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YLR-Series User Guide

Part Number: P21-010106, YLR-Series SLED 3.0
Published: April 2015
Revision: B
DCO: 956

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Preface

Ensure you read and understand this guide in its entirety and familiarize yourself with the operating and maintenance instructions before you use the product. IPG strongly recommends that all operators of the product read and pay particular attention to all safety information contained herein prior to operating the product.

This guide should stay with the product to provide you and all future operators, users, and owners of the product with important operating, safety, and other information.

For technical assistance concerning the product, contact IPG Customer Service.

Audience

The audience for this guide are system integrators and technicians responsible for installing and operating the YLR-Series laser in industrial and non-industrial installations.

Contents

Preface

Audience . . . . . i-i

1 Overview of the YLR-Series Fiber Lasers

Introduction 1-1
Audience 1-1

Safety Information and Conventions 1-2

Safety Features and Compliance to Government Requirements . . 1-3
Compliance to Regulatory Standards (on applicable units) 1-3
Class A Digital Device 1-4
Electromagnetic Compatibility 1-4
Laser Classification 1-5
Safety Label Locations 1-6
Emission-On Indicator 1-13

General Safety Instructions 1-14
Specular Reflections 1-14
Equipment and Solvents 1-14
Safety Recommendations 1-14
Optical Safety 1-15
Electrical Safety 1-15
Environmental Safety 1-16

Additional Safety Resources 1-19

2 Using Your Device

Overview 2-1
Main Features 2-1
Applications 2-1

Model Configurations 2-1
Laser Model Designation Codes 2-1

Certification 2-3
YLR Series — Front Panel View 2-3
YLR Series — Rear Panel View 2-6
Optical Output Fiber Terminations 2-9
Products with a Connector 2-9
Products with a Collimator 2-10
Model Specifications 2-10
Unpacking Instructions 2-11
Unpacking a Unit from a Cardboard Box 2-11
Unpacking a Unit from a Wooden Crates 2-14
Using the YLR-Series 2-16
Connecting Electrical Power 2-16
Interface Wire Specification 2-17
Connections to External Circuits 2-17
Interlock Safety Circuit 2-18
Interface Connector Pin Assignments 2-19
Initial Power-Up Sequence 2-24
Key Control 2-24
YLR-Series System Operation 2-25
Rear Panel: 7-pin and 24-pin Connectors 2-26
Operation Control Modes 2-29
Turning on the Device in Local Control Mode 2-30
Turning on the Device in Remote Control Mode 2-30
Selecting Operation Modes 2-31
Pulse Mode (QCW) 2-31
Operational Sub-Modes 2-32
Standalone Mode (Modulation and Gate control disabled) . . 2-32
Modulation Mode 2-32
Gate Mode 2-32
External (Analog) Power Control 2-32
Pulse Shaper Program (Optional Feature) 2-33
Using the Touch-Screen Display 2-33

3 Computer Interface/Commands

RS-232 Configuration 3-1
Ethernet TCP/IP Interface 3-1
Interface Commands 3-2

4 Pulse Shaping

Overview 4-1
PC Requirements 4-2
Ethernet TCP/IP Interface 4-3
RS-232 Configuration 4-3
Key Terms 4-3
Installing the Pulse Shaper Software 4-4
Configuring a Local Area Connection for Ethernet 4-9
Pulse Shaper Configuration Procedures 4-12
Connecting using Ethernet 4-12
Connecting Using RS-232 4-13
Using the Offline Option 4-14
Exporting a Configuration 4-15
Importing a Configuration 4-15
Using the Pulse Shaper Program 4-17
Laser Control Tab 4-20
Shape Editor Tab 4-21
Creating a New Pulse Shape Profile 4-27
Creating a Single Pulse Shape 4-28
Shifting a Pulse Shape 4-29
Pulse Shape Storage and Recall 4-30
On a Laser 4-30
On a Host PC 4-31
Deleting a Pulse Profile 4-31
Single Pulse Activation 4-33
Single Pulse Activation using the Touch-Display Screen 4-34
Scaling Editor 4-35
Creating a New Pulse Scale 4-36
Sequence Editor 4-37

Creating a New Pulse Sequence 4-38
Building a Sequence 4-39
Modifying a Pulse Sequence 4-42
Pulse Sequence Storage and Recall 4-42
On a Laser 4-42
On a Host PC 4-43
Deleting a Pulse Sequence 4-43
Pulse Sequence Activation 4-45
Pulse Sequence Activation using the Touch-Screen Display 4-46
Remote Control Interface 4-47

5 Troubleshooting

Error Messages on the Display and Status Bits 5-1

A Web User Utility

Overview A-1
Configuration Procedures A-1
Configuring an Ethernet Connection A-1
Configuring an RS-232 Serial Connection A-1
Configuring a LAN Connection for Ethernet A-2
Website Data Settings A-5
Accessing the Web User Utility A-7

B Service

Service and Repairs B-1
Serviceable Items B-1
Replacing Fuses B-2
Replacing the Filter Media B-2

C Optical Fiber Connector Inspection and Cleaning

Overview C-1

D Warranty

Limited Express Product Warranties D-1

Warranty Limitations D-1

Limitation of Remedies and Liabilities D-2

Software D-2

Firmware License Agreement D-2

Software License Agreement for LaserNet™ D-6

IPG Laser GmbH® D-6

Single Use License D-6

MICROSOFT CORPORATION EMBEDDED SOFTWARE END USER LICENSE AGREEMENT D-10

E Product Returns

Returns to the United States E-1

Shipping Instructions: E-2

Warranty Returns E-2

Non-Warranty Returns E-2

Returns to Germany E-3

F Glossary

. . . . . F-1

Overview of the YLR-Series Fiber Lasers

Introduction

The IPG Photonics YLR-Series fiber lasers are developed to meet industrial market demands of efficient reliable maintenance-free high power lasers. These lasers are a diode-pumped Ytterbium fiber laser with output powers ranging from 1W up to 1.5 kW operating at the wavelength region of 1060 - 1100 nm.

The YLR-Series fiber lasers can be air or water-cooled. The wall plug efficiency for a fiber laser is typically exceeds 30 percent. All YLR-Series fiber lasers are Class 4 laser products and are designed and tested with important safety features. Follow this guide and apply laser safety practices for 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 other people near the laser must be aware of these special hazards.

Audience

The audience for this guide are system integrators and technicians responsible for installing and operating the IPG YLR-Series fiber lasers in industrial and non-industrial installations.

Safety Information and Conventions

To ensure the safe operation and optimal performance of the product, follow all warnings in this guide. Safety precautions must be observed during all phases of operation, maintenance, and service.

Operators must adhere to these recommendations and to apply sound laser safety practices at all times. Never open the chassis. There are no user serviceable parts, equipment or assemblies associated with this product. All internal service and maintenance should only be performed by qualified IPG personnel.

Table 1-1 lists safety conventions and their meanings. These conventions are used throughout this guide.

Table 1-1. Safety Symbols

Symbol	Description
 	Text marked with an **Electrical Warning** symbol or **Laser Warning** symbol refers to a potential personal hazard. It requires a procedure that, if not correctly followed, can result in bodily harm to you or others. Do not proceed beyond the Electrical Warning or Laser Warning symbols until you completely understand and meet the required conditions.
	Text marked with a **Caution** symbol refers to a potential product hazard. It requires a procedure that, if not correctly followed, can result in damage or destruction to the product or components. Do not proceed beyond the Caution symbol until you completely understand and meet the required conditions.
No symbol	Text marked with **Important** refers to pertinent information regarding the operation of the product. Ensure you do not overlook this information.

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 61000-4-8:2010

EN 61000-4-11:2004

EMC Other:

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

Electrical Safety:

61010-1:2010

Laser Safety:

EN 60825-1:2007

CDRH 21 CFR 1040.10

Functional Safety:

The following safety functions are implemented to fulfill the requirements of EN ISO 13849-1:2008 + A1:2009 Cat.3 / PL d and Category 3 (Cat. 3). The safety functions are implemented exclusively in hardware:

- Stop initiated by a safeguard: The safety electronics of the laser monitors the feed fiber cable (optical fiber interlock). If the laser is emitting and the feed fiber is disconnected from a mating device or broken, the safety-related outputs become de-energized.
- Stop initiated by a safeguard: The safety electronics of the laser monitors E-Stop input. If the laser is emitting and the E-Stop is activated, the safety-related outputs become de-energized.
- Safe start/restart button: The safety electronics of the laser monitors safety-related outputs. A fault in the safety-related outputs is detected before the next demand upon the safety-related output.
- Discharge of stored energy: The safety electronics of the laser monitors safety-related inputs. If the laser is emitting and a stop is initiated by a safeguard, the stored energy for the laser is discharged.
- Prevention of unexpected startup: The safety electronics of the laser monitors safety-related inputs. Start of restart cannot occur after activation of a safeguard until safeguard is re-established and separate deliberate action occurs.

Class A Digital Device

This equipment is tested and complies with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment.

This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with this guide, can cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the users are required to correct the interference at their own expense.

Electromagnetic Compatibility

Compliance of the YLR-Series lasers with the EMC requirements is certified by the CE mark if identified by the CE label (Figure 1-1 on page 1-7).

The European requirements for Electromagnetic Compliance are specified in the "EMC Directive." Conformance to the "EMC Directive" 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 Class 4 laser products 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 can cause damage to the eye or skin. Despite the radiation being invisible, the beam can cause irreversible damage to the retina and 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 the 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 emits light over a range of wavelengths.

You must ensure that the laser safety eyewear used protects against light emitted by the device over its entire range of wavelengths. Review the safety labeling on the product (see Figure 1-1 on page 1-7) and verify that the personal protective equipment (for example, enclosures, viewing windows or viewports, garments, and eyewear) being used 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 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 device, 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.



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



CAUTION: Use of the device in a manner other than that described herein can impair the protection provided by the device.

Safety Label Locations

The YLR Series Laser has the required laser safety labels located on the outside of the chassis in various locations. These include warning labels indicating removable or displaceable of the protective housings, apertures through which laser radiation is emitted and labels of certification and identification.

Figure 1-1 shows the required laser safety labels and the locations for the Water-Cooled YLR-Series laser. Figure 1-2 on page 1-7 shows the required laser safety labels and the locations for the Air-Cooled YLR-Series laser.

These include warning labels indicating removable or displaceable protective housings, apertures through which laser radiation is emitted and labels of certification and identification.

Figure 1-1. Safety Label Locations - WC YLR-Series Laser



Figure 1-2. Safety Label Locations - AC YLR-Series Laser

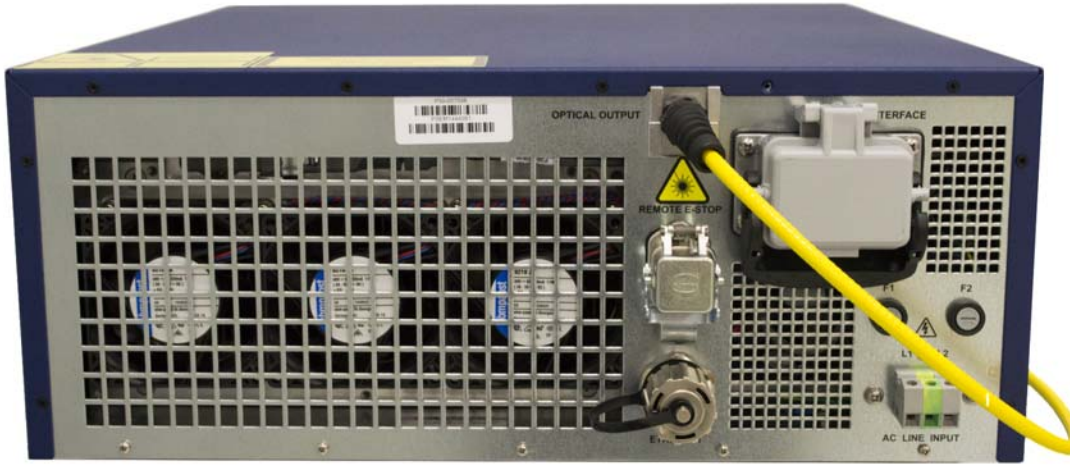
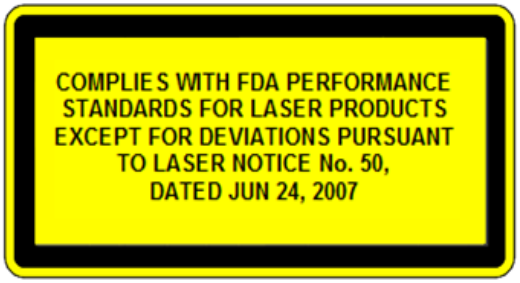
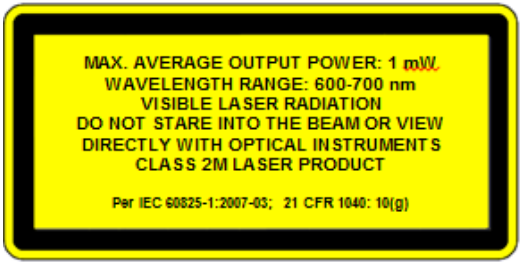
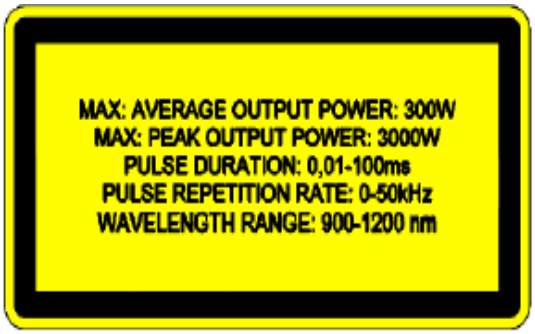
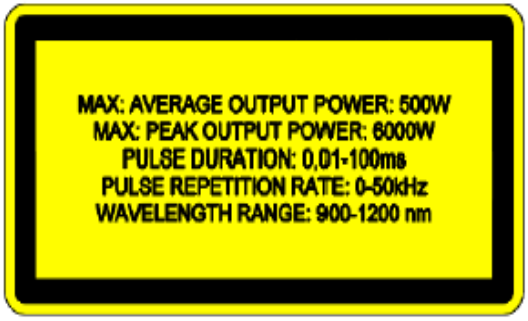
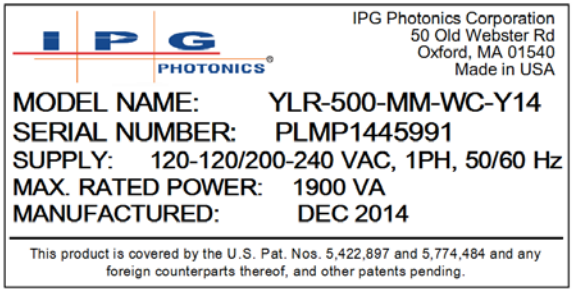


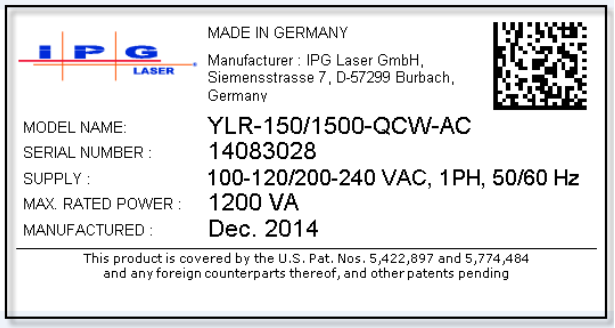
Table 1-2. Safety Label Descriptions

Item	Label Name	Description
1	Aperture Label	
2	FDA Compliance (for US Products)	
3	Class 2M Laser Product Label for Guide Laser	

4	Class 4 Laser Product (Models: YLR-10, YLR-15, YLR-20, YLR-25, YLR-30)	
4	Class 4 Laser Product (Models: YLR-40, YLR-50, YLR-60 to YLR-70)	
4	Class 4 Laser Product (Models: YLR-75, YLR-100, YLR-150)	

4	Class 4 Laser Product (Models: YLR-200, YLR-250, YLR-300, YLR-350)	
4	Class 4 Laser Product (Models: YLR-400, YLR-500, YLR-600, YLR-700)	
4	4. Class 4 Laser Product (Models: YLR-750, YLR-800, YLR-900, YLR-1000)	

4	Class 4 Laser Product (Models: QCW YLR-150/1500)	) 
4	4. Class 4 Laser Product (Models: QCW YLR-300/3000)	
5	Identification Plate (Products Made in the United States)[a]	

5	Identification Plate (Products Made in Germany)[b]	
6	Laser Radiation Hazard Label	
7	Protective Conductor Terminal[c]	
8	Electrical Hazard Label	
9	CE Compliance[d]	

10	Fuse[e]	

a. Refer to Table 2-1 on page 2-2 for Model Designation Codes.
b. Refer to Table 2-1 on page 2-2 for Model Designation Codes.
c. 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.
d. This label indicates compliance with CE marking requirements.
e. This symbol is accompanied with type and rating (for example, T15A, 250VAC, ¼ x 1-1/4).

Emission-On Indicator

The laser is equipped with a an Emission-On Indicator light located on the front panel (see Figure 2-1 on page 2-3). The Emission-On Indicator is turned on when laser emission is ready to emit.

If the laser aperture or a remote laser control is located more than two meters from the indicator on the front panel, then an additional indicator must be located at the aperture or remote control.

Emission ON, Pin 24 on the remote connector is active high when the laser is ready to emit. It can used to provide a laser-ready warning at the aperture or remote control when these are located two or more meters from the front panel.

General Safety Instructions



WARNING: You must exercise caution to avoid and minimize specular reflections as these reflections occur at the laser's wavelength and are invisible.

Specular Reflections

Often there can be numerous secondary laser beams produced at various angles near the laser aperture. These beams are called “Specular Reflections” and are produced when the laser light reflects off a surface where the primary beam is incident.

Although these secondary beams might be less powerful than the total power emitted from the laser, the intensity might 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 can also be damaged from exposure to the laser light.



WARNING: 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. 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, ensure that the lens is of good quality and clean. For cleaning instructions, refer to "Optical Fiber Connector Inspection and Cleaning" on page C-1.

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

Hot or molten pieces of metal can 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.

To ensure electrical safety:

1. Make sure the device 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, ensure that the correct voltage of the AC power source is used. Failure to use the correct voltage can 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 voids the warranty.

Environmental Safety



WARNING: Never look directly into a laser aperture (such as fiber, collimator, or scanning head) when the Start button or remote Start circuit is activated. Ensure 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 to prevent eye and skin exposure to visible and invisible collateral 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).



CAUTION: Water-cooled lasers must not operate at temperatures below the respective ambient dewpoint (see Table 1-3 on page 1-17).

- The device might have fans for active cooling. Ensure there is sufficient airflow to cool the device. Any objects or debris that cover the ventilation holes must be inspected. Filter media should be inspected at regular intervals to maintain sufficient airflow into the device.
- Operation at higher temperatures 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. See “Replacing the Filter Media” on page B-2 for details.

Table 1-3. 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									

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

Additional Safety Resources

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

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 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

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

Note

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

Ensure that the standard you are using such as ANSI, IEC, and OSHA are current.

Using Your Device

Overview

The IPG Photonics YLR-Series fiber lasers are developed for use in industrial applications. The lasers are compact and efficient letting you replace 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 Configurations

IPG offers many YLR-Series configuration models. This guide is designed to provide complete instructions for all models. Therefore, specific difference in models is noted where applicable.

Laser Model Designation Codes

Figure 2-1 on page 2-2 shows the model designation methodology for 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.

Figure 2-1. YLR-Series Laser Models

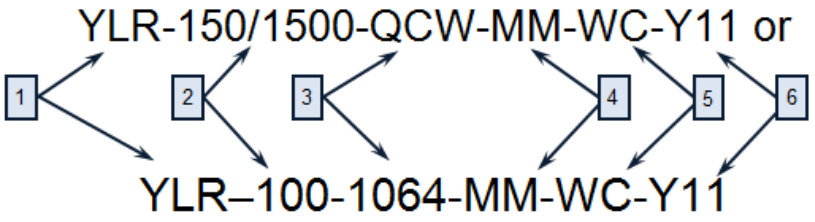


Table 2-1. Laser Model Designation Codes

Number	Item	Code
1	YLR	Ytterbium Laser 19-inch Rack Mount
2	Power in W	Range of 20 to 1500 Watts
3	Wavelength in nm	Item is listed if wavelength is not standard. 1070 nm (standard)
4	Polarization/Output Beam Characteristic	MM — for Multi-Mode LP — for Linearly Polarized If an item is not listed, then the beam is single-mode and randomly polarized.
5	Additional Information	WC — Water Cooled device AC — Air Cooled device
6	Additional Information	The last two digits of the model year,

Table 2-2. Available YLR Series Models

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

Certification

IPG Photonics certifies that your system is thoroughly tested and inspected and meets published specifications prior to shipping. Upon receiving your device, check the packaging and parts for any possible damage that might have occurred in transit. If there is damage, contact IPG Photonics immediately. It is the responsibility of the purchaser/end-user to bring the end system into compliance with all applicable regulations.

YLR Series — Front Panel View

The YRL Series front panel includes two options: panel with a display and panel without a display.

Figure 2-2 shows the front panel of the YLR-Series, which includes an option with a display. Table 2-3 lists details for each component.

Figure 2-2. Front Panel View with Display



Table 2-3. Front Panel Descriptions

Item	Feature	Description
1	Keyswitch (Local Interface option only)	The 3-position key switch controls the laser operation mode: Left position — Chassis Powered On, Remote Control Mode Central position — Chassis powered Off Right position — Chassis Powered On, Local Control Mode **Note:** The key cannot be removed in the Remote Control Mode or Local Control Mode positions.
2	Emergency Stop Button (E-Stop) (Local Interface option only)	Temporarily suspends power to the laser module. When active, the main DC power supply is disabled. You can reset it by turning clockwise.
3	Start Button with Indicator (Local interface option only)	When pressed, turns On the internal main power supply of the laser assuming that the Power key is in the Local Mode 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 (Local interface option only)	Use to set device settings and to display measured parameters and alarm messages.
5	Emission On Indicator	Local Control Mode: The indicator blinks for a short period after emission is enabled and before laser radiation is emitted. once laser emission is ON, the indicator is in the steady state “ON.” Remote Control Mode: The indicator is lit once emission is enabled.
6	Front Bezel Panel	Pull on each side to filter element for cleaning or replacement. Refer to Table B-1 on page B-2 for more information.

Figure 2-3 shows the front panel of the YLR-Series, which does not include a display. Table 2-4 lists details for each component.

Figure 2-3. Front Panel View without Display



Figure 2-4. Front Panel Descriptions

Item	Feature	Description
1	Power	When lit, indicates that internal main power supply of the laser is on. When the indicator is on, the internal power supply is active and the laser is capable of producing laser radiation.
2	PS Active	When lit, indicates that the main supply voltage is applied to the laser module inside the device.
3	Emission	When lit, indicates that the emission is activated.
4	Error	When lit, indicates an device error, such as a interlock door is open.
5	Front Bezel Panel	Pull on each side to filter element for cleaning or replacement. Refer to Table B-1 on page B-2 for more information.

YLR Series — Rear Panel View

The YLR-Series is available as a Water-Cooled (WC) or Air-Cooled (AC) laser.

Figure 2-5 shows details of the rear panel of the YLR-Series WC laser. Table 2-4 lists details for each component.

Figure 2-5. Rear Panel View - WC Laser

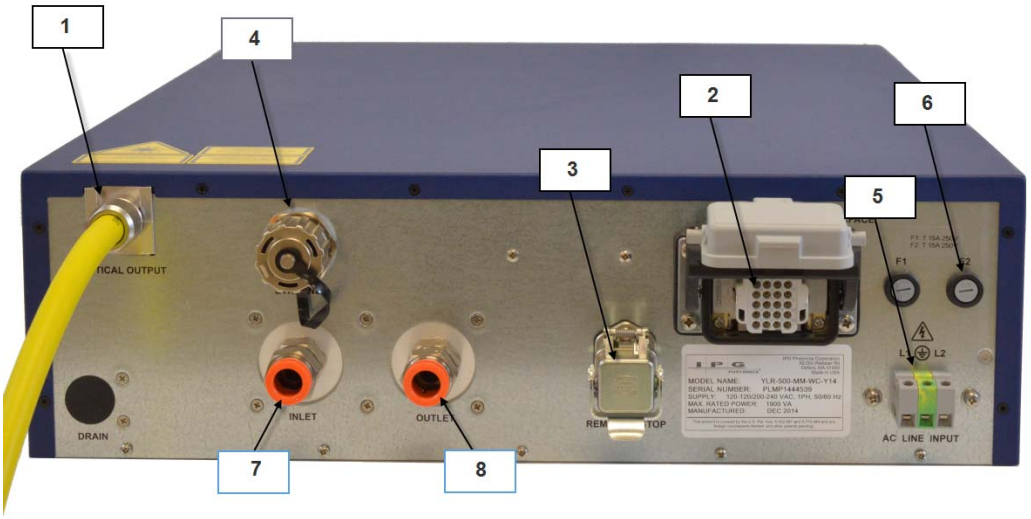


Table 2-4. Rear Panel Descriptions

Item	Feature	Description
1	Laser Output	The output of the laser (fiber cable) is delivered through this location.
2	Hardwiring Interface (24-pin)	The 24-pin connector provides an analog and digital interface for hardwiring control of the laser. See Table 2-5 on page 2-14 for detailed information.
3	Hardwiring Interface (7-pin)	The 7-pin connector provides status of the power supply and front panel Emergency Stop (if present). See Table 2-8 on page 2-23 for detailed information.
4	Ethernet	Ethernet port

Item	Feature	Description
5	AC line input	The 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 B-1 on page B-2 for more information.
7	Coolant Inlet	Liquid Coolant Input Refer to the *SPECIFICATION YTTERBIUM FIBER LASER* document included with this product for coolant details.
8	Coolant Outlet	Liquid Coolant Output Refer to the *SPECIFICATION YTTERBIUM FIBER LASER* document included with this product for coolant details.
9	Drain	Drain for the dehumidifier option.

Figure 2-6 shows details of the rear panel of the YLR-Series AC laser. Table 2-5 lists details for each component.

Figure 2-6. Rear Panel View - AC Laser

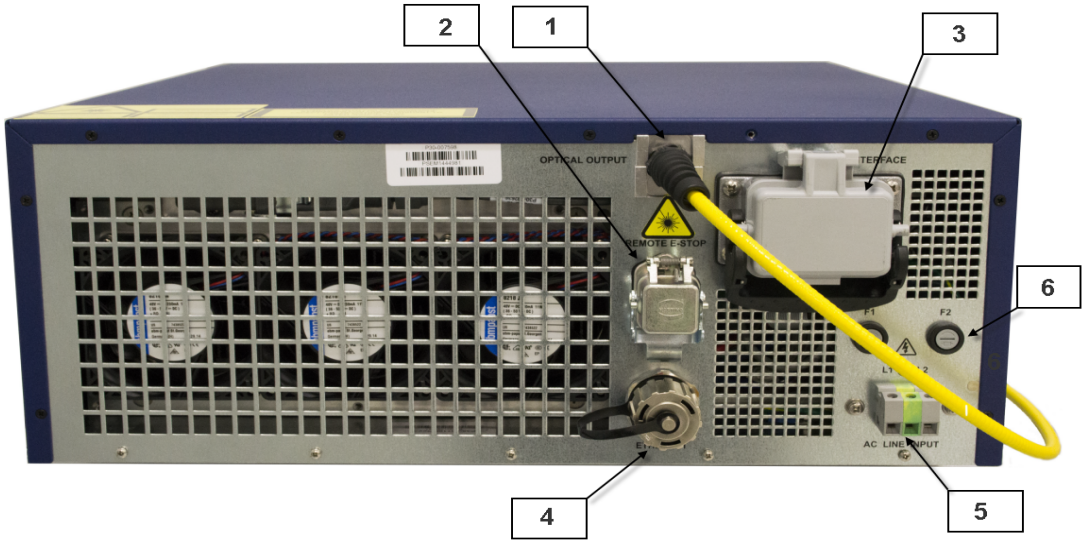


Table 2-5. Rear Panel Descriptions

Item	Feature	Description
1	Laser Output	The output of the laser (fiber cable) is delivered through this location.
2	Hardwiring Interface (7-pin)	The 7-pin connector provides status of the power supply and front panel Emergency Stop (if present). See Table 2-8 on page 2-23 for detailed information.
3	Hardwiring Interface (24-pin)	The 24-pin connector provides an analog and digital interface for hardwiring control of the laser. See Table 2-5 on page 2-14 for detailed information.
4	Ethernet	Ethernet port
5	AC line input	The 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 B-1 on page B-2 for more information.

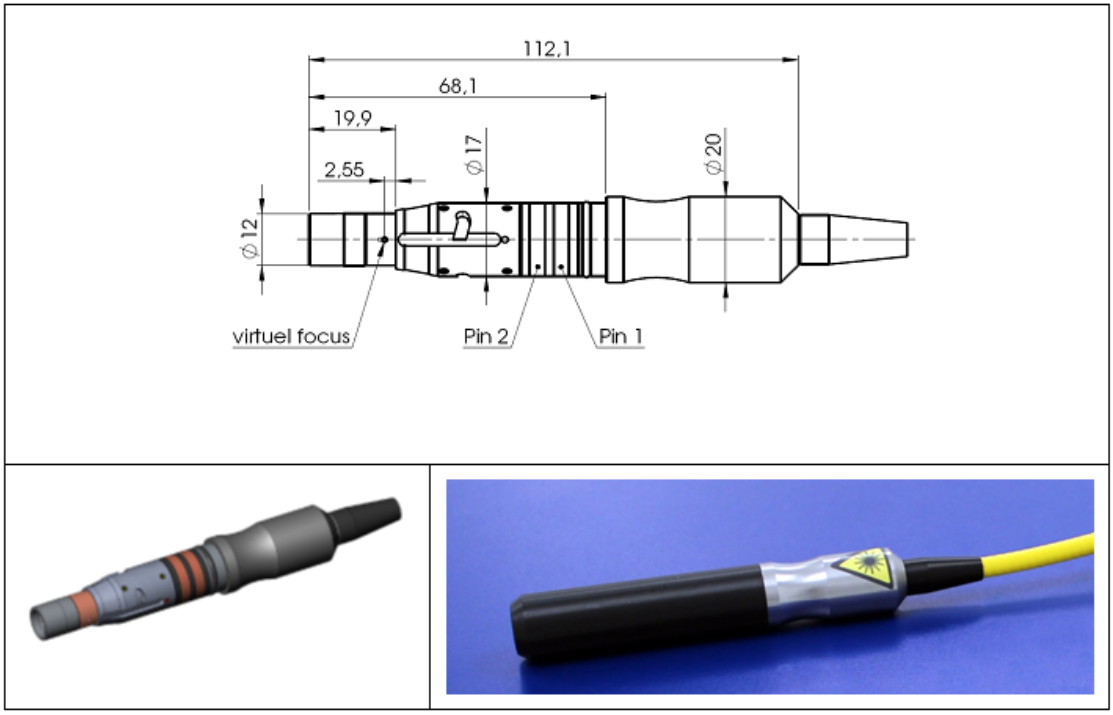
Optical Output Fiber Terminations

Products with a Connector

The end connector of the fiber (as shown in Figure 2-7) uses a protective cap that covers and protects the optical surface and electrical contacts when not in use.

These protective caps must be removed from the connectors when connecting the process fiber cable of the laser to an appropriate optical interface. You should remove the protective caps from the connectors immediately before optical cleaning and mounting in an adapter.

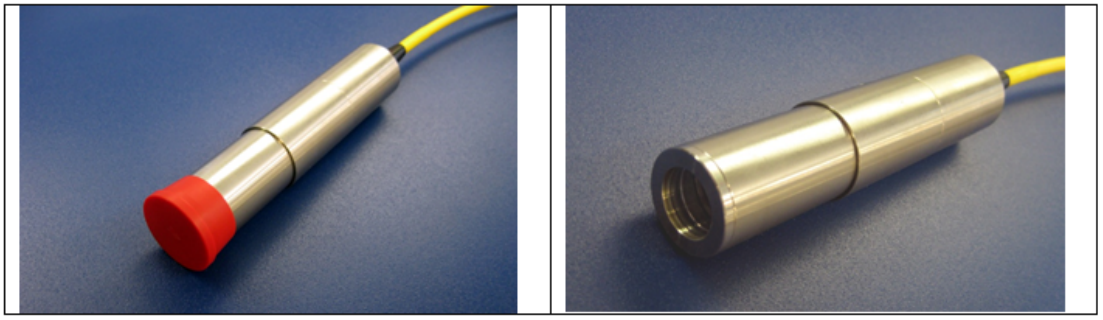
Figure 2-7. Optical Output Fiber Connector



Products with a Collimator

Collimators have a protective window that can be replaced if damaged (as shown in Figure 2-8). You must remove the collimator end cap prior to use. This cap can be re-used when storing the system. Cleaning of the protective window should be performed as needed using the same materials and techniques described in “Optical Fiber Connector Inspection and Cleaning” on page C-1.

Figure 2-8. Fiber End with Collimator



Model 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 the product. These specifications include:

- Optical
- Electrical
- Environmental
- External Layout and Dimensions

Unpacking Instructions

Note

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 you remove 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.



CAUTION: Lift and carry the device by supporting the device from the base. Use the handles (if available for your device) to help position the product while it is properly supported. Do not use the handles for lifting or carrying the device. Do not lift or position the device by any attached fibers or cables.

Laser models that are smaller and relatively lighter are packaged in foam insulated cardboard boxes. See “Unpacking a Unit from a Cardboard Box” on page 2-11.

Laser models that are larger and relatively heavy are packaged in foam insulated wooden crates. See “Unpacking a Unit from a Wooden Crates” on page 2-14.

To minimize the risk of damage to your system, IPG Photonics recommends that you unpack your laser using the following procedures.

Unpacking a Unit from a Cardboard Box

See Figure 2-9 on page 2-13 for an illustration of this procedure.

To unpack your unit from a cardboard box:

1. Place the package on a stable surface such as the floor or a large table.
2. For international shipments, remove the external box to access 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 strongly 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:

Shipping Box Contents	Quantity
Cover, AC Power Inlet (P45-001394)	1
Strain Relief (P40-002294)	1
Strain Relief Nut (P40-002293)	1
Harting 24-pin Interface Connector Kit (P30-007268)	1
Connector (P40-001344)	1
Hood (P40-001343)	1
Cable Seal (P40-000891)	1
Contact Pins (P40-000888)	16
Contact Pins (P40-000887)	10
Keys	2
Harting 7-pin Interface Connector (P30-007305)	1

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

Figure 2-9. Unpacking a Unit from a Cardboard Box

	
Primary Box	Foam Cover
	
Cover Removed	Lifting the Unit

Unpacking a Unit from a Wooden Crates

See Figure 2-10 on page 2-15 for an illustration of this procedure.

To unpack a unit from a wooden crate:

1. Place the package on a stable surface such as the floor or a large table. IPG recommends using a powered screwdriver to remove all of the top screws securing the top lid.
2. Remove the top lid and top foam insert.
3. Using a cutting tool remove the tie wraps securing the fiber to the second insert.
4. Place the fiber on top of the unit and carefully lift it out of the box. IPG strongly recommends two people to lift the unit at all times.
5. Check the inventory of following items:

Shipping Box Contents	Quantity
Cover, AC Power Inlet (P45-001394)	1
Strain Relief (P40-002294)	1
Strain Relief Nut (P40-002293)	1
Harting 24-pin Interface Connector Kit (P30-007268)	1
Connector (P40-001344)	1
Hood (P40-001343)	1
Cable Seal (P40-000891)	1
Contact Pins (P40-000888)	16
Contact Pins (P40-000887)	10
Keys	2
Harting 7-pin Interface Connector (P30-007305)	1

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

Figure 2-10. Unpacking a Unit from a Wooden Crate

Primary Box	
Removing the Tie Wraps	
Lifting the Unit	

Using the YLR-Series



CAUTION: Refer to the *SPECIFICATION YTTERBIUM FIBER LASER* document included with this product for proper electrical power requirements.

Before switching the power on, ensure 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.

Connecting Electrical Power

Refer to the *SPECIFICATION YTTERBIUM FIBER LASER* document included with this product to determine your models power requirements.

Note

A power cord is not provided with the laser.

To connect the electrical power:

1. 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.

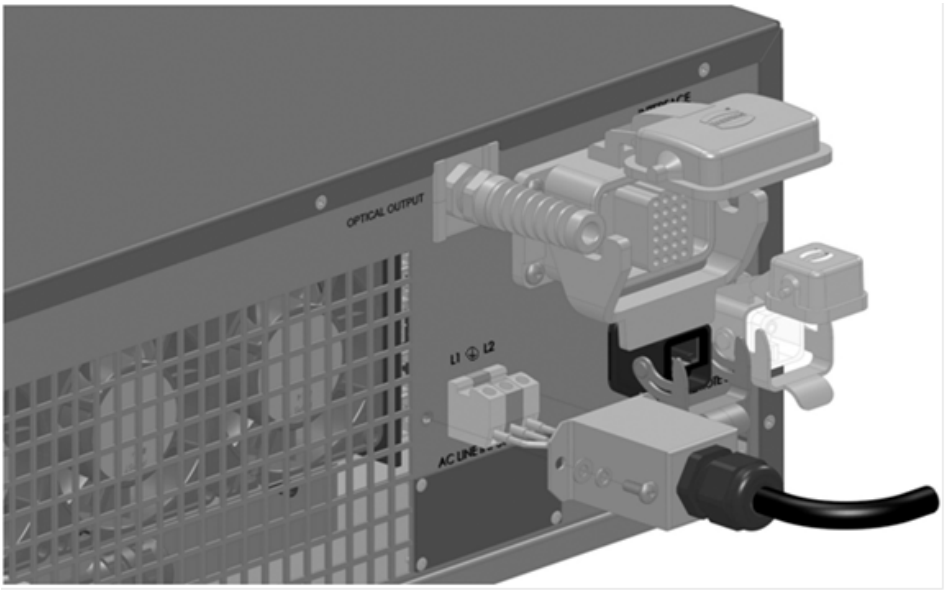
   L2 = Line Voltage, PE = Protective Earth, L1 = Line Voltage

2. Cover the input power terminal block with the supplied cover.
3. Secure the cable with the supplied strain relief.

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

4. Follow all national and local requirements when wiring to the unit.

Figure 2-11. Power Cord Connection



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.



Connections to External Circuits

Except for Mains connection, the external connections between this product and other external devices are PELV (Protected Extra Low Voltage) as defined by IEC 61140. Non-Mains outputs of other devices connected to this product should also be PELV or SELV (Safety Extra Low Voltage).

Interlock Safety Circuit

YLR lasers include an Interlock Safety Circuit that uses a dual-channel system with monitored output and manual reset.

When you open the Interlock, the safety circuit opens and power to the laser diodes is removed.

Follow these steps:

1. Close the 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 is opened, you cannot switch the lasers power supply on until the second pair is opened and then both pairs are closed.

2. If you close the interlock (the Emergency Stop button is also released) and a fault is not detected, press the **Start** button to connect the remote start contacts, which enables the main power supply. The Power Supply (PS) Active signal enters a high state and power is supplied to the laser module. The laser diodes remain inactive until a separate Laser Enable signal transitions high and an output power level set to a non-zero value.

   The power to the laser diodes also turns on. However, under normal conditions the diodes only turn on after emission is enabled.

   When you open the interlock or a fault is detected, the laser diodes are disconnected from the main power supply. The Power Supply Active signal enters a low state.

   A detected fault is latched and circuits 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** button, the safety circuit does not reset until the fault is corrected.

   If the remote **Start** button is shorted (this is the equivalent of holding in the **Start** button), the circuit does not reset when the interlocks are closed until the safety circuit processes both channels open and then closed or the power to the safety circuit is cycled (with the Start button in the opened state in both cases).

Interface Connector Pin Assignments

Table 2-6 provides electrical pin assignments for these Interlock Channels.

Table 2-6. 24-Pin Connector Pinouts

Pin	Signal Name	Signal Type	Signal Level	Signal Drive	Typical Response Time	Description
1	Interlock Ch1A	Contact Closure[a] to pin 4	—	—	< 500 ms CW <1.2 s QCW	Emergency Shutdown according to ISO 13849-1 Cat.3 PL d.[b]
2	Interlock Ch2A	Contact Closure[a] to pin 3				
3	Interlock Ch2B	Contact Closure[a] to pin 2				
4	Interlock Ch1B	Contact Closure[a] to pin 1				
5	RS232 Tx	Serial Communication	—	—	120 ms	Transmit Data
6	RS232 Rx	Serial Communication	—	—		Receive Data
7	RS232 Com	Return	—	—		RS-232 Return
8	Remote Key Switch	Contact Closure[a]	—	—	5 s	Activates the laser control electronics in Remote mode.
9						
10	Remote Start Button	Momentary Contact Closure[a]	—	—	1 s	Activates the internal main power supply and connects it to the laser module in Remote mode.
11						
12	Analog Input to Control Current	Analog Input	1-10 VDC	1 mA (sink)	20 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	5 to 24 VDC	6 mA (sink)	20 µs	5 -24 VDC Input.
16	Modulation -	Return	—	—		Return for signal on pin 15.
17[c]	Guide Control	Digital Input	5 to 24 VDC	6 mA (sink)	120ms	Positive edge turns On red guide laser in Remote Control Mode.
Pin	**Signal Name**	**Signal Type**	**Signal Level**	**Signal Drive**	**Typical Response Time**	**Description**

Table 2-6. 24-Pin Connector Pinouts

18[d]	Emission Enable	Digital Input	5 to 24 VDC	6 mA (sink)	120ms	Positive edge activates emission in Remote Control Mode.
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	5 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.

a. Connection of potential free contacts only. External contact closure must be rated to > 1A /24 VDC.

b. 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.

c. To use this pin, external guide beam control must be enabled (EEABC command).

d. To use this pin, external emission control must be enabled (ELE command).

Note: Connector housing is EMC rated and is the intended connection point for the shielding of the customer's cabling.

Table 2-7. 24-Pin Connector — Additional Details

Pin	Signal Name	Description
1	Interlock Ch1A	These connections are intended to satisfy the Remote Interlock Connector requirement as defined by 21 CFR 1040.10 (f)(3) and IEC 60825-1 (4.4). If the connections between pins 1-4 or 2-3 are breeched by a door interlock or other means, laser emission is prevented.
2	Interlock Ch2A	
3	Interlock Ch2B	
4	Interlock Ch1B	
5	RS232 Tx	—
6	RS232 Rx	
7	RS232 Com	—
8	Remote Key Switch	Intended for use when the laser product is integrated into an end-user system. It is the responsibility of the purchaser/end-user to bring the end system into full compliance with all applicable regulations.
9		
10	Remote Start Button	Intended for use when the laser product is integrated into an end-user system. It is the responsibility of the purchaser/end-user to bring the end system into full compliance with all applicable regulations.
11		
12	Analog Input to Control Current	Intended to control the level of laser output power with either Local or Remote Control Mode enabled, power supply enabled, external emission control enabled (Remote Control Mode only), and analog control enabled. The output power is proportional to the analog voltage being supplied to the device. IPG recommends the integrator sets the voltage on this pin to zero volts when the emission, laser power supply, or the laser main power (VAC) is OFF. IPG also recommends the integrator use a analog voltage source capable of supplying a clean/stable signal. Suggested voltage sources might be in the form of a PLC, Arbitrary Waveform Generator, or other similar products.
13	Analog Output Power Monitor	—
14	Isolated Analog Com	—
15	Modulation +	Modulation mode must be enabled and can be used in either Local or Remote Control modes of operation. Review the product specification for allowable modulation settings specific to your product. Also, the modulation signal is not intended to be used for functional safety or as a safety device. IPG has incorporated a certified safety circuit for this purpose and it is the responsibility of the purchaser/end-user to bring the end system into full compliance with all applicable regulations.
16	Modulation -	—
17	Guide Control	—

Pin	Signal Name	Description
18	Emission Enable	Intended to control the level of laser output power with Remote Control Mode enabled, power supply enabled, and external emission control enabled. The emission enable signal is not intended to be used for functional safety or as a safety device. IPG has incorporated a certified safety circuit for this purpose and it is the responsibility of the purchaser/end-user to bring the end system into full compliance with all applicable regulations. Hardware Control must be set to enable in the laser web interface.
19	Error/Ready	—
20	System Common	—
21	Error Reset	—
22	Power On	Intended to be used by the integrator for indicating the laser control system is turned ON. The signal is active high when the local key is turned on or when the remote key is turned on for models without the display option. If Local Control Mode is ON or in the middle position and the remote key is ON, the control system is OFF. The integrator should use this signal to notify operators using the end product, that the key has been turned on. It is the responsibility of the purchaser/end-user to bring the end system into full compliance with all applicable regulations.
23	Power Supply Active	Intended to be used by the integrator for indicating the power supply is activated. The signal is available whether the laser is in Local Control or Remote Control Mode. The integrator should use this signal to warn operators using the end product that the power supply is active and the laser is capable of emitting laser radition. Since the laser emission is delivered through an optical cable which might be tens of meters in length. This signal is provided so proper warnings are made available at the laser aperture and the remote control system as defined by the integrator. It is the responsibility of the purchaser/end-user to bring the end system into full compliance with all applicable regulations.
24	Emission ON	Intended to be used by the integrator for indicating the laser emission is turned ON. The signal is available whether the laser is in local or remote mode. The integrator should use this signal to warn operators using the end product that emission is turned ON and the product can be or is emitting laser radiation. Since the laser emission is delivered through an optical cable which might be tens of meters in length, this signal is provided so proper warnings are made available at the laser aperture and remote control system as defined by the integration. **Note:** The signal is active when the emission is turned ON and remains active even if the laser output is set at “zero” and no actual laser emission is present. It is the responsibility of the purchaser/end-user to bring the end system into full compliance with all applicable regulations.

Table 2-8. 7-Pin Connector Pinouts

Pin	Signal Name	Signal Type	Signal Level	Signal Drive	Typical Response Time	Description/Comments
1	E-Stop Out Channel 3A	Contact Closure to pin 3[a]				Direct connection to E-Stop button on the front panel. If you press Emergency Stop on the front panel, channels 3 and 4 are open. Intended to be used by integrators to shut down parts of the system or entire system when the laser front panel E-stop is activated. Only applicable to laser option with display and controls on the front panel.
2	E-Stop Out Channel 4A	Contact Closure to pin 4[a]				
3	E-Stop Out Channel 3B	Contact Closure to pin 1[a]				
4	E-Stop Out Channel 4B	Contact Closure to pin 2[a]				
5	PS_Active1	Digital Output	24 VDC	<100mA (source)	120 ms[b]	A high condition indicates that the internal main power supply is active. Redundant signal for indicating the power supply has been activated. The signal is available whether the laser is in Local Control or Remote Control Mode. The integrator should use this signal to warn operators using the end product, that the power supply is active and capable of emitting laser radiation. It is the responsibility of the purchaser/end-user to bring the end system into full compliance with all applicable regulations.
6	No Connection	—	—	—	—	
7	Common	Return	—	—	—	Return for signals on pins 5.

a. Contact closure components rated 24VDC, 1A.

b. Interlock response time (500 ms and 1.2s QCW models) must be additionally considered to ensure the safe state of the device.

Note: Connector housing is EMC rated and is the intended connection point for the shielding for the customer's cabling.

Initial Power-Up Sequence



CAUTION: 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.

To initially power-up the system:

1. Ensure 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 "Optical Fiber Connector Inspection and Cleaning" on page C-1 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 ensure that you wear appropriate laser safety eyewear at all times while operating the product. Ensure all power is removed from the laser when handling the delivery cable.

5. Ensure 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.
8. Verify that the external cooling unit is powered on (for Water-Cooled models only).

Key Control

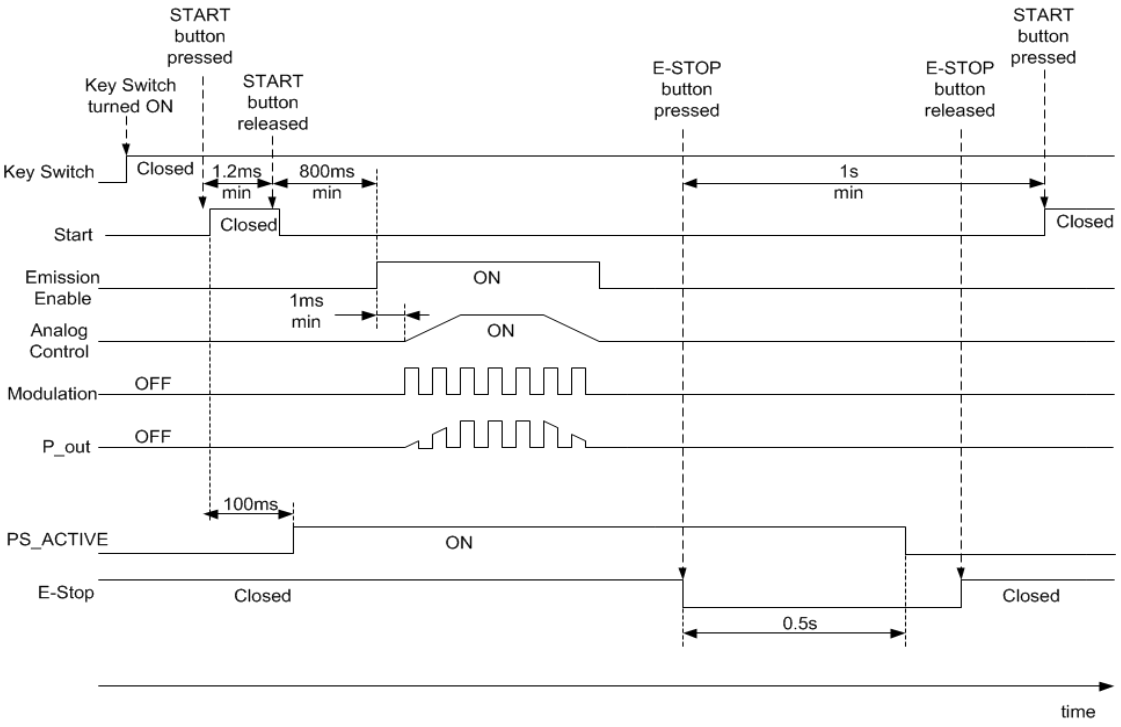
You cannot turn on or operate the device until the key switch is in the ON or REM position. ON or REM is only applicable to products with the Local Control option. Products that do not have this option need to close the remote key circuit, pins 8 and 9 on remote connector (refer to Table 2-6 on page 2-19).

You cannot switch between ON and REM without moving position into OFF and then waiting a few seconds.

YLR-Series System Operation

The YRL-Series system operation is illustrated in Figure 2-12.

Figure 2-12. YLR-Series Timing



Rear Panel: 7-pin and 24-pin Connectors

There are two connectors on the rear panel of chassis: 7-pin and 24-pin. Figure 2-13 on page 2-27 shows the connections to 24-pin connector. Figure 2-14 on page 2-28 shows the connections to the 8-pin connector.

The two Interlock contacts ILK1 and ILK2 are connected between pins 1-4 and 2-3.

The Keyswitch is connected between pins 8 and 9. This switch should be closed to power system up in Remote Control Mode. The Start button is connected between pins 10 and 11. When closed it starts system in Remote Control Mode.

There is an isolated RS-232 interface (signals on pins 5 and 6 are referenced to return on pin 7). Two isolated analog signals on pins 12 and 13 are referenced to analog return on pin 14. Two differential modulation signals on pins 15 and 16 are also isolated. The control and diagnostic signals on pins 17-19 and pins 21-24 are referenced to return on pin 20 and are isolated.

Figure 2-13. 24-Pin Connector Interfaces

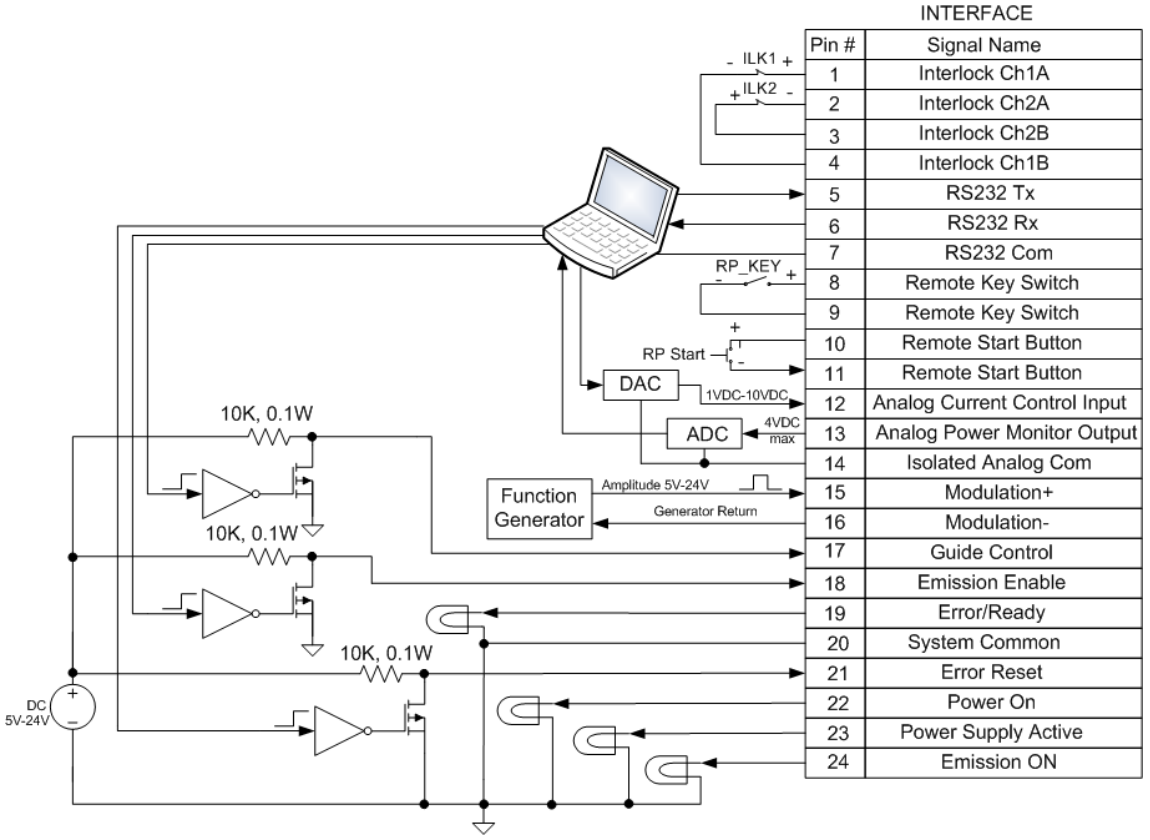
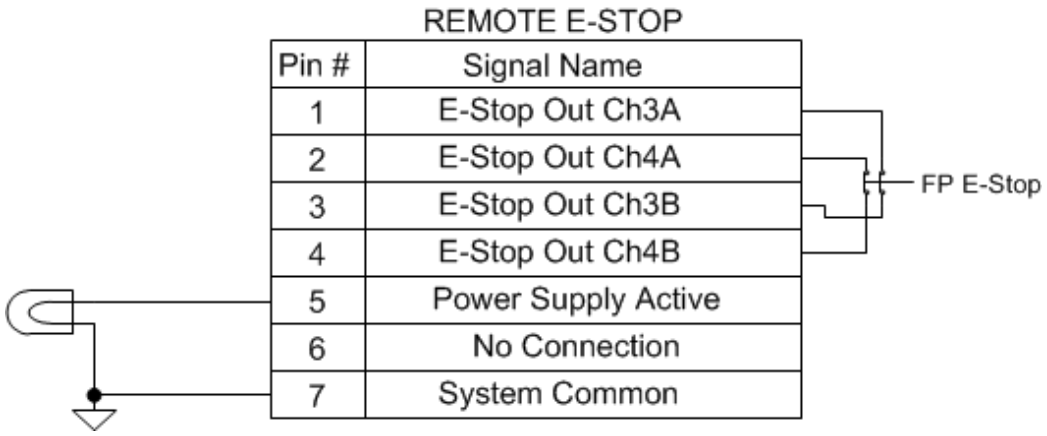


Figure 2-14. 7-Pin Connector



Two contacts of the E-Stop button are connected between pins 1-4 and 2-3. When you push the E-Stop button, these contacts become open. They return to closed state when E-Stop button is released.

One isolated Power Supply Active signal on pins 5 is referenced to the return on pin 7.

Operation Control Modes

There are two control modes for the laser: Local and Remote. You select these modes using the Keyswitch on the front panel (see Figure 2-2 on page 2-3).

If the Keyswitch is in the ON position, the Local control mode is activated. If the Keyswitch is in REM position, the Remote control mode is activated.

Table 2-9 details the differences between these two modes:

Table 2-9. Local and Remote Control Modes

	Local (Keyswitch "ON" position	**Remote (Keyswitch "REM" position)**	
Control Electronics Enabling	Enabled	Remote Laser Power Keyswitch	
Main Power Supply Enabling	Start button	Remote Start Button	
Emission Control	RS-232, Ethernet, Touch-screen	Hardware Emission Control Enabled[a]	Hardware Emission Control Disabled[b]
		External Interface	RS-232, Ethernet
Guide Laser Control	RS-232, Ethernet, Touch-screen	External Aiming Beam Control Enabled[c]	External Aiming Beam Control Disabled[d]
		External Interface	RS-232, Ethernet
Operation Mode Selection	RS-232, Ethernet, Touch-screen	RS-232, Ethernet	

a. 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.

b. To set "Hardware Emission Control Disabled" send the command "DLE" via the RS-232 interface or change it in settings menu using Touch Screen display.

c. To set "External Aiming Beam Control Disabled" send the command "DEABC" via the RS-232 interface or change it in settings menu using Touch Screen display.

d. To set "External Aiming Beam Control Disabled" send the command "DEABC" via the RS-232 interface or change it in settings menu using Touch Screen display.

Turning on the Device in Local Control Mode

To turn on the device in Local Control Mode:

1. Turn the front panel Keyswitch clockwise to the ON position.
2. Press the Start button to turn on the main power supply.
3. Wait until the laser becomes active.

   The laser is now ready for operation. You can now select a proper operation mode.

Turning on the Device in Remote Control Mode

To turn on the device in Remote Control Mode:

1. Turn the front panel Keyswitch counterclockwise to the REM position.
2. Close contact pins eight and nine to provide the remote keyswitch function.
3. Make momentary closure of pins 10 and 11 to activate the main power supply.
4. Turn the emission on. Refer to “Local and Remote Control Modes” on page 2-29.
5. Wait until the laser becomes active.

   The laser is now ready for operation. You can now select a proper operation mode.

Selecting Operation Modes

In both control modes (Local and Remote), there are two main modes of laser emission:

- Continuous (CW)
- Pulsed (QCW)

Pulse Mode (QCW)

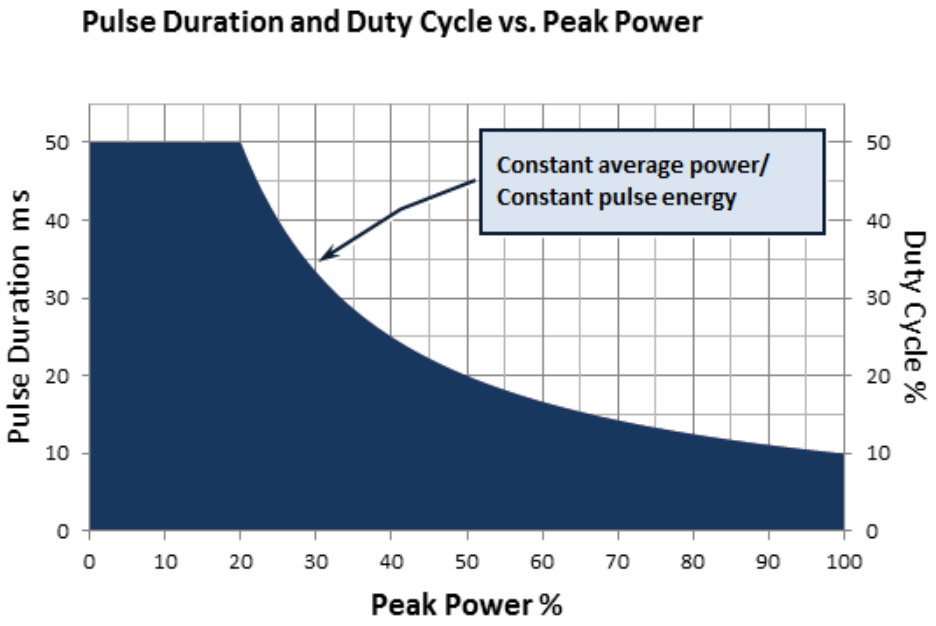
Pulse Mode (for QCW models only, Pulse-mode enabled) laser internally generates a sequence of pulses. Pulse duration and pulse repetition rate can be configured by:

- Sending corresponding commands via RS-232 interface, or
- Using the Pulse Settings sub-menu on the touch-screen display

The main difference between Pulse and CW modes is that in Pulse Mode the maximum peak power is considerably higher than in CW.

However, the maximum pulse duration and the maximum duty cycle are limited to certain values (refer to the *SPECIFICATION YTTERBIUM FIBER LASER* document and refer to Figure 2-15). When in CW mode, the maximum pulse duration and duty cycle are not applicable.

Figure 2-15. Pulse (QCW) Operational Range



Operational Sub-Modes

For each mode of laser emission (Continuous or Pulse), there are four operational sub-modes:

- Standalone
- Modulation
- Gate
- 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 is 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 Mode).

Modulation Mode

- The value of pump LD current is controlled as in the 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 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 2-5 on page 2-14 for more information).
- Pulse sequence generation, modulation and gating are performed as in corresponding modes above.

Pulse Shaper Program (Optional Feature)

- You can create and store arbitrary waveform pulses in the Pulse Profiles library.
- You can create and store Pulse sequences (combinations of pulse profiles, delays, and repeats) in the Pulse Sequences library.
- Pulses can be started by Emission On command/signal (when Gate Mode is disabled) or by the "Gate" signal applied to Pins 15-16 of External Interface Connector (when Gate Mode is enabled).
- You cannot select Waveform Mode if either External (Analog) Control or Modulation Mode is enabled.

See "Pulse Shaping" on page 4-1 for details on using the Pulse Shaper program.

Using the Touch-Screen Display

You can use the touch-screen display on the front panel for manual control of the device. You can view information about the device's state and settings. In addition, activating certain commands from the main window invokes additional submenu windows. In Remote Mode, the touch-screen display function is disabled and can only be used for display purposes.

Figure 2-16. Main Menu Screen

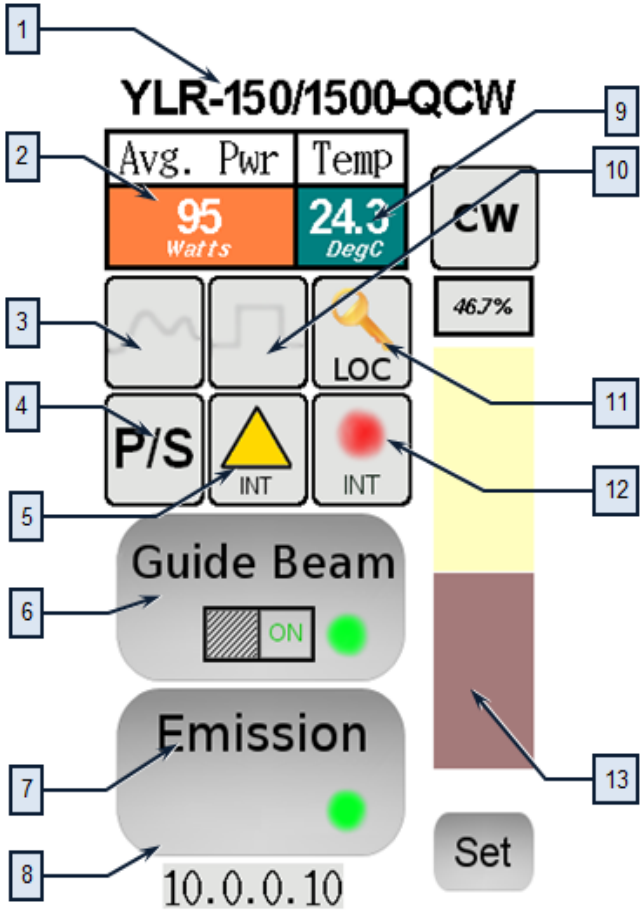


Table 2-10. Main Menu Descriptions for Touch-Screen Display

Item	Description
1	Model Name.
2	Power Indication/Setting: Touching this field displays the Setpoint window where you can enter the required setpoint value.
3	When active (inactive shown) indicates that the analog (external) power control is enabled or in Pulse Waveform Mode.
4	When active, shows that the main supply voltage is applied to the laser module inside the device.
5	Indicates the state of the emission control: “Internal” (hardware control disabled) or “External” (hardware control enabled).
6	Touching this button turns the guide laser ON or OFF.
7	Touch this button to activate or deactivate the emission.
8	IP address indication/setting. Touching this field opens the window where you assign an IP address to the system.
9	Internal Temperature display.
10	When active, indicates that the Modulation or Gate Mode is enabled.
11	Indicates the current operational state: Local or Remote.
12	Indicates the state of the guide laser control: Internal or External.
13	Setpoint Bar: Touch **Set** and drag your finger up or down to set the required value. Press **Lock** when finished.

Figure 2-17. Sub-Menus Screen

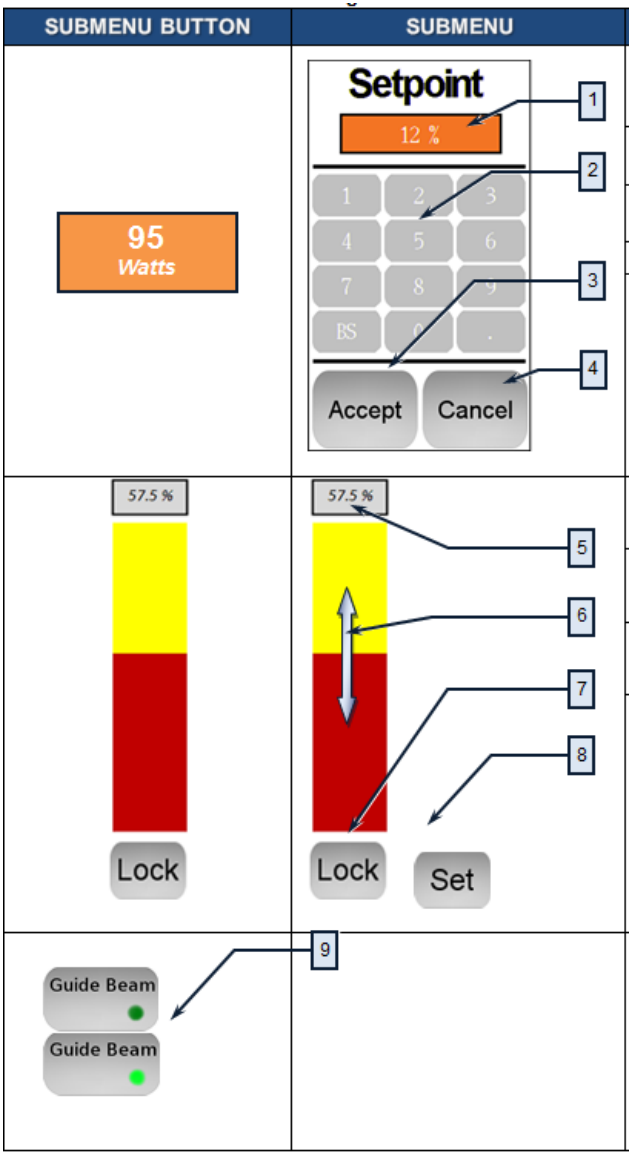


Table 2-11. Sub-Menus Descriptions

Item	Description
1	Current Power setpoint value (in percentage) of maximum power (for example, 12%).
2	Enter the Power setpoint in percentage of the maximum power.
3	Accept new Power setpoint.
4	Return to the previous screen.
5	Power setpoint value in percentage of maximum power (for example, 57.5%).
6	Power Control Bar (disabled when locked).
7	Press **Lock** to unlock the Power Control Bar function (“Set” is displayed).
8	Press **Set** to change the power to the new setpoint and lock the Power Control Bar.
9	Press to turn on the Guide Beam. A Green dot lights up

Figure 2-18. Sub-Menus Screen

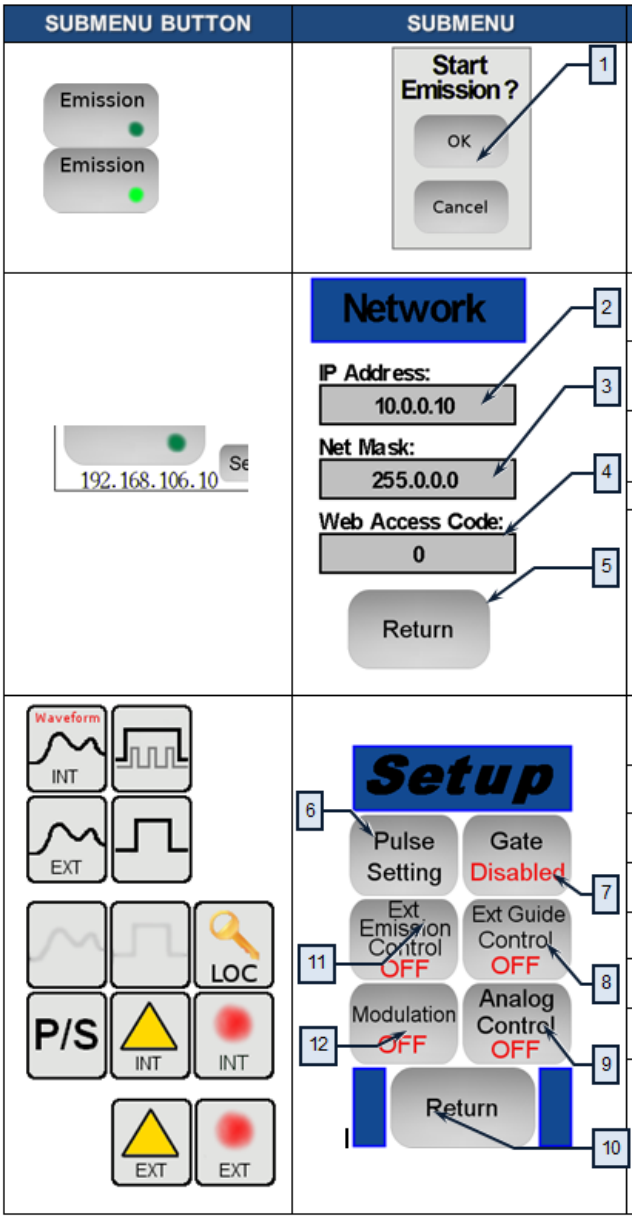


Table 2-12. Sub-Menus Descriptions

Item	Description
1	Press the Emission Button and you are asked to confirm the emission startup process by pressing **OK**. Press **Cancel** to exit.
2	Press the **IP address** box to enter a new IP address.
3	Press the **Net Mask** box to enter a new net mask address.
4	Press the **Web Access Code** box to enter a new web access address.
5	Press **Return** to go back to the previous screen.
6	Opens the Pulse Settings menu (function described lower in table).
7	Enable or Disable the Gate mode
8	Enable or Disable the External Guide Laser control.
9	Enable or Disable the External Analog Power control.
10	Return to the previous screen.
11	Enable or Disable the Emission Control mode.
12	Enable or Disable the Modulation mode.

Figure 2-19. Sub-Menus Screen

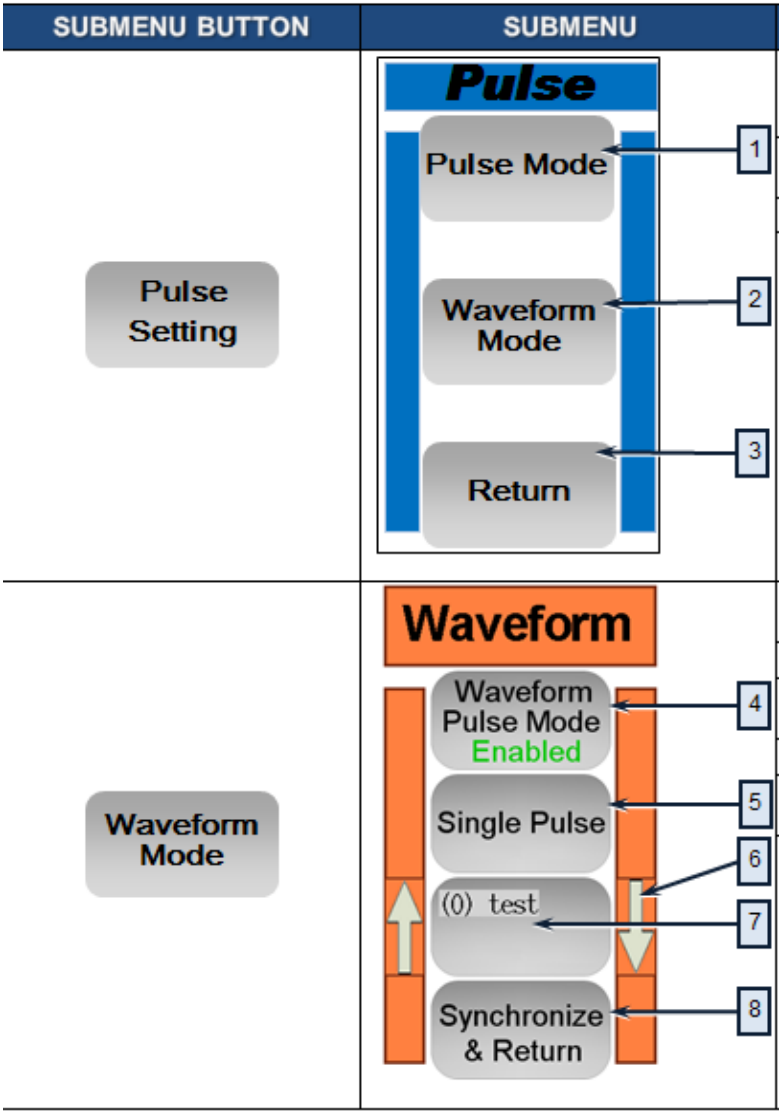


Table 2-13. Sub-Menus Descriptions

Item	Description
1	Opens Pulse Mode sub-menu.
2	Opens Waveform Mode sub-menu.
3	Return to the previous screen.
4	Enables or Disables the Waveform Pulse Mode.
5	Single Pulse/Pulse Sequence.
6	Use the Up/Down Arrows to scroll to select a program from memory.
7	Selected the program in memory.
8	Transfers the selected program to the laser.

Figure 2-20. Sub-Menus Screen

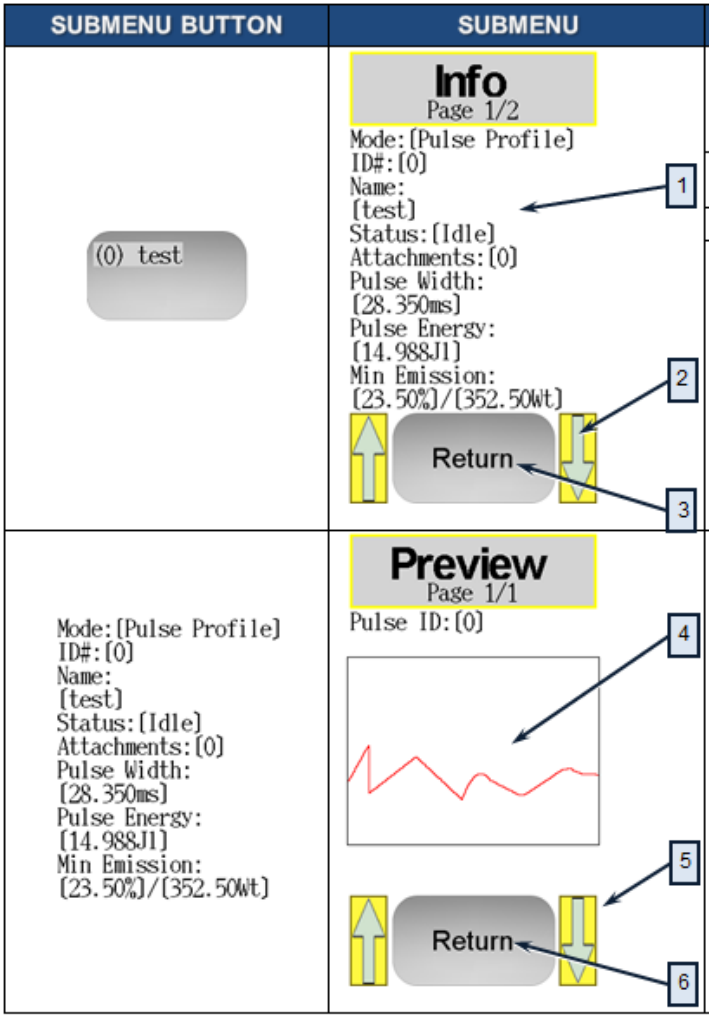


Table 2-14. Sub-Menus Descriptions

Item	Description
1	Pulse Program Information Screen. Clicking anywhere in this area displays the Preview Screen.
2	Use the Up and Down arrows to scroll to select a program from memory.
3	Return to the previous screen.
4	Pulse Program Preview screen.
5	Use the Up and Down arrows to scroll to select a program from memory.
6	Return to the previous screen.

Figure 2-21. Sub-Menus Screen

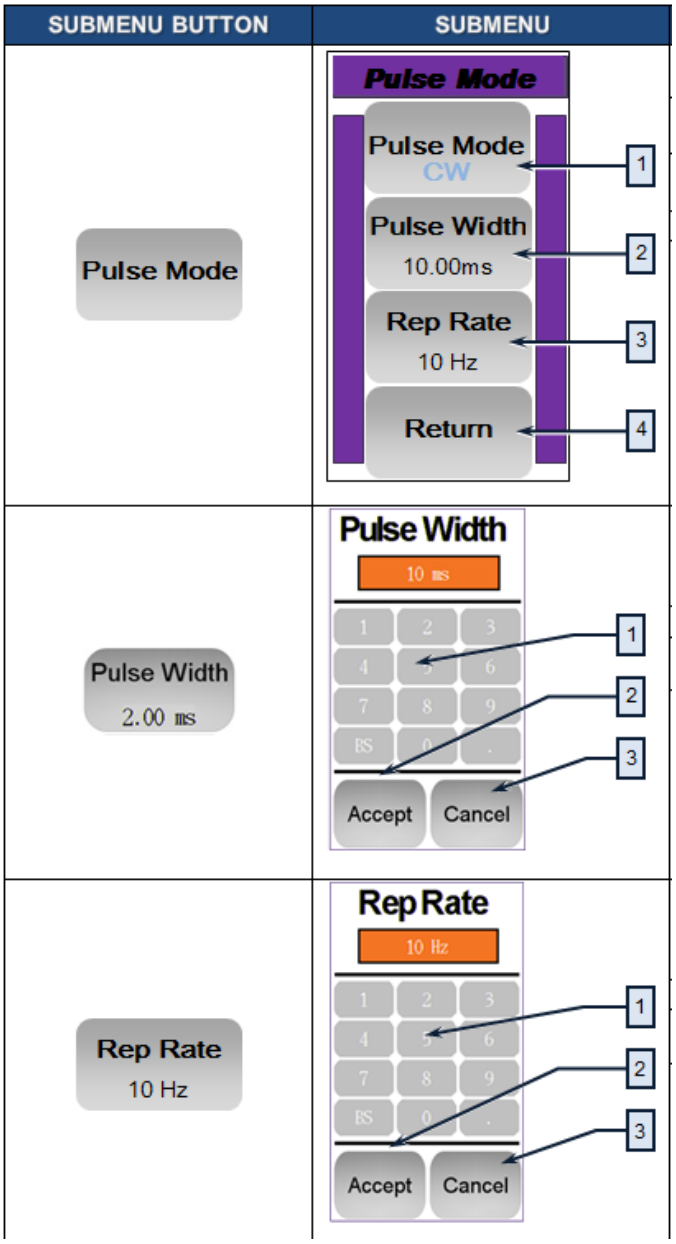


Table 2-15. Sub-Menus Descriptions

Item	Description
1	Toggles between the Continuous (CW) and Pulsed (QCW) modes.
2	Opens Pulse Width dialog.
3	Opens Pulse Width dialog.
4	Return to the previous screen.
5	Enter Pulse Width in milliseconds (ms) range is 0.2 to 20 ms in .05 ms increments.
6	Accept the Pulse Width.
7	Cancel and return to the previous screen.
8	Enter Repetition Rate in Hertz (Hz) range is 1 to 5000 Hz in 1 Hz increments.
9	Accept the Repetition Rate.
10	Cancel and return to the 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 “Interface Commands” on page 3-2. See “Interface Connector Pin Assignments” on page 2-19 for details on 24-pin interface connectivity.

The RS-232 interface is configured with the following parameters:

Table 3-1. RS-232 Parameters

Parameter	Value
Baud Rate	57,600
Data Bits	8
Stop Bits	1
Parity	None
Flow Control	None

Ethernet TCP/IP Interface

The IP address of the laser is shown on the front panel. Touching the screen where the address is shown displays the network setup menu where you can change the network settings.

The laser listens for connections on port 10001. The command must be sent as a single string in a single packet. The individual commands are described in “Interface Commands” on page 3-2.

Table 3-2. Ethernet Interface Pinouts

Pin	Description	Notes
1	TX+	Transmit Data +
2	TX-	Transmit Data -
3	RX+	Receive Data +
4	N/C	Not Connected

Pin	Description	Notes
5	N/C	Not Connected
6	RX-	Receive Data -
7	N/C	Not Connected
8	N/C	Not Connected

Interface Commands

All commands and responses consist of printable ASCII characters. Commands are typically three or four letter mnemonic codes followed by a parameter, if required.

All commands and responses are terminated with a <Carriage Return> (CR, 0x0D, \r) character If a CR terminated string is received, but a valid command is not found, a response of "BCMD" is sent.

The commands are shown in Table 3-3, “Interface Commands” 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 generates a response. The responses generally consist of the command echoed back. If there is a returned value, it is separated from the echoed command by a ':' character.

Table 3-3. Interface Commands

Code	Description	Example
ABN	Aiming Beam ON	Sent: “ANB” Response: “ABN” “ERR: Cannot enable guide beam because external guide control is enabled.”
ABF	Aiming Beam OFF	Sent: “ABF” Response: “ABF” “ERR: Cannot disable guide beam because external guide control is enabled.”
DEABC	Disable External Aiming Beam Control —Disables hardware aiming beam control.	Sent: “DEABC” Response: “DEABC”

Code	Description	Example
DEC	Disable External Control — Disables the analog current control input. Disables Dynamic Scaling in Waveform mode.[a]	Sent:"DEC"" Response: "DEC" or "ERR: Emission is ON!"
DGM	Disable Gate Mode — Disables internal pulse generator.	Sent: "DGM" Response: "DGM" or "ERR: Emission is ON!"
DLE	Disable Hardware Emission Control — Disables hardware emission control.	Sent: "DLE"" Response: "DLE" or "ERR: Emission is ON!"
DMOD	Disable Modulation — Disables the modulation mode.	Sent: "DMOD"" Response: "DMOD" or "ERR: Emission is ON!"
DPM[b]	Disable PULSE Mode — Disables PULSE mode.	Sent: "DPM" Response: "DPM" or "ERR: Emission is ON!"
EEABC	Enable External Aiming Beam Control - Enables hardware aiming beam control.	Sent: "EEABC" Response: "EEABC"
EEC	Enable External Control — Enables the analog current control input. Enables Dynamic Scaling in Waveform mode.[a]	Sent: "EEC" Response: "EEC" or "ERR: Emission is ON!"
EGM	Enable Gate Mode — Enables internal pulse generator gated by signal applied to modulation input.	Sent: "EGM" Response: "EGM" or "ERR: Emission is ON!"
ELE	Enable Hardware Emission Control — Enables hardware emission control.	Sent: "ELE" Response: "ELE" or "ERR: Emission is ON!"
EMOD	Enable Modulation – Enables the modulation mode.	Sent: "EMOD" Response: "EMOD" or "ERR: Emission is ON!"
EMOFF	Stop Emission – Stops emission.	Sent:: "EMOFF"" Response: "EMOFF" or "ERR: Emission is ON!"
EMON	Start Emission – Starts emission.	Sent: "EMON" Response: "EMON"
EPM[b]	Enable Pulse Mode — Enables Pulse mode.	Sent: "EPM" Response: "EPM"

Code	Description	Example
ESTA	Read Extended Device Status — The extended status is reported as a number of bit-encoded 32-bit words. The response contains the information required by IPG for remote troubleshooting.	Sent: “ESTA” Response: “ESTA: 256;0;0;0;0;0;0;0;46;3”
LFP[C]	Lock Front Panel – Locks touch-screen display on the front panel of the laser.	Sent:: “LFP” Response: “LFP” or “ERR: Emission is ON!”
HELP	In case of no parameters returns the list of applicable commands. In case of a specified command name as a parameter returns the command description.	Sent: “HELP” Response: “Commands: STA ROP RPP RCT EMON EMOFF RET … RIP SIP RMASK SMASK RBAUD SBAUD HELP Done HELP <Command> for more information on a specific command” Sent: “HELP RPP” Response: “HELP: RPP - Read Peak Power” Sent: “HELP RCD” Response: “HELP: RCD - Command Not Listed”

Code	Description	Example
RBAUD	Read Baud Rate — Reads the current RS-232 baud rate. The response is the command echoed back, followed by a delimiter of ": " and then the communication speed index (see below). Index Speed (bits/s) 0 - 110 1 - 300 2 - 1200 3 - 2400 4 - 4800 5 - 9600 6 - 19200 7 - 38400 8 - 57600 default 9 - 115200	Sent: "RBAUD" Response "RBAUD: 8"
RCE	Reset Critical Error — Followed by the code received from IPG clears critical errors.	Sent: "RCE 1123456123" Response: "RCE: Code Accepted" or "ERR: Code Incorrect"
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 is an echo of the command, a delimiter of ": ", and the temperature in degrees centigrade.	Sent: "RCT" Response: "RCT: 34.5"
REC	Read Error Counter — Reads critical error counter.	Sent: "REC" Response: "REC: 37"
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: 7.28;2.83;ND"
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 is the command echoed back, followed by a delimiter of ": " and 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	Example
ROP	Read Output Power — Reads the output power in watts. The response is the command echoed back, a delimiter, 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: 99.6" (Indicates that the output power is 99.6 watts) Sent: "ROP" Response: "ROP: Off" (Indicates that emission is off.)
RPP	Read Peak Power — Reads the output peak power in Watts. The response will be the command echoed back, a delimiter, 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: "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	Read Pulse Repetition Rate — Reads the pulse repetition rate of the internal pulse generator. The response is the command echoed back, followed by a delimiter of ":" and then the pulse width in Hz.	Sent: "RPRR" Response: "RPRR: 10.00" (Indicates that the PRR is 10 Hz.)
RPW	Read Pulse Width — Reads the pulse width of the internal pulse generator. The response is the command echoed back, followed by a delimiter of ":"and then the pulse width in ms.	Sent: "RPW" Response: "RPW: 5.550" (Indicates that the pulse width is 5.55 ms.)
RSN	Read Serial Number — Reads the serial number of the device.	Sent: "RSN" Response: "RSN: 6103081"

Code	Description	Example
SBAUD	Set Baud Rate — Followed by an index (see below) sets RS-232 baud rate. The command sent via RS-232 has no response and the communication speed is changed just after receiving the command. The response to the command sent via Ethernet is the command echoed back, followed by a delimiter of ": "and then the communication speed index. Index Speed (bits/s) 0 - 110 1 - 300 2 - 1200 3 - 2400 4 - 4800 5 - 9600 6 - 19200 7 - 38400 8 - 57600 default 9 - 115200	Sent: "SBAUD 9" Response (Ethernet only): "BAUD: 9" or "ERR: Invalid Baud Setting. Valid Settings = [] [0:110] [1:300] [2:1200] [3:2400] [4:4800] [5:9600] [6:19200] [7:38400] [8:57600] [9:115200] [END]" or "ERR: Emission is ON!"
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 can also be set to 0. The response from the laser is 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: Argument out of range" (The setpoint is unchanged.) Sent: "SDC 34.2" Response: "ERR: External control enabled" (The setpoint is unchanged.)
SPRR	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 is the command echoed back, a delimiter of ":" and then the pulse repetition rate. A value that is outside the acceptable range receives a response of "ERR: Duty cycle too high" or "ERR: Frequency out of range."	Sent: "SPRR 10" Response: "SPRR: 10" (PRR is set to 10 Hz.) Sent: "SPRR 100" Response: "ERR: Duty cycle too high" (PRR is unchanged.) Sent: "SPRR 100000" Response: "ERR: Argument out of range" (PRR is unchanged.)

Code	Description	Example
SPW	Set Pulse Width — Sets the pulse width. The units are in ms. 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 is the command echoed back, a delimiter of ":" and then the pulse width. A value that is outside the acceptable range receives 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: "SPW 11000" Response: "ERR: Argument out of range." (The pulse width is unchanged.) Sent: "SPW 8" Response: "ERR: Duty cycle too high." (The pulse width is unchanged.)
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. **Note:** Each of the bits have a meaning as listed in Table 3-4 on page 3-9.	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.
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"
SQSEL	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. Note: It is not possible to switch to sequence mode if Waveform mode is enabled and no sequences exist. An error is returned if that is the case. If the Key Switch is in the Remote position, a waveform configuration is automatically executed before a response is returned.	Sent: "SQSEL 5" Response: "New setting applied. Waveform Mode: Pulse Sequence Selected Sequence: ID[5] – Name[Test1]"
UFP	Unlock Front Panel — Unlocks touch-screen display on the front panel of the laser.	Sent: "UFP" Response: "UFP" or "BCMD" in case of key is in REMOTE position" or "Emission is ON!"

a. Lasers with Pulse Shaping option only.

b. QCW Models only.

c. Laser with Touch-Screen Display only.

Table 3-4. Bit Meanings

Bit 0	-	0	=	Normal Operation
	-	1	=	Command Buffer Overload
Bit 1	-	0	=	Normal Operation
	-	1	=	Overheat
Bit 2	-	0	=	Emission Off
	-	1	=	Emission On
Bit 3	-	0	=	Back Reflection OK
	-	1	=	High Back Reflection Level
Bit 4	-	0	=	Analog Power Control Disabled
	-	1	=	Analog Power Control Enabled
Bit 5[a]	-	0	=	Normal Operation
	-	1	=	Pulse Too Long
Bit 6	-	Reserved		
Bit 7	-	Reserved		
Bit 8	-	0	=	Aiming Beam OFF
	-	1	=	Aiming Beam ON
Bit 9	-	0	=	Normal Operation
	-	1	=	Pulse too Short
Bit 10[a]	-	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[b]	-	0	=	Emission is out of the 3 second start-up state.
	-	1	=	Emission is in the 3 second start-up state.

	(in ON position of the Keyswitch only)			
Bit 16	-	0	=	Gate Mode Disabled
	-	1	=	Gate Mode Enabled
Bit 17[a]	-	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[b]	-	0	=	Front Panel Display is Unlocked
	-	1	=	Front Panel Display is Locked
Bit 21[b]	-	0	=	Keyswitch is in ON position
	-	1	=	Keyswitch is in REM position
Bit 22[c]	-	0	=	Waveform Pulse Mode OFF
	-	1	=	Waveform Pulse Mode ON
Bit 23[a]	-	0	=	Normal Operation
	-	1	=	Duty Cycle Too High
Bit 24	-	0	=	Normal Operation
	-	1	=	Low Temperature
Bit 25	-	0	=	Normal Operation
	-	1	=	Power Supply Alarm
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	=	Fiber Interlock OK
	-	1	=	Fiber Interlock Active

Bit 31[a]	-	0	=	Normal Operation
	-	1	=	High Average Power

a. QCW Models only.

b. Lasers with Touch-Screen Display only.

c. Lasers with Pulse Shaping Option only.

Table 3-5. TCP-IP Configuration Commands

Code	Description	Example
DDHCP	Disable DHCP - Disables DHCP client	Sent: “DDHCP” Response: “DDHCP” or “ERR: Emission is ON!”
EDHCP	Enable DHCP - Enables DHCP client.	Sent: “EDHCP” Response: “EDHCP” or “ERR: Emission is ON!”
RDGW	Read Default Gateway — Reads the current default gateway of the device. The response is the command echoed back, followed by a delimiter of “: “ and then the default gateway in dot-decimal notation.	Sent: “RDGW” Response: “RDGW: 192.168.1.1”
RDHCP	Read DHCP — Reads the current status of DHCP client function. The response is the command echoed back, followed by a delimiter of “: “and then either “ON” or “OFF.”	Sent: “RDHCP” Response: “RDHCP: OFF”
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: 192.168.1.230"
RLHN	Read Local Host Name — Reads the current local host name of the device. The response is the command echoed back, followed by a delimiter of “:” and then the name.	Sent: “RLHN” Response: “RLHN: IPG-12004020”
RMAC	Read MAC Address — Reads the current MAC address of the laser. The response is the command echoed back, followed by a delimiter of “:” and then the MAC address in a form of six groups of two hexadecimal digits, separated by hyphens (-).	Sent: “RMAC” Response: “RMAC: A1-B2-C3-D4-E5-F6”
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: 255.255.240.0”

Code	Description	Example
RSTIP	Reset TCP/IP Settings - Resets the settings to the default ones: DHCP client OFF IP Address: 192.168.3.230 Default Gateway: 192.168.0.1 Subnet Mask: 255.255.240.0 Local Host Name: IPG-"serial number"	Sent: "RSTIP" Response: "RSTIP" or "ERR: Emission is ON!"
SDGW	Set Default Gateway — Followed by a number in dot-decimal notation sets the default gateway for the laser.	Sent: "SDGW 192.168.0.1" Response: "SDGW: 192.168.0.1" or "ERR: Emission is ON!"
SIP	Set IP — Followed by a number in dot-decimal notation sets the IP address for the laser.	Sent: "SIP 192.168.1.231" Response: "SIP: 192.168.1.231" or "ERR: Emission is ON!"
SMAC	Set MAC Address — Followed by six groups of two hexadecimal digits, separated by hyphens (-), sets the MAC address for the laser.	Sent: "SMAC 12-34-56-78-EF-EF" Response: "SMAC: 12-34-56-78-EF-EF" or "ERR: Emission is ON!"
SMASK	Set Subnet Mask - Followed by a number in dot-decimal notation sets the subnet mask for the laser.	Sent: "SMASK 255.255.0.0" Response: "SMASK: 255.255.0.0" or "ERR: Emission is ON!"
SLHN	Set Local Host Name — Specifies the name of the device within the network.	Sent: "SLHN IPG-12004020" Response: "SLHN: IPG-12004020" or "ERR: Emission is ON!"

The following commands in Table 3-6 are for lasers with the Pulse Shaping option only.

Table 3-6. Waveform Mode (Pulse Shaping) Specific Commands

Code	Description	Example
DWPM	Disable Waveform Pulse Mode — Disables internal arbitrary waveform generator (pulse shaping).	Sent: “DWPM” Response: “DWPM” or “ERR: Emission is ON!”
EWPM	Enable Waveform Pulse Mode -— Enables internal arbitrary waveform generator (Pulse Shaping).	Sent: “EWPM” Response: “EWPM” or “ERR: No pulses available, cannot enable waveform mode.” or “ERR: No sequences available, cannot enable waveform mode.” or “ERR: Emission is ON!” or “ERR: Laser is not in Pulse Mode!”
PCFG	Configure Waveform Mode — Returns the status of the Waveform Mode and the ID number of the selected Pulse Profile or Pulse Sequence.	Sent: “PCFG” Response: “PCFG: [] [Status:Disabled] [Mode:Profile] [ID:2] [END]”
PRLS	Profile List — Displays a list of available Pulse Profiles stored in the device library.	Sent: “PRLS” Response: “PRLS: [] [0:New Shape 0] [2:New Shape 2] [END]”
PRSEL	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.	Sent: “PRSEL 2” Response: "PRSEL: [2:New Shape 2]” or “ERR: Entered pulse ID is not valid” or “ERR: No pulses are available”
SQLS	Sequence List — Displays a list of available Pulse Sequence programs stored in the device library.	Sent: “SQLS” Response: “SQLS: [] [0:New Program 0] [4:New Program 4] [END]”

Code	Description	Example
SQSEL	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.	Sent: “SQSEL 4” Response: “SQSEL: [4:New Program 4]” or “ERR: Entered sequence ID is not valid” or “ERR: No sequences are available”

Pulse Shaping

Overview

The Pulse Shaper program lets you sketch pulse points. It automatically fills in pulse (power level) lines, and computes all the emission pulse characteristics simultaneously. It also performs auto-correction in case constraints are violated.

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 pre-configured in the laser.

Pulses are not zeroed visually when they go under the power threshold, although that is not reflected in the pulse energy calculation.

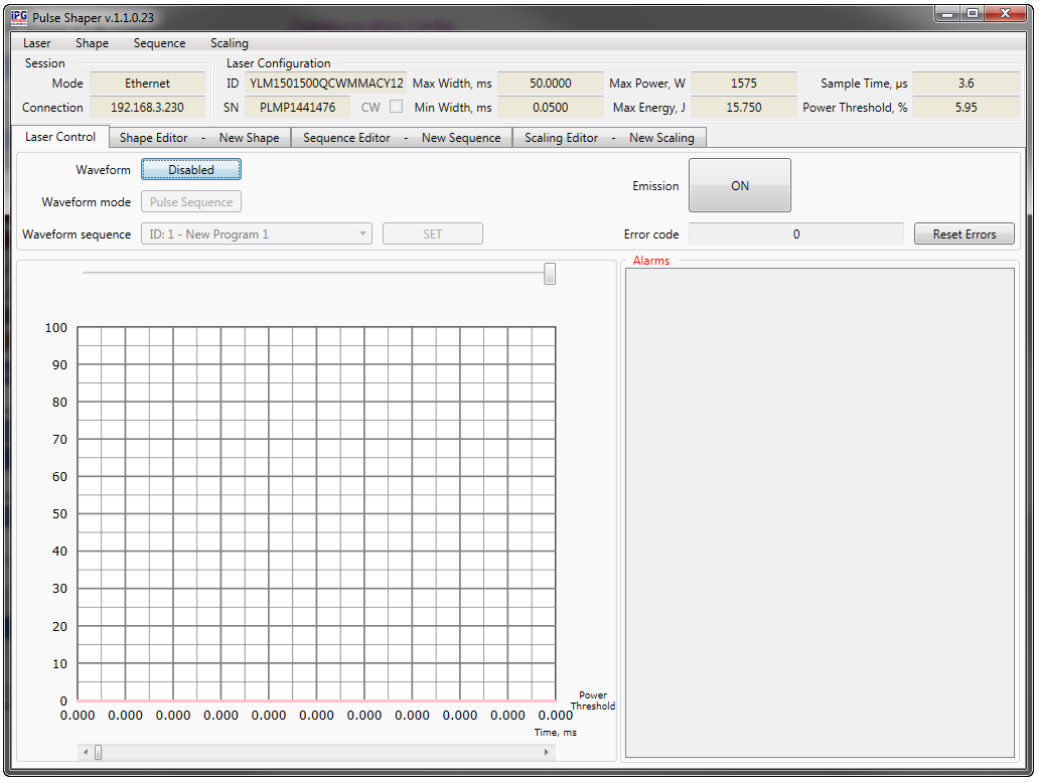
To avoid pulse energy limits, either shorten your pulse widths or reduce the value of the Time Scale.

Each time you change a Pulse Shape profile, the pulse widths are updated to reflect the current sketched pulse. You cannot exceed the limits established in the laser configuration.

You can create effective Pulse Shapes to meet the changing requirements of your applications. You can store Pulse Shapes in a Pulse Profiles library on the laser or locally to your computer. You can also create and store Pulse Sequences (combinations of pulse profiles, delays, and repeats) in a Pulse Sequences library or locally to your computer.

Figure 4-1 shows the Pulse Shaper interface.

Figure 4-1. Pulse Shaper Interface



PC Requirements

The following minimum requirements are necessary for installing and using the Pulse Shaping software:

- x86 machine with at least 512 MB RAM, 5 GB hard disk, mouse and keyboard, VGA monitor and a Ethernet or Serial (RS-232) communication port
- Operating System: Windows 7
- Software: MS .NET Framework, Version 4.5
- Pulse Shaping program: Designated release version executable

Ethernet TCP/IP Interface

See “Ethernet TCP/IP Interface” on page 3-1 for details on the Ethernet Interface.

See Table 3-2 on page 3-1 for a list of Ethernet Interface pinouts.

RS-232 Configuration

See “RS-232 Configuration” on page 3-1 for details on RS-232 configuration.

See Table 3-1 on page 3-1 for a list of RS-232 parameters.

Key Terms

- **Shape Editor** — Lets you create and edit various Pulse Shapes and save them in the Pulse library.
- **Sequence Editor** — Lets you create a sequence of pulses (pulse train) using Pulse Shapes from Pulse library.
- **Scaling Editor** — Lets you scale pulses within a sequence (ramp up and down).
- **Waveform** — A waveform is the shape and form of a signal.

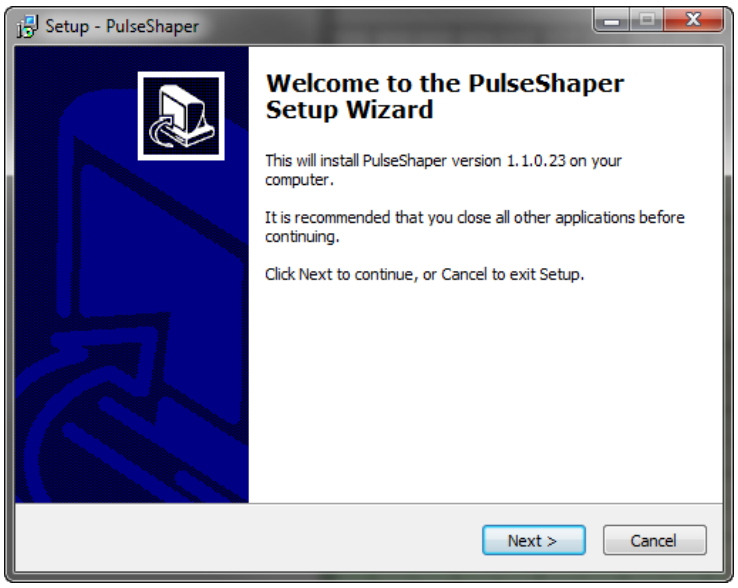
Installing the Pulse Shaper Software

To install the software package, run the Pulse Shaper Setup, which creates a folder with the Pulse Shaper program.

To install the Pulse Shaper software:

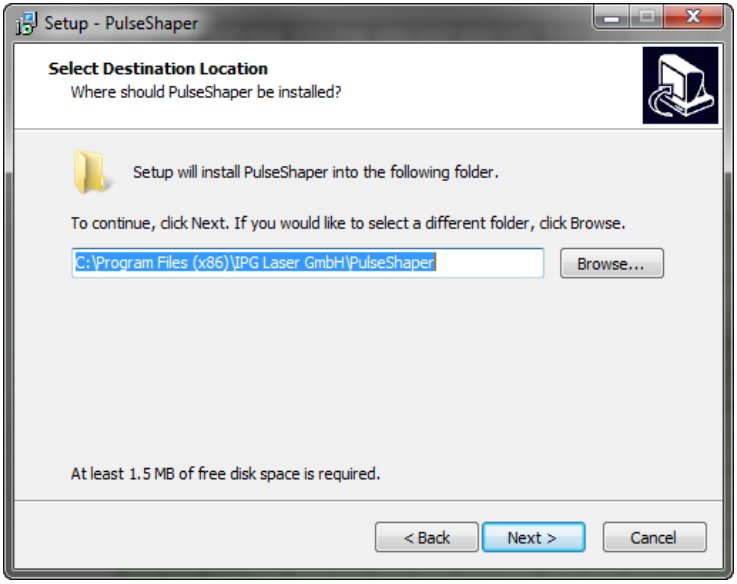
1. Run the **PulseShaper Setup.exe** and select a language. The PulseShaper Setup Wizard appears as shown in Figure 4-2.

Figure 4-2. PulseShaper Setup Wizard



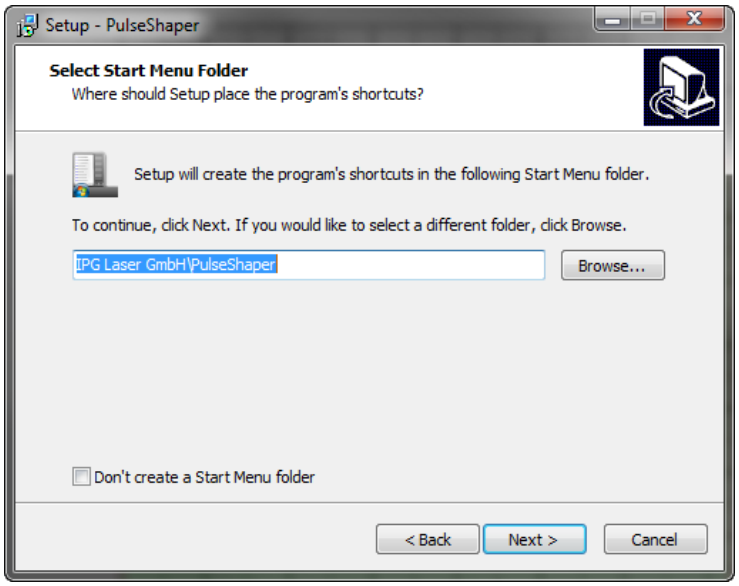
2. Click **Next** to continue.
3. Select a destination location or accept the default location for the installation as shown in Figure 4-3 and click **Next**.

Figure 4-3. PulseShaper Setup - Location Destination



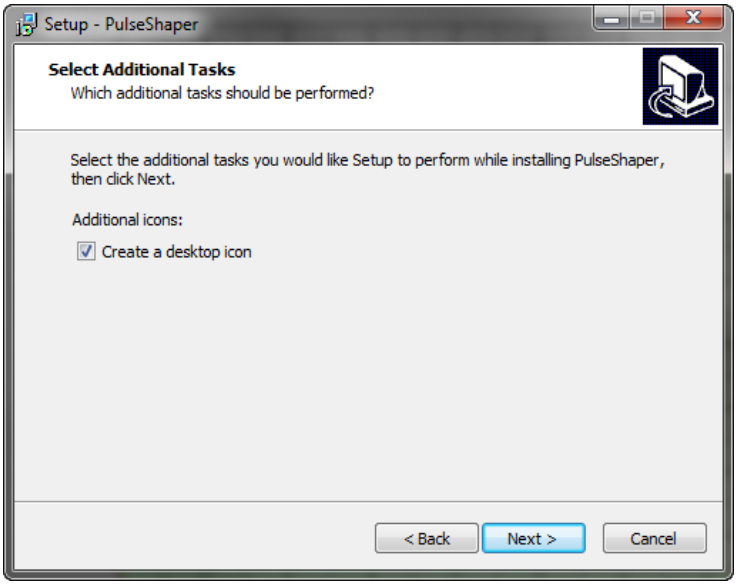
4. Click **Next** to accept the default Start Menu folder for the Pulse Shaper shortcut.
   a. Click **Browse** if you want to change the default Start menu to another location.
   b. Click the **Don't create a Start Menu folder** checkbox to skip this step.

Figure 4-4. PulseShaper Setup - Program Shortcut



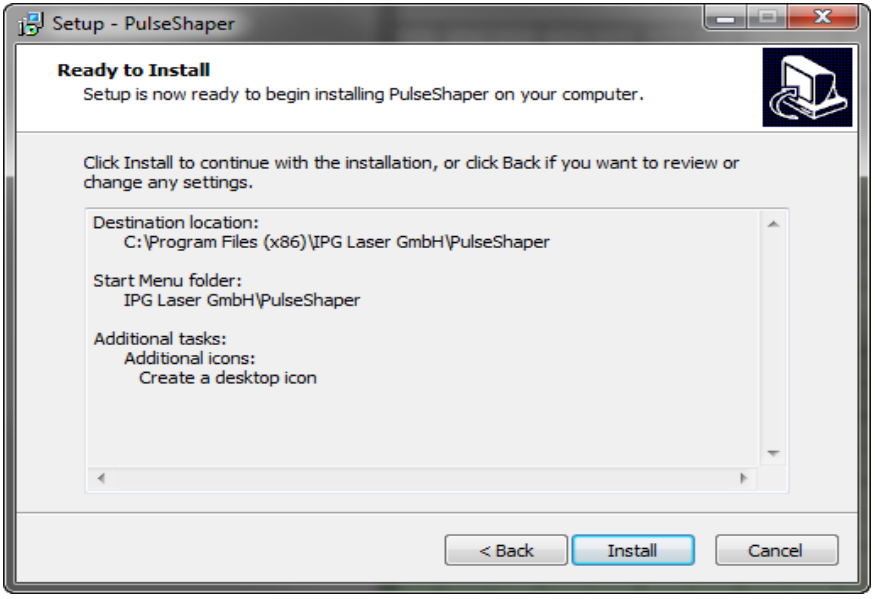
5. Click **Next** to create a PulseShaper icon on your desktop (default) as shown in Figure 4-5.
   a. Deselect the **Create a desktop icon** checkbox if you want to skip this step.

Figure 4-5. PulseShaper Setup - Desktop Icon



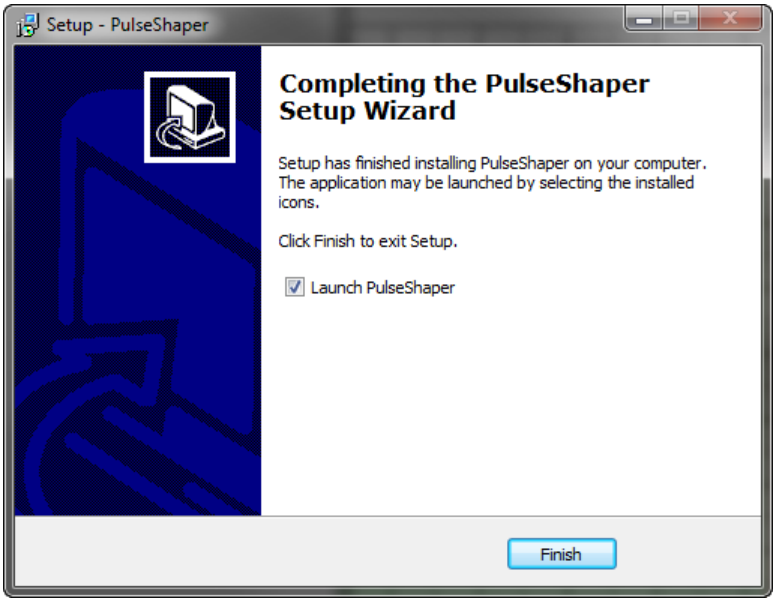
6. Click **Install** to continue with installation as shown in Figure 4-6.

Figure 4-6. PulseShaper Setup - Ready to Install



7. Click **Finish** to exit Setup as shown in Figure 4-7. By default, the Pulse Shaper program launches when you exit Setup.
   a. Deselect the **Launch PulseShaper** checkbox if you do not want Pulse Shaper to launch upon exiting Setup.

Figure 4-7. PulseShaper Setup - Finish

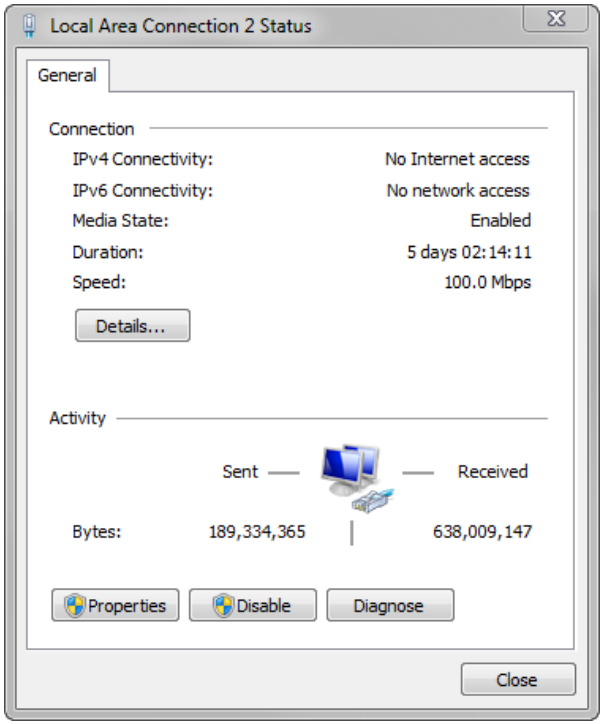


Configuring a Local Area Connection for Ethernet

To configure a local area connection for Ethernet:

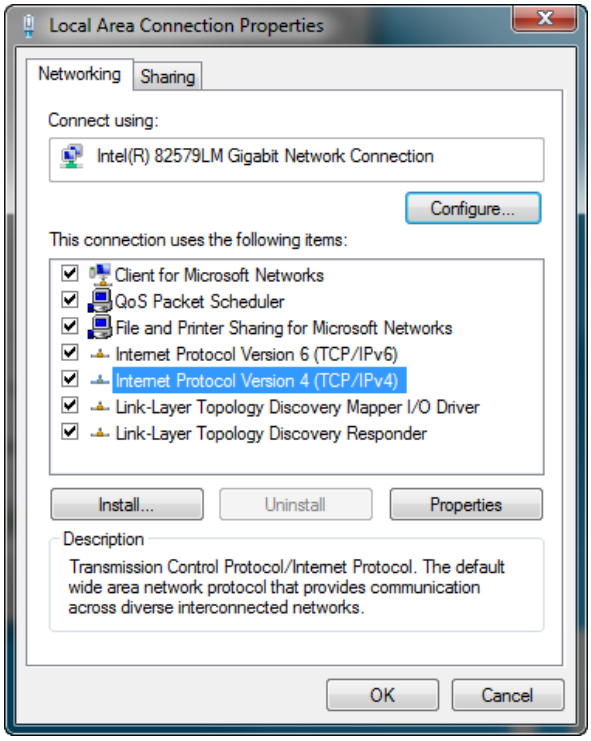
1. Go to **Control Panel -> Network and Internet -> Network and Sharing Center**.
2. Click **Change adapter settings**.
3. Select a Local Area Connection icon. The following window appears as shown in Figure 4-8.

Figure 4-8. Local Area Connection Status



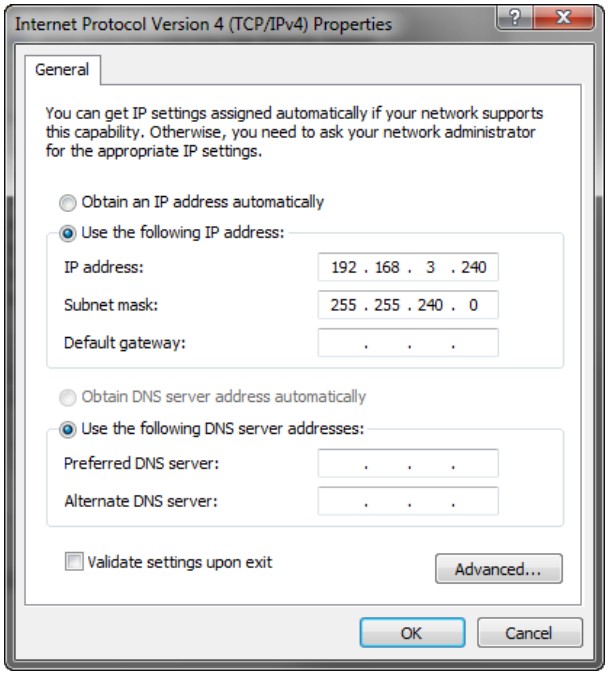
4. Click **Properties**. The following window appears as shown in Figure 4-9.

Figure 4-9. Local Area Connection Properties



5. Select **Internet Protocol Version 4 (TCP/IPv4)**.
6. Click the **Properties** button. The following window appears as shown in Figure 4-10.

Figure 4-10. Internet Protocol Version 4 Properties



7. Click the **Use the following IP address** radio button to manually assign the IP address.
8. Assign the IP address to 192.68.3.23x (x cannot be 0).
9. Assign the subnetmask setting to 255.255.240.0.
10. Click **OK** to accept these manual changes.

Pulse Shaper Configuration Procedures

You can connect to the Pulse Shaper program from either an Ethernet or RS-232 connection.

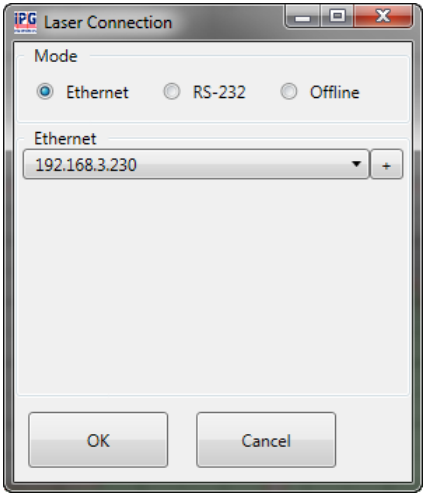
Connecting using Ethernet

You can connect to the Pulse Shaper using an Ethernet connection from your computer to the laser. This procedure starts a connection to the laser over a network via a specific IP Serial Port.

To connect using Ethernet:

1. Connect your PC to the laser using network cable.
2. Configure the Local Area Connection settings for Ethernet as explained in “Configuring a Local Area Connection for Ethernet” on page 4-9.
3. Start the Pulse Shaper program.
4. Click **Laser->Connect**. The Laser Connection dialog box appears as shown in Figure 4-11.

Figure 4-11. Pulse Shaper - Ethernet Laser Connection



5. Click the **Ethernet** radio button.
6. Select the IP address of the laser from the drop-down listbox.
7. Click **OK**.

The status is displayed in the **Session** box indicating that the connection is successful.



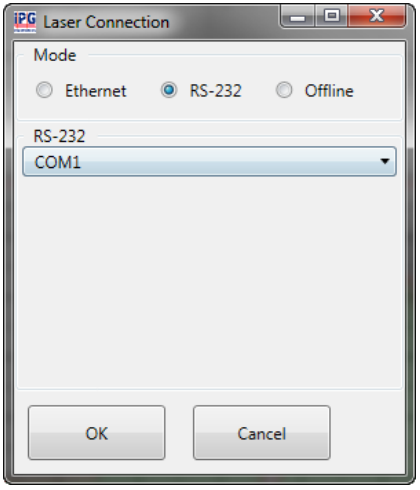
Connecting Using RS-232

You can connect to the Pulse Shaper program using an RS-232 Serial connection from your computer to the laser. This procedure starts a connection to the laser over RS-232 serial cable via a specific port on the host machine.

To configure an RS-232 serial connection:

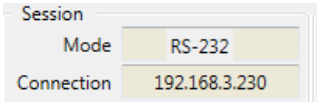
1. Connect a RS-232 serial cable from your computer to the laser.
2. Start the Pulse Shaper program.
3. Click **Laser->Connect**. The Laser Connection dialog box appears as shown in Figure 4-12.

Figure 4-12. Pulse Shaper - RS-232 Laser Connection



4. Click the **RS-232** radio button.
5. Select a valid COM port on the laser from the drop-down listbox.
6. Click **OK**.

The status is displayed in the **Session** box indicating that the connection is successful.



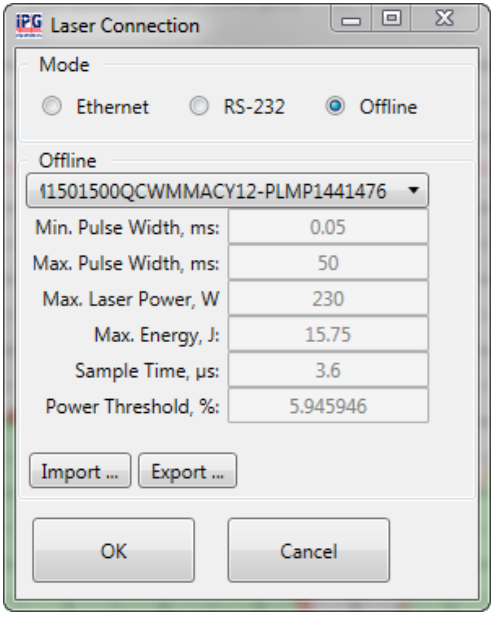
Using the Offline Option

You can export and import a configuration from a laser connection and store it for later use with the Offline option. When you export a configuration, the chart (including unused time segments) is preserved with the original time scale.

To use the Offline option:

1. Start the Pulse Shaper program.
2. Click **Laser->Connect**. The Laser Connection dialog box appears as shown in Figure 4-13.
3. Click **Offline**.

Figure 4-13. Pulse Shaper - Offline Option



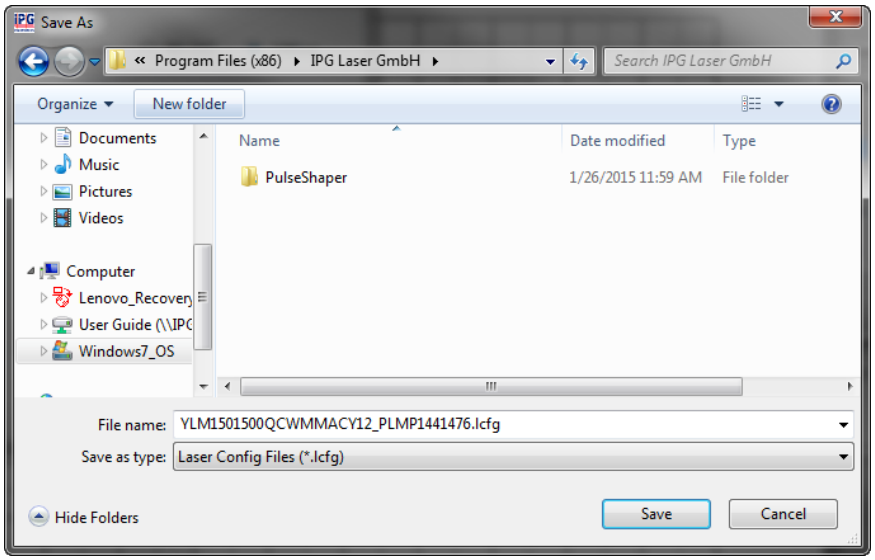
4. Export or import a pulse configuration as detailed in the next sections.

Exporting a Configuration

To export a saved configuration from a previous laser connection (lcfg file.):

1. Click **Export...** The following dialog box appears as shown in Figure 4-14 on page 4-15.

Figure 4-14. Export Configuration



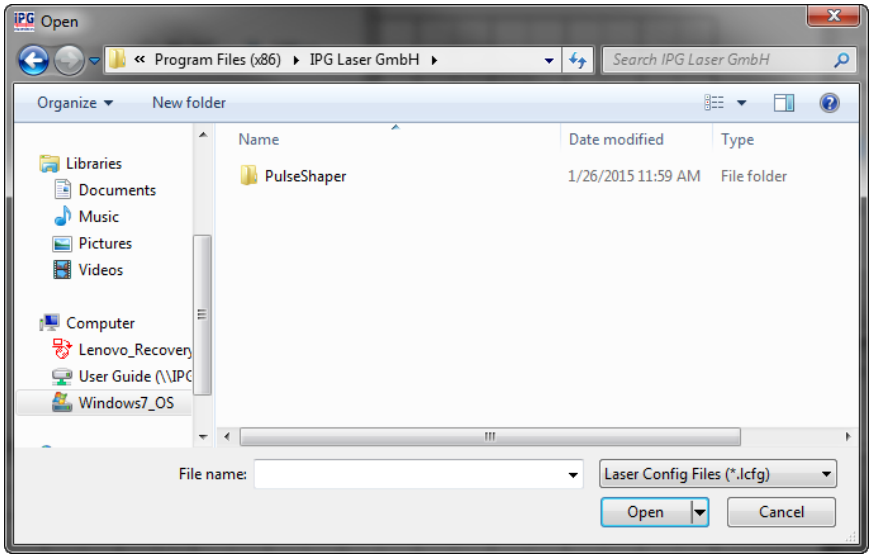
2. Accept the default filename or rename the file and click **Save**.

Importing a Configuration

To import a saved configuration from a previous laser connection (lcfg file.):

1. Click **Import...** The following dialog box appears as shown in Figure 4-15 on page 4-16.

Figure 4-15. Import Configuration



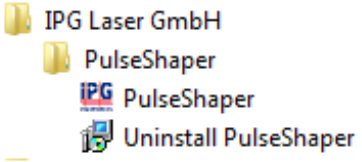
2. Select the configuration file (.lcfg) and click **Open**.
3. Click **Yes** to overwrite an existing configuration if applicable.

Using the Pulse Shaper Program

To start the Pulse Shaper program:

1. Go to **All Programs ->IPG Laser GmbH ->PulseShaper**.
2. Select **PulseShaper.**

Figure 4-16. Pulse Shaper Program



The Pulse Shaper interface appears as shown in Figure 4-17.

Figure 4-17. Pulse Shaper Interface

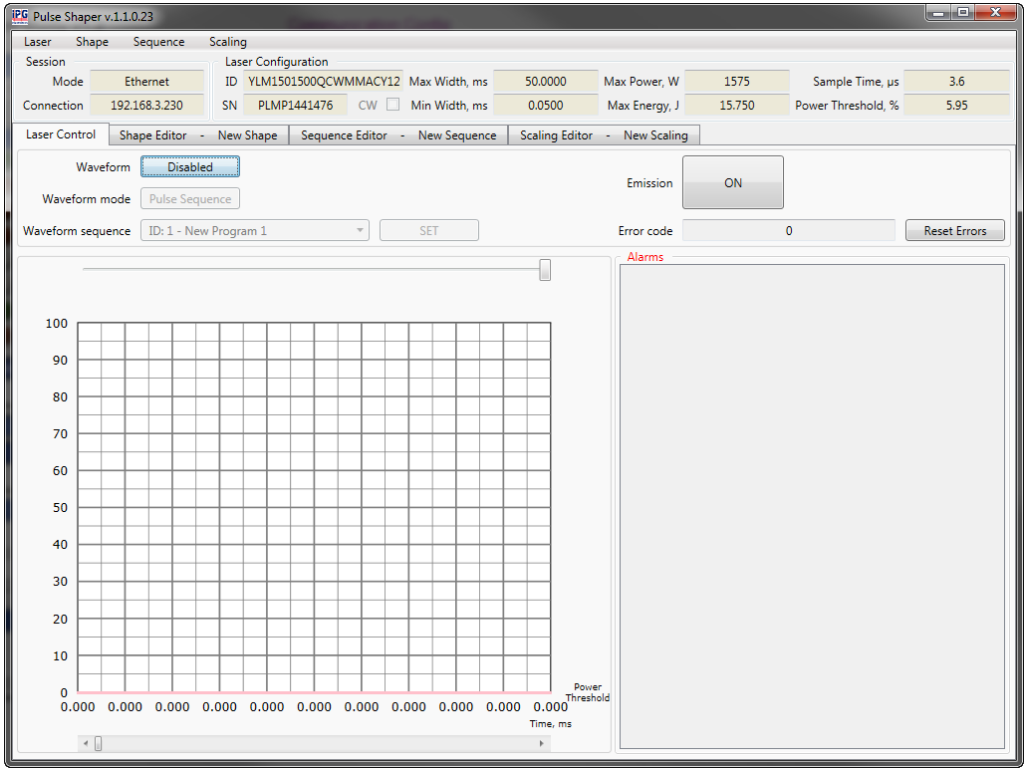


Table 4-1 provides the descriptions for the four menu items in the Pulse Shaper program.

Table 4-1. Pulse Shaper Menu Items

Menu Name	Description
Laser	• **Connect** — Connects to the laser via Ethernet or RS-232. You can also the Offline option and import a saved Pulse Profile configuration file. • **Disconnect** — Disconnects the Pulse Shaper program from the laser. • **Synchronization** — Synchronizes the Pulse Shapes with the laser using the Ethernet IP address or RS-232 connection. • **Backup** — Backs up the configuration profile to a .bkp file. • **Restore** — Restores the configuration profile from a backup file. All current data is replaced with data stored in the backup file. • **Pulse mode** — Indicates that Pulse mode is active. • **Exit** — Closes the Pulse Shaper program.
Shape	• **New** — Creates a new Pulse Shaping profile. • **Read from Laser** — Loads and displays a Pulse Shaping profile from the laser. • **Write to Laser** — Saves the current Pulse Shaping profile to the laser. This option only saves the effective pulse. • **Delete in Laser** — Deletes a Pulse Shaping profile that is stored in the laser. • **Read from File** — Loads and displays a Pulse Shaping profile from a saved file (.shp) on your computer. • **Write to File** — Saves the current Pulse Shaping profile to a file (.shp) to your computer.
Sequence	• **New** — Creates a new Pulse Sequence. • **Read from Laser** — Loads and display a Pulse Sequence from the laser. • **Write to Laser** — Saves a Pulse Sequence to the laser. • **Delete in Laser** — Deletes a Pulse Sequence from the laser. • **Read from File** — Loads and displays a Pulse Sequence from a saved file (.sec) on your computer. • **Write to File** — Saves a Pulse Sequence to a file (.sec) to your computer.
Scale	• **New** — Creates a new Pulse Scale. • **Read from Laser** — Loads and display a Pulse Scale from the laser. • **Write to Laser** — Saves current Pulse Scale to the laser. This option only saves the effective Pulse Scale. • **Delete in Laser** — Deletes a Pulse Scale that stored in the laser. • **Read from File** — Loads and display a Pulse Scale from a file (.scl) on your computer. • **Write to File** — Saves current Pulse Scale to a file (.scl) to your computer.

Table 4-2 provides descriptions for the Pulse Shaper main window options.

Table 4-2. Main Window Descriptions

Name	Description
Session Panel	
Mode	Displays the active session type.
Connection	Displays the connection status (Ethernet or RS-232).
Laser Configuration Panel	
ID	The configuration identification for the laser.
SN	The serial number of the laser.
CW	Indicates if the CW operating mode (Continuous Wave) is active. In CW mode, the maximum pulse duration and duty cycle are not applicable.
Max Width, ms	Maximum allowed pulse width.
Min Width, ms	Minimum allowed pulse width.
Max Power, W	Maximum allowed pulse power.
Max Energy, J	Maximum allowed pulse energy.
Sample Time, µs	Minimum interval for pulse points.
Power Threshold %	Emission (current) effective zero level.

Laser Control Tab

The Laser Control tab lets you activate a Pulse Sequence.

Figure 4-18 shows the Laser Control tab.

Figure 4-18. Laser Control Tab

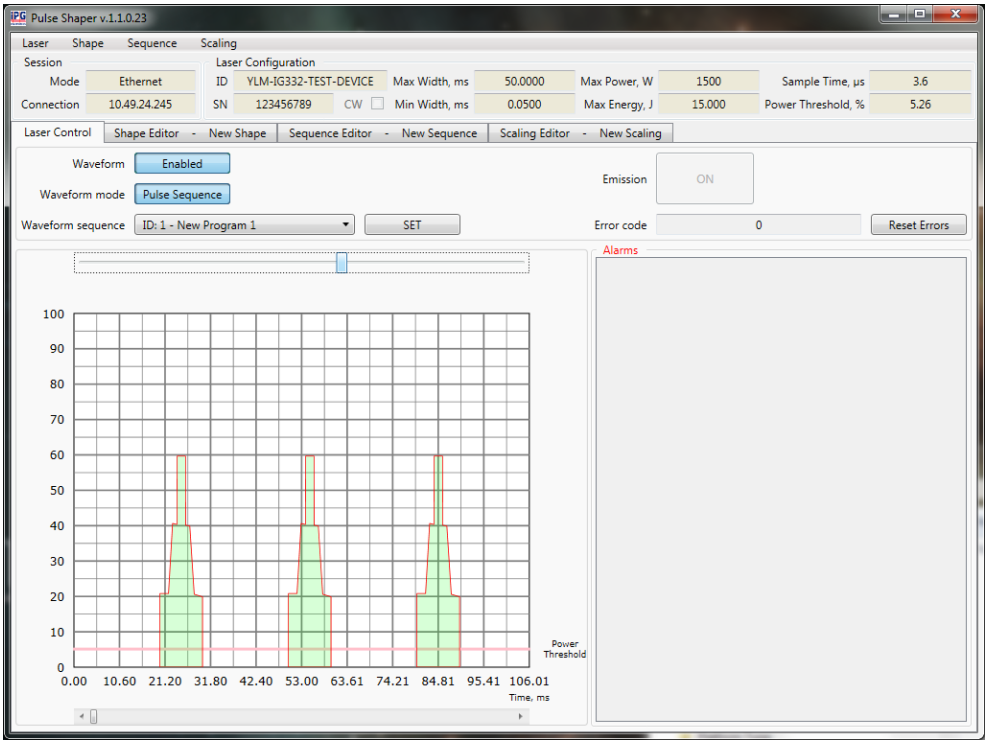


Table 4-3 provides descriptions for the options in the Laser Control tab.

Table 4-3. Laser Control Tab Descriptions

Name	Description
Waveform	Toggles the waveform status.
Waveform mode	Toggles between a Single Pulse and Pulse Sequence.
Waveform sequence	Select a Pulse Sequence from the listbox. Click **SET** to apply the Pulse Sequence for viewing in the chart.
Emission	Click **ON** to show the emission power in the chart.
Error Code	Click **Reset Errors** to clear error codes after they are addressed.

Shape Editor Tab

The Shape Editor lets you create and edit various Pulse Shape profiles and save them in the Pulse Shapes library on the laser or locally to your computer.

Figure 4-19 shows the Shape Editor tab.

Figure 4-19. Shape Editor Tab

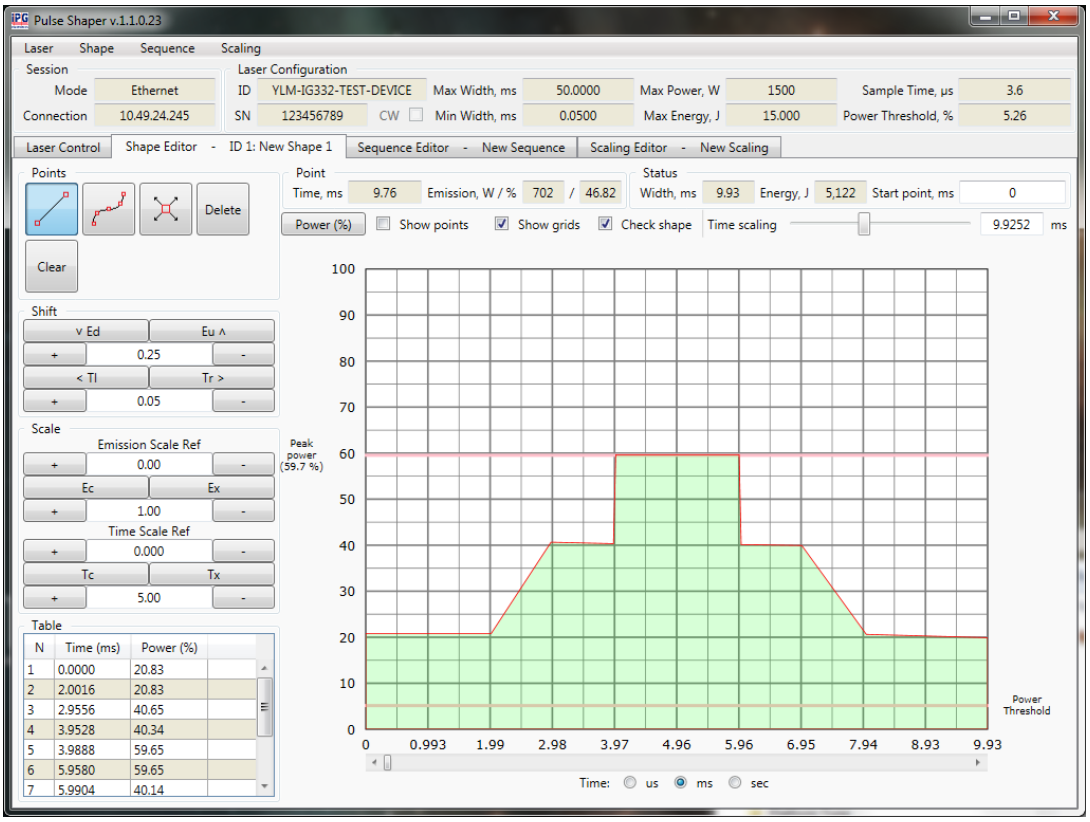


Figure 4-20 shows the Points Panel in the Shape Editor tab.

Figure 4-20. Shape Editor Tab - Points Panel

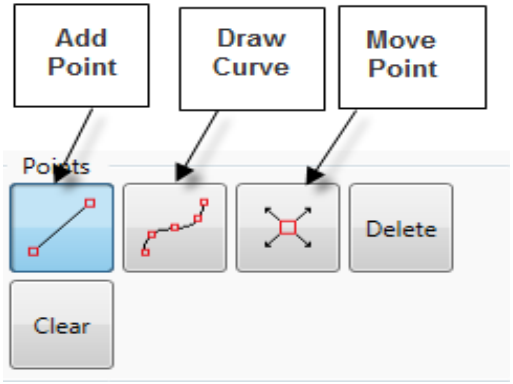


Figure 4-21 shows the Shift Panel in the Shape Editor tab.

Figure 4-21. Shape Editor Tab - Shift Panel

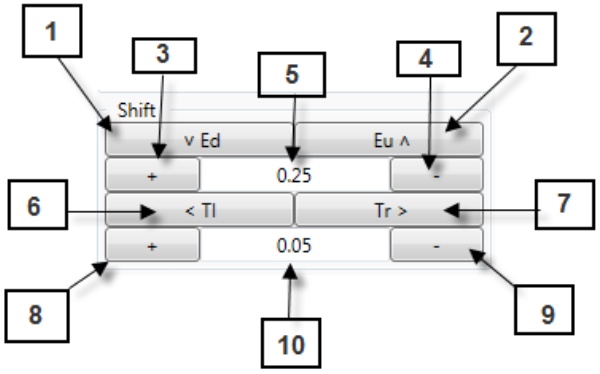


Table 4-4 provides descriptions for the Point and Shift Panel controls in the Shape Editor tab.

Table 4-4. Shape Editor Tab - Points and Shift Panel Controls

Item	Name	Description
Points		
	Add Point Tool	Plots pulse points in the chart and automatically forms lines.
	Draw Curve Tool	Plots an arbitrary pulse in the chart and automatically forms points and lines along the graph (using your mouse).
	Move Point Tool	Relocates a pulse point on the chart.
	Delete Point	Deletes a pulse point from the Table box.
	Clear	Clears the entire pulse chart.
Shift Panel[a]		
1	Emission Shift Down	Shifts all pulse points down in emission.
2	Emission Shift Up	Shifts all pulse points up in emission.
3	Increase Emission Shift Step	Increases the emission shifting step size.
4	Decrease Emission Shift Step	Decreases the emission shifting step size.
5	Emission Step	Sets the emission shifting step size (.25 - 100%).
6	Time Shift Left	Shift all pulse points back in time.
7	Time Shift Right	Shifts all pulse points forward in time.
8	Increase Time Shift Step	Increases the time shifting step size.
9	Decrease Time Shift Step	Decreases the time shifting step size.
10	Emission Scale Ref	Sets the reference point for emission scaling (0 - 100%).

a. Due to the digitized nature of the pulses, approximations are used to compute modulations. Modulation step values (especially very small ones) might not have an effect. IPG recommends you save the original pulse while manipulating the pulse for easy comparison between the modulated pulse and the original.

Figure 4-22 shows the Scale Panel in the Shape Editor tab.

Figure 4-22. Shape Editor Tab - Scale Panel

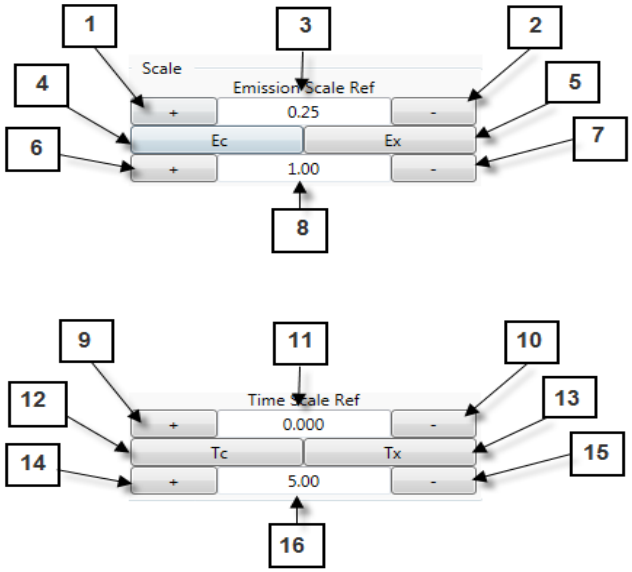


Table 4-5 provides descriptions for the Scale Panel controls in the Shape Editor tab.

Table 4-5. Shape Editor Tab - Scale Panel Controls

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

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

Figure 4-23 shows the chart in the Shape Editor tab.

Figure 4-23. Shape Editor Tab - Chart



Table 4-5 provides descriptions for the options in the Chart in the Shape Editor tab.

Table 4-6. Shape Editor Tab - Chart

	Name	Description
Chart Panel[a]		
1	Time (X-axis)	Time domain in µs, ms, or sec.
2	Emission (Y-axis)	Emission level in percent power.
3	Power Threshold	Visual representation of the current threshold level in the laser configuration. Appears in pink box in the chart. Any pulse data within does not have any power.
4	Profile Memory	Current pulse memory utilization/maximum allowable.

a. Due to the digitized nature of the pulses, approximations are used to compute modulations, so modulation step values, especially the very small ones might not have an effect. It is recommended to save original pulse while manipulating the pulse so it is easy to compare the modulated pulse against the original.

Creating a New Pulse Shape Profile

To create a new Pulse Shape profile:

1. Select **Shape -> New**.
2. Select a time scale unit (µs, ms, or sec) from one of the **Time:** buttons at the bottom of the window.
3. Draw the shape by adding points.
4. To change points, modify values in the Table box in the left pane.
5. Once the Pulse Shape is complete, you can save it to the Pulse Shapes library or locally on your computer.
    a. To save to the Pulse Shapes library, on the laser select **Shape -> Write to Laser**.
    b. To save to your computer, select **Shape -> Write to File**.

Creating a Single Pulse Shape

For simple applications, you might require only a Single Pulse shape.

To create a single Pulse Shape:

1. Select **New** from the **Shape** menu. A new shape appears in the Shape Editor tab.
2. Select the **Add Point** tool and use your mouse to plot points along the pulse chart. Lines are automatically generated to connect the plotted dots.
3. Click the **Show points** checkbox to display the graphical points along the grid lines in the chart.
4. Select the **Move** tool and drag and move any pulse point. You should be able to move the pulse point in any direction.
5. Select **Delete** and click on any existing point. The point is removed and the pulse line is regenerated to connect the neighboring points.
6. Select the **Add Point** tool and click between any two existing pulse points. The pulse lines are updated to connect the new point to the neighboring ones.
7. Click **Clear** to remove the entire pulse chart.

Shifting a Pulse Shape

You can manipulate an existing Pulse Shape to create new variations. This method can save you time and achieve better symmetry. See Figure 4-21 for an illustration of Shift Panel controls.

To shift a pulse:

1. Select **New** from the **Shape** menu.
2. Create a preliminary pulse (preferably an alternating one) such as a square or sine wave.
3. Set an emission step percentage value in the Shift Panel.
4. In the Shift Panel, click Emission Shift Down (**Eu** ∧) or Emission Shift Up (∨ **Ed**) to introduce an emission offset to the pulse.
5. Set a certain Time Step value in the Shift Panel.
6. Click Time Shift Left (**Tr>**) Time Shift Right (**<Tl**) to introduce a time offset to the pulse.
7. Set an 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, set 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.
8. Use the **Time scaling** slider to set a Time scale value. It should be the effective zero point of your pulse to get the best result.

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. IPG recommends you save the original pulse prior to modulating a pulse.

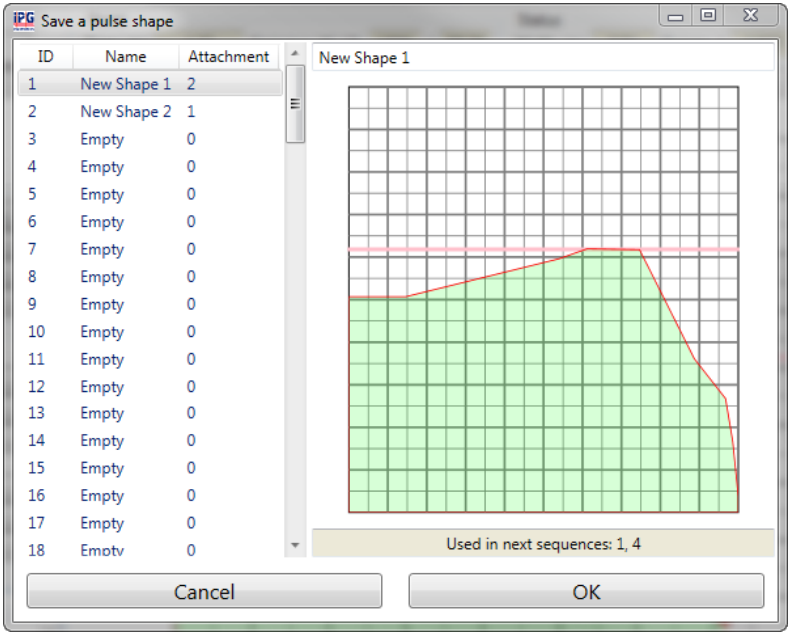
Pulse Shape Storage and Recall

On a Laser

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

1. Sketch a Pulse shape as explained in “Creating a Single Pulse Shape” on page 4-28.
2. Select **Shape->Write to Laser.**

Figure 4-24. Write a Pulse Profile to the Laser



3. Select a pulse ID or enter a new name for the pulse profile and click **OK**.

   The message “Shape was saved” appears.

   The pulse data is encoded and transmitted to the laser for storage.

To recall:

1. Select **Shape->Read from Laser**.
2. Select a pulse profile ID and click **OK**.

The Pulse Shape is fetched, decoded, and displayed on the chart. The displayed pulse might appear differently as any unused time in the chart is removed as only the effective pulse width is saved.

On a Host PC

You can write Pulse Sequences to your computer to use and activate them in the Sequence Editor.

To save a Pulse Sequence your computer:

1. Select **Shape -> Write to File**.
2. Enter a name for the file and click **Save**.

To recall a Pulse Shape:

1. Select **Shape->Read from File**.
2. Select a pulse ID and click **OK**.

   The Pulse Shape is fetched and loaded into the chart.

Deleting a Pulse Profile

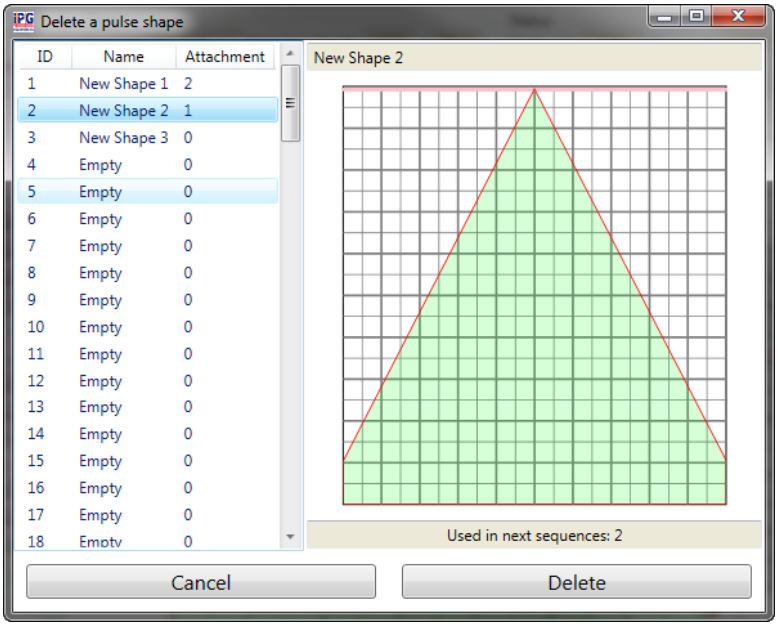
You can only delete or make changes to a pulse if the pulse profile status is “Idle”. The “In Use” status identifies that the laser is configured with that pulse.

You cannot delete a pulse profile that has an attachment status greater than zero, which means that the pulse is used by one or more existing sequences. However, you can overwrite a pulse if you accept to bypass the warning.

To delete a Pulse Shape profile:

1. Select **Shape->Delete in Laser**. The Delete a Pulse Shape dialog box appears.

Figure 4-25. Delete a Pulse Profile in the Laser



2. Select a profile ID to delete.
3. Click **Delete.**
4. Click **Yes** in the confirmation box.

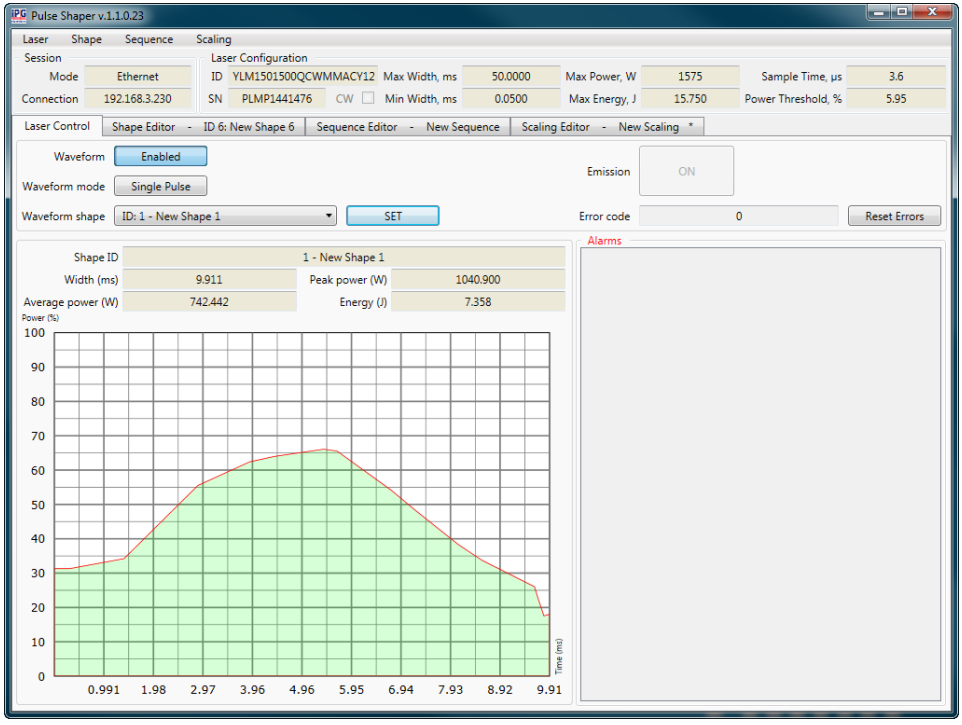
Single Pulse Activation

To activate a Single Pulse:

1. Select **Laser -> Connect**. See "Pulse Shaper Configuration Procedures" on page 4-12 for the steps for connecting via Ethernet or RS-232.
2. Click the Laser Control tab.
3. Toggle the **Waveform** button to **Enabled**.
4. Toggle the **Waveform mode** to **Single Pulse**.
5. Select a Waveform shape from the listbox.
6. Click **SET**.
7. Click **Emission** to confirm and start countdown.

   The selected pulse is emitted after the countdown.
8. Click **Emission** again to clear the status. This also stops a pulse sequence if it is set to infinite repeats.

Figure 4-26. Single Pulse Activation



Single Pulse Activation using the Touch-Display Screen

This section requires connection to the laser.

1. After storing a pulse to the laser, ensure the Emergency 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. You can access these modes from the Setup submenu in the Touch-Screen Display.

2. On the laser touch-screen, select **Setup->Pulse Setting-> Waveform Mode**.
3. Toggle **Waveform Pulse Mode** to Enabled.
4. Select **Single Pulse**.
5. 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!!" is displayed.

6. Pulse Information/Preview (optional) —To view 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 through all available pages.
7. Click anywhere in the text space to go to the Preview page. You can see the shape of the pulse.
8. Click **Return** twice to go back to the Waveform page.
9. Click **Configure & Return**.

   It is important to configure the laser with the selected pulse (once) before usage.
10. After the configuration is complete, click **Return** twice to go back to the main page.
11. Click **Emission** and then click **OK** to confirm and start countdown. The selected pulse is emitted after the countdown.
12. Click **Emission** again to clear the status.

Scaling Editor

The Scaling Editor lets you scale pulses within a sequence (ramp up and down).

If Analog Power Control is enabled, it allows on-the-fly scaling of the Pulse Sequence by varying analog input signal. You do not need to use Scaling Editor. See “Accessing the Web User Utility” on page A-5 to enable Analog Power Control.

Figure 4-27 shows the Scaling Editor tab.

Figure 4-27. Scaling Editor

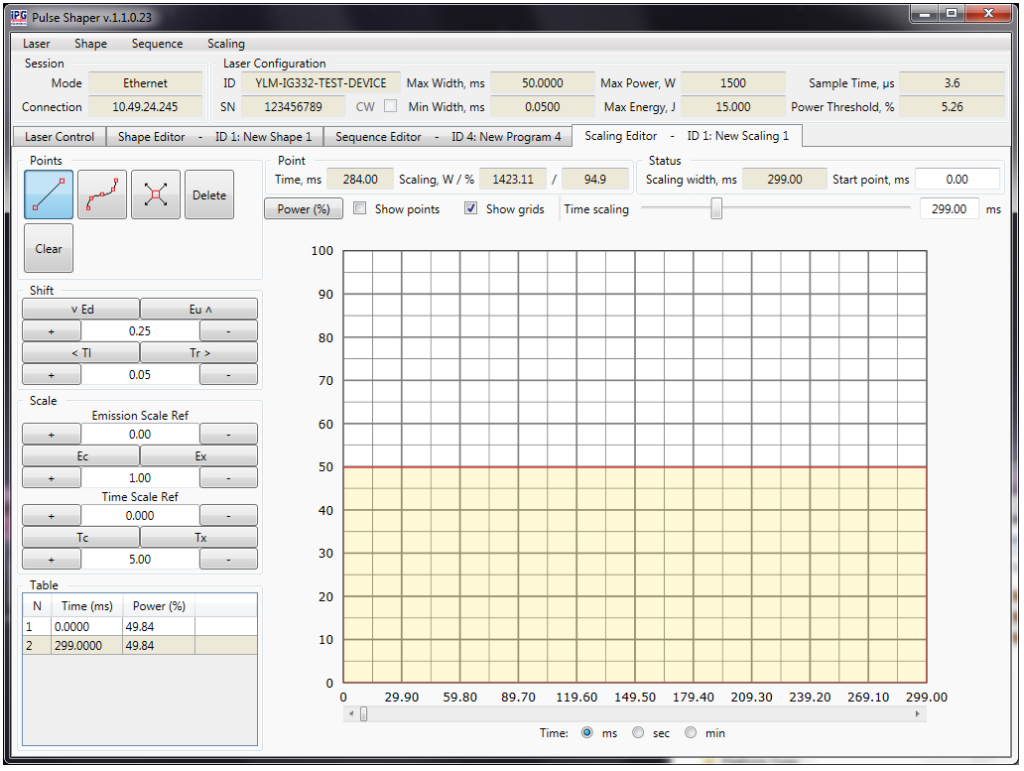


Table 4-5 provides descriptions for in Scaling Editor controls.

Table 4-7. Scale Editor Controls

	Name	Description
Point Panel		
1	Time, ms, sec, or min	Time scale unit in ms, sec, or min.
2	Scaling, W %	Enter a start point value for viewing the Pulse Scale in the chart.
3	Power (%)	Click the **Power** button to toggle between percentage and watts.
4	Show points	Click the **Show points** checkbox to display graphical points along the grid lines in the Scale chart. This option is disabled by default.
5	Show grid	Click **Show grids** to display a grid of horizontal and vertical lines for aligning pulse points in the Scale chart.This option is enabled by default.
6	Time scaling	Use the **Time scaling** slider to adjust the zoom in and out. Use the time shift controls and alignment cursors for more accurate editing. Use the Time and Emission indicators in the Status panel for guidance.
Status Panel		
3	Scaling width, ms, sec, or min	Total time between start and finish.
4	Start point, ms, sec, or min.	Start value from a certain point.

Creating a New Pulse Scale

.To create a Pulse Scale:

1. Select **Scale -> New**.
2. Select a scaling width.
3. Draw the scale by adding points.
   a. To save to the Pulse Sequence library, on the laser select **Scale -> Write to Laser**.
   b. To save to your computer, select **Scale -> Write to File.**

Sequence Editor

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.

The Pulse Shaping program checks each created sequence for average power and other laser limitation violation, and prompts you to make adjustments.

The Sequence Editor lets you create a sequence of pulses (pulse train) using Pulse Shapes from Pulse Sequence library.

Figure 4-28 shows the Sequence Editor tab.

Figure 4-28. Sequence Editor Tab

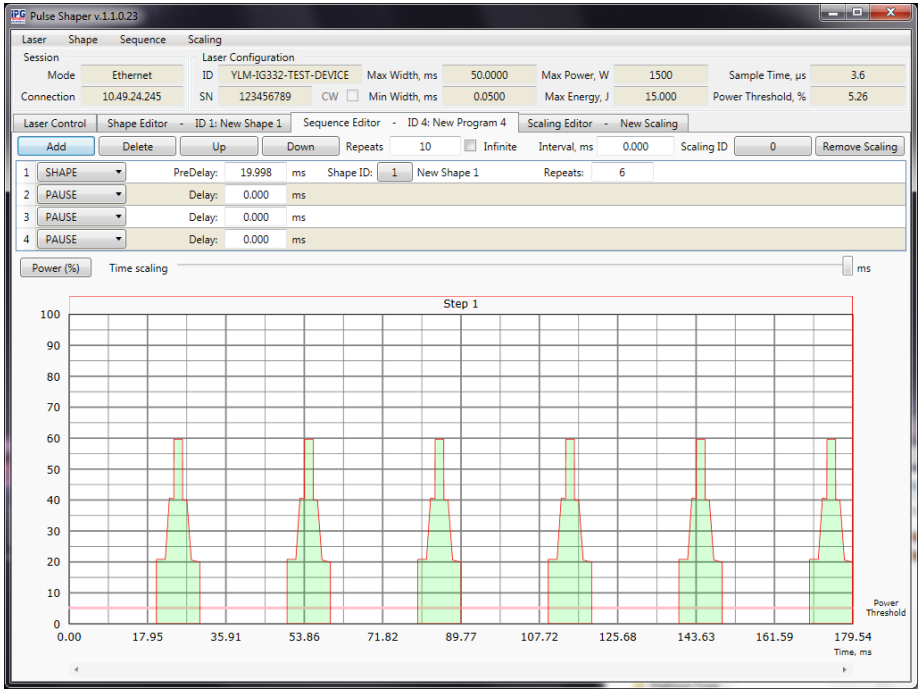


Table 4-8 provides descriptions for in Sequence Editor controls.

Table 4-8. Sequence Editor Controls

Name	Description
Add	Click **Add** to insert a sequence step prior to the one currently selected.
Delete	Click **Delete** to remove the selected sequence step.
Up	Click **Up** to move the selected sequence up in the order of sequence steps.
Down	Click **Down** to move the selected sequence step down in the order of sequence steps.
Repeats	The number of repeats for the current sequence.
Infinite	Check the **Infinite** checkbox for continuous repeats of the current sequence.
Interval. ms	Enter a interval value.
Scaling ID	Click to open the Pulse Scaling dialog box where you can select a scaling ID.
Remove Scaling	Click **Remove Scaling** to remove the select scaling ID from the **Scaling ID** box.
Name	Names of the current sequence.
Pre-Delay	A delay that precedes every repetition of the corresponding sequence step.
Repeats	The number of times to repeat the corresponding.

Creating a New Pulse Sequence

You can make a pulse train with variable Pulse Shapes and pulse repetition rates.

To create a Pulse Sequence:

1. Select **Laser -> Connect**. See "Pulse Shaper Configuration Procedures" on page 4-12 for the steps for connecting via Ethernet or RS-232.
2. Select **Sequence -> New**.
3. Select the required Pulse Shape from Pulse Shapes library.
4. Define the delays between pulses in the **Delay** box.
5. Enter the number of repeats in the **Repeats** box.
6. Select scaling of pulses (ramp up/ramp down) from the Pulse library and add them on top of the sequence.

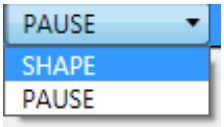
   If Analog Power Control is enabled, it allows on-the-fly scaling of the Pulse Sequence by varying analog input signal. You do not need to use Scaling Editor. See "Accessing the Web User Utility" on page A-5 to enable Analog Power Control.

   a. To save to the Pulse Sequence library, on the laser select **Sequence -> Write to Laser**.
   b. To save to your computer, select **Sequence -> Write to File**.

Building a Sequence

To build a sequence:

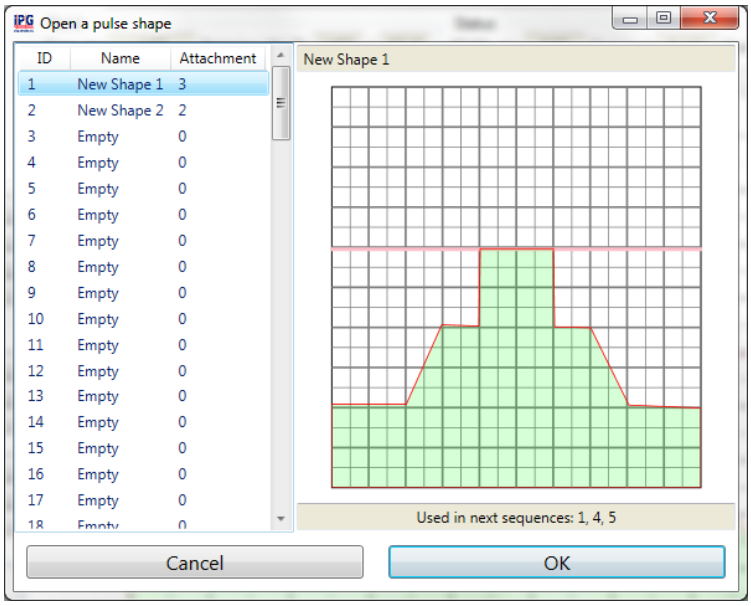
1. Select **New** from the **Sequence** menu. A new Pulse Sequence appears in the Sequence Editor tab.
2. Click **Add** to add a sequence step.
3. Enter a value (in ms) in the **Delay** box.
4. Select a Pulse Profile from the listbox.



5. Enter a number of repeats (number of times the selected Pulse Profile with delay must be repeated) in the **Repeats** box.
6. Click **Add** again to add more sequence steps.

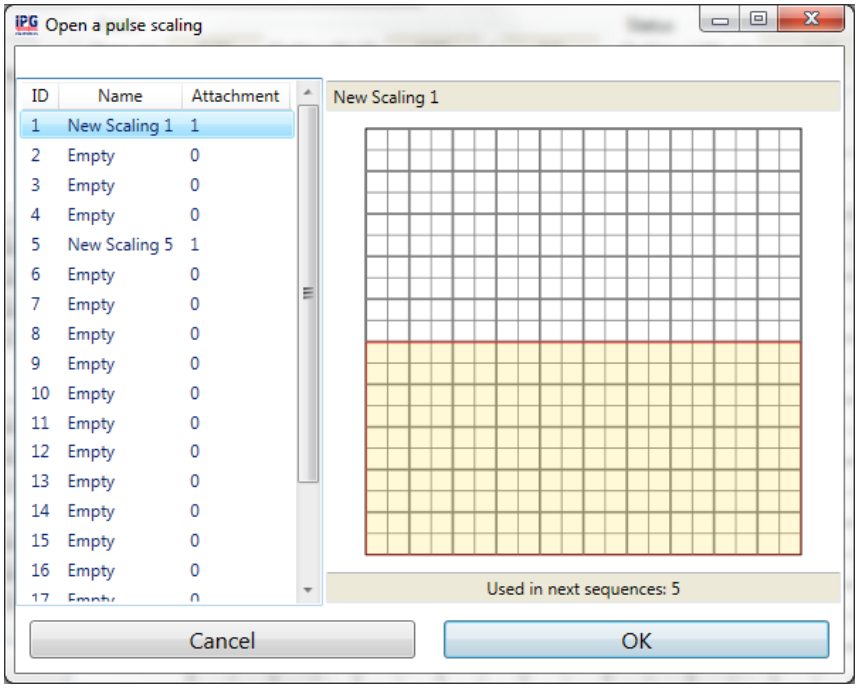
   You can set the number of sequence repeats by setting values in the **Repeats** box and **Interval, ms** box.
7. Click the Shape ID button to display a list of Pulse Shapes as shown in Figure 4-29.

Figure 4-29. Pulse Shapes Dialog Box



8. Select a shape ID for the sequence and click **OK**.
9. Click the Scaling ID button to display a list of Pulse Scaling IDs as shown in Figure 4-30.

Figure 4-30. Pulse Scaling Dialog Box



10. Select a scaling ID for the sequence and click **OK**.

    The preview of the sequence is refreshed when changes are made to the pulse. Additionally, laser limitation violations are re-checked.

Modifying a Pulse Sequence

To modify a sequence:

1. Highlight an existing step.
2. Click **Up** to shift up the selected sequence step in the sequence order.
3. Click **Down** to shift down the selected sequence step in the sequence order.
4. Click **Delete** to remove the selected sequence step.

Pulse Sequence Storage and Recall

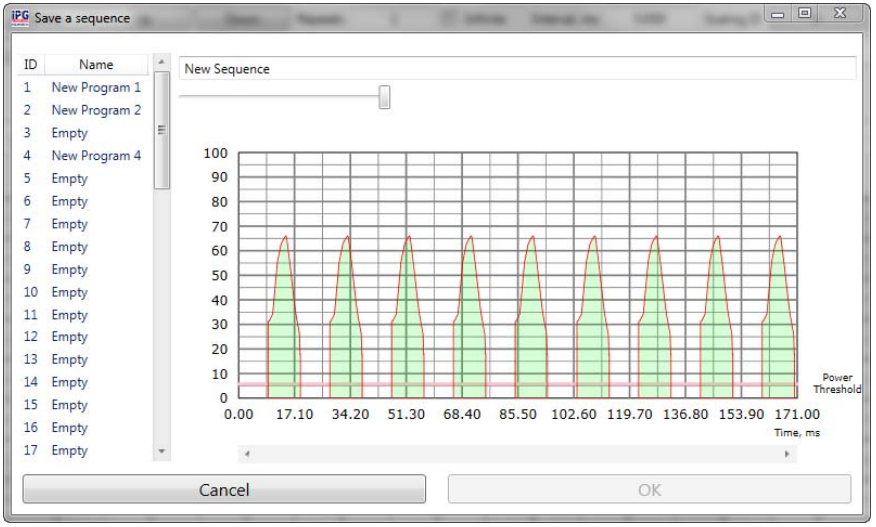
This section requires connection to the laser.

On a Laser

You can write Pulse Sequences to the laser to use and activate them in the Sequence Editor.

1. Select **Sequence->Write to Laser.** The Save Sequence dialog box appears.

Figure 4-31. Save Sequence



2. Select a sequence ID or enter a new name for the sequence and click **OK**.

   The message “Sequence was saved” appears.

To recall a Pulse Sequence:

3. Select **Sequence->Read from Laser**.
4. Select a sequence ID and click **OK**.

   The sequence is fetched and loaded into the chart.

On a Host PC

You can write Pulse Sequences to your computer to use and activate them in the Sequence Editor.

To save a Pulse Sequence your computer:

1. Select **Sequence -> Write to File**.
2. Enter a name for the file and click **Save**.

To recall a Pulse Sequence:

1. Select **Sequence->Read from File**.
2. Select a sequence ID and click **OK**.

   The sequence is fetched and loaded into the chart.

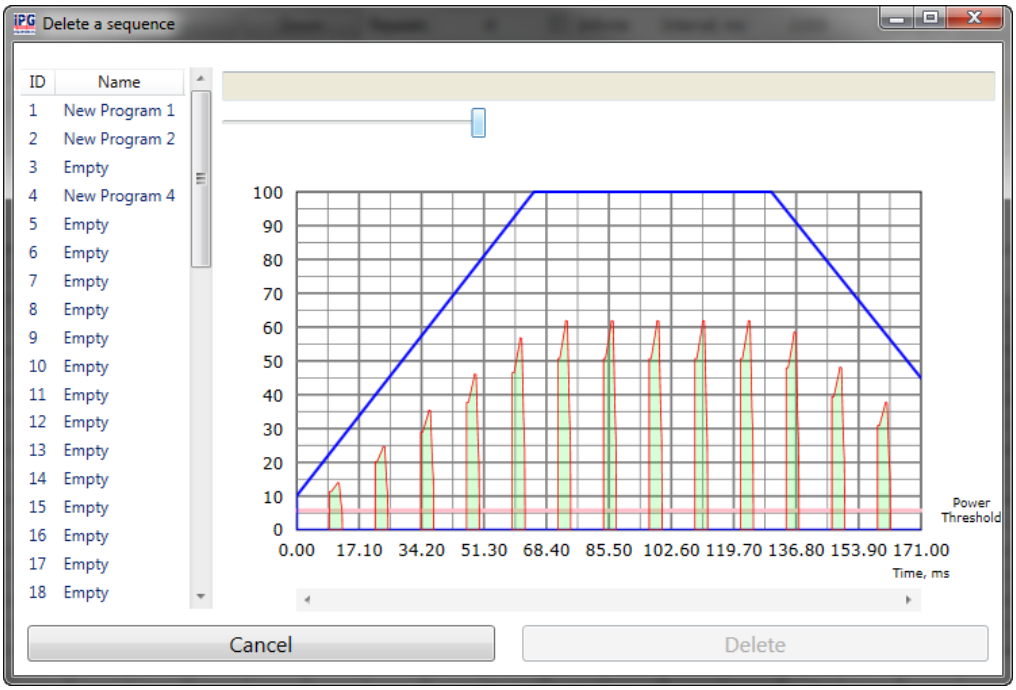
Deleting a Pulse Sequence

You cannot delete a Pulse Sequence if the status is not “Idle.” When the status is “In Use” it means that the laser is configured with that Pulse Sequence.

To delete a Pulse Sequence:

1. Select **Sequence->Delete in Laser**.

Figure 4-32. Delete a Sequence in the Laser



2. Select a sequence ID to delete.
3. Click **Delete**.
4. Click **Yes** in the confirmation box.

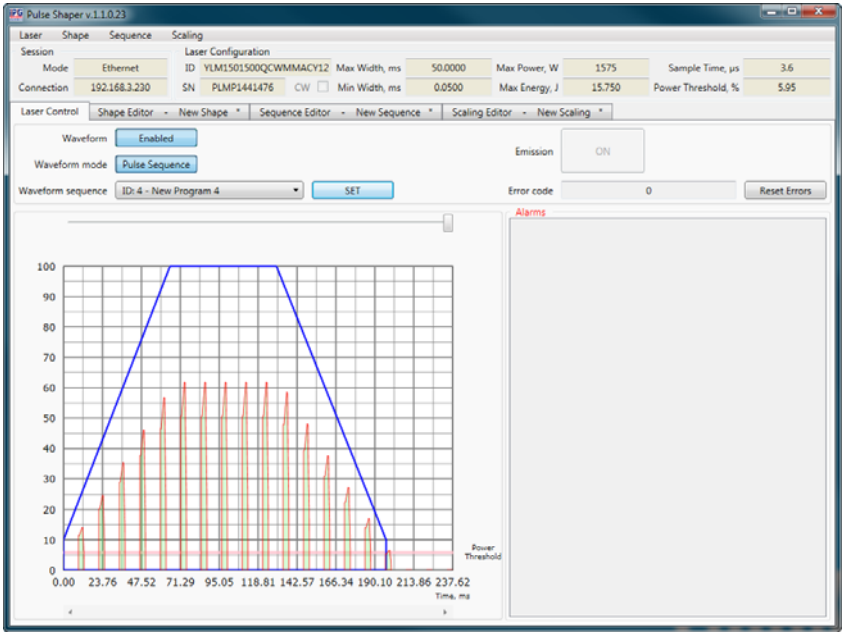
Pulse Sequence Activation

To activate a Pulse Sequence:

1. Click the Laser Control tab.
2. Toggle the **Waveform** button to **Enabled**.
3. Toggle the **Waveform mode** to **Pulse Sequence**.
4. Select a Waveform sequence from the listbox.
5. Click **SET**.
6. Click **Emission** to confirm and start countdown.

   The selected pulse is emitted after the countdown.
7. Click **Emission** again to clear the status. This also stops a pulse sequence if it is set to infinite repeats.

Figure 4-33. Pulse Sequence Activation



Pulse Sequence Activation using the Touch-Screen Display

You can use the Touch-Screen Display on the laser's front panel for manual control. You can view information about the laser's state and settings.

After storing a Pulse Sequence to the laser, ensure the E-stop button is released on the laser. 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, select **Pulse Menu->Pulse Setting**.

To activate a Pulse Sequence from the Touch-Screen Display on the laser:

1. Select **Pulse Menu->Pulse Setting->Waveform Mode.**
2. Toggle **Waveform Pulse Mode** to **Enabled**.
3. Select **Pulse Sequence**.
4. Use the Up and Down arrows to select a specific Pulse Sequence.
5. Pulse Sequence Information/Preview (Optional) - To view information about the Pulse Sequence, click on the Pulse Browser button. The information page appears. You can use the arrows to scroll through all available pages.
6. Click anywhere in the text space to go to the Preview page. You can see the shape of the pulses in the sequence. Use the arrows to see the entire page.
7. 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.
8. Click **Configure & Return**. After the configuration is complete, click Return twice to go back to the main page.
9. Click **Emission**, and then click **OK** to confirm and start countdown.

   The selected pulse is emitted after the countdown. Click **Emission** again to clear the status. This also stops a pulse sequence if it is set to infinite repeats.

Remote Control Interface

This interface is designed to provide remote control. It covers the pulse-shaping feature and it not meant to be a comprehensive control utility.

Note

This interface works simultaneously with the Touch-Screen display.

To start the interface:

1. Select **Remote Control** from the top menu.
2. Use the Setup panel to enable the Waveform (pulse) mode.
3. Select the pulse or sequence mode.
4. Select a pulse or sequence then configure the laser.

Troubleshooting

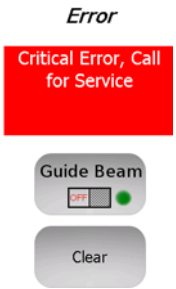
Error Messages on the Display and Status Bits

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

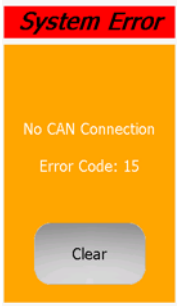
Table 5-1. Error Messages with Possible Solutions

Issue	Comments
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”). 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 is switched off. Cause: The case temperature of the laser is too low. 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.

Issue	Comments
Overheat (Bit 1)	
	Result: The power supply and laser emission is switched off. Cause: This means that case temperature of the laser is too high. Possible Solution: 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 is 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. If it appears again, contact IPG Photonics for assistance.
Power Supply Failure (Bit 19)	
	Result: The power supply and laser emission is 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, contact IPG Photonics for assistance.

Issue	Comments
Power Supply Failure 2 (Bit 25)	
	Result: The internal main power supply is 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 pre-installed maximal applicable level. Possible Solution: 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 is switched off. Cause: The system has detected an error that is considered critical. Possible Solution: Neither reset command (“RERR”) nor restart of the device clears 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.

Issue	Comments
Duty Cycle Too High	
	Result: The duty cycle is too high. Cause: The duty cycle is the percentage of how long the laser is in the “on” state in the given modulated period. Possible Solution: Check the modulation signal. Try to reset the error. If it appears again, contact IPG Photonics for assistance.
High Pulse Energy	
	Result: The pulse energy of the laser is too high. Cause: A pulsed laser periodically emits pulses of energy in an ultra-short time duration. Possible Solution: Check the modulation signal. Try to reset the error. If it appears again, contact IPG Photonics for assistance.

Issue	Comments
Average Power Too High	
	Result: The laser power is too high. Cause: The system has detected an error that is considered critical. Possible Solution: Check the modulation signal. Try to reset the error. If it appears again, contact IPG Photonics for assistance.
Pulse Too Long	
	Result: The laser pulse is too long. Cause: The system has detected an error that is considered critical. Possible Solution: Check the modulation signal. Try to reset the error. If it appears again, contact IPG Photonics for assistance.
Internal Communication Error	
	Result: There is no CAN connection. Cause: Occurs when there is no connection to the Controller Area Network (CAN). Possible Solution: Try to reset the error. If it appears again, contact IPG Photonics for assistance.

Issue	Comments
Pulse Too Short	
	Result: Pulse Too Short warning appears in touch-screen display. Cause: The system has detected an error that is considered critical. Possible Solution: Click Warning in the touch-screen display. The warning message appears. Try to reset the error. If it appears again, contact IPG Photonics for assistance.

Web User Utility

Overview

You can troubleshoot your laser using the IG337 Web User Utility, which provides status information and digital control functionality.

This appendix explains how to configure your computer's communication protocols to connect to the laser via a PC.

Configuration Procedures

You can connect to the Web User Utility from either an Ethernet or RS-232 connection.

Configuring an Ethernet Connection

The following procedure assumes you are familiar with operating the YLM-QCW laser. IPG recommends that you review all safety and operational procedures before proceeding.

1. Connect PC to the laser using a standard Ethernet cable.
2. Manually configure the Local Area Connection settings for Ethernet (see “Configuring a LAN Connection for Ethernet” on page A-2).
3. Open your web browser and enter the IP address of the Internet Protocol. If the connection is successful, the IG337 Web User Utility page appears (as shown in Figure A-6).

Configuring an RS-232 Serial Connection

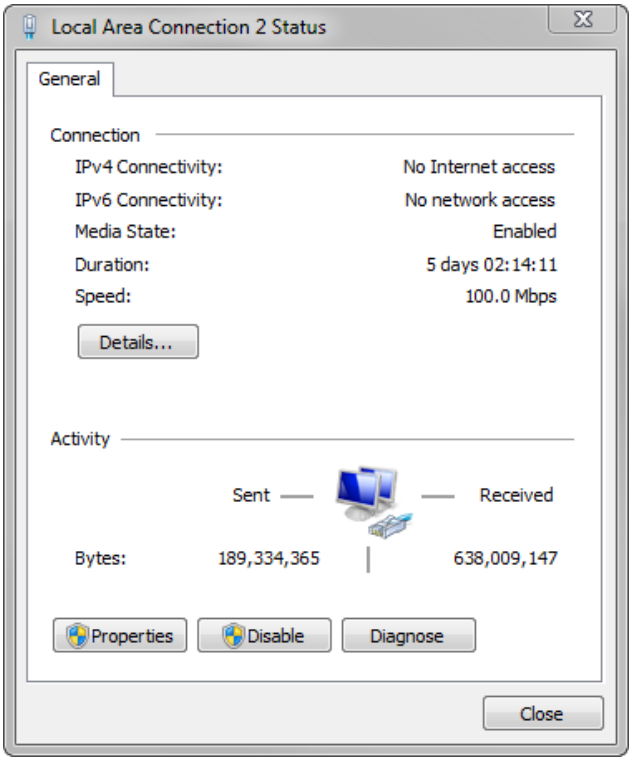
See “Connecting Using RS-232” on page 4-13 for step-by-step instructions.

Configuring a LAN Connection for Ethernet

To configure a LAN connection for Ethernet:

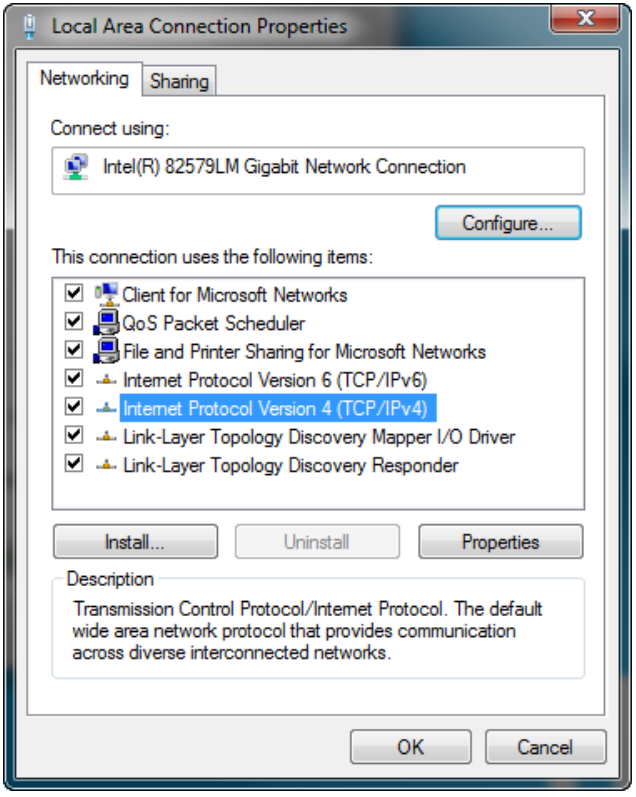
1. Go to **Control Panel -> Network and Internet -> Network and Sharing Center**.
2. Click **Change adapter settings**.
3. Select a Local Area Connection icon. The following window appears as shown in Figure A-1.

Figure A-1. Local Area Connection Status



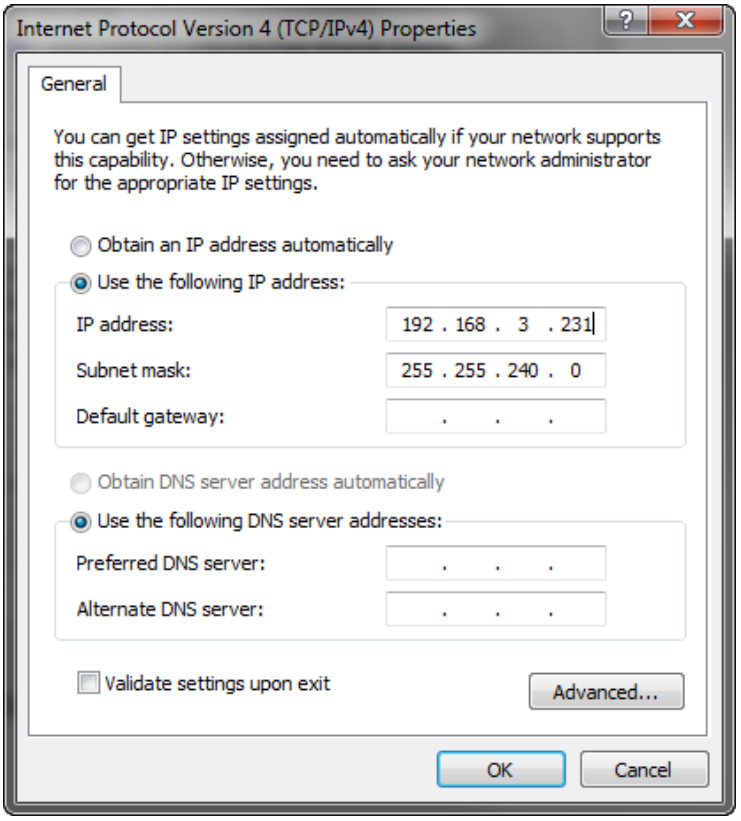
4. Click **Properties**. The following window appears as shown in Figure A-2.

Figure A-2. Local Area Connection Properties



5. Select **Internet Protocol Version 4 (TCP/IPv4).**
6. Click **Properties**. The following window appears as shown in Figure A-3.

Figure A-3. Internet Protocol Version 4 Properties



7. Click the **Use the following IP address** radio button to manually assign the IP address.
8. Assign the IP address to 192.168.3.23x (x cannot be 0 as it is the default IP address of the Laser).
9. Assign the Subnetmask to 255.255.240.0.
10. Click **OK** to accept your changes.

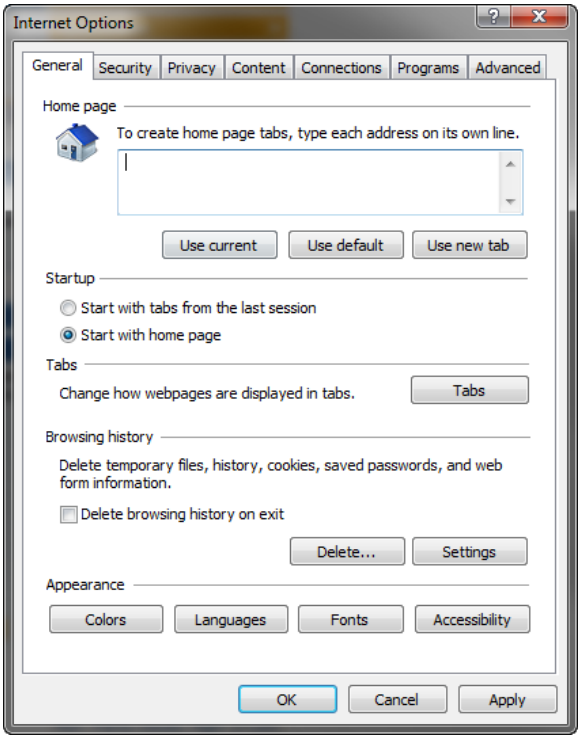
Website Data Settings

To ensure the most current Web User Utility interface is downloaded to your web browser, you need to modify the Website data settings in Internet Explorer.

To modify the Website data settings:

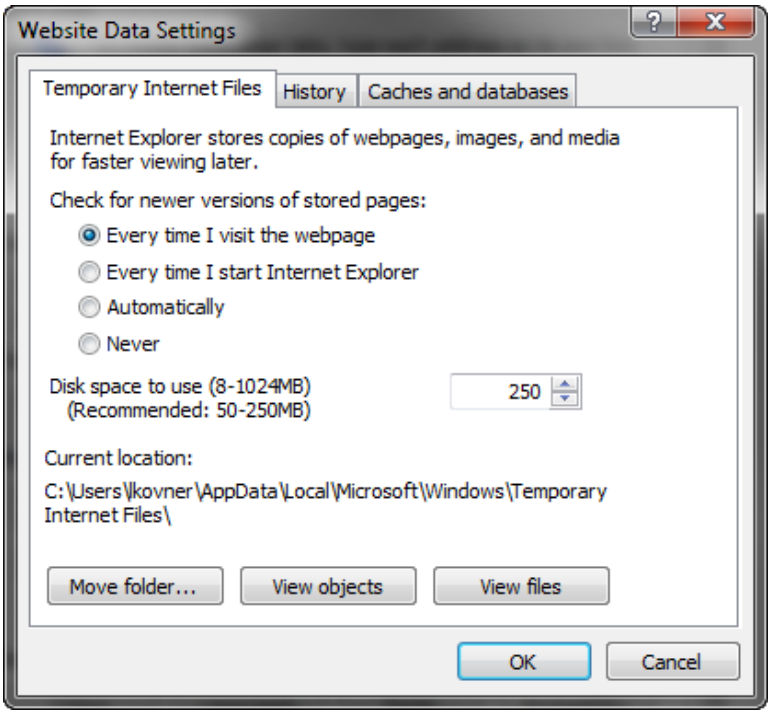
1. Open Internet Explorer.
2. Select **Tools -> Internet Options**.

Figure A-4. Internet Explorer Options



3. Click **Settings**.

Figure A-5. Website Data Settings



4. Click **Everytime I visit the webpage**.
5. Click **OK** to save this setting.

Accessing the Web User Utility

To access Web Utility:

1. Enter the IP address of the laser in a web browser. The Web User utility appears.

Figure A-6. IG337 Web User Utility

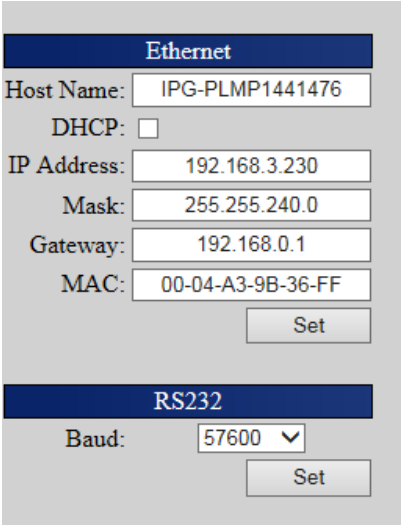


The items (0 to 31) in the Status group are listed in Table 3-5 on page 3-8 (Bit Meanings).

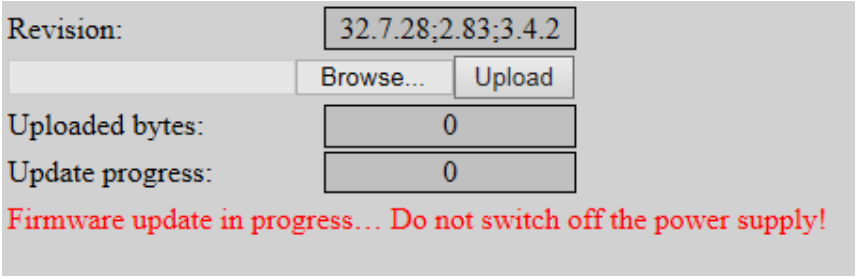
See Table 2-6 on page 2-19 for details on main control functions.

See Figure 2-13 on page 2-17 guidelines on setting the Pulse Generator.

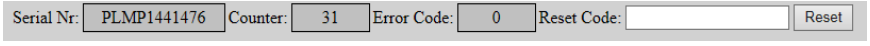
2. Click the **Communication Configuration** link at the top of the screen to change the IP address or baud rate. The following page appears.



3. Click the **Revision** link to upload the latest laser module software version. The following page appears:



4. Click the **Ellipsis** button (...) to reset critical errors. The following page appears:



5. Provide the Serial Number, Counter, and Error Code to receive a reset code from IPG Customer Service.
6. Turn on the Aiming Beam and verify that it is visible at the optical output.

Service

Service and Repairs

There are no operator serviceable parts inside. Only the fuses and filter media are replaceable. 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 guide carefully. However, if you have questions regarding the safety, set-up, operation or maintenance of your IPG product, call the Customer Service department.

If you cannot resolve the issues by using this guide or over the telephone with a technical support representative, you might need to return the product to IPG. See “Product Returns” on page E-1 for more details.

Serviceable Items



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 can 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.



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:

1. Disconnect the power source and remove the 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. Replace the fuse(s) and covers and tighten securely.

Replacing the Filter Media

Inspect the filter media weekly and clean or replace as needed. Only use IPG parts when replace filter media.

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). Upon removal, the filter element will be exposed.
3. Remove the used filter and clean or replace with a new filter (Refer to Table B-1).
4. Snap the cover back on and dispose of the dirty filter element.

Table B-1. Replacement Parts

Description	Laser Category[a]	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

a. Refer to Laser Model Designation Codes

Optical Fiber Connector Inspection and Cleaning

Overview

You should regularly check the fiber connector for dust, dirt, or damage before you connect to any external optic. The use of a dirty, or improperly cleaned, fiber connector can lead to serious damage to the laser (Figure C-6 on page C-7 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 voids 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

Figure C-1. Materials for Cleaning a Fiber Connector





Important

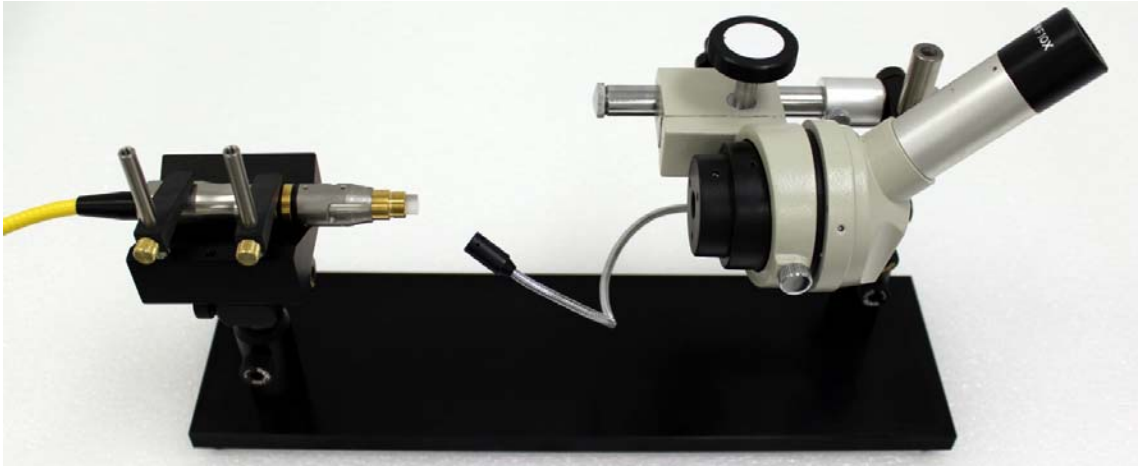
You need to wear powder free rubber gloves during this cleaning procedure. Damage to the fiber connector can occur due to mishandling. The use of incorrect cleaning procedures or chemicals for cleaning is not covered by the warranty.

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.

To clean the fiber connector:

1. Switch off the laser main power by pressing the Emergency Stop button 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.
4. Place pressure on the center of the securing arm before tightening the locking screw as shown in Figure C-2.

Figure C-2. Fiber Connector Mounted on IPG Microscope



5. Remove cap and sleeve from connector as shown in Figure C-3.

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 C-3. Fiber Cap and Sleeve Removed



6. Focus the microscope onto the connector surface.
7. 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 (see Figure C-6 on page C-7).

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

8. Inspect the surface carefully. Any contamination might lead to dark spots on the surface and eventual fiber failure (see Figure C-6 on page C-7 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.
9. 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.

10. While wearing powder free gloves, fold the lint free optical wipe into halves until it is roughly 1 X 1 ½" rectangle (see Figure C-4 on page C-5). 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.

11. Re-inspect the lens.
12. Repeat step 10 with Acetone if lens is still contaminated.
13. 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 10.



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

14. 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.

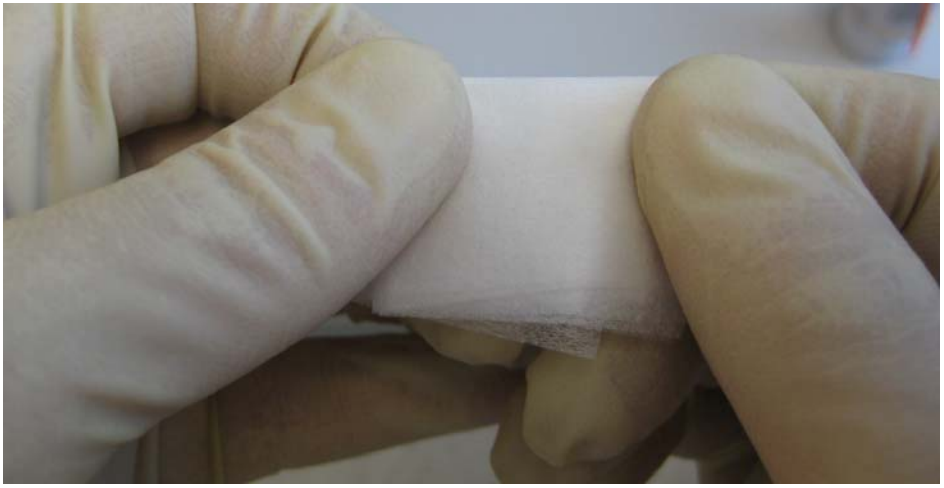


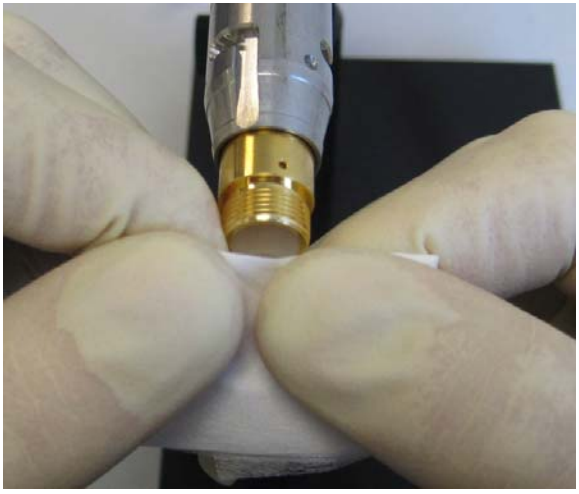
Damage to the fiber connector can occur due to mishandling, the use of incorrect cleaning procedures, or chemicals for cleaning. This is not covered by the warranty.

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 Make sure you clean the cap and sleeve before installing them back onto connector.

Figure C-4. Fiber End-Face Cleaning



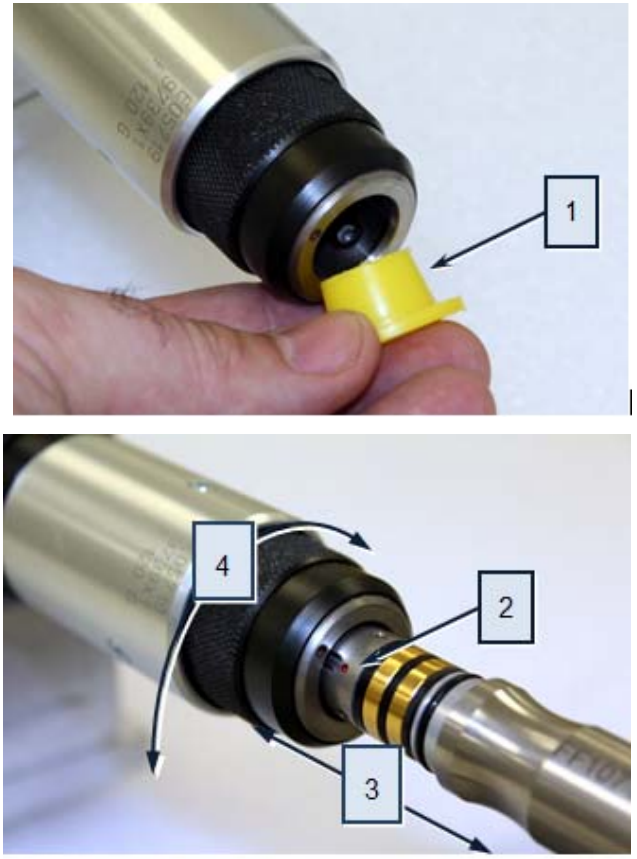


Start to clean with even pressure.



Drag in only one direction.

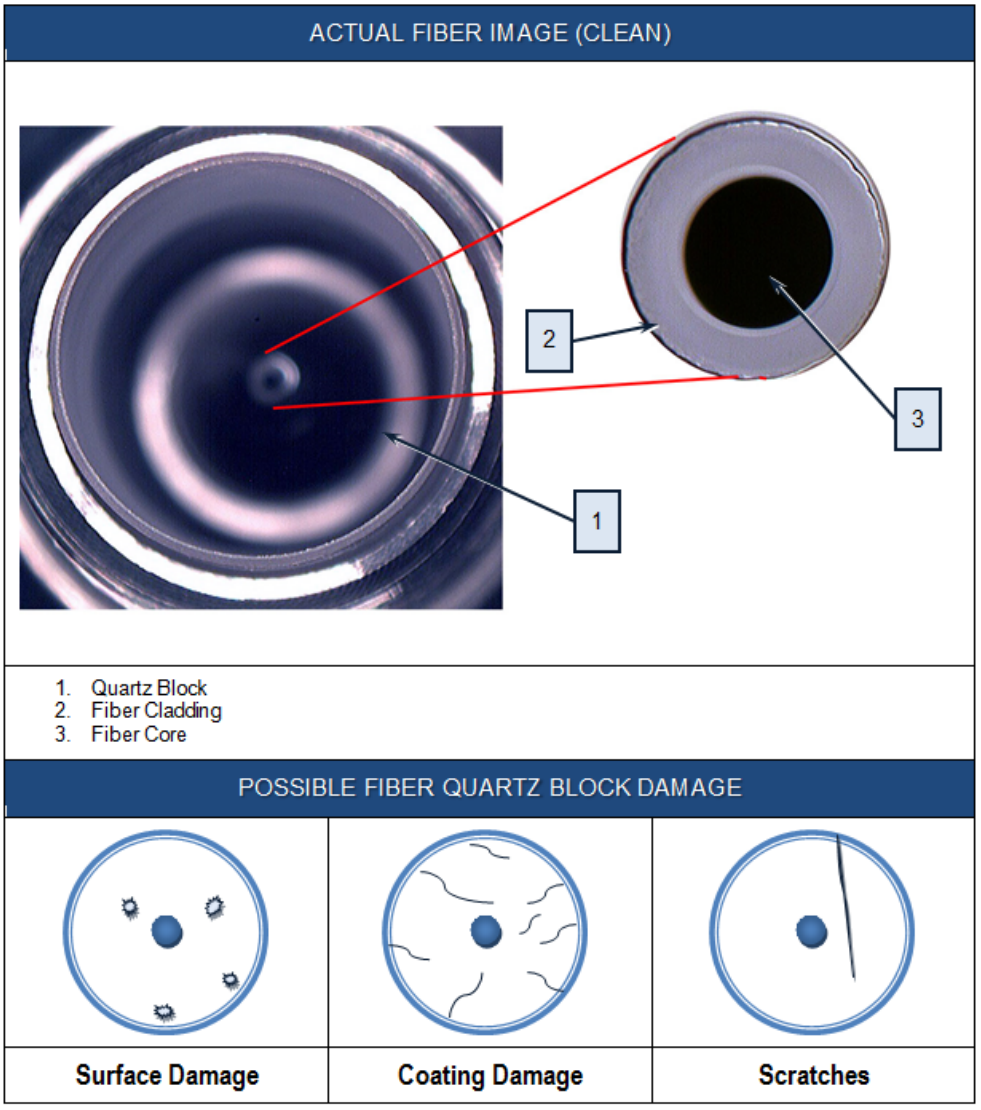
Figure C-5. Installing the Fiber



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.
4. Lock the fiber into place by rotating the bayonet knurled ring.

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

Figure C-6. Fiber Quartz Block Inspection



Warranty

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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

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Shipping address for returns to US:

IPG Photonics Corporation

50 Old Webster Road

Oxford, MA 01540

Attn: Product Returns

Tel: 508-373-1100

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

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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. 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
CAN	Controller Area Network
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 = 103 volts
kW	Kilowatts = 103 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 = 106 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
VDC	Volts Direct Current
W	Watts (power)

Index

Numerics

7-pin connector pinouts … 2-23

C

Certification … 2-3
cleaning procedures … C-1
Collimator … 2-10
Connecting Electrical Power … 2-16
Continuous (CW) Operation Mode … 2-31
Control Modes
    Local Mode … 2-29
    Remote Mode … 2-29

E

Emission On Indicator … 2-4
Emission-On Indicator … 1-13
E-Stop button … 2-4
Ethernet TCP/IP Interface … 3-1
External (Analog) Power Control … 2-32

F

filter media … B-2
front panel view … 2-3, 2-4
Functional Safety … 1-4
fuses … B-2

G

Gate Mode … 2-32

I

Initial Power-Up Sequence … 2-24
Interface Commands … 3-2
Interface Wire Specification … 2-17
Interlock Safety Circuit … 2-18

K

Key Control … 2-24
Keyswitch … 2-4

L

Laser Model Designation Codes … 2-1
Local Control Mode … 2-4, 2-29

M

Model Configurations … 2-1
model specifications … 2-10
Modulation Mode … 2-32

O

Operation Control Modes … 2-29
Operation Modes
    Continuous (CW) … 2-31
    Pulsed (QCW) … 2-31
Operation Sub-Modes … 2-32
Optical Fiber Connector Inspection and Cleaning … C-1
Optical Output Fiber Terminations … 2-9
    systems with a collimator … 2-10
    systems with a connector … 2-9

P

Product Returns … E-1
Pulse Shaper
    Ethernet connection … 4-12
    exporting … 4-15
    importing … 4-15
    installing … 4-4
    menus … 4-18
    Offline option … 4-14
    RS-232 connection … 4-13
Pulse Waveform … 2-33
Pulsed (QCW) Operation Mode … 2-31

R

rear panel view … 2-6, 2-7
Remote Control Mode … 2-4, 2-29
replacing filter media … B-2
replacing fuses … B-2
returns … E-1
RS-232 Configuration … 3-1

S

Sequence Editing … 4-39
Service and Repairs … B-1
Standalone Mode … 2-32
system timing … 2-25

T

Touch-Screen Display … 2-4, 2-33
Troubleshooting … 5-1

U

Unpacking Instructions … 2-11
    cardboard box … 2-11
    wood crate … 2-14

Y

YLR-Series System
    using … 2-16



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March 2015

Part Number
P21-010106

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