Model EQ-77
LDLS™
Laser-Driven Light Source

Operation Manual

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Part Number DOC-7070

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-77 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
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

Signed for and on behalf of:

Energetiq Technology, Inc.
Woburn, Massachusetts USA 13 October 2017

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-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

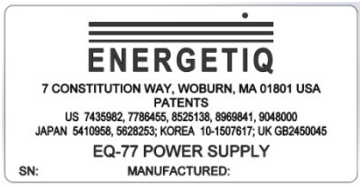
No regular maintenance is required for the EQ-77. Any service to the system must be performed only by factory authorized and trained technicians. To avoid injury, under no circumstances should the user open or modify the Lamp House or Power Supply Controller enclosure.

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

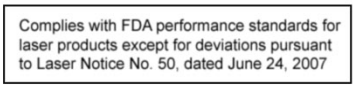
The following safety labels appear on the product. Figure 1 shows the location of each label on the EQ-77 system.

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.

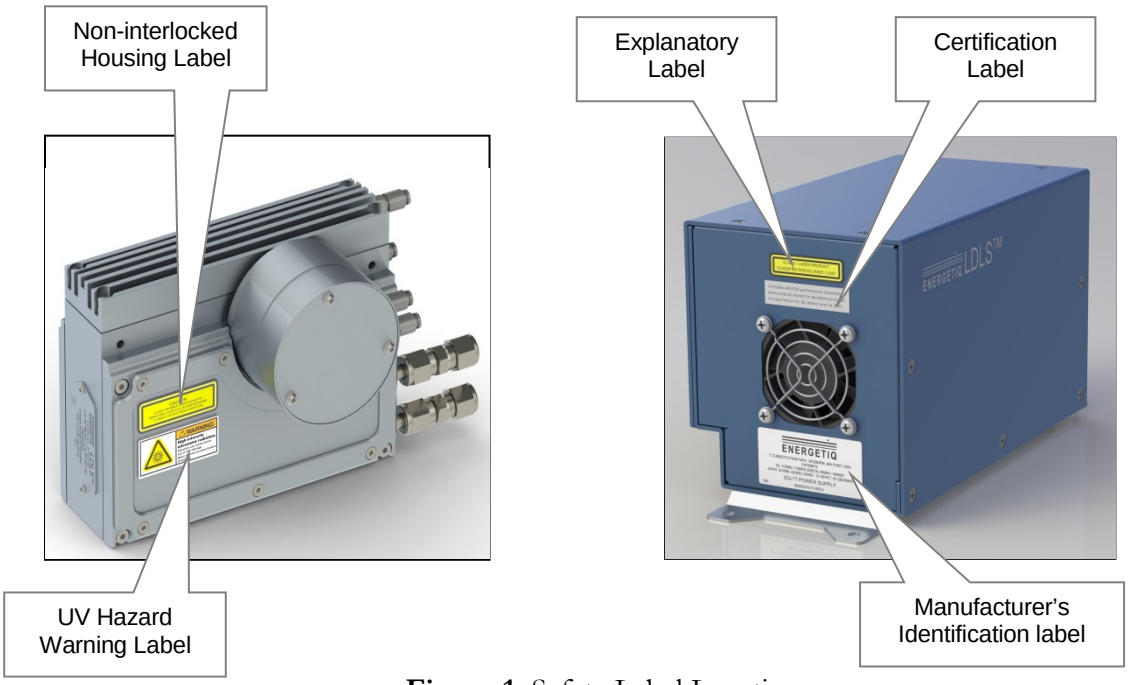


Figure 1: Safety Label Locations

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.

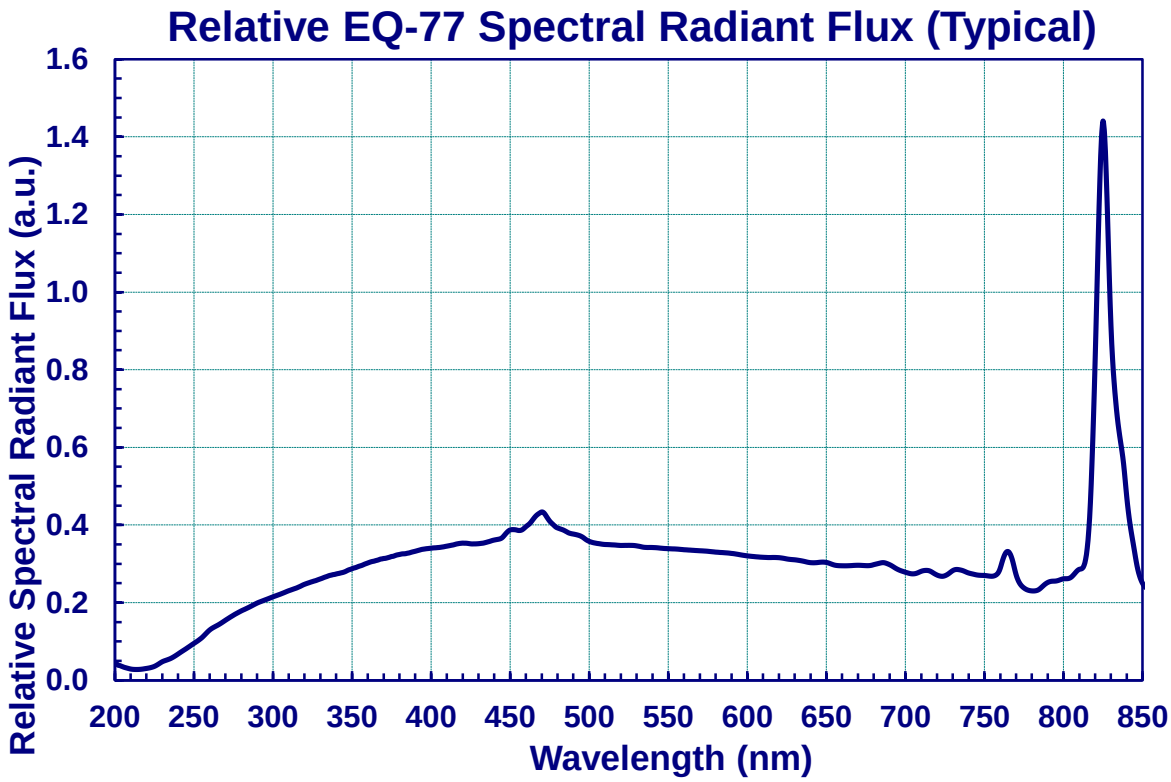


Figure 2: Typical Output Spectrum

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.

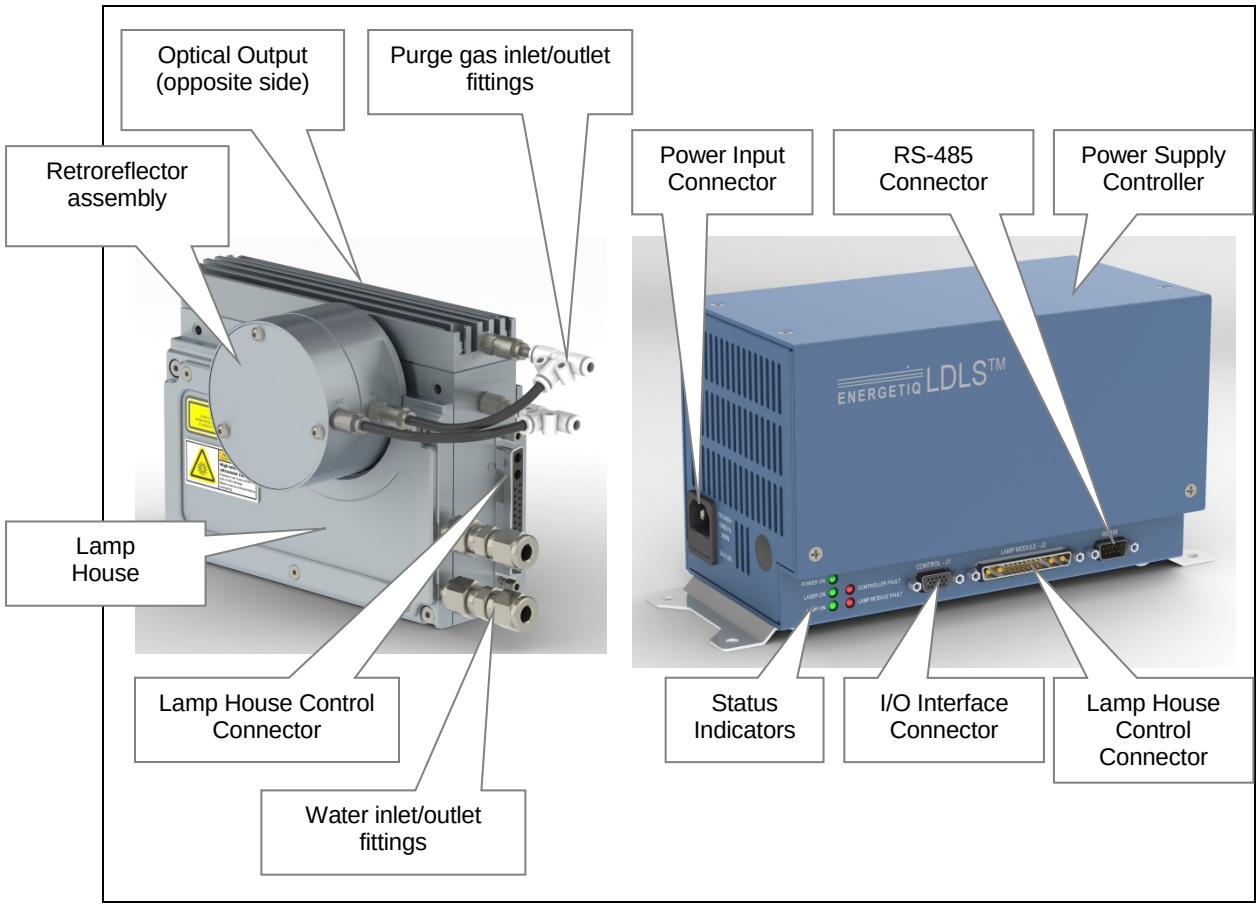


Figure 3: EQ-77 Lamp System

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

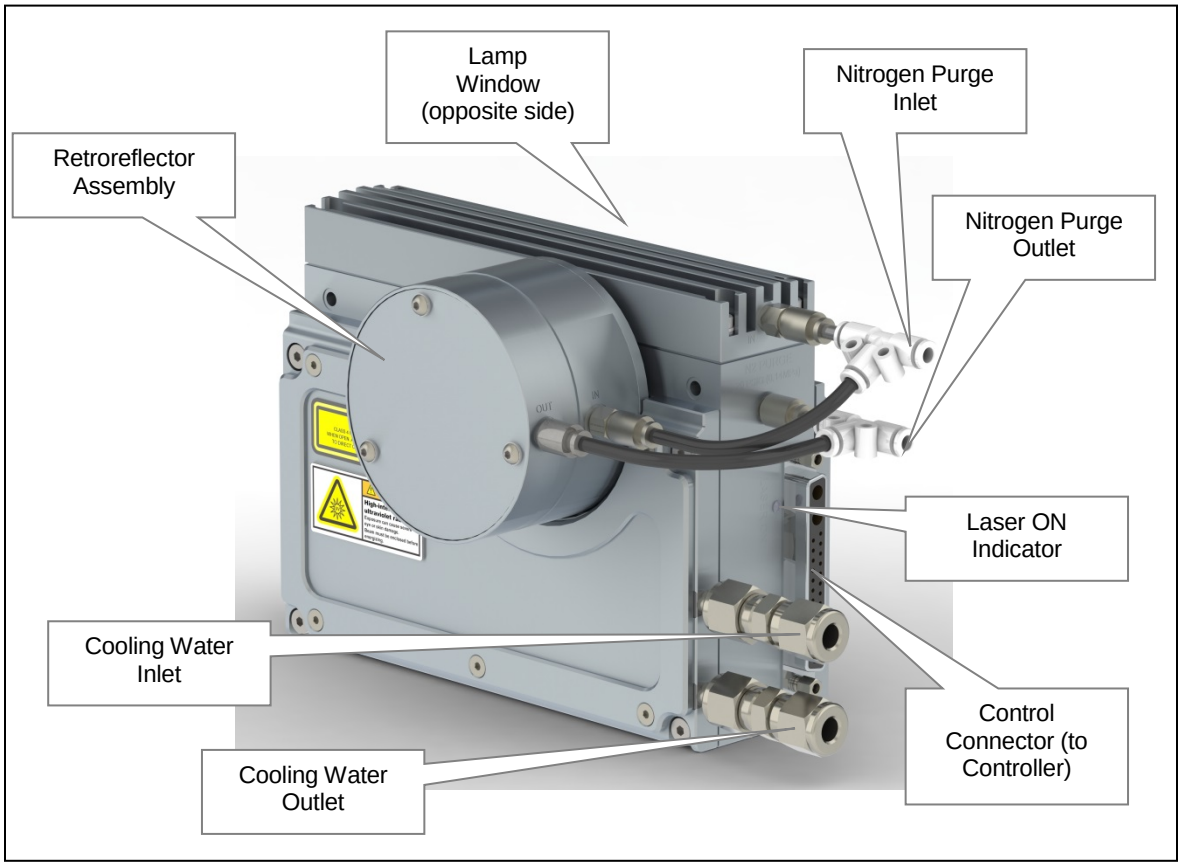


Figure 4: Lamp House Assembly

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.

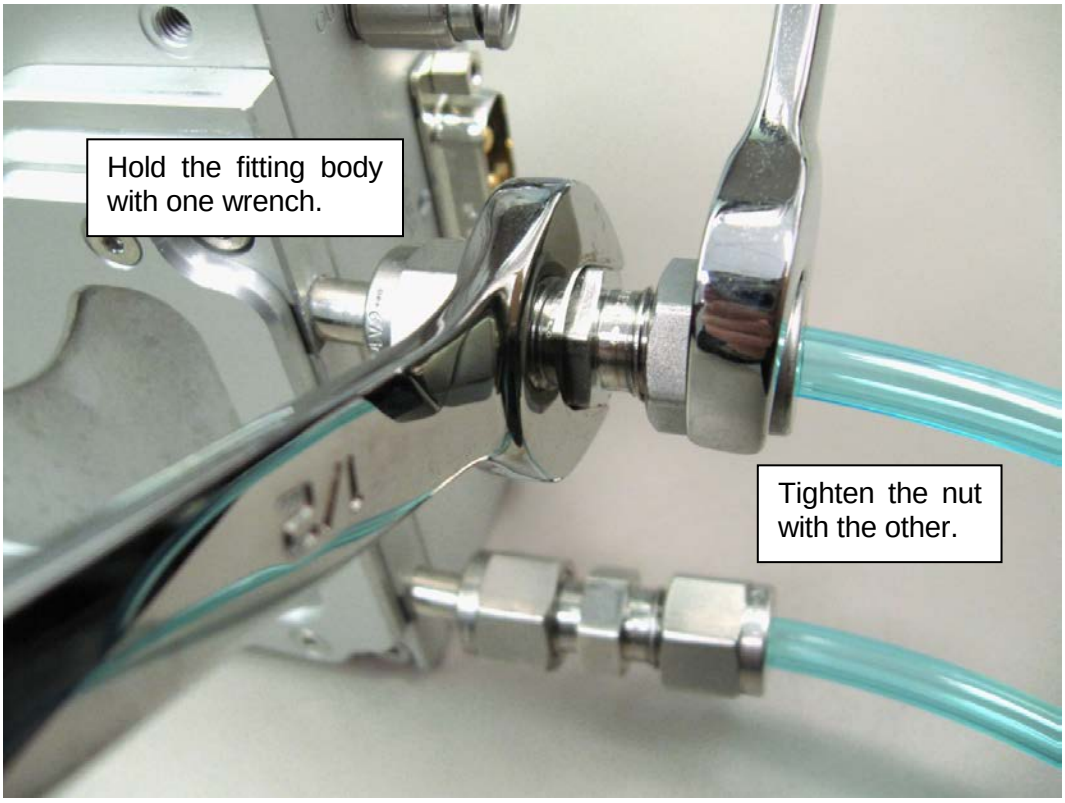


Figure 5: Water fittings

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.

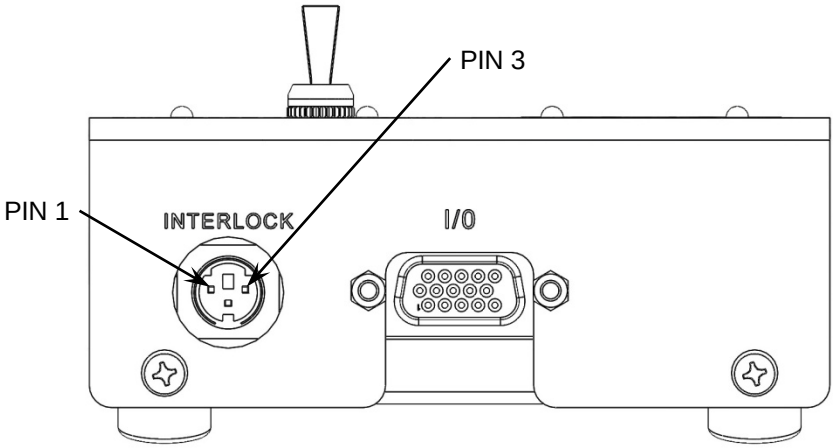


Figure 6: EQ-99-RC Remote Control Rear Panel

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.

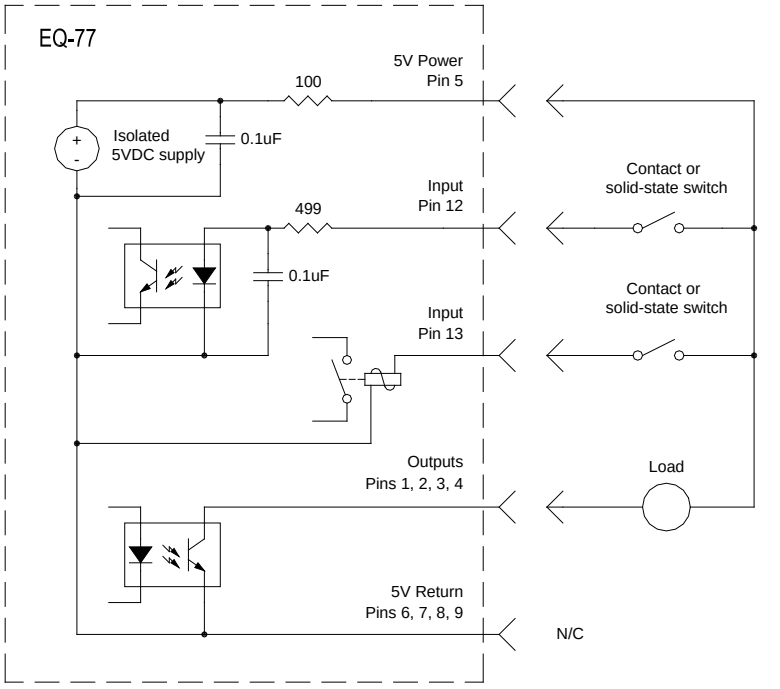
Port settings are 9600 bps, 8 data bits, 1 stop bit, no parity, no handshaking.

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

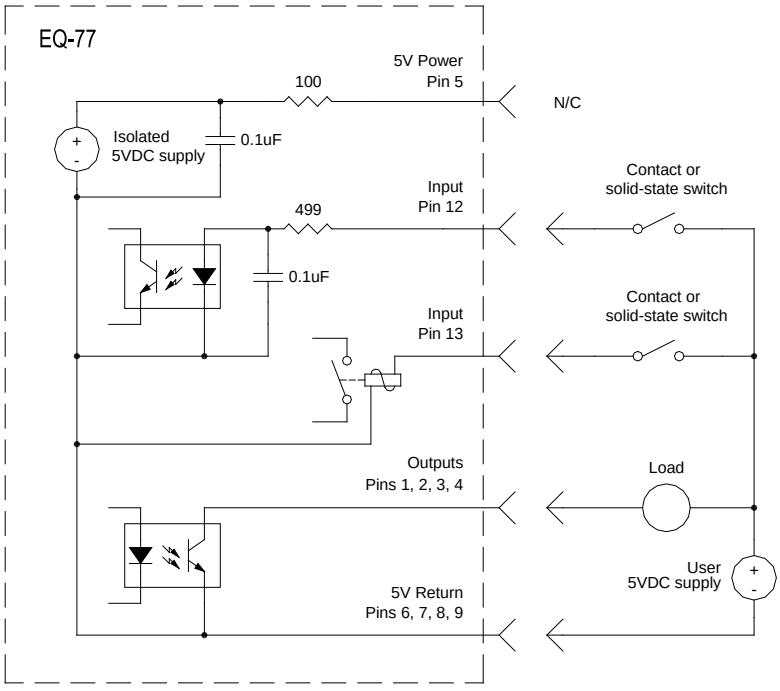
Table 3: I/O Connector Pin Assignment

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

Fault Indicator Block Diagram

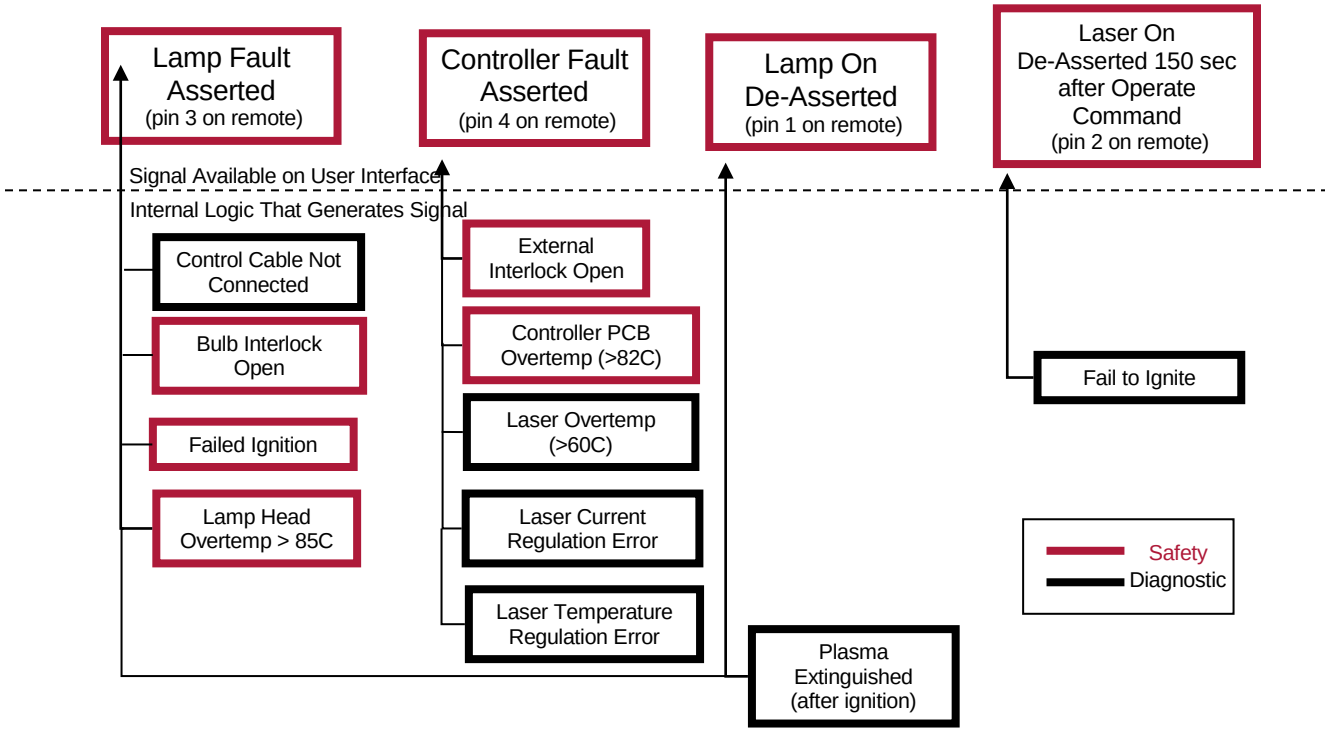


Figure 8: Fault Indicator Block Diagram

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

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.
26 January 2018	4	Updated CE Mark, Logo, Page footer format

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