Model EQ-99
LDLS™
Laser-Driven Light Source

Operation and Maintenance Manual

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Part Number DOC-4957

ENERGETIQ

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Declaration of Conformity

We, the manufacturers

Energetiq Technology Inc.
7 Constitution Way
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hereby declare that the product family

LDLS™ Laser-Driven Light Source
Model EQ-99 High Brightness Broadband Light Source

is in conformity with the requirements of the following standards

EN61010-1 (2001)	Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use: Part 1 – General Requirements
CISPR 11:2003	Industrial, scientific and medical equipment - Radio-frequency disturbance characteristics - Limits and methods of measurement
IEC61000-4-2:2001	Electrostatic Discharge Immunity
IEC61000-4-3:2002	Radiated Electromagnetic Field Immunity
IEC61000-4-6:2003	Radio Frequency Common Mode Immunity
IEC61000-4-8:1994	Power Frequency Magnetic Field Immunity
EN61326-1:2006	Electrical equipment for measurement, control and laboratory use. EMC requirements. General requirements
EN60825-1 (2007)	Safety of laser products - Part 1: Equipment classification and requirements

in accordance with the provisions of

2006/95/EC	EU Low Voltage Directive
2004/108/EC	EU Electromagnetic Compatability Directive.

Signed,

Paul Blackborow, CEO

12/16/10
Date

at Woburn, Massachusetts USA

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Chapter 1

GENERAL INFORMATION

Safety

WARNING

This unit emits ultraviolet (UV) radiation that is harmful to humans. Avoid exposure to the direct or reflected output beam. Make certain that the appropriate output beam shields and optics are in place prior to energizing the unit. All interlocks must be satisfied prior to operation; failure to do so may lead to hazardous conditions.

CAUTION

The EQ-99 emits dangerous levels of UV radiation. Even short exposures to skin or eyes may cause burns. Ensure that only authorized personnel are in the vicinity of source during operation. Personnel in vicinity of operating source should wear protective eyewear, clothing, and gloves. Lighted UV warning lights and signs posted on doors to lab areas may help prevent accidental exposure.

WARNING

The EQ-99 controller utilizes an internal Class 4 IR laser capable of causing severe injury to eyes or skin. Do not open or attempt to service this unit. Contact Energetiq regarding any problems with the unit.

General Precautions

The output beam from the EQ-99 should be blocked when not in use with an electronic shutter or other appropriate beam blocking device. Due to the possibility of generating ozone when ambient oxygen is exposed to short wavelength light, the beam should always be enclosed in an appropriate beam pipe, tube, or enclosed space. We suggest purging any beam transport space with dry nitrogen gas.

The EQ-99 source must also be cabled correctly and connected to a socket with a protective earth ground prior to operation.

Refer to the Installation section of this manual (Chapter 3) for details of the facilities connections.

Other than a bulb replacement, there are no user-serviceable parts inside the EQ-99. For any problems encountered during operation, please contact Energetiq Technology for assistance. **If there is a component failure, do not attempt to open the Power Supply Controller or Lamp House enclosure of the EQ-99.**

The EQ-99 utilizes a quartz lamp containing a high-pressure gas fill. Explosion of the lamp and possible injury from flying fragments can occur if the lamp is mishandled.

Do not open the enclosure of either the Lamp House enclosure or the Power Supply Controller. Dangerous invisible infrared laser beams and hazardous voltages exist inside the units. Opening the chassis both voids the warranty and exposes the user to dangerous radiation and hazardous voltages.

CAUTION

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

Laser Information

The EQ-99 uses a patented (U.S. Patent #7,435,982, others pending) laser drive system to excite a plasma that radiates in the UV as well as the visible bands. A class 4 laser is located in the Power Supply Controller enclosure. Laser energy is delivered via an armored fiber to the Lamp House enclosure and connected with an SMA-type connector. Safety interlocks shut down the laser power if the SMA connector is removed from the Lamp House enclosure. The optical configuration of the Lamp House ensures that the direct laser beam can not exit the unit. The EQ-99 laser product is designated as Class 1 during all normal operation.

The parameters of the non-accessible internal laser are given below in Table 1.

Wavelength	974 nm
Emission Type	CW
Laser Power for classification	<8 mW via 7mm measurement aperture
Beam Diameter	~29 mm at aperture
Divergence	>100 mRad
Transverse Beam Mode	Diffuse

Table 1: Embedded Laser Parameters

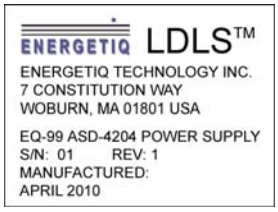
No regular service is required for the EQ-99. Any service to the system must be performed only by factory authorized and trained technicians. To avoid injury, under no circumstances should the user open or modify the Lamp House or Power Supply Controller enclosure.

The unit must not be operated if the covers are removed or it is defective in any way. Contact Energetiq if any problems with the equipment are suspected.

Labels and Safety Notification

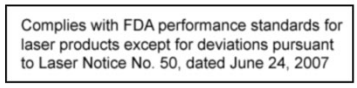
The following safety labels appear on the product. Figure 1 shows the location of each label on the EQ-99 system.

UV Hazard warning label – indicates hazardous levels of UV light are present.



Manufacturer's identification label – gives the manufacturer's name and address, and the model, serial number, and date of manufacture of the equipment.

Explanatory label – states the classification of the laser product. Class 1 is the lowest hazard level classification.



Certification label – states that the equipment has been tested and verified to meet the standards indicated.

Non-interlocked housing label – notifies of a potential hazard when covers are removed.

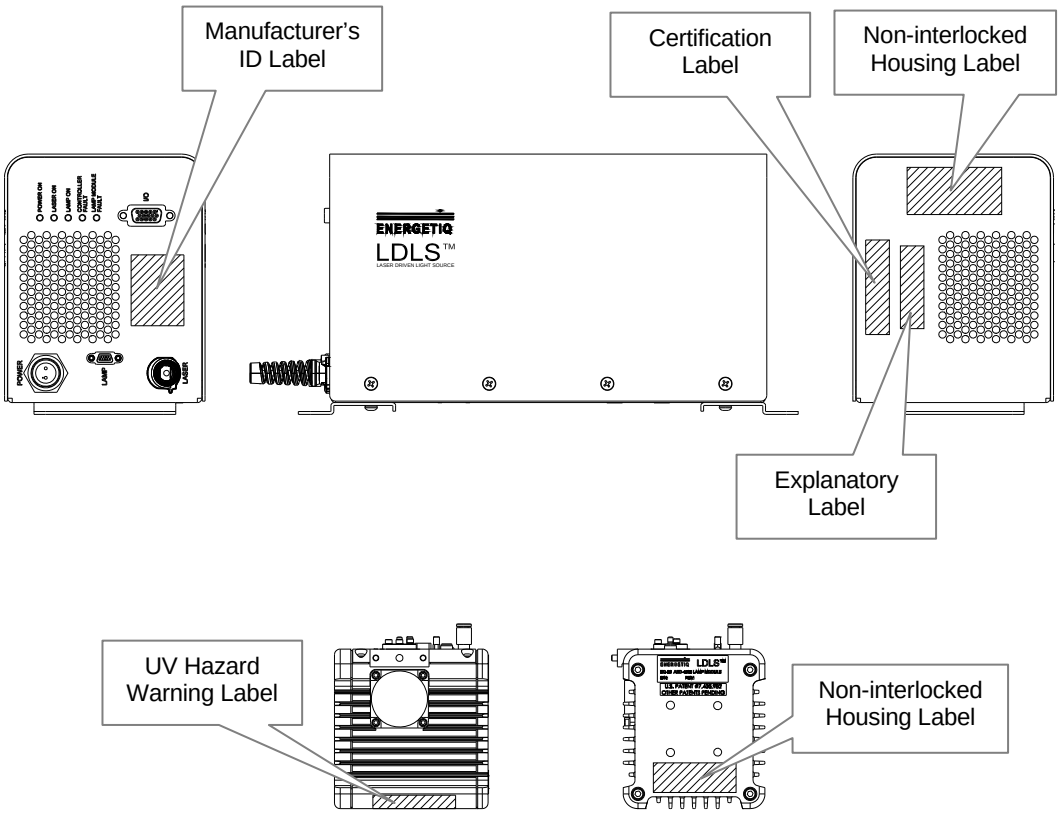


Figure 1: Safety Label Locations

Safety Interlocks

The EQ-99 is equipped with interlocks to prevent operation of the device when the following conditions are present

1. Bulb is not installed into the Lamp House enclosure
2. The laser fiber is not connected to the Lamp House enclosure
3. An external interlock is open

External Interlock

External interlock pins are provided for the customer's use (see Chapter 3 for connection details). Any suitable normally-open contact or solid-state switch can operate the interlock circuit.

The interlock circuit must be connected to enable the operation of the unit. Should the interlock connection open during operation or standby, the source is immediately disabled, and all light output from the aperture ceases.

Chapter 2

DESCRIPTION

General

The EQ-99 is a broad-band lamp system for use in a wide variety of applications. The lamp produces high brightness, broad-band light from DUV wavelengths through visible and beyond. The output is very stable, and has a long lifetime before any service is required. A simple control interface ensures ease of use.

Some of the advantages of the EQ-99 include:

- Very high brightness across complete spectrum
  - 170nm through visible and beyond
- Eliminates need for multiple lamps (replaces D2/Tungsten/Xenon Arc)
  - Simplified optical system
- Excellent spatial stability
  - Repeatable measurements
- Superior short and long term power stability
  - Repeatable measurements
- Electrodeless operation for long life
  - Reduced consumable costs
  - Minimal recalibration of instrument

The EQ-99 system consists of a Power Supply Controller unit, Lamp House unit, and interconnecting cables. Connection to DC power is required for operation. Connection to nitrogen purge gas is optional, but recommended for best performance. See Chapter 3 for connection details.

Specifications

Optical Performance

- Typical output spectrum: see Figure 2.

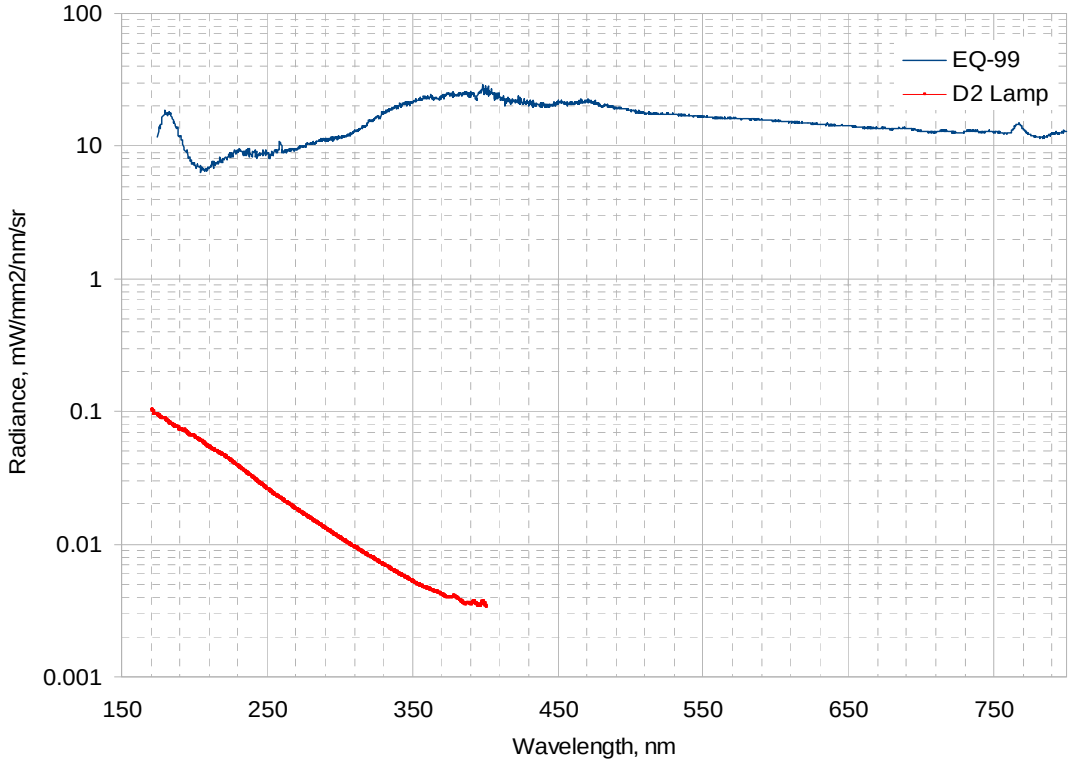


Figure 2: Typical Output Spectrum

Physical Specifications

Dimensions (H x W x D)

- Lamp House: 82 x 86 x 76 mm (3.2 x 3.4 x 3.0 in)
- Power Supply Controller: 140 x 108 x 254 mm (5.5 x 4.2 x 10.0 in)

Weight

- Lamp House: 0.7 kg (1.5 lbs)
- Power Supply Controller: 2.2 kg (5.0 lbs)

Utility Requirements

- Electrical: 24VDC, 125W
- Cooling: natural convection and internal fan, no auxiliary cooling necessary
- Purge gas (optional): clean dry nitrogen, 20 psig (0.14 MPa) supply pressure

Remote Interface

Digital Inputs

- Type: Optocoupler LED
- Logic: Active High
- Input voltage: 5VDC
- Input current: 8mA

Digital Outputs

- Type: Open collector to ground (digital common)
- Logic: Active Low
- Voltage: 30VDC max.
- Sink current: 30mA max.

User Power

- Voltage: 5VDC, referenced to digital common
- Current: 50mA maximum

Environmental Requirements

Operating

- Ambient temperature: 15–35°C
- Relative Humidity: non-condensing, 80% max. for temperatures up to 31°C, decreasing linearly to 50% max. at 40°C.
- Pollution Degree 2 (normally only non-conductive pollution; occasional, temporary condensation possible)
- Installation Category II
- Indoor use only

Transport

- Temperature: -5–95°C
- Relative Humidity: non-condensing, 95% max.

System Description

As shown in Figure 3 the EQ-99 system consists of a Power Supply Controller unit, Lamp House, laser fiber optic cable, and Lamp House signal cable (not shown). Power and I/O interface connections (also not shown) are provided by the user.

The following sections provide descriptions of the system components and controls, and gives an overview of their functions. Refer to the "Installation" section of this manual (Chapter 3) for more detailed information.

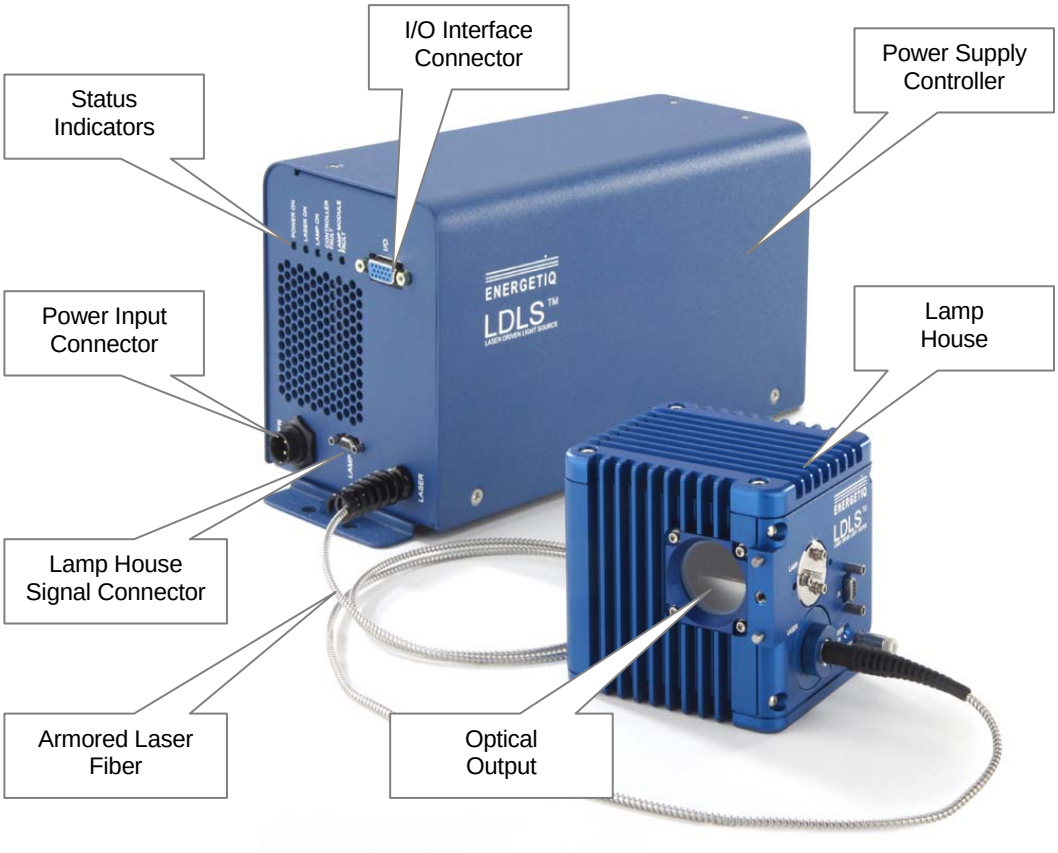


Figure 3: EQ-99 Lamp System

Power Supply Controller

The Power Supply Controller contains:

- IR Diode Laser
- Laser power supply
- Thermo-electric cooler for laser
- Permanently attached, armored laser fiber optic cable
- Control electronics
- Status indicator LEDs
- Interface connectors

Rear panel features (refer to Figure 3):

Status Indicator LEDs

These five LEDs indicate the system status. The function of these indicators is shown below in Table 2.

LED Label	**Meaning (when lit)**
POWER ON	DC power is connected to the EQ-99 Power Supply Controller
LAMP ON	UV Light is on
LASER ON	Laser power is ON and laser light is being delivered to the Lamp House
CONTROLLER FAULT	One of the following has occurred in the Power Supply Controller: 1. External interlock open 2. Controller internal temperature too high 3. Loose or missing cover 4. Laser power not reaching setpoint
LAMP MODULE FAULT	One of the following has occurred in the Lamp House module: 1. Lamphouse internal termperature too high 2. Laser fiber not correctly connected 3. Bulb not correctly installed

Table 2: Status Indicator LED Functions

Input/Output (I/O) Connector

Provides access to control and status signals. See Chapter 3 for pin assignments and functions.

This is the only operator interface to the EQ-99 – there are no local controls. Energetiq offers the EQ-99-RC Remote Control Module which connects to the Input/Output connector and provides a means of local control. Contact Energetiq for additional information.

Power Input Connector

This is the input connector for 24 VDC power. Power can be provided using the optional EQ-99-PS001 (US and Japan) or EQ-99-PS002 (Europe). Alternatively, the EQ-99 can be powered directly from a customer provided 24VDC power supply. See Chapter 3 for detailed information.

Lamp House Signal Connector (mini D sub – 9-pin)

Provides various power and control signals to/from the Lamp House module. No other connector or cable may be used with the EQ-99 other than the one supplied.

Armored Laser Fiber

The laser light is delivered from the Power Supply Controller to the Lamp House via a fiber optic cable with armored protection. It is critical that this armored fiber be treated with care and inspected for any abnormalities prior to operation. The fiber is permanently attached to the Power Supply Controller, and connected to the Lamp House by an SMA-type connector.

Lamp House

The Lamp House assembly contains:

- Lamp
- Igniter
- IR pumping optics
- Output window
- Laser ON indicator
- Interface connectors

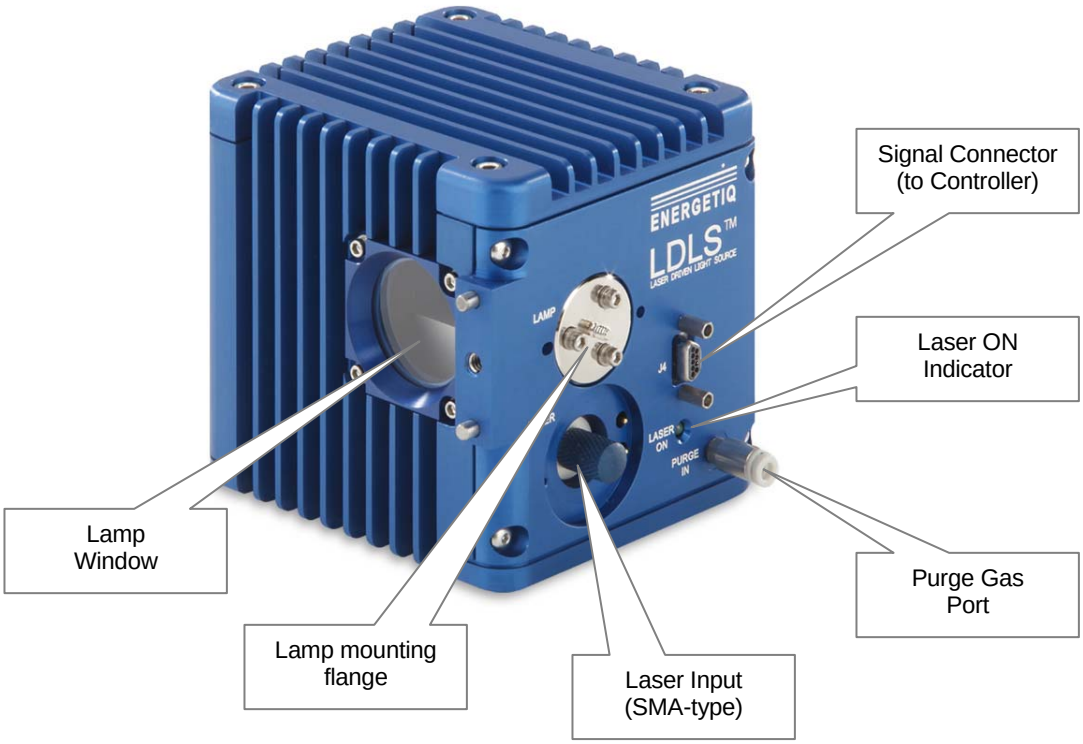


Figure 4: Lamp House Assembly

External features (refer to Figure 4):

Lamp Window

The lamp window at the optical output provides protection from the high pressure bulb inside the Lamp House. An internally-threaded SM1 adapter is provided for easy connection of optical hardware.

Nitrogen Purge Inlet

This is the inlet fitting for nitrogen purge gas. Purge gas is optional but is recommended for best performance. With no purge, ozone will form from atmospheric oxygen and attenuate the light output in the 220 – 280nm band. In addition, atmospheric oxygen and water vapor will attenuate the output below 200nm.

There is no return fitting for the purge nitrogen. The purge flow normally escapes within the Lamp House enclosure, and then to atmosphere.

Laser Input

This is the inlet connector for the armored fiber from the Power Supply Controller. It contains a set of interlock pins that disable the laser when the SMA connector is not properly in place.

Laser On Indicator

This LED is illuminated when the laser is ON.

J4 Signal Connector (mini D sub – 9-pin)

Provides various power and control signals to/from the Power Supply Controller. No other connector or cable may be used with the EQ-99 other than the one supplied.

Chapter 3

INSTALLATION

Unpacking

Upon arrival, start by inspecting all parts of the system for completeness and any damage incurred in shipping. The EQ-99 shipping box should contain:

1) EQ-99 Power Supply Controller unit
1) EQ-99 Lamp House unit
1) Black interconnecting cable from Lamp House to Power Supply Controller (9 pin mini D-sub).

OPTIONAL
1) EQ-99-RC Remote Control Module with interlock connector
1) I/O cable with 15 pin D- connector at each end
1) 24 VDC Power Supply (universal input voltage)

If any part is missing or appears damaged, contact Energetiq immediately. Do not attempt to substitute any parts. There are no user-serviceable parts inside the EQ-99 Lamp House or Power Supply Controller unit.

Connections

Installation of the EQ-99 consists of connecting electrical and gas supplies, and connecting the Lamp House module to the user's equipment.

Electrical Power

The EQ-99 requires 24VDC at 6.0A minimum (150W rating). Power consumption is approximately 100W during normal operation.

Power can be provided using the optional EQ-99-PS001 (US and Japan) or EQ-99-PS002 (Europe). Alternatively, power can be provided directly via a customer provided 24VDC power supply. Connect to a 24VDC source as follows:

Connector:	Kycon KPPX-4P
Pins 3 & 4	+24VDC
Pins 1 & 2	24VDC return

Purge Gas

Purge gas is optional but is recommended for best performance. With no purge, ozone will form from atmospheric oxygen and attenuate the light output in the 220 – 280nm band. In addition, atmospheric oxygen and water vapor will attenuate the output below 200nm.

If required, connect a source of nitrogen purge gas to the port on the Lamp House. The fitting is a push-to-connect type, sized for 4 mm tubing.

Clean and dry nitrogen from either a dewar or research-grade N_2 bottle is recommended. Do not use any other purge gas. Grade 6 or better gas purity is recommended to maintain cleanliness of the optics. Supply pressure should be 20 psig (0.14 MPa). With a 20 psig inlet pressure, the EQ-99 will consume approximately 1 slm of flow.

There is no return fitting for the purge nitrogen. The purge flow normally escapes within the Lamp House enclosure, and then to atmosphere.

Optical Interface

The lamp window accommodates a light output of 0.47 NA. A pair of pins and a 6-32 threaded hole are available for mounting. An internally-threaded SM1 adapter is provided for connection of optical hardware. See Figure 5 below for mechanical layout of the Lamp House.

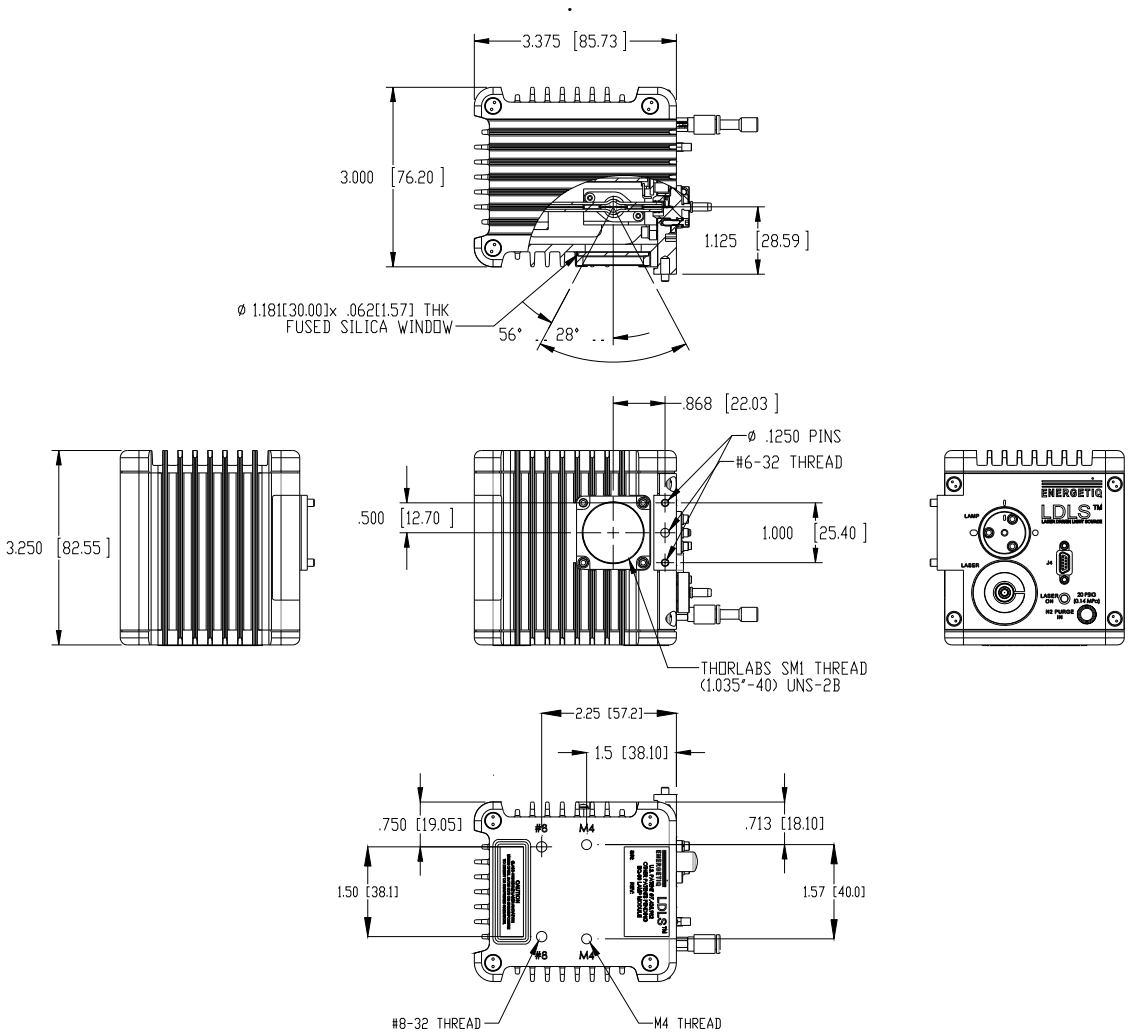


Figure 5: Lamp House mechanical layout

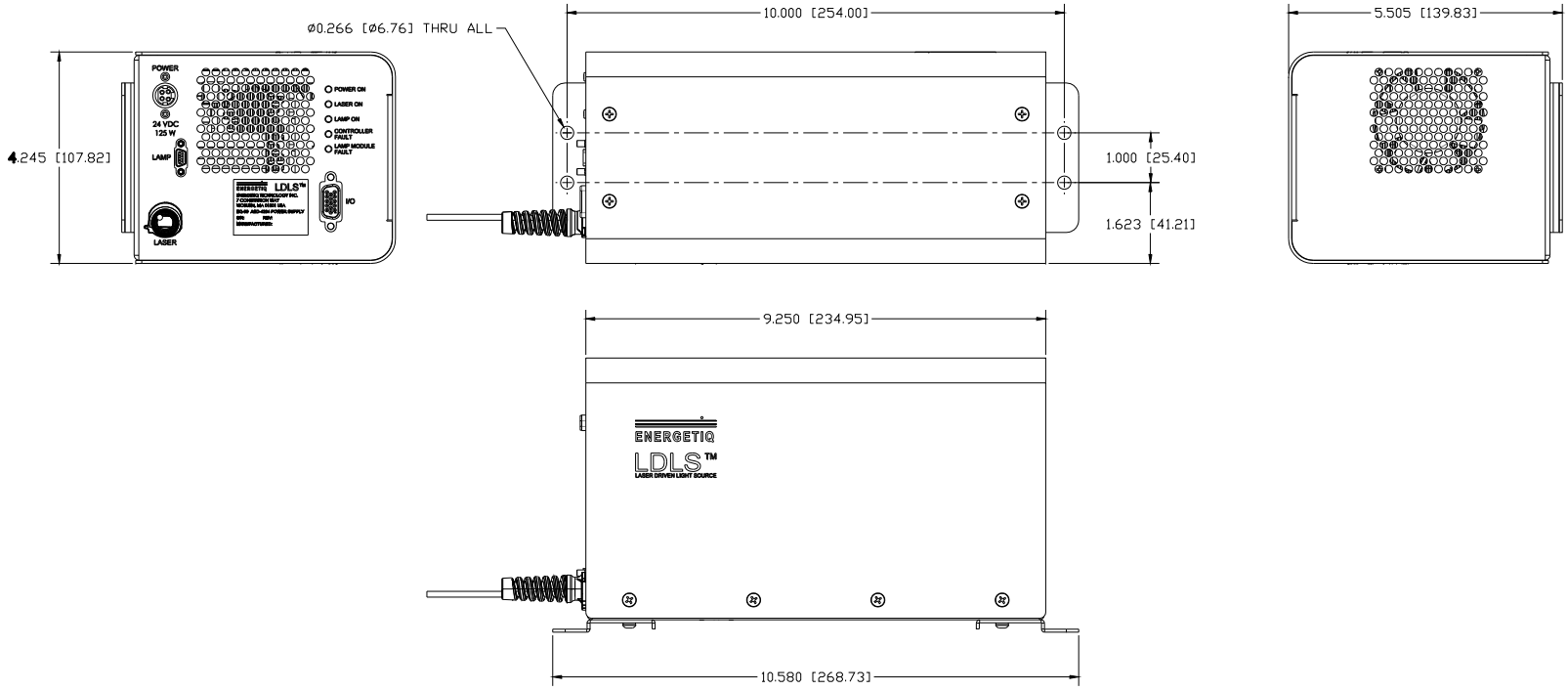


Figure 6: Power Supply Controller mechanical layout

Signal Connections

The EQ-99 is controlled through the remote I/O connector.

Table 3 gives the pin assignments and functions for this interface. Connect to the user's control system using a suitable cable. Mating connector is a standard high-density 15-pin d-sub male (for example, Amp part no. 748364-1 with contacts 1658670-2).

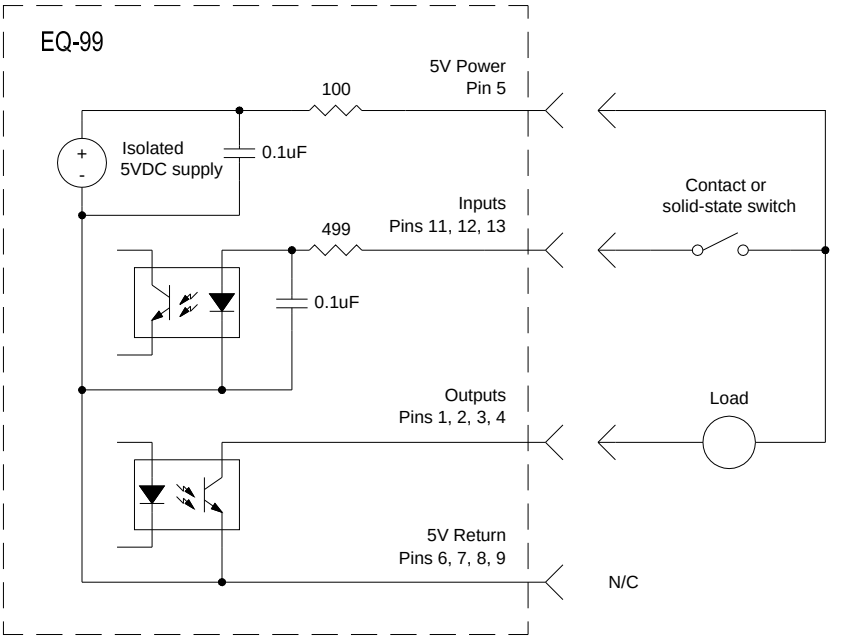
Optionally, connect a model EQ-99-RC remote control module to the I/O connector using the supplied cable

User I/O can be powered either by the EQ-99 internal isolated power supply, or an external supply.

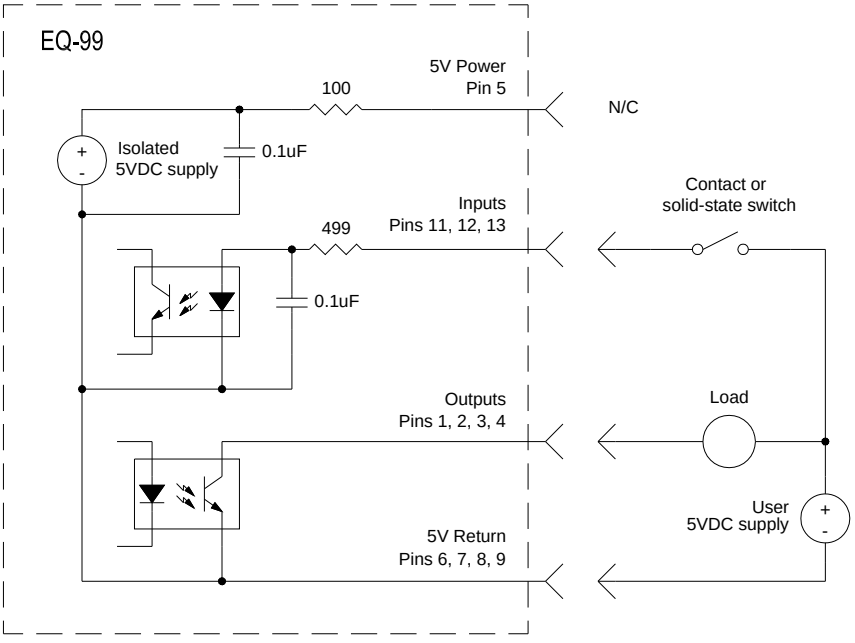
Figure 7 shows connection schematics for both configurations.

Description	Pin #	Details
Commands (Inputs)		
LAMP ENABLE	11	LAMP ENABLE REQUEST, apply +5V (referenced to digital common) to enable lamp ignition
LAMP OPERATE	12	OPERATE REQUEST, apply +5V (referenced to digital common) to initiate ignition (must be after Lamp Enable Request)
EXTERNAL INTERLOCK	13	EXTERNAL INTERLOCK, apply +5V (referenced to digital common) to close interlock and allow operation
Status Indicators (Outputs)		
LAMP ON	1	Pulled to digital common when ON
LASER ON	2	Pulled to digital common when ON
LAMP MODULE FAULT	3	Pulled to digital common when OK, float on FAULT
CONTROLLER FAULT	4	Pulled to digital common when OK, float on FAULT
ISOLATED +5V SUPPLY	5	250mW capable, thru 100 ohms, referenced to digital common
DIGITAL COMMON	6,7,8,9	Galvanically isolated from system
RESERVED	10	Do not connect
RESERVED	14,15	Do not connect

Table 3: I/O Connector Pin Assignments



USING EQ-99 POWER SUPPLY



USING EXTERNAL POWER SUPPLY

Figure 7: Remote Interface Schematic

Installation Procedure

1. Mount the Power Supply Controller unit rigidly to either an optical breadboard plate or another suitable mounting structure using the supplied tabs on the bottom of the chassis. The holes are sized to accept standard ¼-20 optical bench hardware, and spaced to be compatible with a standard 1" grid mounting hole pattern. See Figure 6 for dimensional and mounting details.
2. Connect the Lamp House unit output to the user equipment. The beam should always be either directly coupled to a fiber optic cable, or enclosed in an appropriate beam pipe, tube, or enclosed space and purged with nitrogen. Operating the source without any output target or beam transport is not recommended, and may lead to unsafe operating conditions. Consult Energetiq for applications information and suggested configurations.

   The Lamp House should be mounted in the orientation shown in Figure 5, with the output window on the side and the flat surface of the housing on the bottom. The lamp has been factory aligned in this position. Mounting the lamp in a different orientation will cause the plasma position inside the bulb to shift slightly. If using an optical fiber for the light output, this will result in slight misalignment and a resulting drop in output power.
3. Setup the Lamp House unit with appropriate ultraviolet safety measures and laser light safety measures in place. It is recommended that any enclosure or aperture-blocking hardware utilize switches wired to the EQ-99 external interlock circuit.
4. Place the Power Supply Controller close to the Lamp House unit. Do not block the air vent of the Power Supply Controller.
5. Connect the black 9 pin mini D-sub interconnect cable from the Power Supply Controller (labeled TO LAMP) to the Lamp House (labeled J4).
6. The EQ-99 is delivered with the armored laser fiber connected to the lamp house. This is done to minimize the possibility of debris or particles contaminating the end of the laser fiber. Energetiq strongly recommends leaving the laser fiber connected, unless it is necessary to disconnect it for installation or routing of the laser fiber. If the laser fiber must be disconnected, apply SMA caps immediately to both ends, and follow directions on inspection and cleaning of the laser fiber described in Chapter 5.
7. If necessary, connect the SMA connector to the Lamp House laser input and tighten..
8. If required, connect nitrogen purge gas to the Lamp House. Refer to "Facilities Requirements" above.
9. Connect user's control system to the I/O interface connector per
10. Alternately, if using the EQ-99-RC Remote Control Module, place it on a clean rigid surface. Install the supplied 15-pin cable from the Power Supply Controller to the EQ-99-RC.
11. Connect 24VDC input power source to the Power Supply Controller.

The system is now ready to operate.

Chapter 4

OPERATION

Starting

Once the lamp is set up properly, verify that all personnel that will be in contact with the lamp system are aware of the potential hazards involved. It is the responsibility of the user to verify that the lamp is being used safely.

This example assumes the use of the EQ-99-RC Remote Control Module to provide local control. If using a custom control system, substitute the appropriate digital input and output lines from Table 3 for the switches and LEDs described below.

1. With the EQ-99-RC Remote Control Module connected properly, review the status LEDs on the Power Supply Controller. The POWER ON LED should be lit, and neither the CONTROLLER FAULT nor LAMP MODULE FAULT LEDs should be lit.

2. Turn on the ENABLE switch (place switch in up position) and wait 2 seconds.

3. Turn on the OPERATE Switch (place switch in UP position).

4. Within several seconds the LASER ON LED will light. Laser light is now present in the Lamp House.

5. In approximately 20-90 seconds the igniter will be turned on automatically and the plasma will ignite. The LAMP ON LED will be lit. The duration of the warm up time (20-90 seconds) will depend on the temperature and previous operating condition of the EQ-99. The EQ99 will automatically detect when the unit has reached the optimum conditions for ignition.

If the LAMP ON LED is not lit within 90 seconds maximum after step 4, the lamp failed to ignite (this is very unusual). However, if this occurs, turn both the ENABLE and OPERATE switches to the OFF position (down) and begin at Step 1 again.

Stopping

To turn the LAMP off, simply turn the OPERATE Switch to the OFF position. When finished using the lamp, turn the ENABLE switch to the OFF position and remove the 24VDC supply voltage.

To minimize wear on the ignition components, it is best to avoid frequently starting and stopping the lamp. It is recommended to run the lamp continuously if long off-periods are not required.

Chapter 5

MAINTENANCE

Fiber Cleaning Process

Fiber Cleaning Basics:

- The LDLS laser fiber connector is carefully inspected and is clean prior to shipment. Energetiq strongly recommends leaving the laser fiber connected, unless necessary for installation or routing of the laser fiber.
- Leave Laser Fiber SMA connected whenever possible.
- If the SMA fiber must be disconnected, always use a cap on both ends.
- Store caps open side down when possible.
- Blow out caps with CDA (Clean Dry Air) prior to use.
- Never leave the fiber disconnected without a cap.
- Follow the fiber inspection and cleaning process (Figure 8) before making a laser fiber SMA connection.
- Operating the LDLS with a contaminated fiber introduces the risk of decreased performance or damage to the unit.

Fiber Inspection and Cleaning Process

CAUTION

Disconnect power from the EQ-99 Power Supply Controller unit before performing fiber inspection.

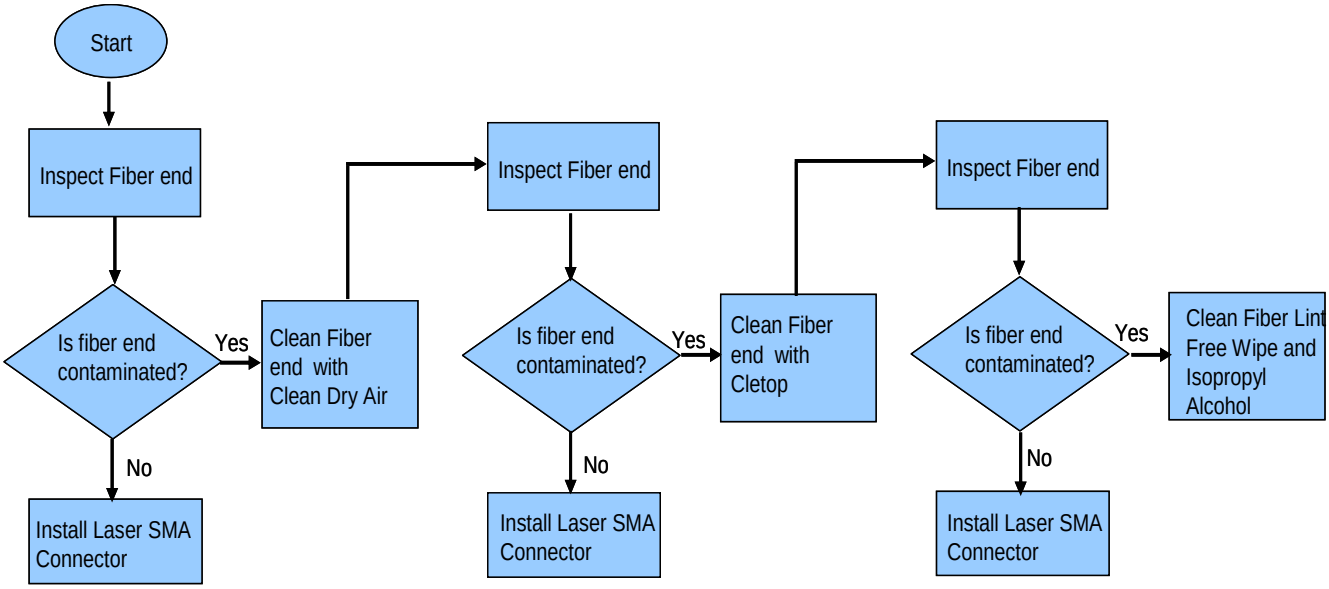


Figure 8: Fiber Cleaning Process Flowchart

Fiber Inspection Tools

Figure 9: Thorlabs FS-200 Handheld Fiber Inspection Scope

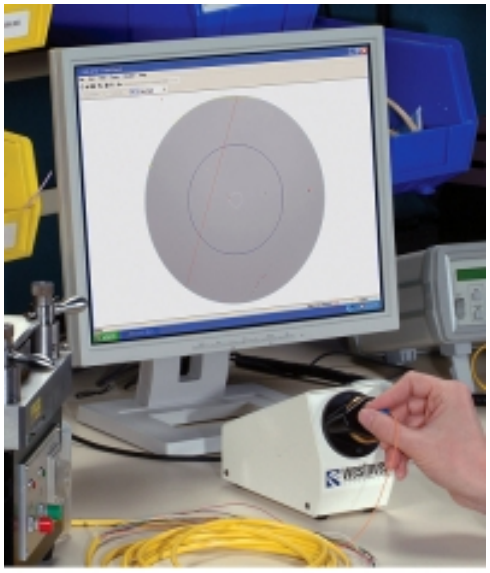


Figure 10: Westover FVD-2400 Benchtop USB/PC Operated Fiber Viewer

Examples of Fiber Images

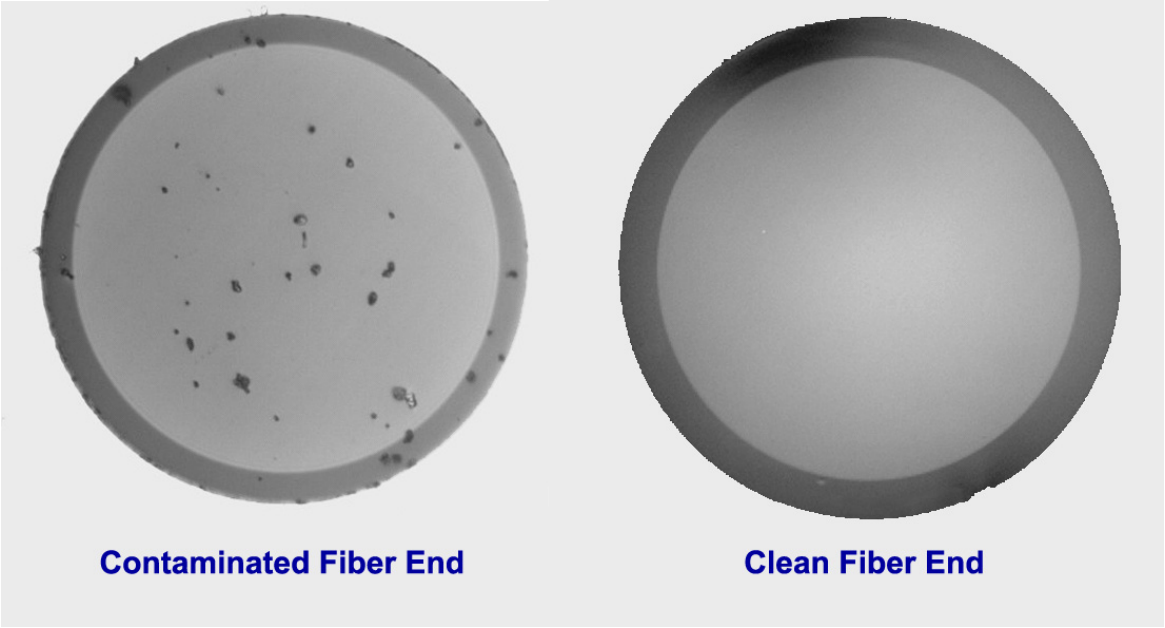


Figure 11: Fiber End Images

Fiber Cleaning Tools

1. Clean Dry Air
2. Dust Off (or similar clean, compressed air)
3. Cletop (www.cletop.com)

Cletop Type A SMA cleaner with Blue tape	14100500
Box of 6 Replacement Blue Tape Reels	14100700

4. Lint Free Wipe with Isopropyl Alcohol

Troubleshooting

See below if any problems are encountered in operating the EQ-99-FC.

Condition:

Controller Fault and/or Lamp House Fault LED(s) are ON.

Action:

- Always begin operation of the source by verifying the interlocks.
- Confirm that the external interlock contact is closed (or that the black jumper plug is fully inserted into the back of the EQ-99-RC Remote Control Box)
- Check that the bulb and laser fiber are properly connected at the Lamp House unit.
- To reset or clear Fault condition, turn both the "Enable" and "Operate" switches to the OFF position. Wait 1 second, then turn the "Enable" switch to the on position
- If all of the interlocks are OK and either the lamp or controller interlock faults will not clear, please contact the factory.

Condition:

Lamp fails to ignite after several tries.

Action:

Contact Energetiq.

Lamp Replacement

Contact Energetiq if a bad lamp is suspected.

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Model EQ-77
LDLS™
Laser-Driven Light Source

Operation Manual

Revision 3 April 2016

Part Number DOC-7070

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Declaration of Conformity

We, the manufacturers

Energetiq Technology Inc.
7 Constitution Way
Woburn, Massachusetts USA

hereby declare that the product family

LDLS™ Laser-Driven Light Source
Model EQ-77 High Brightness Broadband Light Source

is in conformity with the requirements of the following standards

EN61010-1 (2010)	Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use: Part 1 – General Requirements
CISPR 11:2009	Industrial, scientific and medical equipment - Radio-frequency disturbance characteristics - Limits and methods of measurement
EN61326-1:2013	Electrical equipment for measurement, control and laboratory use. EMC requirements. General requirements
EN61000-3-2:2014	Electromagnetic compatibility (EMC) - Part 3-2: Limits - Limits for harmonic current emissions (equipment input current less than or equal to 16 A per phase)
EN61000-3-3:2013	Electromagnetic compatibility (EMC) - Part 3-3: Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current less than or equal to 16 A per phase and not subject to conditional connection
EN60825-1 (2007)	Safety of laser products - Part 1: Equipment classification and requirements

in accordance with the provisions of

2006/95/EC	EU Low Voltage Directive
2 004/108/EC	EU Electromagnetic Compatibility Directive
2011/65/EU	EU RoHS2 Directive

Signed,

Paul Blackborow, CEO
at Woburn, Massachusetts USA

13 July 2015
Date

TABLE OF CONTENTS

Chapter 1

GENERAL INFORMATION

Safety

WARNING

This unit emits ultraviolet (UV) radiation that is harmful to humans. Avoid exposure to the direct or reflected output beam. Make certain that the appropriate output beam shields and optics are in place prior to energizing the unit. All interlocks must be satisfied prior to operation; failure to do so may lead to hazardous conditions.

CAUTION

The EQ-77 emits dangerous levels of UV radiation. Even short exposures to skin or eyes may cause burns. Ensure that only authorized personnel are in the vicinity of source during operation. Personnel in vicinity of operating source should wear protective eyewear, clothing, and gloves. Lighted UV warning lights and signs posted on doors to lab areas may help prevent accidental exposure.

WARNING

The EQ-77 utilizes an internal Class 4 IR laser capable of causing severe injury to eyes or skin. Do not open or attempt to service this unit. Contact Energetiq regarding any problems with the unit.

General Precautions

The output beam from the EQ-77 should be blocked when not in use with an electronic shutter or other appropriate beam blocking device. Due to the possibility of generating ozone with some models of EQ-77 when ambient oxygen is exposed to short wavelength light, the beam should always be enclosed in an appropriate beam pipe, tube, or enclosed space. We suggest purging any beam transport space with dry nitrogen gas.

The EQ-77 source must also be cabled correctly and connected to a power source with a protective earth ground prior to operation.

Refer to the Installation section of this manual in Chapter 3 for details of the facilities connections.

There are no user-serviceable parts inside the EQ-77. For any problems encountered during operation, please contact Energetiq Technology for assistance. **If there is a component failure, do not attempt to open the Power Supply Controller or Lamp House enclosure of the EQ-77.**

The EQ-77 utilizes a quartz lamp containing a high-pressure gas fill. Explosion of the lamp and possible injury from flying fragments can occur if the lamp is mishandled.

Do not open the enclosure of either the Lamp House or the Power Supply Controller. Dangerous invisible infrared laser beams and hazardous voltages exist inside the Lamp House. Opening the chassis both voids the warranty and exposes the user to dangerous radiation and hazardous voltages.

CAUTION

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

Laser Information

The EQ-77 uses a patented* laser drive system to excite a plasma that radiates in the UV as well as the visible bands. A class 4 laser is located in the Lamp House enclosure. The optical configuration of the Lamp House ensures that the direct laser beam cannot exit the unit. The EQ-77 laser product is designated as Class 1 during all normal operation.

The parameters of the non-accessible internal laser are given below in Table 1.

Wavelength	974 nm
Emission Type	CW
Laser Power for classification	<36 mW via 7mm measurement aperture
Beam Diameter	~25 mm at aperture
Divergence	>100 mRad
Transverse Beam Mode	Diffuse

Table 1: Embedded Laser Parameters

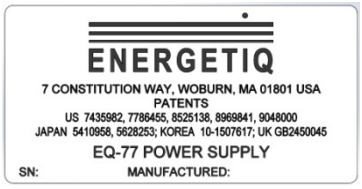
No regular maintenance is required for the EQ-77. Any service to the system must be performed only by factory authorized and trained technicians. To avoid injury, under no circumstances should the user open or modify the Lamp House or Power Supply Controller enclosure.

The unit must not be operated if the covers are removed or it is defective in any way. Contact Energetiq if any problems with the equipment are suspected.

* US 7435982, 7786455, 8525138, 8969841, 9048000, 9185786 ; Japan 5410958, 5628253; Korea 10-1507617; UK GB2450045

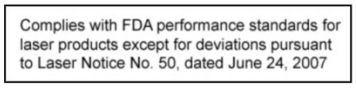
The following safety labels appear on the product. Figure 1 shows the location of each label on the EQ-77 system.

UV Hazard warning label – indicates hazardous levels of UV light are present.



Manufacturer's identification label – gives the manufacturer's name and address, and the model, serial number, and date of manufacture of the equipment.

Explanatory label – states the classification of the laser product. Class 1 is the lowest hazard level classification.



Certification label – states that the equipment has been tested and verified to meet the standards indicated.

Non-interlocked housing label – notifies of a potential hazard when covers are removed.

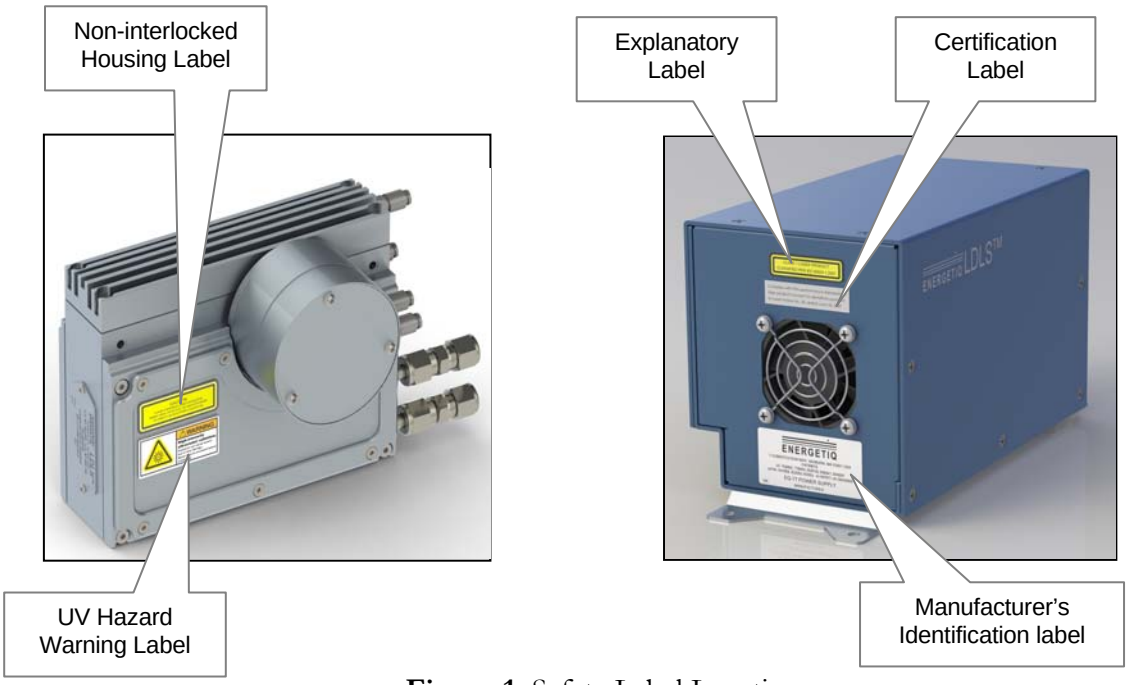


Figure 1: Safety Label Locations

Safety Interlocks

The EQ-77 is equipped with interlocks to prevent operation of the device when any of the following conditions are present:

1. An external interlock is open
2. No bulb is installed

External Interlock

External interlock pins are provided for the customer's use (see Chapter 3 for connection details). Any suitable normally-open contact or solid-state switch can operate the interlock circuit. The contact or switch should be rated for 80mA minimum at 5VDC.

The interlock circuit must be connected to enable the operation of the unit. Should the interlock connection open during operation or standby, the source is immediately disabled, and all light output from the aperture ceases.

Chapter 2

DESCRIPTION

General

The EQ-77 is a broad-band lamp system for use in a wide variety of applications. The lamp produces high brightness, broad-band light from DUV wavelengths through visible and beyond. The output is very stable, and has a long lifetime before any service is required. A simple control interface ensures ease of use.

Some of the advantages of the EQ-77 include:

- Very high brightness across complete spectrum
  - 190nm through visible and beyond
- Eliminates need for multiple lamps (replaces D2/Tungsten/Xenon Arc)
  - Simplified optical system
- Excellent spatial stability
  - Repeatable measurements
- Superior short and long term power stability
  - Repeatable measurements
- Electrodeless operation for long life
  - Reduced consumable costs
  - Minimal recalibration of instrument

The EQ-77 system consists of a Power Supply Controller unit, Lamp House unit, and interconnecting cable. Connection to AC power is required for operation. Connections to nitrogen purge gas and cooling water are required. See Chapter 3 for connection details.

Specifications

Optical Performance

- Typical output spectrum: see Figure 2.

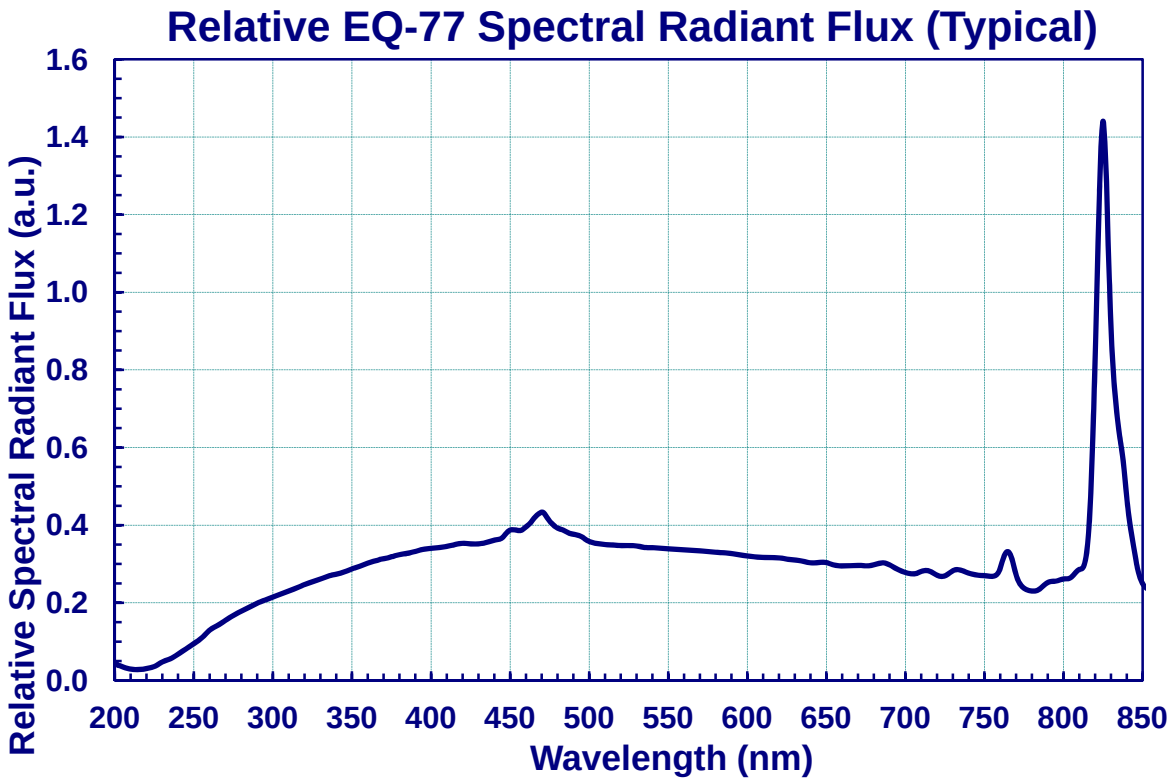


Figure 2: Typical Output Spectrum

Physical Specifications

Dimensions (H x W x D)

- Lamp House: 128 x 175 x 102 mm (5.0 x 6.9 x 4.0 in)
- Power Supply Controller: 152 x 250 x 132 mm (6.0 x 9.8 x 5.2 in)

Weight

- Lamp House: 2.2 kg (4.9 lb)
- Power Supply Controller: 2.9 kg (6.5 lb)

Utility Requirements

- Electrical: 100 – 240 V~, 50/60 Hz, 350 W
- Purge gas: clean dry nitrogen, filtered to 5um, 20 psig (0.14 MPa) supply pressure
  - Fittings: 4mm push-to-connect
- Cooling water: >= 1 liter/minute, 18 – 30 °C, 100 psig (0.69 MPa) max. inlet pressure
  - Fittings: 1/4-inch Swagelok

Remote Interface

Digital Inputs

- Type: Optocoupler LED
- Logic: Active High
- Input voltage: 5VDC
- Input current: 8mA

External Interlock Input Only (pin 13)

- Type: Relay Coil
- Logic: Active High
- Input voltage: 5VDC
- Input current: 80mA

Digital Outputs

- Type: Open collector to ground (digital common)
- Logic: Active Low
- Voltage: 30VDC max.
- Sink current: 30mA max.

User Power

- Voltage: 5VDC, referenced to digital common
- Current: 400mA maximum

Serial Interface

- Type: RS-485 4-wire (full duplex)
- Connector: Male 9-pin d-sub
- Termination: 120 ohms across receiver input (pins 2 and 7)
- Interface protocol: see Chapter 4
- Port settings: 9600 bps, 8 data bits, 1 stop bit, no parity, no handshaking

Environmental Requirements

Operating

- Ambient temperature: 15–35°C
- Relative Humidity: non-condensing, 80% max. for temperatures up to 31°C, decreasing linearly to 50% max. at 35°C.
- Pollution Degree 2 (normally only non-conductive pollution; occasional, temporary condensation possible)
- Installation Category II
- Indoor use only

Transport

- Temperature: -5–70°C
- Relative Humidity: non-condensing, 95% max.

System Description

As shown in Figure 3 the EQ-77 system consists of a Power Supply Controller unit, Lamp House, Controller to Lamp house interconnect cable (not shown), and power input cable (not shown). I/O interface connections (also not shown) are provided by the user.

The following sections provide descriptions of the system components and controls, and give an overview of their functions. Refer to the "Installation" section of this manual (Chapter 3) for more detailed information.

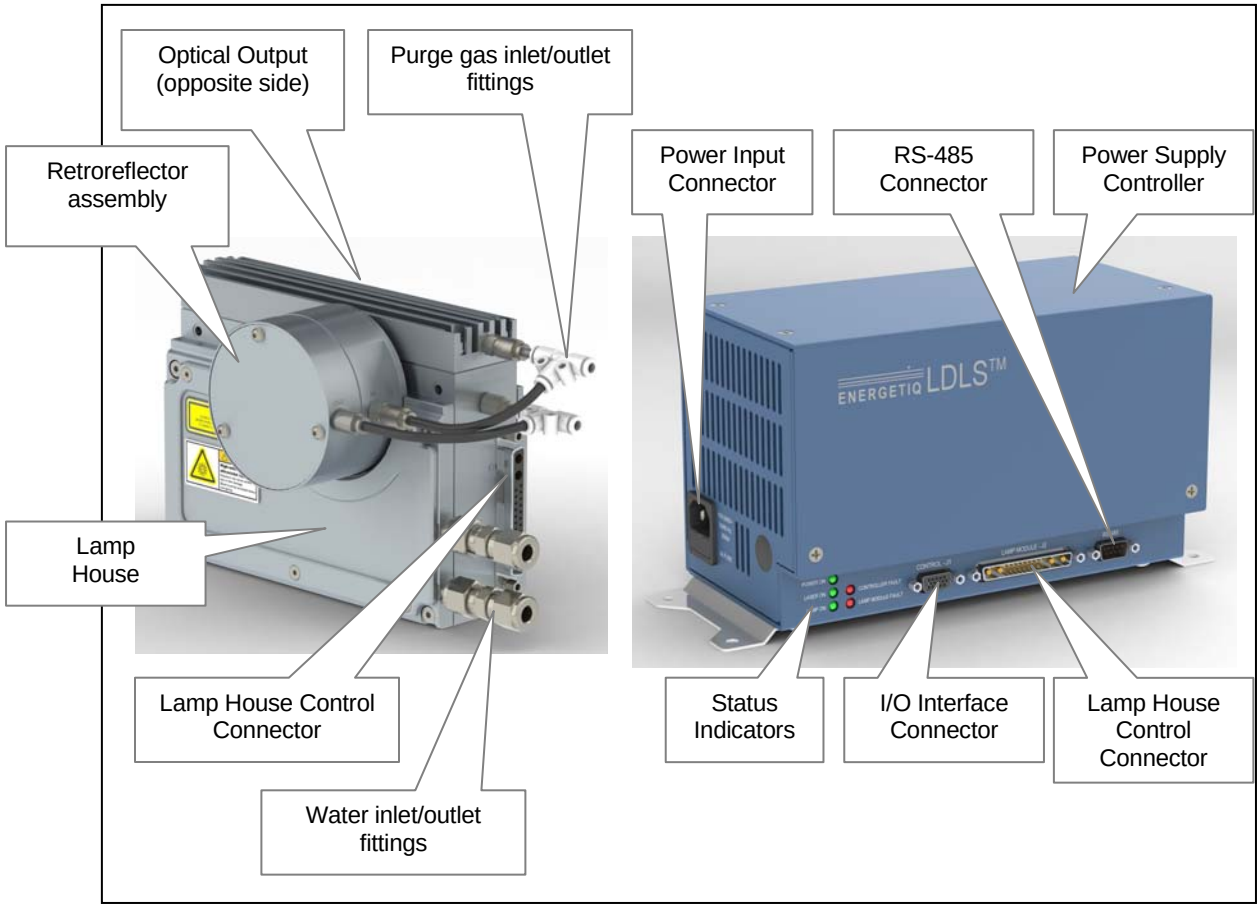


Figure 3: EQ-77 Lamp System

Power Supply Controller

The Power Supply Controller contains:

- Laser power supply
- Thermo-electric cooler control system for laser
- Control electronics
- Status indicator LEDs
- Interface connectors

External features (refer to Figure 3):

Status Indicator LEDs

These five LEDs indicate the system status. The function of these indicators is shown below in

Table **2**.

LED Label	**Meaning (when lit)**
POWER ON	AC power is connected to the EQ-77 Power Supply Controller
LAMP ON	UV Light is on
LASER ON	Laser power is ON and laser light is being produced within the Lamp House
CONTROLLER FAULT	One of the following has occurred in the Power Supply Controller: 1. External interlock open 2. Controller internal temperature too high 3. Laser power not reaching setpoint 4. Laser temperature fault 5. Internal power supply voltage low
LAMP MODULE FAULT	One of the following has occurred in the Lamp House module: 1. Control Cable not connected properly 2. Lamphouse internal temperature too high 3. Ignition Failure

Table 2: Status Indicator LED Functions

Input/Output (I/O) Connector

Provides access to control and status signals. See Chapter 3 for pin assignments and functions.

This is the only operator interface to the EQ-77 – there are no local controls. Energetiq offers the EQ-99-RC Remote Control Module which connects to the Input/Output connector of the EQ-77 or EQ-99 and provides a means of local control. Contact Energetiq for additional information.

Power Input Connector

This is an IEC 320 inlet connector for AC power input. See Chapter 3 for detailed information.

Lamp House Control Connector (21-pin mixed D-sub)

Provides various power and control signals to/from the Lamp House module. No other connector or cable may be used with the EQ-77 other than the one supplied.

RS-485 Connector (9-pin D-sub)

Connector for optional RS-485 interface. See Chapters 3 and 4 for electrical details and commands.

Lamp House

The Lamp House assembly contains:

- Lamp
- Igniter
- Laser
- Thermoelectric cooler
- IR pumping optics
- Output windows
- Retroreflector assembly
- Laser ON indicator
- Interface connectors

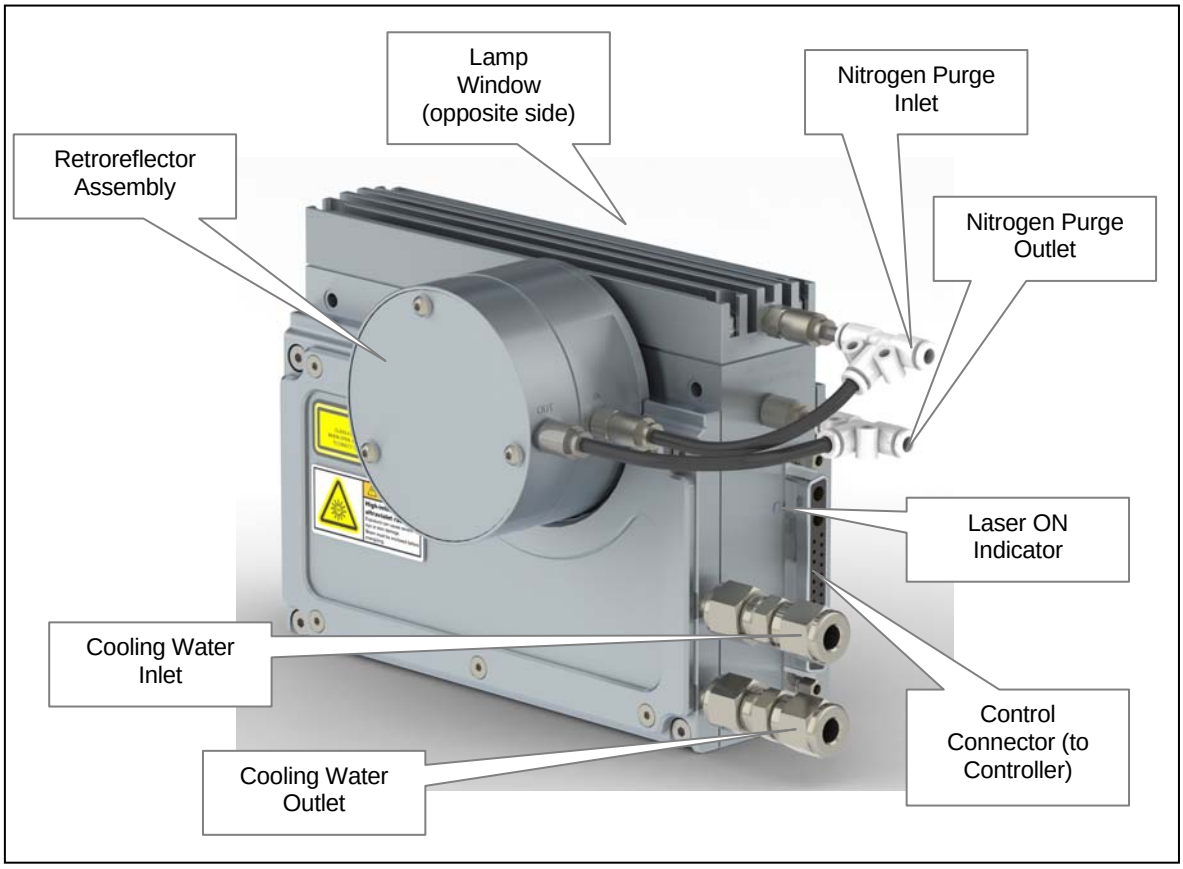


Figure 4: Lamp House Assembly

External features (refer to Figure 4):

Lamp Windows

The lamp windows at the optical output provide protection from the high pressure bulb inside the Lamp House. An internally-threaded SM1 adapter is provided for easy connection of optical hardware.

Nitrogen Purge Inlet / Outlet

These are the fittings for the required nitrogen purge gas. With no purge, ozone will form from atmospheric oxygen and attenuate the light output in the 220 – 280nm band. In addition, atmospheric oxygen and water vapor will attenuate the output below 200nm.

Cooling Water Inlet / Outlet

These fittings are for connection of cooling water required by the Lamp House.

Laser On Indicator

This LED is illuminated when the laser is ON.

Control Connector (21-pin mixed D-sub)

Provides various power and control signals to/from the Power Supply Controller. No other connector or cable may be used with the EQ-77 other than the one supplied.

Chapter 3

INSTALLATION

Unpacking

Upon arrival, start by inspecting all parts of the system for completeness and any damage incurred in shipping. The EQ-77 shipping box should contain:

1) EQ-77 Power Supply Controller unit
1) EQ-77 Lamp House unit
1) Black interconnecting cable from Lamp House to Power Supply Controller (21-pin mixed D-sub).

OPTIONAL
1) EQ-99-RC Remote Control Module with interlock connector
1) I/O cable with 15 pin D- connector at each end

If any part is missing or appears damaged, contact Energetiq immediately. Do not attempt to substitute any parts. There are no user-serviceable parts inside the EQ-77 Lamp House or Power Supply Controller unit.

Connections

Installation of the EQ-77 consists of connecting electrical, water, and purge gas supplies, and connecting the Lamp House module to the user's equipment. Read "Installation Procedure" first before making any connections.

Electrical Power

The EQ-77 requires 100 – 240 V~, 50/60 Hz input voltage. Power consumption is 350 W maximum during normal operation. Some OEM versions have higher current requirements.

Purge Gas

Purge gas required for operation. With no purge, ozone will form from atmospheric oxygen and attenuate the light output in the 220 – 280nm band. In addition, atmospheric oxygen and water vapor will attenuate the output below 200nm.

The purge port fitting is a push-to-connect type, sized for 4mm O.D. tubing.

Clean and dry nitrogen from either a Dewar or research-grade N_2 bottle is recommended. Do not use any other purge gas. Grade 6 or better gas purity is recommended to maintain cleanliness of the optics, and gas should be filtered to <5um. Supply pressure should be 20 psig (0.14 MPa). With a 20 psig inlet pressure, the EQ-77 will consume approximately 0.5 slm of flow.

Cooling Water

Cooling water fittings are 1/4-inch Swagelok female. Coolant flow rate of at least 1 liter/minute is required. Inlet temperature should be between 18°C and 30°C

Care must be taken when making connections to avoid damage to the fittings and tubing. Two wrenches must always be used – one to hold the fitting body, and another to tighten the nut. See Figure 5.

To make the connection: first insert tubing into the fitting and tighten the nut finger tight. Then tighten the nut 1-1/4 turns from the finger-tight position, using two wrenches as shown.

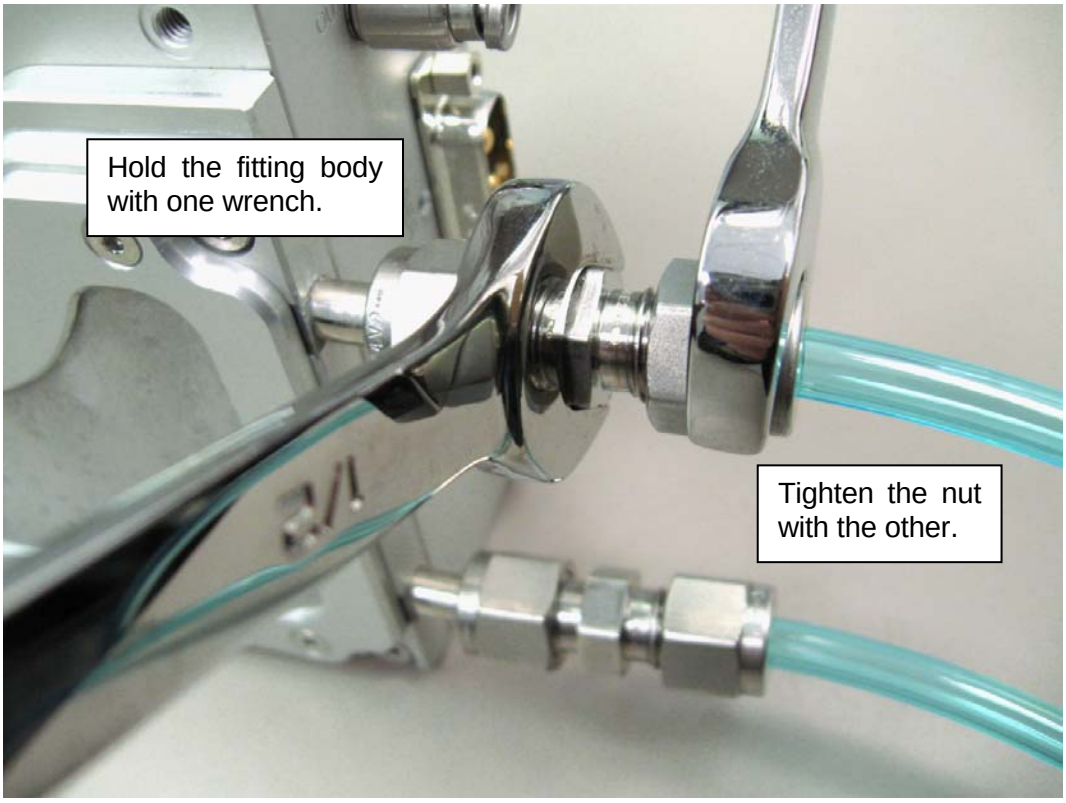


Figure 5: Water fittings

Optical Interface

See drawing OTD-7111 in Appendix A for mechanical layout of the Lamp House.

Signal Connections

The EQ-77 is controlled through the remote I/O connector.

Table 3 gives the pin assignments and functions for this interface. Connect to the user's control system using a suitable cable. Mating connector is a standard high-density 15-pin d-sub male (for example, Amp part no. 748364-1 with contacts 1658670-2).

Optionally, connect a model EQ-99-RC remote control module to the I/O connector using the supplied cable. The EQ-99-RC is shipped with an interlock jumper plug installed. To use the remote interface function, connect a remote contact or solid-state switch across pins 1 and 3. Mating connector is a standard 3-pin mini-DIN, CUI Inc. part no. MD-30 or equivalent. See Figure 6 for pin connections.

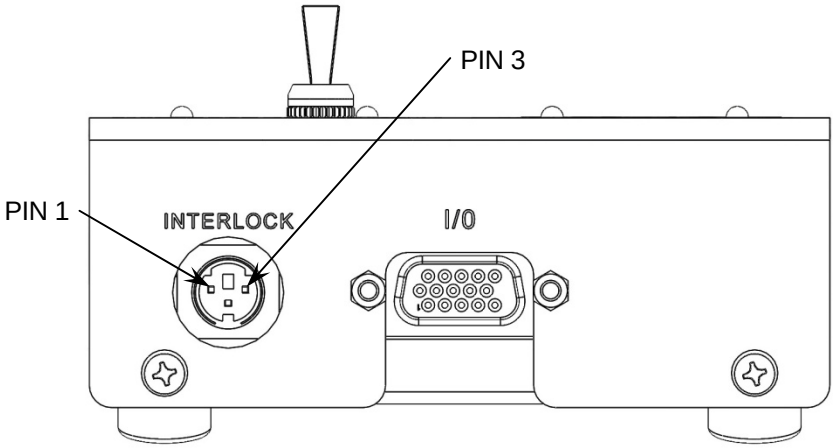


Figure 6: EQ-99-RC Remote Control Rear Panel

User I/O can be powered either by the EQ-77 internal isolated power supply, or an external supply.

Figure 7 shows connection schematics for both configurations.

Lamp House I/O

The black 21-pin mixed D-sub cable is used to connect the Lamp House to the Power Supply Controller. This cable should be connected before AC power is applied to the Power Supply Controller.

RS-485 Interface

Connector J2 is a standard 9-pin male d-sub. Mating connector is a standard 9-pin female d-sub (for example, AMP part no. 205203-3 with contacts 1-66504-0). See Table 4 for pin connections.

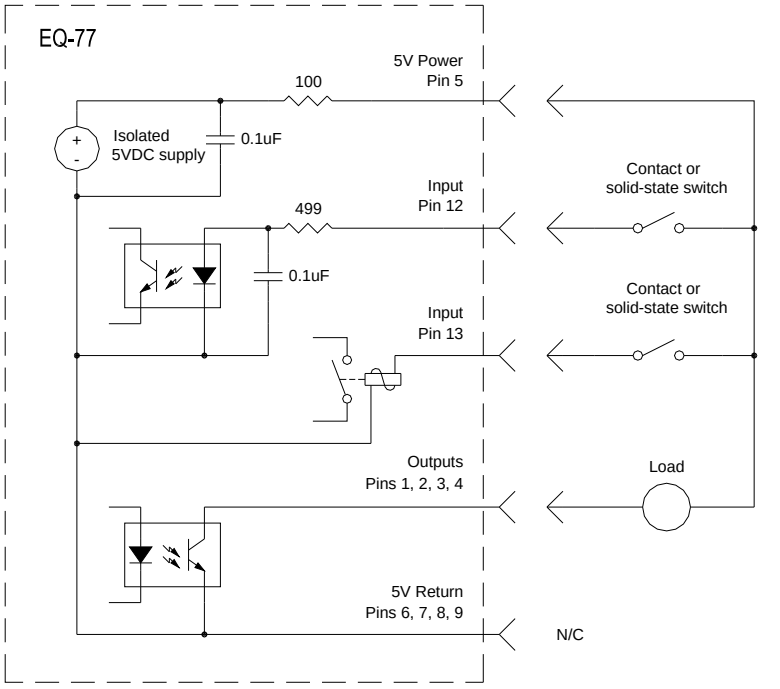
Port settings are 9600 bps, 8 data bits, 1 stop bit, no parity, no handshaking.

Description	Pin #	Details
Commands (Inputs)		
LAMP OPERATE	12	OPERATE REQUEST, apply +5V (referenced to digital common) to initiate start cycle
EXTERNAL INTERLOCK	13	EXTERNAL INTERLOCK, apply +5V (referenced to digital common) to close interlock and allow operation. Current draw is 80mA at 5VDC.
Status Indicators (Outputs)		
LAMP ON	1	Pulled to digital common when ON
LASER ON	2	Pulled to digital common when ON
LAMP MODULE FAULT	3	Pulled to digital common when OK, float on FAULT
CONTROLLER FAULT	4	Pulled to digital common when OK, float on FAULT
ISOLATED +5V SUPPLY	5	400mA maximum, referenced to digital common
DIGITAL COMMON	6,7,8,9	Galvanically isolated from system
RESERVED	10, 11	Do not connect
RESERVED	14,15	Do not connect

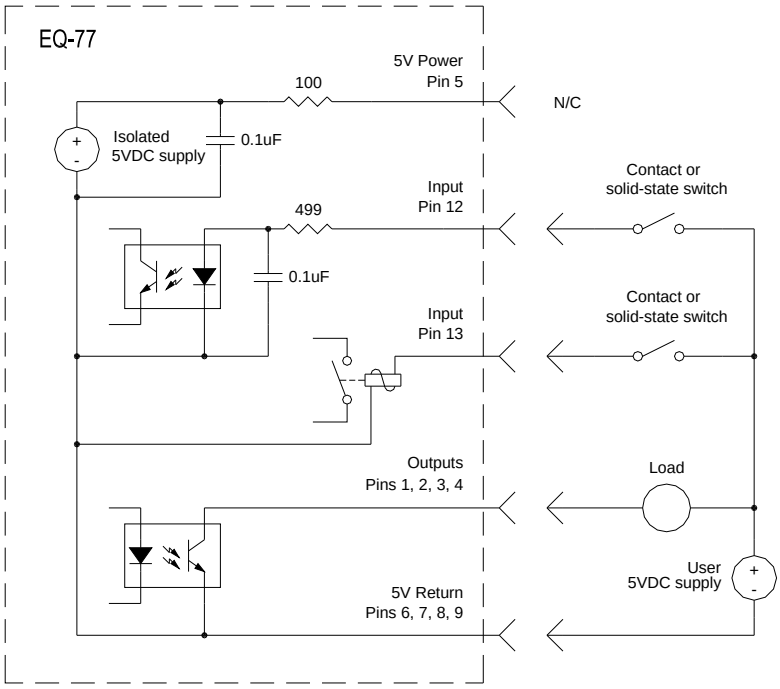
Table 3: I/O Connector Pin Assignment

Description	Pin #	Details
TRANSMIT A (–)	8	From EQ-77, connect to host RECEIVE A
TRANSMIT B (+)	3	From EQ-77, connect to host RECEIVE B
RECEIVE A (–)	7	To EQ-77, connect to host TRANSMIT A
RECEIVE B (+)	2	To EQ-77, connect to host TRANSMIT B
GROUND	5, 9	Galvanically isolated from system
RESERVED	1, 4, 6	Do not connect

Table 4: RS-485 Interface Pin Assignment



USING EQ-77 POWER SUPPLY



USING EXTERNAL POWER SUPPLY

Figure 7: Remote Interface Schematic

Installation Procedure

1. Place the Power Supply Controller on a stable surface. The Power Supply Controller must be placed within 2 meters of the Lamp House due to the length of the interconnecting cable. See drawing OTD-6881 in Appendix A for dimensional details.
2. Connect the Lamp House unit optical output to the user equipment (after removing the window cover). The beam should always be either directly coupled to a fiber optic cable, or enclosed in an appropriate beam pipe, tube, or enclosed space and purged with nitrogen. Operating the source without any output target or beam transport is not recommended, and may lead to unsafe operating conditions. Consult Energetiq for applications information and suggested configurations.

   The Lamp House should be mounted in the orientation shown in Figure 4, with the output window on the side and the lamp mounting surface oriented horizontally. The lamp has been factory aligned in this position. Mounting the lamp in a different orientation will cause the plasma position inside the bulb to shift slightly and may cause performance variations.

   Setup the Lamp House unit with appropriate ultraviolet safety measures and laser light safety measures in place. It is recommended that any enclosure or aperture-blocking hardware utilize switches wired to the EQ-77 external interlock circuit.

   See drawing OTD-7111 in Appendix A for mechanical details of the Lamp House.
3. Connect the black 21-pin mixed D-sub interconnect cable from the Power Supply Controller to the Lamp House.
4. Connect nitrogen purge gas to the Lamp House. Refer to "Connections" above.
5. Connect cooling water to the Lamp House. Refer to "Connections" above.
6. Connect user's control system to the I/O interface connector per Table 3 and Figure 7.
7. Alternately, if using the EQ-99-RC Remote Control Module, place it on a clean rigid surface. Install the supplied 15-pin cable from the Power Supply Controller to the EQ-99-RC.
8. Connect AC input power source to the Controller Unit.

The system is now ready to operate.

Chapter 4

OPERATION

Starting

Once the lamp is set up properly, verify that all personnel that will be in contact with the lamp system are aware of the potential hazards involved. It is the responsibility of the user to verify that the lamp is being used safely.

This example assumes the use of the EQ-99-RC Remote Control Module to provide local control. If using a custom control system, substitute the appropriate digital input and output lines from Table 3 for the switches and LEDs described below.

1. With the EQ-99-RC Remote Control Module connected properly, review the status LEDs on the Power Supply Controller. The POWER ON LED should be lit, and neither the CONTROLLER FAULT nor LAMP MODULE FAULT LEDs should be lit.

2. Turn on the OPERATE Switch (place switch in UP position).

3. Within several seconds the LASER ON LED will light. Laser light is now present in the Lamp House.

4. In approximately 20-150 seconds the igniter will be turned on automatically and the plasma will ignite. The LAMP ON LED will be lit. The duration of the warm up time (20-150 seconds) will depend on the temperature and previous operating condition of the EQ-77. The EQ-77 will automatically detect when the unit has reached the optimum conditions for ignition.

5. If a bulb fails to ignite within 150 seconds after the OPERATE switch was activated, the LASER ON LED will go out, the LAMP FAULT LED will be lit, and LAMP ON LED will remain off. This is very unusual. However, if this occurs, turn the OPERATE switch to the OFF position (down) and begin at Step 1 again. If this occurs multiple times, contact Energetiq service

Stopping

To turn the LAMP off, simply turn the OPERATE Switch to the OFF position. If the lamp will not be used for some time, the AC supply can be turned off.

To minimize wear on the ignition components, it is best to avoid frequently starting and stopping the lamp. It is recommended to run the lamp continuously if long off-periods are not required.

Serial Interface

The RS-485 serial interface is provided for user adjustment of laser operating power, in order to increase or decrease light output. The EQ-77 is shipped with the laser power set to a factory default value of 100% of full scale power. Laser power can be increased or decreased in increments of 0.5% of full scale. The following describes the serial commands and their functions.

Commands consist of a single ASCII character, case-sensitive. This can be transmitted to the EQ-77 via a terminal emulation program, or the user's control system. Response from the EQ-77 will be a string of ASCII characters, format depending on the command issued.

Command character	Function	Reply from EQ-77
U	Increases the present laser power setpoint by 0.5% of full scale	`Power = XX.X%`
D	Decreases the present laser power setpoint by 0.5% of full scale	`Power = XX.X%`
Q	Queries the value of the present laser power setpoint (in % of full scale)	`Power = XX.X%`
F	Resets laser power setpoint to factory default value	`Power = XX.X%`
B	Saves present settings to flash memory. This command should be issued after the settings are at their desired values. If not, changes will be lost if power to the EQ-77 is interrupted.	`Calibration data copied to FLASH Memory.`

?	Displays a help menu listing the available commands	`EQ77 firmware v02d (FRM-7117 R005) build date 11/18/15`
		` (c) Energetiq Technology, Inc.`
		` operational commands:`
		` U/D - raise/lower laser power by 0.5%`
		`  Q  - Query present laser power`
		`  F  - reset laser power to Factory default`
		`  B  - Burn present settings to non-volatile flash`
		`  ?  - this help menu.`

Table 5: Serial Interface Command Set

TROUBLESHOOTING

Fault Indicator Block Diagram

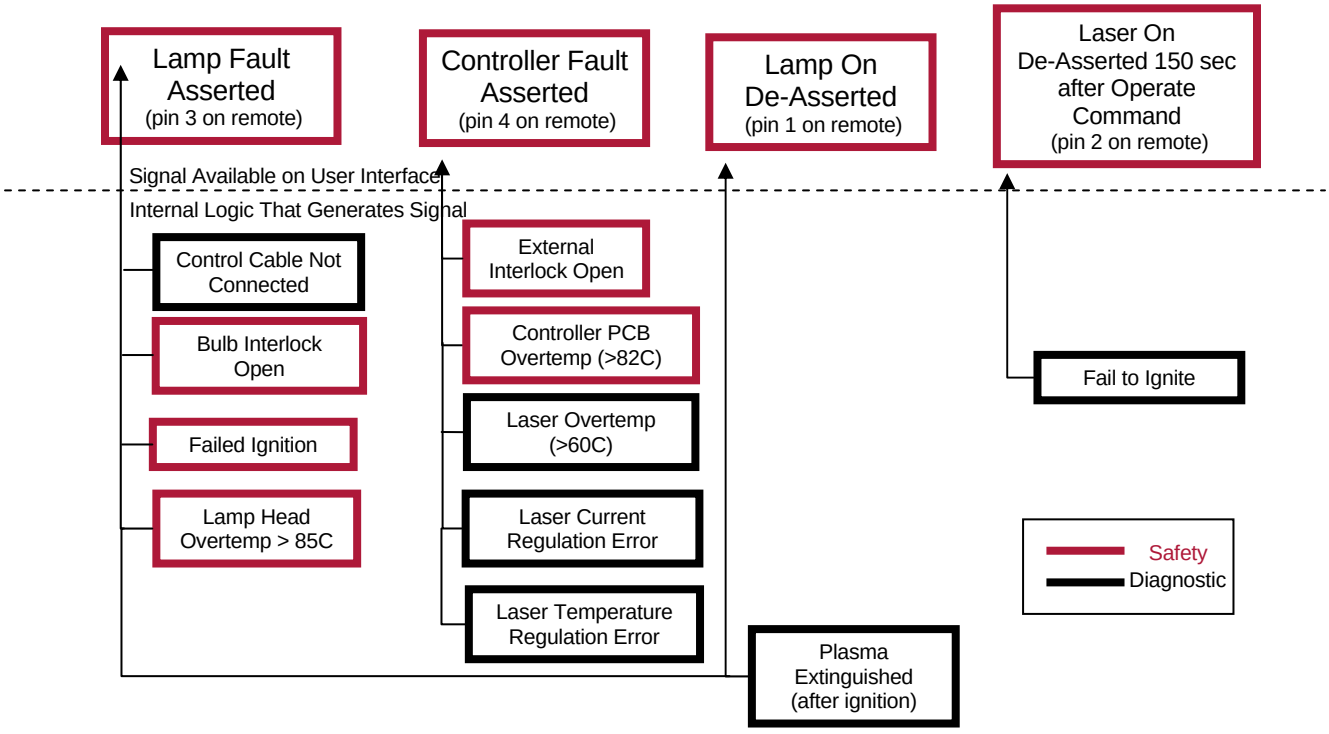


Figure 8: Fault Indicator Block Diagram

See below if any problems are encountered in operating the EQ-77.

Condition:

Controller Fault and/or Lamp House Fault LED(s) are ON.

Action:

- Always begin operation of the source by verifying the interlocks.
- Confirm that the external interlock contact is closed (or that the black jumper plug is fully inserted into the back of the EQ-99-RC Remote Control Box)
- To reset or clear a Fault condition, actuate the "Operate" switch from the ON position to the OFF position. If a fault was generated while the "Operate" switch was in the OFF position, first actuate the switch to the ON position, then to the OFF position. The unit will not turn on if a fault condition exists.
- If all of the interlocks are OK and either the lamp or controller interlock faults will not clear, please contact the factory.

Condition:

Lamp fails to ignite after several tries.

Action:

Contact Energetiq.

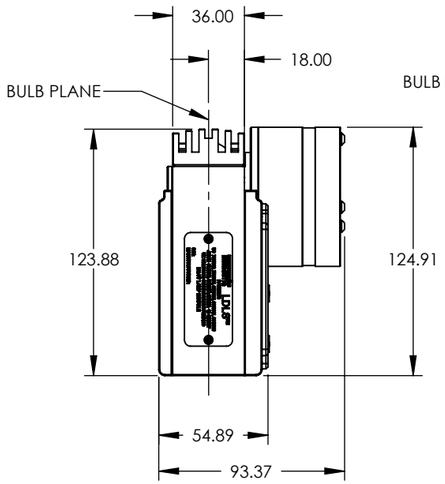
Appendix A

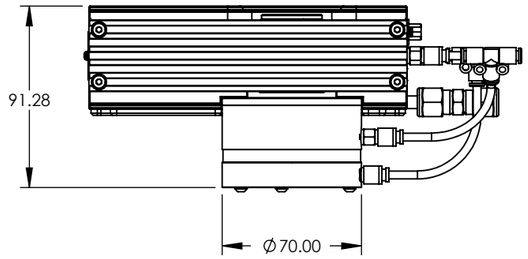
ENGINEERING DRAWINGS

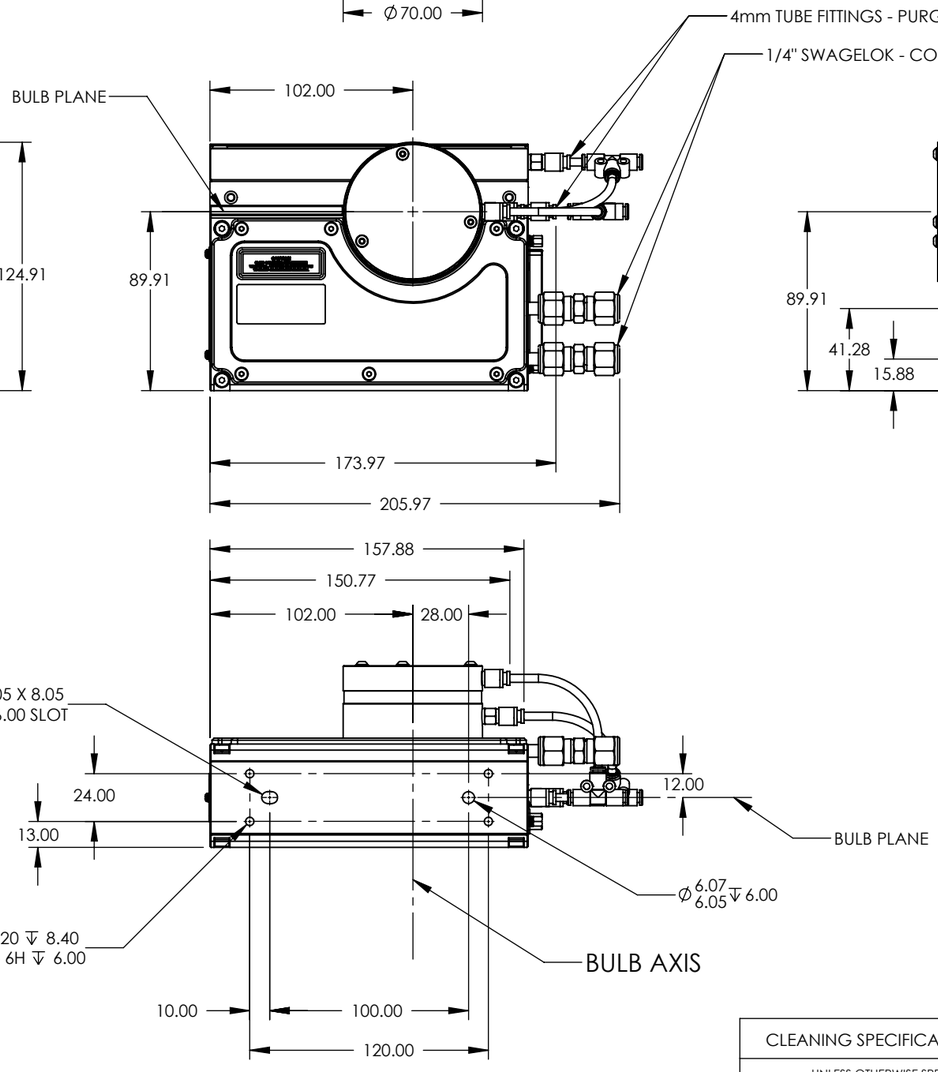
The following engineering drawings are included for reference.

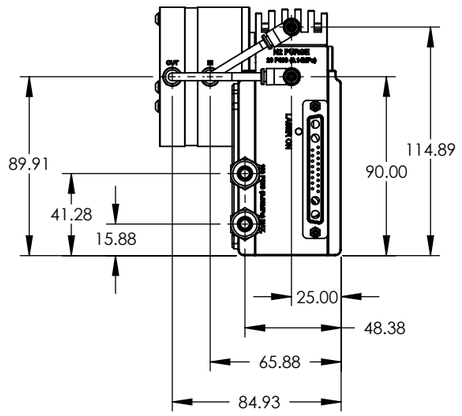
Drawing number	Revision	Title
OTD-7111	2	EQ-77 Lamp Housing Outline
OTD-6881	4	EQ-77 Power Supply Assembly

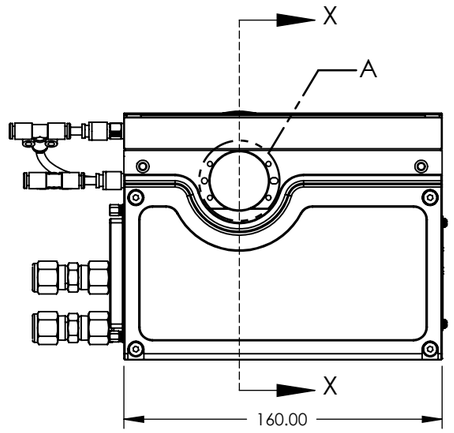
REVISIONS			
REV.	DESCRIPTION	DATE	APPROVED
1	PROTOTYPE RELEASE	6/2/2015	
2	ADDED CROSS-SECTION VIEW SHEET 2	12/15/2015	

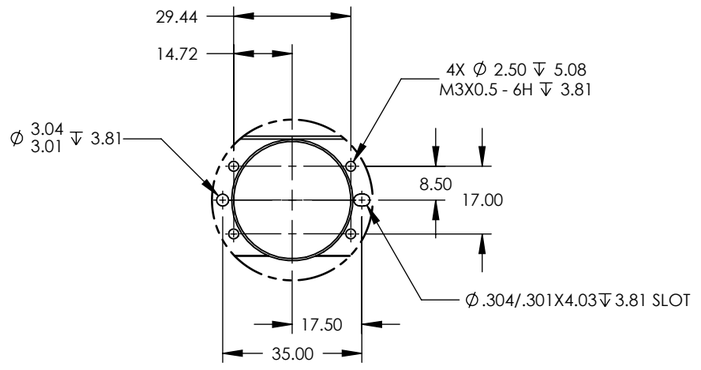












DETAIL A
SCALE 2 : 3

CLEANING SPECIFICATION: DEGREASE AND DI WATER RINSE

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES [MILLIMETERS] & TOLERANCES ARE:

DECIMALS	ANGLES	MACHINE FINISH
.XX ± .01 .XXX ± .005 .XXXX± .0010	± 1°	32

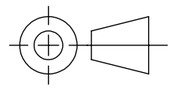
DO NOT SCALE DRAWING
INTERPRET DIM AND TOL PER ASME Y14.5M-1994

MATERIAL

FINISH

APPROVALS	DATE
DRAWN: XXX	XX/XX/00
MFG ENG: XXX	XX/XX/XX
ENGINEER: XXX	XX/XX/00

THIRD ANGLE PROJECTION



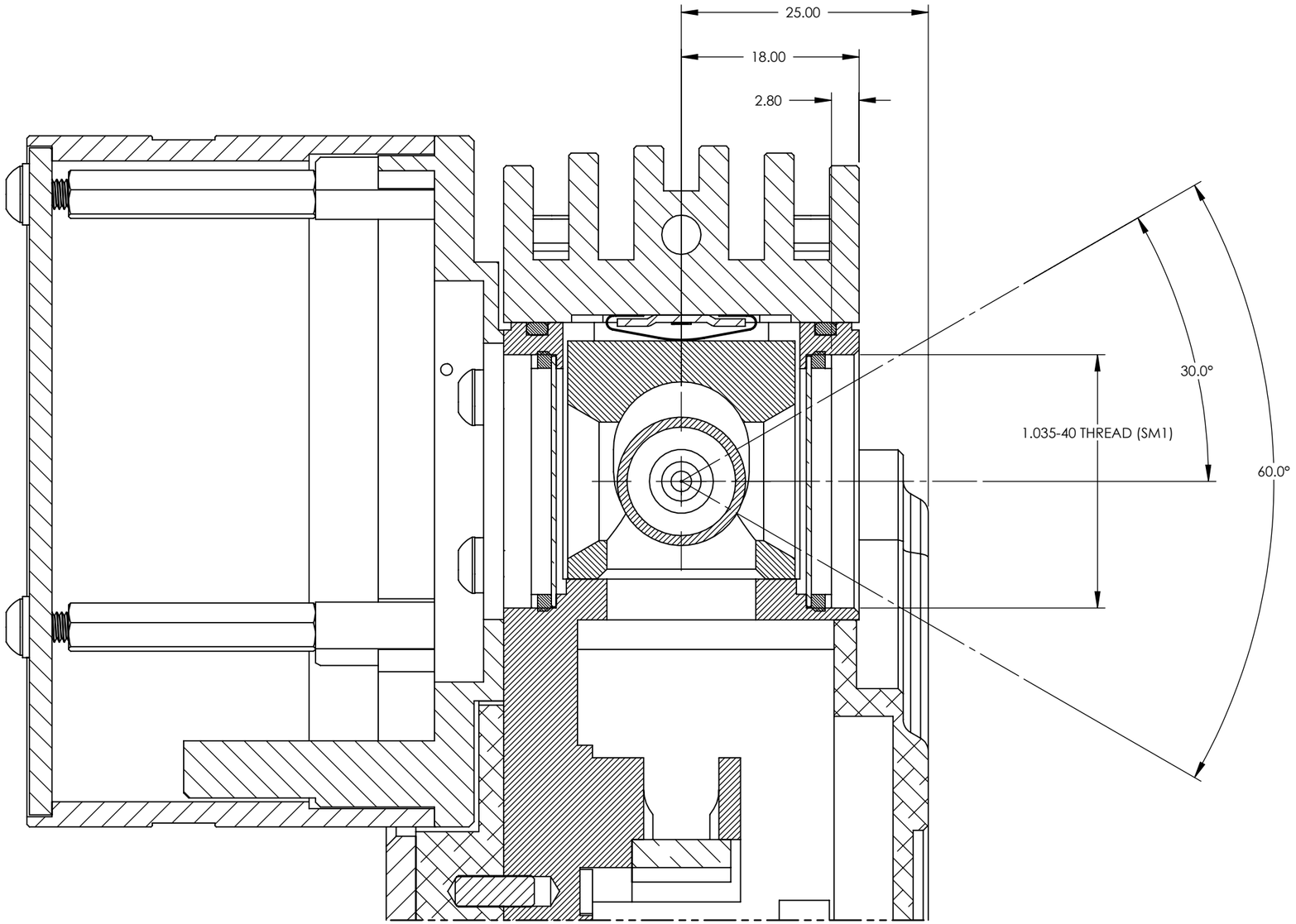
ENERGETIQ

ENERGETIQ TECHNOLOGY INC.
7 CONSTITUTION WAY
WOBURN, MA 01801

TITLE: EQ-77 LAMP HOUSING OUTLINE

SIZE	DWG NO	REV
B	OTD-7111	2

FILE: OTD-7111.SLDDRW | SCALE: NONE | SHEET 1 OF 2



OUTPUT NUMERICAL APERTURE
NA = 0.5

SECTION X-X
SCALE 2 : 1

UNLESS OTHERWISE SPECIFIED DIMENSIONS
ARE IN INCHES [MILLIMETERS] & TOLERANCES ARE:

DECIMALS	ANGLES	MACHINE FINISH
.XX ± .01 .XXX ± .005 .XXXX± .0010	± 1°	32

DO NOT SCALE DRAWING
INTERPRET DIM AND TOL PER ASME Y14.5M-1994

MATERIAL

FINISH

APPROVALS	DATE
DRAWN: XXX	XX/XX/00
MFG ENG: XXX	XX/XX/XX
ENGINEER: XXX	XX/XX/00

THIRD ANGLE PROJECTION

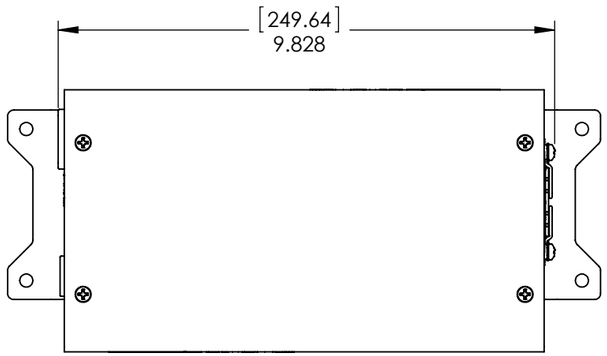
ENERGETIQ
ENERGETIQ TECHNOLOGY INC.
7 CONSTITUTION WAY
WOBURN, MA 01801

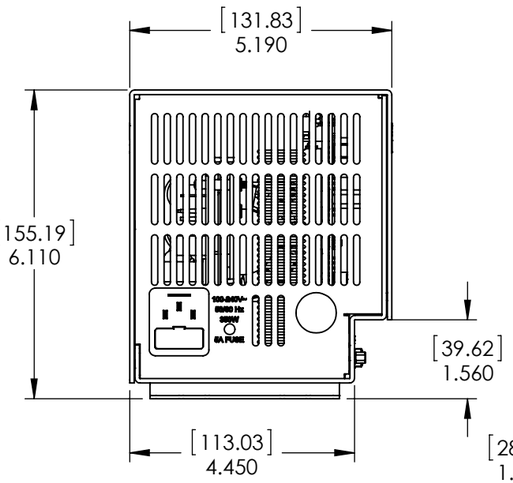
TITLE
EQ-77 LAMP HOUSING ASSY

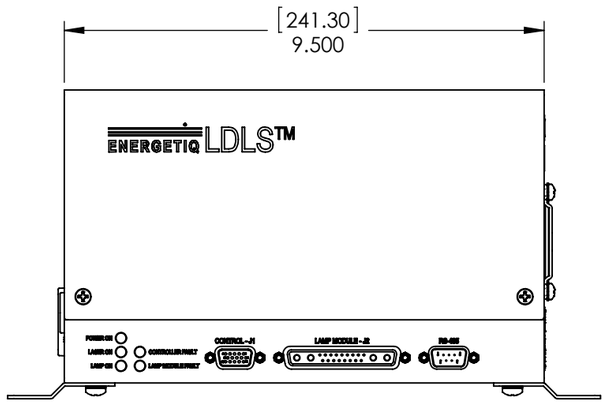
SIZE	DWG NO	REV
B	OTD-7111	2

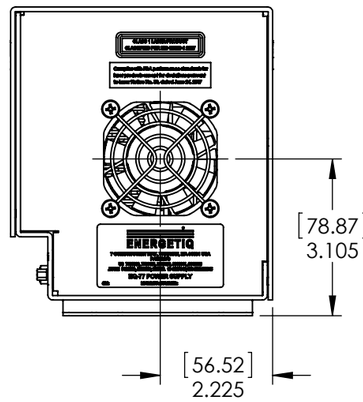
FILE: OTD-7111.SLDDRW | SCALE: NONE | SHEET 2 OF 2

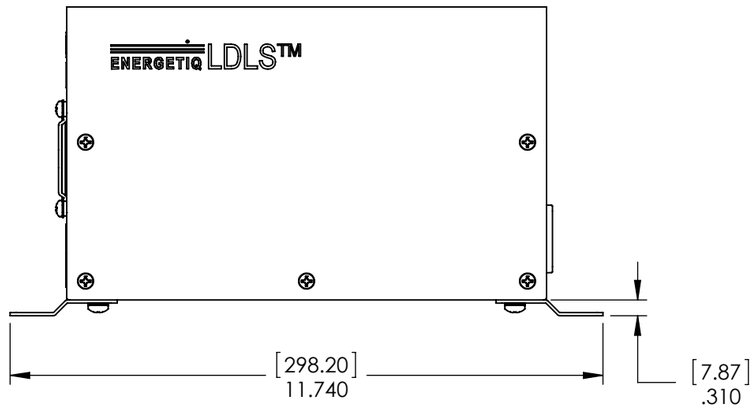
REVISIONS			
REV.	DESCRIPTION	DATE	APPROVED
3	NEW MOUNTING SCHEME	7/7/2015	
4	ADD REFERENCE TO ALTERNATE MOUNTING METHOD	12/9/2015	

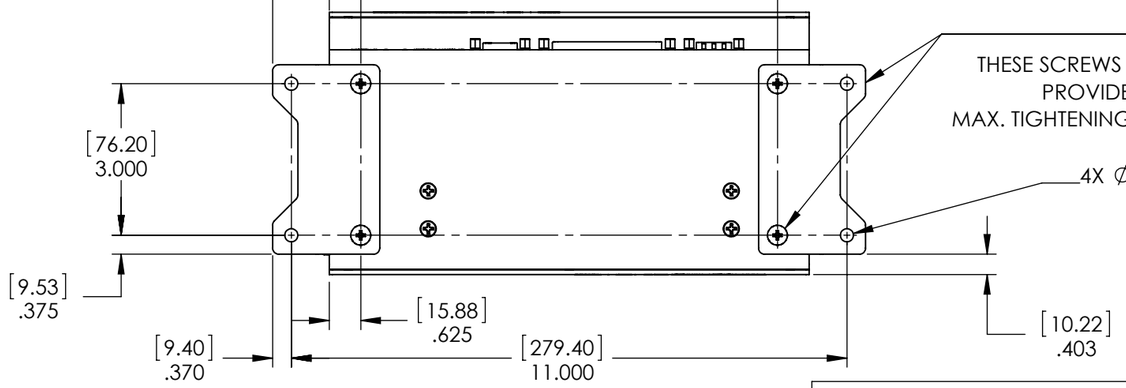












CLEANING SPECIFICATION: DEGREASE AND DI WATER RINSE

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES [MILLIMETERS] & TOLERANCES ARE:

DECIMALS	ANGLES	MACHINE FINISH
.XX ± .01 .XXX ± .005 .XXXX± .0010	± 1°	32

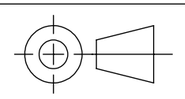
DO NOT SCALE DRAWING
INTERPRET DIM AND TOL PER ASME Y14.5M-1994

MATERIAL

FINISH

APPROVALS	DATE
DRAWN: RC	10/26/14
MFG ENG: XXX	XX/XX/XX
ENGINEER: XXX	XX/XX/00

THIRD ANGLE PROJECTION



ENERGETIQ

ENERGETIQ TECHNOLOGY INC.
7 CONSTITUTION WAY
WOBURN, MA 01801

TITLE: EQ-77 POWER SUPPLY ASSY

SIZE	DWG NO	REV
B	OTD-6881	4

FILE: OTD-6881.SLDDRW | SCALE: NONE | SHEET 1 OF 1

Appendix B

REVISION HISTORY

Date	Revision	Description
17 June 2015	1	Initial release
15 December 2015	2	Updated graphics, added RS-485 interface info
30 March 2016	3	Added RS-485 port settings, added water fitting connection procedure, added water inlet max. pressure spec.

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http://www.energetiq.com

Model EQ-400
LDLS™
Laser-Driven Light Source

Operation Manual

Revision 7 April 2018

Part Number DOC-7388

ENERGETIQ

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EU Declaration of Conformity

Product type:

LDLS™ Laser-Driven Light Source

Manufacturer:

Energetiq Technology, Inc.
7 Constitution Way
Woburn, Massachusetts 01801 USA

This declaration of conformity is issued under the sole responsibility of the manufacturer.

Object of the declaration:

Model EQ-400 Series High Brightness Broadband Light Source

The object of the declaration described above is in conformity with the relevant Union harmonisation legislation:

2014/35/EU	EU Low Voltage Directive
2014/30/EU	EU Electromagnetic Compatibility Directive
2011/65/EU	EU RoHS2 Directive

Standards used:

EN61010-1 (2010)	Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use: Part 1 – General Requirements
EN 55011:2009 +A1:2010	Industrial, scientific and medical equipment - Radio-frequency disturbance characteristics - Limits and methods of measurement
EN61326-1:2013	Electrical equipment for measurement, control and laboratory use. EMC requirements. General requirements
EN61000-3-2:2014	Electromagnetic compatibility (EMC) - Part 3-2: Limits - Limits for harmonic current emissions (equipment input current less than or equal to 16 A per phase)
EN61000-3-3:2013	Electromagnetic compatibility (EMC) - Part 3-3: Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current less than or equal to 16 A per phase and not subject to conditional connection
IEC 60825-1:2014	Safety of laser products - Part 1: Equipment classification and requirements

Signed for and on behalf of:

Energetiq Technology, Inc.
Woburn, Massachusetts USA 19 April 2018

Matthew Besen, President and CTO

TABLE OF CONTENTS

Chapter 1

GENERAL INFORMATION

Safety

WARNING

This unit emits ultraviolet (UV) radiation that is harmful to humans. Avoid exposure to the direct or reflected output beam. Make certain that the appropriate output beam shields and optics are in place prior to energizing the unit. All interlocks must be satisfied prior to operation; failure to do so may lead to hazardous conditions.

CAUTION

The EQ-400 emits dangerous levels of UV radiation. Even short exposures to skin or eyes may cause burns. Ensure that only authorized personnel are in the vicinity of source during operation. Personnel in vicinity of operating source should wear protective eyewear, clothing, and gloves. Lighted UV warning lights and signs posted on doors to lab areas may help prevent accidental exposure.

WARNING

The EQ-400 utilizes an internal Class 4 IR laser capable of causing severe injury to eyes or skin. Do not open or attempt to service this unit. Contact Energetiq regarding any problems with the unit.

General Precautions

The output beam from the EQ-400 should be blocked when not in use with an electronic shutter or other appropriate beam blocking device. Due to the possibility of generating ozone with some models of EQ-400 when ambient oxygen is exposed to short wavelength light, the beam should always be enclosed in an appropriate beam pipe, tube, or enclosed space. We suggest purging any beam transport space with dry nitrogen gas.

The EQ-400 source must also be cabled correctly and connected to a power source with a protective earth ground prior to operation.

Refer to the Installation section of this manual in Chapter 3 for details of the facilities connections.

There are no user-serviceable parts inside the EQ-400. For any problems encountered during operation, please contact Energetiq Technology for assistance. **If there is a component failure, do not attempt to open the Power/Control Unit or Lamp House enclosure of the EQ-400.**

No regular maintenance is required for the EQ-400. Any service to the system must be performed only by factory authorized and trained technicians. To avoid injury, under no circumstances should the user open or modify the Lamp House or Power/Control Unit enclosure.

The unit must not be operated if the covers are removed or it is defective in any way. Contact Energetiq if any problems with the equipment are suspected.

The EQ-400 utilizes a quartz lamp containing a high-pressure gas fill. Explosion of the lamp and possible injury from flying fragments can occur if the lamp is mishandled.

Do not open the enclosure of either the Lamp House or the Power/Control Unit. Dangerous invisible infrared laser beams and hazardous voltages exist inside the Lamp House. Opening the chassis both voids the warranty and exposes the user to dangerous radiation and hazardous voltages.

CAUTION

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

INVISIBLE LASER RADIATION
AVOID EYE OR SKIN EXPOSURE TO
DIRECT OR SCATTERED RADIATION
CLASS 4 LASER PRODUCT

The EQ-400 is a Class 4 Laser Product. All appropriate laser safety measures should be in place before operating the system. Consult your facility's laser safety officer. Laser protective eyewear should be worn at all times while operating the system.

The EQ-400 also produces high-intensity UV radiation. Eyewear should protect not only from laser radiation at 1070 nm, but also from UV radiation in the band from 190 to 400 nm.

For further safety information, refer to ANSI Z136.1 Standard for Safe Use of Lasers, available from Laser Institute of America (www.laserinstitute.org).

Laser Information

The EQ-400 uses a patented* laser drive system to excite a plasma that radiates in the UV as well as the visible bands. A Class 4 laser is located in the Power/Control Unit enclosure. The optical configuration of the Lamp House ensures that the direct laser beam cannot exit the unit. The EQ-400 laser product is designated as Class 4 during all normal operation.

The parameters of the non-accessible internal laser are given below in Table 1.

Wavelength	1070 nm
Emission Type	CW
Laser Power for classification	400W
Beam Diameter	5 mm
Divergence	0.3 mRad
Transverse Beam Mode	Single Mode

Table 1: Embedded Laser Parameters

* US 7435982, 7786455, 8525138, 8969841, 9048000, 9185786 ; Japan 5410958, 5628253; Korea 10-1507617; UK GB2450045; others pending

Nominal Ocular Hazard Distance (NOHD) based on 400W 1070nm pump laser under a failure mode condition where aperture is itself accessible: 4 meters

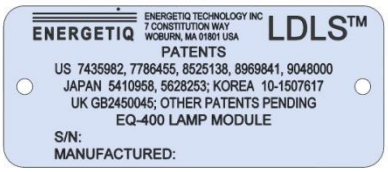
Required Optical Density (OD) for safety eyewear: 6 or higher at 1070 nm

These values are based on a theoretical failure condition.

Labels and Safety Notification

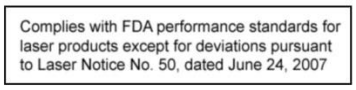
The following safety labels appear on the product. Figure 1 shows the location of each label on the EQ-400 system.

UV Hazard warning label – indicates hazardous levels of UV light are present.



Manufacturer's identification label – gives the manufacturer's name and address, and the model, serial number, and date of manufacture of the equipment.

Explanatory label – states the classification of the laser product.

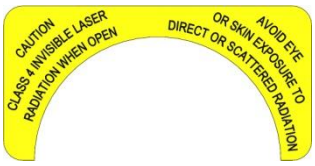


Certification label – states that the equipment has been tested and verified to meet the standards indicated.

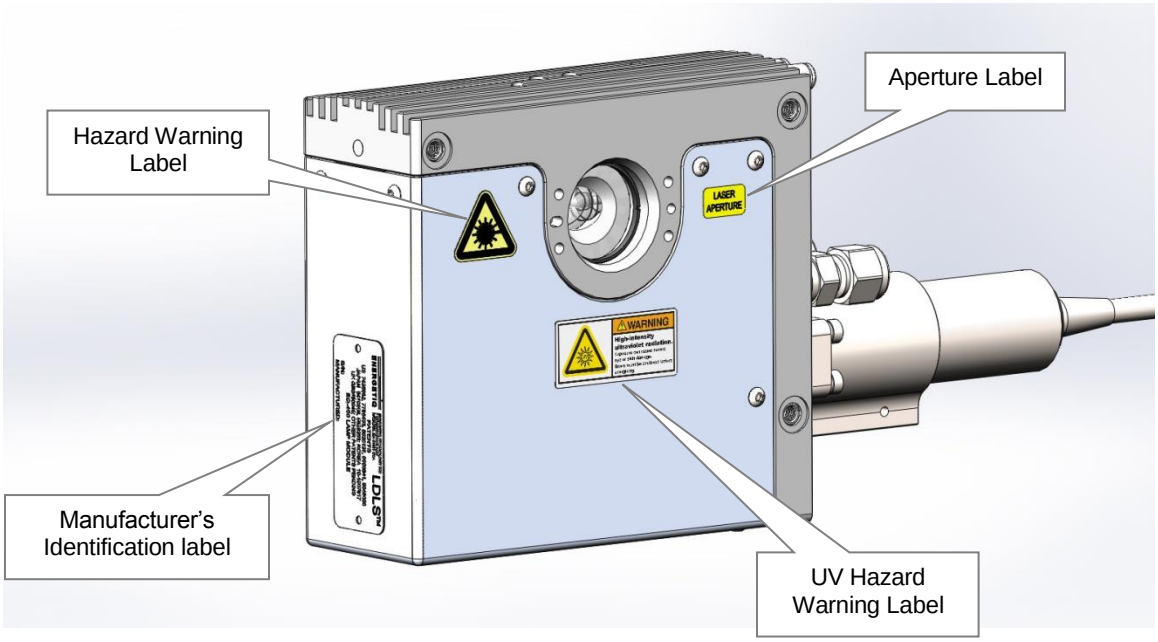
Aperture label – indicates the outlet aperture for laser radiation

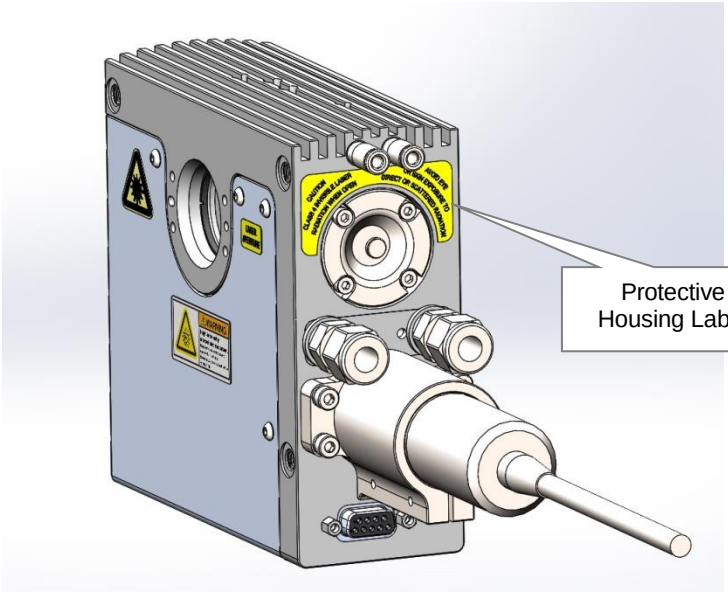
Hazard warning label – indicates that a laser hazard is present

Protective housing label – warns of an enclosed laser radiation hazard



Protective housing label – warns of an enclosed laser radiation hazard


Hazard Warning Label
Aperture Label
Manufacturer's Identification label
UV Hazard Warning Label
LASER APERTURE
WARNING


Protective Housing Label

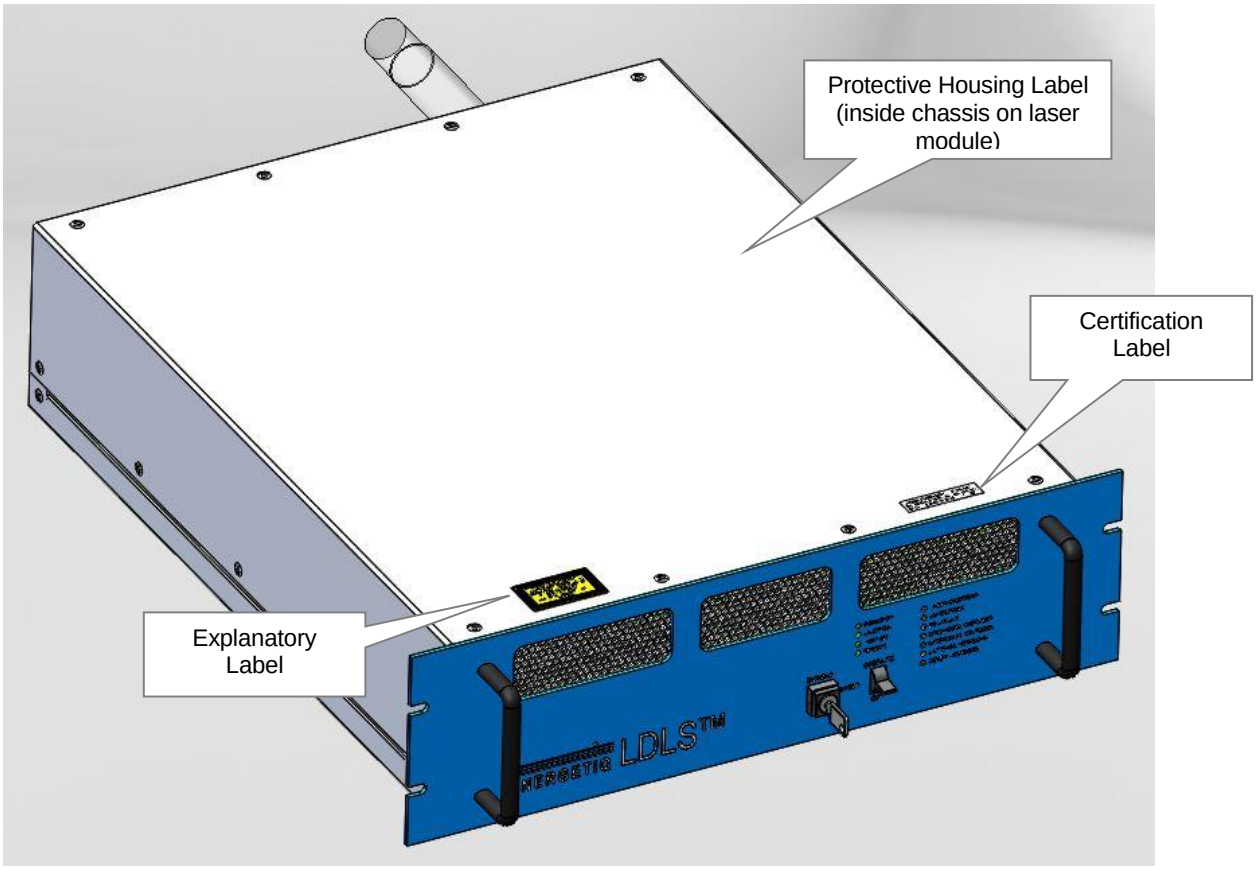


Figure 1: Safety Label Locations

Safety Interlocks

The EQ-400 is equipped with interlocks to prevent operation of the device when any of the following conditions are present:

1. A remote interlock is open
2. Lamp House cover not installed
3. Laser fiber not connected to Lamp House
4. Power/Control Unit cover not in place

Remote Interlock

Remote interlock pins are provided for the customer's use (see Chapter 3 for connection details). Any suitable normally-open contact or solid-state switch can operate the interlock circuit. The contact or switch should be rated for 8mA minimum at 5VDC.

The interlock circuit must be connected to enable the operation of the unit. Should the interlock connection open during operation or standby, the source is immediately disabled, and all light output from the aperture ceases.

Chapter 2

DESCRIPTION

General

The EQ-400 is a broad-band lamp system for use in a wide variety of applications. The lamp produces high brightness, broad-band light from DUV wavelengths through visible and beyond. The output is very stable, and has a long lifetime before any service is required. A simple control interface ensures ease of use.

Some of the advantages of the EQ-400 include:

- Very high brightness across complete spectrum
  - 190nm through visible and beyond
- Eliminates need for multiple lamps (replaces D2/Tungsten/Xenon Arc)
  - Simplified optical system
- Excellent spatial stability
  - Repeatable measurements
- Superior short and long term power stability
  - Repeatable measurements
- Electrodeless operation for long life
  - Reduced consumable costs
  - Minimal recalibration of instrument

The EQ-400 system consists of a Power/Control Unit (PCU), Lamp House unit, and interconnecting cable. Connection to AC power is required for operation. Connections to nitrogen purge gas and cooling water are required. See Chapter 3 for connection details.

Specifications

Optical Performance

- Typical output spectrum: see Figure 2.

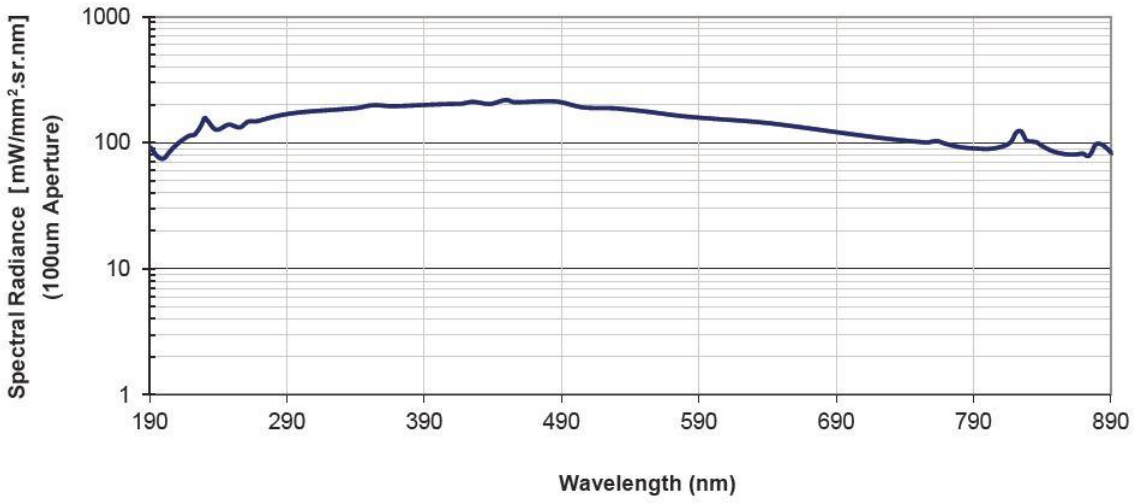


Figure 2: Typical Output Spectrum

Physical Specifications

Dimensions (H x W x D)

- Lamp House: 136 x 145 x 56 mm (5.4 x 5.7 x 2.2 in)
- Power/Control Unit: 133 x 483 x 584 mm (5.2 x 19.0 x 23.0 in)

Weight

- Lamp House: 2.7 kg (6.0 lb)
- Power/Control Unit: 18.8 kg (41.5 lb)

Utility Requirements

- Electrical: 200 – 240 V~, 50/60 Hz, 7A, 1700 W max.
- Purge gas: clean dry nitrogen, filtered to 5um, 20 psig (0.14 MPa) supply pressure, maximum flow rate 0.7 liters/minute
  - Fittings: 4mm push-to-connect
- Cooling water (Power/Control Unit): 3 – 4 liters/minute, 18 – 24 °C
  - Fittings: 8mm push-to-connect
- Cooling water (Lamp House): >= 1 liter/minute, 18 – 30 °C
  - Fittings: 8mm Swagelok

Remote Interface

Digital Inputs

- Type: Optocoupler LED
- Logic: Active High
- Input voltage: 5VDC
- Input current: 8mA

Digital Outputs

- Type: Open collector to ground (digital common)
- Logic: Active Low
- Voltage: 30VDC max.
- Sink current: 30mA max.

User Power

- Voltage: 5VDC, referenced to digital common
- Current: 200mA maximum

Serial Interface

- Type: RS-485 4-wire (full duplex)
- Connector: Male 9-pin d-sub
- Termination: 120 ohms across receiver input (pins 2 and 7)
- Interface protocol: see Chapter 4.
- Port settings: 9600 bps, 8 data bits, 1 stop bit, no parity, no handshaking

Environmental Requirements

Operating

- Ambient temperature: 15–35°C
- Relative Humidity: non-condensing, 80% max. for temperatures up to 31°C, decreasing linearly to 50% max. at 35°C.
- Pollution Degree 2 (normally only non-conductive pollution; occasional, temporary condensation possible)
- Installation Category II
- Indoor use only

Transport

- Temperature: -5–70°C
- Relative Humidity: non-condensing, 95% max.

System Description

The EQ-400 system consists of a Power/Control Unit (PCU), Lamp House, Controller to Lamp House interconnect cable, and power input cable. Laser light is generated in the PCU and transmitted to the Lamp House by an optical fiber permanently attached to the PCU.

The following sections provide descriptions of the system components and controls, and give an overview of their functions. Refer to the "Installation" section of this manual (Chapter 3) for more detailed information.

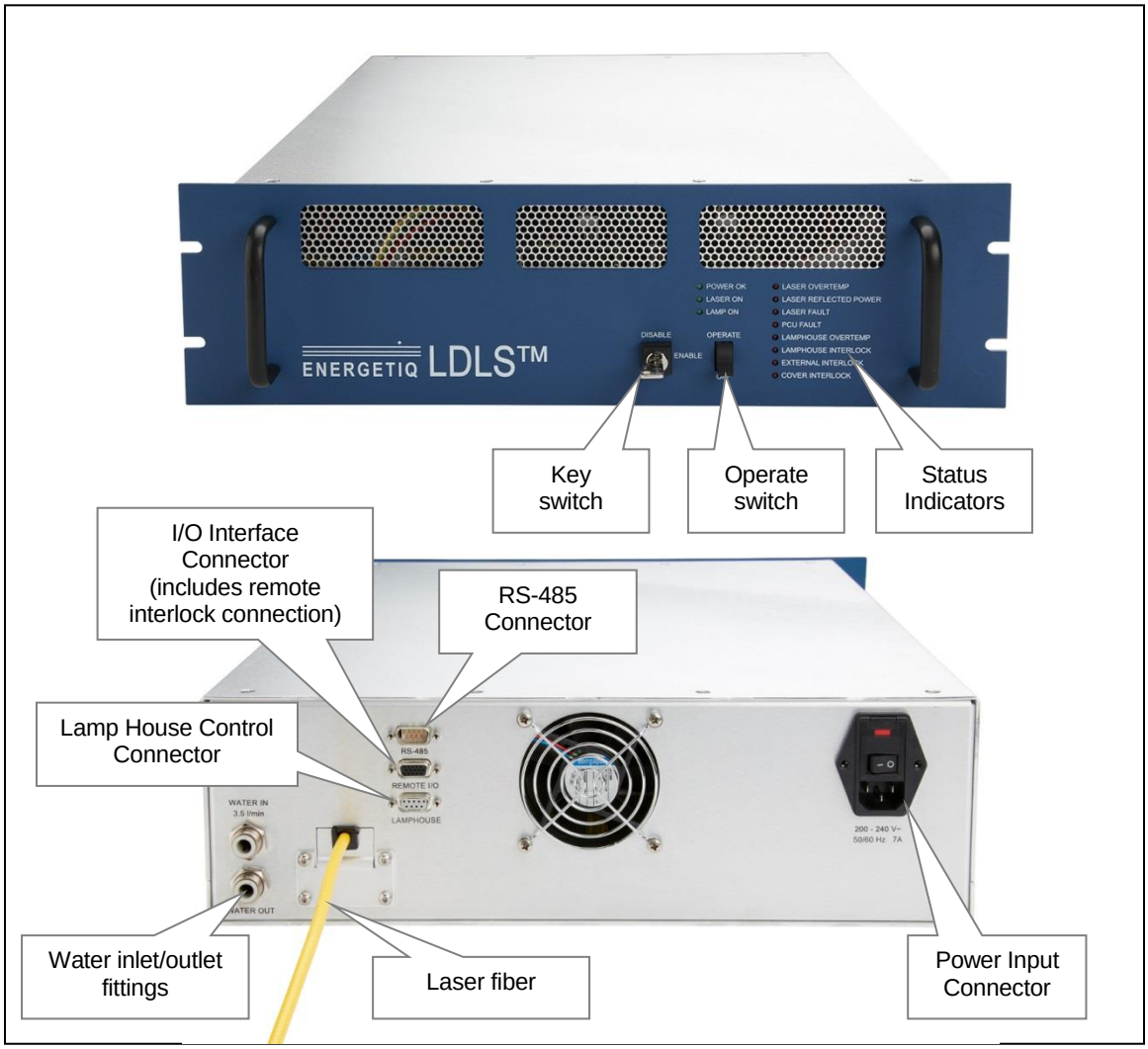


Figure 3: EQ-400 Power/Control Unit

Power/Control Unit (PCU)

The Power/Control Unit contains:

- Laser module
- Laser power supply
- Control electronics
- Status indicator LEDs
- Operate switch
- Keyswitch
- Interface connectors
- Cooling water connectors

External features (refer to Figure 3):

Status Indicator LEDs

These LEDs indicate the system status. The function of these indicators is shown below in Table **2**.

LED Label	**Meaning (when lit)**
POWER OK	AC power is connected to the EQ-400 PCU
LAMP ON	UV Light is on
LASER ON	Laser power is ON and laser light is being produced within the Lamp House
REMOTE	System is in remote control mode
LASER OVERTEMP	Laser internal temperature too high
LASER FAULT	Laser module internal fault
PCU FAULT	One of the following has occurred in the Power/Control Unit: 1. Controller internal temperature too high 2. Laser power not reaching setpoint 3. Internal power supply voltage low 4. Lamp failed to ignite
LAMPHOUSE OVERTEMP	Lamphouse internal temperature too high
LAMPHOUSE INTERLOCK	One of the following has occurred in the Lamp House module: 1. Control Cable not connected properly 2. Laser fiber not connected properly
EXTERNAL INTERLOCK	External interlock open
COVER INTERLOCK	PCU cover(s) not in place

Table 2: Status Indicator LED Functions

Operate switch

Turns the lamp on or off.

Key switch

Enables or disables operation of the lamp. The keyswitch must be in the ENABLE position for the lamp to operate. The key can only be removed in the DISABLE position.

I/O Interface Connector

Provides access to control and status signals. Control signals are only active when the system is in remote control mode. See Chapter 3 for pin assignments and functions.

This connector also functions as the remote interlock connector.

Lamp House Control Connector (9-pin D-sub)

Provides various power and control signals to/from the Lamp House module. No other connector or cable may be used with the EQ-400 other than the one supplied.

RS-485 Connector (9-pin D-sub)

Connector for optional RS-485 interface. See Chapters 3 and 4 for electrical details and commands.

Power Input Connector

This is a fused IEC 320 inlet connector for AC power input. Fuses are 5 x 20mm, 10A, 250V, time delay type. See Chapter 3 for detailed information.

Water inlet/outlet fittings

Connections for cooling water for the internal laser module.

Laser fiber

Transmits laser energy from the PCU to the Lamp House.

Lamp House

The Lamp House assembly contains:

- Lamp
- Igniter
- IR pumping optics
- Output windows
- Laser ON indicator
- Control connector

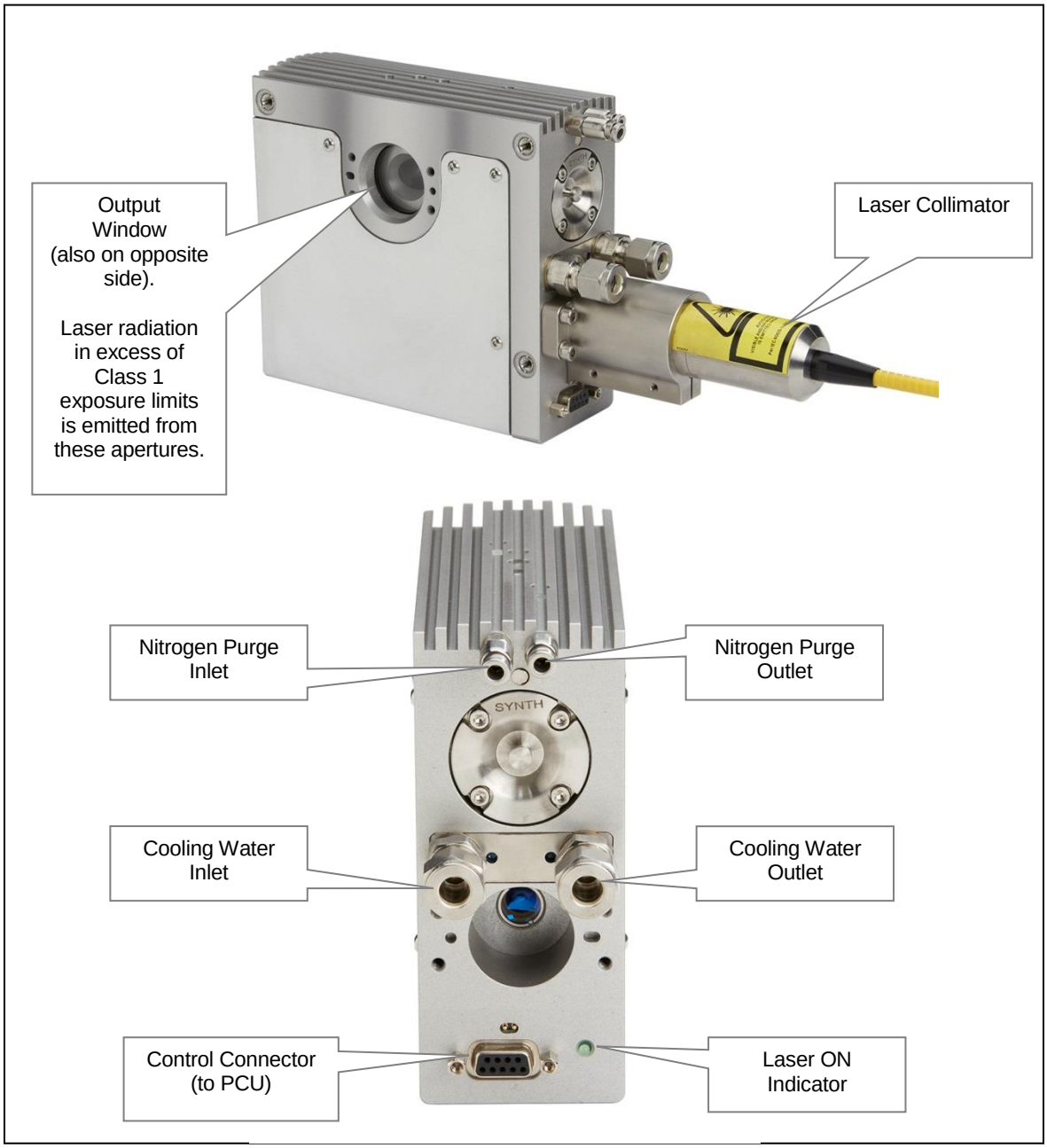


Figure 4: Lamp House Assembly

External features (refer to Figure 4):

Output Windows

The lamp windows at the optical output provide protection from the high pressure bulb inside the Lamp House. An internally-threaded SM30 adapter is provided for easy connection of optical hardware. An optional retroreflector can be installed on the output window on one side of the Lamp House if only one optical output is required.

In addition to the light output, invisible laser radiation exceeding Class 1 emission limits is emitted from the output apertures.

Nitrogen Purge Inlet / Outlet

These are the fittings for the required nitrogen purge gas. With no purge, ozone will form from atmospheric oxygen and attenuate the light output in the 220 – 280nm band. In addition, atmospheric oxygen and water vapor will attenuate the output below 200nm.

Cooling Water Inlet / Outlet

These fittings are for connection of cooling water required by the Lamp House.

Laser On Indicator

This LED is illuminated when the laser is ON.

Control Connector (9-pin D-sub)

Provides various power and control signals to/from the Power Supply Controller. No other connector or cable may be used with the EQ-400 other than the one supplied.

Chapter 3

INSTALLATION

Unpacking

Upon arrival, start by inspecting all parts of the system for completeness and any damage incurred in shipping. The EQ-400 shipping box should contain:

1) EQ-400 Power Supply Controller unit
1) EQ-400 Lamp House unit
1) Interconnecting cable from Lamp House to Power Supply Controller (9-pin D-sub).
1) AC Power cable
1) Chiller tubing kit (Optional)

If any part is missing or appears damaged, contact Energetiq immediately. Do not attempt to substitute any parts. There are no user-serviceable parts inside the EQ-400 Lamp House or Power Supply Controller unit.

Installation Procedure

See Chapter 2 for interface specifications and facilities requirements.

1. Place the Power/Control Unit in a standard 19-inch rack or on a stable surface. The PCU must be placed within 3 meters of the Lamp House due to the length of the interconnecting cable. See drawing OTD-8198 in Appendix A for dimensional details.

   Note: The PCU weighs 18.8 kg (41.5 lb). A two-person lift is recommended. Use care when moving the PCU not to bend the fiber optic cable sharply. Minimum bend radius is 50mm.

2. Connect the Lamp House unit optical output to the user equipment. The beam should always be either directly coupled to a fiber optic cable, or enclosed in an appropriate beam pipe, tube, or enclosed space and purged with nitrogen. Operating the source without any output target or beam transport is not recommended, and may lead to unsafe operating conditions. Consult Energetiq for applications information and suggested configurations.

   The Lamp House should be mounted in the orientation shown in Figure 4, with the output window on the side and the lamp mounting surface oriented horizontally. The lamp has been factory aligned in this position. Mounting the lamp in a different orientation will cause the plasma position inside the bulb to shift slightly and may cause performance variations.

Setup the Lamp House unit with appropriate ultraviolet safety measures and laser light safety measures in place. It is recommended that any enclosure or aperture-blocking hardware utilize switches wired to the EQ-400 remote interlock circuit.

See drawing OTD-8159 in Appendix A for mechanical details of the Lamp House.

3. Connect the laser fiber to the Lamp House as follows:

WARNING

The collimator must never be detached from its mounting bracket.
Doing so could allow dangerous invisible laser radiation to be emitted.

   a. Remove plastic cap from the end of the laser collimator

      Note: always keep this cap in place when the laser fiber is not connected to the Lamp House.

   b. Inspect collimator lens for dust or contamination

   c. Insert the collimator and bracket into the socket in the Lamp House

   d. Secure the bracket to the Lamp House using the four socket head screws and a 3mm hex driver. Torque the screws to 20 in-lbs.

4. Connect the 9-pin D-sub interconnect cable from the Power/Control Unit to the Lamp House.

5. Connect nitrogen purge gas to the 4mm push-to-connect fittings on the Lamp House.

6. Connect cooling water to the 8mm Swagelok fittings on the Lamp House.

7. Connect cooling water to the 8mm push-to-connect fittings on the rear of the PCU.

8. Connect an interlock switch or jumper plug (supplied) to the interlock pins of the remote I/O connector (functions as remote interlock connector).

9. If using remote control mode, connect user's control system to the remote I/O connector using a suitable cable.

   Table 3 gives the pin assignments and functions for the remote interface. Mating connector is a standard high-density 15-pin d-sub male (for example, Amp part no. 748364-1 with contacts 1658670-2).

   User I/O can be powered either by the EQ-400 internal isolated power supply, or an external supply. Figure 5 shows connection schematics for both configurations.

10. If using the optional RS-485 interface, connect the host computer to the RS-485 connector on the rear of the PCU. Mating connector is a standard 9-pin female d-sub (for example, AMP part no. 205203-3 with contacts 1-66504-0). See Table 4 for pin connections.

11. Connect an AC input power source to the standard IEC 320 style inlet on the rear of the PCU.

The system is now ready to operate.

Description	Pin #	Details
Commands (Inputs)		
LAMP OPERATE	12	OPERATE REQUEST, apply +5V (referenced to digital common) to initiate start cycle
EXTERNAL INTERLOCK	13	EXTERNAL INTERLOCK, apply +5V (referenced to digital common) to close interlock and allow operation.
REMOTE MODE ENABLE	11	REMOTE MODE ENABLE, apply +5V (referenced to digital common) to enable remote control mode
Status Indicators (Outputs)		
LAMP ON	1	Pulled to digital common when ON
LASER ON	2	Pulled to digital common when ON
LAMP MODULE FAULT	3	Pulled to digital common when OK, float on FAULT
CONTROLLER FAULT	4	Pulled to digital common when OK, float on FAULT
ISOLATED +5V SUPPLY	5	200mA maximum, referenced to digital common
DIGITAL COMMON	6,7,8,9	Galvanically isolated from system
RESERVED	10, 14,15	Do not connect

Table 3: I/O Connector Pin Assignment

Description	Pin #	Details
TRANSMIT A (–)	8	From EQ-400, connect to host RECEIVE A
TRANSMIT B (+)	3	From EQ-400, connect to host RECEIVE B
RECEIVE A (–)	7	To EQ-400, connect to host TRANSMIT A
RECEIVE B (+)	2	To EQ-400, connect to host TRANSMIT B
GROUND	5, 9	Galvanically isolated from system
RESERVED	1, 4, 6	Do not connect

Table 4: RS-485 Interface Pin Assignment

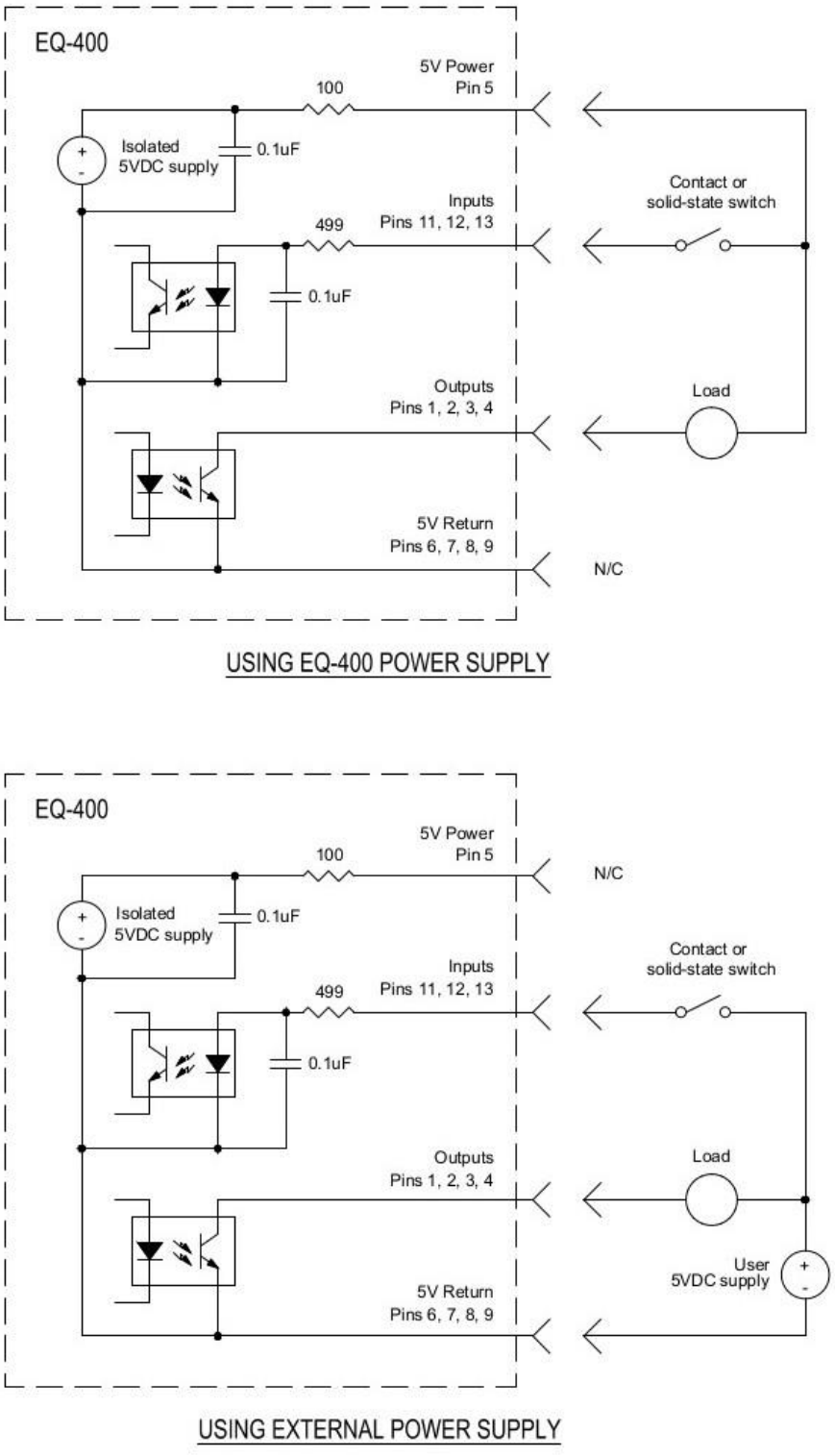


Figure 5: Remote Interface Schematic

Chapter 4

OPERATION

Starting

Once the lamp is set up properly, verify that all personnel that will be in contact with the lamp system are aware of the potential hazards involved. It is the responsibility of the user to verify that the lamp is being used safely. All safety measures appropriate for a Class 4 laser product should be taken, including protective eyewear as described in Chapter 1.

1. Verify that all interlocks are in place and none of the red fault LEDs on the PCU front panel are lit. The green POWER OK LED should be lit.

2. Place the keyswitch in the ENABLE position.

3. Turn on the OPERATE Switch (place switch in UP position).

   Note: If the lamp has been on within the last 5 minutes, the POWER OK LED will be flashing and re-start will not be possible. This is to allow the Lamp House to cool down before the next ignition cycle.

4. Within several seconds the LASER ON LED will light. Laser light is now present in the Lamp House.

5. Within several seconds the igniter will be turned on automatically and the plasma will ignite. The LAMP ON LED will light. To avoid thermal shock to the Lamp House components, the EQ-400 starts with the laser at half power. After 20 seconds the laser will switch to full power.

6. If the bulb fails to ignite within 6 seconds after the OPERATE switch was activated, the LASER ON LED will go out, the PCU FAULT LED will be lit, and LAMP ON LED will remain off. If this occurs, turn the OPERATE switch to the OFF position (down) and begin at Step 1 again. If this occurs multiple times, contact Energetiq service.

Stopping

To turn the lamp off, simply turn the OPERATE Switch to the OFF position. It is recommended to turn the keyswitch to the DISABLE position. The key can be removed if needed for safety or personnel access reasons. If the lamp will not be used for some time, the AC supply can be turned off.

To minimize wear on the ignition components, it is best to avoid frequently starting and stopping the lamp. It is recommended to run the lamp continuously if long off-periods are not required.

Manual Reset

If any fault occurs during operation of the lamp (including actuation of the remote interlock), the laser is immediately shut off, and light output ceases. When the fault condition is cleared, the lamp will not automatically restart. The system must be manually reset by turning the OPERATE switch to the OFF position. Then, assuming that the fault or interlock condition no longer exists, the lamp can be restarted by turning the switch to the OPERATE position.

If a fault occurs while the lamp is not operating (switch in the OFF position), the switch must be turned to OPERATE and then back to OFF to clear the fault. The lamp can then be started normally by turning the switch to OPERATE.

Serial Interface

The RS-485 serial interface is provided for user adjustment of laser operating power, in order to increase or decrease light output. The EQ-400 is shipped with the laser power set to a factory default value of 100% of full scale power. Laser power can be increased or decreased in increments of 0.5%, from 40% to 100% of full scale. The interface also allows monitoring of system status.

Commands consist of a single ASCII character, case-sensitive. This can be transmitted to the EQ-400 via a terminal emulation program, or the user's control system. Response from the EQ-400 will be a string of ASCII characters, format depending on the command issued. Reply strings are terminated by a CR - LF pair (hex 0D 0A).

The following describes the serial commands and their functions.

Command character	Function	Reply from EQ-400
U	Increases the present laser power setpoint by 0.5% of full scale	Power = XXX.X%
D	Decreases the present laser power setpoint by 0.5% of full scale	Power = XXX.X%
Q	Queries the value of the present laser power setpoint (in % of full scale)	Power = XXX.X%
F	Resets laser power setpoint to factory default value	Power = XXX.X%
B	Saves present settings to flash memory. This command should be issued after the settings are at their desired values. If not, changes will be lost if power to the EQ-400 is interrupted.	Calibration data copied to FLASH Memory.
H	Query bulb operating time	Bulb time = XXXX secs
Z	Zero bulb operating time	Send 'z' within 10 sec. to confirm.
z	Confirm zeroing of bulb time	Bulb hours zeroed & flash saved
L	Query laser operating time	Laser time = XXXX secs
T	Query lamphead temperature	LH temp = XX.X degC
S	Query system status. Returns a 16-bit decimal number representing the present system status. See below for bit mapping.	0 to 65535
?	Displays a help menu listing the available commands	EQ400 firmware vXXX build date mm/dd/yyyy (c) Energetiq Technology, Inc. U/D Inc/Dec laser pwr (by 0.5% full scale) Q Query laser pwr setpoint F Reset laser pwr to default B Burn settings to flash memory H Query bulb operating hrs Z Zero bulb operating hrs z (confirm above within 10 sec) L Query laser operating hrs T Query lamphead temp S Query system status ? This menu

Table 5: Serial Interface Commands

Bit #	Definition
0 (LSB)	Fault status: 1 = one or more faults present, 0 = no faults
1	Laser status: 1 = on, 0 = off
2	Lamp status: 1 = on, 0 = off
3	Laser temperature: 1 = overtemperature, 0 = OK
4	Laser power supply voltage: 1 = out of range, 0 = OK
5	Laser current source: 1 = fault, 0 = OK
6	Lamphead temperature: 1 = overtemperature, 0 = OK
7	PCU temperature: 1 = overtemperature, 0 = OK
8	Lamphead interlock: 1 = open, 0 = OK
9	External interlock: 1 = open, 0 = OK
10	PCU cover interlock: 1 = open, 0 = OK
11	Laser photodiode signal: 1 = low, 0 = OK
12	Lamp photodiode signal: 1 = low, 0 = OK
13	Ignition status: 1 = failed to ignite, 0 = OK
14	System control mode: 1 = remote, 0 = local
15	Reserved – always 0

Table 6: System Status Word

Appendix A

ENGINEERING DRAWINGS

The following engineering drawings are included for reference.

Drawing number	Revision	Title
OTD-8159	1	EQ-400 Lamp Housing Outline
OTD-8198	2	EQ-400 Power Supply Assembly

Appendix B

REVISION HISTORY

Date	Revision	Description
07 September 2016	Prelim	Preliminary version
23 January 2017	1	Initial release
08 February 2017	2	Added protective housing label and additional safety information
10 February 2017	3	Updated labeling information
7 September 2017	4	Miscellaneous edits
20 October 2017	5	Added serial interface description
12 March 2018	6	Error corrections, spec. clarifications, CE declaration
April 2018	7	CE declaration

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