

# Operation and Maintenance Manual for Surelite™ Lasers

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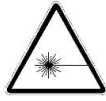
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## Preface

The internationally recognized warning symbols shown here are used throughout the manual to alert the user of potential hazards when operating this laser.



The radiation symbol is to alert the user to the danger of laser radiation when performing certain operations and when the danger of exposure is the greatest. It is also used when the optical hazards are present.



The lightning or thunderbolt indicates the presence of high voltage which may pose a danger to the user or the equipment.



The exclamation point symbol is to draw attention to other potential hazards not included under the optical or electrical categories. The user should be aware of special care that needs to be taken when performing potentially hazardous procedures.



The Safety section is placed as the first chapter of the manual to emphasize its importance and the need for everyone to read it before working with the laser.

The installation section includes a copy of the installation instructions for future reference. The site requirements are listed, as is the initial installation process, step by step.

The Operation section begins with the daily startup and shutdown procedures. The single shot operation is discussed here, also. The LED status information and error messages are explained. Optimization procedures for the harmonics are found on page 33 and a detailed description of the installation and removal of the harmonics is given starting on page 39.

In the Subassembly section, the laser bench features are discussed. Optics, electronics and mechanics located on the bench are described first, followed by detailed descriptions of the Power Cooling Unit (PCU).

Instructions for careful cleaning of optics, replacing flashlamps and replacing of cooling group filters are given in the Maintenance section.

The Troubleshooting chapter presents common problems that are encountered and ways to solve them in both the electronic and optical areas. It is here that the more complicated procedures such as eliminating free-running are discussed.

Section 8: Warranty details the Amplitude Laser Inc. warranty and gives Service telephone and FAX numbers for further help. The Operator Notes gives the user a convenient place to keep maintenance records and other information.

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## Préface

Les symboles de danger reconnus internationalement présentés ici sont utilisés tout au long du manuel pour avertir l'utilisateur des risques possibles lors de l'utilisation de ce laser.



Le symbole de radiation sert à avertir l'utilisateur du danger d'exposition à la radiation laser lors de l'exécution de certaines opérations et lorsque ce danger est le plus grand. Il est aussi utilisé en cas de risques optiques.



Le signe d'éclair indique la présence d'une haute tension qui peut représenter un danger pour l'utilisateur ou l'équipement.



Th Le point d'exclamation sert à attirer l'attention sur d'autres risques possibles non inclus dans les catégories optique et électrique. L'utilisateur devrait être conscient des mesures de protection particulières à prendre lors de l'exécution de procédures potentiellement dangereuses.



La section Sécurité est en tête du premier chapitre de ce manuel afin de souligner son importance et la nécessité incombant à chaque utilisateur de la lire avant de commencer à utiliser un laser.

La section Installation comprend une copie des instructions de montage pour future référence. Les exigences de site sont énumérées comme l'est le processus d'installation initial, étape par étape.

La section Fonctionnement commence avec les procédures de mise en route et mise en arrêt quotidiennes. Le fonctionnement en décharge unique est aussi expliqué dans cette section. La DEL informant du statut et les messages d'erreur sont aussi expliqués. Les procédures d'optimisation des harmoniques sont données à la page -33 et une description détaillée de la mise en place et de l'élimination des harmoniques commence à la page 39.

Dans la section Sous-Unité, les caractéristiques de l'unité laser sont expliquées. La description des éléments optiques, électroniques et mécaniques présents dans l'unité précède celle détaillée de l'unité de refroidissement de l'alimentation (Power Cooling Unit - PCU).

Des instructions pour un nettoyage soigneux des éléments optiques, pour le remplacement de la lampe éclair et des filtres du dispositif de refroidissement se trouvent dans la section Entretien.

Le chapitre Dépannage présente les problèmes couramment rencontrés et indique les mesures à prendre dans les domaines de l'électronique et de l'optique. C'est aussi dans ce

chapitre que les procédures plus complexes telles que l'élimination du fonctionnement libre sont expliquées.

L'Annexe décrit la garantie Amplitude Laser Inc. et fournit les numéros de téléphone et de fax du service après-vente. Les Notes de l'Utilisateur offrent à l'utilisateur un endroit pratique pour conserver les rapports d'entretien et d'autres informations utiles.

## Vorwort

Die hier abgebildeten, international verständlichen Warnsymbole werden in der gesamten Anleitung dazu verwendet, den Benutzer auf mögliche Gefahrenquellen beim Laserbetrieb hinzuweisen.



Das Strahlungssymbol warnt den Benutzer vor gefährlicher Laserstrahlung bei bestimmten Betriebsverfahren und bei den stärksten Strahlengefährdungen. Es wird auch für optische Gefahrenquellen verwendet.



Das Blitzsymbol weist auf das Vorliegen von Hochspannung hin, die eine Gefährdung für Benutzer oder Gerät darstellt.



Das Ausrufezeichensymbol soll auf weitere Gefahren aufmerksam machen, die nicht unter die Kategorie Optik oder Elektrik fallen. Der Benutzer sollte auf besondere Maßnahmen achten, die bei evtl. gefährlichen Verfahren anzuwenden sind.



Das erste Kapitel dieser Anleitung ist der Sicherheitsabschnitt, da dieser äußerst wichtig ist und vor dem Betreiben des Lasers von jedem Benutzer gelesen werden sollte.

Der Abschnitt zur Installation enthält für den zukünftigen Bedarf ein Exemplar der Installationsanleitung. Hier sind sowohl die Standortanforderungen als auch eine schrittweise Erläuterung der Erstinstallation enthalten.

Der Abschnitt zum Betrieb beginnt mit der täglichen Einschalt- und AbschaltRoutine. Außerdem werden der Einzelpulsbetrieb behandelt und die Leuchtdioden-Statusinformationen und -Fehlermeldungen erläutert. Die Oberschwingungsoptimierung wird auf Seite 33 beschrieben, und auf Seite 39 beginnt eine ausführliche Beschreibung des Ein- und Ausbaus der Oberschwingungsgeneratoren.

Der Abschnitt zu den Untereinheiten behandelt die Merkmale der Laserfläche. Zunächst werden die optischen, elektronischen und mechanischen Komponenten der Laserfläche beschrieben und anschließend die Strom/Kühleinheit (PCU) detailliert erläutert.

Anweisungen zur sorgfältigen Reinigung der Optik, zum Austauschen der Blitzlampen und der Filter der Kühlgruppe sind im Wartungsabschnitt enthalten.

Das Kapitel Fehlersuche und -behebung beschreibt bekannte Probleme (Elektronik und Optik), die auftreten können, sowie Abhilfemaßnahmen. Hier werden auch kompliziertere Verfahren, wie das Verhindern von "Freischwingern", erörtert.

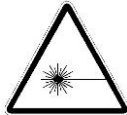
Der Anhang enthält die Amplitude Laser Inc.-Garantie sowie Service-Rufnummern und -Faxnummern, unter denen weitere Hilfestellung verfügbar ist. Unter "Benutzernotizen" kann der Benutzer bequem Wartungsdaten und sonstige Informationen aufbewahren



# Section 1: Laser Safety Precautions

## Class IV Laser Safety Precautions

**CAUTION : USE OF CONTROLS OR ADJUSTMENTS OR PERFORMANCE OF PROCEDURES OTHER THAN THOSE SPECIFIED HEREIN MAY RESULT IN HAZARDOUS RADIATION EXPOSURE.**



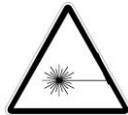
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### LASER RADIATION!

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

---

- Amplitude Laser Inc.'s Surelite lasers are class IV high power lasers whose beam is, by definition, a safety hazard. Take precautions to prevent accidental exposure to both direct and reflected beams.
- Diffuse as well as specular beam reflections can cause severe eye and skin damage.
- Infrared radiation passes easily through the cornea, which focuses it onto the retina, where it can cause instantaneous permanent damage or blindness. Even small doses from scatter can be harmful.



---

### LASER RADIATION!

Avoid eye and skin exposure to direct or scattered radiation!

---

## General safety rules



---

### WARNING!

If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

---

The following is a summary of general safety precautions, which are to be observed by anyone working with the laser. For a complete listing of safety standards see the ANSI booklet listed above.

- Never look directly into a laser beam or its reflection. Visual alignment of these sources shall not be attempted while the power supply is energized. Permanent damage to the eye can occur.

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- Keep all unnecessary personnel out of the work area. Remove all shiny reflective surfaces (including rings, watch bands, metal pencils etc.) and all flammable materials with their containers from the work area.
- Operate lasers only in well-marked areas with controlled access. Be sure to post appropriate warning signs visible to all.
- Operate lasers under the supervision of qualified personnel only. When not in use, shut down laser completely.
- Keep the laser firing area well lit so that the pupils of worker's eyes will be constricted. This reduces the amount of light entering the eye and lessens the chance of eye damage.
- A fire-resistant background should be in place behind the target area. The surrounding areas should be coated with a material that absorbs any scattered radiation that might occur.
- Tracking of individuals, vehicular traffic, aircraft or any airborne objects by means of laser radiation is prohibited.
- Never leave laser running unattended.



---

### **LASER RADIATION!**

Wear laser protective eyewear of sufficient optical density and suitable wavelength to protect the eyes from the maximum energy produced. Direct eye contact with the laser beam can cause permanent eye damage.

---

## **Optical Safety**

- Be sure that the light from the flashlamps is obscured from the eye as it is damaging if viewed directly.
- Eye safety is the greatest concern. Be aware at all times that this is a Class IV laser, the highest and most dangerous classification. Specular reflections from the main beam off a polished surface can cause severe eye damage. Use the following information and contact your Laser safety Officer (LSO) to provide protection.

1064nm	Nominal O.D.=6.1	MPE=50 mJ/m <sup>2</sup>	NOHD=15.17 km
532nm	Nominal O.D.=6.8	MPE=41.4 J/m <sup>2</sup>	NOHD=210 m
355nm	Nominal O.D.=2.2	MPE=41.4 J/m <sup>2</sup>	NOHD=147.5 m
266nm	Nominal O.D.=3.7	MPE=600 mJ/m <sup>2</sup>	NOHD=903 km

**996-0207**

## Section 1: Laser Safety Precautions

- Be sure that there are no volatile substances in the lab which the laser could ignite.
- Mark the lab well with warning signs when the laser is operating and provide interlocks for all doors.

### Electrical Safety



---

#### HIGH VOLTAGE!

To prevent accidents from electrical shock, ensure that the capacitors are completely discharged and the power is turned off before performing any maintenance or repairs to the system. Electric shock and burns resulting from input power or capacitor discharge can cause serious injury or death.

Be aware that high voltages are present in the laser heads once ac power is toggled on.

---

### Safety Features

#### Interlocks

The Surelite has interlock switches which stop it from firing when the:

- laser head (rod) temperature is too high.
- laser head cover is open.
- cooling water flow is too low.
- external interlock (if installed) is open.

All interlocks must be OK before the Surelite will fire. If any interlock is tripped, including the external interlock, the amber INTERLOCK LED will light and laser firing will stop. The interlock must be reset before the laser can be restarted.

You may also wire your Surelite so that opening a door to the laser laboratory (or opening any other switch) will shut off the laser.

## Laser covers

Covers protect against stray laser radiation from the Surelite. Interlocks prevent laser operation when they are open. Do not defeat interlock when covers are removed.



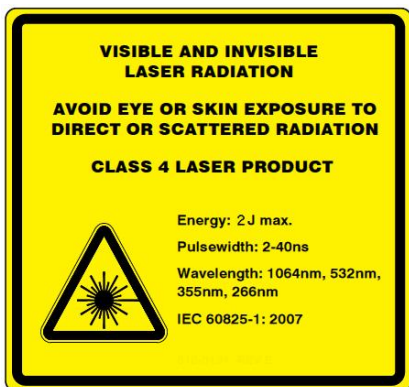
## Exit shutter

The Surelite has an exit beam shutter located outside its housing. Closing the beam shutter merely prevents the beam from exiting; it does not shut down the laser.

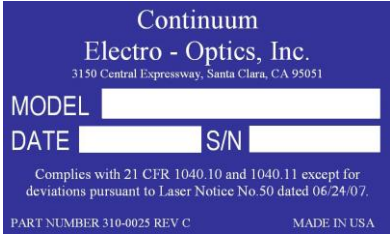



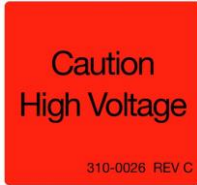


The following safety labels are used throughout the Surelite laser. Refer to diagrams A & B for their location.


## Safety Labels

The following safety labels are used throughout the Surelite laser. Refer to Figure 1, Figure 2, Figure 3, and Figure 4 on pages 13 and 14 for their locations.

 <p><b>CAUTION</b> CLASS 4 VISIBLE AND INVISIBLE LASER RADIATION WHEN OPEN AND INTERLOCKS DEFEATED AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION 310-0170 REV. C</p>	<p>Item 1. 310-0170</p> <p>Found on the Oscillator head cover.</p>
 <p><b>AVOID EXPOSURE</b> VISIBLE AND INVISIBLE LASER RADIATION IS EMMITTED FROM THIS APERTURE 310-0169 REV C</p>	<p>Item 2. 310-0169</p> <p>Found above exit port of the laser and SSP.</p>
 <p><b>VISIBLE AND INVISIBLE LASER RADIATION</b> <b>AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION</b> <b>CLASS 4 LASER PRODUCT</b> Energy: 2J max. Pulsewidth: 2-40ns Wavelength: 1064nm, 532nm, 355nm, 266nm IEC 60825-1: 2007</p>	<p>Item 3. 310-0187</p> <p>Found on the side of the Oscillator.</p>

**Section 1: Laser Safety Precautions**

 <p>Continuum Electro - Optics, Inc. 3150 Central Expressway, Santa Clara, CA 95051</p> <p>MODEL <input type="text"/> DATE <input type="text"/> S/N <input type="text"/></p> <p>Complies with 21 CFR 1040.10 and 1040.11 except for deviations pursuant to Laser Notice No.50 dated 06/24/07.</p> <p>PART NUMBER 310-0025 REV C      MADE IN USA</p>	<p>Item 4. 310-0025</p> <p>Found on the Oscillator and Power Control Unit.</p>
 <p><b>Open this side for cooling group maintenance.</b></p>	<p>Item 5. 310-0023</p> <p>Found on the cooling group side of the Power Control Unit.</p>
 <p><b>DANGER</b> INTERLOCK DEFEATED Avoid eye or skin exposure to direct or scattered radiation</p> <p>310-9124 REV A</p>	<p>Item 6. 310-9124</p> <p>Found on the interlock defeat.</p>
 <p><b>DANGER HIGH VOLTAGE</b> Access limited to authorized Continuum Service personnel only.</p>	<p>Item 7. 310-0022</p> <p>Found on the power supply side of the Power Control Unit.</p>
 <p><b>Caution High Voltage</b></p> <p>310-0026 REV C</p>	<p>Item 8. 310-0026</p> <p>Found on the top of the Marx Bank box.</p>
 <p><b>CAUTION HIGH VOLTAGE</b> BEFORE WORKING ON THIS UNIT — SWITCH OFF POWER SUPPLY — DISCONNECT ALL PLUGS</p> <p>310-0028 REV B</p>	<p>Item 9. 310-0028</p> <p>Found on the 811 Laser Head.</p>
	<p>Item 10. 310-9077</p> <p>Found on the Oscillator cover.</p>

<p>Invisible and/or visible laser radiation is emitted through these apertures. 310-0018 REV C</p>	<p>Item 11. 310-0018</p> <p>Found above the output on the Surelite Separation Package (SSP).</p>
	<p>The Surelite I, II, III &amp; EX are CE marked to show conformity with the applicable EU EMC Directive.</p>
<p>Invisible and/or visible laser radiation inputs through these apertures. 310-0019 REV B</p>	<p>Item 12. 310-0019</p> <p>Found above the input on the Surelite Separation Package (SSP).</p>
<p><b>SURELITE INTERLOCK CODES</b></p> <ul style="list-style-type: none"> <li>00 NORMAL RETURN</li> <li>01 SURELITE NOT IN SERIAL MODE</li> <li>02 COOLANT FLOW INTERRUPTED</li> <li>03 COOLANT OVER TEMPERATURE</li> <li>04 NOT USED</li> <li>05 LASER HEAD PROBLEM</li> <li>06 EXTERNAL INTERLOCK</li> <li>07 END OF CHARGE NOT DETECTED</li> <li>08 SIMMER NOT DETECTED</li> <li>09 FLOW SWITCH STUCK ON</li> </ul>	<p>Item 13. 310-0140</p> <p>Found on back panel of Power Control Unit.</p>

Section 1: Laser Safety Precautions

Figure 1 Location of labels on the Surelite oscillator

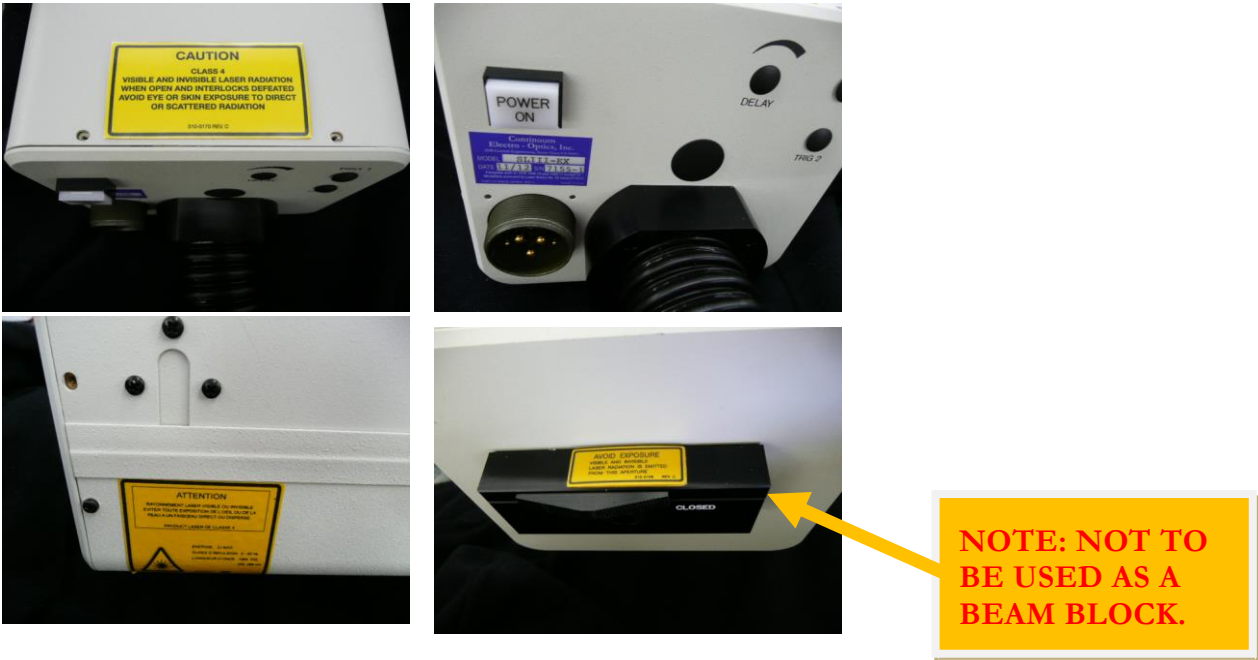


Figure 2 Location of labels on Surelite Separation Package (SSP)

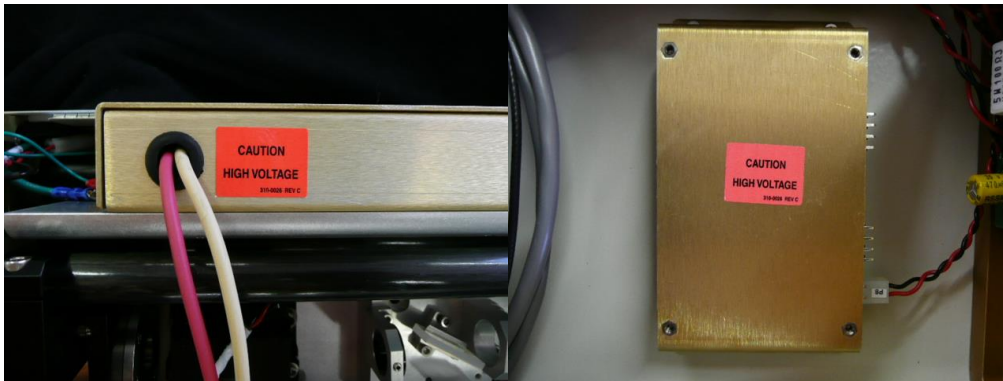


## Operation and Maintenance Manual for Surelite™ Lasers

Figure 3 Labels on the 811 Laser Head



Figure 4 Safety labels on the Laser Head



### Government and industry safety regulations

Amplitude Laser Inc.'s user information is in compliance with section 1040.10 of 21 CFR Chapter I, Subchapter J concerning Radiological Health published by U.S. Department of Health & Human Services Center for Devices & Radiological Health, 1988.

The American National Standards Institute (ANSI), a member of the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC), has published a booklet on laser safety standards. Amplitude Laser Inc. strongly suggests that all of its customers purchase a copy of the American National Standard for the Safe Use of Lasers in order to read and implement necessary precautions. Write or call the publisher listed below for information about obtaining a copy of ANSI Z136.1-1986.



## **Section 1: Laser Safety Precautions**

Publisher: Laser Institute of America  
12424 Research Parkway  
Suite 130  
Orlando, FL 32826  
(800) 345-2737

## **References for safety regulations**

Regulations of Administration & Enforcement of The Radiation Control for Health & Safety Act of 1968, U.S. Dept. of Health & Human Services, Public Health Service & Food & Drug Administrations, April 1988.

American National Standard for the Safe Use of Lasers, Laser Institute of America, 1986.

Laser Safety Guide, Laser Institute of America, 1977.

A Guide for Control of Laser Hazards, American Conference of Governmental Industrial Hygienists, 1976.

Sylvania Safety Rules, Frank S. Canario, Safety Engineer, 1967.

# Declaration of Conformity



Continuum Electro-optics Inc., under our sole responsibility declares that the products listed here conform to the following EC Directives and European Standards.

## High Energy Nanosecond Lasers

Product Description	Conforms to EC Directives	Conforms to European Standards
<u>Surelite Series</u> Models: Surelite I, Surelite II, Surelite III & Surelite EX Wavelengths: 1064nm, 532nm, 355nm, 266nm	<u>EMC Directive</u> 2004/108/EC  <u>Low Voltage Directive</u> 2006/95/EC	<u>Safety</u> EN 61010-1:2010 General requirements  EN60825-1 Safety of laser products - Equipment classification and requirements  <u>EMC</u> EN 61326-1:2006 EMC General requirements  EN 61000-3-2 (Harmonics) EN 61000-3-3 (Flicker) EN 61000-4-2 (ESD) EN 61000-4-3 (RF Immunity) EN 61000-4-4 (EFT) EN 61000-4-5 (Surge) EN 61000-4-6 (Conducted Immunity) EN 61000-4-11 (Voltage Dips & Interruptions)

Signed for Continuum



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## Section 2: Installation

### Installation requirements

The Surelite I & II laser systems are customer installed. The Surelite III & EX laser systems are installed by Amplitude Laser Inc. personnel. The sections below give detailed instructions regarding installation, tools necessary for installation and equipment required to monitor laser performance. Read the Installation section completely before beginning the installation. If you have any questions or problems while performing the installation or to schedule an installation, call Amplitude Laser Inc. Service at 1-877-272-7783.

### Site

Install the laser in a closed and clean location. Your laser will work best in a temperature stabilized environment. Therefore, it is advisable to set up the system in an air conditioned room, placed so that no vents blow directly on the laser and the laboratory temperature does not exceed 85°F (29.4°C). The laser should be mounted on a solid work table that includes tapped 1/4-20 bolt holes (or M6) at 1" centers so that the system can be secured to the table surface.

Choose a location for the power supply cabinet such that:

- the back panel of the cabinet is not more than 10 feet (3.3m) away from where the umbilical exits the laser.
- the back panel of the cabinet is at least 2 feet (61cm) from a wall to allow an unobstructed air flow to the cooling group.
- each side of the cabinet is at least 8 inches (20 cm) away from the wall or other obstacle to allow an unobstructed air flow to the power supply.

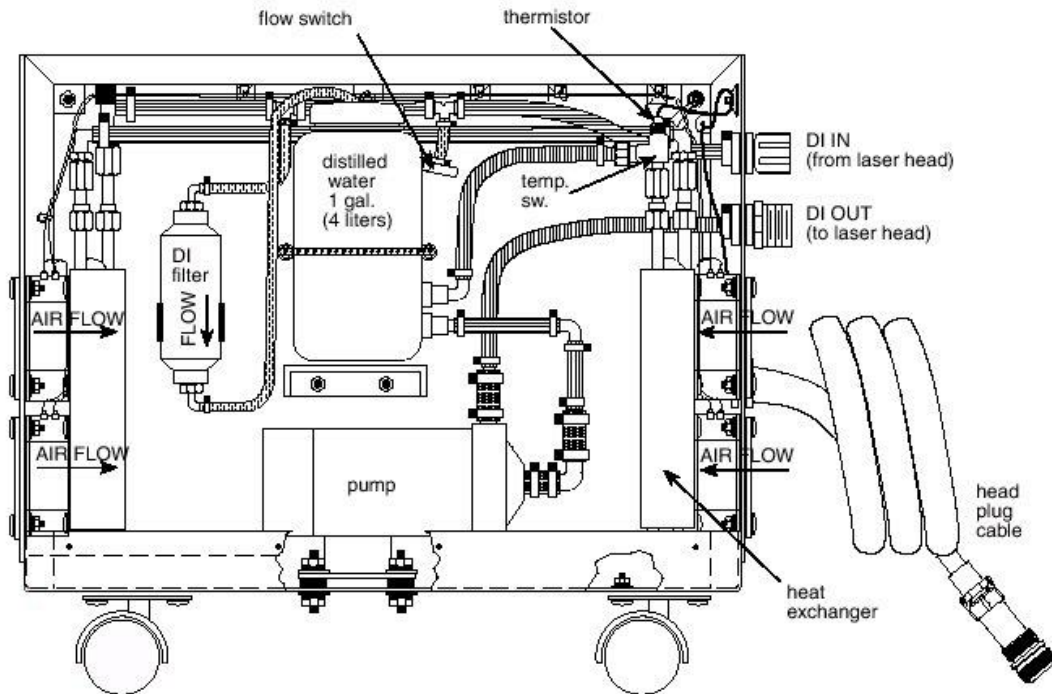
### Power

- The voltage requirement is 200-240 V~, 50-60 Hz, single phase.
- The amperage requirement is 10A.

### Water

The water-to-air cooled heat exchanger requires no external cooling water hook-up.

Figure 5 Cooling group chassis assembly for SL I-20 Hz.



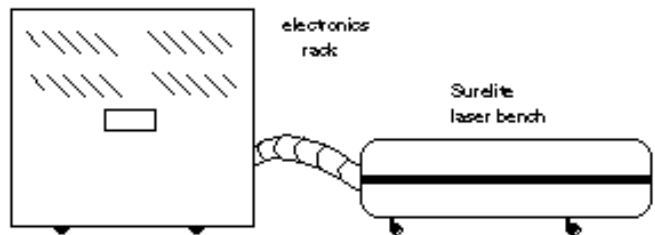
## Supplies

You will need the following to install the Surelite:

- Plug to fit your lab's 200-240 V~ socket
- Distilled water, 1.5 gallons (6 liters), 1 M/cm resistivity or better (water from a glass distiller will meet this requirement)
- 50 ml of methanol, reagent grade or better (for cleaning optics)
- Lens tissue
- Laser safety glasses for the fundamental infrared and its harmonics
- Power meter with volume absorbing detector

## REQUIRED TOOLS

- metric Allen keys: 1.5, 2, 2.5, 3, 4 & 5 mm (provided with laser)
- adjustable 6" wrench
- Phillips screwdriver
- standard screwdriver
- flashlight
- inspection mirror
- small ruler (~15 cm or 6")



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- 3/32 Allen k

# Unpacking Instructions

## Crate Inspection

Check the crate for damage before unpacking the laser. If damaged, please notify both the freight company and Amplitude Laser Inc. before proceeding with the installation.

## Unpacking

Please read through these instructions before attempting to unpack the Surelite.

Only a claw hammer or pry bar is needed for prying up the clamps. Remember to keep the crate after unpacking for future use. Warranty repairs require that the system be returned shipped in its original crate.

1. Place the crate near the optical table. Leave space to install the built-in ramp.
2. Remove all clamps but the two holding the front of the crate.
3. Remove the top of the crate and set it aside. Carefully release the last two clamps on front of the crate and set aside. This front side of the crate is marked "ramp" and will be used in step 9.
4. Remove manual package from umbilical shelf. The installation section of the manual will be needed after unpacking is completed. Unwind the umbilical and drape it over the back end of the crate.
5. Remove the umbilical shelf.
6. Using the finger hole, pull the foam cover from the laser bench.
7. Using the hand holds, have two people reach and cradle the laser bench. Lift the bench up and out of the foam enclosure and place it on the table. **Do not** lift the laser up by the umbilical.

8. Remove the 2 boxes containing the Surelite Separation Package (SSP) and accessories. Place near laser bench. Empty them of all hardware.

9. Take the front section of the crate and use a ramp. Install the ramp by inserting inside lip to

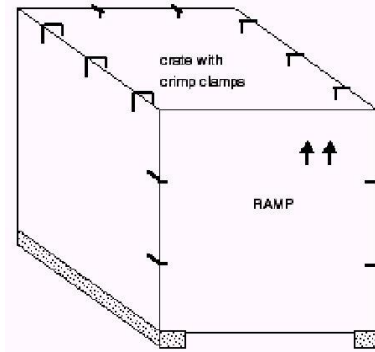


Figure 8 Surelite crate

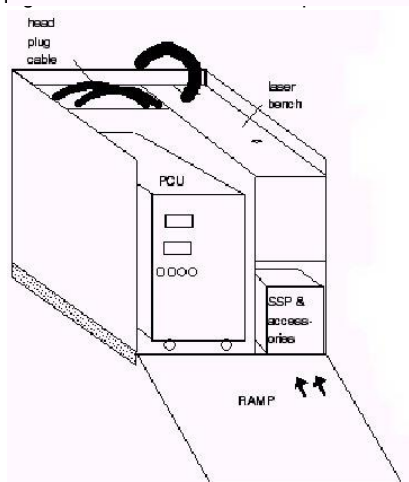
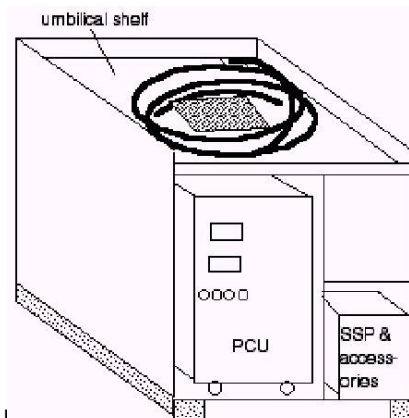


Figure 7 Surelite crate with umbilical shelf removed

## Operation and Maintenance Manual for Surelite™ Lasers

snugly into the groove below the Power Cooling Group (PCU). Arrows should point towards the inside of the crate.

10. Lift the PCU head plug cable (with military plug) out of the crate and lay it on top of the PCU.
11. Carefully roll the PCU down the ramp. Position the PCU close to the laser bench.
12. Remove the ramp.
13. After unpacking is complete, reassemble the crate for storage. Don't forget to include the cardboard boxes. We suggest that you store a copy of these instructions in the crate for future repacking.

## Installation



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### HIGH VOLTAGE!

The laser head and power supply contain lethal voltages and currents. Never operate the laser with the power supply cover removed.

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### HIGH VOLTAGE!

Observe all the precautions that are outlined in **Section 1: Laser Safety Precautions**, especially when the laser head cover is open. When open, operate the laser only in low energy mode.

---

## STEPS

1. Empty the accessory box. Examine the contents and identify the following items:
  - (4 ea.) 1/4 -20 1.5" hex head bolts (8 with Surelite Separation Package, SSP)
  - (4 ea.) 1/4-20 flat washers (8 with SSP)
  - (4 ea.) "L" brackets (8 with SSP)
  - 4 (4 ea.) Foot pads (donuts) (8 with SSP)
  - (1 ea.) Interlock defeat bracket with plastic knurled bolt
  - (1 ea.) Set metric Allen keys
  - (2 ea.) System key

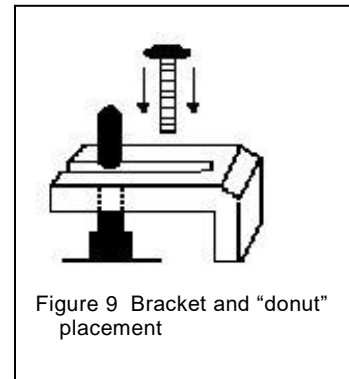


Figure 9 Bracket and "donut" placement



- (1 ea.) Single Shot Cable that plugs into front of Power Cooling Unit (PCU)
  - (1 ea.) 250V~ 16A power cord.
2. Tilt the laser bench and use a ruler to check the length of the 4 legs that support the laser. All should be of equal length. If not, adjust the leg lengths to ensure that the bench sits squarely on the table and does not rock.
  3. Place the laser bench at the desired position on the table top. Use the “L” brackets, foot pads, ¼ -20 bolts and washers from the accessory box to secure the system to the table.
  4. Locate the two water lines that run through the umbilical from laser. These lines have standard garden hose male/female connectors.
    - At the rear of PCU locate the two hose fittings labeled **DI IN** and **DI OUT**. Connect the umbilical garden hose male-to-female connectors, to the PCU panel garden hose connectors.
  5. Take the 9 pin D connector from umbilical and plug it into the **LASER HEAD** connector on PCU rear panel.
    - Locate ground strap from umbilical and connect to ground lug at rear of PCU.
  6. Take the head plug cable marked **FLASHLAMP** from rear of PCU, uncoil it and plug into socket at rear of laser bench. Remember to tighten the twist collar on the cable connector.
  7. Determine the cooling group (CG) side of PCU. It will have a label on it that reads “Open this side for cooling group maintenance”. Remove the 8 screws holding CG access panel in place.
  8. Lift panel up and off unit and put aside. Locate reservoir and fill to within 2 inches of top with distilled water.
  9. Locate the power cord in the accessory box and install the plug to fit the 200-240 Vac wall socket. The power cord consists of 3 wires, brown, blue and green/yellow. Connect the wires as follows:
    - brown wire to a **HOT**
    - blue wire to a **COMMON or HOT**
    - green/yellow wire to **EARTH GROUND**.
    - The ac line voltage should be 200-240 V~. Phase relation between the 2 hots is not critical and can be between 120-180°.
    - Between the brown and blue wire the voltage measurement should be 200-240 V~.
  10. Plug the square molded female end of ac line into 220 V~ plug on rear panel of PCU marked “220V~10A 50-60Hz” INPUT.

## Flow test the system



### CAUTION!

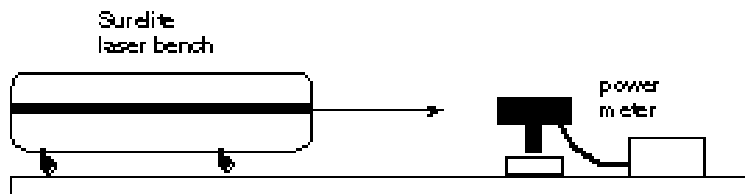
Before the first startup of the laser, be sure to **review the entire manual**, especially the section beginning on page **80** concerning elimination of free-running.

1. Plug the PCU into the 200-240 V~ power source.
2. On the front of the PCU, flip the red AC POWER switch up to the On position (see page 3-1 for Startup). After 8.8.8. and the rev #, the panel LED readout should say **oFF**.
3. Turn the keyswitch to the **On** position. After approximately 10 seconds, the pump will turn on and begin to circulate water through the system.
4. If error code E02 displays, turn off the keyswitch and repeat the step above.
5. Flow test the system for 5 minutes while checking for water leaks at the rear and inside the PCU.
6. If no leaks are detected, shut the system down and reinstall the cooling group cover panel.

## Measure total energy

1. On the Error! Reference source not found. on page Error! Bookmark not defined. of this manual, note the following:
  - FLASHLAMP DISCHARGE VOLTAGE setting
  - Q-SWITCH DELAY setting.

Figure 10 Setup for energy measurement



While referring to **Section 3: System Operation** on page **29**, steps 1 to 3, verify that the FLASHLAMP DISCHARGE VOLTAGE and Q-SWITCH DELAY readouts are at QA indicated settings.

1. Position volume absorbing head power meter in front of exit port of laser bench. Tilt meter head slightly so that reflections from head **do not** go back into exit port.
2. Switch the meter to the 10 watt scale.

## Section 2: Installation

3. Perform the DAILY STARTUP procedure. See page 29 in **Section 3: System Operation**.

Note: For thermal stabilization of Pockels cell and harmonic generators, the system software will not allow the SHUTTER button to open for 30 minutes after the red AC POWER toggle is first turned on.

4. Measure power coming from the exit port and compare with the value for total energy indicated in QA.
5. If power is comparable then proceed with optimizing harmonic crystals. See **Harmonics optimization** on page 33.
6. If energy is low, see **Section 6: Troubleshooting** on page 74.

Figure 11 Rear panel SL I-20 PCU

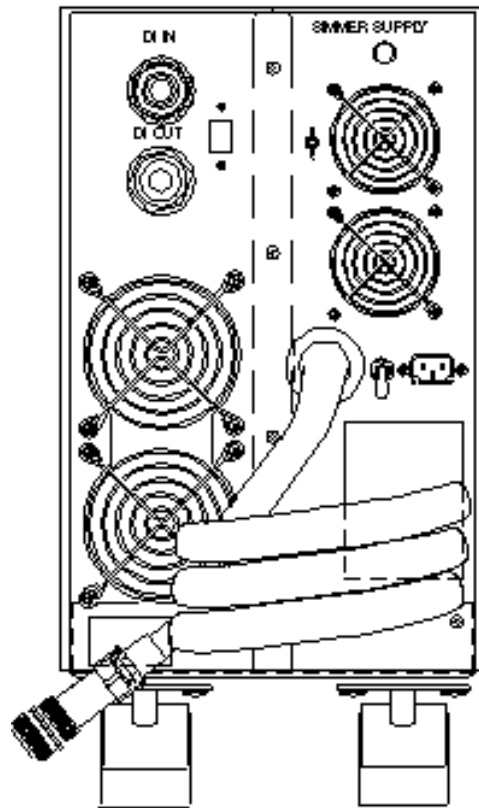


Figure 12 Front panel SL I-20 PCU

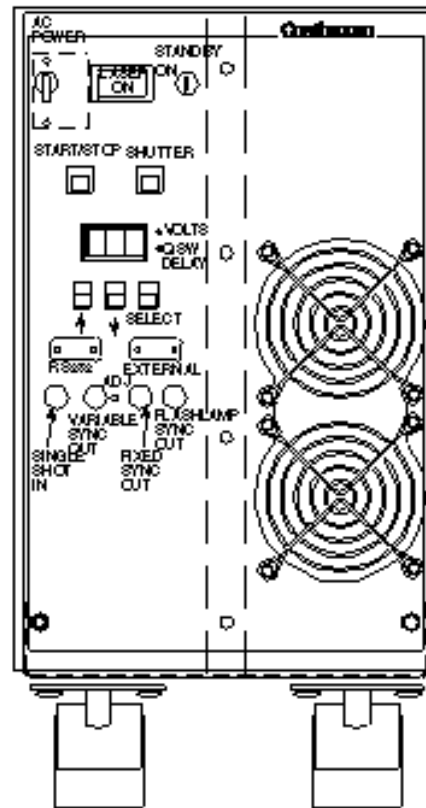
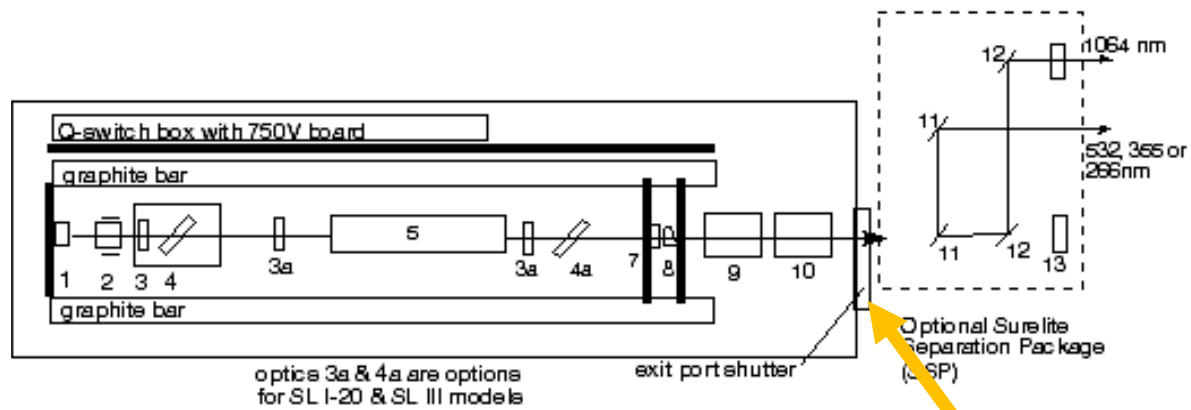


Figure 13 Optical Surelite Separator Package (SSP)



**NOTE: NOT TO BE USED AS A BEAM BLOCK.**

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## Section 2: Installation

Table 1 Part numbers for the Surelite laser bench

Ref.	Name	Surelite I	Surelite II	Surelite III
1	Rear mirror 10 Hz	104-0003	104-0003	104-0002
1	Rear mirror 20 Hz	104-0049	104-0001	
2	Pockels cell	202-0265	202-0265	202-0266
3	$\lambda/4$ plate	108-0001	108-0001	108-0001
4	Dielectric polarizer	199-0116	199-0116	199-0116
5	811U-06 head (upper) Rod Flashlamp "O" ring kit	507-0700 201-0056 203-0019 507-0710		
5	811U-07 head (upper) Rod Flashlamp "O" ring kit		507-1000 201-0004 203-0019 507-1005	
5	812V-09 head (vertical) Rod Flashlamp "O" ring kit			507-0900 201-0005 203-0032 507-0905
6	Intra-cavity shutter	619-1438	619-1438	619-1438
7	Mirror, Gaussian 10 Hz	104-0064	104-0074	104-0071
7	Mirror, Gaussian 20 Hz	104-0069	104-0071	
8	Output beam compensator	199-0102	199-0102	199-0102
9	Doubler Type 1 Doubler Type 2	619-2700 619-2640	619-2700 619-2640	619-2700 619-2640
10	Tripler	619-2720	619-2720	619-2720
11	Dichroics 532 nm Dichroics 355 nm Dichroics 266 nm	105-0022 105-0023 105-0025	105-0022 105-0023 105-0025	105-0022 105-0023 105-0025
12	Dichroics 1,064 nm	105-0002	105-0002	105-0002
13	Beam dump	619-1437	619-1437	619-1437

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## Section 3: System Operation

### Daily Startup

1. Check the water reservoir level before beginning **Startup** for the first time.
2. The toggle switch labeled, **AC Power**, should have been left on after the last use. If not, do the following:
  - On the front panel of the Surelite power unit, flip the toggle switch up that is labeled **AC POWER** (this is the **On** position). After a quick diagnostic check, the LEDs on the front panel display will readout 888, software rev. #, then **OFF**. The “Power On” button is located on the rear panel of the laser head.
  - After approximately 6 seconds, the **LASER ON** lights will turn on. They are located on the top of the laser head and on the front panel of the power supply.
3. Insert the key into the keyswitch and rotate it counter-clockwise to the On position. The readout LED will momentarily display the following.

Total # flashlamp discharges	Displays as a series of 3 displays for millions, thousands, and hundreds.
Water flow startup	FLo displays while system waits for water flow to be verified in the laser heads.
Flashlamp discharge frequency	Displays the last saved rep, in Hertz (flashes/second).

4. Press the **SELECT** button and toggle the LED display through these six modes to verify the accuracy of all the settings. The normal values are:

Rep Rate	Factory set for either 10 or 20 Hz
Q-switch	Set to the value listed in the Quality Assurance Document at the front of the manual
Pulse Division	P01 (laser output with every discharge of flashlamp)
Pump Voltage	Set to the value listed in the Quality Assurance Document at front of manual.
Serial Mode	SoF (serial port off)
External Mode	EoF (External mode off)

5. Press the **START/STOP** button and its LED will come on. The laser head will now flash at the designated frequency. Allow the system to run for 15-20 minutes to thermally stabilize the YAG head before proceeding.
6. Put on laser safety goggles.
7. On the front of the laser bench, slide the exit port shutter to the **OPEN** position.



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#### **LASER RADIATION!**

The next step results in laser output.

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8. Press the **SHUTTER** button and its LED will come on. An audible click will be heard from laser bench as the intra-cavity shutter withdraws from the oscillator. The system should now lase.

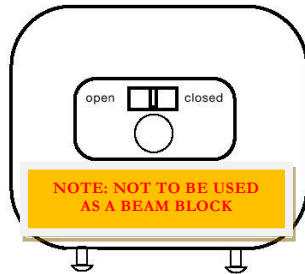
Note: During the first 20 minutes after the red AC Power toggle is turned on, the software will not allow the SHUTTER to open. This enables thermal stabilization of the Pockels cell and harmonic generators.

9. If harmonic crystals are used, allow laser output to pass through crystals for 5 minutes and then optimize the crystals for maximum energy. See **Harmonics optimization** on page 33.

## Daily Shutdown

1. Depress the **START/STOP** button. The LEDs on the **START/STOP** button and **SHUTTER** button should turn off. A click will be heard as the intra-cavity shutter drops. The laser head flashlamps should stop flashing.

2. On port



3. Turn system should

the front of the laser bench, slide the exit shutter to the **CLOSED** position.

key clockwise to **STANDBY** and the **LASER ON** light will shut off. After 1 second a beep will sound and then the will power down. The LED display read **oFF**. Remove key.

4. Leave toggle switch labeled **AC POWER** up and in the **ON** position.

Note: The AC POWER can be toggled off if there are no plans to use the laser for an extended period of time.

## Display readouts

This is an explanation of the 3 digit LED readout that appears on the front panel of the Power Cooling Unit. The explanations are listed in the order in which they appear at start up and then if you step through the displays by pressing the **SELECT** button.

- 8.8.8. This is a test sequence where all segments of the red LED display are illuminated so that the user can verify that there are no burned out display sections.
- rxX Rev number of software being run in system. The current revision level will be displayed when laser is turned on.
- oFF Displayed when the **AC POWER** is toggled on and the keyswitch is in the **STANDBY** position.
- 000 The flashlamp discharge count is displayed during the startup sequence. This count is given in a series of three displays of numbers. The first being millions, the second thousands and the third hundreds.



### Section 3: System Operation

- Flo Displayed during start up sequence. Indicates pause in system startup while logic waits for water flow to be established in the laser heads. The pause can be as long as 40 seconds.
- Fxx Frequency of flashlamp discharge. Normal value for 10 Hz system is F10, for a 20 Hz system, F20. This value can be changed within preset boundaries by pressing **ARROW UP** or **ARROW DOWN** buttons.
- XXX Q-switch delay setting in microseconds. Red light labeled **Q-SW DELAY**  $\mu$ s next to LED display should also be on. This value indicates the time between the command to fire the flashlamp and the command to fire the Pockels cell. The normal value is listed in the QA in front of the manual.
- Pxx Flashlamp discharge divider for laser output. Take the frequency of flashlamp discharge and divide it by Pxx to get the frequency of laser output. (Example: Fxx = F10 and Pxx = P05 then for every fifth discharge of the flashlamps you get laser output. The system lases at 2 Hz) This feature allows user to change the frequency of laser output without changing the flashlamp discharge rate. The value of Pxx can be changed from 0-99 by pressing the **ARROW UP** or **ARROW DOWN** buttons. Normal value for Pxx is P01.
- XXX Flashlamp discharge voltage in kilovolts. Red light labeled **VOLTS KV** next to LED display should also be on. This indicates the charge voltage of the laser head flashlamp capacitor. The normal value is listed in the QA in front of the manual.
- SoF Indicates that the serial mode of operation through the RS232 port is off and the system is running on its own internal clock commands.
- Son Indicates that the serial mode of operation through the RS232 port is on and the system will await indicated input commands to operate. (See page 44.)
- EoF Indicates that the external mode of operation through the **EXTERNAL** connector is off and the system is running on its own internal clock commands.
- Eon Indicates that the external mode of operation through the **EXTERNAL** connector is on and the system will await indicated input commands to operate. (See page 44.)

### Error messages

There are nine programmed error messages. When they appear, they are accompanied by flashing and beeping. The definitions for the error messages are given below. Refer to **Table 12 Electrical troubleshooting** on page 74 to resolve these problems.

- E00 Normal return.
- E01 Surelite not in serial mode. Serial port is turned off. To operate in serial mode, press **SELECT** then **ARROW UP** button.

- E02 Coolant flow interrupted. Check water level and kinks in water lines.
- E03 Coolant temperature over temp. Cooling water temperature is too high.
- E04 (not used)
- E05 Laser head problems.
- E06 External interlock. External interlock has opened.
- E07 End of charge not detected before lamp fire.
- E08 Lamp simmer not detected.
- E09 Flow switch stuck on.
- CSE This is displayed if a “ check sum error” occurs in the EEPROM. This display means that the EEPROM has lost its saved memory and has reverted to preset software limits. It will be necessary to toggle through the display menu and re-enter the QA values for frequency (Fxx), lamp pump voltage, Q-switch delay and pulse division (P01). If display does not go away after recycling keyswitch, contact Amplitude Laser Inc..

### Single shot (SS) button

An operational feature of your Surelite is the ability to operate the system in a single shot mode. That is, a single laser pulse on demand. This feature can be very useful when aligning downstream optics or verifying target position.

### To enable SS

To enable the Single Shot operation do the following:

1. Perform the Daily Shutdown procedure found on page **30**.
2. Locate the Single Shot (SS) cable that was shipped with your system in the Accessories Box. It is approximately 15 ft. (4.5 m) long, has a momentary push button switch at one end, and a BNC connector at the other.
3. Connect the Single Shot cable to BNC connector labeled **SINGLE SHOT** on front panel of PCU.
4. Turn the keyswitch to the **ON** position.
5. Press the **SELECT** button and toggle to pulse division (Pxx). Check that the pulse division displayed is >00. The normal reading for a system would be P01.

### Section 3: System Operation

Note: If system operation mode was in P00 prior to initialization and user wants a mode other than single shot, he must press SELECT ARROW UP button to obtain desired laser output.

6. Press the **START/STOP** button. Laser head should now flash.
7. Press the **SHUTTER** button on. System will now be lasing.
8. Initially press the SS button once and lasing output will stop but the laser head will continue to flash.
9. From this point on, each subsequent press of the SS button results in a single laser pulse.

#### To disable Single Shot (SS) operation

1. With the system on, the laser head flashing and **SHUTTER** button **ON**, depress **SS** button and hold down for 10 seconds. Normal lasing operation will resume.

Note: If there is no laser output press SELECT button for Pulse Division and verify that display is >P00 (normal is P01).

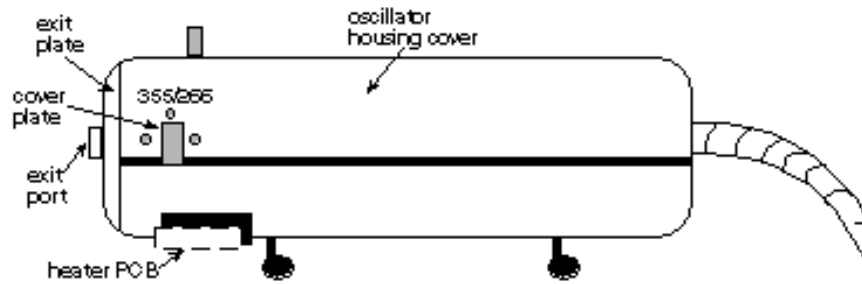
2. The **SS** can be disconnected from PCU or left connected as desired.

#### Harmonics optimization

Abbreviations used for Amplitude Laser Inc. harmonics are as follows:

- SLD Surelite doubler
- SLT Surelite third harmonic
- SLF Surelite fourth harmonic.

Figure 14 Surelite laser head



## Second Harmonic Generation (SLD)

Table 2 Surelite second harmonic specifications

Doubling	Surelite I	Surelite I	Surelite I	Surelite III	Surelite II	Surelite III	Surelite EX
532 nm	10	20	30	10	20	10	10
Energy (mJ)	200	160	130	300	250	425	375
Stability	± 3.0						
Pulsewidth	≈ 1 ns < input of 1,064 nm						
Polarization	> 95% vert.						
Linewidth	≈ 1.5 x linewidth of 1,064 nm						

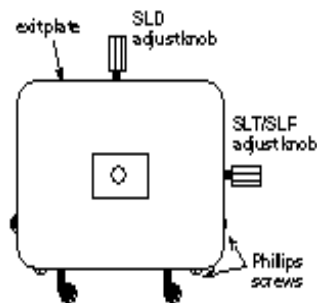
1. Shut down laser system.
2. Locate the second harmonic crystal model SLD-2 and install. See procedure on page 39. If already installed, remove third harmonic crystal (SLT) or fourth harmonic (SLF) crystal if attached to SLD-2. See procedure on page 39.

Note: For maximum 532 nm energy the second harmonic crystal model SLD-2 must be used. Using the second harmonic crystal model SLD-1 will lower 532 nm energy by >25%.

3. Install 532 nm dichroics in Amplitude Laser Inc.'s optional Surelite Separation Package (SSP).
4. Position the SSP as indicated in drawing **Figure 13** on page 26.
5. Perform **Daily Startup Procedure** with the single shot mode operational. See page 29.
6. Note the voltage reading on the front of the PCU and then lower the lamp voltage (using **ARROW DOWN** button) by ~300 V to just above the lasing threshold.
7. With >OD~4 goggles on, hold a piece of white paper (an index or business card) in front of the exit port and press the single shot button. A small green spot should be seen on the card. The IR will be fluorescent white.
8. Position the SSP so that the 532 nm and the IR fall cleanly on their respective mirror surfaces with no clipping. See **Figure 15** on page 37.

### Section 3: System Operation

9. Steer the 532 nm separated from the 532 nm/1,064 nm into a volume absorbing power meter set on the 3 watt scale.
10. Reset voltage to the original setting by using the **ARROW UP** button on front of the PCU (step 6) and return to continuous operation.
11. Locate the SLD adjust knob on the **top** of laser housing assembly and slowly rotate knob for maximum energy. Unless it is suspected to be grossly misadjusted, do not rotate more than one full turn in either direction.



### Third Harmonic Generation (SLT)

Table 3 Surelite third harmonic specification

Tripling 355 nm	Surelite I 10	Surelite I 20	Surelite I 30	Surelite II 10	Surelite II 20	Surelite III 10	Surelite EX 10
Energy (mJ)	65/100	60/100	25/70	100/160	70/120	165/225	125/220
Stability	± 4.0						
Pulsewidth	≈ 1ns < input of 1,064 nm						
Polarization	>95% horizontal						
Linewidth	≈ 1.5 x linewidth of 1,064 nm						

1. Shut down laser system.
2. Remove housing cover and its cover plate shown on page 34 to allow adjustment knob of SLT or SLF to seat properly.
3. Locate the second harmonic crystal model SLD-1 and install. See procedure on page 39.
 

Note: For maximum 355 nm energy, the second harmonic crystal model SLD-1 must be used with the third harmonic crystal model SLT. Using the second harmonic crystal model SLD-2 will lower 355 nm energy by >25%.
4. Locate the third harmonic crystal model SLT and install. See procedure on 39.
5. Install 355 nm dichroics in Amplitude Laser Inc.'s optional Surelite Separation Package (SSP).
6. Position the SSP as indicated in Figure 13 on page 26.
7. Perform **Daily Startup Procedure** with the single shot mode operational. See page 29.
8. Note voltage reading on front of PCU and then lower lamp voltage (use **ARROW DOWN** button) ~ 200V to just above lasing threshold.
9. With >OD~4 goggles on, hold a piece of white paper (an index or business card) in front of the exit port and press the single shot button. A small blue spot should be seen on the card. The IR will be fluorescent white.

10. Position the SSP so that the 355 nm and the IR fall cleanly on their respective mirror surfaces with no clipping. See **Figure 15** on page **37**.
11. Steer the 355 nm separated from the 532 nm/1,064 nm into a volume absorbing power meter set on the 3 Watt scale.
12. Reset voltage using **ARROW UP** button on front of PCU to original setting (noted in step 7) and return to continuous operation.
13. Locate the SLT/SLF adjust knob on the **side** of laser housing assembly and slowly rotate knob for maximum energy. The knob should not have to be rotated more than one full turn either clockwise or counter clockwise. Unless it is suspected to be grossly misadjusted, do not rotate more than one full turn either clockwise or counter clockwise.
14. Locate SLD adjust knob on **top** of laser housing assembly and slowly rotate knob for maximum energy. Unless gross misadjustment is suspected, **do not** rotate more than one full turn in either direction.
15. Keep repeating steps 12 and 13 until the 355 nm energy has been maximized.

### Fourth Harmonic Generation (SLF)

Table 4 Surelite fourth harmonic specification

Quadrupling 266 nm	Surelite I 10	Surelite I 20	SLI 30	Surelite II 10	SLI 20	Surelite III 10	Surelite EX 10
Energy(mJ)	60	45	30	80	60	100	90
Stability (%)	± 7						
Pulsewidth	~1 ns less than input of 1,064 nm						
Polarization	>95% horiz.						
Linewidth(cm-1)	1.0						

Performance Parameters at 266 nm:

1. Shut down laser system.
2. Remove housing cover and its cover plate shown on page **34** to allow adjustment knob of SLT or SLF to seat properly.
3. Locate the second harmonic crystal model SLD-2 and install. See procedure on page **39**.

Note: For maximum 266 nm energy the second harmonic crystal model SLD-2 must be used with the fourth harmonic crystal model SLF. Using the second harmonic crystal model SLD-1 will lower 266 nm energy by >25%.

4. Locate the fourth harmonic crystal model SLF and install. See procedure on page **39**.
5. Install 266 nm dichroics in Amplitude Laser Inc.'s optional Surelite Separation Package (SSP).

### Section 3: System Operation

6. Position the SSP as indicated in **Figure 13** on page 26.
7. Perform **Daily Startup** procedure with the single shot mode operational. See page 39.
8. Note voltage reading on front of PCU and then lower lamp voltage (use **ARROW DOWN** button) ~200 V to just above lasing threshold.
9. With >OD~4 goggles on, hold a piece of white paper (an index or business card) in front of the exit port and press the single shot button. A small blue spot should be seen on the card. The IR will be fluorescent white.
10. Position the SSP so that the 266 nm and the 532 nm/1,064 nm fall cleanly on their respective mirror surfaces with no clipping. See diagram on page 37.
11. Steer the 266 nm separated from the 532 nm/1,064 nm into a volume absorbing power meter set on the 1 Watt scale.
12. Reset voltage using **ARROW UP** button on front of PCU to original setting (noted in step 7) and return to continuous operation.
13. Locate the SLT/SLF adjust knob on the **side** of laser housing assembly and slowly rotate knob for maximum energy. You should not have to rotate more than one full turn either clockwise or counter clockwise. Unless it is suspected to be grossly misadjusted, do not rotate more than one full turn either clockwise or counter clockwise.
14. Locate SLD adjust knob on **top** of laser housing assembly and slowly rotate knob for maximum energy. Unless it is suspected to be grossly misadjusted, do not rotate more than one full turn in either direction.

Figure 15 SSP 1,2,3,4 optical layout (top view with cover off)

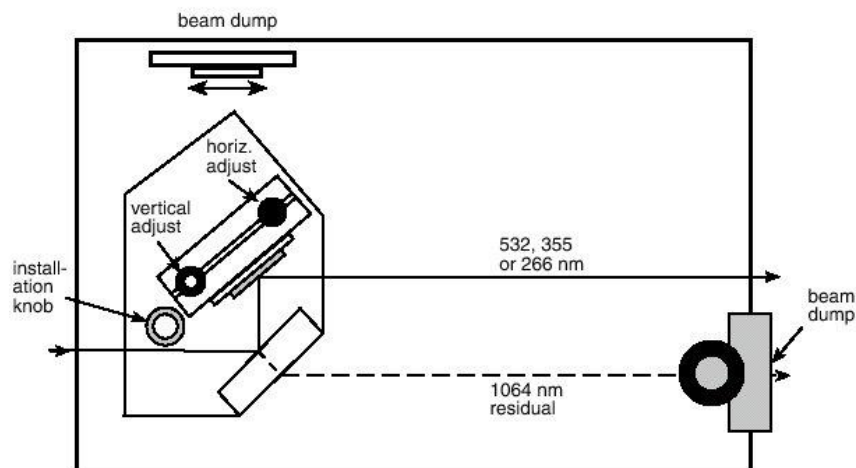


Figure 16 SSP 1-A, 2-A, 3-A, 4-A optical layout (top view - cover off)

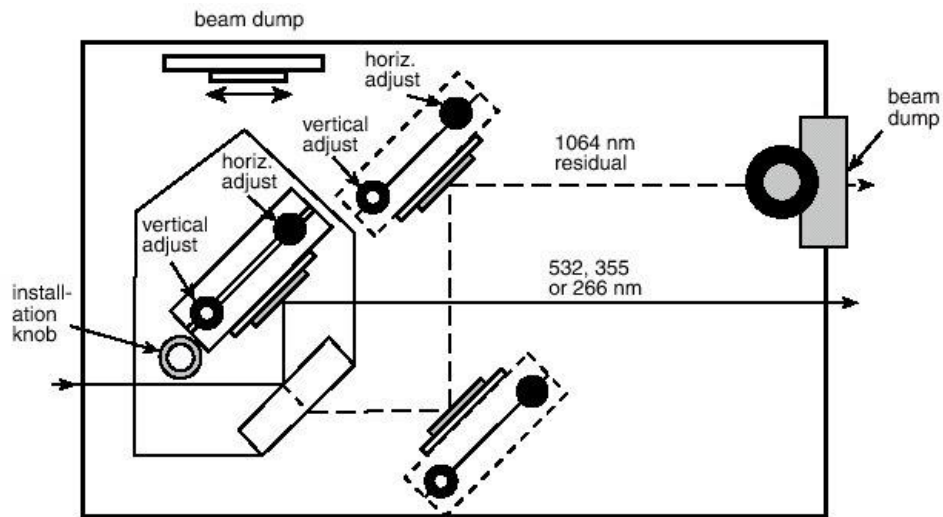


Figure 17 SSP mirror mount

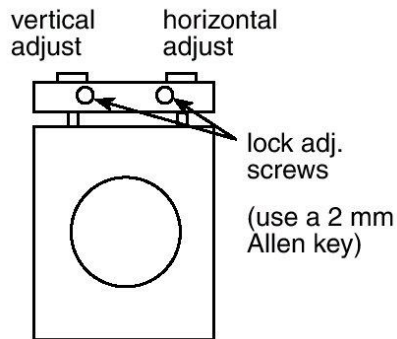


Figure 18 SSP output face

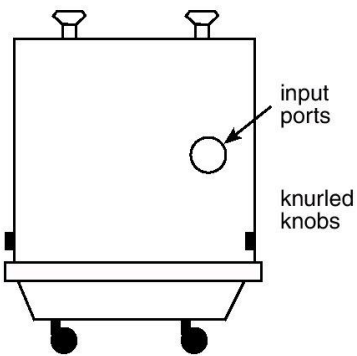
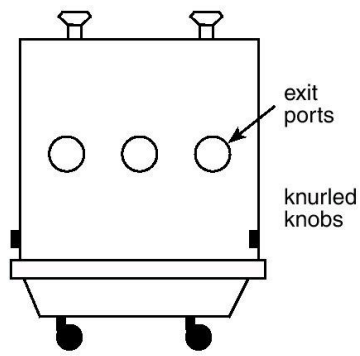


Figure 19 SSP output face





## Installation & removal of harmonic generators

### Installation of SLD

#### NECESSARY EQUIPMENT

- 2.5 mm Allen key
- Second harmonic generator (SLD-1 or SLD-2)
- (3 ea.) 35 mm long M3 Allen bolts
- Phillips #2 screwdriver

#### STEPS

1. Shut the system down by performing Daily Shutdown Procedure. See page **30**.
2. Remove laser housing cover that is held in place by the 2 Phillips head screws at each end.
3. Determine proper harmonic generator orientation. See page **41**.
4. Second harmonic (SLD) - adjust knob on top and the SLD output face is toward exit port.
5. Hold the harmonic generator above the heater PCB and plug the heater cable into an open 4 pin connector on the heater PCB. Be sure contact is made. See drawing on page **41**.
6. Place three M3 Allen bolts into deeply recessed bolt holes on exit face of the harmonic generator. Align the harmonic bolt holes to those on the horseshoe shaped bracket and screw in bolts using a 2.5 mm Allen key.
7. Reinstall laser housing cover.

### Installation of SLT or SLF

#### NECESSARY EQUIPMENT

- Phillips #2 screwdriver
- Third harmonic generator (SLT) or fourth harmonic generator (SLF)

#### STEPS

1. Shut the system down by performing Daily Shutdown Procedure. See page **30**.
2. Remove the laser housing cover that is held on by the 2 Phillips head screws at each end.
3. Determine proper harmonic generator orientation. See page **41**.

- Third harmonic (SLT) - adjust knob points horizontally to the **side**) and the output face is toward the exit port.
  - Fourth harmonic (SLF) - adjust knob points horizontally to the **side**) and the output face is toward the exit port.
4. Hold the harmonic generator above the heater PCB and plug the heater cable into an open 4 pin connector on the heater PCB. Be sure contact is made. See **Figure 20** on page **41**.
  5. Slide the male guide pins (on input face of SLT or SLF) into their female counterparts located on output face of the second harmonic generator.
  6. While holding the SLT or SLF in place, rotate the locking collar clockwise until the harmonic generator is snugly secured to the second harmonic generator. See page **41**.

Note: For Surelite III

Secure harmonic generator housing to the support bracket on the graphite structure with an M4x10 mm bolt, flat washer and lock washer.

7. Remove the cover plate for the SLT or SLF adjustment knob.
8. Reinstall laser housing cover.

## Removal

### NECESSARY EQUIPMENT

- 2.5 mm Allen key
- Phillips #2 screwdriver

### STEPS

1. Shut the system down by performing Daily Shutdown Procedure. See page **30**.
2. Remove the laser housing assembly cover that is held on by the two Phillips head screws at each end.
3. While holding the harmonic generator do the following:
  - SLD-1 - use a 2.5 mm Allen key to remove the 3 deeply recessed (~35 mm) M3 Allen bolts located in the mounting holes on the output face. See drawings on page **41**.
  - SLD-2 - use a 2.5 mm Allen key to remove the 3 deeply recessed (~35 mm) M3 Allen bolts located in the mounting holes on the output face. See drawings on page **41**.
  - SLT - turn locking collar counter clockwise until the harmonic generator is loose.
  - SLF - turn locking collar counter clockwise until the harmonic generator is loose.
4. Once the harmonic generator is loose, reach down to the heater PCB and unplug the heater cable. Grasp the white plastic connector and pull firmly and directly away from the board. **DO NOT** pull on the cable because it will damage the connector.

### Section 3: System Operation

Note: For the Surelite III

- Remove M4 x 10 mm bolt, lock washer, and flat washer from the support bracket attached to the graphite structure.
- Now lift harmonic generator up and out of the laser bench, wrap the harmonic generator in lens tissue, put it in a plastic bag, and store it in a desiccator.
- Reinstall the cover plate for the SLT or SLF adjustment knob.
- Reinstall the laser housing assembly cover.

Figure 20 Top view of heater connectors

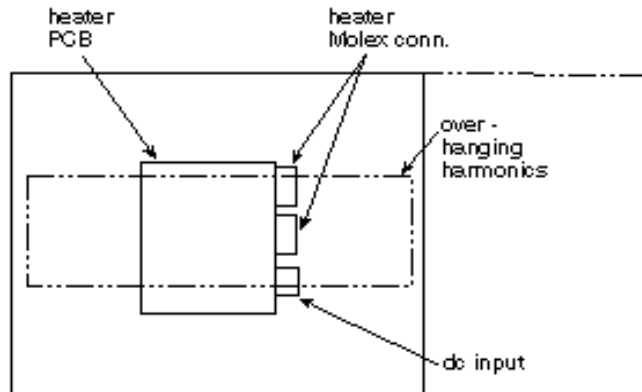


Figure 21 SLD output face

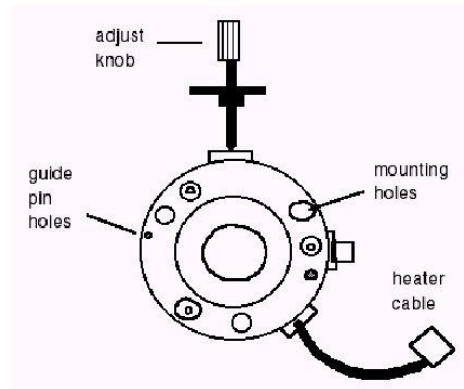


Figure 22 SLD input face

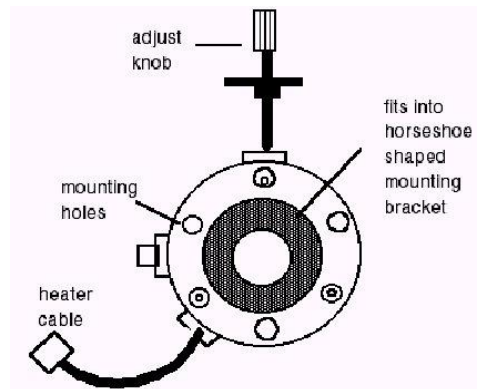


Figure 23 Harmonics side view

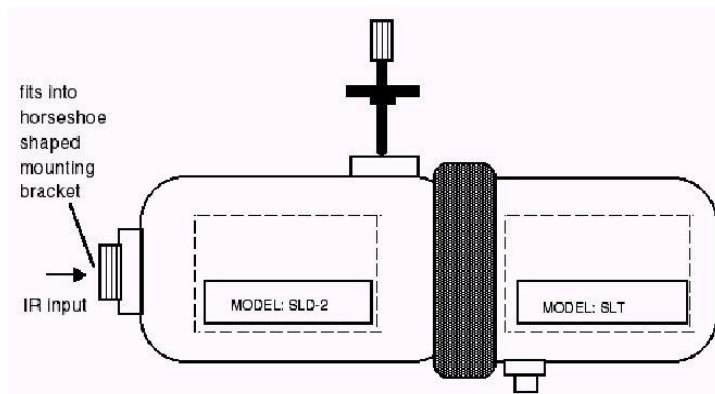


Figure 24 SLT/SLF input face

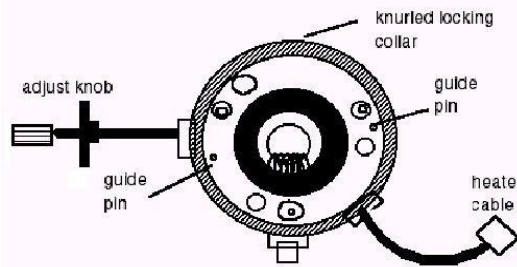
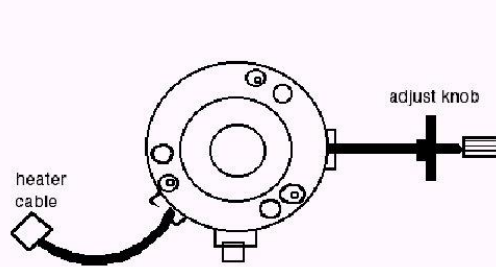


Figure 25 SLT/SLF output face



## RS232 serial port

For customers who wish to control the laser from their own computer, Amplitude Laser Inc. has provided two methods of external control; through an RS232 interface or with Direct Access Triggering (DAT). With RS232 operation, ASCII commands are transmitted via the RS232 interface. The RS232 is used with an IBM PC compatible or a Macintosh as long as the host computer incorporates an RS232 control format. The DAT method of operation communicates with the laser via TTL level signals. The explanation of DAT is on page 45.

## Software

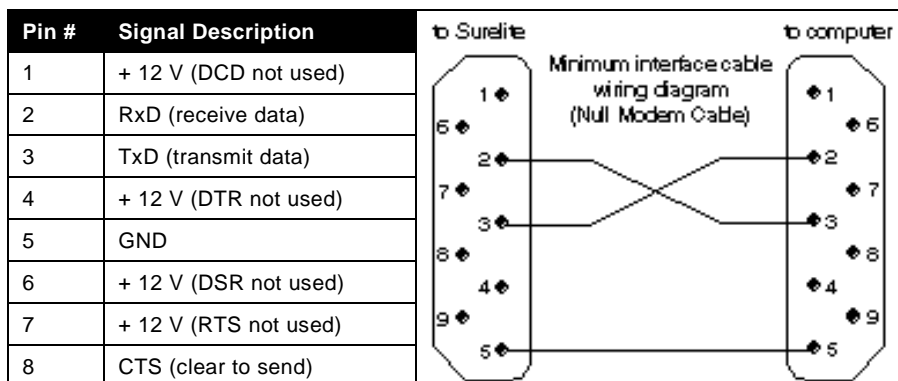
Some softwares that allow the output of ASCII commands via the RS232 cable are:

- Procomm for the Mac
- Windows 3.x Terminal for the PC
- Windows 95\98 Hyper Terminal.

## To enable RS232

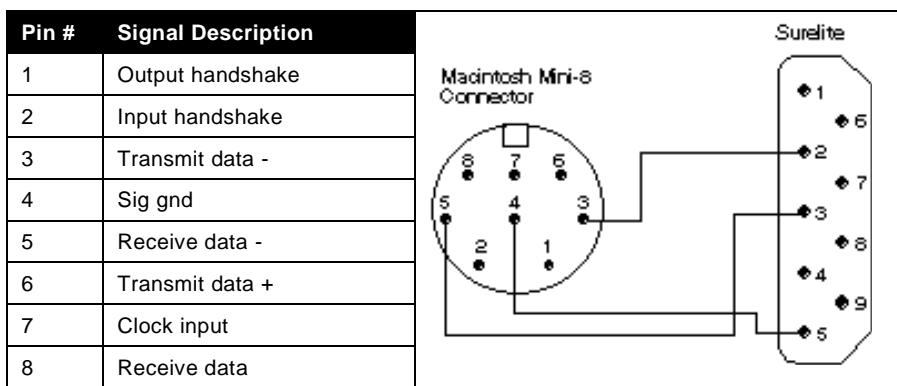
1. Make up a female-to-female null modem cable not to exceed 50 ft. (15.6m) in length. See **Figure 26** for wiring diagram and pin designation.

Figure 26 Wiring diagram and pin designation



### Section 3: System Operation

9	(not used)	
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Note: If the computer has a 25 serial port connector, an adapter is needed to bring the 25 pin connector down to a 9 pin.

2. Install cable between the computer RS232 port and the 9 pin D connector on the front panel of PCU labeled **RS232**.
3. Plug the Surelite into ac supply and toggle on the **AC POWER**.
4. Turn the keyswitch to the **ON** position.
5. Press the **SELECT** button until **SoF** is displayed on the LED readout.
6. Press the **UP ARROW** button so that display reads **Son**. The serial port is now enabled.
7. The user can now transmit desired ASCII code commands via the RS232 cable.

## Control commands

The RS232 communication parameters are:

**9600 BAUD, 8 BIT, NO PARITY, 1 STOP BIT (8N1)**

Table 5 Functions and RS232 Commands

Function	RS232 Command
Single Shot	SS PD must be in 000 mode
Security	SE Read only
Shutter	SH [0/1] (off/on)
Start/Stop	ST [0/1] (off/on)
Q-switch delay	QS [XXX] Needs three digits
Repetition Rate	RR [XX.X]
Power supply voltage	VA [X.XX]
Pulse division	PD [XXX] 001 Single shot
Shot counter	SC

Note: Remember that all of the above commands must be written exactly as shown using upper case and spaces as indicated. For instance, SH (space)1 (return) will open the shutter.

Commands that require a parameter must include leading/trailing zeros as in the following examples:

- QS 195 (pulse division set to 195  $\mu$ S)
- VA 0.90 (Lamp voltage set to 0.9 kV)

Each command is an ASCII string, and must be terminated by a Carriage Return character. There are two commands which cause the Surelite to send back ASCII characters; **SE** (interlocks) and **SC** (shot counter). The response to **SE** is a 2 digit ASCII code, terminated by a Carriage Return character. This response gives the status of the system. The possible values returned are listed in Table 6 below.

Table 6 ASCII response

Returns	Description
00	Normal return
01	Surelite not in serial mode
02	Coolant flow interrupted
03	Coolant temperature over temp
04	(not used)
05	Laser head problem
06	External interlock
07	End of charge not detected before lamp fire
08	Simmer not detected
09	Flow switch stuck on.

The response to **SC** (Shot count) is a 9 digit ASCII code terminated by a Carriage Return. An example is shown in Table 7 below.

Table 7 SC response

Returns	Description
000123456	shot count = 123,456

### To disable RS232

1. With system running, transmit the ASCII code ST 0.
2. Press **START/STOP** button to off.
3. Press **SELECT** button to **Son**.
4. Press **ARROW DOWN** button to **SoF**.
5. Resume normal operation.

### Direct Access Triggering (DAT)

#### Stanford Research Pulse Generator Setup

##### NECESSARY EQUIPMENT

- 1 ea. Delay Generator model #DG535
- 2 ea. Standard BNC cables
- 1 ea. 9 pin “D” connector, male

##### STEPS

1. Make up a special cable consisting of 2 BNC cables and a 9 pin D male.
  - Label one of the BNC cables FIRE and the other Q-SWITCH.

## Operation and Maintenance Manual for Surelite™ Lasers

- Take the FIRE and Q-SWITCH BNC cables and remove the connector from one end and expose the center conductor and shield.
- Solder center conductor of the FIRE BNC to pin 7 of the 9 pin D connector.
- Solder the shield of the FIRE BNC to pin 2 of the 9 pin D connector.
- Solder the center conductor of the Q-SWITCH BNC to pin 6 of the 9 pin D connector.
- Solder the shield of the Q-SWITCH BNC to pin 3 of the 9 pin D connector.

### 2. Program the DG535 as follows:

- TRIGGER - set to internal and 10 Hz or desired rep rate.
- OUTPUTS - set all outputs to High Z, TTL and NOR-MAL
- DELAYS -
  - $A = T = + 0$
  - $B = A + 10 \mu\text{s}$
  - $C = A + 150 \mu\text{s}$
  - $D = C + 10 \mu\text{s}$

### 3. Connect the special cable 9 pin D to the external connector on front of PCU.

### 4. Connect the FIRE BNC to AB\Bar (positive going to negative).

### 5. Connect the Q-switch BNC to CD/Bar (positive going to negative).

### 6. At the rear of the PCU flip the Q-SWITCH SELECT toggle to the EXT position (for lowest jitter).

### 7. Start up the Surelite as follows:

- Toggle on AC power
- Turn keyswitch to ON
- Press SELECT button until “Eof” is displayed
- Press UP ARROWS so that display reads “Eon”
- Press on the START/STOP button



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### **LASER RADIATION!**

Lasing output occurs at next step!

---

- Press on the SHUTTER button.

### 8. Adjust the Delay of “C” on the DG535 to maximize laser power. Final “C” delay is normally between 100 $\mu\text{s}$ and 300 $\mu\text{s}$ .



## To enable DAT

The Surelite laser may be directly controlled by user provided TTL level signals. Select this mode of operation when the application requires laser output be synchronized with other occurrences. Listed below are the steps necessary to externally trigger your Surelite.

### NECESSARY EQUIPMENT

- User supplied TTL negative going signal ( 5 V .0 V 10  $\mu$ s wide)
- 9 pin D style male connector
- Shielded cable (suggest RG-174 coaxial cable)

### DAT Mode 1 ( $\pm 10$ ns jitter)

In this mode the operator can fire the laser by providing a single negative going pulse (5 V .0 V). Jitter time of the laser output with respect to the input fire command will be  $\pm 10$  ns. Lead time between the fire command and laser output will be  $\sim 180$   $\mu$ s.

1. Flip up external Q-switch toggle located on rear panel of the PCU to **INT** position (see page **26**).
2. Solder center lead of coaxial cable to pin 7 of a D style male connector. Solder shield of same coaxial cable to pin 2 of the male D connector.
3. Plug D connector made in step 2 to the **EXTERNAL** connector on front panel of the PCU.
4. Plug the Surelite into ac supply and toggle on the **AC POWER**.
5. Turn the keyswitch to the **ON** position.
6. Press the **SELECT** button until **EoF** is displayed on the LED readout.
7. Press **UP ARROW** button so that display reads **Eon**.
8. Open exit port shutter at front of the laser bench.
9. Press the **START/STOP** button located of front panel of the PCU to **ON**.
10. Press the **SHUTTER** button located of front panel of the PCU to **ON**.
11. Input the Fire Command onto pin 7 of the D connector. User circuit should generate a TTL level pulse that goes from 5V .0V for 10  $\mu$ s each time laser output is desired.

### DAT Mode 2 ( $\pm 1$ ns jitter)

This mode give the lowest possible jitter between input commands and laser output. Mode 2 requires the input of 2 TTL level negative going signals (5 V .0 V, 10  $\mu$ s wide).

The first TTL signal called Fire Command will cause the laser head lamps to flash. This signal proceeds lasing by  $\sim 180 \mu\text{s}$ . The second TTL signal called Q-switch Command fires the Pockels cell and precedes lasing by  $\sim 170 \text{ ns}$ .

1. Flip down external Q-switch toggle located on rear panel of the **PCU** to **EXT** position (see Figure facing page 3-1).
2. Make the following connections on the D style male connector:
  - Q-switch Command - solder center lead of co-axial cable to pin 6 and solder shield of same coaxial cable to pin 3 of the connector.
  - Fire Command - solder center lead of a second coaxial cable to pin 7. Solder shield of second coaxial cable to pin 2.
3. Plug D connector made in step 2 to the **EXTERNAL** connector on front panel of the **PCU**.
4. Plug the Surelite into ac supply and toggle on the **AC POWER**.
5. Turn the keyswitch to the **ON** position.
6. Press the **SELECT** button until **EoF** is displayed on the LED readout.
7. Press **UP ARROW** button so that display reads **Eon**.
8. Open exit port shutter at front of the laser bench.
9. Press the **START/STOP** button located of front panel of the **PCU** to **ON**.
10. Press the **SHUTTER** button located of front panel of the **PCU** to **ON**.
11. Input the Fire Command onto pin 7 of the D connector (TTL level 5 V .0 V,  $10 \mu\text{s}$  wide).
12. Input Q-switch Command onto pin 6 with a delay of  $\sim 180 \mu\text{s}$  with respect to Fire Command (TTL level 5 V .0 V,  $10 \mu\text{s}$  wide).
13. Adjust .T between Fire Command and Q-switch Command for maximum energy.

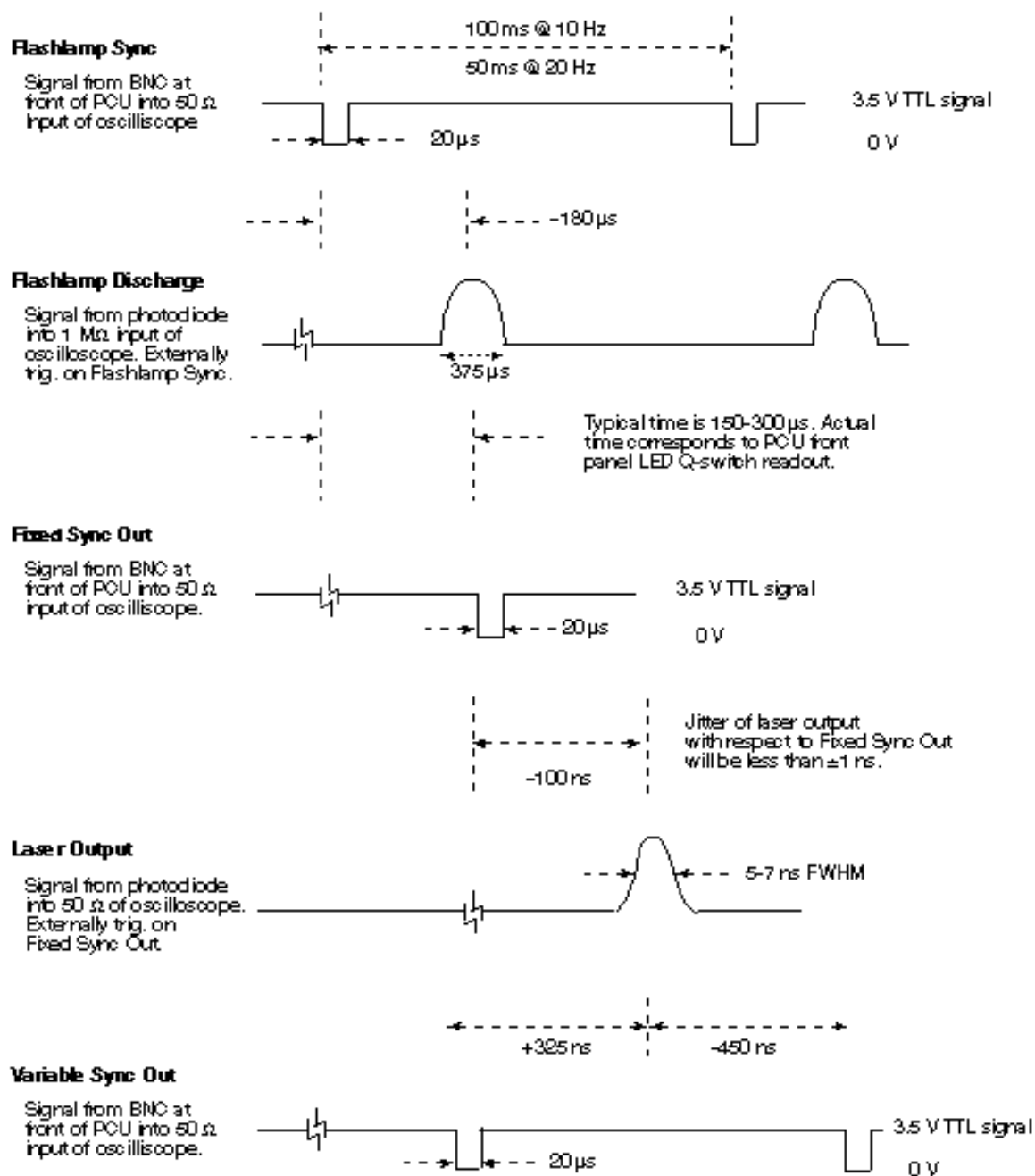
Note: When running the system in the external mode you must flash the laser head lamps at approximately the same frequency that the system was optimized at time of purchase. Changing lamp frequency will change thermal lensing of the YAG rod which can result in reduced system performance.

### To disable DAT

1. Press the **START/STOP** button to stop lamps from flashing.
2. Press the **SELECT** button to **Eon**.
3. Press the **ARROW DOWN** button to **EoF**.

- Resume normal operation.

Figure 27 Surelite chronograph



## Override of shutter lockout

For reliable operation and spec. performance of the Surelite laser, key components on the laser system are thermally stabilized. To ensure that thermal stabilization has been reached at initial startup, there is a 20 minute period after ac power is first applied before the **SHUTTER** button can be toggled open.

Attempts to toggle the **SHUTTER** button open before this 20 minute period has expired will only result in the power supply beeping each time the **SHUTTER** button is pressed. If during the course of daily operation of the laser, there is a momentary interruption in ac power (<5 minutes), it is possible to resume operation immediately without having to wait for 20 minutes. This is done by performing the procedure below. However, do **NOT** use this override unless it is certain that thermal stabilization has been restored.



---

### CAUTION!

Running the system **before** thermal stabilization has been reached **will result in serious damage** to your laser system.

---

1. On the front panel of the Surelite power unit, flip red toggle switch labeled **AC POWER** down (this is the **OFF** position).
2. Depress simultaneously the **START/STOP** button, the **SHUTTER** button and the **ARROW DOWN** button.
3. While depressing simultaneously the 3 buttons, flip the red toggle switch labeled up to the **ON** position.
4. Continue depressing the three buttons until the LED display reads **oFF**.
5. Insert the key into keyswitch and turn counter clockwise to **ON**.
6. Press **START/STOP** button and its red LED comes on. The laser head will now flash at the designated frequency.
7. Put on laser safety goggles.



---

### LASER RADIATION!

The next step results in laser output.

---

8. Press the **SHUTTER** button and its red LED comes on. An audible click can be heard from laser bench as the intra-cavity shutter withdraws from the oscillator. The system should now lase.

# Section 4: Subassembly and Module Descriptions

## Laser bench optics

### Optical layout

Figure 28 shows the optics positioned on the laser bench. Table 8 provides many of the part numbers.

Figure 28 Overview of Surelite laser bench

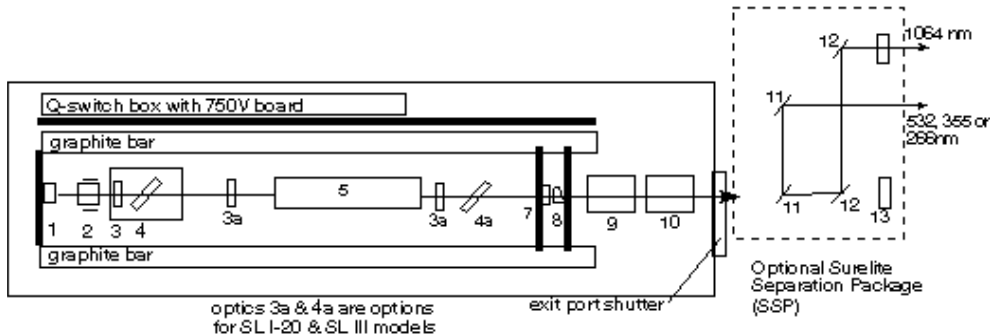


Table 8 Part numbers for Surelite laser bench

Ref.	Name	Surelite I	Surelite II	Surelite III
1	Rear mirror 10 Hz	104-0003	104-0003	104-0002
1	Rear mirror 20 Hz	104-0049	103-0030	
2	Pockels cell	202-0265	202-0265	202-0266
3	$\lambda/4$ plate	108-0001	108-0001	108-0001
4	Dielectric polarizer	199-0116	199-0116	199-0116
5	811U-06 head (upper) Rod Flashlamp "O" ring kit	507-0700 201-0056 203-0019 507-0710		
5	811U-07 head (upper) Rod Flashlamp "O" ring kit		507-1000 201-0004 203-0019 507-1005	
5	812V-09 head (vertical) Rod Flashlamp "O" ring kit			507-0900 201-0005 203-0032 507-0905
6	Intra-cavity shutter	619-1438	619-1438	619-1438
7	Mirror, Gaussian 10 Hz	104-0064	104-0074	104-0071
7	Mirror, Gaussian 20 Hz	104-0069	104-0071	
8	Output beam compensator	199-0102	199-0102	199-0102
Ref.	Name	Surelite I	Surelite II	Surelite III

9	Doubler Type 1	619-2700	619-2700	619-2700
	Doubler Type 2	619-2640	619-2640	619-2640
10	Tripler	619-2720	619-2720	619-2720
11	Dichroics 532 nm	105-0022	105-0022	105-0022
	Dichroics 355 nm	105-0023	105-0023	105-0023
	Dichroics 266 nm	105-0025	105-0025	105-0025
12	Dichroics 1,064 nm	105-0002	105-0002	105-0002
13	Beam dump	619-1437	619-1437	619-1437

## Laser heads

### General description

Amplitude Laser Inc.'s Surelite lasers use the 811U-06 head for the Surelite I, the 811U-07 head for the Surelite II models, and a 821V-09 head for the Surelite III model. They all have a beam height of 43 mm. The head is a modular design incorporating a rod, a flashlamp and coupling medium. It has a linear flashlamp which is in a close coupled configuration surrounded by a high brilliance magnesium oxide diffuser. This results in a high pumping efficiency that minimizes thermal loading and reduces power consumption. These features combine to create the excellent pumping homogeneity required for producing high gain, superior quality beams.

### Rods

The head is designed to pump Nd+3 doped YAG. The doping levels vary from 0.9 to 1.4%. The YAG rod ends have hard dielectric antireflective coatings (AR). The rod length is 115 mm measured along the optical axis. The diameter of the 811U-06 rod is 6 mm and the 812V-09 rod is 9 mm.

### Flashlamps

The heads are pumped by linear flashlamps. The lamp has a voltage polarity that must be observed. The flashlamp anode can be identified by a red marking on the lamp electrode whereas the cathode has no marking. The discharge system of the flashlamp uses a negative, critically damped pulse (-1.8 kV max) with a duration of 200 microseconds full width half max (FWHM). The gas in the flashlamp is xenon with a pressure of 1-3 atmospheres.

### Cooling

Flashlamps and laser rods must be cooled by distilled, deionized water. Resistivity of distilled, deionized cooling water should not fall below 500 kΩ/cm. Do not mix any chemical products with the distilled water.

## Section 4: Subassembly and Module Descriptions

Table 9 Part numbers for Surelite laser heads (single flashlamp)

Name	Surelite I	Surelite II	Surelite III
811U-06 head (upper)	507-0700		
Rod	201-0056		
Flashlamp	203-0019		
"O" ring kit	507-0710		
811U-07 head (upper)		507-1000	
Rod		201-0004	
Flashlamp		203-0019	
"O" ring kit		507-1005	

Figure 29 811U-06 laser head with one flashlamp

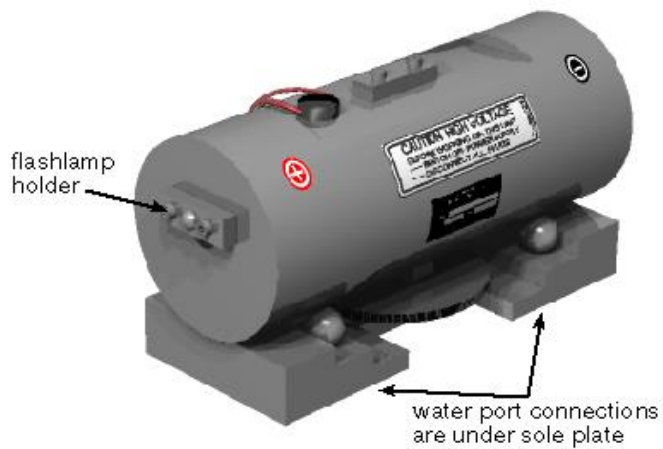
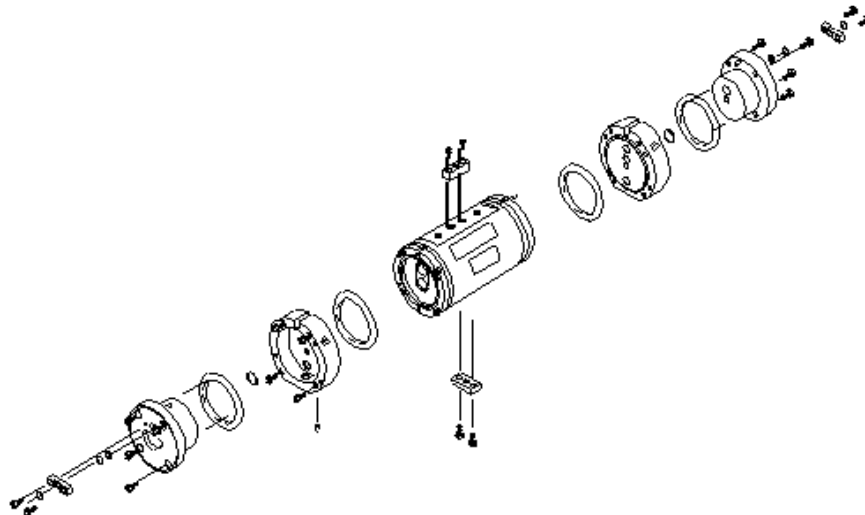


Figure 30 Exploded 811U-06 or 811U-07 laser head drawing



Operation and Maintenance Manual for Surelite™ Lasers

Table 10 Part numbers for Surelite laser heads (two flashlamps)

Name	Surelite I	Surelite II	Surelite III
812V-09 head (vertical)			507-0900
Rod			201-0005
2 Flashlamps			203-0032
"O" ring kit			507-0905

Figure 31 812V-09 laser head with two flashlamps

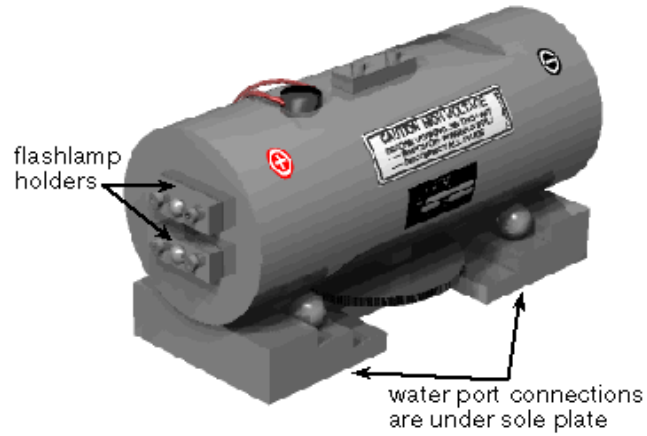
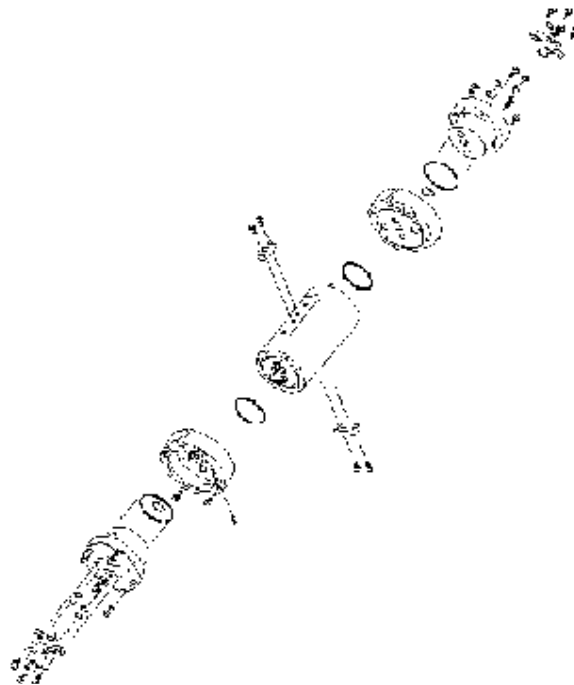


Figure 32 Exploded 812V-09 laser head with two flashlamps





### Laser bench electronics

#### Active Q-switch

The combination of a polarizer, Pockels cell and  $\lambda/4$  plate within the oscillator is known as a Q-switch. A Q-switch prevents lasing in the resonator until the laser gain reaches its peak and then opens the cavity to allow oscillation. This then produces ultra-fast, high peak power laser pulses.

#### Principle of operation

The Q-switch consists of the following:

- Optical
  - Pockels cell
  - Plate polarizing element
  - Quarter-wave plate
- Electrical
  - Timed pulse generated by the PCU unit
  - Marx bank (750 V)
  - 750 volt power board

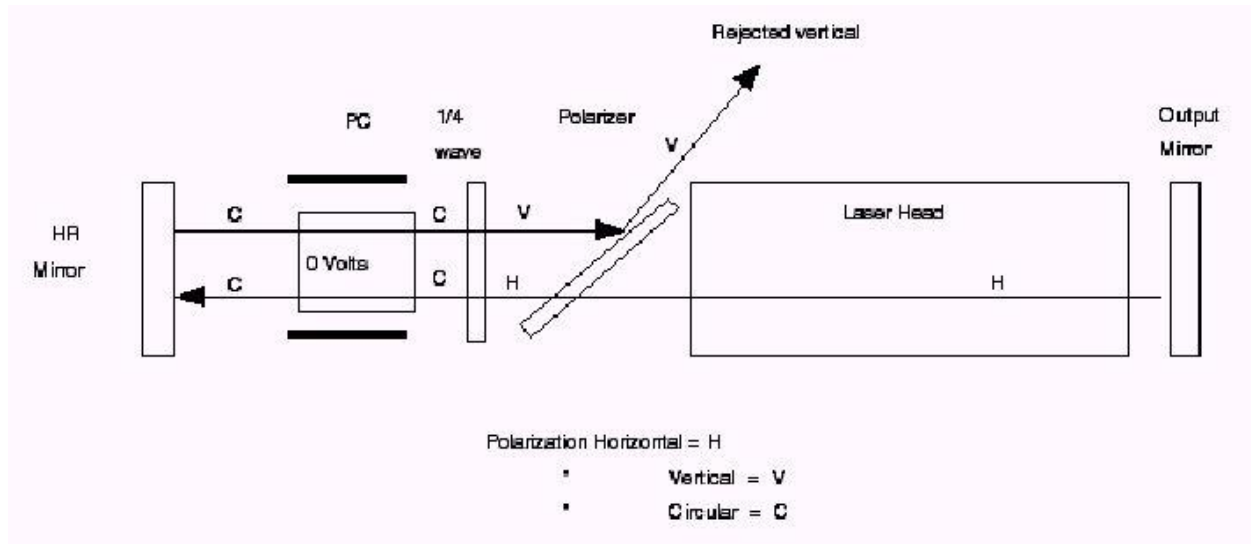
#### POCKELS CELL

The Pockels cell has a longitudinal field KD\*P crystal with a 15 mm clear aperture mounted at 43 mm beam height. A voltage of  $\sim 3600$  V results in a quarter wave of rotation for photons at 1,064 nm passing in either direction. A voltage of 0 volts results in no rotation.

#### PLATE POLARIZER

The thin film multilayer dielectric polarizer has an angle of incidence of  $57^\circ$ . In its standard orientation, the polarizer is highly transparent ( $>95\%$ ) to horizontally polarized light while being highly reflective ( $>99\%$ ) to vertically polarized light. The contrast/extinction ratio is  $>500:1$ .

Figure 33 Cavity closed with no lasing



### QUARTER-WAVE PLATE

The plate used introduces a quarter wave rotation to photons at 1,064 nm as they pass in either direction through the plate. The plate has a clear aperture of 15 mm and is mounted at a beam height of 43 mm.

### TIMED PULSE GENERATED BY PCU

The control unit tracks the firing of the flashlamps in the laser head and then at a preselected delay of  $\sim 200 \mu\text{s}$  triggers the Marx bank with a +15 V pulse. The signal is normally set to fire at the peak of the gain curve of the oscillator YAG rod.

### MARX BANK (750V)

This board charges 7 capacitors in parallel and then discharges them through fast switching transistors in series so that the voltage on each capacitor is summed. This generates an  $\sim 4 \text{ kV}$  pulse with a rise time of 20 ns. This board is in a metal box next to the Pockels cell.

### 750 VOLT POWER BOARD

This board, located above the oscillator cavity in a small box with the Marx bank, generates the dc voltage necessary to power the Marx board. The dc voltage is adjustable by a pot accessible through a hole in the top of the laser bench. Turning the pot clockwise raises the voltage.

## Section 4: Subassembly and Module Descriptions

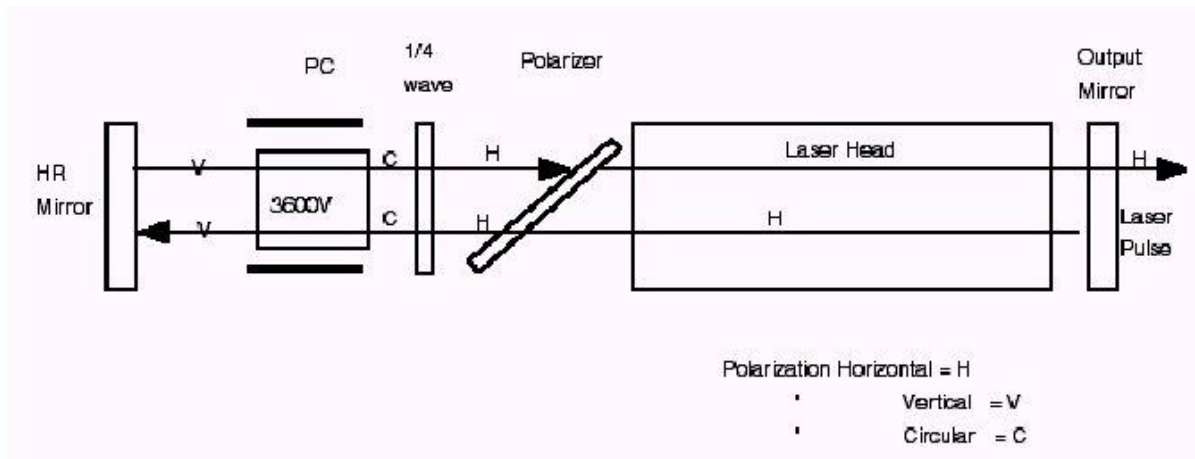
### CAVITY CLOSED

The beam propagating within the oscillator cavity makes a double pass through the Pockels cell and  $\lambda/4$  plate. At 0 volts on the Pockels cell (PC) it adds no rotation while the  $\lambda/4$  plate adds  $45^\circ$  with each pass, giving a total rotation of  $90^\circ$ . Thus the horizontal beam that transmitted through the plate polarizer is rotated to vertical and is rejected by the polarizer and no oscillation occurs.

### CAVITY OPEN

The beam propagating within the oscillator cavity makes a double pass through the Pockels cell and  $\lambda/4$  plate. At 3600 volts on the PC it adds  $45^\circ$  rotation and the  $\lambda/4$  plate adds  $45^\circ$  with each pass, giving a total rotation of  $180^\circ$ . Thus, the horizontal beam that transmitted through the plate polarizer is rotated to vertical and back to horizontal, so that it is transmitted by the polarizer allowing oscillation to occur.

Figure 34 Cavity open and lasing



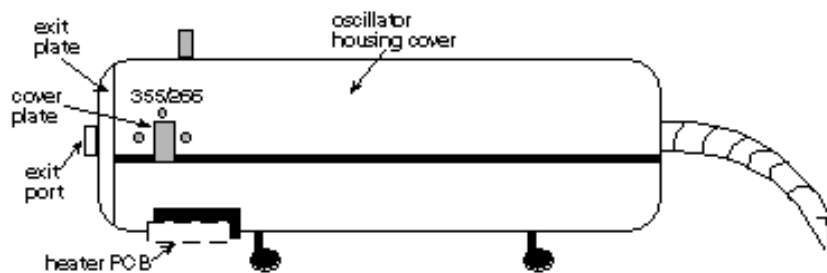
### Harmonic generators

The Surelite series can generate laser light at the Nd:YAG fundamental wavelength (1,064 nm) or its second, third or fourth harmonic (532, 355, 266 nm). This is achieved by passing the fundamental beam through a second (SLD), a second plus third (SLT), or a second and fourth (SLF) harmonic generator.

These optional harmonic generators are positioned at the end of the laser bench, and can be optimized with adjustment knobs located on the top (for the SLD) and on the right (for the SLT/SLF).

# Operation and Maintenance Manual for Surelite™ Lasers

Figure 35 Extra Harmonic Generator



## Section 4: Subassembly and Module Descriptions

### Wavelength separation

In most cases, only one wavelength is wanted at a time, and some means of separating the various wavelengths emerging from the harmonics is needed. This is the role of the Surelite Separation Packages (SSP-1, 2 & 3). Each is a set of dichroic mirrors, which isolates the desired wavelength and steers the beam toward the appropriate output port. There are three output ports and each can be opened or blocked by a user-removable beam dump.

- SSP-1 is needed to separate the YAG second harmonic from the fundamental after doubling.
- SSP-2 is needed to separate either the YAG second or third harmonic from the fundamental (or fundamental and second harmonic), after either doubling or both doubling and tripling.
- SSP-3 is needed to separate the YAG second, third or fourth harmonic from the fundamental and second harmonic after doubling and tripling.

In all SSP's, another option (SSP-1A, -2A or 3A) adds two mirrors for infrared output from port 3. The SSP's also safely dispose of all unused beams into beam dumps.

Figure 36 SSP mirror mount

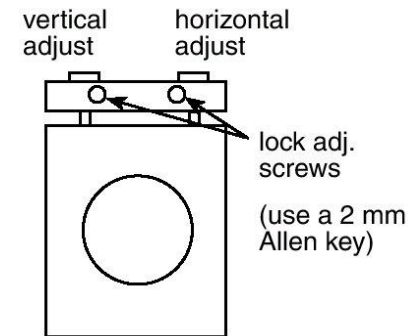


Figure 37 SSP input face

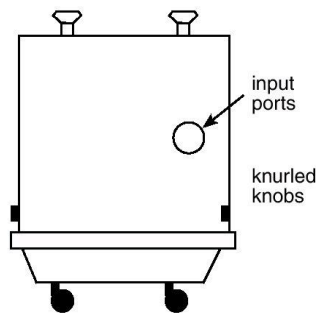
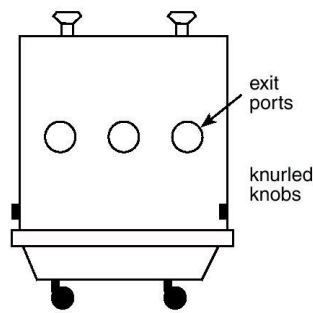


Figure 38 SSP output face



Operation and Maintenance Manual for Surelite™ Lasers

Figure 39 SSP 1,2,3,4 optical layout (top view with cover off)

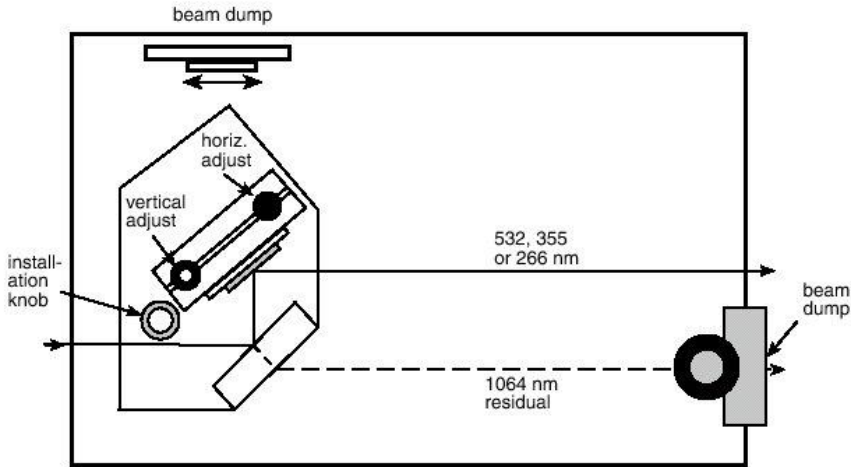
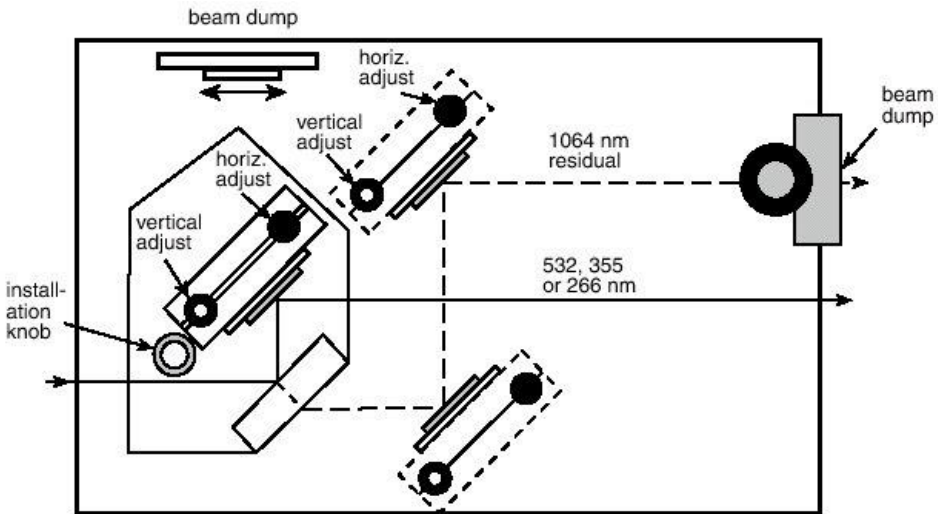
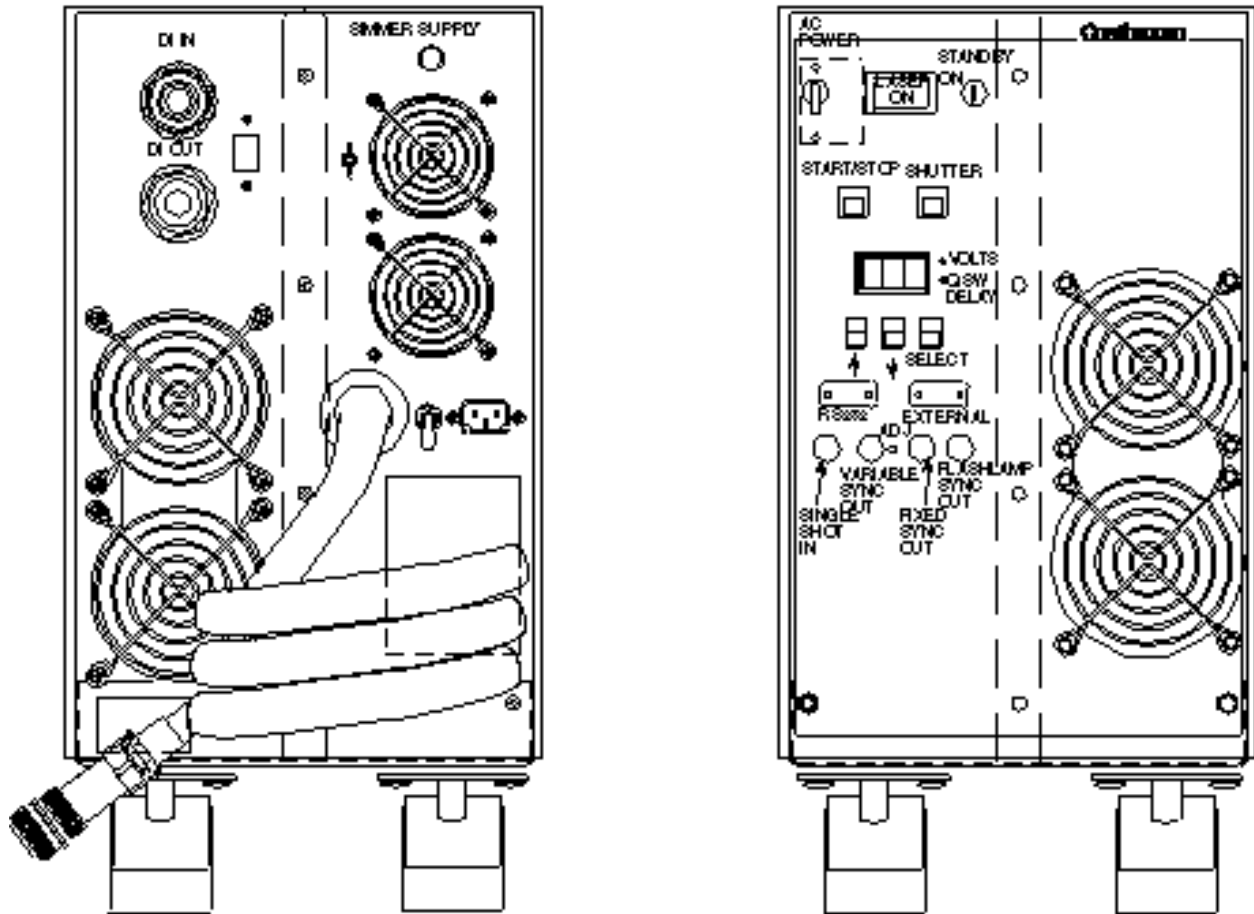


Figure 40 SSP 1-A, 2-A, 3-A, 4-A optical layout (top view - cover off)



## Section 4: Subassembly and Module Descriptions

Figure 41 Surelite I 20 Hz rear and front panels



### Power/Cooling Unit (PCU)

The PCU unit generates the following:

- control of the system with the necessary power-up time delays, clock rep rate signals, charge/fire commands and Q-switch delays.
- monitoring of the 9 security loops on the front panel.
- power for state-of-the-art MOSFET switching power boards that run at a drive frequency of 40 kHz. Current from the board charges up the storage capacitor.
- capacitance of 30  $\mu$ F at 2.0 kV. In addition to energy storage for the flashlamp, the system also provides an initial trigger pulse to ionize the gas in the flashlamps.

### Structure & organization

The PCU unit is packaged very compactly. The unit is 11.25" (28.6 cm) wide 20.75" (52.7 cm) tall and 24.5" (62.2 cm) deep. The weight of the PCU unit is 85 pounds (38.6 kg). The system is designed to operate on ac voltages ranging from 200 to 240 V 50-60 Hz at less than 10 amps.

## Front panel

**AC POWER.** This toggle is a circuit breaker rated at 15 amps at 250 VAC.

**LASER ON LED.** This red LED comes on when water flow is established.

**KEY SWITCH.** Turning the key from off to **ON** position resets system logic and enables power-up sequence to begin.

**START/STOP.** This button switch starts and stops the laser head flashlamp.

**SHUTTER BUTTON.** Depressing this switch to the **OPEN** position will open the intra-cavity shutter on the laser bench and start lasing. Depressing this switch again will **CLOSE** the shutter. An audible click is heard when opening or closing the intra-cavity shutter.

**DISPLAY READOUT LED.** This digital display read-out shows all the error messages and commands. The messages are explained on page 31. The red **VOLTAGE KV** LED and **Q-SW DELAY  $\mu$ s** LED light up when the **DISPLAY** LED shows their readings.

**SELECT BUTTON.** This button allows the user to step through the different operating parameters which are explained on page 30. The select **ARROW UP** and select **ARROW DOWN** buttons are used to change the value of display parameters.

**RS232 9-pin male plug.** See page 42 for serial plug for RS232 operation.

**EXTERNAL 9 pin female plug.** The optional externals plug for a remote control device:

**External interlock loop.** See page 63.

**DAT** (direct access triggering). See page 45.

**SINGLE SHOT.** This connector accepts the Single Shot Cable (SS). When the SS is plugged in you get one laser pulse each time one manually presses the SS fire button. When the SS is disconnected the laser will fire at the last saved rep rate.

**VARIABLE SYNC OUT.** This connector provides a variable trigger output which is adjustable via a pot to the right of **VARIABLE SYNC OUT** BNC on front panel of the PCU. The signal provided is negative going TTL signal (3.5 V to 0 V into a 1 M termination) that can be adjusted from 325 ns before lasing to 450 ns after lasing.

**FIXED SYNC OUT.** This BNC connector provides a negative going TTL signal (3.5 V to 0 V into a 1 M termination) approximately 100 ns before laser pulse output.

**FLASHLAMP SYNC.** This BNC style connector provides a +3.5 V pulse at the start of the firing of the flashlamp. This signal occurs  $\sim 180 \mu$ s before lasing output (depends on **Q-SWITCH DELAY** setting).



## Section 4: Subassembly and Module Descriptions

### Rear panel

**DI IN.** The distilled water input hose connector carrying warm water from laser head back to cooling group.

**DI OUT.** The distilled water output hose connector carrying water from cooling group to laser head.

**LASER HEAD.** 9-pin D-style connector that runs between PCU and laser bench. The cable carries 24 VDC and "fire" pulses for Q-switch and laser bench security loop.

**FLASHLAMP.** Large black triaxial cable that carries the high voltage and high current from the PCU to the flashlamp on the laser bench.

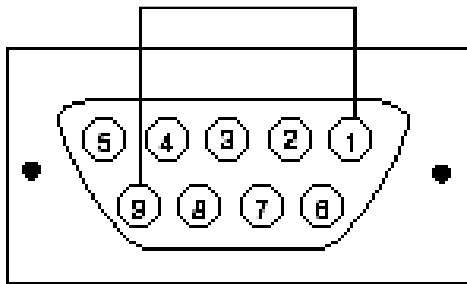
**INPUT 220 VAC.** IEC style connector that is the receptacle for all input of ac line power.

**EXT. QSW. SELECT.** This toggle switch allows the user to trigger the Q-switch internally or externally. See pages 47 and 49.

### External interlock loop

An external security interlock is available on the Surelite. An example of its use is the user who wants to install an external interlock on the lab door.

Figure 42 External plug



9 pin D  
female plug  
found on  
front panel  
of PCU

**EXTERNAL**

The important thing to remember is that once the external interlock is active, continuity must be maintained between pins 1 & 9 of the external D connector. If continuity is broken, E06 error message is displayed and the system shuts down. This D connector is labeled **EXTERNAL** and is located on the front panel of the PCU (see page 61).

### To enable external interlock

1. Flip the red toggle switch labeled **AC POWER** on front of PCU to the up (**ON**) position.
2. Turn the keyswitch counter clockwise to the **ON** position.

3. Press the **SELECT** button for **Q-SW. DELAY**. The red LED next to the label **Q-SW. DELAY** will be illuminated.
  - Press **ARROW UP** button until 999 is reached.
  - Continue to press for an additional 20 seconds or until an audible beep is heard.
4. The external interlock is now activated.
5. **Note:** Remember that continuity between pins 1 & 9 is necessary for operation or error message E06 will be displayed.
6. While the system is still in the Q-switch delay mode, use **ARROW DOWN** button to return Q-switch value to original setting found on the QA page at beginning of the manual.

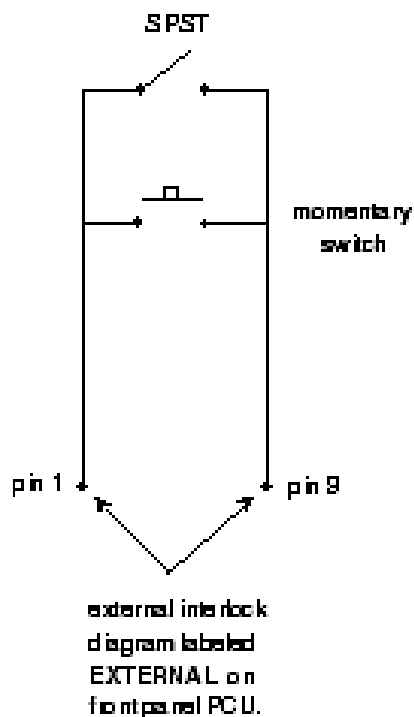
### Security installation

**Lab Door.** Mount a Single Pole Single Throw (SPST) switch above the door so that when the door is open the switch is open and when the door is closed the switch is closed. Also install a momentary switch in parallel with switch so that if you wish to open the door someone in or out of the lab you do not

the SPST to let have to shut

**dc Motor.** Wire the relay primary in parallel supply that runs the motor. When the dc on, the relay will be activated, the SPST be closed and the Surelite can run. Also momentary switch in parallel with the SPST that if you wish to shut down the motor for period without stopping the laser it will be

with the dc supply is switch will install a switch so a brief possible.



(on)

ON

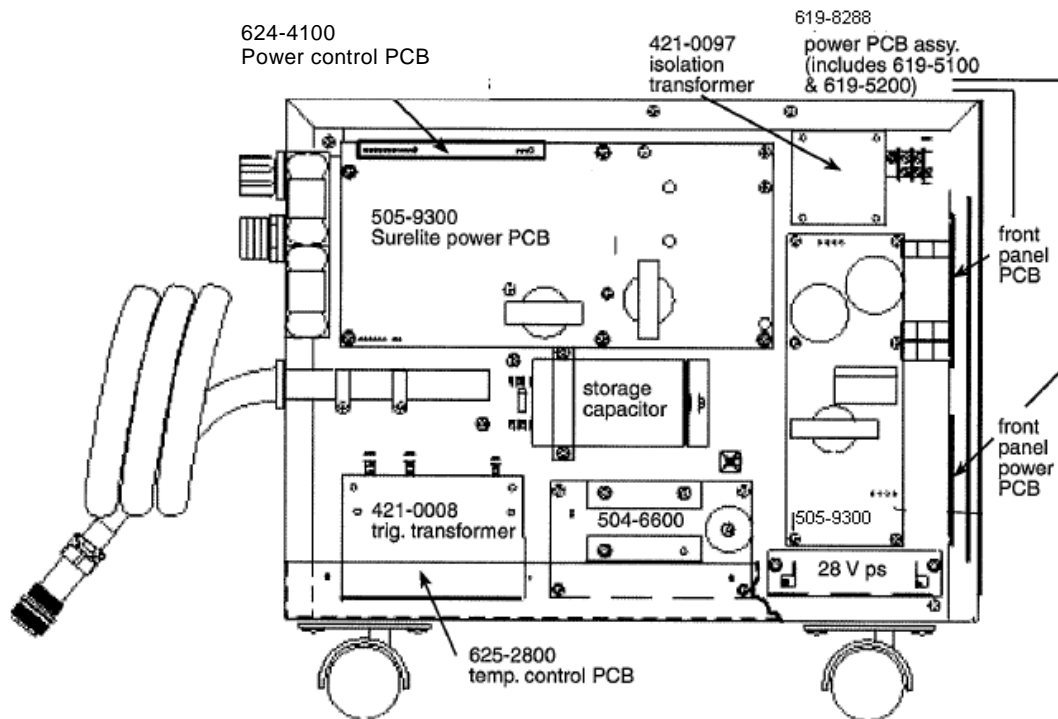
### To disable external interlock

1. Flip the red toggle switch labeled **AC POWER** on front of the PCU to the up position.
2. Turn the keyswitch counter clockwise to the position.
3. Press the **SELECT** button for the **Q-SW. DELAY**. The red LED next to the label **Q-SW. DELAY** will be illuminated.
  - Press the **ARROW UP** button until 999 is reached.
  - Continue to press for an additional 20 seconds or until audible beep is heard.

## Section 4: Subassembly and Module Descriptions

- The external interlock is now disabled.

Figure 43 Power supply chassis assembly



### Cooling Group, CG

#### General description

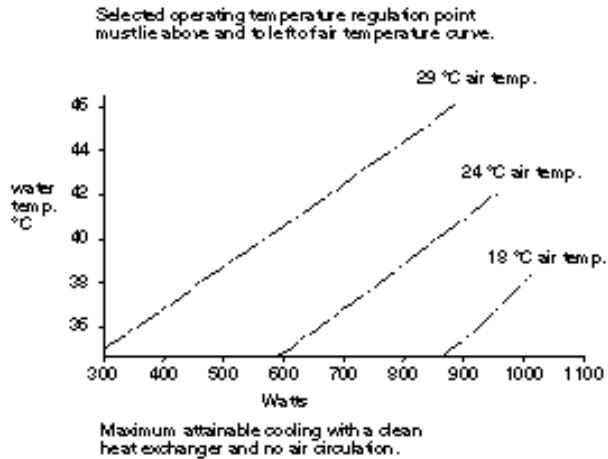
The cooling group half of the unit provides a temperature stabilized circulating loop of distilled water to the laser head, cooling the laser rod and flashlamp by water/air forced convection. It contains a distilled water reservoir, a magnetically coupled pump, a deionizing filter cartridge and a finned tube radiator heat exchanger with a cooling fan (two fans for a 20 Hz laser). The pressure/volume characteristics of the cooling water pump are matched to the laser head power dissipation/flow requirements.

#### Internal features

Referring to the assembly drawing, the pressure/flow and water temperature interlock switches are visible. The operation of the cooling fans is controlled by the PCBA temperature control, mounted on the opposite side of the chassis. It coordinates temperature maintenance and proportional fan speed to provide a temperature stabilization within  $\pm 0.2^\circ \text{C}$ . Water temperature is sensed by a thermistor which controls fan speed. (The temperature sensing circuitry is protected against open or short circuit sensor leads.)

## Operation and Maintenance Manual for Surelite™ Lasers

Figure 44 Cooling chart



There are no controls for the cooling group on the front panel of the power unit/cooling group. In the event of any interlock fault, the cooling unit is powered down by the PCU at the same time the laser is shut down.

**DI IN.** Returns heated water from laser head.

**DI OUT.** Takes cooled water to the laser head.

**LASER HEAD.** 9-pin plug for cable in umbilical.

**FLASHLAMP.** This is the head plug cable.

**220VAC INPUT.** The ac input cable connects directly to the PU side.

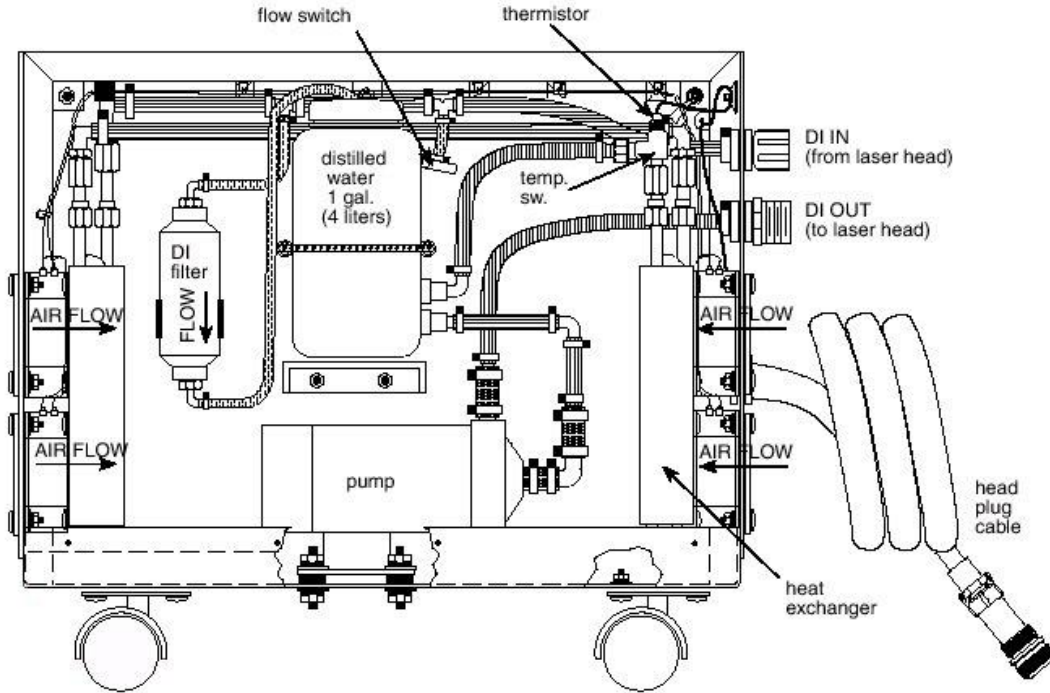
## Maintenance

Remove the eight screws holding the cooling group metal cover. The deionizing filter cartridge (Amplitude Laser Inc. Part #313-0099), will be visible at the top. The filter should be changed every three to six months (along with the distilled water) as a routine maintenance procedure. Distilled water may be added to the distilled water bottle filling it to within 1 inch (~2cm) from the top (with the cooling lines empty).

The finned radiator should also be inspected every six months and carefully brushed or vacuumed clean of dust and lint if necessary. The cooling water loop and connections should be inspected when replacing DI filter or whenever the laser is moved.

### Section 4: Subassembly and Module Descriptions

Figure 45 Cooling group chassis assembly for Surelite I 20 Hz



## Section 5: Maintenance

Table 11 System maintenance schedule

	Each month	Every 6 months	Every 12 months
Check system alignment. See Troubleshooting.	X		
Clean/inspect optics. See page 5-1.	X		
Change DI filter in cooling unit. See page 5-3.		X	
Replace flashlamps. See page 5-2.			X
Clean CG radiator.		X	
Inspect cooling water loop connections.		X	

### Cleaning optics

Examine the optics biweekly and clean as inspection warrants. Initial cleaning can be done with pulsed air. Then, if streaks or dust persist, the optics should be carefully cleaned with soft optical tissue and either reagent grade methanol or isopropyl alcohol.

#### NECESSARY EQUIPMENT

- reagent grade (or better) methanol
- hemostat (surgical pliers)
- finger cots or surgical style gloves
- cotton swabs
- eyedropper
- lens tissues

### Unmounted optics

1. Always wash your hands first in order to remove all dirt and oil residues and put on finger cots or gloves.
2. Hold one sheet of lens tissue over the optic to be cleaned.
3. Using eyedropper, place a few drops of good quality methanol on top of the lens tissue.
4. Drag the lens tissue across the optic once only.
5. If a residue of solvent is left on the optic, repeat the procedure using less solvent and a new tissue until no residue remains.

## Mounted optics and rods

1. Wrap lens tissue on a cotton tipped applicator.
2. Apply a few drops of methanol directly on lens tissue and shake off excess.
3. Swab optic gently with the applicator starting at the center and working towards the edge.
4. Repeat step 3, using a dry swab to remove residue.

## Flashlamp replacement

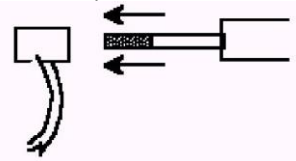
### NECESSARY EQUIPMENT

- new flashlamp (see pages 53 or 54)
- exploded head drawings (pages 53 & 54)
- 2.5 mm Allen wrench
- lens tissue
- cotton swabs
- ~50 ml distilled water
- safety glasses

### STEPS

1. Study exploded head drawings on pages 53 and 54.
2. Turn off **AC POWER** switch on the front panel of power unit.
3. Unplug main ac power cord at the wall socket.
4. Disconnect head plug cable at the rear of the laser bench by unscrewing the threaded collar (large green/black military style connector). See drawing on page 38.
5. Disconnect the two leads that run to the thermal switch located on top of the laser head. The leads can be disconnected by pulling firmly in the horizontal direction on the two crimp-on connectors.

Figure 46 Lamp electrode release



connectors  
connector,

6. Use your fingers to gently pull off the lamp from the lamp electrodes. Pull only on the not the wire.
7. Release the laser head from its base cradle plate the thumbwheel clockwise. The thumbwheel is located below the laser head. Note the orientation of the head as you remove it; anode end of head faces the output coupler.
8. Remove the laser head from the bench and place it on a solid, flat, level work area.

## Operation and Maintenance Manual for Surelite™ Lasers

9. Put on safety glasses.
10. Use a 2.5 mm Allen wrench to remove the Allen bolts holding the white plastic lamp retainers at each end of the laser head.
11. With a cotton swab wet each end of the exposed flashlamp electrode with water, and then using a gentle twisting motion, remove the white plastic lamp retainers.
12. Pull firmly on either flashlamp electrode and push on the other to remove the lamp.
13. **Do not** touch the glass barrel of the new lamp. Hold the lamp by the metal electrodes. Inspect glass barrel and clean with lens tissue and methanol if necessary. Note anode/cathode orientation of new lamp and insert the lamp into the head according to “+” and “-” stickers on the side of the head.
14. Slide the new lamp into the laser head and install the Teflon backing ring and then the black “O” ring over the ends of the lamp electrodes.  
**Note:** Wet all parts with distilled water before reinsertion.
15. Press black lamp “O” rings flush to laser head end plates before installing nylon lamp retainers.
16. Wet the exposed electrode and then replace the white plastic lamp retainers. Use a gentle pushing, twisting motion.
17. Once the lamp retainers have been slipped over the lamp electrodes, check to make sure the lamp is centered in the head and then bolt the lamp retainers in place. Tighten screws for snug fit. Do not over tighten.
18. Place the laser head in base cradle while checking orientation once again and begin to screw the thumbwheel counter clockwise to reattach the laser head to its cradle. Gently rock the laser head as you tighten the thumbwheel. The head should mate firmly against the cooling water “O” rings.
19. Reattach the lamp connectors at each end. Make sure lamp electrodes are dry before sliding lamp connectors over the lamp ends.
20. Reattach the two leads to the thermal switch.
21. Reconnect head plug cable at rear of the laser bench (large green/black military style connector).
22. Flow test the lamps. To do this plug in the ac power cord and then perform steps 1 and 2 in the Daily Startup Procedure.
23. If the lamp leaks, repeat this procedure from step 2. If the laser head leaks from around the cradle tighten the thumbwheel screw a bit more. If it continues to leak remove the head and inspect cradle “O” rings for damage.
24. Log the date and action in “Operator Notes” at the end of manual and the procedure is complete.



## Replacing DI filter

### NECESSARY EQUIPMENT

- New DI filter (PN#313-0099)
- 1 ½ gallons distilled water (6 liters)
- 3/32" Allen wrench
- 6" adjustable wrench
- Roll of teflon tape

### STEPS

1. Look for this label on the cooling group side of the unit. **Do not** open the power unit side. The cooling group cannot be accessed from the power unit side.
2. Review the drawings for the two cooling groups. See page 72.
3. Turn off main ac circuit breaker on the front panel of power/cooling group (PCU) and disconnect power cord from the wall socket.
4. Remove the eight screws from top and bottom of the cooling group cover.
5. Note flow direction arrow on the filter before pulling from the holding clamp.
6. Remove the squeeze clamps from tubing. Grasp the tubing and pull it off the barbed connectors on both ends of the filter.
7. Unscrew the barbed elbow fittings from old DI filter. Replace the old teflon tape with new and screw the fit-tings into the new DI filter.
8. Install new DI filter with the arrow pointing in the same direction as before and reinstall plastic tubing on the barbed connectors. Replace the squeeze clamp.
9. Flow test the CG. To do this plug in the ac power cord and then perform steps 1 and 2 in the **DAILY STARTUP PROCEDURE** on page 29.
10. Run the CG for ~3 minutes. Turn keyswitch to **STANDBY** and turn off the **AC POWER** switch. Unplug the main ac power cord. Check for water leaks. If there are none, reinstall cover and replace the screws.
11. Log the date and action in “ Operator Notes” at the end of the manual and the procedure is complete.

**Open this side  
for cooling  
group  
maintenance.**

Operation and Maintenance Manual for Surelite™ Lasers

Figure 47 Cooling group chassis without fans on the front panel

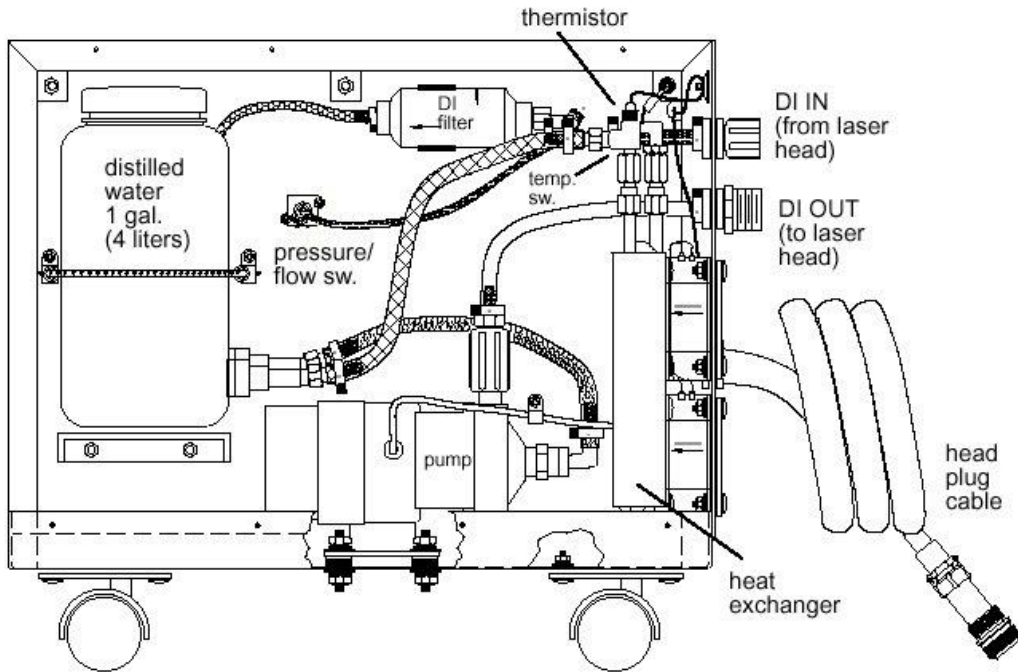
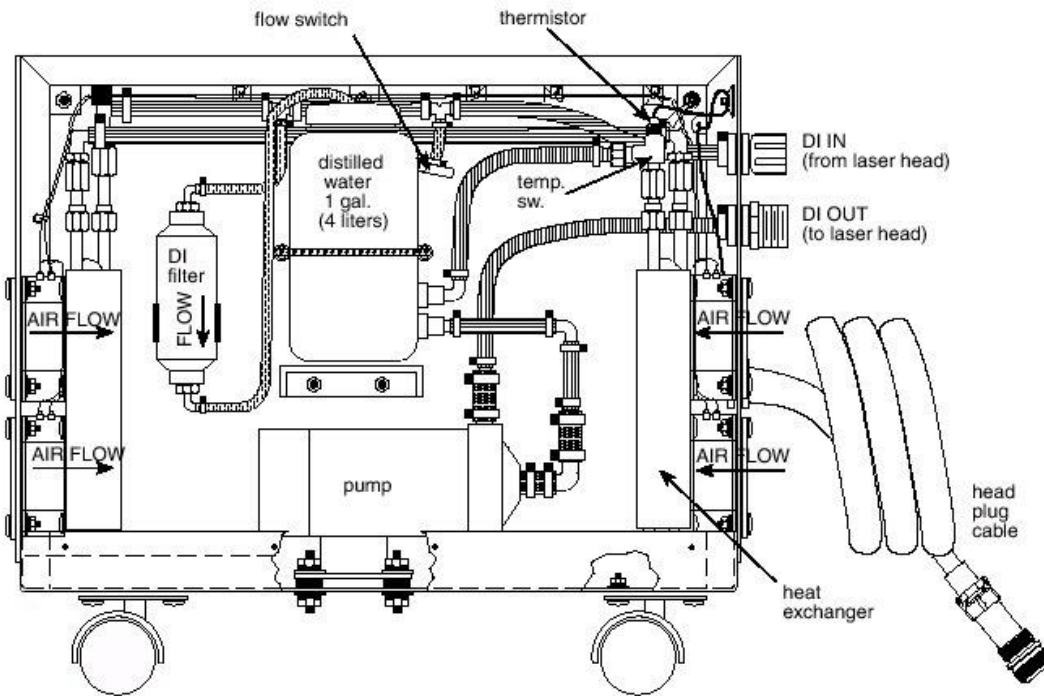


Figure 48 Cooling group chassis assembly for Surelite I 20 Hz



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# Section 6: Troubleshooting

## Electrical Troubleshooting

Table 12 Electrical troubleshooting

Problem	Action
LED display readout will not come on	<p>Check lab ac power source.</p> <p>Reset the <b>MAIN</b> ac breaker on the front panel of PCU.</p> <p>Verify connection of the <b>INPUT 220 VAC</b> power cord.</p> <p>Turn key switch off and then on.</p>
E01 error message displayed; Serial port OFF	<p>Press the <b>SELECT</b> button until read-out display reads <b>SoF</b>.</p> <p>Press the <b>ARROW UP</b> button once and the readout will read <b>Son</b>.</p> <p>Proceed with RS232 external operation.</p>
E02 error message displayed; Water flow interrupt	<p>Fill cooling reservoir to within 2 inches (-5 cm) of the top with distilled water.</p> <p>Check for kinks or obstructions in water lines.</p> <p>Verify that pump is running.</p>
E03 error message displayed; Cooling water temp. too high	<p>Verify that cooling fan(s) located in the rear of the cooling section are operating.</p> <p>Clean the heat exchanger grill as described in the Cooling Group Section. See page 4-15.</p> <p>Ensure that the PCU is at least 1 ft. (30 cm) from walls or other objects that might obstruct airflow.</p> <p>Lab temperature is =85°F (29°C).</p> <p>Fill cooling reservoir to within 2 inches (-5 cm) of top with distilled water.</p>
E04 error message	(not used)
E05 error message displayed; Laser bench interlock has opened	<p>Remove oscillator-housing lid and activate interlock switches with your finger.</p> <p>If manually activating the switches with your hand eliminates the error message, then reposition the switches higher on the bracket.</p> <p>Check with an ohmmeter for continuity between the 2 poles of the thermal switch located on top of the laser head (see page 4-2).</p>
E06 error message displayed; External interlock has opened	<p>Check customer installed lab interlock loop for an open connection.</p> <p>Locate the <b>EXTERNAL</b> 9 pin D connector on the front panel.</p> <p>Jumper pin 9 to pin 1.</p> <p>Reset the system logic by turning key switch <b>OFF</b> and <b>ON</b>.</p> <p>Disable the external security (see procedure page <b>64</b>).</p>
E07 error message displayed; No end of charge	<p>Check the connection of head plug cable at rear of laser bench.</p> <p>Power down the system and then restart.</p> <p>Replace the flashlamp in the laser head.</p>
E08 error message displayed; Simmer not detected	<p>Check fuse on rear panel of PCU (3 A 250 V).</p> <p>Remove the laser bench-housing lid and install the interlock defeat bracket.</p> <p>Redo system startup, page 3-1.</p> <p>Observe the end of the laser head and see if a faint glow is detected.</p> <p>Replace the flashlamp.</p>
E09 error message displayed; Flow switch stuck	<p>Locate the pressure/flow switch in cooling section of PCU.</p> <p>Check for obstruction in the water line that runs to the switch.</p> <p>Check to make sure the pump is running.</p> <p>Replace the pressure/flow switch.</p>
Intra-cavity shutter will not open	Intra-cavity shutter will not open

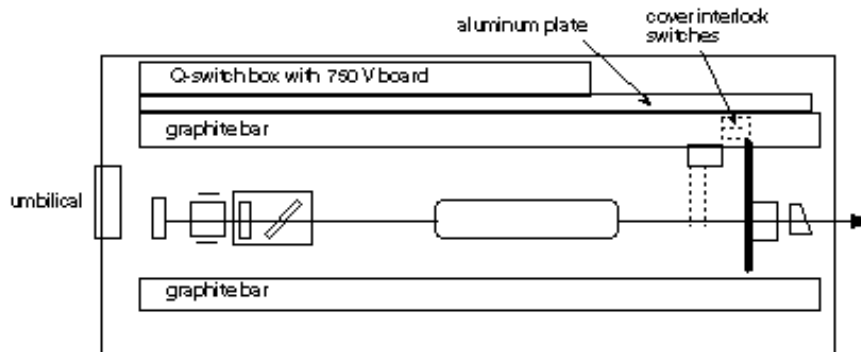
## Section 6: Troubleshooting

Problem	Action
	<p>Software will not allow <b>SHUTTER</b> to open for 20 minutes after initial ac power on. Be sure 20 minutes have elapsed. See page 3-24 for software override procedure.</p> <p>Shut down the system and then restart.</p> <p>If red LED on the <b>SHUTTER</b> button comes on then:</p> <p>With a voltmeter, measure the dc voltage on the connector to the shutter when <b>SHUTTER</b> button switch is activated (should be 24 V).</p> <p>Physically remove the shutter assembly and test with an external 24 VDC supply.</p>
Head flashes but there is no lasing output	<p>Verify that the Pulse Division readout panel display is set at P01 and not P00.</p> <p>Verify that the <b>SHUTTER</b> button is depressed and the intra-cavity shutter is no longer blocking the oscillator.</p> <p>Verify the voltage on the readout panel display (front of PCU) matches QA value listed in the front of the manual.</p> <p>Verify the Q-switch delay on readout panel display (front of PCU) matches QA value listed in the front of the manual.</p>
CSE error message displayed	<p>Refers to "check sum error" in the EEPROM.</p> <p>Reenter QA values listed in the front of the manual (see page 3-4).</p> <p>Contact Amplitude Laser Inc. if display does not go away.</p>

Table 13 Optical troubleshooting table

Problem	Proposed Action	Reference
Low IR Energy or Poor Beam Quality	Check oscillator alignment. Check for damaged optics. Replace the flashlamp.	page 76 Make a list of damaged optics & contact Amplitude Laser Inc.. page 69
Low Harmonics Energy or Poor Beam Quality	Check for damaged harmonic crystals or optics. Angle tune the crystal for maximum energy. Check 1,064 nm energy.	Make a list of damaged optics & contact Amplitude Laser Inc.. page 33 page 34
Poor shot-to-shot Stability	Check for free-running. Check for damaged optics. Replace the flashlamp. Check cooling group for contamination.	page 80 Make a list of damaged optics & contact Amplitude Laser Inc.. page 69 page 84
No Lasing	Perform electronic troubleshooting first if head is flashing. Check lasing in the free-running mode.	page 74 page 80

Figure 49 Cover interlock switches



## Oscillator alignment optimization

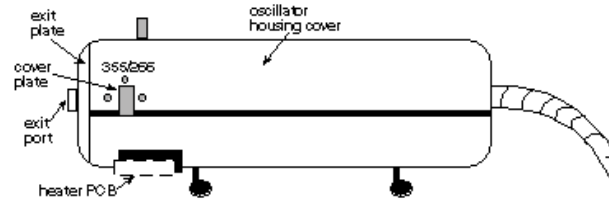
This section will describe procedures for optimizing oscillator performance.

### NECESSARY EQUIPMENT

- power meter with a volume absorbing head
- 2 mm metric Allen key
- Interlock Defeat Bracket
- Phillips screwdriver

**STEPS**

1. Perform the Shutdown procedure. (See page 30.)
2. Remove oscillator housing cover secured by 4 Phillips head screws.
3. Install the Interlock Defeat Bracket.
4. Position power meter ~3" (7.6 cm) from the exit port so that it will intercept the laser beam.



5. Locate and identify the horizontal and vertical adjust knobs at the rear of the oscillator. (See Figure 50.) Observe how a 2 mm Allen key will fit in the slots and allow adjustment of these controls.

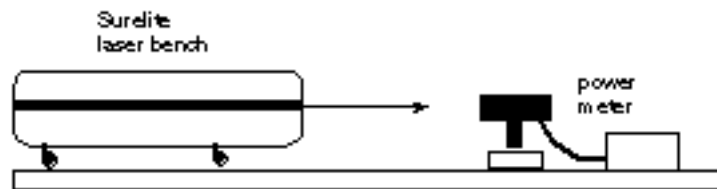
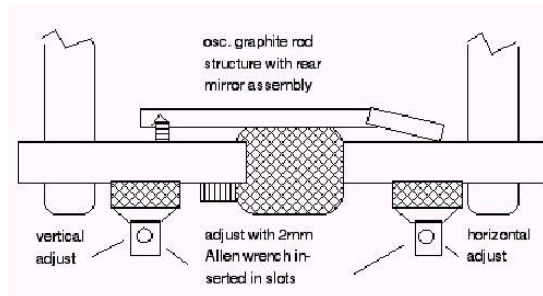


Figure 50 Rear mirror horizontal and vertical controls



6. Perform the System Startup procedure (page 29).

**Burn paper alignment**

This section describes specific procedures for aligning and optimizing oscillator performance.

### NECESSARY EQUIPMENT

- Kodak Linagraph paper (type 1895, CAT#1986108)
- clear plastic bags
- 1 metric Allen wrench set
- Mirror mount adjustment tool

When the Linagraph (or “burn paper”) is new it will have a pink emulsion on one side of it. Expose this side to room light for approximately 30-40 minutes to turn the emulsion to a light brown color. Once it's this color the paper will give the best representation of the laser beam profile.

The back surface of the paper is the one that does not have the emulsion on it. When taking shots (or “burns”) into this side of the paper it is called a “back” burn. Since the emulsion is very sensitive to the laser energy it tends to saturate easily. By taking burns through the back of the paper the energy is attenuated slightly, making interpretation of the burn pattern easier.



#### WARNING!

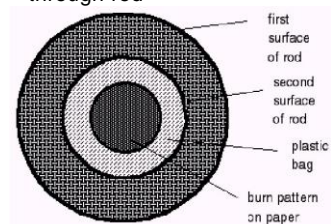
The output coupler (6) should NEVER be adjusted. Misalignment of this optic may necessitate a system realignment by a factory engineer.

1. Allow the system to warm up and then set to P00 (single shot mode).
2. Take a piece of burn paper (approximately a 3" x 5" strip) and place it in a plastic bag.
3. Remove any harmonic generating crystals
4. Place the paper in the beam path just after the output port. It is important to position the paper so that its back surface is facing the output of the oscillator (6).
5. Open the shutter by activating the **SHUTTER** key.
6. Press the **FIRE** button. The laser will now output a single pulse.
7. Close the intracavity shutter by depressing the **SHUTTER** button.
8. Remove the “burn” paper from the bag and examine the pattern.

Note: Remember the orientation of the paper when the “burn” is taken. This will make it easier to determine which axis of the mirror mount to adjust.

The burn pattern should be a dark circle roughly same diameter as the oscillator rod. Inside of this there should be another circle that is smaller and

Figure 51 Image as seen through rod



the circle  
a

196-0207



## Section 6: Troubleshooting

light brown color. The light brown indicates higher energy in that area.

9. Adjust the “ rear” mirror (1) for optimum burn pattern and maximum energy. For example, if the light brown circle is in the lower half of the dark circle then the beam needs to come up. This would require a vertical adjustment.

**Note:** The mirror has both vertical and horizontal adjustment (see Figure 50 on page 77). The vertical adjustment is the stainless steel threaded post that is on the upper left corner of the mount (when viewing the mount from the back). The horizontal adjustment is on the lower right corner.

10. Repeat previous steps until the light brown circle is centered.

**Note:** If after following this procedure the output beam does not look similar to the initial installation burn patterns, then a more complex realignment may be required. Contact Amplitude Laser Inc. Service Department for information.



---

### CAUTION!

Never attempt to adjust the output coupler (the mirror mount nearest to the exit port).

---

11. Once normal power has been restored, shut down the system, remove the interlock defeat bracket and reinstall oscillator housing cover.
12. Resume normal operation.

### Oscillator optimization (with an oscilloscope)

For the Surelite series lasers that employ the “ Gaussian” oscillator, optimizing cavity alignment using an oscilloscope can be very useful.

If the oscillator is well aligned the output pulsewidth is at its narrowest (5-8 ns). The converse is also true. When the cavity is misaligned the pulsewidth will broaden. Therefore, monitoring the pulse width while making oscillator adjustments will allow you to achieve optimum cavity alignment.

#### NECESSARY EQUIPMENT

- Burn paper
- Clear plastic bags
- High density Styrofoam beam dump
- Photodiode with ~1 ns rise time
- BNC cable
- >350 MHz oscilloscope with enhanced view screen

This procedure optimizes the oscillator by monitoring the pulsewidth.

Note: This procedure should be done in conjunction with the alignment procedure described previously in this section.

1. Remove harmonic crystals.
2. Place the beam block in the beam path after the output port.
3. Set up the oscilloscope:
  - Plug in photodiode to 50  $\Omega$  termination.
  - Run a trigger BNC cable from the “ Fixed sync out” BNC (located on the PCU front panel display) to the time base of the scope.
  - Set the triggering of the scope to trigger off the +5 V TTL sync pulse.
  - Adjust the time base to view a 5-10 ns pulse. The trigger pulse will occur ~90 ns before lasing.
  - Place the photodiode on the bench so that it will be able pick up the laser light scattered off the beam block.

Be sure that the voltage setting on the power unit is set to the laser's normal operating voltage.

4. Activate P01 and press SHUTTER button.
5. While viewing the pulsewidth on the scope adjust the vertical position of the back mirror M#1. Make very small adjustments at first to be able to determine effect of the adjustment.

When making adjustments to the back mirror the pulse will change in size (pulsewidth) as well as move in time. Generally, when adjusting the mirror in the correct direction the pulse will move to the left indicating reduced build-up time.

6. Optimize the vertical position.
7. Now repeat the process while adjusting the horizontal axis.
8. Once the alignment is optimized, take single shot burns to verify oscillator alignment.

Note: A very small adjustment on the back mirror can have an effect on the pulsewidth though it may not be noticeable on the burn paper.

## Eliminating free-running

Free-running is a term used to describe the phenomenon of a Q-switched oscillator actually lasing before the Q-switch is open. This effect can be damaging to optics and result in power fluctuations and reduced harmonic conversion efficiency.

There are generally three ways in which free-running can occur:

## Section 6: Troubleshooting

**Misalignment.** If the polarization optics, especially the  $\lambda/4$  plate and the Pockels cell, become misaligned, then the polarization within the cavity becomes slightly undefined. This means that the dielectric polarizer does not receive linearly polarized light. Therefore, when the polarizer is supposed to be rejecting energy out of the cavity, a certain amount “leaks” through. That “leakage” energy then builds up and becomes lasing. Since this lasing occurs before the Q-switch is opened, it is called free-running.

**Increased pump.** If the flashlamp voltage is increased, the oscillator will reach a level at which, due to the increased gain, it begins to lase. This occurs because the polarization optics cannot reject enough energy out of the cavity.

**Optical feedback.** Optical feedback from an external reflective surface, can increase the amount of energy in the oscillator cavity. This increased energy, just as with turning up the pump voltage, can exceed the polarization optics ability to reject enough energy out of the cavity.

During normal laser operation free-running will manifest itself in the form of erratic shot-to-shot stability or even a snapping sound coming from the laser. If this occurs, stop the Q-switching immediately. Then follow the procedure listed below to check for and eliminate free-running.



---

### CAUTION!

The following adjustments should be made with the Q-switch off (using the SELECT button on front of PCU, toggle to pulse division and set value to P00), the lamps flashing and the cavity shutter open.

---

### NECESSARY EQUIPMENT

- oscilloscope with 1 M input (fast scope not required)
- 1 photodiode rise time of  $\sim 1$  ns
- 1 Styrofoam high density beam block
- 1 metric Allen wrench set

### STEPS

1. Place a beam block in the beam path  $\sim 12$ " from the output so that it intercepts the laser output.
2. Place a photodiode so that it monitors the light scattered off of the beam block.
3. Set up an oscilloscope (does not have to be a fast scope).
  - Connect the photodiode to a 1 M  $\Omega$  input on the scope.
  - Run a trigger BNC cable from the **FLASHLAMP SYNC** BNC connectors (located on front of the PCU) to the external trigger input on the scope.
  - Set the time base to 100  $\mu$ s.

## Operation and Maintenance Manual for Surelite™ Lasers

4. Ensure that the PCU lamp voltage is set to the normal operating voltage.
5. Start the laser (flashlamps firing only).
6. Adjust the photodiode so that it detects a small amount of the flashlamp light and scope displays lamp discharge curve.
7. Now open the intracavity shutter by switching the **SHUTTER** toggle to **OPEN**.

**Note:** To maintain thermal stabilization of the Pockels cell and harmonic generators, the software will not allow the **SHUTTER** button to open for 20 minutes after the red **AC POWER** toggle is first turned **ON**.

8. Check the scope display for any change in waveform. When the shutter is opened, the scope display should be basically unchanged.

Figure 52 Flashlamp signal



the

9. If the waveform starts with a gentle slope then abruptly increases to a jagged peak, the laser is free-running.

10. If the laser is not free-running at this time, go to step 16.

**Note:** To eliminate the free-adjustments to the polarization optics be made.

Figure 53 Flashlamp rise – free-running pulse



running, need to

11. At this time make a small adjustment to the vertical axis of the Pockels cell through the vertical adjustment access hole located at the top of the Pockels cell mount.

12. Note the vertical amplitude of the scope display. If it becomes less, then the previous adjustment was made in the correct direction.

13. Continue to adjust the vertical axis until the amplitude of the trace is as small as possible or until the free-running stops. If the free-running stops, then go on to step 16.

Figure 54 Flashlamp rise – further adjustment required



14. Now follow the same procedure as in steps 12 and 13, only this time adjust the horizontal axis located on the lower corner of the Pockels cell mount.

15. Continue these adjustments until the free-running has been eliminated.

16. Close the intracavity shutter and increase the pump voltage by 100 V.



### CAUTION!

Do not exceed 1.8 kV unless otherwise instructed to do so by a Amplitude Laser Inc. representative.

---

17. Open the intracavity shutter and look at the oscilloscope to see if the laser is free-running.
18. If the laser is in a free-running state, then repeat steps 11 through 15 while at this higher pump voltage.

**Note:** Once the oscillator optics are properly adjusted, passive free-running should not occur until the pump voltage has exceeded 100 V above the normal operating level. In many cases this voltage “buffer” will be even greater than 100 V.

19. Once the “buffer” voltage is ~100 V, return the pump voltage to its normal level. (See QA chart in front of the manual immediately following the title page.)

**Note:** After completing the free-running test procedure, it is very important to check the oscillator alignment once again. Any movement of the Pockels cell may cause a misalignment, requiring a back mirror adjustment (see page 6-6).

### Flashlamp voltage adjustment

It is common for flashlamps to last 20-30 million shots, but during that time the efficiency of the lamps will decline. Initially, it is possible to compensate for the decline by increasing pump voltage. However, after a point, the thermal loading on the YAG rod will adversely affect beam quality. This procedure instructs you on how to increase flashlamp pump voltage to compensate for lamp aging.

#### NECESSARY EQUIPMENT

- power meter
- IR card

#### STEPS

1. Before increasing the pump voltage to bring the laser output back to spec energy, make sure that your power decrease is not due to misalignment or optical damage.
2. Verify the energy specs by reviewing the Error! Reference source not found. on page Error! Bookmark not defined. the front of the manual.
3. Position a power meter to monitor the IR energy. If the system has optional harmonics, measure the total energy of the combined wavelengths. Due to losses in the harmonic crystals, expect the measured combined total to be 15-20% below published spec for IR alone.

4. Increase the pump voltage by 20 V on the PCU by the pressing the **SELECT** button until red LED is lit next to **VOLT-AGE KV** on the front panel of the PCU.
5. Now use the **ARROW UP/ARROW DOWN** buttons as needed to reach +20 V.
6. Open the intra-cavity shutter. Allow the laser to Q-switch and measure the energy.
7. If still below specs, repeat steps 4 thru 6.

**Note:** If the total voltage increases exceed the installed voltage by more than 100 V, then the flashlamps should be replaced.

8. Check the free-running buffer. It needs to be at least 100 V. See **Eliminating free-running** on page 80.
9. If the energy is back to its spec level, log the date and action in “ Operator Notes” at the end of the manual and the procedure is complete.

## Cooling group contamination

This section describes the procedure for flushing the cooling group if it becomes contaminated with organic material (algae).

### NECESSARY EQUIPMENT

- 1 pint (~500 ml) 30% hydrogen peroxide
- 3 gal. distilled water
- 1 DI filter (PN#313-0099)

### STEPS

1. Look for this label on the cooling group side of the unit. DO NOT open the power unit side. The cooling group cannot be accessed from the power unit side.
2. Review the cooling group drawing. (Page 65 or 72.)
3. Turn off main ac circuit breaker on the front panel of power/cooling group (PCU) and disconnect power cord from the wall socket.
4. Remove the eight screws from top and bottom of the cooling group cover.
5. Using an inspection light, look into the tank. Note any signs of floating white, green or brown contamination.
6. If contamination is present, then the unit will have to be flushed.
7. Drain the cooling group and refill with new distilled water.
8. Remove the old DI filter and pinch off the DI filter water lines.

**Open this side  
for cooling group  
maintenance.**

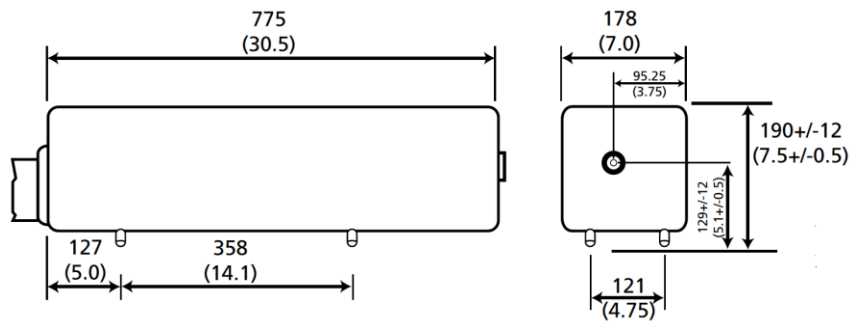
## **Section 6: Troubleshooting**

9. Add 1 pint (~500 ml) of 30% hydrogen peroxide to distilled water in the reservoir.
10. Allow the peroxide to circulate for 1 hour.
11. Turn the cooling group off and drain the reservoir.
12. Refill the reservoir with distilled water. Allow it to circulate for 15 minutes and then drain the reservoir.
13. Refill the reservoir with distilled water again and inspect for contamination. If contamination is still present, repeat steps 5-11.
14. Install a new DI filter and fill the reservoir with distilled water.
15. Log date and work done and resume normal operation.

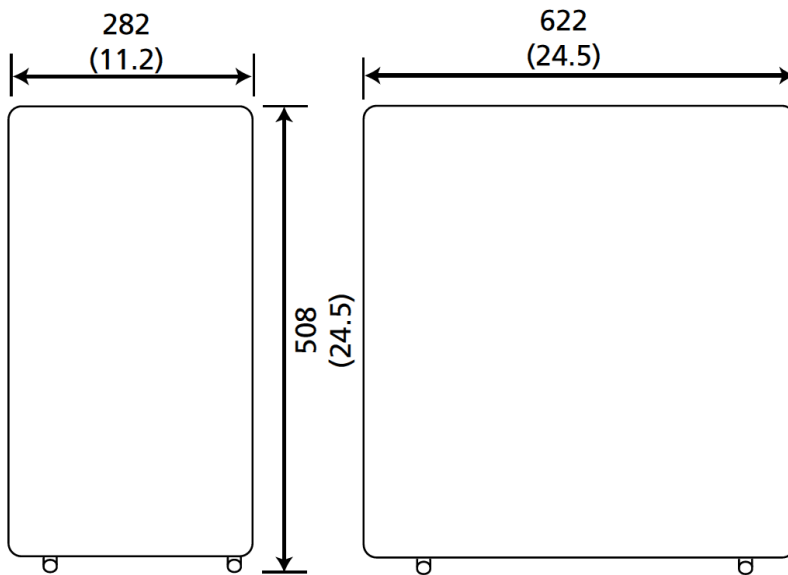
# Section 7: Physical Layout

Figure 55 Surelite physical dimensions

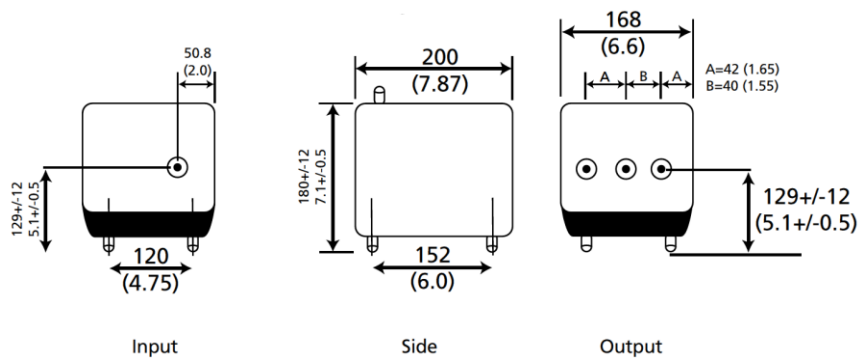
Surelite Optical Head (52 lbs / 24 kg)



Surelite Power Supply (96 lbs / 44 kg)



Surelite Separation Package (SSP)





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## **Section 8: Warranty**

### **Express warranty**

Unless otherwise specified, all mechanical, electronic and electro-optical assemblies manufactured by Amplitude Laser Inc. are warranted to be free from defects in workmanship and materials for a period of one (1) year from date of shipment.

Exclusions are:

1. optics, crystals and flashlamps which are warranted for 90 days.

### **Limitation of remedy**

The remedy available under this warranty shall be the repair of the defective material so long as the following are observed:

1. This warranty does not apply to equipment or components which inspection by Amplitude Laser Inc. shall disclose to have become defective or unworkable due to abuse, mishandling, misuse, accidental alteration, negligence, improper operation or other causes beyond Amplitude Laser Inc.'s control.
2. This warranty shall not apply in the event that the original device identification markings have been removed, defaced or altered or if any parts have been substituted or modified without the express consent of Amplitude Laser Inc..
3. The customer's general account at Amplitude Laser Inc. is current and not delinquent in whole or in part.

### **Disclaimer of implied warranty**

The foregoing is in lieu of all other warranties Express or Implied, and there are no warranties of Merchantability or fitness or any other remedies available other than as expressed herein.

### **Returns, adjustments & servicing**

If warranty or general repair or service to a Amplitude Laser Inc. product is requested by the customer involving the product's return to Amplitude Laser Inc., the terms of the return shall include the following:

1. The customer shall obtain a return authorization number from the Amplitude Laser Inc. Service Department.
2. The product must be properly packed in the original Amplitude Laser Inc. shipping container. Additional shipping containers may be purchased from Amplitude Laser Inc. if needed. All water must be re-moved from the water-cooled products prior to packing.

### Section 8: Warranty

3. Freight and insurance (for the full value of the shipped goods) charges must be prepaid by the Buyer and all risk of loss, damage or delay in shipment shall be borne solely by the Buyer.

4. After receipt of product, Amplitude Laser Inc. reserves the right to inspect the product and to determine the cause of failure and warranty status. Amplitude Laser Inc. shall have no duty to perform a warranty repair where the product has suffered damage in shipment that prevents a determination by Amplitude Laser Inc. of the cause or existence of the asserted defect

5. If the product is found to be under warranty it will be repaired or replaced free of charge in accordance with the terms of the Amplitude Laser Inc. warranty. The warranty period on a repaired or replacement product shall be the balance of the warranty period remaining on the original product, i.e. no new warranty is created by such a repair.

6. If the product is determined to be of a non-warranty status the customer will be advised and a written purchase order for the repair or service work will be required before the work begins. The cost and terms of non-warranty service shall be according to Amplitude Laser Inc.'s then prevailing policies which are subject to change.

**Service center information:** Visit the Amplitude Laser Inc. Web Site for complete information.

**Amplitude Laser Inc.®**  
140 Baytech Drive  
San Jose, CA 95134 USA  
Main Phone: 408-727-3240

Service Phone: 877-272-7783  
[service@Amplitude Laser Inc.lasers.com](mailto:service@Amplitude Laser Inc.lasers.com)

[www.Amplitude Laser Inc.lasers.com](http://www.Amplitude Laser Inc.lasers.com)

# Appendix A: PIV Operation and Maintenance

## PIV description

### Particle Image Velocimetry

Particle Image Velocimetry (PIV) is a powerful method of monitoring complex velocity distributions in diverse media. Typical applications include shear and laminar flows, exhaust plumes, and airflow around vehicles and aircraft.

The PIV process compares two images, separated in time, taken of light-scattering particles injected into the flow medium. A Q-switched, pulsed Nd:YAG laser beam, shaped by cylindrical optics, produces a sheet of light which illuminates a cross-section of the flow medium. Photographic film or a CCD camera is used to capture two consecutive images (a “double exposure”) of the scatter passing through this cross section. A wealth of information on the scattering particles’ velocities can be re-corded. The recorded data is deconvoluted using several correlation integrals, achieving a complete two dimension velocity vector field for large flow areas.

## PIV overview

### PIV systems

To meet the needs of PIV users and systems manufacturers, Amplitude Laser Inc.’s PIV systems are designed for stability, beam quality, and variable pulse separation. The PIV series has two main configurations:

- Surelite I PIV
- Surelite II PIV

Amplitude Laser Inc. mounts two Surelite lasers on a stable and compact laser bench. Optics on the same bench combine a pulse from each laser to pass through a single, temperature stabilized KDP frequency doubling crystal. The result is two 532 nm pulses with nearly identical energy, beam uniformity and polarization. Dichroic separation is also included. Separation times between the pulses may vary over a wide range, from 40 ns up to 100 ms. Long-term performance data shows that PIV lasers maintain constant energy and excellent beam pointing stability throughout the day.

Amplitude Laser Inc. also provides PIV systems which combine two separate Q-switched, pulsed Nd:YAG laser beams on another optical bench. This Beam Access Platform (BAP) uses the same PIV beam combination optics and temperature stabilized doubling crystal. A BAP system can achieve specifications similar to the PIV series. Lasers in these systems easily convert to other applications. Instead of using a single optical bench, these PIV systems give added flexibility and can provide higher energy, faster repetition rates and seeded pulses.

### Beam Quality

PIV requires that the dual pulses have the same spatial overlap, energy and symmetry. Each dual pulse laser system leaves the factory matched in energy and beam quality. Extensive long-term stability testing ensures that performance remains optimized.

### Stability

A stable mechanical design is the key to the PIV's stability and overall reliability. A decoupled kinematic graphite mount holds each resonator securely and ensures isolation from thermal and mechanical stress.

### Ease of Use

All PIV systems feature a menu-driven power supply which gives push-button access to all system parameters. It can be programmed to run in automatic and manual modes. The doubling crystal can be remotely phase matched to optimize energy output using a control mounted external to the laser.

A self-contained cooling system and independent power supplies for each resonator provide easy control of the PIV system, and TTL and RS-232 interfaces allow flexible external control.

### Safety

Safety interlocks continually check for proper cooling water flow, level and temperature. The intracavity shutters open only after the rods are thermally stabilized, preventing thermal lens damage.

### Lifetime

The PIV systems run at very low Surelite or Powerlite output pump levels. This translates into longer lifetime for key components: rods, lamps and power supplies last longer because of reduced stress.

### PIV pulse timing

### External control

User supplied TTL or RS232 signals may control laser pulse timing and energy. **Section 3: System Operation** of your Surelite Manual or Section 3 of your Powerlite manual have the details.

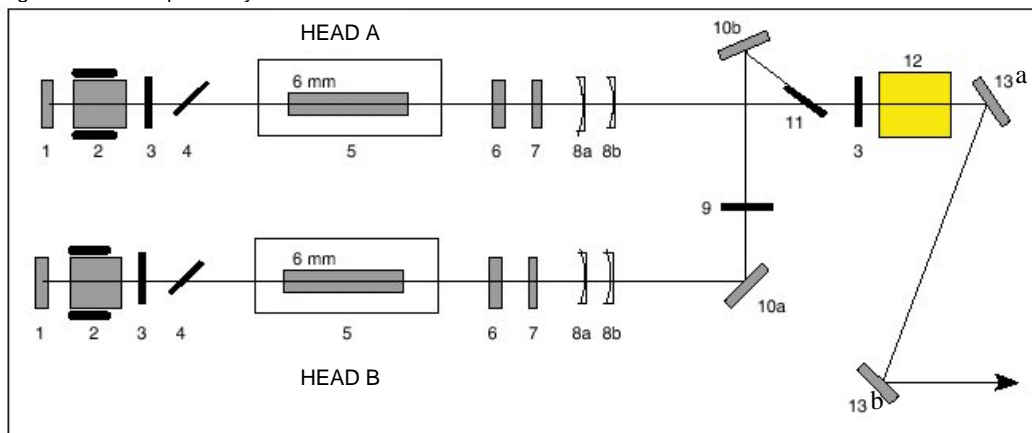
## PIV Optical description

**Figure 56** shows the PIV optical layout. Two 1064 nm fundamental Nd:YAG laser beams are first combined on a common optical axis and passed through a single doubling crystal. 532 nm dichroic separation optics then provide two green output pulses.

The beam from laser A defines this common optical axis. Horizontally polarized, it passes directly through the beam merger, a dielectric polarizer (11), which combines this beam with the second laser's output.

The beam from laser B is also horizontally polarized; it passes through half wave plate (9) external to the cavity changing fundamental output of laser B to vertical polarization so that the dielectric polarizer (11) reflects the beam into the horizontally polarized beam path. The two mirrors (10a & b) optimize the overlap. The  $\lambda/4$  plate (3) then gives both beams circular polarization. Because they now have circular polarization, the doubling crystal (12) converts them equally to their second harmonic. A pair of dichroics (13a and b) now strips the unconverted 1064 nm light and steers the vertically 532 nm second harmonic pulses towards the PIV experiment.

Figure 56 PIV optical layout



### LEGEND

- |   |   |
|---|---|
| <ul style="list-style-type: none"> <li>1. HR mirror</li> <li>2. Pockels cell</li> <li>3. <math>\lambda/4</math> plate</li> <li>4. Dielectric polarizer</li> <li>5. Head</li> <li>6. Gaussian mirror output coupler</li> </ul> | <ul style="list-style-type: none"> <li>7. Compensator</li> <li>8. Shaping lenses</li> <li>9. <math>\lambda/2</math> plate</li> <li>10. 45° mirror, 1064 nm</li> <li>11. Polarizer, 199-0055</li> <li>12. SHG (second harmonic generator) crystal, in a sealed oven</li> <li>13. 45° mirror, 532 nm</li> </ul> |
|---|---|

## Second harmonic generation

In the doubling process, two 1,064 nm photons enter the KDP crystal collinear and with the same (circular) polarization. They combine into a single photon, provided that the

## Appendix A: PIV Operation and Maintenance

resulting photon conserves both energy and momentum. A combined photon with doubled frequency satisfies energy conservation. Angular momentum conservation gives the doubled photon a different (horizontal) polarization. Linear momentum conservation requires the combined photon to have the same velocity as the incoming photon pair. In the non-linear crystal, there is a particular angle (the phase matched angle), at which the crystal's birefringence gives the combined photon, with both different frequency and polarization, the same velocity as the input photons.

The doubling crystal is enclosed in an oven kept at a constant temperature of 35° C, to prevent water vapor from damaging the crystal and to optimize and stabilize the doubled output. A toggle switch on the PIV cover controls a motor-driven oven rotation stage for easy optimization of the phase matching angle.

### PIV Physical Layout

Figure 57 PIV optical head package dimensions

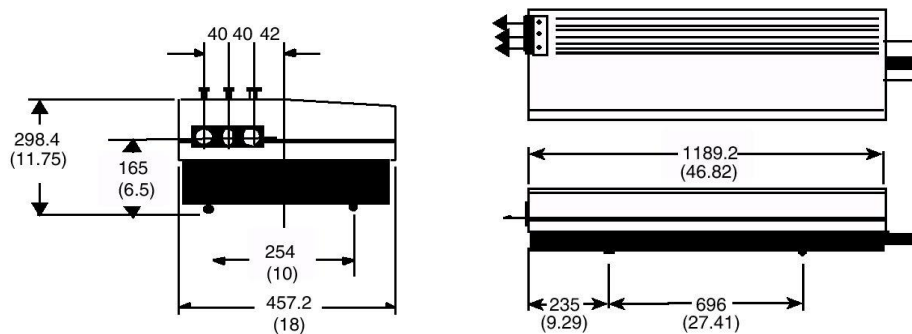
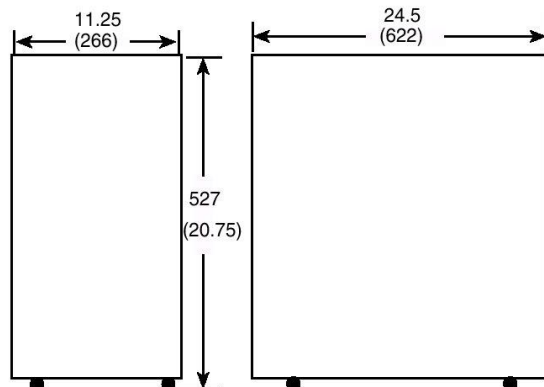


Figure 58 PIV power supply package dimensions



## PIV Operation

### Startup

1. Lower the PIV beam dump to engage it.
2. Turn on both lasers and allow them to come to warm up; follow the instructions in your Surelite or Powerlite YAG laser manual. If desired, take burns and/or check beam energies to verify proper operation.



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#### **WARNING!**

Be sure to wear goggles and observe all safety procedures.

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3. Also allow any external pulse timing control circuitry to warm up.
4. Open the 1,064 nm output shutter of each laser.
5. After waiting at least 20 minutes, you may wish to tune the PIV doubling crystal. Use the SHG toggle switch mounted on the laser bench to change the crystal angle. A power meter in the output will aid in finding the angle yielding maximum energy.
6. Push the shutter buttons to close both laser intracavity shutters.
7. If controlling the lasers externally, begin sending the desired pulse sequence to both of them.
8. If desired, adjust the beam separation (see the
9. **Beam alignment** and **Beam power balance** sections, below).
10. Push the shutter buttons again to open both intracavity shutters; then raise the PIV beam dump to begin PIV operation.

### Shutdown

1. Turn off both YAG lasers; refer to their manuals for details.
2. Lower the PIV beam dump to engage it.
3. Turn off any timing pulse generator.



### Optical adjustments

To maintain best PIV performance, it is occasionally necessary to coalign both beams, balance their energies and adjust the doubling crystal angle. Procedures to perform these operations follow below.

### Adjustable optics

See **Figure 56**. Laser B beam steering mirrors (10a) and (10b), and output steering dichroics (13a) and (13b) all use the same mounts. Each mount has vertical and horizontal adjustments. It is unnecessary and undesirable to move the waveplates (9 and 3) or the dielectric polarizer (11) during any of these adjustments.

### Beam alignment

Beam alignment involves adjusting steering optics (10a), (10b), (13a) and (13b) only. Adjust neither the wave plates (9) and (3) nor the dielectric polarizer (11), nor the position of the crystal oven (12). Perform this procedure only if misalignment is obvious.

1. Allow both lasers about 20 minutes to reach thermal equilibrium.
2. Attenuate both 532 nm beams, either by reducing their Q-switch delays, reducing their flashlamp voltages, or detuning the crystal. Wear goggles to further attenuate the green light.
3. Fire laser A at its normal repetition rate, and set laser B to single shot operation.
4. Steer laser A beam to the PIV experiment with dichroics (13a) and (13b).
5. Place a white target (e.g. a business card) 5 to 500 cm after the PIV beam exit, and observe the laser A spot. Firing laser B will show a second spot nearby. Use mirror (10a) to overlap both spots.
6. Place the white target as far as possible (but not farther than two meters) beyond its previous position. Use mirror (10b) to completely overlap these two beams.
7. Repeat the above two steps until the beam overlap is satisfactory. Additional output steering using dichroics (13a) and (13b) will not affect the overlap.
8. Restore both lasers to full power operation, and optimize the crystal angle if output power is low.
9. Engage both intracavity shutters.

### Crystal phase matching

Phase matching the doubling crystal is occasionally necessary to maintain maximum energy of the doubled pulses. A toggle switch, mounted on the side of the laser bench, controls a motor which rotates the crystal while the PIV cover remains closed. To phase match the crystal do the following:

1. Turn on both lasers and allow them to warm up at least 20 minutes, then raise their 1,064 nm beam blocks to disengage them.
2. Set a power meter in the PIV output and open the PIV beam dump.
3. Move the SHG toggle switch back and forth to find the crystal position yielding maximum power. Remember that as the crystal rotates, beam power goes through many minor maxima, but the central maximum has significantly more power.

### Beam power balance

PIV requires that the pulse from each laser have the same energy. The best way to balance the energies is to adjust the time interval between the flashlamp firing and opening the Q-switch, using external control pulses. Adjusting flashlamp voltage produces a similar result.

### Flashlamp voltage

The simplest way to change the YAG beam energy is to adjust the flashlamp discharge voltage on the YAG power supply. Refer to your Surelite or Powerlite manual for details. This method has the disadvantage of causing the beam to diverge, its pulse width to increase, and its harmonic conversion efficiency to decrease.

### External control

External control of both flashlamp and Q-switch firing allows control over pulse energy in the same way. Both the RS232 interface and Direct Access Triggering (DAT Mode 2) allow this control. Pages **39** to **45** of a Surelite manual give details.

To balance the pulse power from both lasers, do the following:

1. Turn on both Surelites and allow them to warm up.
2. Place a power meter in the PIV output beam and push the shutter button to close the intracavity shutter of one laser. Then measure the power of the other laser.
3. Reverse the shutter positions of both lasers and adjust the energy of the second laser to match the first. Do this either by adjusting the flashlamp discharge voltage and/or the timing between the fire and Q-switch pulses.

## **Maintaining PIV optics**

Periodically inspect the crystal and surfaces of all PIV optical components for dust, discoloration, and damage. Cleaning or replacing them, if necessary, will promote good system performance and longer lifetime. Be sure to replace the laser cover when finished.

Systematically examine the surfaces of each optic and oven window for dust, fingerprints, discoloration, and burn marks in the surface coating. Use a bright flashlight to light the surfaces. An inspection mirror may also be helpful. Inspect the SHG crystal without opening the oven. Please refer to your YAG manual for details about inspecting, cleaning and replacing optics.

Note: When cleaning the dielectric polarizer or a wave plate, only clean the center of the optic. If solvent reaches the edge of the optic, it may dissolve mounting glue, contaminating the optic. Do not apply pressure during cleaning, for these optics are thin and delicate.

## **Cleaning or replacing the SHG crystal**

The SHG (doubling) crystal is mounted in a sealed oven, and damage to a crystal face can be seen through the oven window. Amplitude Laser Inc. recommends that the entire oven assembly be exchanged when the inside of a window or a crystal face shows damage. To remove the crystal oven assembly, do the following:

1. With both lasers off, loosen the pair of screws holding the oven to its rotating stage. These two screws are at the top of the oven and face laser A. Also unplug the 9-pin heater cable from the oven.
2. Remove the oven and replace it with a new one. Retighten both screws and reconnect the heater cable.
3. Phase match the crystal using the SHG toggle switch.

## Appendix A: PIV Operation and Maintenance

### PIV Specifications

Table 14 PIV part numbers

Figure 56	P/N	Description	Use
<b>Optics</b>			
9	108-0004	Half wave plate	Horizontally polarizes beam B
10b	105-0086	1064 nm mirror	Steers beam B
10a	105-0002	1064 45° mirror	Steers beam B
11	199-0055	Dielectric polarizer	Combines beams A and B
3	108-0001	Quarter wave plate	Circularly polarizes both beams
13	105-0022	45° dichroics (2)	Steer 532 nm output beams
<b>SHG Crystal Oven Parts</b>			
12	617-8000	Oven assembly	Includes windows, crystal, heaters
	202-0137	KDP doubling crystal	Generates 532 nm from both beams
	110-0004	Input window	Seals doubling crystal oven
	110-0006	Exit window	Seals doubling crystal oven
	422-0019	Motor	Adjusts crystal phase match angle
	608-4104	Motor pulley	
	611-8200	Oven heater PCB	Controls oven temperature; needs 24V

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