IPG PHOTONICS

YLR-SERIES USER GUIDE

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Patent Rights

This product is patented. Please see product for more information.

Preface

Please take time to read and understand this User Guide and familiarize yourself with the operating and maintenance instructions that we have compiled for you before you use the product. We recommend that the operator read the section titled “Safety Information” prior to operating the product.

This User’s Guide should stay with the product to provide you and all future users and owners of the product with important operating, safety and other information.

US Export Control Compliance (for US products only)

IPG’s policy and business code is to comply strictly with the U .S. export control laws.

Export and re-export of lasers manufactured by IPG are subject to the US Export Administration Regulations administered by the Department of Commerce, Bureau of Industry and Security.

The applicable restrictions vary depending on the specific product involved, intended application, the product destination and the intended user. In some cases, an individual validated export license is required from the US Department of Commerce prior to resale or re-export of certain products. Please contact IPG, if you are uncertain about the obligations imposed by US law.

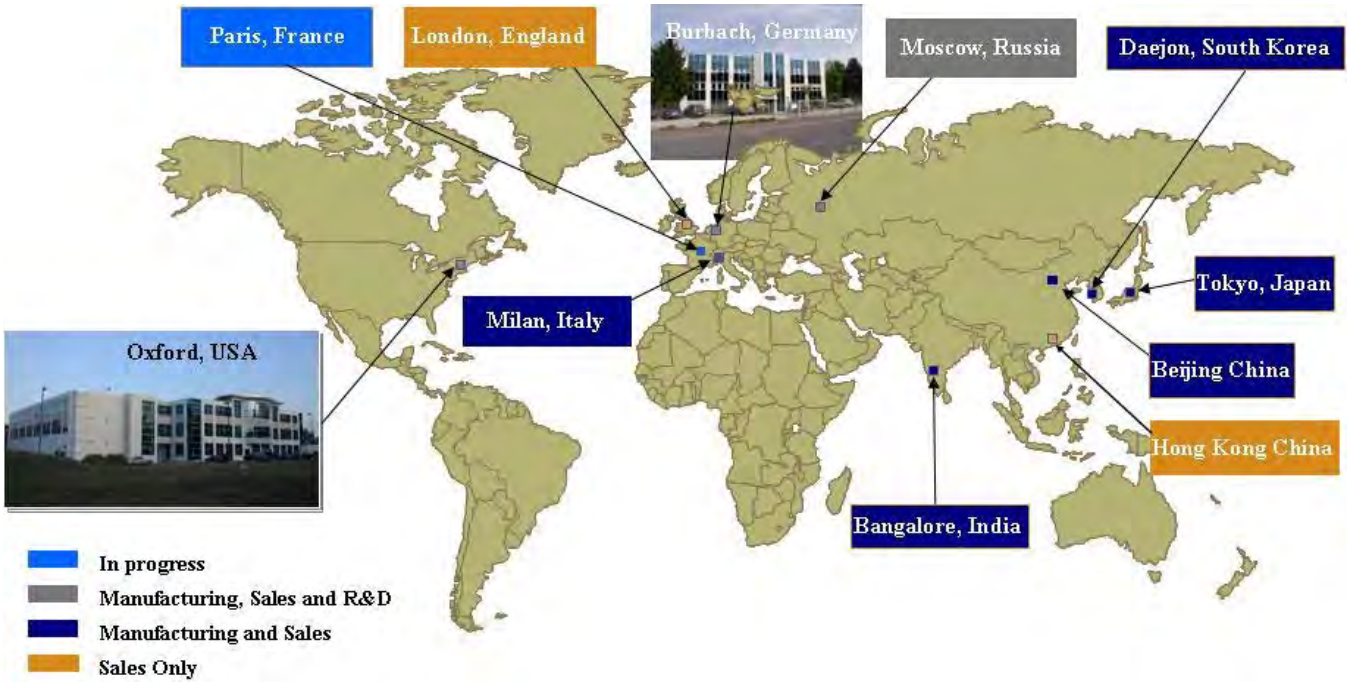
IPG PHOTONICS CORPORATION

IPG delivers fiber lasers in all domains of laser material processing, medical engineering and scientific institutes and universities. IPG is the accepted market leader in this modern fiber laser technology. The IPG Photonics Corporation contains subsidiaries in many European, Asiatic and American developed counties. Production sites for these lasers are in both Oxford, Massachusetts in the US and in Burbach, Germany with a vertical range of manufacture of 90%. This helps to guarantee a high grade of competence and reliability.

High output power, excellent beam quality, high stability and mobility are outstanding predicates of the fiber laser. The superiority of the fiber laser is efficiency, flexibility, modularity, thermal and mechanical robustness that comes along with a simple constructive assembly. Further important characteristics for the industrial use are low running costs.

Economic feasibility studies show, that it is possible to realize faster, better and more cost-effective industrial applications with high power fiber laser. IPG has the production capacity for a production in high piece numbers. Additional information can be found at www.ipgphotonics.com.

IPG Companies with present service



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INTRODUCTION

The IPG YLR-Series product line has been developed to meet industrial market demands of efficient reliable maintenance-free high power lasers. YLR products are diode-pumped ytterbium fiber lasers with output powers ranging from 20 W up to 1.5 kW operating at the wavelength region of 1060 – 1100 nm.

These lasers can be air or water-cooled. The wall plug efficiency of an YLR laser typically exceeds 30%. All IPG YLR-Series fiber lasers are Class 4 laser products and are designed and tested with safety in mind. By following this User's Guide and applying sound laser safety practices, it will be a safe and reliable device.

Laser light exhibits unique characteristics that pose safety hazards that are not normally associated with other light sources. Therefore, all operators and people near the laser must be aware of these special hazards.

In order to ensure the safe operation and optimal performance of the product, please follow these warnings in addition to the other information contained elsewhere in this manual. These safety precautions must be observed during all phases of operation, maintenance, and service of this instrument. Operators are urged to adhere to these recommendations and to apply sound laser safety practices at all times. Never open the device. There are no user serviceable parts (internally), equipment or assemblies associated with this product. All internal service and maintenance will be performed only by qualified IPG personnel.

SAFETY INFORMATION

Safety Conventions

This User Guide uses various words and symbols (Table 1) are designed to call your attention to hazards or important information.

SYMBOL	DESCRIPTION
Or	WARNING: Refers to a potential *personal* hazard. (Electrical) (Laser radiation) It requires a procedure that, if not correctly followed, may result in bodily harm to you and/or others. Do not proceed beyond the WARNING sign until you completely understand and meet the required conditions.
	CAUTION: Refers to a potential product hazard. It requires a procedure that, if not correctly followed, may result in damage or destruction to the product or components. Do not proceed beyond the CAUTION sign until you completely understand and meet the required conditions.
NO SYMBOL	IMPORTANT: Refers to any information regarding the operation of the product. Please do not overlook this information.

Table 1: User Guide Safety Symbols

Safety Features and Compliance to Government Requirements

Compliance to Regulatory Standards (on applicable units)

EMC Emissions:
- EN 55011:2009 + A1:2010
- CISPR 11:2009 + A1:2010
- FCC Class A

EMC Immunity:
- EN 61000-3-2:2006+A1:2009+A2:2009
- EN 61000-3-3:2008
- EN 61326-1:2006
- EN 61000-4-2:2009
- EN 61000-4-3:2006 + A1:2007 + A2:2010
- EN 61000-4-4:2004+A1:2010
- EN 61000-4-5:2006
- EN 61000-4-6:2009
- EN 61000-4-11:2004

EMC Other:
- This Class A digital apparatus complies with Canadian ICES-003.

Electrical Safety:
- EN 61010-1:2001

Laser Safety:
- EN 60825-1:2007
- CDRH 21 CFR 1040.10

Functional Safety:
- EN ISO 13849-1:2008 + A1:2009 Cat.3 / PL d

Electromagnetic Compatibility

Compliance of this laser with the EMC requirements is certified by the CE mark if identified by the CE label (Figure 1).

The European requirements for Electromagnetic Compliance are specified in the “EMC Directive”. Conformance to the “EMC” is achieved through compliance with the harmonized standards EN55011 for emission and EN 61326-1:2006 for immunity. The laser meets the emission requirements for Class A, group 1 as specified in EN55011.

Laser Classification

The governmental standards and requirements specify that lasers must be classified according to their output power or energy and the laser wavelength. All YLR-Series lasers are classified as a high power Class 4 laser instrument under 21 CFR, subchapter J, part II, 1040.10(d). According to the European Community standards, this device is classified as Class 4 based on EN 60825-1, clause 9 This product emits invisible laser radiation at or around a wavelength of **1070 nm**, and the total light power radiated from the optical output is greater than **20 to 1500 W** (depending on model) per optical output port. Direct or indirect exposure of this level of light intensity may cause damage to the eye or skin. Despite the radiation being invisible, the beam may cause irreversible damage to the retina and/or cornea. Appropriate and approved laser safety eyewear must be worn at all times while the laser is operational.

⚠ Warning: You must use appropriate laser safety eyewear when operating this device. The selection of appropriate laser safety eyewear requires that the end user accurately identify the range of wavelengths emitted from this product. If the device is a tunable laser or Raman product, it will emit light over a range of wavelengths.

The end user must ensure that the laser safety eyewear used protects against light emitted by the device over its entire range of wavelengths. Please review the safety labeling on the product (Figure 1: Safety Label Locations) and verify that the personal protective equipment (e.g. enclosures, viewing windows or viewports, eyewear, etc.) being utilized is adequate for the output power and wavelength ranges listed on the product.

Suppliers include LaserVision USA, Kentek Corporation and Rockwell Laser Industries offer this laser safety material and/or equipment. There are other laser personal protective equipment providers. IPG provides the names of these providers solely as a convenience and does not endorse or recommend any of them, or their products or services. Furthermore, IPG assumes no liability for any of their recommendations, products or services.

Whether the laser is used in a new installation or to retrofit an existing system, the end user is solely responsible for determining the suitability of all personal protective equipment.

⚠ Caution: Do not install or terminate fibers or collimators when laser is active.

Key Control

The instrument cannot be turned on or operated until the system keyswitch is in the ON or REM position [CFR 1040.10 (f)(4)/EN 60825-1, clause 4.6].

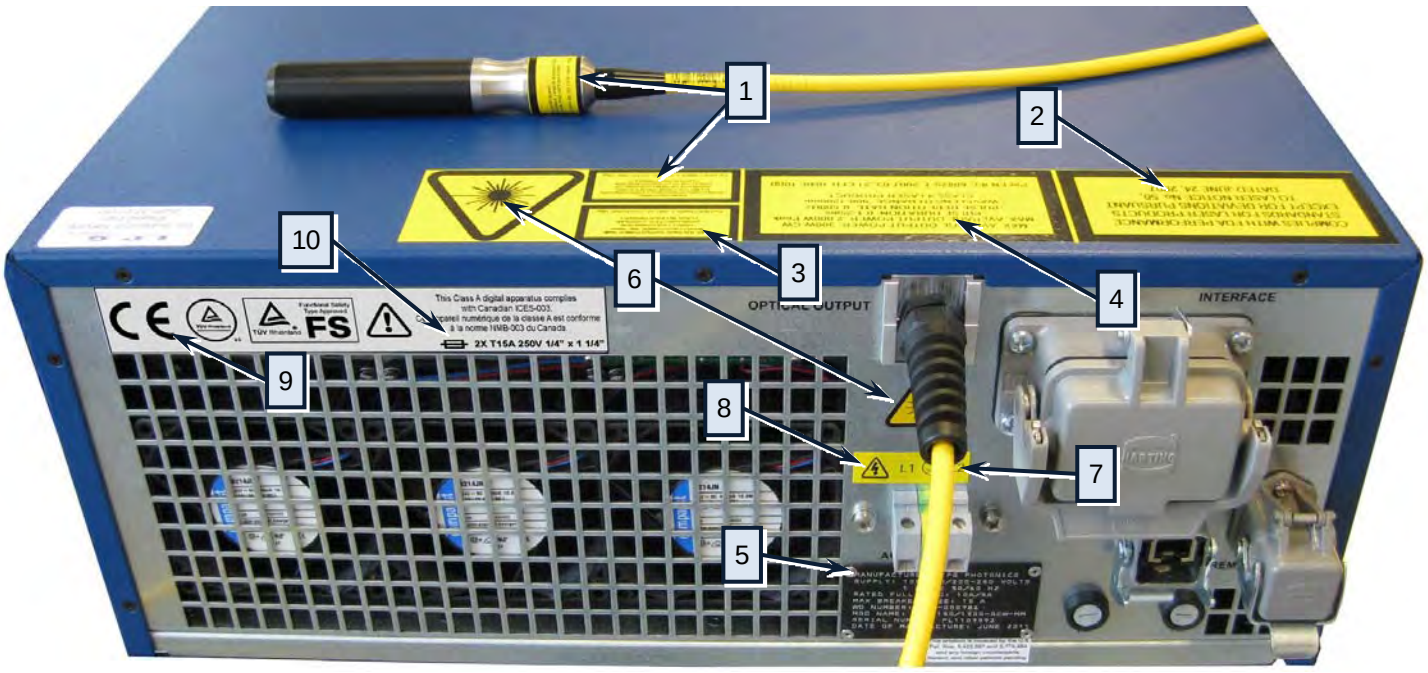
⚠ Warning: Use of controls or adjustments, or performance of procedures other than those specified herein, may result in hazardous radiation exposure.

⚠ Caution: Use of the system in a manner other than that described herein may impair the protection provided by the system.

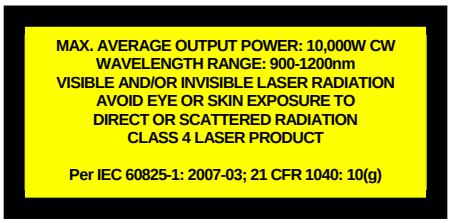
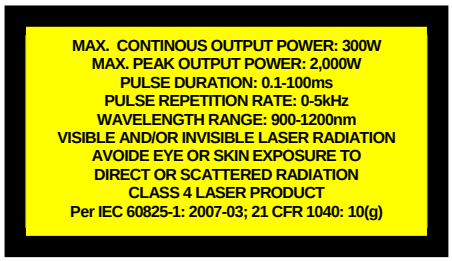
Safety Label Locations

Figure 1: Safety Label Locations show the required laser safety labels and the locations. These include warning labels indicating removable or displaceable protective housings, apertures through which laser radiation is emitted and labels of certification and identification [CFR 1040.10(g), CFR 1040.2, and CFR 1010.3/EN60825-1, Clause 5].

Figure 1: Safety Label Locations



AVOID EXPOSURE- VISIBLE AND/OR INVISIBLE LASER RADIATION IS EMITTED FROM THIS APERTURE Per IEC 60825-1-2007-03; 21 CFR 1040: 10(g)	COMPLIES WITH FDA PERFORMANCE STANDARDS FOR LASER PRODUCTS EXCEPT FOR DEVIATIONS PURSUANT TO LASER NOTICE No. 50, DATED JUN 24, 2007	MAX.AVERAGE OUTPUT POWER: 1mW WAVELENGTH RANGE: 600-700nm VISIBLE AND/OR LASER RADIATION DO NOT STARE INTO THE BEAM OR VIEW DIRECTLY WITH OPTICAL INSTRUMENTS CLASS 2M LASER PRODUCT Per IEC 60825-1-2007-03; 21 CFR 1040: 10(g)
1. Aperture Label	2. FDA Compliance (for US product)	3. Class 2M Laser Product Label for Guide Laser
MAX. AVERAGE OUTPUT POWER: 50W CW WAVELENGTH RANGE: 900-1200nm VISIBLE AND/OR INVISIBLE LASER RADIATION AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION CLASS 4 LASER PRODUCT Per IEC 60825-1: 2007-03; 21 CFR 1040: 10(g)	MAX. AVERAGE OUTPUT POWER: 50W CW WAVELENGTH RANGE: 900-1200nm VISIBLE AND/OR INVISIBLE LASER RADIATION AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION CLASS 4 LASER PRODUCT Per IEC 60825-1: 2007-03; 21 CFR 1040: 10(g)	MAX. AVERAGE OUTPUT POWER: 100W CW WAVELENGTH RANGE: 900-1200nm VISIBLE AND/OR INVISIBLE LASER RADIATION AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION CLASS 4 LASER PRODUCT Per IEC 60825-1: 2007-03; 21 CFR 1040: 10(g)
4. Class 4 Laser Product (Models: YLR-5, YLR-10)	4. Class 4 Laser Product (Models: YLR-20, YLR-30)	4. Class 4 Laser Product (Models: YLR-50)
MAX. AVERAGE OUTPUT POWER: 250W CW WAVELENGTH RANGE: 900-1200nm VISIBLE AND/OR INVISIBLE LASER RADIATION AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION CLASS 4 LASER PRODUCT Per IEC 60825-1: 2007-03; 21 CFR 1040: 10(g)	MAX. AVERAGE OUTPUT POWER: 500W CW WAVELENGTH RANGE: 900-1200nm VISIBLE AND/OR INVISIBLE LASER RADIATION AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION CLASS 4 LASER PRODUCT Per IEC 60825-1: 2007-03; 21 CFR 1040: 10(g)	MAX. AVERAGE OUTPUT POWER: 1000W CW WAVELENGTH RANGE: 900-1200nm VISIBLE AND/OR INVISIBLE LASER RADIATION AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION CLASS 4 LASER PRODUCT Per IEC 60825-1: 2007-03; 21 CFR 1040: 10(g)
4. Class 4 Laser Product (Models: YLR-100)	4. Class 4 Laser Product (Models: YLR-200, YLR-300)	4. Class 4 Laser Product (Models: YLR-400, YLR-500, YLR-600, YLR-700)

		
4. Class 4 Laser Product (Models: YLR-1000)	4. Class 4 Laser Product (Models: QCW)	5. Identification Plate(Products Made in the United States)[1]
5. Identification Plate (Products Made in Germany)[2]	6. Laser Radiation Hazard Label	7. PROTECTIVE CONDUCTOR TERMINAL[3]
8. Electrical Hazard Label	9. CE Compliance[4]	10. FUSE[5]

Laser Radiation Emission Indicator

The laser is equipped with a laser radiation emission indicator light located on the front panel (see Figure 5: Front Panel Layout). The laser radiation emission indicator is turned on when laser emission is present [CFR 1040.10(f)(5)/EN 60825-1, clause 4.7].

General Safety Instructions

⚠ Warning: You must exercise caution to avoid/minimize specular reflections as these reflections occur at the laser's wavelength and are invisible!

Specular Reflections

[1] Refer to Table 3 for Model Designation Codes.
[2] Refer to Table 3 for Model Designation Codes.
[3] This symbol is specifically reserved for the PROTECTIVE CONDUCTOR TERMINAL and no other. It is placed at the equipment earthing point and is mandatory for all grounded equipment

Often there can be numerous secondary laser beams produced at various angles near the laser. These beams are called specular reflections and are produced when the laser reflects off a smooth surface of the primary beam. Although these secondary beams may be less powerful than the total power emitted from the laser, the intensity may be great enough to cause damage to the eyes and skin as well as materials surrounding the laser.

Equipment and Solvents

Light-sensitive elements in equipment, such as video cameras, photomultipliers and photodiodes may also be damaged from exposure to the laser light.

⚠ Caution: The laser light is strong enough to cut or weld metal, burn skin, clothing and paint. In addition, this light can ignite volatile substances such as alcohol, gasoline, ether and other solvents.

Exposure to solvents or other flammable materials and gases must be avoided and must be relocated away from this device.

Safety Recommendations

IPG recommends that you follow these procedures to operate the IPG laser safely:

- Never look directly into the laser output port when power is supplied to the laser.
- Avoid positioning the laser and all optical components at eye level.
- Provide enclosures for laser beam.
- Ensure that all personal protective equipment (PPE) is suitable for the output power and wavelength range listed on the laser safety labels that are affixed to the product.
- Use the laser in a room with access controlled by door interlocks. Post warning signs. Limit access to the area to individuals who are trained in laser safety while operating the laser.
- Avoid using the laser in a darkened environment.
- Do not enable the laser without a coupling fiber or equivalent attached to the optical output connector.
- Always switch the laser off when working with the output such as mounting the fiber or collimator into a fixture, etc. If necessary, align the output at low output power and then increase the output power gradually.
- Do not install or terminate fibers or collimators when laser is active.
- If this instrument is used in a manner not specified in this document, the protection provided by the instrument may be impaired and the warranty will be voided.

Optical Safety

⚠ Caution: If the output of the device is delivered through a lens with an anti-reflection coating, make sure that the lens is of good quality and clean. For cleaning instructions, refer to the "Optical Fiber Connector Inspection and Cleaning Guide".

Any dust on the end of the collimator assembly can burn the lens and damage the laser.

Hot or molten pieces of metal may be present when using this laser. Exercise caution if debris is being generated in your application.

Electrical Safety

⚠ **Warning: The input voltage to the laser is potentially lethal. All electrical cables and connections should be treated as if it were a harmful level. All parts of the electrical cable, connector or device housing should be considered dangerous.**

1. Make sure this instrument is properly grounded through the protective conductor of the AC power cable. Any interruption of the protective grounding conductor from the protective earth terminal can result in personal injury.
2. Always use your device in conjunction with properly grounded power source.
3. For continued protection against fire hazard, replace the line fuses (if applicable) with only the same types and ratings. The use of other fuses or material is prohibited.
4. Before supplying the power to the instrument, make sure that the correct voltage of the AC power source is used. Failure to use the correct voltage could cause damage to the instrument.
5. Before switching the power on, ensure that line voltage corresponds to the specified level.
6. There are no operator serviceable parts inside. Refer all servicing to qualified IPG personnel. To prevent electrical shock, do not remove covers. Any tampering with the product will void the warranty.

Environmental Safety

⚠ **Warning: Never look directly into a live fiber or collimator and make sure that you wear appropriate laser safety eyewear at all times while operating the product.**

Proper enclosures must be used to secure a laser safe work area. This includes but is not limited to laser safety signs, interlocks, appropriate warning devices and training/safety procedures. In addition, it is important to install the output assembly away from eye level.

⚠ **Warning: Ensure that all personal protective equipment (PPE) is suitable for the output power and wavelength range listed on the laser safety labels that are affixed to the product.**

The interaction between the laser and the material being processed can also generate high intensity UV and visible radiation. Ensure that all laser enclosures are in place to prevent eye damage from visible radiation.

⚠ **Caution: Damage to the laser is possible, unless caution is employed in operating the device.**

IPG provides the following recommendations to promote the long life of the IPG laser:

- Do not expose the device to a high moisture environment (>95% humidity).

⚠ **Water-cooled lasers must not operate at temperatures below the respective ambient dewpoint (see Figure 2)**

Figure 2: Dewpoint Table

AMBIENT DEWPOINT[1]										
Room Temperature	Maximum Relative Humidity									
	10%	20%	30%	40%	50%	60%	70%	80%	90%	95%
10 °C	-20	-11.9	-6.8	-3.0	0.6	2.6	4.8	7.6	8.4	9.2
15 °C	-16.4	-7.9	-2.4	1.5	4.7	7.3	9.6	11.6	13.4	14.2
20 °C	-12.5	-3.7	1.9	6.0	9.25	12.0	14.4	16.4	18.3	19.2
25 °C	-8.7	0.5	6.2	10.5	13.8	16.7	19.1	21.3	23.2	24.1
30 °C	-5.0	4.6	10.5	15.0	18.4	21.4	23.9	26.2	28.2	29.1
40 °C	2.6	12.7	19.1	23.8	27.6	30.7	33.5	35.9	38.0	39.0
50 °C	10.0	20.8	27.6	32.6	36.7	40.0	43.0	45.6	47.9	49.0
	Laser Operating Temperature Range									

- The device may have fans for active cooling. Make sure there is sufficient airflow to cool the device, any objects or debris that cover the ventilation holes must be removed at all times.
- Operation at higher temperatures will accelerate aging, increase threshold current and lower slope efficiency. If the device is overheated, do not use it and call IPG for assistance.
- Ensure that the work area is properly vented. Gases, sparks and debris that can be generated from interaction between the laser and the work surface can pose additional safety hazards.
- Inspect the filter media weekly and clean or replace as needed. Refer to “Replacing the Filter Media” section.

[1] These values are calculated using the August-Roche-Magnus approximation.

Additional Safety Resources

For additional information regarding Laser Safety, please refer to the list below:

Laser Institute of America (LIA)
13501 Ingenuity Drive, Suite 128
Orlando, Florida 32826
Phone: 407.380.1553, Fax: 407.380.5588
Toll Free: 1.800.34.LASER

American National Standards Institute
ANSI Z136.1, American National Standard for the Safe Use of Lasers
(Available through LIA)

International Electro-technical Commission
IEC 60825-1, Edition 1.2
Safety of laser products –
Part 1:
Equipment classification, requirements and user's guide.
(Available through LIA)

Center for Devices and Radiological Health
21 CFR 1040.10 – Performance Standards for Light-Emitting Products

US Department of Labor – OSHA
Publication 8-1.7 – Guidelines for Laser Safety and Hazard Assessment.

Laser Safety Equipment
Laurin Publishing
Laser safety equipment and Buyer's Guides

IPG Photonics recommends that the user of this product investigate any local, state or country requirements as well as facility or building requirements that may apply to installing or using a laser or laser system.

L'INFORMATION DE SÛRETÉ (SAFETY INFORMATION)

Conventions de Sûreté

Mots et symboles d'utilisations de ce guide d'utilisateur de divers (Tableau 2) sont conçus pour attirer votre attention sur des risques ou l'information importante.

SYMBOLE	DESCRIPTION
Ou	AVERTISSEMENT : Se rapporte à un risque personnel potentiel. (Élém. élect.) (Rayonnement de laser) Il exige un procédé qui, sinon correctement suivi, peut avoir comme conséquence le mal corporel à toi et/ou à d'autres. Ne procédez pas au delà du panneau d'AVERTISSEMENT jusqu'à ce que vous complètement comprenniez et rencontriez les conditions priées.
	ATTENTION : Se rapporte à un risque potentiel de produit. Il exige un procédé qui, sinon correctement suivi, peut avoir comme conséquence les dommages ou la destruction au produit ou aux composants. Ne procédez pas au delà du signe d'ATTENTION jusqu'à ce que vous complètement comprenniez et rencontriez les conditions priées.
AUCUN SYMBOLE	IMPORTANT : Se rapporte à n'importe quelle information concernant l'opération du produit. Veuillez ne pas donner sur cette information.

Tableau 2: Symboles de sûreté de guide d'utilisateur

Dispositifs et conformité de sûreté aux conditions de gouvernement

Conformité aux normes de normalisation (sur les unités applicables)

EMC Émissions:
- EN 55011:2009 + A1:2010
- CISPR 11:2009 + A1:2010
- FCC Classe A

EMC Immunité:
- EN 61000-3-2:2006+A1:2009+A2:2009
- EN 61000-3-3:2008
- EN 61326-1:2006
- EN 61000-4-2:2009
- EN 61000-4-3:2006 + A1:2007 + A2:2010
- EN 61000-4-4:2004+A1:2010
- EN 61000-4-5:2006
- EN 61000-4-6:2009
- EN 61000-4-11:2004

EMC autre :
- Cet appareillage numérique de la Classe A est conforme à la sûreté Canadienne d'ICES-003.

Sûreté Électrique :
- En 61010-1 : Sûreté

2001 de Laser :
- En 60825-1 : 2007
- Sûreté Fonctionnelle de CDRH 21

CFR 1040.10 :
- OIN 13849-1 D'EN : 2008 + A1 : 2009 Cat.3/PL d

Compatibilité Électromagnétique

La conformité de ce laser avec les conditions d'EMC est certifiée par la marque de la CE s'identifié par l'étiquette de la CE (Figure 3, point 8).

Les conditions européennes pour la conformité électromagnétique sont définies dans la “Directive d'EMC”. La conformité au “EMC” est réalisée par la conformité aux normes harmonisées EN55011 pour l'émission et l'en 61326-1 : 2006 pour l'immunité. Le laser répond aux exigences d'émission pour la Classe A, groupent 1 comme indiqué dans EN55011.

Classification de Laser

Les normes et les conditions gouvernementales indiquent que des lasers doivent être classifiés selon leur de puissance de sortie ou énergie et la longueur d'onde de laser. Tous les lasers de YLR-Séries sont classifiés comme instrument de laser de la Classe 4 de puissance élevée au-dessous de 21 CFR, le sous-chapitre J, la partie II, 1040.10 (d). Selon les normes de la Communauté Européenne, ce dispositif est classifié comme Classe 4 basée sur en 60825-1, la clause 9.
Ce produit émet un rayon laser invisible à ou autour d'une longueur d'onde de **1070 nm**, et la puissance lumineuse totale rayonnée par la sortie optique est supérieure à **20 à 1500 W** (selon le modèle) par port de sortie optique. L'exposition directe ou indirecte de ce niveau d'intensité de la lumière peuvent causer des dommages à l'œil ou la peau. Malgré les radiations étant invisible, le faisceau peut causer des

dommages irréversibles à la rétine et / ou de la cornée. Appropriée et approuvée lunettes de sécurité laser doit être porté en tout temps alors que le laser est opérationnel.

⚠ Avertissement : Vous devez employer la sûreté de laser appropriée eyewear en actionnant ce dispositif. Le choix de la sûreté de laser appropriée eyewear exige de l'utilisateur d'identifier exactement la gamme des longueurs d'onde émises de ce produit. Si le dispositif est un laser ou un produit réglable de Raman, il émettra la lumière sur une gamme des longueurs d'onde.

⚠ L'utilisateur doit s'assurer que l'eyewear de sûreté de laser utilisé se protège contre la lumière émise par le dispositif sur sa gamme entière des longueurs d'onde. Veuillez passer en revue la sûreté marquant sur le produit (Figure 3) et vérifient que le matériel de protection personnel (par exemple. les clôtures, les fenêtres ou les viewports de visionnement, eyewear, etc.) étant utilisé est proportionné pour les gammes de puissance de sortie et de longueurs d'onde énumérées sur le produit.

⚠ Les fournisseurs comprennent LaserVision Etats-Unis, Kentek Corporation et Rockwell Laser Industries offrir ce matériel de sécurité laser et / ou de matériel. Il existe d'autres laser personnelle fournisseurs d'équipement de protection. IPG fournit les noms de ces fournisseurs uniquement comme une commodité et ne cautionne ni ne recommande aucun d'entre eux, ou leurs produits ou services. Par ailleurs, l'IPG n'assume aucune responsabilité pour toute leurs recommandations, les produits ou services.

Si le laser est utilisé dans une nouvelle installation ou pour monter en rattrapage un système existant, l'utilisateur est seulement responsable de déterminer la convenance de tout le matériel de protection personnel.

⚠ Attention : N'installez pas ou ne terminez pas les fibres ou les collimateurs quand le laser est en activité.

Contrôle des Clés

L'instrument ne peut pas être mis en marche ou actionné jusqu'à ce que le keyswitch de système soit dans la position de fonctionnement [CFR 1040.10 (f) (4) /EN 60825-1, la clause 4.6].

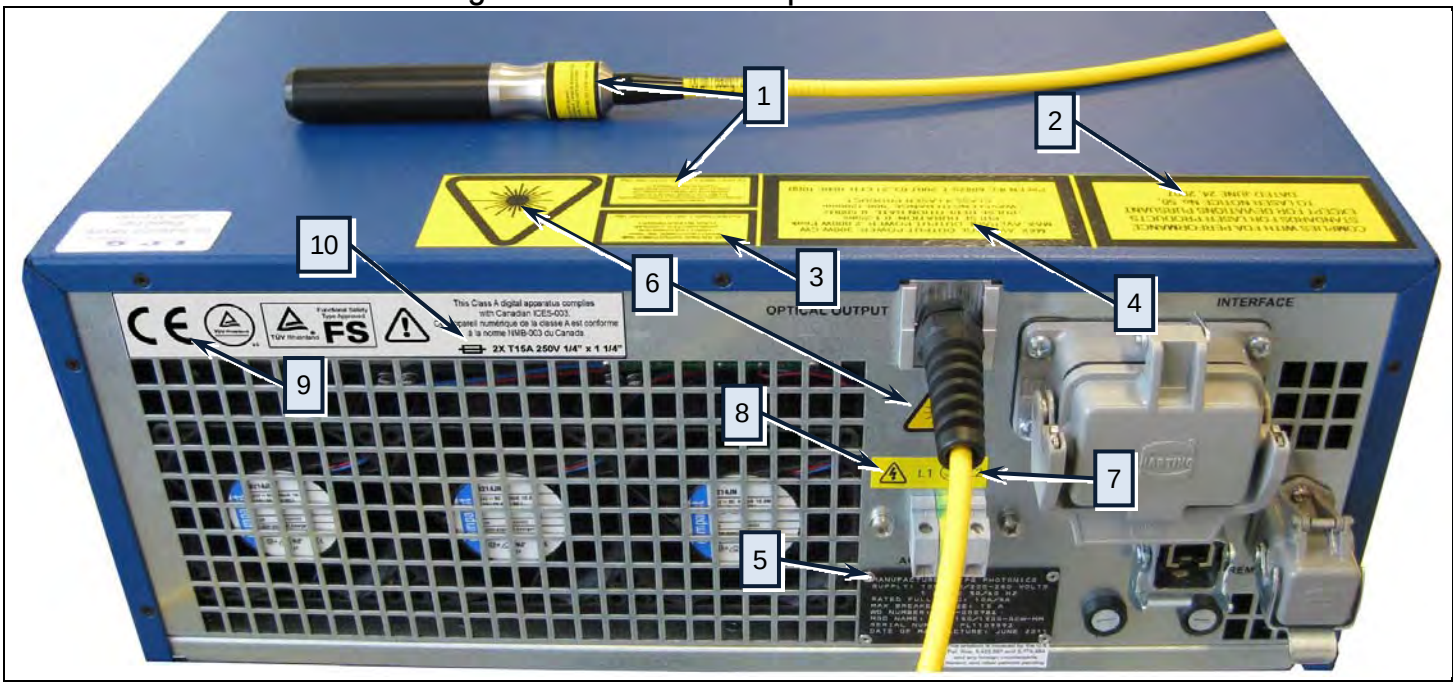
⚠ Avertissement : L'utilisation des commandes ou des ajustements, ou l'exécution des procédures autres que ceux indiquées ci-dessus, peut avoir comme conséquence l'exposition de la radiation dangereuse.

⚠ Attention : L'utilisation du système en quelque sorte autre que cela décrit ci-dessus peut altérer la protection fournie par le système.

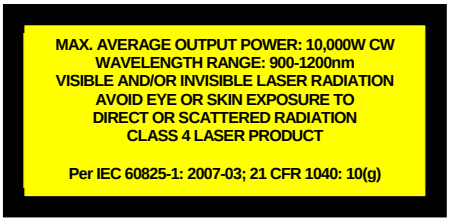
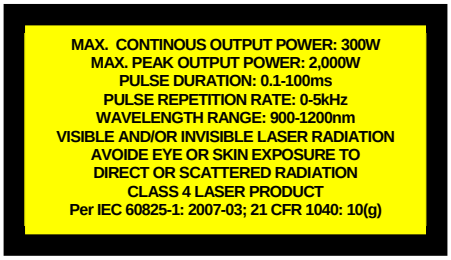
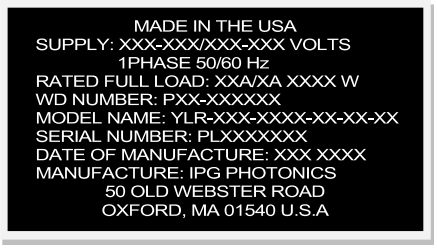
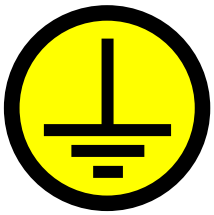
Endroits D'étiquette de Sûreté

Figure 3: Endroits D'étiquette de Sûreté montrer les étiquettes requises de sécurité laser et les emplacements. Il s'agit notamment des étiquettes d'avertissement indiquant amovible ou déplaçable boîtiers de protection, des ouvertures à travers lesquelles le rayonnement laser est émis et les étiquettes de certification et d'identification [CFR 1040.10 (g), CFR 1040.2, et CFR 1010.3/EN60825-1, la clause 5].

Figure 3: Endroits D'étiquette de Sûreté



AVOID EXPOSURE- VISIBLE AND/OR INVISIBLE LASER RADIATION IS EMITTED FROM THIS APERTURE Per IEC 60825-1-2007-03; 21 CFR 1040: 10(g)	COMPLIES WITH FDA PERFORMANCE STANDARDS FOR LASER PRODUCTS EXCEPT FOR DEVIATIONS PURSUANT TO LASER NOTICE No. 50, DATED JUN 24, 2007	MAX.AVERAGE OUTPUT POWER: 1mW WAVELENGTH RANGE: 600-700nm VISIBLE AND/OR LASER RADIATION DO NOT STARE INTO THE BEAM OR VIEW DIRECTLY WITH OPTICAL INSTRUMENTS CLASS 2M LASER PRODUCT Per IEC 60825-1-2007-03; 21 CFR 1040: 10(g)
1. ouverture étiquette	2. Conformité FDA (pour les produits américains)	3. Classe Label 2M produit laser pour guide laser
MAX. AVERAGE OUTPUT POWER: 50W CW WAVELENGTH RANGE: 900-1200nm VISIBLE AND/OR INVISIBLE LASER RADIATION AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION CLASS 4 LASER PRODUCT Per IEC 60825-1: 2007-03; 21 CFR 1040: 10(g)	MAX. AVERAGE OUTPUT POWER: 50W CW WAVELENGTH RANGE: 900-1200nm VISIBLE AND/OR INVISIBLE LASER RADIATION AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION CLASS 4 LASER PRODUCT Per IEC 60825-1: 2007-03; 21 CFR 1040: 10(g)	MAX. AVERAGE OUTPUT POWER: 100W CW WAVELENGTH RANGE: 900-1200nm VISIBLE AND/OR INVISIBLE LASER RADIATION AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION CLASS 4 LASER PRODUCT Per IEC 60825-1: 2007-03; 21 CFR 1040: 10(g)
4. Produit laser de classe 4 (Modèles: YLR-5, YLR-10)	4. Produit laser de classe 4 (Modèles: YLR-20, YLR-30)	4. Produit laser de classe 4 (Modèles: YLR-50)
MAX. AVERAGE OUTPUT POWER: 250W CW WAVELENGTH RANGE: 900-1200nm VISIBLE AND/OR INVISIBLE LASER RADIATION AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION CLASS 4 LASER PRODUCT Per IEC 60825-1: 2007-03; 21 CFR 1040: 10(g)	MAX. AVERAGE OUTPUT POWER: 500W CW WAVELENGTH RANGE: 900-1200nm VISIBLE AND/OR INVISIBLE LASER RADIATION AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION CLASS 4 LASER PRODUCT Per IEC 60825-1: 2007-03; 21 CFR 1040: 10(g)	MAX. AVERAGE OUTPUT POWER: 1000W CW WAVELENGTH RANGE: 900-1200nm VISIBLE AND/OR INVISIBLE LASER RADIATION AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION CLASS 4 LASER PRODUCT Per IEC 60825-1: 2007-03; 21 CFR 1040: 10(g)
4. Produit laser de classe 4 (Modèles: YLR-100)	4. Produit laser de classe 4 (Modèles: YLR-200, YLR-300)	4. Produit laser de classe 4 (Modèles: YLR-400, YLR-500, YLR-600, YLR-700)

		
4. Produit laser de classe 4 (Modèles: YLR-1000)	4. Produit laser de classe 4 (Modèles: QCW)	5. Plaque d'identification (Produits Fabriqué aux États-Unis)[1]
		
5. Plaque d'identification (Produits fabriqués en Allemagne)[2]	6. Etiquette laser risque d'irradiation	7. TERMINAL DE PROTECTION CONDUCTEUR[3]
8. Etiquette de risque électrique	9. conformité CE[4]	10. FUSIBLE[5]

Indicateur D'émission de Rayonnement de Laser

Le laser est équipé d'un voyant de signalisation d'émission de rayonnement de laser situé sur le panneau plan (Figure 5: Front Panel Layout). L'indicateur principal d'émission de rayonnement de laser est tourné sur quand l'émission de laser est présente [CFR 1040.10 (f) (5)/EN 60825-1, la clause 4.7].

Instructions de Sûreté Générales

⚠ Avertissement : Vous devez exercer l'attention pour éviter/réduisez au minimum des réflexions spéculaires pendant que ces réflexions se produisent à la longueur d'onde du laser et sont invisibles!

Réflexions Spéculaires

Souvent, on peut être nombreux faisceaux laser secondaires produites à différents angles près du laser. Ces faisceaux sont appelés reflets spéculaires et sont produites lorsque le laser se réfléchit sur une

[1] Refer to Table 3 for Model Designation Codes.
[2] Refer to Table 3 for Model Designation Codes.
[3] This symbol is specifically reserved for the PROTECTIVE CONDUCTOR TERMINAL and no other. It is placed at the equipment earthing point and is mandatory for all grounded equipment
[4] This label indicates compliance with CE marking requirements.
[5] This symbol is accompanied with type and rating (e.g. T15A, 250VAC, ¼ x 1-1/4)

surface lisse du faisceau primaire. Bien que ces faisceaux secondaires peuvent être moins puissante que la puissance totale émise par le laser, l'intensité peut être suffisamment importante pour causer des dommages aux yeux et la peau ainsi que des matériaux entourant le laser.

Équipement et Dissolvants

Des éléments sensibles à la lumière dans l'équipement, tel que les appareils-photo visuels, les photomultiplicateurs et des photodiodes peuvent également être endommagés de l'exposition à la lumière de laser.

⚠ **Attention : La lumière de laser est assez forte pour couper ou souder le métal, la peau de brûlure, l'habillement et la peinture. En outre, cette lumière peut mettre à feu les substances volatiles telles que l'alcool, l'essence, l'éther et d'autres dissolvants.**

L'exposition aux dissolvants ou d'autres matériaux et gaz inflammables doit être évitée et doit être replacée loin de ce dispositif.

Recommandations de Sûreté

IPG recommande que vous suivez ces procédures pour actionner le laser d'IPG sans risque:

- Ne regardez jamais directement dans le port de rendement de laser quand le courant est rétabli.
- Ne jamais regarder directement dans le port de sortie du laser lorsque l'alimentation est fournie au laser.
- Fournissez les clôtures pour le rayon laser.
- Assurez-vous que tout le matériel de protection personnel (PPE) convient à la gamme de puissance de sortie et de longueurs d'onde énumérée sur les étiquettes de sûreté de laser qui sont apposées au produit.
- Utilisez le laser dans une chambre avec l'accès commandé par des couplages de porte. Panneaux d'avertissement de poteau. Limitez l'accès au secteur aux individus qui sont formés dans la sûreté de laser tout en actionnant le laser.
- Évitez d'à l'aide du laser dans un environnement obscurci.
- Ne permettez pas le laser sans fibre ou équivalent d'accouplement fixé au connecteur de débit optique.
- Commutez toujours le laser outre de en travaillant avec le rendement tel que monter la fibre ou le collimateur dans un montage, etc. Au besoin, alignez le rendement à bas de puissance de sortie et puis augmentez le de puissance de sortie graduellement.
- N'installez pas ou ne terminez pas les fibres ou les collimateurs quand le laser est en activité.
- Si cet instrument est utilisé en quelque sorte non indiqué dans ce document, la protection fournie par l'instrument peut être altérée et la garantie sera vidée.

Sûreté Optique

⚠ Attention : Si le rendement du dispositif est fourni par un objectif avec un enduit d'antiréflexion assurez-vous que l'objectif est de la bonne qualité et nettoyez. Pour des instructions de nettoyage, référez-vous "Optical Fiber Connector Inspection and Cleaning Guide".

Toute poussière sur la fin du collimateur peut brûler l'objectif et endommager le laser. Vérifiez la qualité de la tache émise du rendement de laser aux niveaux de basse puissance en utilisant une visionneuse infrarouge et puis augmentez graduellement le de puissance de sortie.

Les morceaux chauds ou fondus de métal peuvent être présents à l'aide de ce laser. Exercez l'attention si des débris sont produits dans votre application.

Sûreté Électrique

⚠ Avertissement : La tension d'entrée au laser est potentiellement mortelle. Tous les câbles et raccordements électriques devraient être traités comme si c'étaient un niveau nocif. Toutes les pièces du logement électrique de câble, de connecteur ou de dispositif devraient être considérées dangereuses.

- Assurez-vous que cet instrument est correctement fondu par le conducteur protecteur du câble de courant alternatif. N'importe quelle interruption du conducteur fondant protecteur de la borne protectrice de la terre peut avoir comme conséquence des blessures.
- Utilisez toujours votre dispositif en même temps que la source correctement au sol de puissance.
- Pour la protection continue contre le risque d'incendie, remplacez la ligne fusibles (si c'est approprié) avec seulement les mêmes types et estimations. L'utilisation d'autre fond ou le matériel est interdit.
- Avant d'assurer la puissance à l'instrument, assurez-vous que la tension correcte de la source de courant alternatif Est employée. Le manque d'employer la tension correcte a pu endommager l'instrument.
- Avant que commutant la puissance assurez-vous dessus que tension secteur correspond au niveau indiqué.
- Il n'y a aucune pièce utile d'opérateur à l'intérieur. Référez-vous tous qui entretiennent au personnel qualifié d'IPG. Pour empêcher le choc électrique, n'enlevez pas les couvertures. Trifouillant le produit en videront la garantie.

Sûreté Environnementale

⚠ Avertissement : Ne regardez jamais directement dans une fibre ou un collimateur de phase et assurez-vous que vous portez la sûreté de laser appropriée eyewear à tout moment tout en actionnant le produit.

Des clôtures appropriées devraient être employées pour fixer une zone de travail sûre de laser. Ceci inclut mais n'est pas limité aux signes de sûreté de laser, aux couplages, aux dispositifs et à la formation d'avertissement appropriée/aux procédures de sûreté. En outre, il est important d'installer le montage de rendement loin de la hauteur d'oeil.

⚠ **Avertissement : Assurez-vous que tout le matériel de protection personnel (PPE) convient à la gamme de puissance de sortie et de longueurs d'onde énumérée sur les étiquettes de sûreté de laser qui sont apposées au produit.**

L'interaction entre le laser et le matériel étant traités peut également produire du rayonnement UV et évident de forte intensité. Assurez-vous que toutes les clôtures de laser sont en place pour empêcher des dommages d'oeil du rayonnement évident.

⚠ **Attention Les dommages au laser est possible, sauf si la prudence est employée dans l'exploitation du dispositif.**

IPG fournit les recommandations suivantes de favoriser le de longue vie du laser d'IPG :

- Ne pas exposer l'appareil à un environnement très humide (humidité> 95%).

⚠ **Refroidie par eau lasers ne doit pas fonctionner à des températures inférieures au point de rosée respectifs ambiante**

Figure 4: Tableau Point de rosée

AMBIENT DEWPOINT[1]										
Température ambiante	Humidité relative maximale									
	10%	20%	30%	40%	50%	60%	70%	80%	90%	95%
10 °C	-20	-11.9	-6.8	-3.0	0.6	2.6	4.8	7.6	8.4	9.2
15 °C	-16.4	-7.9	-2.4	1.5	4.7	7.3	9.6	11.6	13.4	14.2
20 °C	-12.5	-3.7	1.9	6.0	9.25	12.0	14.4	16.4	18.3	19.2
25 °C	-8.7	0.5	6.2	10.5	13.8	16.7	19.1	21.3	23.2	24.1
30 °C	-5.0	4.6	10.5	15.0	18.4	21.4	23.9	26.2	28.2	29.1
40 °C	2.6	12.7	19.1	23.8	27.6	30.7	33.5	35.9	38.0	39.0
50 °C	10.0	20.8	27.6	32.6	36.7	40.0	43.0	45.6	47.9	49.0
	Laser Range Température de fonctionnement									

- Le dispositif peut avoir des ventilateurs pour le refroidissement actif. Assurez-vous qu'il y a flux d'air suffisant pour refroidir le dispositif, tous les objets ou des débris qui couvrent les trous de ventilation doivent être enlevés à tout moment.
- L'opération à températures élevées veulent accélèrent le vieillissement, l'efficacité courante et inférieure de seuil d'augmentation de pente. Si le dispositif est surchauffé, ne l'employez pas et n'appelez pas IPG pour l'aide.
- Assurez-vous que la zone de travail est correctement exhalée. Les gaz, les étincelles et les débris qui peuvent être produits de l'interaction entre le laser et la surface de travail peuvent poser des risques en matière de sécurité additionnels.
- Inspectez les médias de filtrage par semaine et nettoyez ou les remplacez comme nécessaire. Référez-vous à la section “Replacing the Filter Media“.

[1] These values are calculated using the August-Roche-Magnus approximation.

Ressources Additionnelles de Sûreté

Pour l'information additionnelle concernant la sûreté de laser référez-vous svp à la liste ci-dessous :

Laser Institute of America (LIA)
13501 Ingenuity Drive, Suite 128
Orlando, Florida 32826
Phone: 407.380.1553, Fax: 407.380.5588
Toll Free: 1.800.34.LASER

American National Standards Institute
ANSI Z136.1, American National Standard for the Safe Use of Lasers
(Available through LIA)

International Electro-technical Commission
IEC 60825-1, Edition 1.2
Safety of laser products –
Part 1:
Equipment classification, requirements and user's guide.
(Available through LIA)

Center for Devices and Radiological Health
21 CFR 1040.10 – Performance Standards for Light-Emitting Products

US Department of Labor – OSHA
Publication 8-1.7 – Guidelines for Laser Safety and Hazard Assessment.

Laser Safety Equipment
Laurin Publishing
Laser safety equipment and Buyer's Guides

IPG Photonics recommande que l'utilisateur de ce produit étudient n'importe quels gens du pays, conditions d'état ou de pays aussi bien que le service ou conditions de bâtiment qui peuvent s'appliquer à installer ou à employer un laser ou le système de laser.

PRODUCT DESCRIPTION

The YLR-Series Ytterbium Fiber Laser was developed for use in industrial applications. This laser is compact and efficient allowing them to be replacing bulky and less efficient lasers. Main application are welding, cutting and brazing.

Main Features:

- High quality fiber output
- High power
- Reliable, long lifetime
- Compact, rugged package
- Efficient
- External computer interface

Applications:

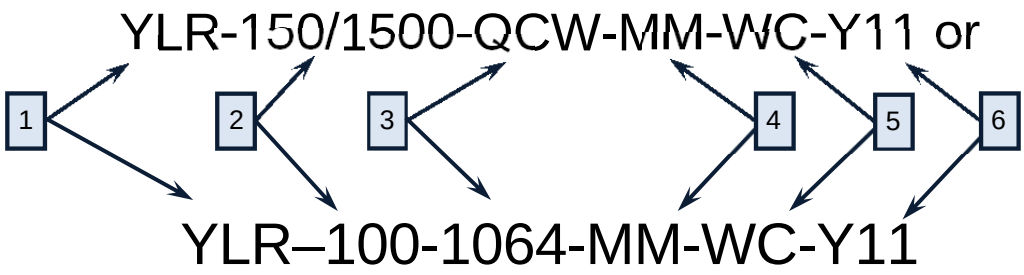
- Industrial applications
- Scientific research

Model Configuration

IPG offers many YLR configuration modes. This manual is designed to give complete instructions for all models. Therefore, specific difference in models will be noted where applicable.

Laser Model Designation Codes

Table 3 illustrates the model designation methodology of all YLR-Series lasers. In addition, models are also categorized according to chassis type with their respective “U” or Rack Unit code. The subsequent AC or WC code designates whether the model is Air Cooled or Water Cooled. The U categories offered are 3U-AC, 3U-WC, 4U-AC, 4U-WC and 6U-AC.



ITEM	CODE
1. "YLR"	Ytterbium Laser 19" Rack Mount
2. Power in W	Range of 20 to 1500 watts 150/1500 – average power / peak power
3. Wavelength in nm	Item is listed if wavelength is not standard. 1070 nm (Standard) QCW for quasi continuous wave models.
4. Polarization/Output Beam Characteristic	MM – for Multi-Mode LP – for Linearly Polarized If item is not listed then the beam is Single-Mode, Randomly Polarized.
5. Additional Information	WC – Water Cooled AC – Air Cooled
6. Additional Information	The last two digits of Model Year

AVAILABLE MODELS	
Category	**Model**
3U-AC	YLR-20, YLR-30, YLR-50, YLR-100-AC
3U-WC	YLR-100-WC, YLR-200-WC, YLR-300-WC, YLR-400-WC, YLR-500-WC, YLR-600-WC, YLR-700-WC
4U-AC	YLR-200-AC, YLR-300-AC, YLR-400-AC, YLR-150/1500-QCW-AC
4U-WC	YLR-1000-WC
6U-AC	YLR-500-AC, YLR-600-AC

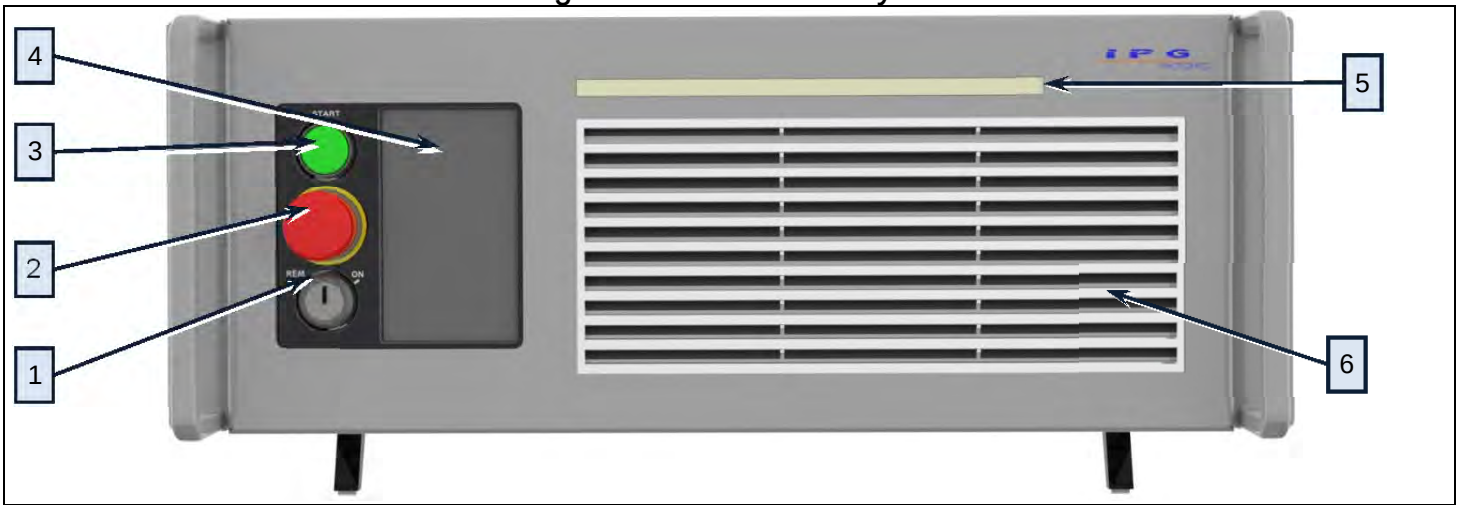
Table 3: Laser Models and Designation Codes

Certification

IPG certifies that this instrument has been thoroughly tested and inspected, and found to meet published specifications prior to shipping. Upon receiving your device, check the packaging and parts for any possible damage that may have occurred in transit. If damage is apparent, please contact IPG immediately.

Front Panel View

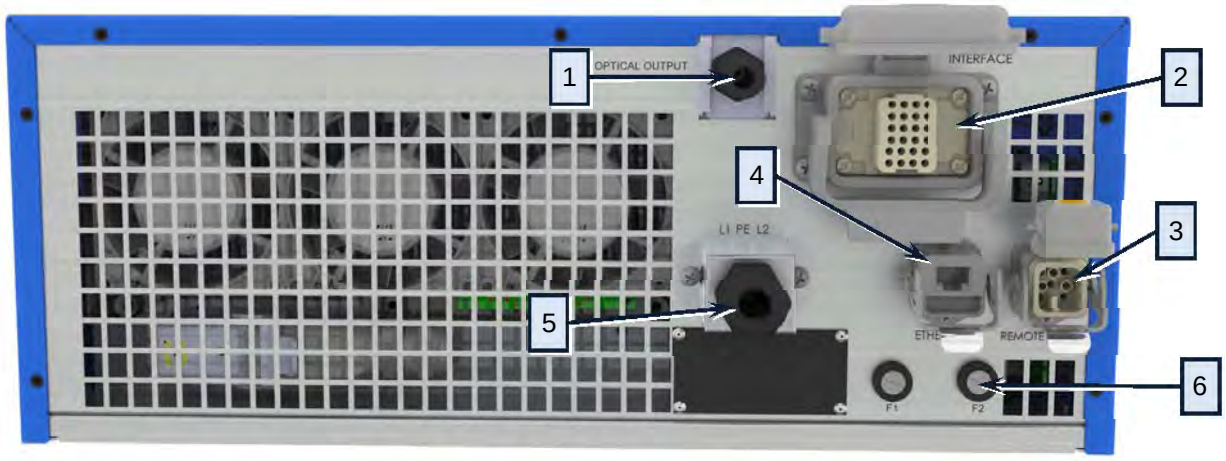
Figure 5: Front Panel Layout



ITEM	DESCRIPTION
1. Keyswitch	3-position key switch controls the laser operation mode: Left position – Remote mode, Central position – laser Off, Right position – Local mode. Note: The key cannot be removed in the Remote or Local mode positions.
2. Emergency Stop Button	Temporarily suspends power to the laser module. When active, main DC power supply is disabled. (Reset by turning clockwise or pulling out).
3. Start Button w/Indicator	When pressed, turns ON the internal main power supply of the laser assuming that the POWER key is in the LOCAL position. When the indicator is “ON” the internal power supply is active and the laser is capable of producing laser radiation.
4. Touch-screen Display	Is used to set device settings and to display measured parameters and alarm messages.
5. Emission On Indicator	LOCAL Mode: The indicator will blink for a short period after emission is enabled and before laser radiation is emitted. Once laser emission is “ON”, the indicator will be steady state “ON.” REMOTE Mode: The indicator is lit as soon as emission is enabled.
6. Front Bezel Panel	This is removed by pulling on each side to access the filter element (refer to Table 18: Replacement Parts).

Rear Panel View

Figure 6: Rear Panel Layout



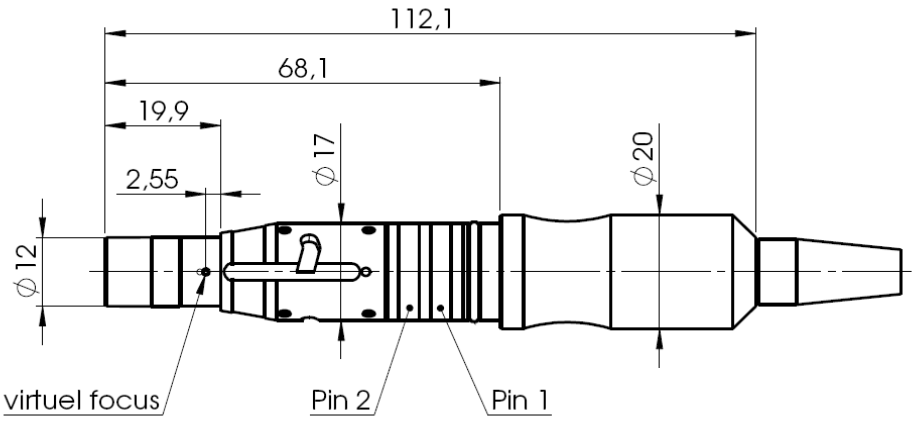
ITEM	DESCRIPTION
1. Laser Output (fiber removed)	The output of the laser (fiber cable) is delivered through this location.
2. Hardwiring Interface (24-pin)	24-pin connector provides digital interface or hardwiring control of the laser. See Table 4: 24-pin Connector Pinout for detailed information.
3. Hardwiring Interface (8-pin)	8-pin connector provides status of the Power Supply and E-Stop. See Table 5: 8-pin Connector Pinout for detailed information.
4. Ethernet	Ethernet Port
5. AC line input	3-pin screw terminal connector for AC input wiring. Refer to the SPECIFICATION YTTERBIUM FIBER LASER document included with this product to determine your models power requirement.
6. AC line fuses	Replaceable fuses F1, F2 (refer to Table 18: Replacement Parts)

Optical Output Fiber Terminations

Machines with a Connector

The end connector of the fiber (Figure 7) utilizes a protective cap that covers and protects the optical surface and electrical pins of the safety systems within the process fiber when not in use. These protective caps must be removed from the connectors when connecting the process fiber cable of the laser to an optical head. The protective caps should only be removed from the connectors immediately before optical cleaning and mounting in an adapter.

Figure 7: Optical Output Fiber Connector



Machines with a Collimator

Collimators come with a protective window that can be replaced if damaged. The collimator end cap must be removed prior to use and should be used when storing the machine. Cleaning of the protective window should be performed as needed using the same materials and techniques described in the “Optical Fiber Connector Inspection and Cleaning Guide” section.

Figure 8: Fiber End with Collimator

SPECIFICATIONS

Because the YLR-Series product line is extensive, all specifications for your specific model are listed in the supplemental document titled “SPECIFICATION YTTERBIUM FIBER LASER” included with your order.

Optical Specifications

Refer to the SPECIFICATION YTTERBIUM FIBER LASER document included with this product.

Electrical Specifications

Refer to the SPECIFICATION YTTERBIUM FIBER LASER document included with this product.

Environment Specifications

Refer to the SPECIFICATION YTTERBIUM FIBER LASER document included with this product.

External Layout and Dimensions

Refer to the SPECIFICATION YTTERBIUM FIBER LASER document included with this product.

UNPACKING INSTRUCTIONS

In order to minimize the risk of damage to your device IPG recommends that you unpack your laser using the following procedure.

Unpacking Procedure for Cardboard Box

Laser models that are smaller and relatively lighter are packaged in foam insulated cardboard boxes.

If the packaging shows any signs of external damage, check unit for damages and notify the shipping agent immediately.

Particular care must be taken when removing the unit from the packing case to ensure that the fiber optic cable is not broken or damaged. A comprehensive packing list is included with the system documentation. Upon receipt of the laser, check all items against this list and contact IPG immediately if any of the items are missing or if any damage to the unit is evident. If any damage to the unit is evident or suspected, do not attempt to install or operate the laser in any case.

See Figure 9 for illustrations regarding this procedure.

1. Place the package on a stable surface such as the floor or a large table.
2. For international shipments you will need to remove the external box to get the primary box
3. Open the primary box and remove the foam cover and store for later use.
4. Place the fiber on top of the unit and carefully lift it out of the box. IPG highly recommends two people to lift the unit at all times.
5. Open the internal box and remove the top foam insert.
6. Check the inventory of following items:
    - Cover, AC Power Inlet(P45-001394) – Qty. 1
    - Strain relief (P40-002294) – Qty. 2
    - Strain Relief Nut (P40-002293) – Qty. 1
    - Harting (24-pin) Interface Kit (P30-000721) – Qty. 1
        - Connector (P40-001344) – Qty. 1
        - Hood (P40-001343) – Qty.1
        - Cable Seal (P40-000891) – Qty. 1
        - Contact Pins (P40-000888) – Qty. 16
        - Contact Pins (P40-000887) – Qty. 10
    - Filter media – Qty. 1 (Contact IPG for Filter specification)
    - Ethernet Adapter Kit (P40-001244) – Qty. 1
    - Keys – Qty. 2
    - 8-pin Interface Connector (P30-001734) – Qty. 1

7. Retain all packaging for future transportation or storage needs.

Figure 9: Unpacking Cardboard Box

Primary Box	Foam Cover
Cover Removed	Lifting the Unit

Unpacking Procedure for Wooden Crates

Laser models that are larger and relatively heavy are packaged in foam insulated wooden crates.

If the packaging shows any signs of external damage, check unit for damages and notify the shipping agent immediately.

Particular care must be taken when removing the unit from the packing case to ensure that the fiber optic cable is not broken or damaged. A comprehensive packing list is included with the system documentation. Upon receipt of the laser, check all items against this list and contact IPG immediately if any of the items are missing or if any damage to the unit is evident. If any damage to the unit is evident or suspected, do not attempt to install or operate the laser in any case.

See Figure 10 for illustrations regarding this procedure.

1. Place the package on a stable surface such as the floor or a large table.
2. IPG recommends using a powered screwdriver to remove all of the top screws securing the top lid
3. Remove the top lid and top foam insert
4. Using a cutting tool remove the tie wraps securing the fiber to the second insert

5. Place the fiber on top of the unit and carefully lift it out of the box. IPG highly recommends two people to lift the unit at all times.
6. Check the inventory of following items:
    - Cover, AC Power Inlet(P45-001394) – Qty. 1
    - Strain relief (P40-002294) – Qty. 2
    - Strain Relief Nut (P40-002293) – Qty. 1
    - Harting (24-pin) Interface Kit (P30-000721) – Qty. 1
        - Connector (P40-001344) – Qty. 1
        - Hood (P40-001343) – Qty.1
        - Cable Seal (P40-000891) – Qty. 1
        - Contact Pins (P40-000888) – Qty. 16
        - Contact Pins (P40-000887) – Qty. 10
    - Filter media – Qty. 1 (Contact IPG for Filter specification)
    - Ethernet Adapter Kit (P40-001244) – Qty. 1
    - Keys – Qty. 2
    - 8-pin Interface Connector (P30-001734) – Qty. 1
7. Retain all packaging for future transportation or storage needs.

Figure 10: Unpacking Wooden Crates

Primary Box	
Removing the Tie Wraps	
Lifting the Unit	

USING YOUR DEVICE

Precautions

⚠ **Caution: Refer to the SPECIFICATION YTTERBIUM FIBER LASER document for proper electrical power requirements.**

Before switching the power on, make sure that the incoming AC voltage is equal to the level noted in the specification.

Operate only in an environment with sufficient airflow capacity that allows for the specified heat load developed during operation.

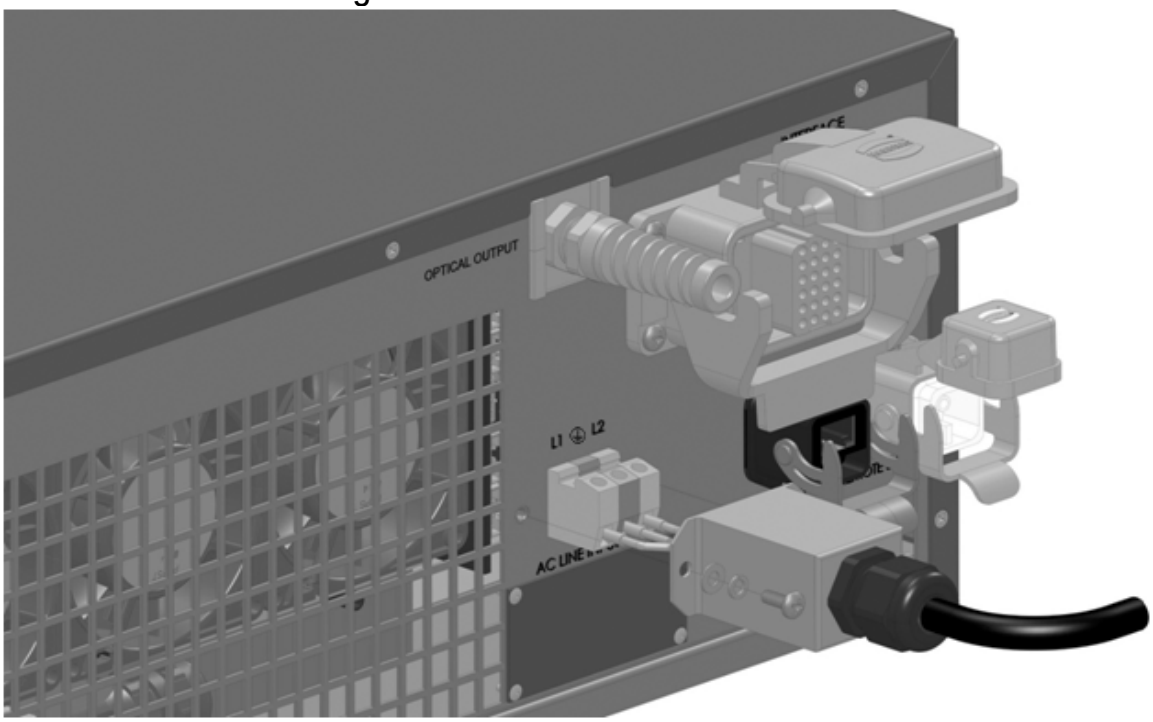
Electrical Power Connection

A power cord is not provided with the laser. Wire the power input terminal block on the rear panel of the laser to the voltage, phase and frequency indicated on the SPECIFICATION YTTERBIUM FIBER LASER document for your particular model. L2 = Line Voltage, PE = Protective Earth, L1 = Line Voltage.

The electrical connection to the unit shall be permanently connected to dedicated AC mains with a circuit breaker that does not exceed 20 Amps. This shall be in close proximity to the unit and within easy reach of the operator and marked as the disconnecting device for the unit.

Follow all national and local requirements when wiring to the unit. Refer to the SPECIFICATION YTTERBIUM FIBER LASER document included with this product to determine your models power requirement.

Figure 11: Power Cord Connection



Interlock Description

YLR lasers incorporate an interlock safety circuit that utilizes a dual channel system with monitored output and manual reset. Upon opening the interlock, the safety circuit will open and power to the laser diodes will be removed.

To have the possibility of the main power supply activation, it is necessary to close dual channel interlock (on 24-pin connector: pin1 is connected with pin4 and pin2 is connected with pin3). Otherwise, the internal main power supply is switched off and the emission cannot be turned on. Once any of the pairs of the mentioned above contacts has been opened it is impossible to switch the lasers power supply on until the second pair is opened and then both pairs are closed.

If the interlock is closed (E-stop button is also released), and a fault has not been detected, pressing the START pushbutton will enable the main power supply and the Power Supply (PS) Active signal will go to a high state. The power to the laser diodes will also turn on. However, under normal conditions the diodes themselves will only turn on after emission is enabled.

When the interlock is opened or a fault is detected, the laser diodes will be disconnected from the main power supply and Power Supply Active signal will go to a low state. A detected fault will be latched and onboard relays will open the monitored manual reset loop, thus preventing the laser from being restarted until the fault is addressed. If a fault is detected, such as a shorted interlock channel, or a shorted START pushbutton, the safety circuit will not reset until the fault is corrected.

In the case of a shorted remote START pushbutton (this is the equivalent of holding the START pushbutton in), the circuit will not reset when the interlocks are closed until the safety circuit sees both channels open and then closed with the START pushbutton in the opened state or the power to the safety circuit has been cycled with the START pushbutton in the opened state.

Table 4 provides electrical pin assignments for these interlock channels.

Interlock safety circuit is designed for emergency shutdown according to ISO 13849-1 Cat 3 PL d with B_{10d} of 10^7 and absolute maxim frequency of safety interlock operations 50 cycles/min based on specifications for electro-mechanical components used in the circuit.

External Interfaces

The interface is provided using an 8-pin and 24-pin interface connectors (Figure 6: Rear Panel Layout items two and three). Refer to the “Computer Interface / Commands” section for setting up these interfaces.

Interface Wire Specification

The minimum wire gage is 18AWG at 15 meters (30 meters maximum regardless of gauge). The gage of the wire must increase as the distance increases. For connectivity, the wiring and/or cabling must have an overall shield to ensure proper functionality. The shield is to cover over all conductors and terminate at the unit where the conductors enter/exit the unit.

PIN	SIGNAL NAME	SIGNAL TYPE	SIGNAL LEVEL	SIGNAL DRIVE	TYPICAL RESPONSE TIME	DESCRIPTION
1[1]	Interlock Ch1A	Contact Closure Input[2]	24 VDC	<1A	< 500 ms[3]	Emergency shutdown according to EN 954-1 or ISO 13849-1 Cat.3 PL d. The 24VDC signal will be isolated from the laser system.
21	Interlock Ch2A					
31	Interlock Ch2B					
41	Interlock Ch1B					
5	RS232 Tx				120 ms	Transmit Data
6	RS232 Rx					Receive Data
7	RS232 Com	Return				RS-232 Return
8	Remote Key Switch	Contact Closure Input2	5 or 24 VDC		20 s	Provides AC power to the laser in REMOTE mode
9						
10	Remote Start Button	Momentary Closure Input2	24 VDC		1 s	Activates the internal main power supply in REMOTE mode
11						
12	Analog Input to Control Current	Analog Input	1-10 VDC	1 mA (sink)	100 µs	Analog Input 1-10 VDC = 10 – 100% Setpoint
13	Analog Output Power Monitor	Analog Output	0-5 VDC	11 mA (source)	20 µs	Analog Output 0-4 VDC = 0 - P_{nom}
14	Isolated Analog Com	Return				Return for signals on pins 12, 13
15	Modulation +	Digital Input	CMOS to 24 VDC	6 mA (sink)	20 µs	5 -24 VDC Input
16	Modulation -	Return				Return for signal on pin 15
17	Guide Control	Digital Input	CMOS to 24 VDC	6 mA (sink)	120ms	Positive edge turns On red guide laser in REMOTE mode[4]
18	Emission Enable	Digital Input	CMOS to 24 VDC	6 mA (sink)	120ms	Positive edge activates emission in REMOTE mode[5]
19	Error/Ready	Digital Output	24 VDC	100 mA (source)	120 ms	Low indicates a laser error
20	System Common	Return				Return for signals on pins 17-19, 21-24
21	Error Reset	Digital Input	CMOS to 24 VDC	6 mA (sink)	120 ms	Positive edge resets all resettable errors
22	Power On	Digital Output	24 VDC	100 mA (source)	120 ms	High indicates that key switch is turned on
23	Power Supply Active	Digital Output	24 VDC	100 mA (source)	120 ms	High indicates that the internal main power supply is active
24	Emission ON	Digital Output	24 VDC	100 mA (source)	120 ms	High at the emission is enabled (for customer use as emission indicator at workstation)

Table 4: 24-pin Connector Pinout

[1] Note: To have a possibility of the internal main power supply activation it is necessary to close the dual channel interlock (pin1 is connected with pin4 and pin2 is connected with pin3). Otherwise, the internal main power supply is switched off and the emission cannot be turned on. Once either of these connection pairs is opened, it is impossible to switch the lasers power supply on until the second pair is opened and then both pairs are closed.
[2] Connection of potential free contacts only. External contact closure must be rated to > 1A /24 VDC.
[3] If one of the two discharging channels fails (single fault condition) the interlock response time will be increased to ≤1000 ms.
[4] To use this pin external guide beam control must be enabled (EEABC command).
[5] To use this pin external emission control must be enabled (ELE command).

PIN	SIGNAL NAME	SIGNAL TYPE	SIGNAL LEVEL	SIGNAL DRIVE	TYPICAL RESPONSE TIME	DESCRIPTION
1	E-Stop Out Channel 3A	Contact Closure	< 250 VDC	<3A		Direct connection to E-Stop push-button on the front panel. If E-Stop on the front panel is pressed, channels 3 and 4 are open.
2	E-Stop Out Channel 4A					
3	E-Stop Out Channel 3B					
4	E-Stop Out Channel 4B					
5	PS_Active1	Digital Output	24 VDC	100mA output.	120 ms[1]	A high condition indicates that the internal main power supply is active.
6	PS_Active2	Digital Output	24 VDC	100mA output	120 ms1	A high condition indicates that the internal main power supply is active.
7	Common	Return				Return for signals on pins 5, 6.
8	Common	Return				Return for signals on pins 5, 6.

Table 5: 8-pin Connector Pinout

Initial Power-up Sequence

Power-up Sequence

⚠ WARNING: All electrical connections (and water connections for water-cooled models) must be connected prior to applying power to the unit. In addition and where applicable, all connections must be secured with screws to ensure proper functionality.

1. Ensure that the AC power is removed and the E-Stop button on the front panel is pushed in.
2. Inspect the optical output end face to check for dust and debris (refer to the Optical Fiber Connector Inspection and Cleaning Guide section for more information).
3. Properly align the output fiber into the delivery optics.
4. Properly secure optical output collimator.

⚠ WARNING: NEVER look directly into a live fiber and make sure that you wear appropriate laser safety eyewear at all times while operating the product. Make sure all power is removed from the laser when handling the delivery cable.

5. Make sure the interlock (pins 1 to 4, 2 to 3) on the interface connector is closed.
6. Release (pull out) the E-Stop button on the front panel and ensure that the external E-Stop (from the 24-pin connector) is disengaged if used.
7. Ensure that the air-cooling vents are unobstructed to allow proper cooling of the device. Verify that the external cooling unit is powered on (for water-cooled models).

[1] Interlock response time (500 ms under normal conditions) must be additionally considered to ensure the safe state of the device.

Turning on the device in Local mode

8. Turn the front panel Keyswitch clockwise to the “ON” position.
9. Wait until the message “Safety Circuit Open” is displayed once the electronics initialize the laser.
10. Press the START button to turn the main power supply on.
11. Wait until the laser becomes active (The power output will be displayed as ‘Low’ indicating the laser is ready.).
12. The laser is now ready for operation. You may now select proper operation mode.

Turning on the device in Remote mode

8. Turn the front panel Keyswitch counterclockwise to the “REM” position.
9. Close contact pins eight and nine to provide remote keyswitch function.
10. Wait until the message “Safety Circuit Open” is displayed once the electronics initialize the laser.
11. Make momentary closure of pins 10 and 11 to activate the main power supply.
12. Turn Emission on (refer to Table 6: Local and Remote Control Modes).
13. Wait until the laser becomes active (The power output will be displayed as ‘Low’ indicating the laser is ready.).
14. The laser is now ready for operation. You may now select proper operation mode.

Control Modes of Operation

There are two control modes of the laser ("LOCAL" and "REMOTE") which are selected with the keyswitch on the front panel (Figure 5: Front Panel Layout). If the keyswitch is in the "ON" position, then the "LOCAL" control mode is activated. If the keyswitch is in "REM" position, then the device is in "REMOTE" control mode. Table 6: Local and Remote Control Modes describe the differences between these two modes:

	POWER KEYSWITCH POSITION		
	LOCAL (KEYSWITCH IN ON POSITION)	REMOTE (KEYSWITCH IN REM POSITION)	
CONTROL ELECTRONICS ENABLING	Enabled	Remote Laser Power Key Switch	
MAIN POWER SUPPLY ENABLING	START button	Remote Start Button	
EMISSION CONTROL	RS-232, Ethernet, Touch-screen	Hardware Emission Control Enabled[1]	Hardware Emission Control Disabled[2]
		External Interface	RS-232, Ethernet
GUIDE LASER CONTROL	RS-232, Ethernet, Touch-screen	External Aiming Beam Control Enabled[3]	External Aiming Beam Control Disabled[4]
		External Interface	RS-232, Ethernet
OPERATION MODE SELECTION	RS-232, Ethernet, Touch-screen	RS-232, Ethernet	

Table 6: Local and Remote Control Modes

[1] Default Setting: To set "Hardware Emission Control Enabled" send the command "ELE" via RS-232 interface or select it in setting menu using Touch-screen display.
[2] To set "Hardware Emission Control Disabled" send the command "DLE" via RS-232 interface or change it in settings menu using Touch-screen display.
[3] Default Setting: To set "External Aiming Beam Control Enabled" send the command "EEABC" via RS-232 interface or select it in setting menu using Touch-screen display.
[4] To set "External Aiming Beam Control Disabled" send the command "DEABC" via RS-232 interface or change it in settings menu using Touch-screen display.

Operation Modes

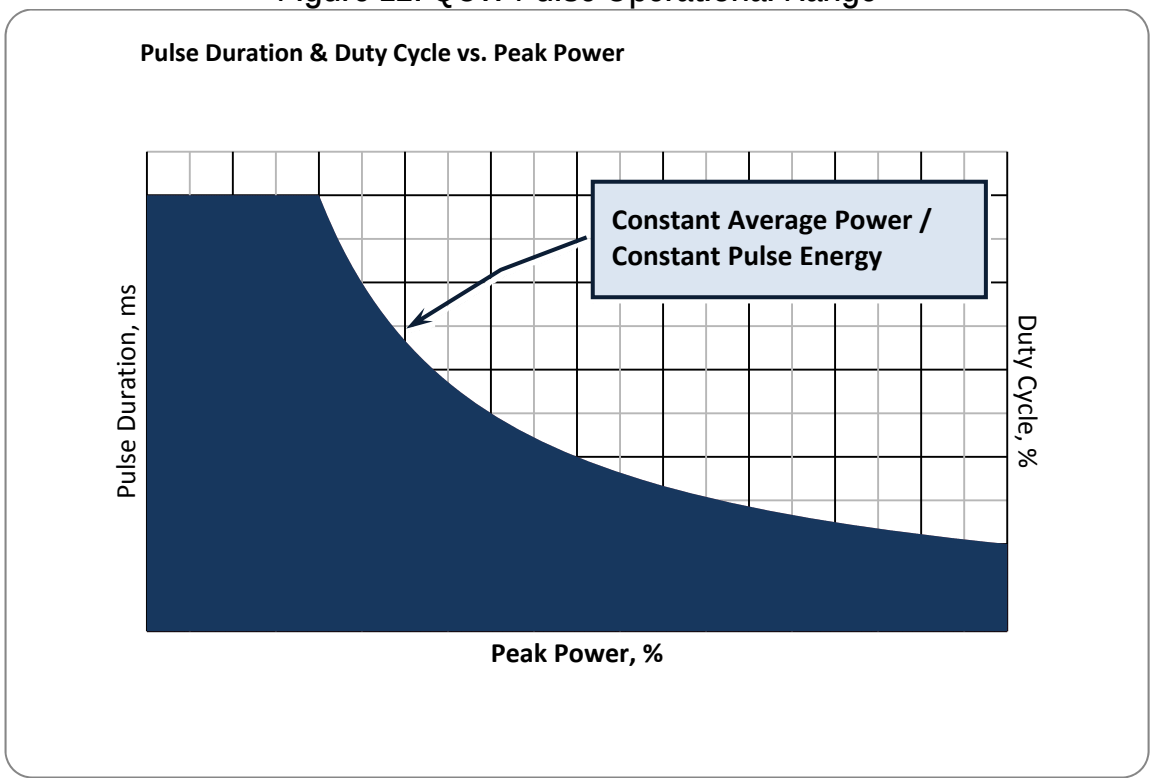
In both control modes (LOCAL and REMOTE), there are two main modes of laser emission - **continuous** (CW) and **pulsed** (QCW):

Pulse Mode (for QCW models only, PULSE mode enabled) laser internally generates sequence of pulses. Pulse duration and pulse repetition rate can be configured by:

- sending corresponding commands via RS-232 interface, or
- using Pulse Settings sub-menu on the touch-screen

The main difference between PULSE and CW modes is that in PULSE mode the maximum peak power is considerably higher than in CW but the maximum pulse duration as well as the maximum duty cycle are limited to certain values (refer to “Specification” and Figure 12) while in CW however, maximum pulse duration and duty cycle are not applicable..

Figure 12: QCW Pulse Operational Range



For each mode of laser emission (CW or PULSE), there are four sub-modes: Standalone, Modulation, Gate and External (Analog) Power Control. The main difference between sub-modes of operation is how the laser power is set and the laser emission is switched on/off:

Continuous Mode (PULSE mode disabled) laser generates CW emission (except for Gate mode).

Standalone Mode (modulation and gate control disabled)

The value of pump LD current (controls output power) is controlled by:

- sending a RS-232 command, or
- sending an Ethernet command, or
- using control buttons on the touch-screen (in LOCAL control mode)

Modulation Mode

- The value of pump LD current is controlled as in the above standalone mode.
- Laser emission is turned on/off by the user-generated "modulation" signal applied to pins 15-16 of External Interface Connector.

Gate Mode

- The value of pump LD current is controlled as in the above standalone mode.
- Laser emission is controlled both, externally and internally - the user-generated "gate" signal applied to pins 15-16 of External Interface Connector starts and stops internal generation of pulses

External (Analog) Power Control

- The value of pump LD current value is controlled by the voltage applied between pins 12 and 14 of the External Interface Connector (see Table 4: 24-pin Connector Pinout).
- Pulse sequence generation, modulation and gating are performed as in corresponding modes above.

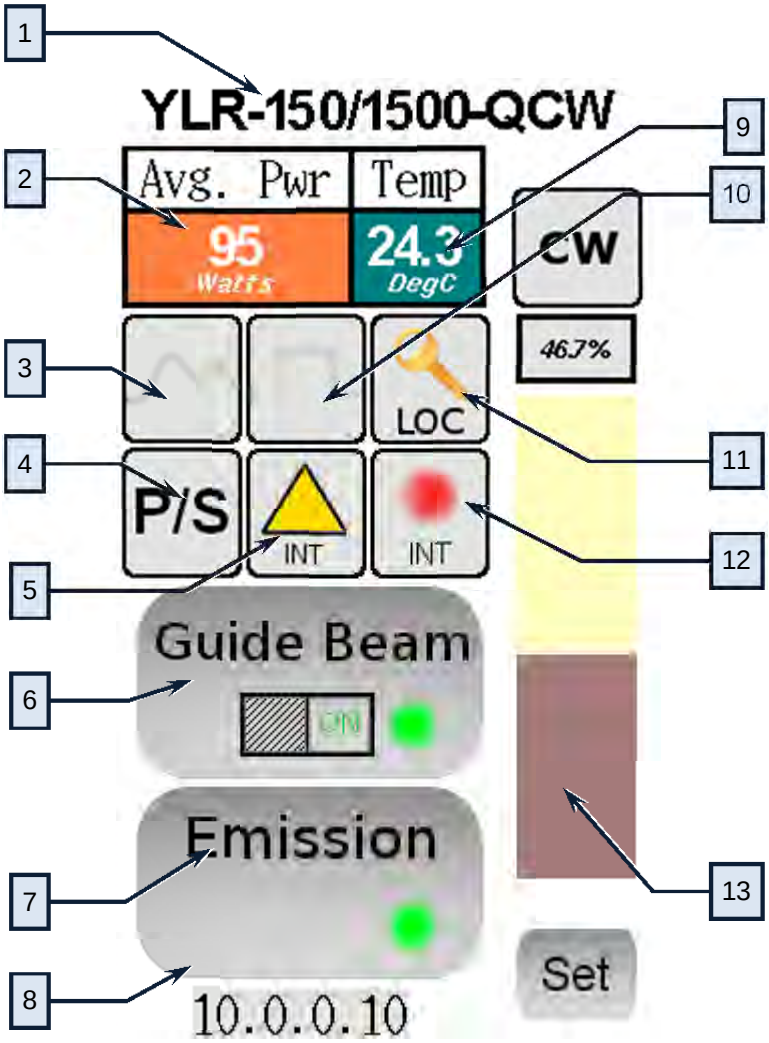
Pulse Waveform (Optional Feature)

- Arbitrary waveform pulses can be created and stored in the Pulse Profiles library.
- Pulse sequences (combinations of pulse profiles, delays and repeats) can be created and stored in Pulse Sequences library.
- Pulses can be started by emission On command/signal (when Gate Mode is disabled) or by “gate” signal applied to Pins 15-16 of External Interface Connector (when Gate Mode is enabled).
- Waveform Mode cannot be selected if either External (Analog) Control or Modulation Mode is enabled.

Touch-screen Display

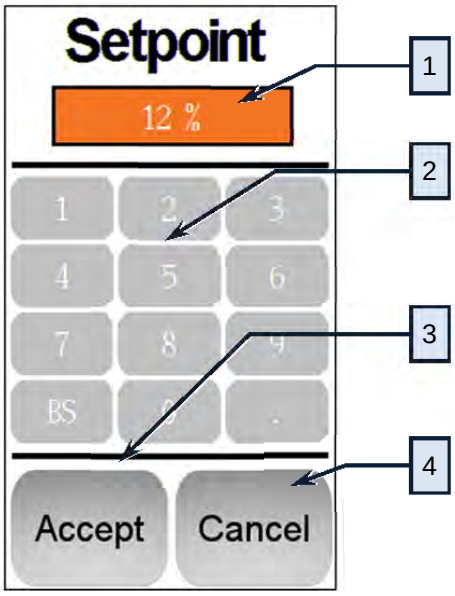
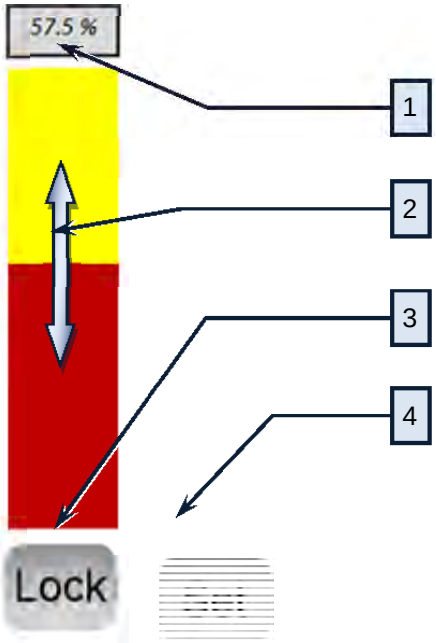
The touch-screen display is used for manual control from the front panel of the device and for the indication of information about the state and settings of the device. In addition, activating certain commands from the main window will invoke additional submenu windows. In remote mode, the touch-screen display function is disabled and can only be used for display purposes.

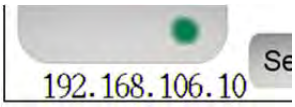
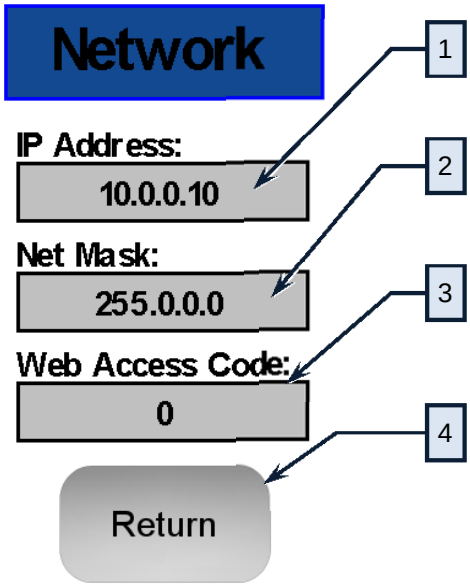
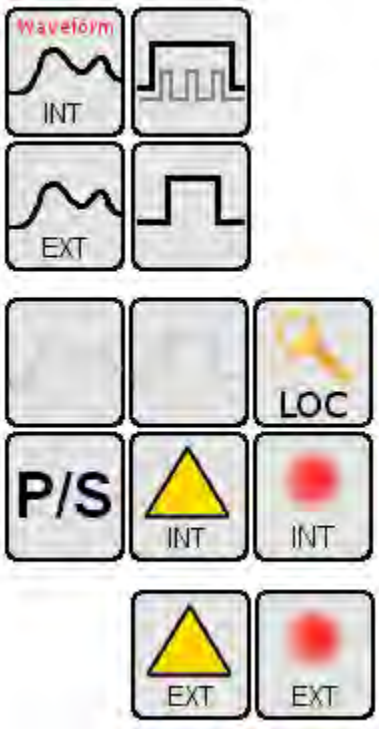
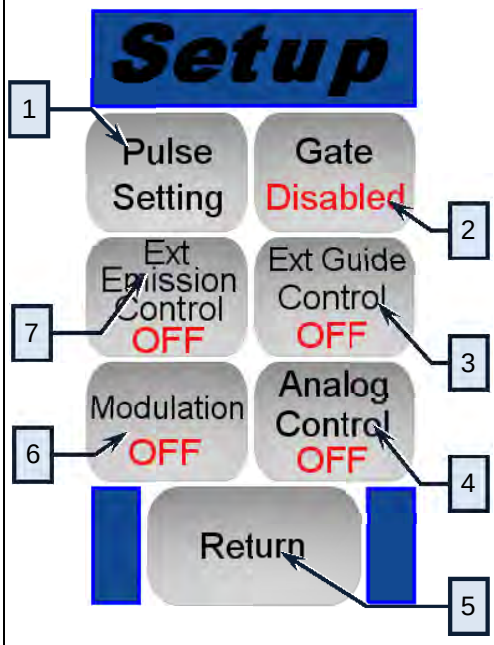
Figure 13: Main Menu Screen

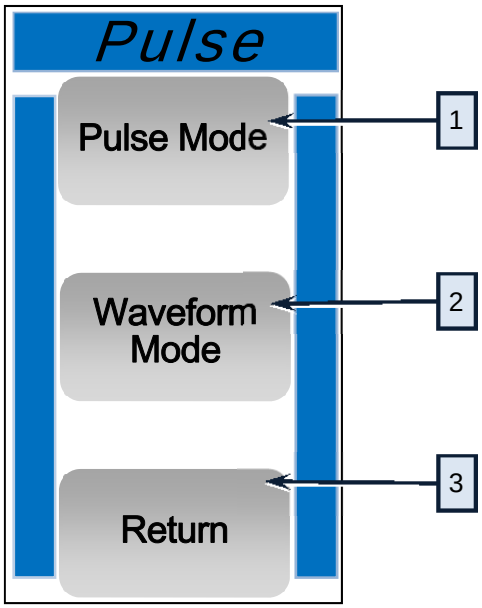
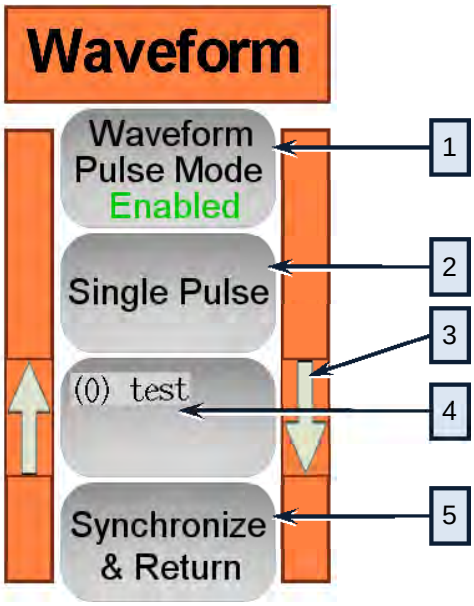
MAIN MENU	ITEM	DESCRIPTION
	1	Model Name
	2	Power Indication / Setting: Touching this field will call “Setpoint” window where you can type in the required setpoint value
	3[1]	When active (inactive shown) - indicates that the analog (external) power control is enabled or in Pulse Waveform Mode.
	41	When active - shows that the main supply voltage is applied to the laser module inside the device.
	51	Indicates the state of the emission control: “Internal” (hardware control disabled) or “External” (hardware control enabled)
	6	Touching this button will turn the guide laser ON or OFF.
	7	Touch this button to activate / deactivate the emission.
	8	IP address indication / setting. Touching this field will call the window where you assign an IP address to the device.
	9	Internal Temperature Display
	101	When active - indicates that the Modulation or Gate Mode enabled.
	11	Indicates the current regime of operation: “Local” or “Remote”
	121	Indicates the state of the guide laser control: “Internal” or “External
	131	Setpoint Bar: Touch “Set”, drag your finger up or down to set the required value. Press “Lock” when finished

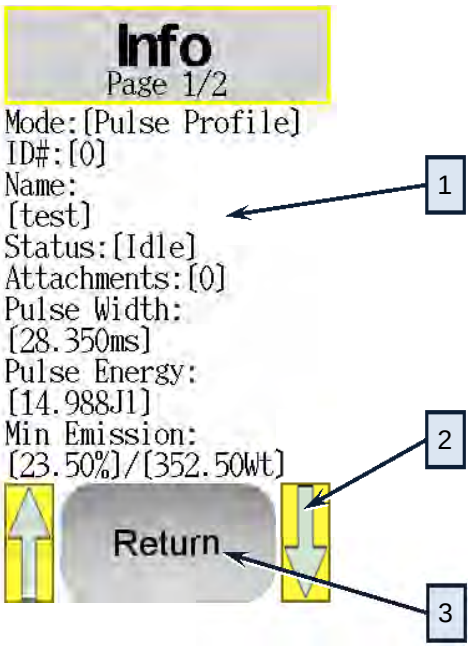
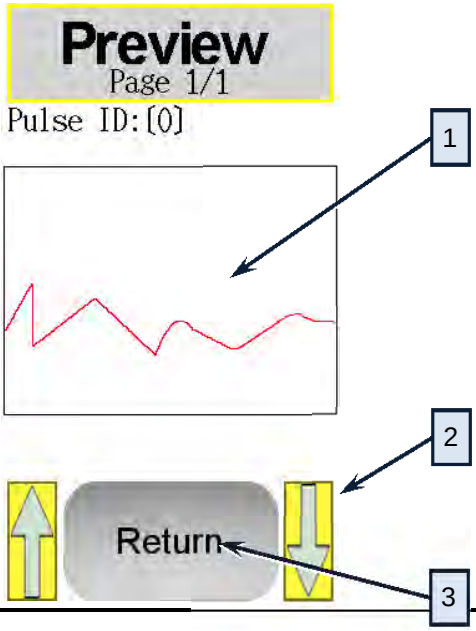
[1] Function described lower in table.

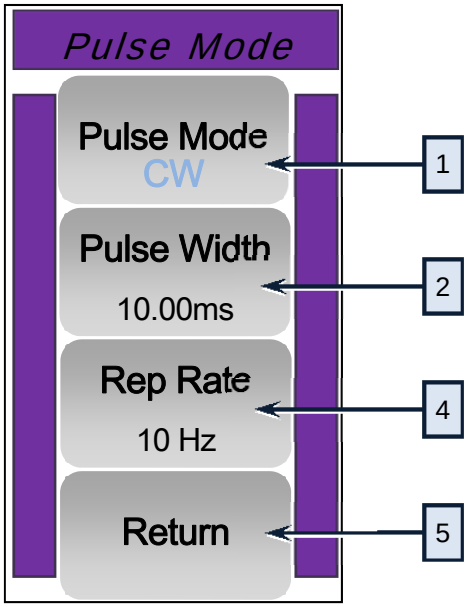
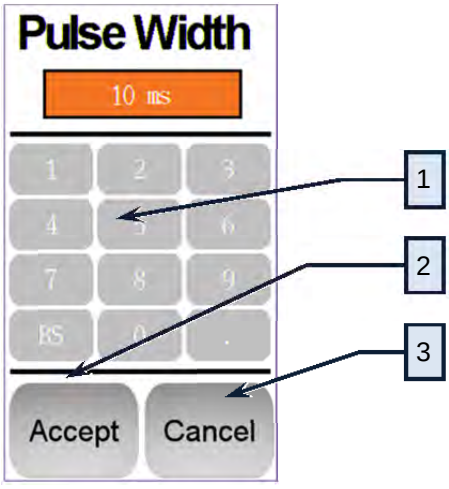
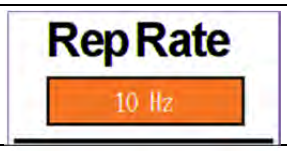
Figure 14: Submenu Menu Screens

SUBMENU BUTTON	SUBMENU	ITEM	DESCRIPTION
		1	Current Power setpoint value in % of max power (e.g. 12 %)
		2	Enter the Power setpoint in % of max power
		3	Accept new Power setpoint
		4	Return to previous screen
		1	Power setpoint value in % of max power (e.g. 57.5%)
		2	Power Control Bar (disabled when locked)
		3	Pressing “Lock” will unlock the Power Control Bar function (“Set” will then be displayed).
		4	Pressing “Set” will change the power to the new setpoint and lock the Power Control Bar.
		Green dot will light when pressed to turn on the Guide Beam	

<table>
<tr><th>SUBMENU BUTTON</th><th>SUBMENU</th><th colspan="2">ITEM</th><th>DESCRIPTION</th></tr>
<tr><td> </td><td>
</td><td colspan="2">Pressing the Emission Button will ask you to confirm the emission startup process by pressing “OK” or “Cancel” to exit.</td></tr>
<tr><td> 
</td><td> 
</td><td>1</td><td>Pressing the address starts dialog to enter the new address.</td></tr>
<tr><td></td><td></td><td>2</td><td>Pressing net mask address starts dialog to enter the new address.</td></tr>
<tr><td></td><td></td><td>3</td><td>Pressing the web access code starts dialog to enter the new address.</td></tr>
<tr><td></td><td></td><td>4</td><td>Returns to previous screen</td></tr>
<tr><td> 
</td><td> 
</td><td>1</td><td>Opens Pulse Settings menu (function described lower in table)</td></tr>
<tr><td></td><td></td><td>2</td><td>Enable / Disable Gate mode</td></tr>
<tr><td></td><td></td><td>3</td><td>Enable / Disable External Guide Laser control</td></tr>
<tr><td></td><td></td><td>4</td><td>Enable / Disable External Analog Power control</td></tr>
<tr><td></td><td></td><td>5</td><td>Return to previous screen</td></tr>
<tr><td></td><td></td><td>6</td><td>Enable / Disable Modulation mode</td></tr>
<tr><td></td><td></td><td>7</td><td>Enable / Disable External Emission control</td></tr>
</table>

SUBMENU BUTTON	SUBMENU	ITEM	DESCRIPTION
Pulse Setting		1	Opens Pulse Mode Submenu (described lower in table)
		2	Opens Waveform Mode Submenu (described lower in table)
		3	Return to previous screen
Waveform Mode		1	Enables/Disables Waveform Pulse Mode
		2	Single Pulse / Pulse Sequence
		3	UP/DOWN Arrows scroll to select a program from memory
		4	Selected program in memory
		5	Transfers selected program to the laser.

SUBMENU BUTTON	SUBMENU	ITEM	DESCRIPTION
(0) test		1	Pulse Program Information Screen Clicking anywhere in this area will bring up the Preview Screen.
		2	UP/DOWN Arrows scroll to select a program from memory
		3	Return to previous screen
Mode:[Pulse Profile] ID#:[0] Name: [test] Status:[Idle] Attachments:[0] Pulse Width: [28.350ms] Pulse Energy: [14.988J1] Min Emission: [23.50%]/[352.50Wt]		1	Pulse Program Preview Screen
		2	UP/DOWN Arrows scroll to select a program from memory
		3	Return to previous screen

SUBMENU BUTTON	SUBMENU	ITEM	DESCRIPTION
Pulse Mode		1	Toggles between CW and QCW pulse modes
		2	Opens Pulse Width dialog (described lower in table)
		3	Opens Repetition Rate dialog (described lower in table)
		4	Return to previous screen
Pulse Width 2.00 ms		1	Enter Pulse Width in milliseconds (ms) range is 0.2 to 20 ms in .05 ms increments
		2	Accept Pulse Width
		3	Cancel and return to previous screen
Rep Rate 10 Hz		1	Enter Repetition Rate in Hertz (Hz) range is 1 to 5000 Hz in 1 Hz increments

SUBMENU BUTTON	SUBMENU	ITEM	DESCRIPTION
		2	Accept Repetition Rate
		3	Cancel and return to previous screen

COMPUTER INTERFACE / COMMANDS

RS-232 Configuration

A three wire (RxD, TxD, GND) interface is used (null modem cable). The individual commands are described in the “Interface Commands” section of the manual. The RS-232 interface is configured with the following parameters:

PARAMETER	VALUE
Baud Rate:	57,600
Data Bits:	8
Stop Bits:	1
Parity:	None
Flow Control:	None

Table 7: RS-232 Parameters

Ethernet TCP/IP Interface

The IP address of the laser will be shown on the front panel of the laser. Touching the screen where the address is shown will bring up the network setup menu where the network settings can be changed. The laser will listen for connections on port 10001. The command must be sent as a single string in a single packet. The individual commands are described in the “Interface Commands” section of the manual.

PIN	DESCRIPTION	NOTES
1	TX+	Transmit Data +
2	TX-	Transmit Data -
3	RX+	Receive Data +
4	N/C	Not Connected
5	N/C	Not Connected
6	RX-	Receive Data -
7	N/C	Not Connected
8	N/C	Not Connected

Table 8: Ethernet Interface Pinout

Interface Commands

All commands and responses will consist of printable ASCII characters. Commands are typically three or four letter mnemonic codes followed by a parameter, if required.
All commands and responses will be terminated with a <Carriage Return> (CR, 0x0D, \r) character If a CR terminated string is received, but no valid command is found, a response of “BCMD” will be sent.
The commands are shown here as all uppercase for clarity; the actual commands are not case sensitive.
A space character is also shown between the command and parameter for clarity. The space is not required.

Every command will generate a response. The responses generally consist of the command echoed back. If there is a returned value, it will be separated from the echoed command by a ':' character.

CODE	DESCRIPTION	EXAMPLES
ABF	Aiming Beam OFF	Sent: "ABF" Response: "ABF"
ABN	Aiming Beam ON	Sent: "ABN" Response: "ABN"
DEABC	Disable External Aiming Beam Control.	Sent: "DEABC" Response: "DEABC"
DEC	Disable External Control – Disables the external control input.	Sent: "DEC" Response: "DEC"
DGM	Disable Gate Mode – Disables internal pulse generator.	Sent: "DGM" Response: "DGM"
DLE	Disable Hardware Emission Control	Sent: "DLE" Response: "DLE"
DMOD	Disable Modulation – Disables the modulation control input.	Sent: "DMOD" Response: "DMOD"
DPM[1]	Disable Pulse Mode	Sent: "DPM" Response: "DPM"
DWPM[2]	Disable Waveform Pulse Mode – Disables internal arbitrary waveform generator (pulse shaping).	Sent: "DWPM" Response: "Waveform Pulse Mode is Disabled"
EEABC	Enabled External Aiming Beam Control	Sent: "EEABC" Response: "EEABC"
EEC	Enable External Control – Enables the external control input.	Sent: "EEC" Response: "EEC"
EGM	Enable Gate Mode – Enables internal pulse generator gated by signal applied to modulation input.	Sent: "EGM" Response: "EGM"
ELE	Enable Hardware Emission Control	Sent: "ELE" Response: "ELE"
EMOD	Enable Modulation – Enables the modulation control input.	Sent: "EMOD" Response: "EMOD"
EMOFF	Stop Emission – Stops emission.	Sent: "EMOFF" Response: "EMOFF"

[1] Only for QCW Laser Models
[2] Models with Pulse Shaping Option Only

CODE	DESCRIPTION	EXAMPLES
EMON	Start Emission – Starts emission. Note: If Waveform Pulse mode is enabled, and a waveform configuration is required, waveform configuration will be executed before emission is started and a response is returned	Sent: "EMON" Response: "EMON"
EPM[1]	Enable Pulse Mode	Sent: "EPM" Response: "EPM"
EWPM[2]	Enable Waveform Pulse Mode – Enables internal arbitrary waveform generator (pulse shaping). Notes: It is not possible to enable pulse mode if no pulse or sequence exist in the current selected mode. An error will be returned if that is the case. If the Key Switch is in the Remote position, a waveform configuration will be automatically executed before a response is returned	Sent: "EWPM" Response: "Waveform Pulse Mode is Enabled"
LFP	Lock Front Panel – Locks touch-screen display on the front panel of the laser.	Sent: "LFP" Response: "LFP"
PCFG2	Configure Waveform Mode – Prepares device for execution of selected Pulse profile or Pulse Sequence.	Sent: "PCFG" Response: "Status: Enabled, Mode: Sequence, ID: 1" "Status: Disabled, Mode: Profile, ID: 1"
PRLS2	Profile List – Displays a list of available Pulse Profiles stored in the device library.	Sent: "PRLS" Response: "[Pulse ID – Pulse Name] [1 – Test1] [2 – Test2] [End of Pulses]"
PRSEL2	Select Profile – Selects Single Pulse Mode and Pulse Profile ID. If the command is not followed by the ID number or the ID is invalid, then the existing selection is used. Note: If the Key Switch is in the Remote position, a waveform configuration will be automatically executed before a response is returned	Sent: "PRSEL 3" Response: "New setting applied. Waveform Mode: Single Pulse Selected Pulse: ID[3] – Name[Test1]"
RBAUD	Read Baud Rate	Sent: "RBAUD" Response: "RBAUD: 5 | 9600"

[1] QCW Models Only
[2] Models with Pulse Shaping Option Only

CODE	DESCRIPTION	EXAMPLES
RCS	Read Current Setpoint – Reads the setpoint for the LD current. The response is the command echoed back, followed by a delimiter of ": ", and then the current setpoint in %.	Sent: "RCS" Response: "RCS: 56.7" (Indicates that the LD current setpoint is 56.7%)
RCT	Read Laser Temperature – Reads the internal temperature of the laser. The response will be an echo of the command, a delimiter of ": ", and the temperature in degrees centigrade.	Sent: "RCT" Response: "RCT: 34.5"
RERR	Reset Errors – Resets any resettable errors.	Sent: "RERR" Response: "RERR"
RET	Read Elapsed Time – Reads the elapsed time the laser has been ON. The time is returned in minutes.	Sent: "RET" Response: "RET: 1105"
RFV	Read current software revision.	Sent: "RFV" Response: "RFV: 1.0.147 "
RIP	Read IP – Reads the current IP address of the device. The response is the command echoed back, followed by a delimiter of ": ", and then the IP address in dot-decimal notation.	Sent: "RIP" Response: "RIP: 10.0.0.2"
RMASK	Read Subnet Mask – Reads the current subnet mask of the device. The response is the command echoed back, followed by a delimiter of ": ", and then the subnet mask in dot-decimal notation.	Sent: "RMASK" Response: "RMASK: 255.0.0.0"
RMEC	Read Module Error Code. Returns error code stored in the laser or zero if normal operation.	Sent: "RMEC" Response: "RMEC: 0"
RNC	Read Minimum Current Setpoint – Reads the minimum current setpoint that can be set in the laser. The response will be the command echoed back, followed by a delimiter of ": ", then the minimum current as a percentage of the maximum.	Sent: "RNC" Response: "RNC: 10.0" (Indicates that the minimum setpoint is 10.0 %)

CODE	DESCRIPTION	EXAMPLES
ROP	Read Output Power – Reads the output power in watts. The response will be the command echoed back, a delimiter of ": ", and then either the power in watts, "Off" if the emission is off, or "Low" if the power is below the reliable measurement threshold of the laser.	Sent: "ROP" Response: "ROP: 96" (Indicates that the output power is 96 watts) Sent: "ROP" Response: "ROP: Off" (Indicates that emission is off) Sent: "ROP" Response: "ROP: Low" (Indicates that the output power is below the accurate measurement range of the laser)
RPP[1]	Read Peak Power – Reads the output peak power in Watts. The response will be the command echoed back, a delimiter, and then the power in watts, "Off" if the emission is off, or "Low" if the power is below the reliable measurement threshold of the laser.	Sent: "RPP" Response: "RPP: 730" (Indicates that the output peak power is 730 watts) Sent: "RPP" Response: "RPP: Off" (Indicates that emission is off) Sent: "RPP" Response: "RPP: Low" (Indicates that the output power is below the accurate measurement range of the laser)
RPRR[2]	Read Pulse Repetition Rate - Reads the pulse repetition rate. The response is the command echoed back, followed by a delimiter of ": ", and then the pulse width in Hz.	Sent: "RPRR" Response: "RPRR: 10" (Indicates that the PRR is 10 Hz)
RPW2	Read Pulse Width - Reads the pulse width. The response is the command echoed back, followed by a delimiter of ": ", and then the pulse width in milliseconds (ms).	Sent: "RPW" Response: "RPW: 5.5" (Indicates that the pulse width is 5.5 ms)
RSN	Read Serial Number – Reads the serial number of the device.	Sent: "RSN" Response: "RSN: 6103081"

[1] PULSE MODE ONLY
[2] GATE MODE ONLY

CODE	DESCRIPTION	EXAMPLES
SBAUD	Set Baud Rate – Followed by an integer number from 2 to 8 corresponding to baud rate from 1200 to 57600.	Sent: "SBAUD 5" Response: "SBAUD: 5 | 9600"
SDC	Set Diode Current – Sets the diode current. The units are in percent of maximum current. The setpoint must be below 100% and above the minimum current setpoint. The current may also be set to 0. The response from the laser will be the command echoed back, a delimiter of ": ", and then the current setpoint for the laser. A value that is outside the acceptable range will receive a response of "ERR: Out of Range".	Sent: "SDC 34.2" Response: "SDC: 34.2" (Current Setpoint is set to 34.2%) Sent: "SDC 104.2" Response: "ERR: Out of Range" (The setpoint is unchanged)
SMASK	Set Subnet Mask – Followed by a number in dot-decimal notation sets the subnet mask for the laser.	Sent: "SMASK 255.0.0.0" Response: "SMASK 255.0.0.0" Response: "SMASK: Error! Invalid Netmask!" (Subnet Mask is unchanged)
SPRR1	Set Pulse Repetition Rate - Sets the pulse repetition rate. The units are in Hz. The pulse width and the duty cycle (dependent on the pulse width and pulse repetition rate) must be within the specified range. The response from the laser will be the command echoed back, a delimiter of ": ", and then the pulse repetition rate. A value that is outside the acceptable range will receive a response of "ERR: Duty cycle too high".	Sent: "SPRR 10" Response: "SPRR: 10" (PRR is set to 10 Hz) Sent: "SPRR 100" Response: "ERR: Duty cycle too high" (The PRR is unchanged)
SPW[1]	Set Pulse Width - Sets the pulse width. The units are in milliseconds. The pulse width and the duty cycle (dependent on the pulse width and pulse repetition rate) must be within the specified range. The response from the laser will be the command echoed back, a delimiter of ": ", and then the pulse width. A value that is outside the acceptable range will receive a response of "ERR: Out of Range" or "ERR: Duty cycle too high".	Sent: "SPW 5.5" Response: "SPW: 5.5" (Pulse Width is set to 5.5 ms) Sent: "SDC 38" Response: "ERR: Out of Range" (The pulse width is unchanged) Sent: "SDC 8" Response: "ERR: Duty cycle too high" (The pulse width is unchanged)

[1] GATE MODE ONLY

CODE	DESCRIPTION	EXAMPLES
SQLS[1]	Sequence List – Displays a list of available Pulse Sequence programs stored in the device library.	Sent: "SQLS" Response: "[Sequence ID – Sequence Name] [1 – Test1] [2 – Test2] [End of Sequence]"
SQSEL1	Select Sequence – Selects Pulse Sequence Mode and Pulse Sequence ID. If the command is not followed by the ID number or the ID is invalid, then the existing (or last) selection is used. Notes: It is not possible to switch to sequence mode if Waveform mode is enabled and no sequences exist. An error will be returned if that is the case. If the Key Switch is in the Remote position, a waveform configuration will be automatically executed before a response is returned	Sent: "SQSEL 5" Response: "New setting applied. Waveform Mode: Pulse Sequence Selected Sequence: ID[5] – Name[Test1]"

[1] Models with Pulse Shaping Option Only

CODE	DESCRIPTION	EXAMPLES
STA	Read device status – The status is reported as a bit-encoded 32-bit word. Undefined bits or bits defined as “Reserved” can be in any state and should be ignored. Each of the bits have the following meaning:	Sent: “STA” Response: “STA: 4100” This translates to the following: 4100 = 0x1004, so bits 2 and 12 are set. This means that emission is on and modulation is enabled.

Bit 0	-	Reserved		
Bit 1	-	0	=	Normal operation
	-	1	=	Overheat
Bit 2	-	0	=	Emission Off
	-	1	=	Emission On or starting
Bit 3	-	0	=	Back Reflection OK
	-	1	=	High Back Reflection Level
Bit 4	-	0	=	External Control Mode Disabled
	-	1	=	External Control Mode Enabled
Bit 5	-	Reserved		
Bit 6	-	0	=	Normal operation
	-	1	=	Module Disconnected
Bit 7	-	Reserved		
Bit 8	-	0	=	Aiming Beam OFF
	-	1	=	Aiming Beam ON
Bit 9[1]	-	0	=	Normal operation
	-	1	=	Pulse too Short
Bit 10[1]	-	0	=	CW Mode
	-	1	=	Pulsed Mode
Bit 11	-	0	=	Power Supply On
	-	1	=	Power Supply Off
Bit 12	-	0	=	Modulation Disabled
	-	1	=	Modulation Enabled
Bit 13	-	Reserved		
Bit 14	-	Reserved		
Bit 15	-	0	=	Emission is out of 3 second start-up state
	-	1	=	Emission is in 3 second start-up state
				(in ON position of the keyswitch only)
Bit 16	-	0	=	Gate Mode Disabled
	-	1	=	Gate Mode Enabled
Bit 17[1]	-	0	=	Normal Operation
	-	1	=	High Pulse Energy
Bit 18	-	0	=	Hardware Emission Control Disabled
	-	1	=	Hardware Emission Control Enabled
Bit 19	-	0	=	Normal operation
	-	1	=	Power Supply Failure
Bit 20	-	0	=	Front Panel Display is Unlocked
	-	1	=	Front Panel Display is Locked
Bit 21	-	0	=	Keyswitch in ON position
	-	1	=	Keyswitch in REM position

[1] QCW MODELS ONLY

CODE	DESCRIPTION	EXAMPLES
STA (cont.)	**Bit 22**[1] - 0 = Waveform Pulse Mode Disabled - 1 = Waveform Pulse Mode Enabled **Bit 23**[2] - 0 = Normal operation - 1 = High Duty Cycle **Bit 24** - 0 = Normal operation - 1 = Low Temperature **Bit 25** - 0 = Power Supply OK - 1 = Power Supply Failure 2 **Bit 26** - Reserved **Bit 27** - 0 = Hardware Aiming Beam Control Disabled - 1 = Hardware Aiming Beam Control Enabled **Bit 28** - Reserved **Bit 29** - 0 = Normal operation - 1 = Critical Error **Bit 30** - 0 = Optical Interlock OK - 1 = Optical Interlock active **Bit 31** - 0 = Normal Operation - 1 = Average Power too High	
SIP	Set IP – Followed by a number in dot-decimal notation sets the IP address for the laser.	Sent: "SIP 10.0.0.2" Response: "SIP: 10.0.0.2"
UFP	Unlock Front Panel – Unlocks touch-screen display on the front panel of the laser.	Sent: "UFP" Response: "UFP"

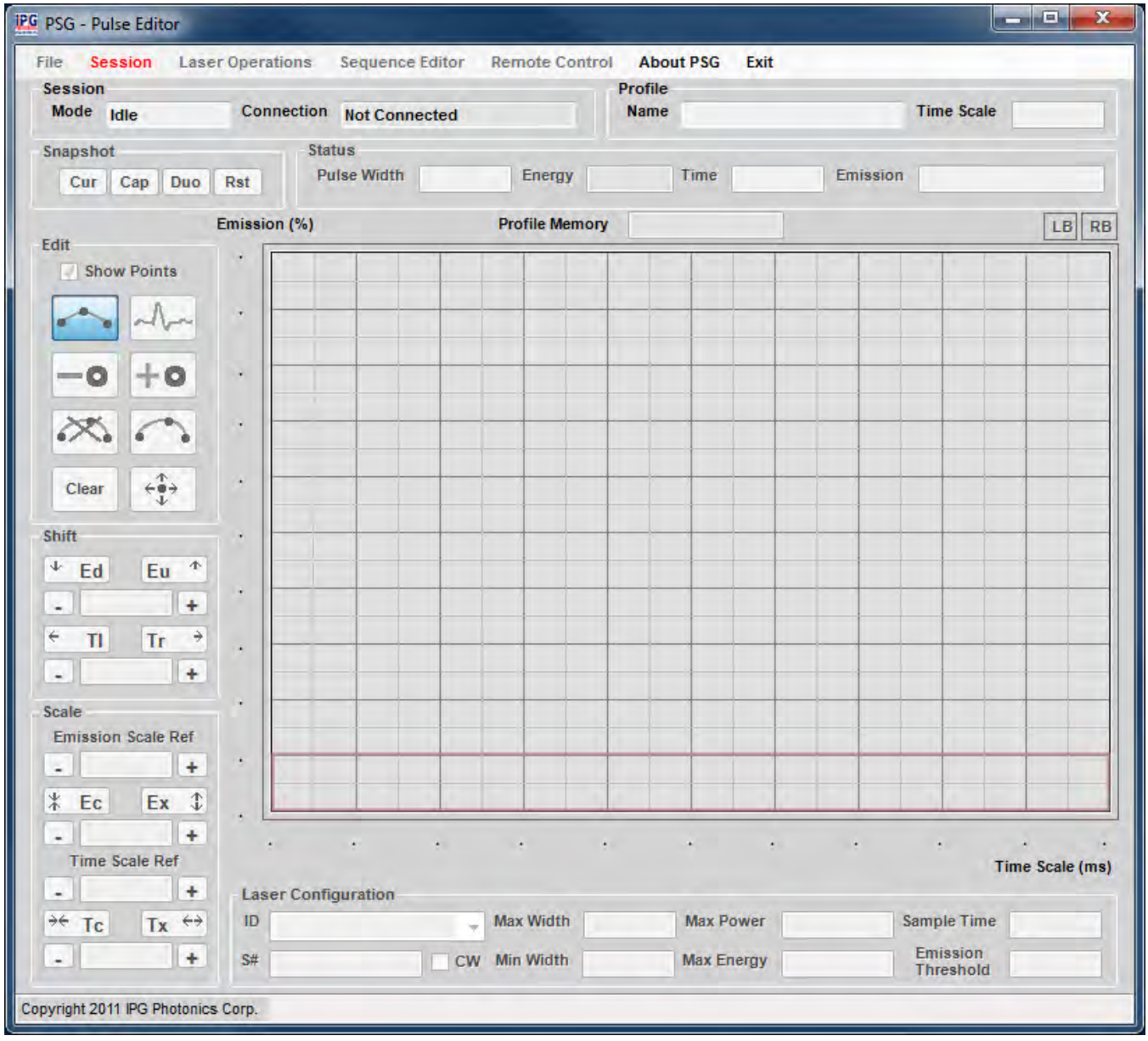
Table 9: Interface Commands

[1] Models with Pulse Shaping Option Only
[2] QCW Models Only

PULSE SHAPING SOFTWARE OPTION

Introduction

The optional Pulse Shaping software was developed to aid users of IPG mid-power lasers in creating effective pulse shapes to meet the ever-changing requirements of their applications.



PC Host Requirements

The following items are the minimum requirements for installing and using the MPPS software:

- An x86 machine, with at least 512MB RAM, 5GB hard disk, mouse and keyboard, VGA monitor and a Ethernet or Serial (RS-232) communication port
- Operating System: Windows 2000 or later w/ .NET framework version 2.0 or higher
- PulseShapingGUI: Designated release version executable

Ethernet TCP/IP Interface

The IP address of the laser will be shown on the front panel of the laser. Touching the screen where the address is shown will bring up the network setup menu where the network settings can be changed. The laser will listen for connections on port 10001. The command must be sent as a single string in a single packet. The individual commands are described in the “Interface Commands” section of the manual.

PIN	DESCRIPTION	NOTES
1	TX+	Transmit Data +
2	TX-	Transmit Data -
3	RX+	Receive Data +
4	N/C	Not Connected
5	N/C	Not Connected
6	RX-	Receive Data -
7	N/C	Not Connected
8	N/C	Not Connected

Table 10: Ethernet Interface Pinout

RS-232 Configuration

A three wire (RxD, TxD, GND) interface is used (null modem cable). The individual commands are described in the “Interface Commands” section of the manual. The RS-232 interface is configured with the following parameters:

PARAMETER	VALUE
Baud Rate:	57,600
Data Bits:	8
Stop Bits:	1
Parity:	None
Flow Control:	None

Table 11: RS-232 Parameters

Installing the Software

To install this software package, run PSG installer as it will create a new folder with the pulse editor program.

Computer Configuration Procedure

Both Ethernet and Serial communications require you to configure the communication protocols of your computer in order to connect to the Laser via a PC.

Ethernet Configuration Option

⚠ **The following procedure assumes that the user is already familiar with operating their respective laser. In addition, it is strongly recommended that you review all safety and operational procedures before proceeding.**

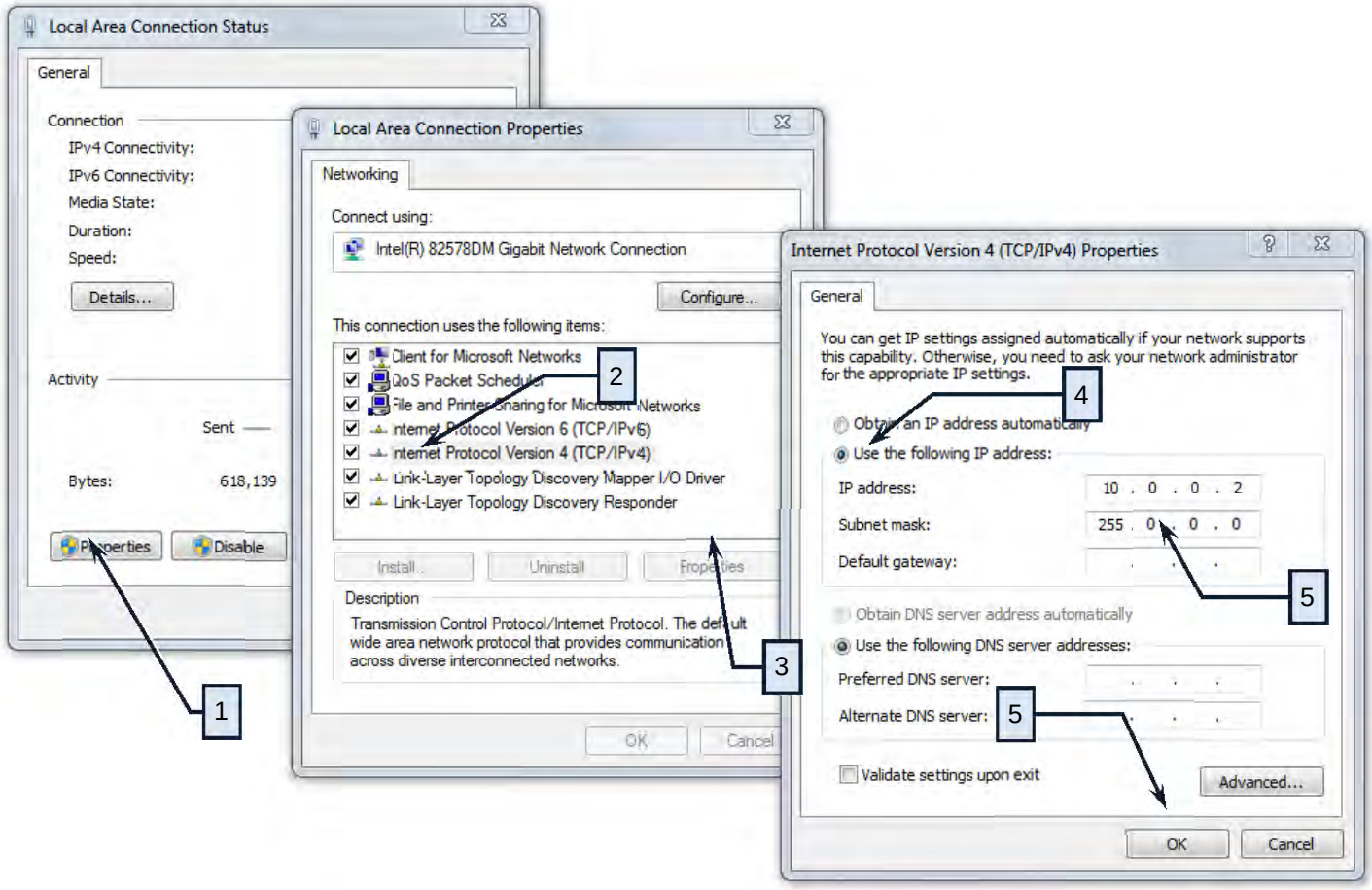
1. Connect PC to the Laser using crossover cable.
2. Manually configure the Local Area Connection settings for Ethernet (refer to Table 12).
3. Start the PSG application (PSG.exe).
4. Click Session->Ethernet
5. Enter the IP address of the laser, then click Connect
6. Ensure the connection is successful, and the status is displayed in the Connection indicator: IP:<Current IP>~Good~

Serial Communication Port Configuration Option

⚠ **The following procedure assumes that the user is already familiar with operating their respective laser. In addition, it is strongly recommended that you review all safety and operational procedures before proceeding.**

1. Connect serial RS-232 cable from PC Host to the Laser.
2. Click Session->Serial Port
3. Enter the Com port the is attached to the laser, then click Connect
4. Ensure the connection is successful, and the status is displayed in the Connection indicator: Port:<COMx>~Good~

Table 12: Configuring the Local Area Connection for Ethernet



STEP	DESCRIPTION
1	Navigate to the Local Area Connection screen on your computer and click the “Properties” command button.
2	Select the Internet Protocol TCP/IP Setting (TCP/IP 4 on Windows 7 OS).
3	Click the Properties command button.
4	Click the Radio Button to “Use the following IP address” to manually assign the IP adress.
5	Assign the IP address to 10.0.0.x (x can not be 10 as 10.0.0.10 is the default IP address of the Laser). Assign the Subnetmask to its default setting to 255.0.0.0 by clicking on the Textbox.
6	Pres the “OK” command button to accept these manual changes.

Quick Start Guide

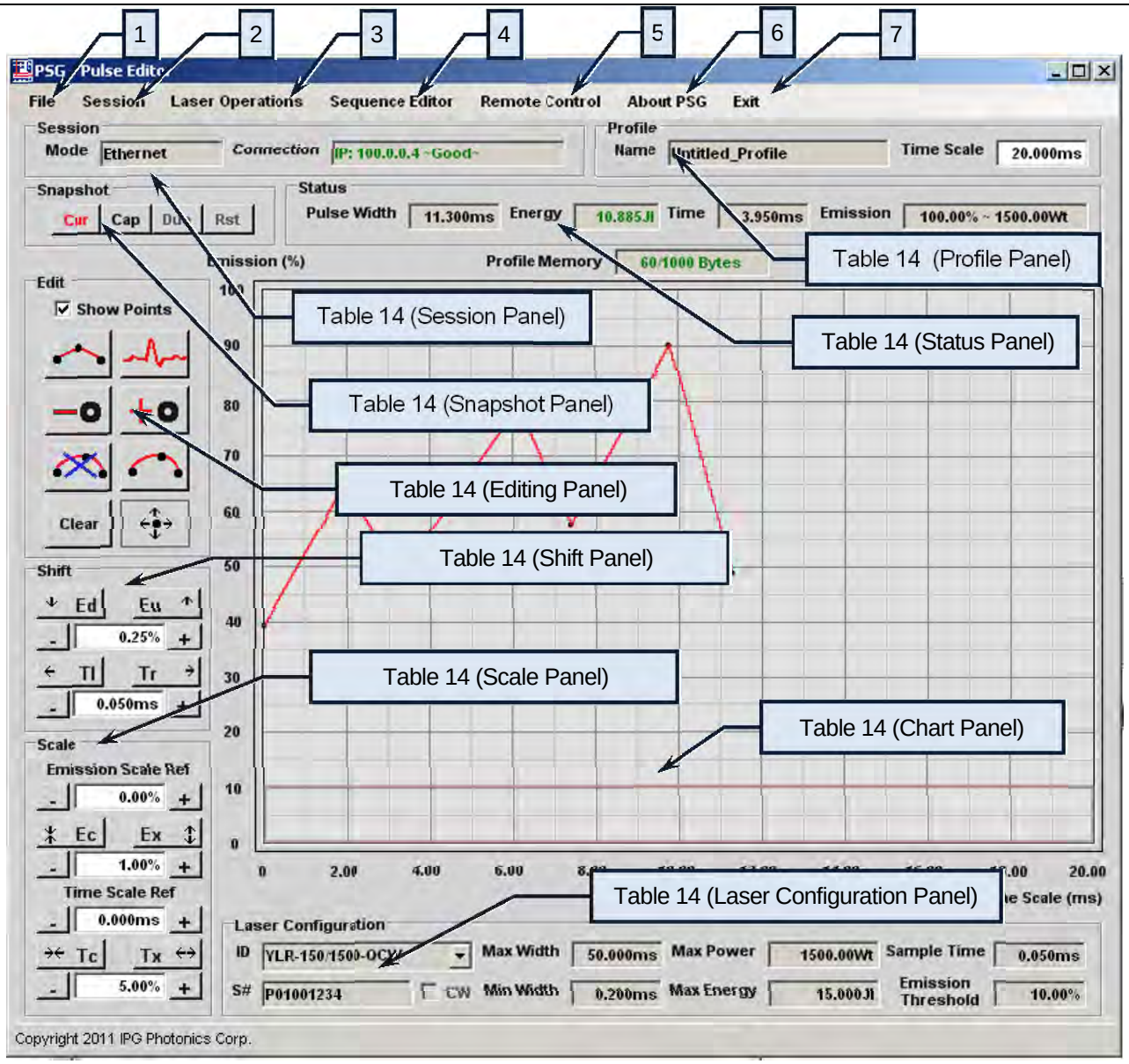
⚠ **The following procedures assume that the user is already familiar with operating their respective laser and with the touch screen menu items found Figure 13 and Figure 14. In addition, it is strongly recommended that you review all safety and operational procedures in the laser's user guide that was supplied with your laser.**

1. Start the PSG application
2. If you're using the network to connect to the Laser:
3. Click Session->Ethernet
4. Enter the IP address of the laser, then click Connect
5. Ensure the connection is successful, and the status is displayed in the Connection indicator: IP:<Current IP>~Good~
6. If you're using the serial port to connect to the Laser:
7. Click Session->Serial Port
8. Enter the Com port the is attached to the laser, then click Connect
9. Ensure the connection is successful, and the status is displayed in the Connection indicator: Port:<COMx>~Good~
10. In the Profile panel, Enter a desired Time Scale
11. Click around in the pulse chart to plot a simple pulse
12. Click Laser Operation ->Write Profile, then select an empty slot, click Write Profile and enter a unique name, then click OK.
13. In PSG, click clear in the Editing panel, then click Laser Operations->Read Profile and select the recently created pulse and click Read Profile to see what was saved in the laser Pulse Profile library.
14. Create more Pulse Profiles required for your applications. Up to 100 profiles can be stored in the laser Pulse Profile library.
15. Click Sequence Editor, In the Arrangement panel click Add, then select the first created pulse under Pulse Profile, click Add again and select the second pulse under Pulse Profile, enter a Pre-Delay value to set pulse repetition rate.
16. In the Sequence panel, set the number of Repeats required for the application.
17. Use the horizontal scroll bar to see the entire sequence preview
18. Click Laser Operation ->Write Sequence, then select an empty slot, click Write Sequence and enter a unique name, then click OK.
19. Create more programs (Pulse Sequences) required for your applications. Up to 100 sequences can be stored in the laser Pulse Sequence library.

Pulse Generator (Waveform Mode)

The touch-screen display (refer to Figure 13 and Figure 14) is used for manual control from the front panel of the device and for the indication of information about the state and settings of the device. In addition, activating certain commands from the main window will invoke additional submenu windows of the Pulse Profile selection. Likewise, the Pulse Generator commands will invoke submenus of the touch screen control.

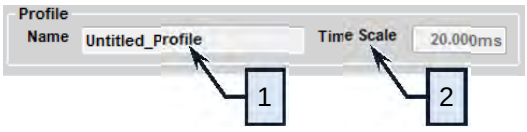
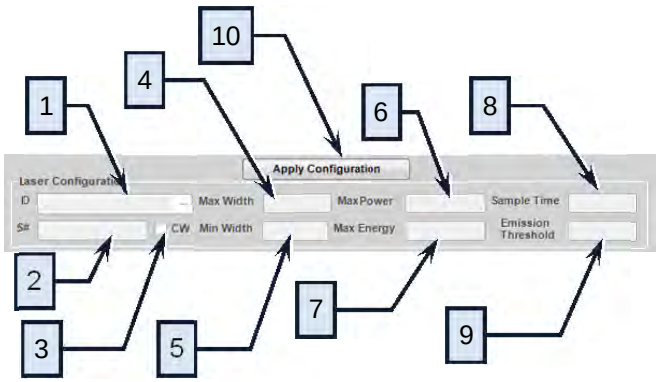
Table 13: PSG Pulse Editor Main Screen

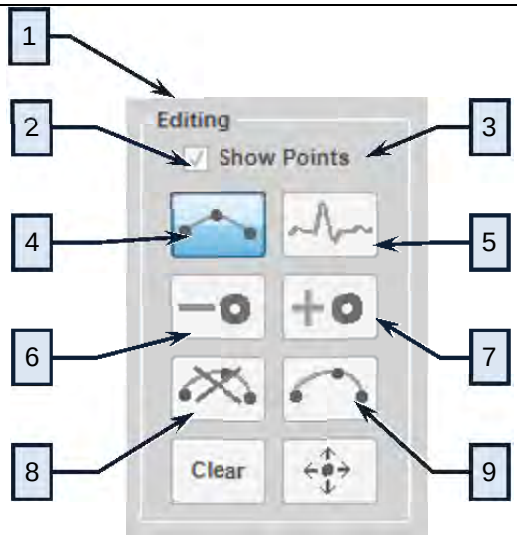
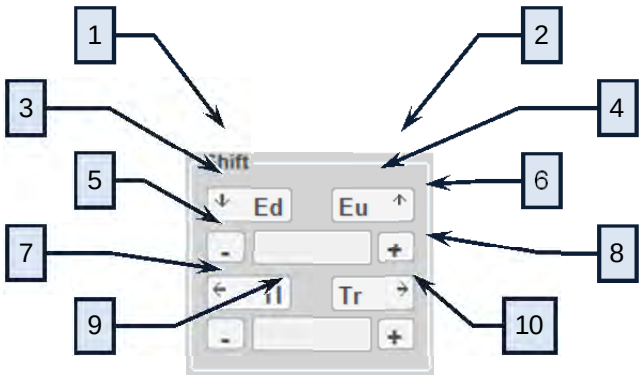


ITEM	DESCRIPTION
1	File Command: Load Profile: Loads and display a pulse profile from the host machine. Save Profile: Saves pulse profile from the host machine, this option saves the entire chart, including unused time segments, so it preserves the original time scale, and stores the LB and RB buffers. Load CSV Profile: Loads a and display comma- separated format pulse profile from the host machine Save CSV Profile: Saves a comma- separated format pulse profile from the host machine, this option only saves the effective pulse, and ignores unused time segments and LB and RB buffers.

ITEM	DESCRIPTION
2	Session: Ethernet: Starts a connection to the laser over a network via a specific IP Serial Port: Starts a connection to the laser over RS-232 serial cable via a specific port on the host machine Offline: Starts an offline session, the user has to enter correct configuration data, or recall automatically saved configuration from a previous laser connection Reset: Disconnects the active session and clear all the window controls
3	Laser Operations: Profile List: Obtains a list of stored pulses from the laser, list query is a semi-passive; the user must typically click Refresh in the Profile List window to get the up-to-date list. Write Profile: Saves current pulse to the laser, this option only saves the effective pulse, and ignores unused time segments and LB and RB buffers. Read Profile: Loads and display a pulse profile from the laser. Delete Profile: Deletes a pulse that is stored in the laser
4	Sequence Editor: Starts the Sequence Editor
5	Remote Control: Starts the Remote Control
6	About PSG: Displays version information
7	Exit: Quits PSG

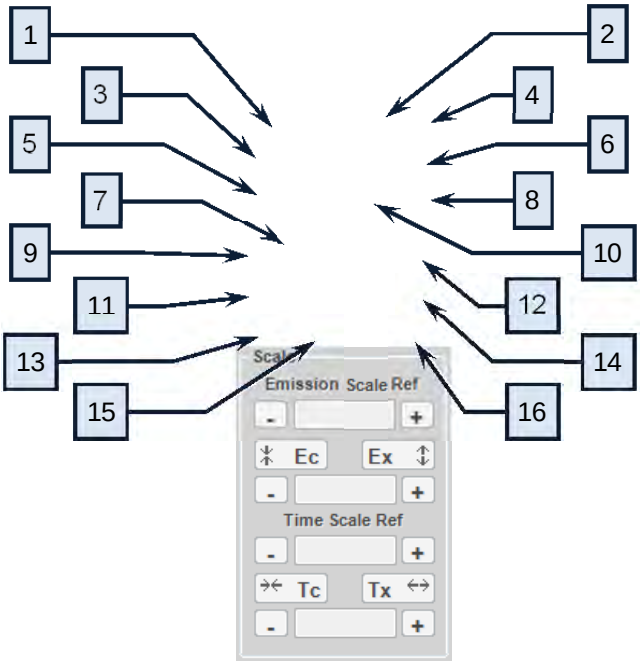
Table 14: PSG Pulse Editor Sub-Menu Screens

SUBMENU PANEL	ITEM	DESCRIPTION
	Session Panel	
	1	Mode: Displays the active session type
	2	Connection: Displays the connection status
	**Profile Panel**	
	1	Name: Displays the name of the current pulse
	2	Time Scale: Displays the current time scale of the chart (0.20 – 50ms)
	**Laser Configuration Panel**	
	1	ID: The identification for the laser
	2	S#: The serial number of the laser
	3	CW: Indicates if CW Mode is active.
	4	Max Width: Maximum allowed pulse width
	5	Min Width: Minimum allowed pulse width
	6	Max Power: Maximum allowed pulse power
	7	Max Energy: Maximum allowed pulse energy
	8	Sample Time: The minimum interval for pulse points
	9	Emission Threshold: Emission (current) effective zero level
	10	Apply Configuration: Accepts change in configuration (e.g. Switching to an Offline Mode Session)
	Status Panel	
	1	Pulse Width: Current pulse width of the pulse in the chart
	2	Energy: Current pulse energy for the pulse in the chart
	3	Time: Current time coordinate of the mouse pointer

SUBMENU PANEL	ITEM	DESCRIPTION
	4	Emission: Current time coordinate of the mouse pointer
	**Editing Panel**	
	1	Show Points: Displays the points between each segment
	2	Pulse Line: Plots pulse points in the chart and lines are automatically formed
	3	Freehand: Plots an arbitrary pulse in the chart and points and lines are automatically formed by mouse movement along the graph
	4	Remove Pulse Point: Removes a pulse point from any position along the chart
	5	Add Pulse Point: Adds a pulse point at any position along the chart
	6	Remove Arc: Removes a previously created arc
	7	Add Arc: Creates an arc between two existing pulse points
	8	Clear: Clears the pulse chart
	9	Move Pulse Point: Relocates a pulse point on the chart between two segments
	**Shift Panel**[1]	
	1	Emission Down: Shifts all pulse points down in emission
	2	Emission Up: Shifts all pulse points up in emission
	3	Decrease Emission Shift Step: Decreases the emission shifting step size
	4	Emission Step: Sets the emission shifting step size (.25 – 100%)
	5	Time Shift Left: Shift all pulse points back in time
	6	Increase Emission Shift Step: Increases the emission shifting step size
	7	Decrease Time Shift Step: Decreases the time shifting step size
	8	Time Shift Right: Shifts all pulse points forward in time
	9	Emission Scale Ref: Sets the reference point for emission scaling (0 – 100%)
	10	Increase Time Shift Step: Increases the time shifting step size

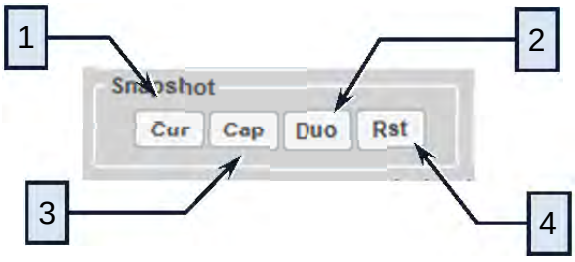
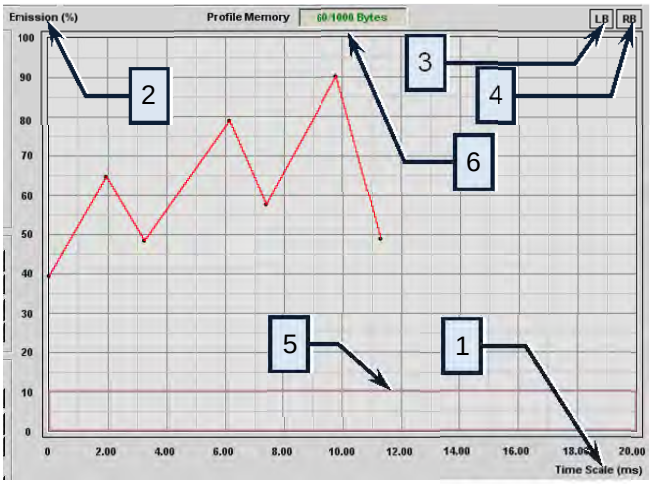
[1] Due to the digitized nature of the pulses, approximations are used to compute modulations, so modulation step values, especially the very small ones may not have an effect. It is recommended to save original pulse or use the Snapshot interface while manipulating the pulse so it's easy to compare the modulated pulse against the original.

SUBMENU PANEL	ITEM	DESCRIPTION



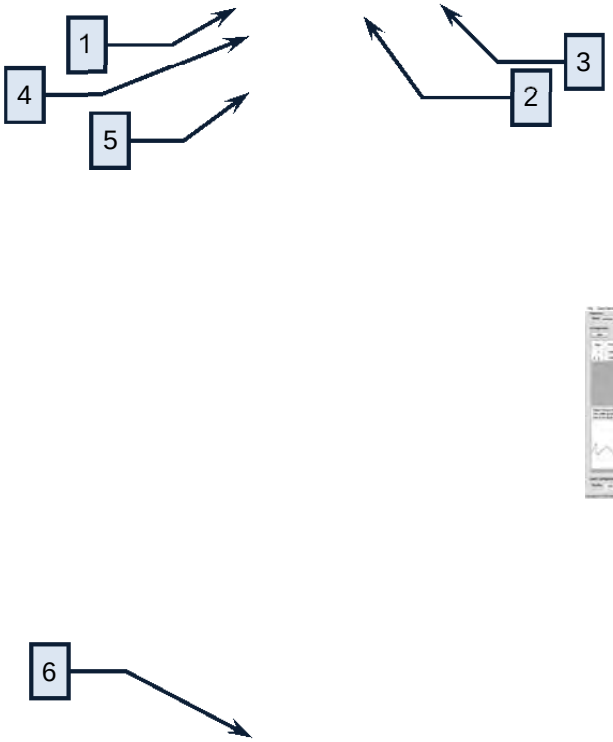
Scale Panel[1]	
1	Decrease Emission Scale Ref: Decreases the reference point for emission scaling
2	Time Step: Sets the time shifting step size (ms)
3	Compress Emission: Compresses all pulse points in emission with regards to the reference point
4	Increase Emission Scale Ref: Increases the reference point for emission scaling
5	Decrease Emission Scale Step: Decreases the step size for emission scaling
6	Expand Emission: Expands all pulse points in emission with regards to the reference point
7	Time Scale Ref: Sets the reference point for time scaling (0 – 50ms)
8	Increase Emission Scale Step: Increases the step size for emission scaling
9	Decrease Time Scale Ref: Decreases the reference point for time scaling
10	Emission Scale Step: Sets the step size for emission scaling (.25 – 100%)
11	Compress Time: Compresses all pulse points in time with regards to the reference point
12	Increase Time Scale Ref: Increases the reference point for time scaling
13	Decrease Time Scale Step: Decreases the step size for time scaling
14	Expand Time: Expands all pulse points in time with regards to the reference point
15	Mod Time Scale: Sets the step size for time scaling (.25 – 100%)
16	Increase Time Scale Step: Increases the step size for time scaling

[1] Due to the digitized nature of the pulses, approximations are used to compute modulations, so modulation step values, especially the very small ones may not have an effect. It is recommended to save original pulse or use the Snapshot interface while manipulating the pulse so it is easy to compare the modulated pulse against the original.

SUBMENU PANEL	ITEM	DESCRIPTION
		**Snapshot panel**[1]
	1	Cur: Displays the current pulse when the Snapshot interface is active
	2	Cap: Enables the Snapshot interface by capturing the current pulse, also used to switch to the saved pulse when editing another.
	3	Duo: When held down, displays both current and saved pulse on the same chart in different colors for comparison
	4	Rst: Resets the Snapshot interface, clears the saved pulse, and any pulse on the chart at the time becomes the current one
		**Chart Panel**
	1	Time (X-axis): Time domain in ms
	2	Emission (Y-axis): Emission level in percent power
	3	LB: Left chart buffer, contains pulse data when lit green, shift pulse to the right to see contents
	4	RB: Right chart buffer, contains pulse data when lit green, shift pulse to the left to see contents
	5	Emission Threshold: Visual representation of the threshold (current) level in the Laser configuration appears as a pink box in the chart. Any pulse data within does not have any power.
	6	Profile Memory: Current pulse memory utilization/ Maximum allowable

[1] Due to the digitized nature of the pulses, approximations are used to compute modulations, so modulation step values, especially the very small ones may not have an effect. It is recommended to save original pulse or use the Snapshot interface while manipulating the pulse so it is easy to compare the modulated pulse against the original.

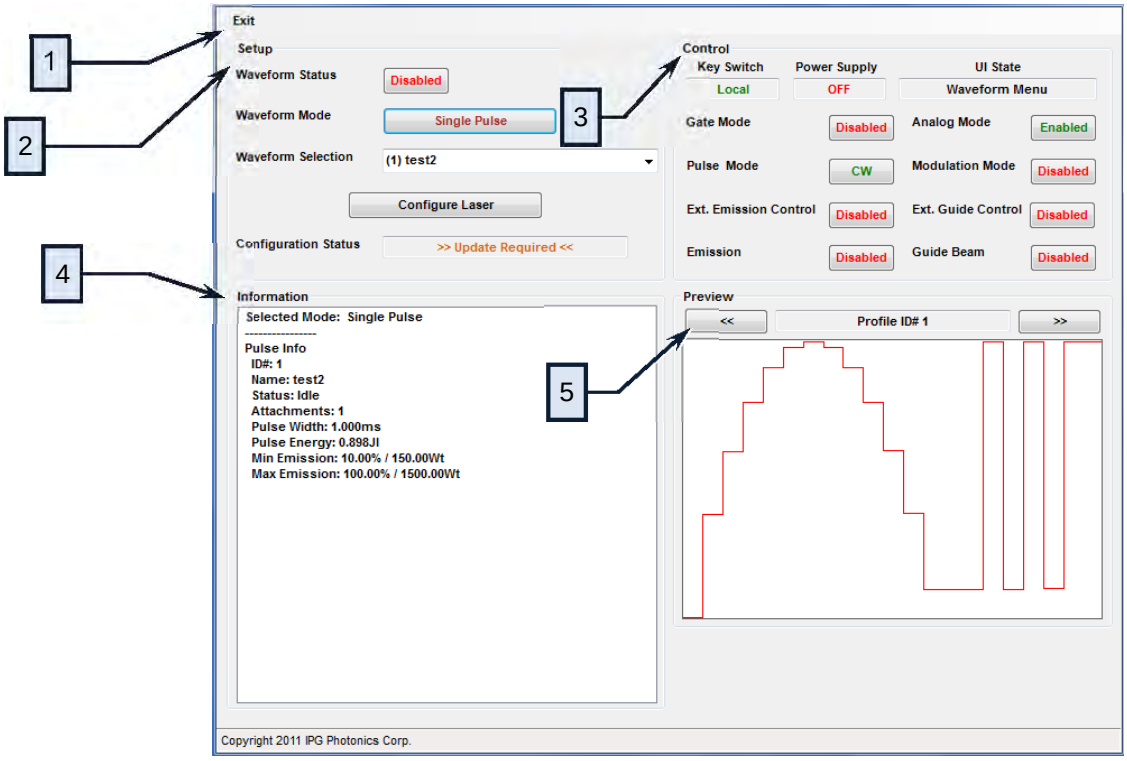
Table 15: Sequence Editor Menu Screen



ITEM	DESCRIPTION
1	File Command: Load Sequence: Loads and display a sequence from the host machine. Save Sequence: Saves a sequence to the host machine.
2	Laser Operations: Sequence List: Obtains a list of stored sequence from the laser, list query is a semi-passive; the user must typically click Refresh in the Sequence List window to get the up-to-date list. Write Sequence: Saves a sequence to the laser Read Sequence: Loads and display a sequence from the laser Delete Sequence: Deletes a sequence from the laser Exit: Quits the Sequence Editor and go back to the Pulse Editor
3	Exit Command: Quits the Sequence Editor and go back to the Pulse Editor
4	Sequence Panel Name: Names of the current sequence Repeats: The number of repeats for the current sequence Infinite Repeats: Toggles infinite number of sequence repeats Intervals: Sets the time interval between each global repeat Reset: Resets all controls

ITEM	DESCRIPTION
5	Arrangement Panel Profiles: Current number of selected pulses in the sequence that are unique/ Maximum allowable Insert: Inserts sequence step prior to the one currently selected Move Up: Moves the selected sequence up in the order of sequence steps Move Down: Moves the selected sequence step down in the order of sequence steps Remove: Removes the selected sequence step Clear: Clears the Arrangement panel Pre-Delay: A delay that precedes every repetition of the corresponding sequence step Pulse Profile: The pulse selection for the specific sequence step Repeats: The number of times to repeat the corresponding
6	Laser Configuration / Sequence Status Panel Add: Adds a sequence step at the end of the sequence, or add the very first step Sequence Steps: Current number of sequence steps / Maximum allowable Average Power: Current maximum average power/ Maximum allowable Profile Memory: Current pulse memory utilization/ Maximum allowable

Table 16: Remote Control Menu Screen



ITEM	DESCRIPTION
1	Exits: Exits the Sequence Editor and goes back to the Pulse Editor
2	Setup Panel Waveform Status: Toggle waveform status Waveform Mode: Toggle between Single Pulse and Pulse Sequence Waveform Selection: Select pulses or sequences Configure Laser[1]: Prepares laser for generation of selected pulse profile or pulse sequence Configuration Status window: Displays the current configuration status
3	Control Panel Key Switch: Displays the current Key Switch position (Local or Remote) Power Supply: Display the Power Supply status (On or Off) UI State: Displays the current menu state of the Touch-screen Gate Mode: Toggles Gate Mode (Enabled or Disabled) Analog Mode: Toggles Analog Mode (Enabled or Disabled) Pulse Mode: Toggles Pulse Mode (CW or QCW) Modulation Mode: Toggles Modulation Mode (Enabled or Disabled) Ext Guide Control: Toggles External Guide Beam Control (Enabled or Disabled)[2] Emission: Toggles External Emission Control (Enabled or Disabled)[3] Guide Beam: Toggles Guide Beam (Enabled or Disabled)
4	Information: Displays important information about the pulse, sequence and sequence step.
5	Preview Panel: Displays a preview of the pulses or sequence, click Next/Prev to browse sequence steps

[1] Waveform Synchronization involves arming the laser with specific pulse or sequence setting; it's not fully automatic to enable the user to be aware of the current settings

[2] If enabled when the laser's key switch is in Remote, it will prevent enabling the guide beam from PSG

[3] If enabled when the laser's key switch is in Remote, it will prevent starting emission from PSG

Pulse Editing

For the following section, please pay attention to the Energy indicator in the Status panel, if it glows red that means you have exceeded the pulse energy limit and automatic correction has occurred, which mean your pulse is being changed automatically. To avoid pulse energy limits, either shorten your pulse widths, or reduce the value of Time Scale in the Profile panel.

Change Time Scale value to zoom in and out then use the time shift controls and alignment cursors for more accurate editing, and always use the Time and Emission indicators in the Status panel for guidance.

Please note that every time a change is made to the pulse, the Pulse Width and Energy indicator are updated to reflect the current sketched pulse, PSG will not allow you to exceed the limits established in the Laser Configuration

A laser emission pulse is a custom time-based emission power signal, constrained by an output sample time, maximum power, maximum energy and minimum current (power) threshold, all of which are preconfigured in the laser. PSG allows sketching of pulse points, and automatically fills in pulse (power level) lines, and computes all the emission pulse characteristics simultaneously, it also perform auto-correction in case constraints are violated.

Please note the pulses are not zeroed visually when they go under the power threshold, although that's not reflected in the pulse energy calculation.

Sketching a Pulse

For simple applications, a single Pulse program may be required. The following procedure demonstrates how to create and load a single pulse program.

1. After starting a session, In the Editing panel, Pulse Line should be the default-selected mode, use the left click on the mouse to plot points along the pulse chart.
2. You will notice that lines are automatically generated to connect the plotted dots.

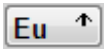
Note: If you reach the maximum laser energy, the Status Panel energy value will turn red and any additional point you try to click will be removed from the pulse line.

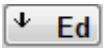
3. In the Editing panel, select the "move point" tool , then drag and move any pulse point, you should be able to move the pulse point in any direction.
4. In the Editing panel, select the "remove point" tool , then click on any existing point, you'll notice the point is removed, and the pulse line is regenerated to connect the neighboring points
5. In the Editing panel, select the "add point" tool , and click between any two existing pulse point, you will notice that the pulse lines are updated to connect the new point to the neighboring ones.
6. In the Editing panel, select the "add arc" tool , then drag and drop and existing pulse line to create different variation of an arc shape replacing the pulse line.

7. In the Editing panel, select the “remove arc” tool , then click on the created arc, you will notice that the arc is removed and replaced with a straight line.
8. In the Editing panel, click “Clear” to wipe the entire pulse chart, you will get a popup window with the option to save the pulse before you remove the pulse you just created. Click “No” for this demonstration.
9. In the Editing panel, click the “free hand” tool , then click and drag the mouse pointer across the chart to create a random continuous shape. This tool will help in modeling a shape that is not possible with the other tools.

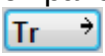
Shifting a Pulse

The Modulation panel in PSG allows you to manipulate the sketched pulse shapes to create new variations, this has many advantages, including saving time and achieving better symmetry.

1. Start by sketching a preliminary pulse, preferably an alternating one, such as a square or sine wave.
2. In the Modulation panel, set a certain Emission Step percentage value, and then click Emission Shift Up 

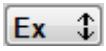
or Emission Shift Down 

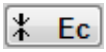
to introduce an emission offset to the pulse.
3. In the Modulation panel, set a certain Time Step value, and then click Time Shift Right

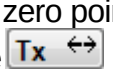
or Time Shift Left 

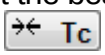
to introduce a time offset to the pulse.

Please not that if the chart is exceeded, the pulse will be stored into Left or Right pulse buffers (“LB” and “RB” located on the top right of the pulse chart). The corresponding buffer will change to a green color if they contain pulse data.

4. In the Modulation panel, set a certain Emission Scale Ref percentage value, it should be the effective zero point of your pulse to get the best result, for example if you are modulating a sine wave, you would set it to be in the center point. Also, set an Emission Scale percentage value then click Expand Emission 

or Compress Emission 

to scale effective emission with respect to the reference point.
5. In the Modulation panel, set a certain Time Scale Ref value, it should be the effective zero point of your pulse to get the best result. Also, set a Time Scale value then click Expand Time 

or Compress Time 

to scale effective time with respect to the reference point.

Note: Because of the sample time constraint, scaling can be unsymmetrical, and there could be a small range of ineffective scaling factors, all that is due to the sample approximation during the calculations. It is strongly recommended to save the original pulse prior to modulating a pulse.

Pulse Comparison

It is useful to compare and contrast different variations of a pulse, especially when performing modulation on a pulse. There are two ways to perform this comparison:

1. Using two instances of PSG: At least one of which has to be started in an Offline session, then the two application windows can be compared side to side.
2. The Snapshot Interface: This interface allows comparison of two pulses on the same chart:

3. Click “Cap” in the Snapshot panel to capture (save) the original pulse
4. Modulate or change the pulse
5. Click “Cap” in the Snapshot panel to switch to the original pulse, any changes to the pulse here will be ignored.
6. Click “Cur” in the Snapshot panel to switch to the pulse in progress, any changes to the pulse here will be saved.
7. Click and hold “Duo” in the Snapshot panel to see both the original pulse and current modified pulse in the same chart each will have an identifying color.
8. Click “Rst” in the Snapshot panel to reset the interface. Note: This will set currently viewed pulse as the current pulse and remove the pulse that is not in the current view.

Pulse Storage and Recall

On Laser

Note: This section requires connection to the laser. It is important to write pulses to the laser in order to use and activate them.

1. First sketch a pulse, then from the top menu, select Laser Operations->Write Profile.
2. Select a slot to write to then click Write Profile, then enter a name to save and click Write Profile.
3. The pulse data will be encoded and transmitted to the laser for storage.
4. To recall, select Laser Operations->Read Profile from the top menu, then select a slot and click Read Profile, the pulse will be fetched, decoded, and displayed on the chart. The displayed pulse may appear differently as any unused time in the chart will be removed as only the effective pulse width is saved.
5. To delete a pulse, select Laser Operation->Delete Profile, select a slot then click Delete Profile.

Note: You will not be allowed to delete a pulse profile that has an attachment status greater than zero, which means that the pulse is used by an existing sequence or sequences. However, you will be allowed to overwrite them if you accept to bypass the warning. You will only be allowed to delete or make changes to a pulse if the pulse profile status is “Idle”. The “In Use” status identifies that the laser is configured with that pulse.

On Host PC

1. In the top menu, select File->Save Profile, then select a name and path for the saved pulse.
2. To recall, select File->Load Profile from the top menu then select the name and path of the file to load.
3. Alternatively, you can use the CSV (comma-separated value) file version of the load and save from the main menu; the advantage is being able to modify the pulse data using a program like MS Excel.

The following is the general format of a Pulse profile in a CSV format, consisting of tags and data values.

Required (header) tags:
[S] - Sample time in ms
[L] - Number of samples
[D] - Start of comma separated percent emission data

Optional tags
[N] - Profile name (The file name is the default)
[C] - Comments, PSG will ignore, optional.
[M] - Pulse profile metadata

Example file (viewed in text editor):
[C],This is a test pulse profile,
[N],testProfile001,
[S],0.050,
[L],10,
[D],50.5,60,50,60,70,80,20,0,20,30

Single Pulse Activation

Note: This section requires connection to the laser.

1. After storing a pulse to the laser, make sure the E-stop button is released on the laser and then press the green button to turn on the power supply

Note: Both Analog and Modulation modes must be set to "Off" to configure the pulse mode and are accessed in the Setup Submenu touch- screen.

2. On the laser touch-screen, select the Setup Submenu->Pulse Setting->Waveform Mode
3. Toggle Waveform Pulse Mode to Enabled, and Single Pulse Selected (button displaying "Single Pulse"), then use the Up/Down arrows to select a specific pulse.

Note: If no pulse profile is saved the laser's pulse profile list then "!! No Profiles Available!!" will be displayed.

4. Pulse Information/Preview (Optional)
5. To get information about the pulse, click on the pulse browser button. This is the button with the name of the pulse. Once the information page appears, you can use the arrows to scroll thru all available pages.
6. Click anywhere in the text space to go to the Preview page, here you can see the shape of the pulse.
7. Click Return twice to go back to the Waveform page.
8. Click Configure & Return.

It is important to configure the laser with the selected pulse (once) before usage.

9. After the configuration is complete, click Return twice to go back to the main page. Then click Emission, and then click OK to confirm and start countdown. The selected pulse will be emitted after the countdown. Click Emission again to clear the status.

Sequence Editing

Note: This section requires connection to the laser

A pulse sequence is an arrangement of pulses, designed for finite or infinite repeats, and organized into steps, each step has an assigned an existing pulse, pre-delay and repeat amount. PSG will check each created sequence for any Average Power and other laser limitation violation, and will prompt the user to make adjustments.

Building a Sequence

1. Start the Sequence Editor by selecting it from the top menu
2. In the Arrangement panel, click Add to add a sequence step
3. In the added step, enter a Pre-Delay value, select a Pulse Profile and enter a number of Repeats (number of times the selected Pulse Profile with Pre-delay must be repeated consequently).
4. Click Add again to add more sequence steps in the same fashion.
5. You can set the number of sequence repeats by setting Repeats and Intervals in the Sequence panel.
6. The preview of the sequence will be refreshed when changes are made to the pulse. Additionally, laser limitation violations are re-checked.
7. A Blank profile is a special “null profile” space holder for introducing delay only as a sequence step.

Modifying a Sequence

1. In the Arrangement panel, highlight an existing step, then click:
2. Insert to insert a new sequence step before the selected one
3. Move Up to shift up the selected sequence step in the sequence order
4. Move Down to shift down the selected sequence step in the sequence order
5. Remove to delete the selected sequence step

Sequence Storage and Recall

Note: This entire section requires connection to the laser.

On the Laser

It is important to write pulse sequences to the laser in order to use and activate them, in the Sequence Editor, select Laser Operations->Write Sequence, then select a slot and click

1. Write Sequence, enter a name for the sequence then click Write Sequence.
2. To recall, select Laser Operations->Read Sequence, then select a slot and click Read Sequence, the sequence will be fetched and loaded into the arrangement panel.
3. To delete a sequence, select Laser Operations->Delete sequence, select a slot then click Delete sequence. Note: It is not possible to delete a sequence if the status is not “Idle”. When the status is “In Use”, it means that the laser is configured with that pulse sequence.

On the Host PC

In the top menu, select File->Save Sequence, then select a name and path for the saved sequence.
To recall, select File->Load Sequence from the top menu then select the name and path of the file to load.

Pulse Sequence Activation

1. After storing a pulse sequence to the laser, make sure the E-stop button is released on the laser and then press the green button to turn on the power supply

Note: Both Analog and Modulation modes must be set to "Off" to correctly configure the pulse sequence mode. To change them for select Pulse Menu->Pulse Setting

2. On the laser touch-screen, select Pulse Menu->Pulse Setting->Waveform Mode
3. Toggle Waveform Pulse Mode to Enabled, and Pulse Sequence Selected, then use the Up/Down arrows to select a specific pulse sequence.
4. Pulse Sequence Information/Preview (Optional)
5. To get information about the pulse sequence, click on the pulse browser button, the information page appears, you can use the arrows to scroll thru all available pages. Click anywhere in the text space to go to the Preview page, here you can see the shape of the pulses in the sequence; use the arrows to see the entire page. Click Return twice to go back to the Waveform page.

It is important to configure the laser with the selected pulse sequence (once) before usage.

6. Click Configure & Return. After the configuration is complete, click Return twice to go back to the main page. Then click Emission, and then click OK to confirm and start countdown. The selected pulse will be emitted after the countdown. Click Emission again to clear the status, this will also stop a pulse sequence if it is set to infinite repeats.

Remote Control Interface

This interface is designed to provide remote control for PSG users, it is focused around the pulse-shaping feature and it not meant to be a comprehensive control utility. Note: This interface will work simultaneously with the touch-screen panel.

1. To start the interface, select Remote Control from the top menu Use the Setup panel to enable the waveform (pulse) mode, select the pulse or sequence mode, select a pulse or sequence then configure the laser.

TROUBLESHOOTING

Error Messages on the Display and Status Bits

The following table describes the errors and possible solutions that are associated with the displayed errors on the touch-screen display or returned status bits via the RS-232 connection.

OPTICAL INTERLOCK (BIT 30)	
	RESULT: The internal main power supply is automatically switched off. CAUSE: Either the delivery fiber cable is mechanically damaged or the output connector is not plugged into an appropriate optical head. POSSIBLE SOLUTION: Send reset error command (“RERR”), and if the message does not disappear, contact a representative from IPG Photonics for assistance.
LOW TEMPERATURE (BIT 24)	
	RESULT: The power supply and laser emission will be switched off. CAUSE: The case temperature of the laser is too low. Please check if outside conditions are within the specified range. POSSIBLE SOLUTION: This message and error bit disappear as soon as case temperature of the laser module drops in the operating range.
OVERHEAT (BIT 1)	
	RESULT: The power supply and laser emission will be switched off. CAUSE: This means that case temperature of the laser is too high. POSSIBLE SOLUTION: Please check if outside conditions are within the specified range and if the conditions for sufficient airflow are provided. This message and error bit disappear as soon as case temperature of the laser modules drops in the operating range.
MODULE DISCONNECTED (BIT 6)	
	RESULT: The power supply and laser emission will be switched off CAUSE: This means that digital data communication with the laser module inside the device is broken. POSSIBLE SOLUTION: Try to reset the error and if it appears again please contact IPG Photonics for assistance

POWER SUPPLY FAILURE (BIT 19)	
	RESULT: The power supply and laser emission will be switched off CAUSE: This means that even though the internal main power supply is switched on there is no voltage applied to the laser module. POSSIBLE SOLUTION: Try to reset the error. If it appears again, please contact IPG Photonics for assistance.
POWER SUPPLY FAILURE 2 (BIT 25)	
	RESULT: The internal main power supply will be automatically deactivated. CAUSE: This means that though the internal main power supply is switched on and the voltage is applied to the laser module, the value of this voltage is not within the preinstalled range. POSSIBLE SOLUTION: Reset the error and switch on the internal main power supply. If the error reappears, contact IPG Photonics for assistance.
HIGH BACK REFLECTION (BIT 3)	
	RESULT: Laser emission is switched off. CAUSE: The back reflected power exceeded the preinstalled maximal applicable level. POSSIBLE SOLUTION: Please check if the focus position is correctly adjusted and that there are no surfaces, which can lead to the high level of back reflection. Reset the error using RS-232 (“RERR” command) or touch-screen display on the front panel.
CRITICAL ERROR (BIT 29)	
	RESULT: The power supply and laser emission will be switched off CAUSE: The system has detected an error that is considered critical. POSSIBLE SOLUTION: Neither reset command (“RERR”) nor restart of the device will clear this error. Contact IPG Photonics for assistance. Be ready to read the Module Error Code (“RMEC” command) from the laser and submit it to an IPG Technical Support Specialist.

Table 17: Error Messages and Status Bits

SERVICE

Service and Repairs

There are no operator serviceable parts inside. Only the fuses and filter media are replaceable. Please refer all internal servicing to qualified IPG personnel.

Many issues and questions regarding the safety, set-up, operation and maintenance of the IPG products can be resolved by reading this User's Guide carefully. However, if you have questions regarding the safety, set-up, operation or maintenance of your IPG product, please call the Customer Service department. If you cannot resolve the issues by using this User's Guide or over the telephone with our technical support group, you may need to return the product to IPG. See PRODUCT RETURNS section for more details.

Serviceable Items

⚠ **WARNING: The unit should never be operated with any of the covers removed, including the front panel fan covers.**

The input voltage to the laser is potentially lethal. All electrical cables and connections should be treated as if it were a harmful level. All parts of the electrical cable, connector or device housing should be considered dangerous.

This device is classified as a high power **Class 4** laser instrument under 21 CFR 1040.10. This product emits invisible laser radiation at or around a wavelength of **1070 nm**, and the total light power radiated from the optical output is greater than **20 to 1500 W** (depending on model) per optical output port. This level of light may cause damage to the eye and skin. Despite the radiation being invisible, the beam may cause irreversible damage to the cornea. Laser safety eyewear is not provided with this instrument, but must be worn at all times while the laser is operational.

⚠ **WARNING: Service personnel should always follow correct Lockout/Tagout procedures per your company's policy to ensure all potential energy is removed from the system before servicing.**

Replacing Fuses

Fuse Ratings: Refer to Table 18: Replacement Parts
To replace the main power fuses, use the following procedure:

1. Unplug the line cord and remove keys from laser.
2. Turn the laser so the rear panel is easily accessible.
3. Locate the fuses and unscrew the covers.

Important: Replace blown or damaged fuses with only the same amperage fuses.

4. Replace the fuse(s) and covers and tighten securely.

Replacing the Filter Media

Inspect the filter media weekly and clean or replace as needed. To access the filters, use the following procedure:

1. Unplug the line cord and remove keys from laser.

2. Remove the front bezel on the front panel of the laser (refer to Figure 5: Front Panel Layout). Upon removal, the filter element will be exposed.
3. Remove the used filter and clean or replace with a new filter (Refer to Table 18).
4. Snap the cover back on and dispose of the dirty filter element.

DESCRIPTION	LASER CATEGORY[1]	PART NUMBER
Filter Media	3U	P45-004679
Filter Media	4U	P45-004676
Filter Media	6U	P45-004679 and P45-004704
Fuse T 10A 250VAC	3U AC	P40-001743
Fuse T 15A 250VAC	3U WC, 4U AC (CW and QCW), 6U AC	P40-001564

Table 18: Replacement Parts

[1] Refer to Laser Model Designation Codes

Optical Fiber Connector Inspection and Cleaning Guide

⚠ **CAUTION: It is imperative that a fiber connector is checked for dust, dirt, or damage every time before it is connected with an optical head or beam coupler. The use of a dirty, or improperly cleaned, fiber connector can lead to serious damage to the laser (Figure 19: Fiber Quartz Block Inspection illustrates possible fiber failures). IPG Photonics is not responsible for any damages due to contaminated connectors. Tampering with the fiber connectors without training by IPG will void the warranty.**

For cleaning a fiber connector, you need the following materials:

- Powder free rubber gloves or finger cots
- Lint free optical cleaning wipes and/or swabs
- Acetone (optical grade, water free)
- Compressed air (oil free, water free)
- Microscope (IPG model or equivalent)
- Light Source

Lens Tissue and Cleaning Swabs	Microscope Kit (IPG US model)

IMPORTANT: It is imperative that you wear powder free rubber gloves during this cleaning procedure!

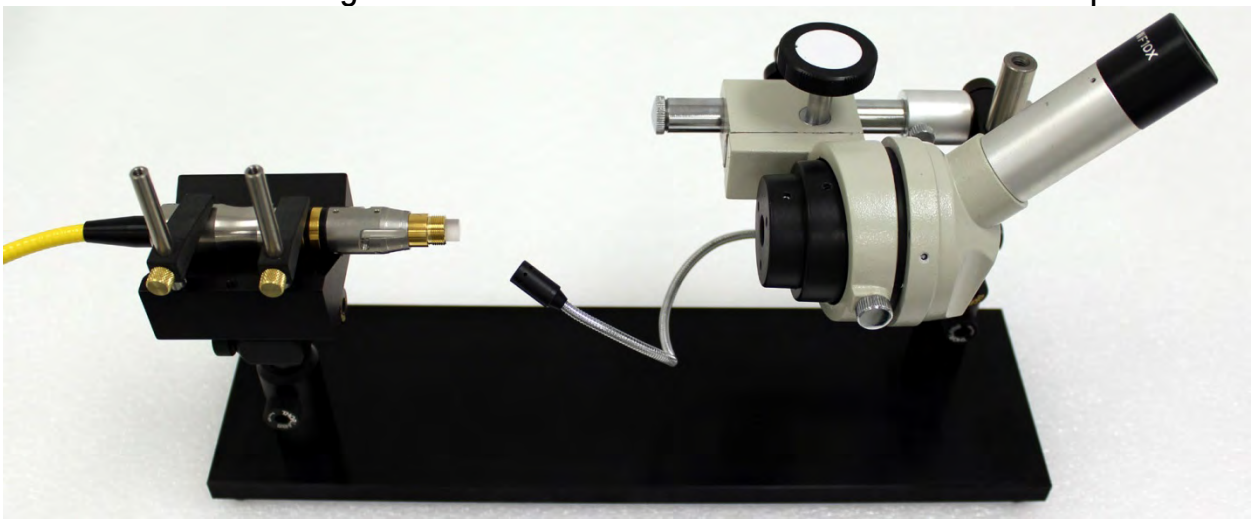
It is hereby stated that damage to the fiber connector can occur due to mishandling, the use of incorrect cleaning procedures or chemicals for cleaning and is not covered by the warranty.

Acetone should be handled and stored in accordance to any local regulations (e.g. OSHA Regulation 29 CFR 1910.1200). Refer to each solvent's MSDS (Material Safety Data Sheet) for additional information.

1. Switch off the laser main power by pressing the E-Stop pushbutton on the front of the unit and turning the Keyswitch to the center position.
2. Leave protective cap on and clean the fiber connector exterior with optical cleaner, wipe it with a clean optical wipe and dry with compressed air.

3. Place fiber connector in the holder of the microscope and then place pressure on the center of the securing arm before tightening the locking screw (Figure 15).

Figure 15: Fiber Connector Mounted on IPG Microscope



4. Remove cap and sleeve from connector (Figure 16).

IMPORTANT: Place the cap face down on a clean surface. Placing the cap face down on a lint free wipe is the best choice if the surfaces are questionable.

Figure 16: Fiber Cap and Sleeve Removed

5. Focus the microscope onto the connector surface.
6. Use light source to illuminate the face of the connector so that the light is reflected from the surface of the microscope. This is achieved if you see a bright golden shine from the IPG (yellow cable) connector end-face or a blue surface for the connector (Figure 19).

IMPORTANT: Always look at the surface at a slight angle to improve visibility.

7. Inspect the surface carefully. Any contamination will lead to dark spots on the surface and eventual fiber failure (see Figure 19 for examples). If contamination is visible on the quartz block, continue to the next step. Proceed to Step 14 if there is no contamination visible.

8. Try to blow away the dust with compressed air from the side.

IMPORTANT: Never blow air directly at the surface because you could embed contaminants into the surface. Always blow across the surface!

9. While wearing powder free gloves, fold the lint free optical wipe into halves until it is roughly 1 X 1 ½" rectangle (Figure 17). Put a few drops of optical cleaner onto the lint free optical cleaning wipe on the folded edge of the wipe, as indicated.

IMPORTANT: Do not ever reuse a lint free optical wipe or swab to clean the end face.

10. Re-inspect lens.
11. Repeat step 9 with Acetone if lens is still contaminated.
12. If necessary, put a drop of Acetone onto a cleaning swab and gently wipe away contamination in a circular motion being careful not to scratch the lens. Then repeat from step 9.

⚠ **CAUTION: Do not touch the tip of the cleaning swab with your fingers and use each swab only once to prevent contamination.**

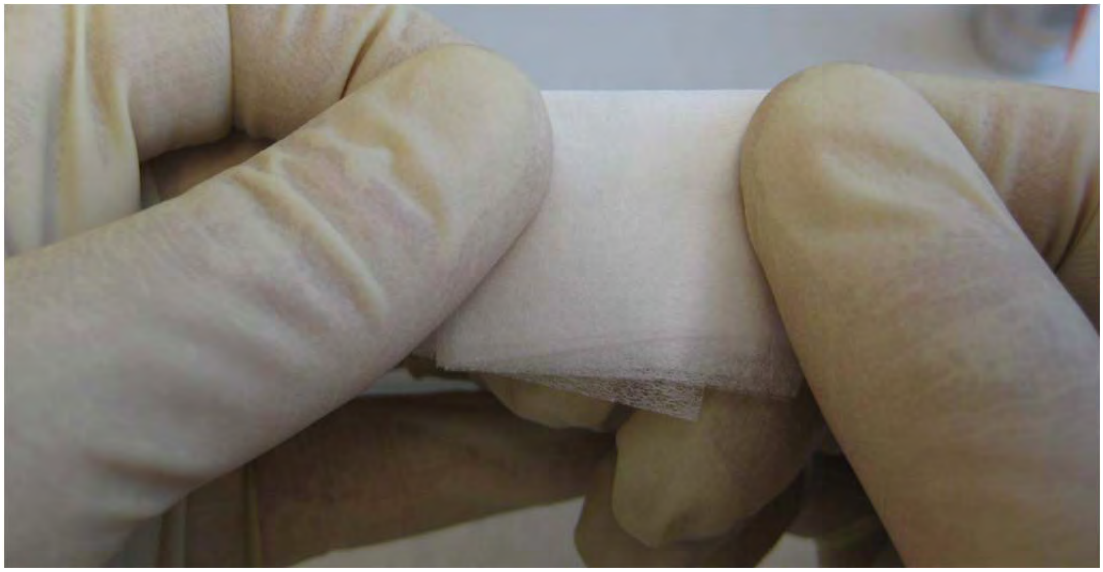
13. Repeat above cleaning steps until all contamination is removed. This cleaning procedure can be stopped at any time if a good result has already been achieved.

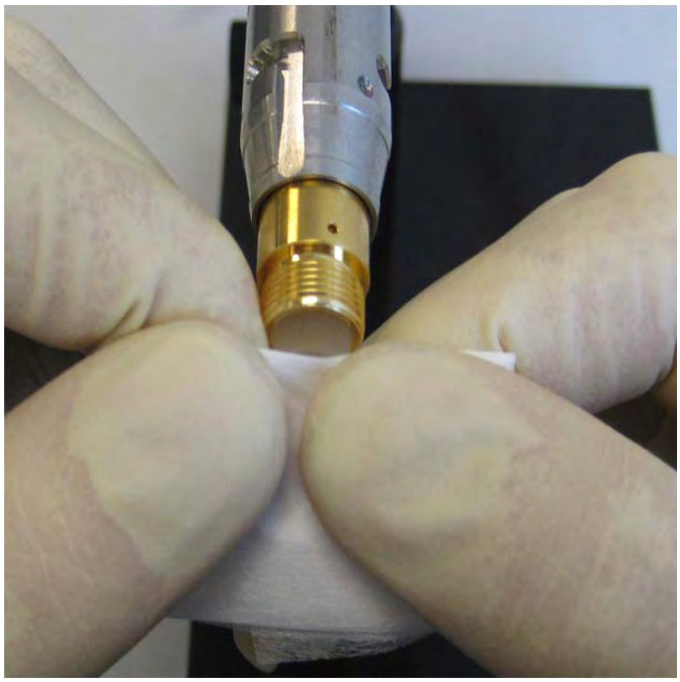
After fiber connector is clean use compressed air to clean the protective sleeve and install onto the connector.

14. Figure 18).

⚠ **CAUTION: It is hereby stated that damage to the fiber connector can occur due to mishandling, the use of incorrect cleaning procedures, or chemicals for cleaning. This is not covered by the warranty.**

Figure 17: Fiber End-face Cleaning

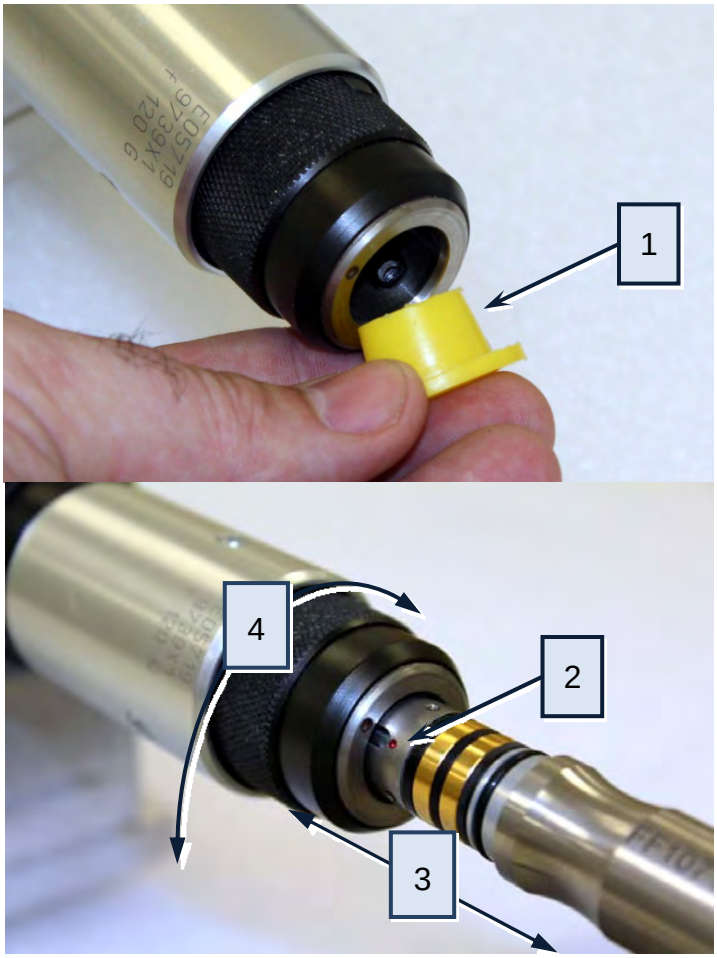




Start to clean with even pressure.

Drag in only one direction.

Figure 18: Installing the Fiber



1. Remove the plastic protection cap at the bayonet enclosure.
2. For connecting the fiber to the bayonet, the red dot at the fiber has to be in line with the red dot at the bayonet enclosure.
3. Gently slide the fiber all the way into the fiber port.[1]
4. Lock the fiber into place by rotating the bayonet knurled ring. [2]

IMPORTANT: Hand tighten only as the use of tools can lead to damage to the bayonet enclosure.

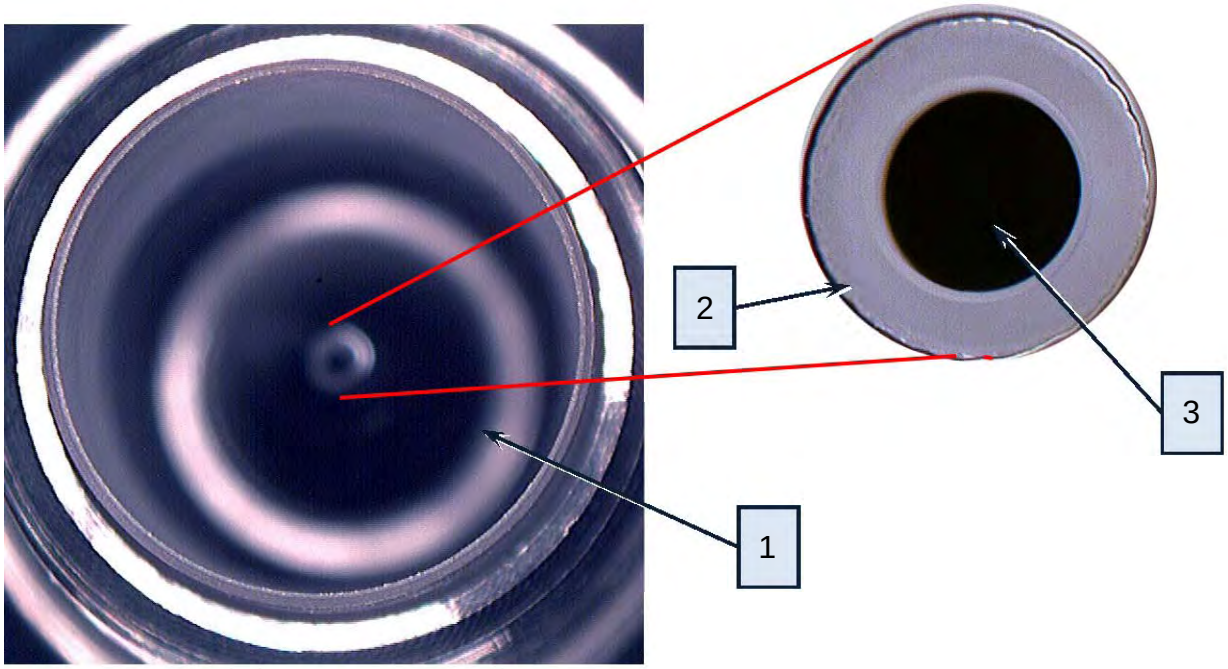
15. If the fiber is not to be connected immediately with a suitable optical component, use compressed air to clean the protection cap and install over the fiber end.

IMPORTANT: Do not forget to clean the cap and sleeve before installing them back onto connector.

[1] A conical guide positions the fiber connector into the interfacing unit.
[2] The connector is locked in position by a bayonet that also ensures correct orientation. The safety interlock system connects only when the bayonet is closed, via the two contact rings of the connector. When managing fiber do not exceed the maximum bend radius is 100mm unstressed and 200mm stressed.

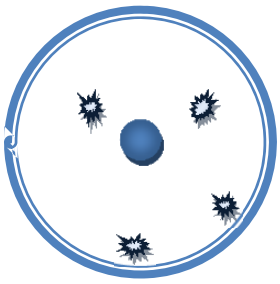
Figure 19: Fiber Quartz Block Inspection

ACTUAL FIBER IMAGE (CLEAN)

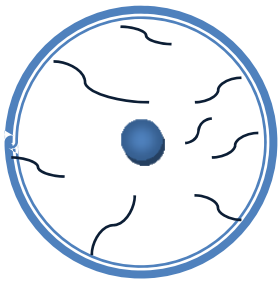


1. Quartz Block
2. Fiber Cladding
3. Fiber Core

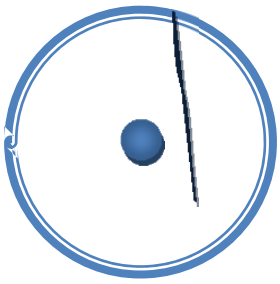
POSSIBLE FIBER QUARTZ BLOCK DAMAGE



Surface Damage



Coating Damage



Scratches

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PRODUCT RETURNS

Returns to the United States

Note: All product returns require a Return Merchandise Authorization (RMA) from IPG.
To obtain an RMA, call the Customer Service department of IPG Photonics Corporation at 508-373-1100 (US) or +49 2736 44 20 451 (Germany).

If you return a product with a RMA, please perform the following procedure:

1. Products must be carefully packed in a suitable shipping container(s). Buyer assumes all responsibility for products damaged in shipment to IPG.
2. Buyer must issue a purchase order for the value of the replaced parts/service items and IPG will issue credit or invoice when the parts/service is received. Speak to IPG Service Manager for the amount authorized under the required purchase order.
3. All requests for repair or replacement under this warranty must be made to IPG within 30 days after discovery of the defect (but not later than 7 days after warranty expiration).
4. All products returned to IPG but which meet applicable specifications, not defectively manufactured or used not in accordance with this User's Guide, will result in the Buyer being charged IPG's standard examination charge.
5. Complete packing list with product model and serial number will ensure prompt repair.
6. Be sure to include with the returned product your 'ship to' address for the return of the serviced product.

Shipping Instructions:

Warranty Returns - Domestic & International Buyers* pay for one-way freight costs and insurance to IPG. IPG will pay for freight return cost and insurance back to the Buyer.

Non-Warranty Returns - Domestic & International Buyers* pay for two-way freight costs and insurance to IPG. If shipment consists of returns that are both warranty and non-warranty, the shipment will be considered as non-warranty.
Shipping address for returns to US:

IPG Photonics Corporation
50 Old Webster Road
Oxford, MA 01540
Attn: Product Returns
Tel: 508-373-1100

* International Returns must include applicable DUTIES AND TAXES, and you must mark air bills with "U.S. GOODS, RETURNED FOR REPAIR."

Returns to Germany

Shipping address for returns to Germany:

IPG Laser GmbH
Siemensstrasse 7
D-57299 Burbach, Germany
Attn: Product Returns
Tel: +49-(0)2736-44-20-451

1. IPG Laser GmbH will only accept returns for which an approved Return Material Authorization (RMA) has been issued by IPG Laser GmbH. You should address to the customer support team at +49-(0)2736-44-20-451 or support.europe@ipgphotonics.com to discuss the return and request an RMA number. **You must return defective products freight prepaid and insured to IPG Laser at the address shown herein. All products which have returned to IPG Laser but which are found to meet all previously applicable specifications for such products or which indicate damage to the fiber connectors not resulting from defect manufacturing, shall be subject to IPG Laser' standard examination charge in effect at the time and these costs shall be charged to the Buyer. All products returned to IPG Laser which are not accompanied by an itemized statement of defects, shall be returned to the Buyer at the Buyer's expense and IPG Laser shall not carry out any evaluation of such products. IPG Laser warrants to Buyer that its services, labor and replacement parts, assemblies and modules will be free of defects in material and workmanship for ninety (90) days from the date of shipment or performance of services.**
2. **Warranty Returns** - Domestic & *International Buyers should pay for **one-way** freight costs to IPG Laser. IPG Laser will reimburse Buyers for applicable reasonable third-party freight costs and IPG Laser will pay for freight return cost back to the Buyer.
3. **Non-Warranty Returns** - Domestic & *International Buyers are responsible for two-way freight costs. If shipment consists of returns that are both warranty and non-warranty, the shipment will be considered as non-warranty. Any UNAUTHORIZED shipments billed to IPG Laser without authorization will be re-invoiced to the Buyer. Confirming purchase orders are required for non-warranty returns.
4. *International Returns **must** include applicable DUTIES AND TAXES, and you must mark air bills with "RETURNED FOR REPAIR". In any event, where IPG Laser accepts a shipment, IPG Laser will invoice to the Buyer for any charges as stated above.
5. Returns for credit will not be accepted unless authorized in advance, in writing by IPG Laser, in accordance with IPG Laser' Terms and Condition, including the warranty provisions. In most cases, restocking fees will apply.
6. All returns must be packaged adequately to avoid damage during shipment.
7. Complete packing list with product model and serial number will insure prompt repair, if the other terms of this form are followed.
8. See the IPG Terms and Conditions for the applicable warranty for the products before you request the return of the products.
9. RMA number will expire 31 days after the date of issue. Thereafter, units received in under the expired RMA number will result in a longer turnaround time. Please include a copy of the completed RMA form with the return of your unit(s).

GLOSSARY

°C	Degrees centigrade or Celsius
°F	Degrees Fahrenheit
λ	Lambda (wavelength symbol)
µs	Microsecond = 10^{-6} second
Amp	Amperes
AC	Alternating current
ADC	Analog-to-digital converter
ASCII	American Standard Code for Information Interchange (U.S. Government)
BTU	British thermal unit
CDRH	Center for Devices and Radiological Health (U.S. Government)
CFR	Code of Federal Regulation (U.S. Government)
cm	Centimeters = 10^{-2} meters
CPU	Central processing unit
CW	Continuous wave (operating mode)
DC	Direct current
EN	European Norm
Hz	Hertz or cycles per second (frequency)
kg	Kilograms
kV	Kilovolts = 10^{3} volts
kW	Kilowatts = 10^{3} watts
l	Liters (volume)
lbs	Pounds
IP	Internet protocol
LD	Laser diode
LCD	Liquid crystal display
LED	Light emitting diode
nm	Nanometer = 10^{-9} meters
mA	Milliamps = 10^{-3} amperes
mm	Millimeter = 10^{-6} meters
MHz	Megahertz = 10^{6} Hertz
mrad	Milliradian = 10^{-3} radians (geometry)
rms	Root mean square or quadratic mean
QCW	Quasi-Continuous wave (operating mode)
TCP	Transmission control protocol
VAC	Voltage alternating current
W	Watts (power)