (FPS) and the laser pulse train with the first giant pulse. If the peak power of these giant pulses is high enough, it can cause the damage to the mirrors and the laser crystals. The giant pulse forms when the lasing was stopped while the pumping light is still on during the laser processing cycle. The amplitude of the giant pulse is dependent on the non-lasing duration as well as the operating current.

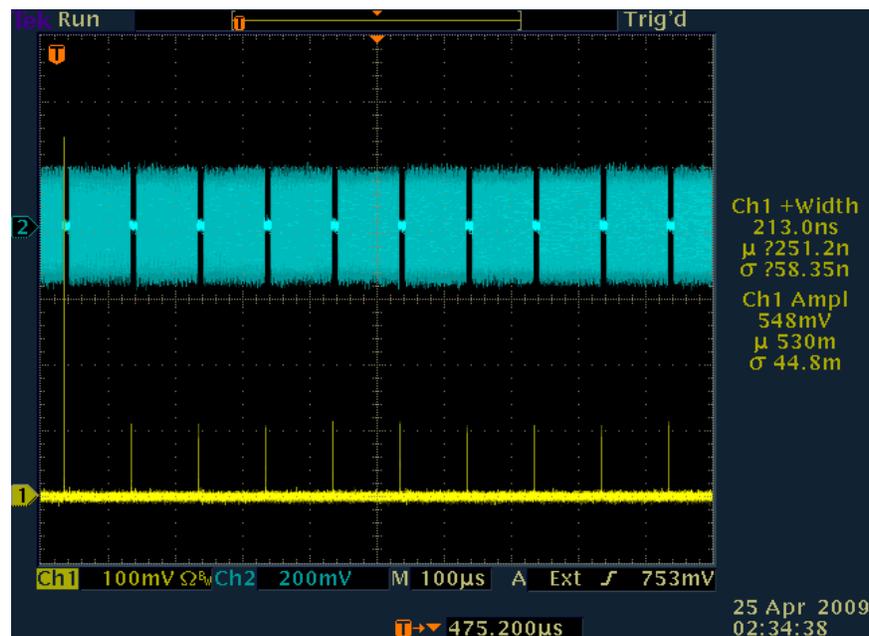


Figure 4-14. First Giant Pulse with FPS Disabled



CAUTION. The FPS has to be enabled and parameters for FPS have to be set properly. Failure to suppress the first giant pulse may cause the internal optical damage as well as damage to the work piece.

For each type of laser processing, a particular operating current and pulse repetition rate are needed. The giant pulse can be suppressed by enabling FPS and setting the proper FPS parameters. For detailed information, please refer the *Configuring the Integrated AO Q-Switch RF Driver* section in *Chapter 3: Operating Basics* in the *eDrive User Manual* (CEO-UMAN-0001).

To set the FPS properly, use a photodiode detect with response time 1 ns and an oscilloscope.

Chapter 5: Maintenance

The chapter contains information in these sections:

- Required Tools and Consumable Parts List
- Prepare for shipment
- Purge housing
- Replace desiccant cartridge
- Maintain chiller
- Check hold off
- Extend lifetime of laser diodes
- Optimize laser performance

Required Tools and Consumable Items List

- OptiShield™ Plus (1 pt: P/N 400113; 1 g: P/N 400115)
- Desiccant cartridge NG CEO (P/N 42-228)
- Desiccant Refill (P/N 643665)
- Desiccant Refill tool (P/N 980412)
- Hydronix Pleated 5µm Filter (P/N SPC-25-1005)
- 1/8" Allen Wrench (P/N 7813A26)
- 3/32" Allen Wrench (P/N 7813A24)
- 9/64" Allen Wrench (P/N 7813A27)
- #011 O-rings for QD (100 pack: P/N 9464K16)

Prepare for Shipment

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

1. Ready a dry gas source in preparation for draining the system. Oil-free, dry filtered air or (N₂) is recommended.
2. Remove coolant connections from back of laser housing.
3. Connect a dry gas line to the **COOLANT OUT** connector on 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 water 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 1/2 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 a shipping container.

All water will need to be removed 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 Patara optics assembly must be kept at low humidity to protect the SHG crystal, which is slightly hygroscopic, and to prevent the possibility of condensation on the laser diode arrays. The Patara 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 Northrop Grumman 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 shown in **Figure 5-1** removes excess moisture from inside the laser head. It is located on the lid of the Patara 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 three sectors of the indicator paper turn completely white or light pink, the module has absorbed all the water it can and must be replaced. Replacement frequency varies with the humidity in the operating environment and if the laser head is opened.

If the desiccant cartridges are exhausted in a short time frame (e.g., two weeks) without the laser head having been opened, contact a Northrop Grumman field service engineer.

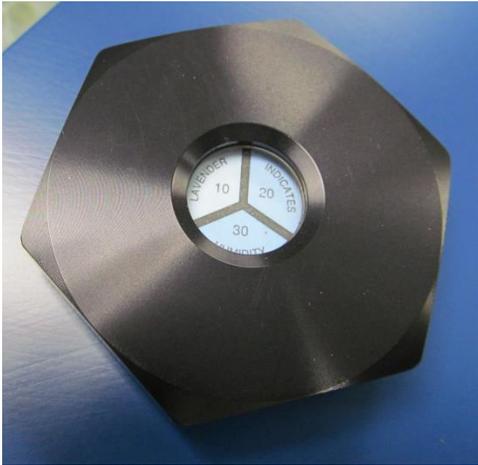


Figure 5-1. Desiccant Cartridge

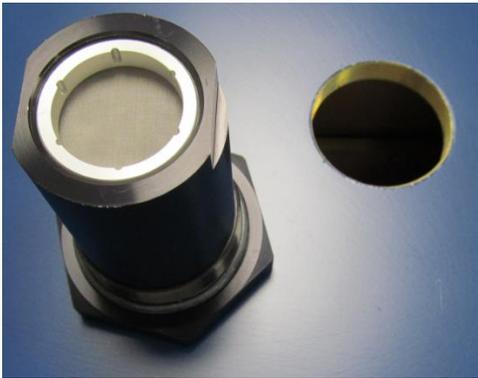


Figure 5-2. Gram Desiccant Bottom



Figure 5-3. Gram Refill and Refill Tool

To replace an exhausted cartridge, unscrew the old cartridge and screw in a new one. Tighten with a quarter turn of a wrench to form a good seal. The desiccant cartridge used in the Patara laser head is an industry standard part (part number 42-228).

Desiccant supplies can be purchased from Northrop Grumman, 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

No cartridge installation tool is needed. The 40 gram desiccant cartridge is hand tightened.



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.

Maintain Chiller

The 5 μm filter and coolant in the chiller should be replaced a minimum of monthly. Comply with the chiller manufacturer's recommendation if more frequent. Drain and refill the chiller per the chiller and coolant manufacturer's instructions.

The filter used is a Hydronix pleated 5 μm polyester filter, part number SPC-25-1005, available at multiple online retailers.

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 pump current to 10 A.
3. Set the Q-Switch internal trigger (or external gate) mode to external trigger mode in the Channel Menu on the eDrive. Ensure there is no input to the external gate BNC on the rear panel of the eDrive.
4. Gradually increase the current to the full operation current level.
5. Observe the beam output on the power meter. Hold off condition is met when no green light is visible.
6. If green is observed, the laser does not hold off and may need internal repair.
7. Reduce the current to 10 A.
8. Return the eDrive to internal trigger (or external gate) mode.

9. Gradually increase the current to the operation current.

Extend Lifetime of Laser Diodes

The specification for laser system optical output is provided in the final test report 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 may be required to maintain power and beam quality so the diodes can continue to be used. Once the maximum current of 30 A is reached, consider replacing diodes or upgrade the laser. Please contact Northrop Grumman 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.



NOTE: Record optimization data on SVC-FORM-0009 (Optimization Worksheet, Patara/Iklwa Field Service), which can be found on the Knowledge Center.

http://www.ngceoservice.com/Level_1_PA-016-QTGP

For this procedure, a green light should be visible from the laser. In the absence of any visible output, please review *Chapter 7: Troubleshooting* or contact Northrop Grumman 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 to 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 eDrive and chiller.

Check the performance with all items set to the values on the laser test report. Verify that all of the eDrive settings are correct.

The water flow rate and coolant temperature have a significant impact on the laser performance. Make sure that the flow rate is above 1.5 gpm and the temperature of the chiller matches results from the original test report.

3. Optimize the chiller temperature. Enter the *Chiller Temp Set Point* value from the ATP Test Report Data Summary into the *Coolant Temp* field on the Patara

Laser Optimization sheet. Vary the chiller temperature and enter values in the *Chiller Temperature* excursion table.

4. Peak up the laser power by tuning the temperature of the TEC controller. Beginning with the TEC Temperature from the ATP Test Report Data Summary, adjust the temperature up and down to optimize.



WARNING. To prevent damaging the HM mirror and LBO crystal, the laser output power should not decrease more than 10% when adjusting the TEC Temperature.

The phase matching of the second harmonic generation (SHG) crystal is crucial for the Patara laser. This is achieved by setting the proper temperature on the SHG crystal, which is controlled by the TEC controller inside the eDrive.

Figure 5-4 illustrates an example of the dependences of power and pulse-to-pulse instability of the laser to the SHG crystal temperature. As shown in the example, the mid-point of the temperature band is around 28.5°C. The laser may have peak power at 29.3°C in this example, but a small temperature change on the SHG could result in a power fluctuation.

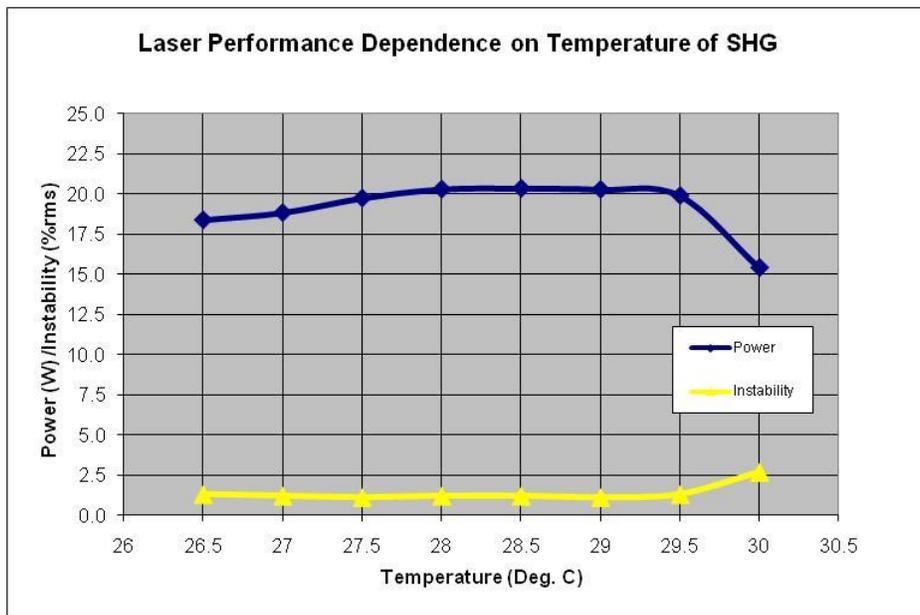


Figure 5-4. Example of Power Dependence and Pulse-to-Pulse Instability of the Laser to SHG Crystal Temp.

5. Peak the laser power by increasing the current.

Figure 5-5 illustrates an example of the dependence of the output power and pulse-to-pulse instability of the Patara laser to operating current. Notice that the laser power increases as the operating current is increased. The laser reached peak power around 23 A. Search for the peak power by changing the current 0.1 A increments around the operating current. Once the peak power is found, lower the

current to reach 99.5 percent of the peak power. This is the proper operating current. In this example, the operating current would be 22.9 A.

The slight difference between the actual operating current and the test report value may be due to the performance difference of the chillers. An increase in the operating current can compensate for the aging of the Patara laser diodes.

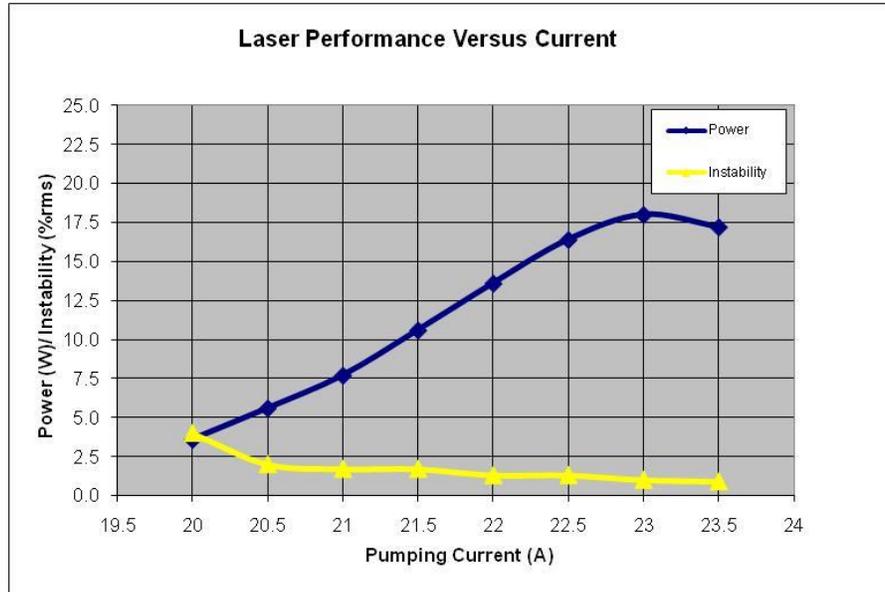


Figure 5-5. Example of Laser Performance Dependence on the Operating Current

6. Peak up the laser with adjustment of the cavity mirrors.



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

- a. Locate the access holes for high-reflection mirror (HR) and harmonic mirror (HM). Notice the positions of HR and HM mirrors with respect to the direction of the laser output in **Figure 5-6**.
- b. Remove screws from access holes only in a dust free environment.
- c. Use a 1/8" ball driver to make adjustments. A fine adjustment is a 1 degree or less rotation. A small adjustment is about a 2° rotation. A coarse adjustment is 15° to 20° rotation. If coarse adjustments are needed to obtain performance, reduce operating current by 2 A. Return to normal operating current when making small and fine adjustments.
- d. The screws for the adjustments of the vertical tilt angle and the horizontal tilt angle are illustrated in **Figure 5-6**.

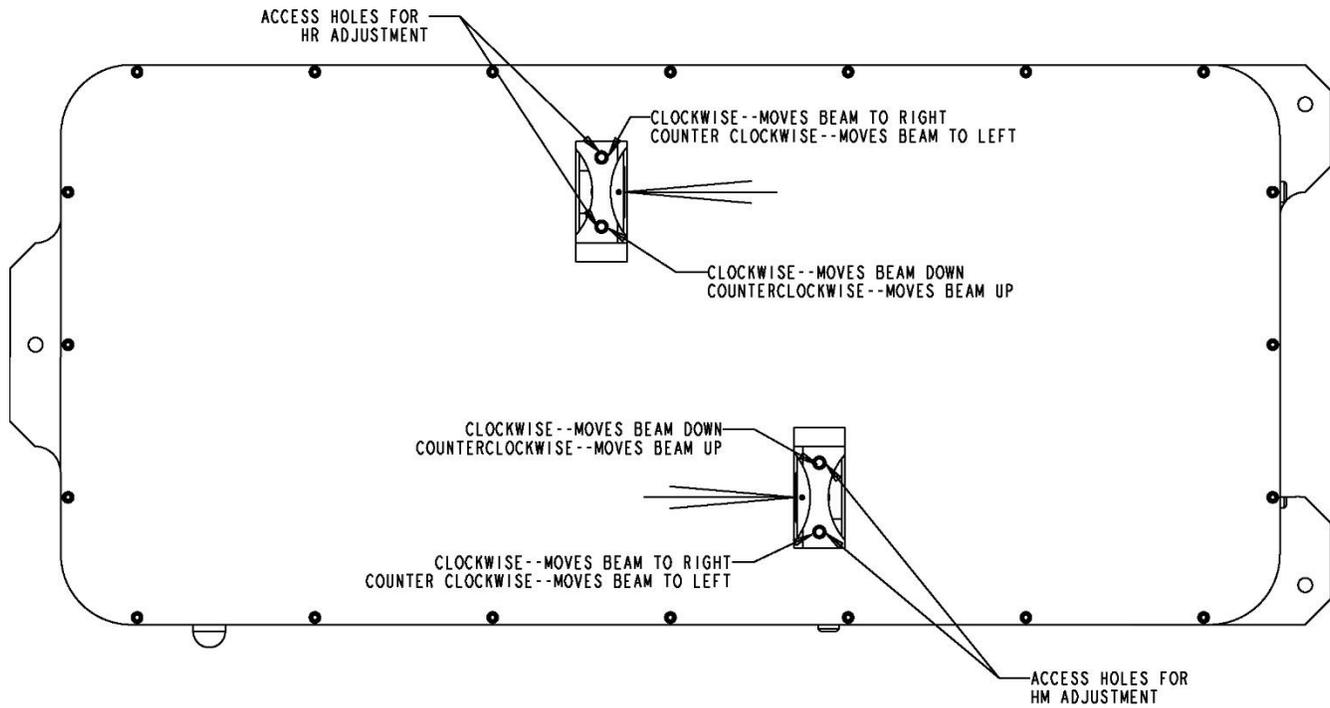


Figure 5-6. Accessible Holes for HR and HM Cavity Mirror Adjustment

e. Optimize power:

- Make small adjustments to the horizontal angle of HM mirror and observe the output power.
- Once a maximum is found, adjust the vertical control of HM mirror to maximize 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.
- Repeat the optimization steps with both the HR and HM until there is no significant performance improvement.
- If Laser is still not within 5% of the original power or not stable, repeat the steps of TEC optimization, eDrive current optimization, and HM, HR adjustment until there is no significant performance improvement.
- If the laser power can't be restored to the specification, or the laser is not stable, then the "walking the cavity" procedure can be tried. Walking the cavity is sometimes required to optimize the laser and involves combining mirror mount and SHG crystal temperature adjustments.
 - Reduce current by 2 A while making coarse adjustments. Return current to normal when making fine adjustments.

- Make a horizontal adjustment to the HM mount. Recover the laser power by making a similar adjustment to the horizontal control of the HR mount. Check and adjust the temperature of SHG crystal.
- Continue if improvement is noted. If there is no improvement, try the opposite direction.
- Perform the same procedure with the vertical adjustments of the HM and HR mount.
- Typically, SHG temperature adjustment is not needed when adjusting vertically. Periodically check for hold off when making these adjustments (see in the *Check Hold Off* section in *Chapter 5: Maintenance*).
- If laser power is within +/-5 percent of nominal (typical power meter accuracy), and it has good beam shape and stability, stop and replace the access screws in the cover.

Chapter 6: Customer Service

At Northrop Grumman, 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 the instrument to peak performance without delay.

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

This chapter provides reference to types of customer service needs:

- Contacting customer service
- Module replacement
- Return the instrument for repair

Contacting Customer Service

To expedite service needs, please complete the questionnaire in *Appendix A: Customer Service* **before** contacting Northrop Grumman Customer Service. Complete the questionnaire with as much detail as possible and retain a copy for the records.

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

Module Replacement

Even though the pump module is user replaceable, we recommend that the laser head be returned to Northrop Grumman for an upgrade. Contact Northrop Grumman for detailed instructions about module replacement.

Return the Instrument for Repair

A return merchandise authorization (RMA) *is required* prior to shipping any instruments to Northrop Grumman. Contact Northrop Grumman or the 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 Northrop Grumman to ship any instruments. If shipping boxes have been lost or destroyed, replacements are available for a nominal charge from Northrop Grumman.

Remove all water from the 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.



CAUTION. Damage from residual water 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.

Chapter 7: Troubleshooting

This chapter is intended to provide possible solutions to common problems encountered with the Patara laser during normal use. For more information please see the troubleshooting guide that is on the owner's manual CD supplied with the laser.



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

The following sections can be found in this chapter:

- Initial checklist
- Laser output power
- eDrive
- Laser Beam Quality

Initial Checklist

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

- Verify the eDrive is operating at the correct output current and the current set point matches the test data sheet supplied with the laser.
- Verify that the SHG crystal is set to the temperature specified on the ATP Test Report Data Summary.
- Verify that the eDrive Q-Switch power control is at 100 percent.
- Ensure that the Q-switch is enabled.
- Verify the Q-switch is set to *Internal Trigger* and to the frequency specified on the test data sheet.
- Verify the chiller set point 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.

Only after verifying these conditions should adjustments to the laser system be attempted.

Laser Output Power

Low Output Power (0.01 W -16 W)

Low Q-switch power: Check the setting of the Q-switch power in the eDrive. Verify that it is set to 100%.

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

Low operating current: Check the set current and actual current. A too high or low current setting will result in low power.

Water temperature not set: Verify the chiller is set to provide the correct water flow rate and temperature to the laser head.

Phase matching condition of SHG crystal is not met: Check the temperature of TEC controller and make sure it works properly.

Laser is running in CW mode or problem with hold off: Check the hold off of the laser, ensure the Q-switch is enabled, and the eDrive's RF driver is functioning properly.

Pulse repetition rate is not correct: Check the pulse rate frequency (PRF) in eDrive or the frequency of trigger pulses.

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 Northrop Grumman for service.

No Output Power

- Verify the operating current is set at the operation point.
- Verify the Q-switch is set to hold off and the laser is triggered at preset PRF with an internal or external triggering source.
- Verify the shutter light on the front panel of the eDrive is turned on indicating that laser shutter is open.
- Verify there are no interlock warning messages on the eDrive and that the eDrive is supplying the correct current.
- Verify the eDrive is not gated off externally and not commanded to low or 0 percent Q-Switch power.

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 forces applied to the laser head.
- Verify that the flow rate to the laser head is above 1.5 gpm and the water flow is not intermittent.
- 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.

Laser Beam Quality

Figure 7-1 shows a typical laser output beam at operating current. Per specification, the roundness of the beam profile at the beam waist should be greater than 90%.

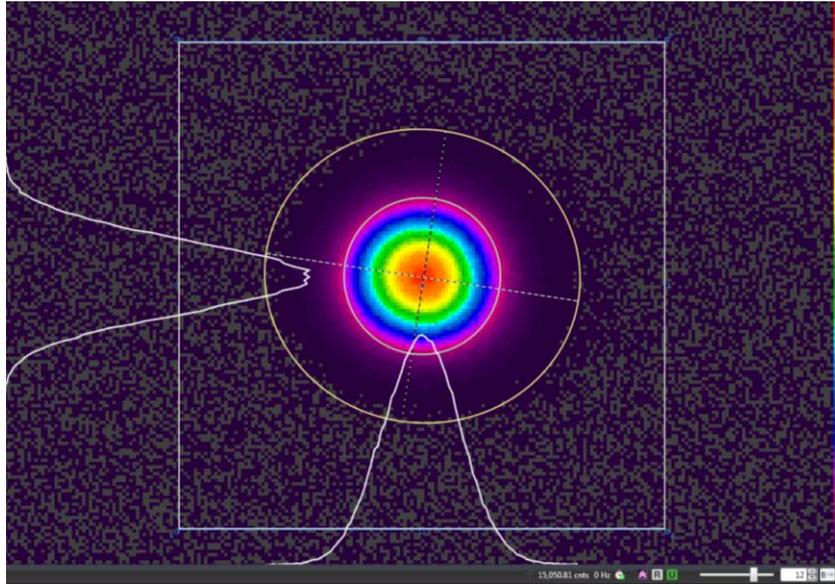


Figure 7-1 – Typical Beam Profile at Beam Waist, Farfield at Operating Current

If the beam profile is abnormal, such as a roundness below 90%, a split beam or alternate beam structure, follow the steps below to improve beam quality:

- **Not Operating at Correct Parameters:** Verify that all operating parameters match the values on the ATP Test Report Data Summary. If all settings are correct, proceed to *Misalignment*.
- **Misalignment:** If the laser is misaligned, the output power will be low. The beam profile may be distorted. The threshold will be higher. Perform the laser power optimization procedures as described in the *Optimize Laser Performance* section in *Chapter 5: Maintenance* to optimize laser output power and beam profile. After optimization, the beam profile and laser output power may be restored at a higher operating current and the laser threshold may be higher, as well. This is normal for aging laser diodes (see the *Optimize Laser Performance* section of *Chapter 5: Maintenance*).
- **Failed Laser Diode Bar:** If the output power is similar to the ATP Test Report Data Summary value, but the beam profile is still distorted, this could be caused by an uneven pumping light distribution. This could be due to a failed laser diode bar. Measure the voltage at the output of the diode current source compared to the diode module voltage on the ATP Test Report Data Summary.
- **Contaminated Coolant:** Indications that the coolant is contaminated are the operating current is higher and the beam profile may be distorted. Refer to SVC-FSB-0001 for chiller cleaning procedures.
- **Damaged Optics:** Optimization will not recover laser output power lost due to damaged optics. Internal and external damaged optics can both cause distortion of the output laser beam, but only damaged optics inside the laser cavity will increase the threshold current. Verify laser output window and all external optics are clean and free of damage. If no damage is found, move the

laser to a clean room environment and remove the cover. Inspect all optics including the diode module rod.

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

eDrive Operation

The following issues may occur in relation to the Patara laser.

CW Power Only, No Optical Pulsing

Perform initial check on system. CW power only or absent optical pulsing is typically caused by the wrong settings or an eDrive problem. Check setting procedures or refer to the *eDrive Operation* section in *Chapter 7: Troubleshooting* for procedures and details.

Hold Off Failure

Perform initial check on system. This problem can be Q-switch low power fault on the eDrive. Refer to the *eDrive Operation* section in *Chapter 7: Troubleshooting* for procedures and details.

Hold off failure can be caused by a failing Q-switch. This requires the internal laser be repaired.

Occasionally, a re-tuned laser can suffer from hold off loss. To remedy, change the angle of the QSW. Since QSW angle cannot be adjusted outside the laser, internal service will be required.

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

Laser Water Fault Detected

Check chiller for operation and low water 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.

Q-Switch Driver Over-Temp Fault

- Verify the cooling fan for the RF driver is operational.
- Verify that the airflow through the driver is not obstructed. This fault will not clear until the RF driver has had time to cool down.

Q-Switch HVSWR Fault

- Check RF cable connection to laser.
- Perform RF output power check.

The Q-switch has failed if the measured RF power is around 20 W with 50 Ω RF dummy load. Contact Northrop Grumman for repair.

Q-Switch Low Power Fault

- Perform RF output power check.
- Verify voltage to RF driver.
- Adjust RF power if needed.

Channel Over Temperature Fault

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

Appendix A: Customer Service

This form has been provided to encourage you to tell us about any difficulties you may have experienced while using the Northrop Grumman 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 (hours):

Questions

What is the water flow rate (gpm)?

What is the set temperature on the chiller (°C)?

What is the water pressure on chiller (psi)?

What are the temperature set and actual reading from TEC controller (°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 Q-switch power (percent)?

Is FPS enabled (yes/no)?

What are the FPS parameters?

What is the pulse repetition frequency (kHz)?

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: st-ceolaser-info@ngc.com**

Appendix B: System International Units

The following System International (SI) units, abbreviations, and prefixes are used throughout Northrop Grumman 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 Government Industrial Hygienists
ANSI	American National Standards Institute
AO	Acousto-optic
AR	Anti-Reflective
ATP	Acceptance Test Procedure
CDRH	Center for Devices and Radiological Health
CW	Continuous Wave
FPS	First Pulse Suppression
HeNe	Helium Neon
HM	Harmonic Mirror
HR	High-Reflection
IEC	International Electrotechnical Commission
LBO	Lithium Triborate
N ₂	Nitrogen
Nd:YAG	Neodymium-Doped Yttrium Aluminum Garnet
nm	Nanometer
OSHA	Occupational Safety and Health Administration
PRF	Pulse Rate Frequency

Acronym	Description
PSI	Pounds per Square Inch
RF	Radio Frequency
RH	Relative Humidity
RMS	Root Mean Square
SHG	Second Harmonic Generator
TEC	Thermal Electric Cooler
TEM00	Transverse Electromagnetic Mode
TTL	Transistor - Transistor Logic
UV	Ultraviolet
VAC	Volts, Alternating Current

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