

Laser-Driven Light Source (LDLS®)

Models: EQ-77 & EQ-77X



Operation Manual

Revision 5

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Energetiq Laser-Driven Light Source (LDLS®) products are designed to be RoHS and REACH compliant and possess a CE marking. For a list of compliance documentation, including the Declaration of Conformity, visit www.energetiq.com/compliance.

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Chapter 1. Safety and Warranty Information

1.1 Safety Warnings

The EQ-77X system is a Class 1 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.

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

This product is designed and tested for use in an industrial environment. If this product is used in residential areas, EMI (electro-magnetic interference) may occur. This product must not be used in residential areas.

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

WARNING



This system emits ultraviolet (UV) radiation that is harmful to humans. Avoid exposure to the direct or reflected output beam. Ensure 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-77X system 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-77X system LDLS 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.

WARNING

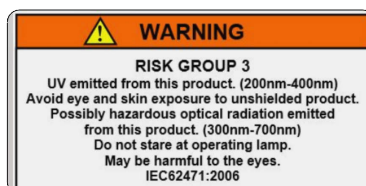


- If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired. Energetiq is not liable for damage or losses resulting from failure to comply with precautions or instructions listed in this manual.
- The power supply must be properly grounded by the outlet to prevent electrical shocks.
- Securely plug in the power supply connector to avoid looseness or play. Loose connections may result in faulty operation.
- This AC power cable supplied is for the EQ-77X system only. This AC cord cannot be used with other electrical equipment. The power shutdown mechanism of this laser unit functions via the AC power cable. Do not arrange the equipment in such a way that becomes difficult to connect or disconnect the AC power cable.

WARNING



When working near the emitted light, always wear protective devices (conforming to ISO 4007/4849/4850/4854/4855 or equivalent regulations). The lamp installed in this housing emits intense ultraviolet rays, which are harmful to the eyes and skin. Looking directly into the emitted light or allowing the light to fall on the skin will damage eyesight or cause skin burns. The following label indicates hazardous radiation:



1.2 General Precautions

The output beam from the EQ-77X system 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. Energetiq recommends purging any beam transport space with dry nitrogen gas.

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

See [Chapter 4. Installation](#) for details of the facilities connections.

There are no user-serviceable parts inside the EQ-77X system. For any problems encountered during operation, please contact Energetiq for assistance. **If there is a component failure, do not attempt to open the LDLS controller or lamp head enclosure of the EQ-77X system.**

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

Do not open the enclosure of either the lamp head enclosure or the LDLS 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.

1.3 Laser Information

The EQ-77X system uses a patented laser drive system to excite a plasma that radiates in the UV as well as the visible bands. Visit www.energetiq.com/patents for a list of Energetiq product patents. A Class 4 laser is located in the lamp head enclosure. The optical configuration of the lamp head ensures that the direct laser beam cannot exit the unit. The EQ-77X system is designated as Class 1 during all normal operation.

The parameters of the non-accessible internal laser are given below in the table [Embedded Laser Parameters](#).

Table 1. Embedded Laser Parameters

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

1.4 Labels and Safety Notifications

The following safety labels appear on the product. The figure [EQ-77X Safety Label Locations](#) shows the location of each label on the EQ-77X system system and the table [Safety Label Meanings](#) describes their meanings.

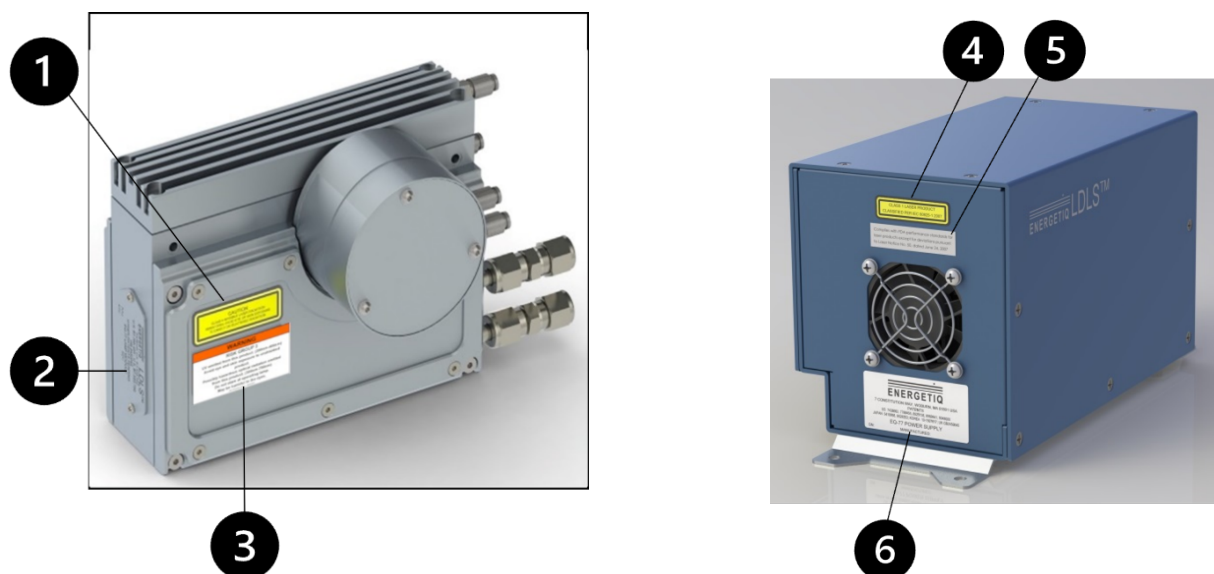




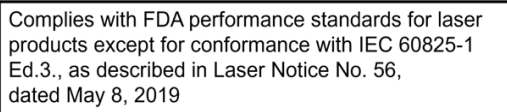



Figure 1. EQ-77X Safety Label Locations

Table 2. Safety Label Meanings

Label #	Label Picture	Description
1		Non-interlocked housing label – notifies of a potential hazard when covers are removed
2		Manufacturer's identification label on lamp house – gives the manufacturer's name and address, and the model, serial number, and date of manufacture of the equipment.
3		UV Hazard warning label – indicates hazardous levels of UV light are present.
4		Explanatory label – states the classification of the laser product. Class 1 is the lowest hazard level classification.
5		Certification label – states that the equipment has been tested and verified to meet the standards indicated

Label #	Label Picture	Description
6		Manufacturer's identification label on LDLS controller—gives the manufacturer's name and address, and the model, serial number, and date of manufacture of the equipment.

1.5 Safety Interlocks

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

1. Lamp bulb is not properly installed in the lamp head.
2. The laser fiber is not properly connected to the lamp head.
3. An external interlock is open.

1.5.1 External Interlock

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

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.

1.6 Warranty

For information on your EQ-77X system's warranty, [contact your local distribution representative](#).

1.7 Correct Disposal of the Unit

When the EQ-77X system has finally been removed from service, observe all local environmental regulations for proper disposal.

1.8 EMC Compliance Standards

- **IEC 61326-1 Emission Limits:** CISPR 11, Group 1, Class A
- **Immunity Requirements:** Table 2
- **Performance Level:**

- **Criteria A**

Light output	Light output remains above 80% and does not turn off.
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- **Criteria B**

Light output	Light output remains above 50% and does not turn off.
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◦ **Criteria C**

Light output	Even if the light turns off, it can be turned on again by manual operation of the operator.
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Chapter 2. System Description

2.1 System Description

This manual describes both the EQ-77 and EQ-77X models of the EQ-77X Laser-Driven Light Source (LDLS®). Unless otherwise noted, these products will be collectively referred to as the EQ-77X system.

The EQ-77X system is a broadband lamp system for use in a wide variety of applications. The lamp produces high brightness, broadband 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-77X system include:

- Very high brightness across complete spectrum
 - 190 nm 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-77X system consists of an LDLS controller, lamp head, and interconnecting cable. Connection to AC power is required for operation. Connection to cooling fluid is required. Connection to nitrogen purge gas is strongly recommended for best performance.

For additional information, contact Energetiq Technology Technical Support Services at +1-781-939-0763 x111 or email: service@Energetiq.com.

2.2 Description of System Components

The EQ-77X system consists of an LDLS controller, lamp head, controller-to-lamp-head 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.



Figure 2. LDLS Controller

Table 3. LDLS Controller Components

#	Component	Description
1	Power input connector	This is an IEC 320 inlet connector for AC power input. See 3.3 Utility Requirements for detailed information.
2	Status indicator	See the table Status Indicator LED Functions for a list of descriptions.
3	I/O Interface connector	Provides access to control and status signals.
4	Lamp control connector (21-pin mixed D-sub)	Provides various power and control signals to/from the lamp head module. No other connector or cable may be used with the EQ-77X system other than the one supplied.
5	RS-485 Connector (9-pin D-sub)	Connector for optional RS-485 interface. See Appendix A. RS-485 Interface Commands and Pin Assignments for electrical details and commands.

Located on the EQ-77X system controller front panel are LED system status indicators. The function of these indicators is described below in the table [Status Indicator LED Functions](#).

Table 4. Status Indicator LED Functions

LED Label	Meaning (When Lit)
POWER ON	AC power is connected to the LDLS controller
LAMP ON	UV Light is on

LED Label	Meaning (When Lit)
LASER ON	Laser power is ON and laser light is being produced within the lamp head
CONTROLLER FAULT	One of the following has occurred in the LDLS controller: <ul style="list-style-type: none">• External interlock open• Controller internal temperature too high• Laser power not reaching setpoint• Laser temperature fault• Internal power supply voltage low
LAMP MODULE FAULT	One of the following has occurred in the lamp head: <ul style="list-style-type: none">• Control cable not connected properly• Lamp head internal temperature too high• Ignition failure

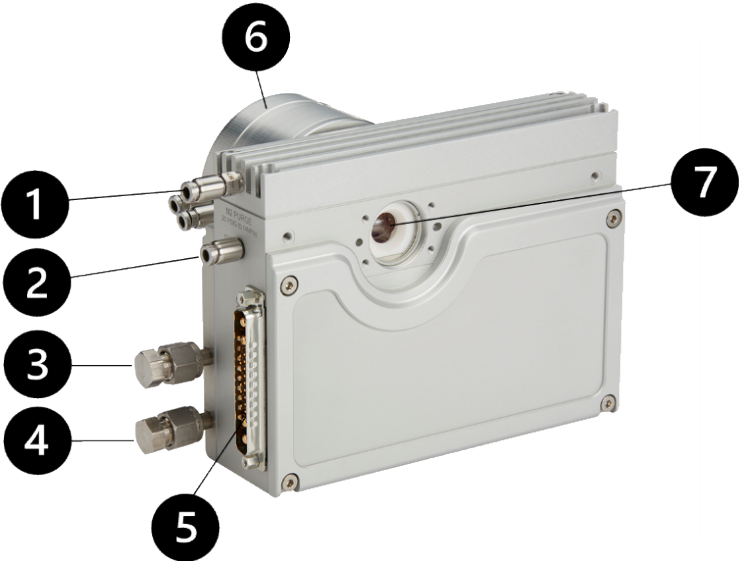


Figure 3. Lamp Head

Table 5. Lamp Head Components

#	Component	Description
1	Nitrogen Purge Inlet	These are the fittings for the nitrogen purge gas. Product use without nitrogen purge gas will result in the buildup of ozone (from atmospheric oxygen) and attenuate the light output in the 220-280 nm band, as well as below 200 nm in the presence of atmospheric oxygen and water vapor.
2	Nitrogen Purge Outlet	

#	Component	Description
3	Cooling Fluid Inlet	These fittings are for connection of cooling fluid required by the lamp.
4	Cooling Fluid Outlet	
5	Control Connector (21-pin mixed D-sub)	Provides various power and control signals to/from the LDLS controller. No other connector or cable may be used with the EQ-77X system other than the one supplied.
6	Retroreflector Assembly	Reflects radiation back to the light source.
7	Lamp Window	The lamp windows at the optical output provide protection from the high-pressure bulb inside the lamp head. An internally-threaded SM1 adapter is provided for easy connection of optical hardware.

Chapter 3. System Specifications and Requirements

3.1 Physical Specifications

Dimensions (H x W x D)

- **Lamp Head:** 125 x 209 x 94 mm (5.0 x 8.3 x 3.7 in)
- **LDLS Controller:** 156 x 299 x 132 mm (6.2 x 11.8 x 5.2 in)

Weight

- **Lamp Head:** 2.2 kg (4.9 lb)
- **LDLS Controller:** 2.9 kg (6.5 lb)

3.2 Remote Interface

Digital Inputs

- **Type:** Optocoupler LED
- **Logic:** Active High
- **Input Voltage:** 5V DC
- **Input Current:** 8 mA

External Interlock Input Only (pin 13)

- **Type:** Relay Coil
- **Logic:** Active High
- **Input Voltage:** 5V DC
- **Input Current:** 80mA

Digital Outputs

- **Type:** Open collector to ground (digital common)
- **Logic:** Active Low
- **Voltage:** 30V DC max
- **Sink Current:** 8mA max

Power

- **Voltage:** 5V DC, referenced to digital common
- **Current:** 50 mA maximum

3.3 Utility Requirements

- **Electrical:** 100 – 240 V~ +/- 10%, 50/60 Hz, 350 W (Fuse:F5AL250V)
- **Purge Gas:** Optional (strongly recommended). Clean dry nitrogen, filtered to 5 um 20 psig (0.14 MPa) supply pressure.

- With no purge, ozone will form from atmospheric oxygen and attenuate the light output in the 220 – 280 nm band. This will reduce the lamp bulb's overall lifetime. In addition, atmospheric oxygen and water vapor will attenuate the output below 200 nm.
- Clean and dry nitrogen from either a dewar or research-grade N2 bottle is recommended. Do not use any other purge gas.
- Grade 4.8 or better gas purity is recommended to maintain cleanliness of the optics.
- With a 20 psig inlet pressure, the EQ-77X system will consume approximately 1 slm of flow.
- **Cooling Fluid:** Required. ≥ 0.5 liter/minute, 18 – 25 °C, 100 psig (0.69 MPa) max. inlet pressure
 - **Fittings:** ¼ inch Swagelok

3.4 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:** Pollution Degree 2 (normally only non-conductive pollution; occasional, temporary condensation possible).
- **Installation Category:** Installation Category II
- **Overvoltage Category:** Overvoltage Category II
- **Indoor/Outdoor Use:** Indoor use only.
- **Operating Altitude:** 2,000 m max.
- **IP Code:** IP Code IP20

Transport

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

Chapter 4. Installation

4.1 Unpacking the System



Upon arrival, inspect all parts of the EQ-77X system for completeness and damage incurred in shipping. Use care when unpacking to avoid damaging the laser fiber optic cable.


If any part is missing or appears damaged, contact Energetiq immediately. Do not attempt to substitute any parts.

At a minimum, the EQ-77X system shipping box contains the following required items:

4.1.1 Required Contents

Table 6. Required Contents of Shipping Box

Qty	Item Description	Picture
1	LDLS controller	
1	Lamp head	

Qty	Item Description	Picture
1	Black interconnecting cable from lamp head to LDLS controller (21 pin mini D-sub)	

4.1.2 Optional Accessories

The EQ-77X system shipping box may also contain the following optional accessories available from Energetiq:

Table 7. Optional Accessories in Shipping Box

Qty	Item Description	Picture
1	Energetiq EQ-99-RC Remote Control with interlock jumper plug and 15-pin D-connector I/O cable	
1	AC power cable <ul style="list-style-type: none"> • NA AC Cable – Assmann model no. AK500/U-1 • EU AC Cable – Qualtek model no. 364002-D01 	

4.2 Installation Procedure

The following section details how to install the EQ-77X system.

Caution: Operating the source without any output target or beam transport is not recommended and may lead to unsafe operating conditions. Similarly, mounting the lamp head in an orientation that differs from its original factory alignment will cause the plasma position inside the bulb to shift slightly and may cause problems with performance and system lifespan. Consult Energetiq for applications information and suggested configurations.

To install the EQ-77X system:

1. Mount the LDLS controller to an optical breadboard plate or other suitable mounting structure using the four supplied holes in the tabs on the bottom of the chassis. Ensure the inlet and outlet air vents of the LDLS controller are not blocked.

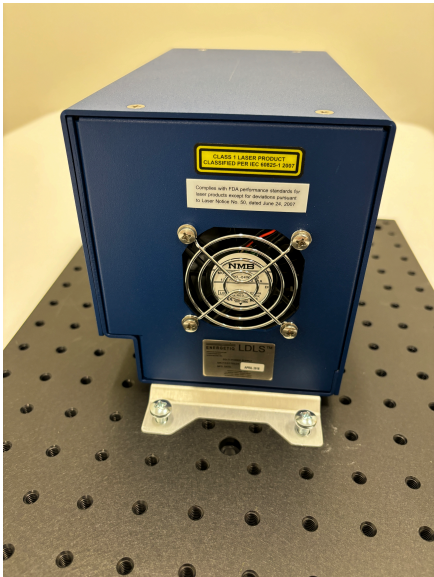


Figure 4. Mounting the LDLS Controller

Note: The tab holes are sized to accept standard $\frac{1}{4}$ "-20 optical bench hardware and spaced to be compatible with a standard 1" grid mounting hole pattern.

2. Mount the lamp head so that the lamp output window is facing outward as shown in the figure below. Four threaded holes on the bottom of the lamp head are available for mounting.

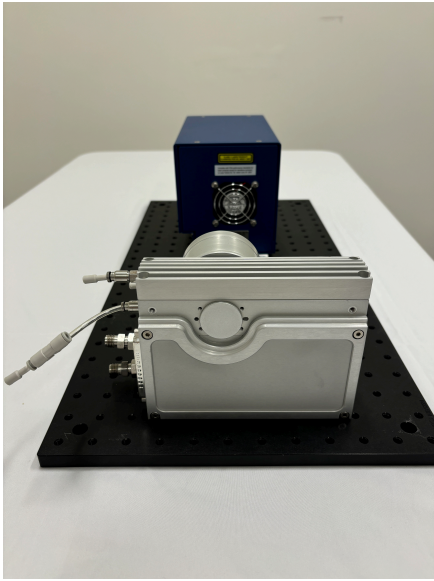


Figure 5. Mounting the Lamp Head

3. Connect the lamp head to the user equipment and set up the lamp head with appropriate ultraviolet safety measures in place. It is recommended that any enclosure or aperture-blocking hardware utilizes switches wired to the EQ-77X system external interlock circuit.
4. Connect the black 21-pin mixed D-sub interconnect cable from the LDLS controller to the lamp head.

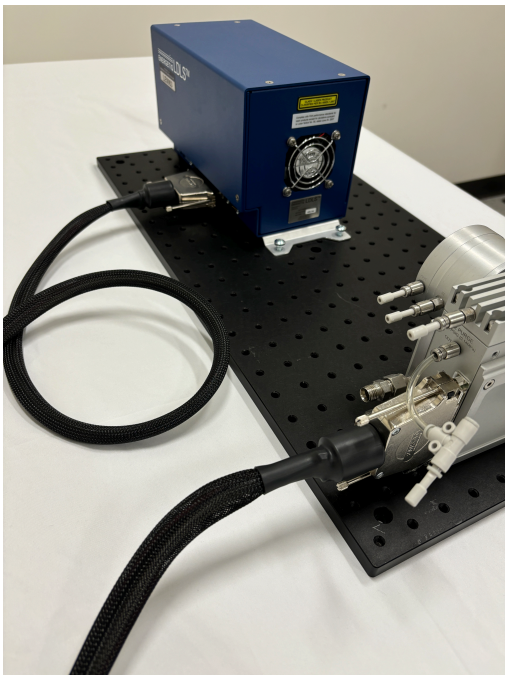


Figure 6. Connecting the Lamp Interconnect Cable

5. If using purge gas, connect a source of nitrogen purge gas to the port on the lamp head. The fitting is a push-to-connect type, sized for 4 mm tubing. Refer to [3.3 Utility Requirements](#) for more information.

- Place the EQ-99-RC remote control on a clean, rigid surface. Install the supplied 15-pin I/O cable from the LDLS controller to the EQ-99-RC remote control.

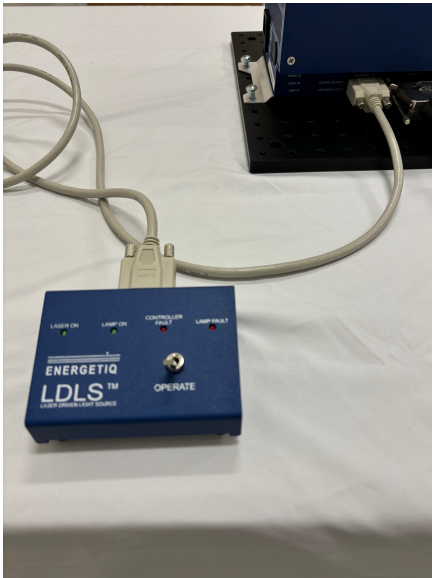


Figure 7. Connecting the I/O Cable to Remote Control

On the back of the remote control, insert the interlock jumper plug into the interlock port.



Figure 8. Inserting the Interlock Jumper Plug

Alternatively, if you are integrating the EQ-77X system into your own interlock system, connect a remote contact or solid-state switch across pins 1 and 3 in the interlock port.

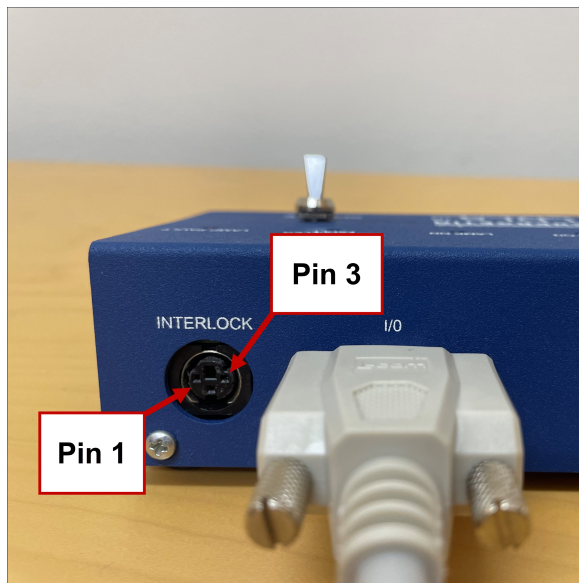


Figure 9. Interlock Pin Locations

If using another remote control system, see for more information.

7. If using the optional RS-485 interface, connect the host computer to the RS-485 port on the LDLS controller.
8. Connect the cooling fluid chiller to the lamp head.

Care must be taken when making connections to the lamp head 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. 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.

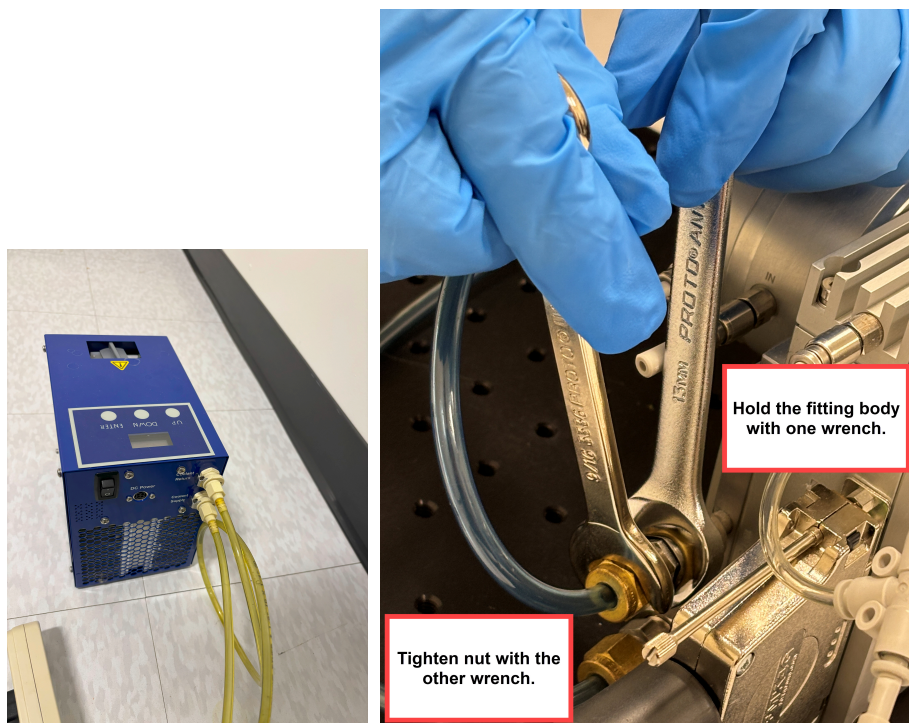


Figure 10. Cooling Fluid Chiller Fittings

9. Connect the cooling fluid chiller power cable to the chiller and a power outlet.



Figure 11. Connecting Chiller Power Cable

10. Connect the AC power cable to the LDLS controller and a power outlet.



Figure 12. Connecting the AC Input Power Source

The system is now ready to operate.

4.3 Installing Alternative Remote Control

If you are using a or a remote control other than the EQ-99-RC Remote Control, the following section details how to install an alternative remote control for the EQ-77X system.

The EQ-77X system is controlled through the remote I/O port.

The table [I/O Port Pin Assignments](#) gives the pin assignments and functions for this interface. Connect to the user's control system using a suitable cable. The 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 to the I/O port 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 the figure [EQ-99-RC Remote Control Rear Panel](#) for pin connections.

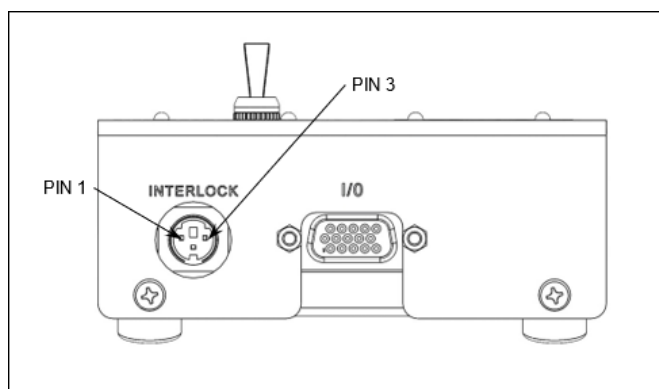


Figure 13. EQ-99-RC Remote Control Rear Panel

Table 8. I/O Port Pin Assignments

Description	Pin #	Details
Commands (Inputs)		
LAMP OPERATE	12	OPERATE REQUEST, apply +5V (referenced to digital common) to initiate ignition
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

Description	Pin #	Details
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, 11, 14, 15	Do not connect

The user's remote I/O port can be powered either by the EQ-77X system internal isolated power supply, or an external supply.

The figure [Remote Interface Schematic](#) below shows connection schematics for both configurations.

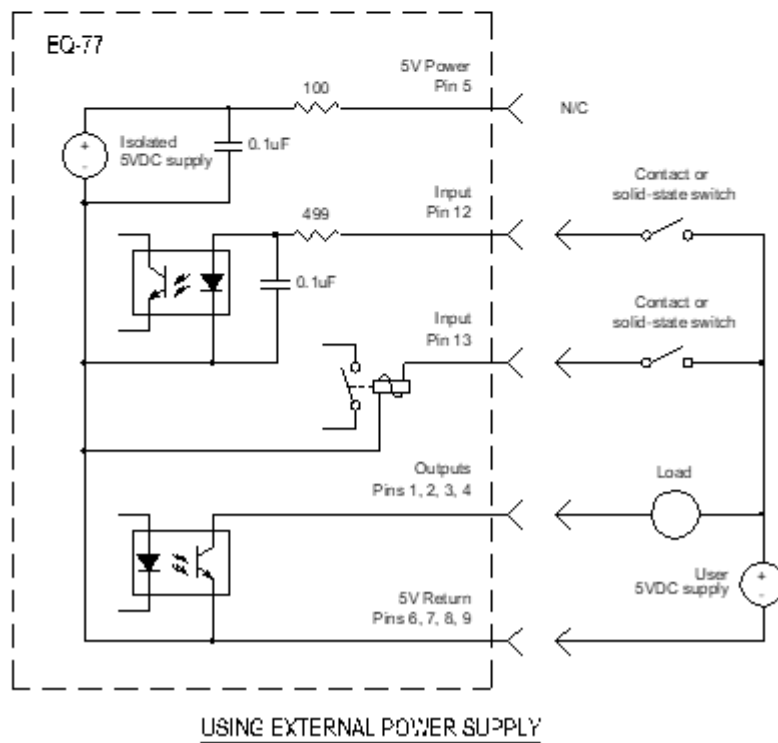
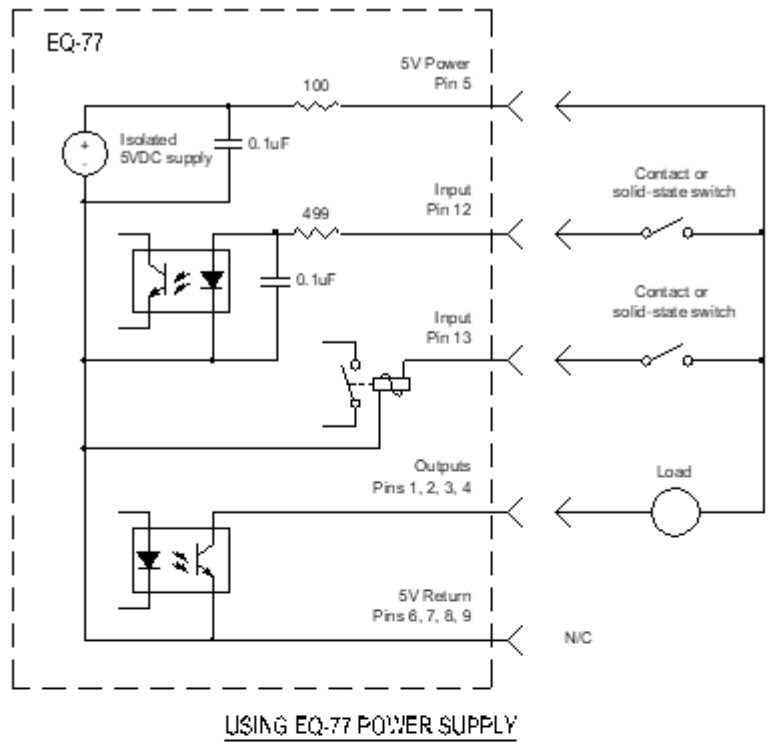


Figure 14. Remote Interface Schematic

4.4 Chiller Information

The EQ-77X system requires a chiller to maintain the cooling requirements in [3.3 Utility Requirements](#). For your convenience, Energetiq offers a suitable chiller produced by Solid State Cooling, Inc. You may also choose to procure a chiller directly through your local Solid State Cooling, Inc representative (SSC Model U190 W Chiller).

Table 9. EQ-77X system System Accessories

Part Number	Description
EQ-77-CHILLER-KIT	EQ-77 Chiller with Tubing Kit

Note: Cooling fluid is not included and must be locally sourced.

Chapter 5. Operating the System

5.1 Starting the System

Caution: Once the EQ-77X system is properly set up, verify that all personnel that will be in contact with the system are aware of the potential hazards involved as described in [Chapter 1. Safety and Warranty Information](#). It is the responsibility of the user to verify that the EQ-77X system is safely being used.

This section assumes you are using of the EQ-99-RC Remote Control to provide local control. If using an alternative control system, substitute the appropriate digital input and output lines from the table [I/O Port Pin Assignments](#) for the switches and LEDs described below.

1. On the back of the cooling fluid chiller, press the power switch to turn on the chiller.



Figure 15. Turning on Chiller Power

2. On the top of the chiller, use the UP and DOWN buttons to set the temperature of the cooling fluid. When the desired temperature is selected, press **ENTER** to set the chiller temperature.

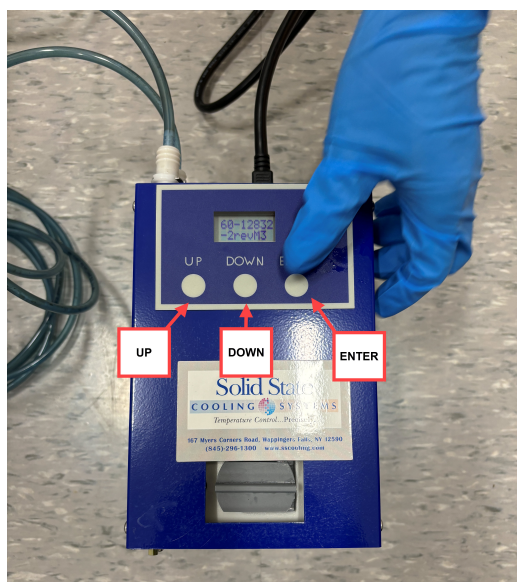


Figure 16. Setting Chiller Temperature

3. Review the status LEDs on the LDLS controller. The POWER ON LED should be lit, and neither the CONTROLLER FAULT nor LAMP MODULE FAULT LEDs should be lit.



Figure 17. LDLS Controller "POWER ON" LED Illuminated

4. On the EQ-99-RC Remote Control, turn the OPERATE switch ON by placing the switch in the "up" position. The LASER ON LED light illuminates, and laser light is now present in the lamp head.

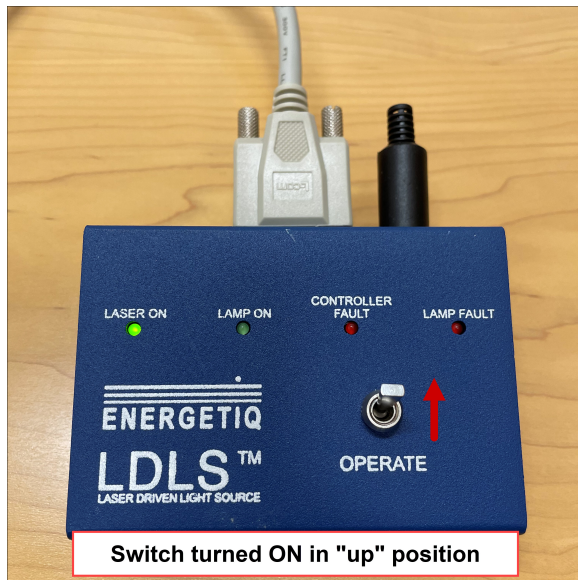


Figure 18. LASER ON LED Illuminated

5. In approximately 20-150 seconds, the igniter automatically turns on and the plasma ignites. The LAMP ON LED light illuminates.



Figure 19. LAMP ON LED Illuminated

6. Allow the EQ-77X system to warm up for 30 minutes.

The system is now ready to be used.

Notes:

- The duration of time needed for the plasma to ignite (20-150 seconds) will depend on the temperature and previous operating condition of the EQ-77X system. The EQ-77X system will automatically detect when the

unit has reached the optimum conditions for ignition.

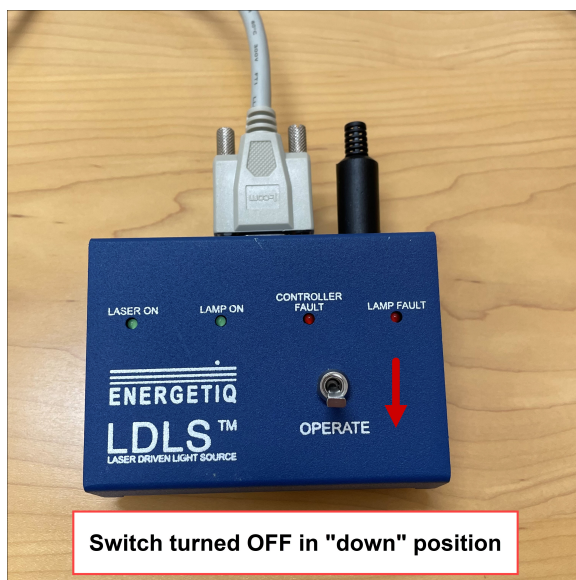
– If a bulb fails to ignite, 150 seconds after the OPERATE switch is turned ON:

- the LASER ON LED will be OFF.
- the LAMP FAULT LED will be ON.
- the LAMP ON LED will remain OFF.

This is very unusual. However, if this occurs, turn the OPERATE switch to the OFF position ("down" position) and restart this procedure at Step 1. If this issue occurs multiple times, see [Chapter 7. Troubleshooting](#) or contact Energetiq's Service department.

5.2 Stopping the System

1. To turn the EQ-77X system OFF, simply turn the OPERATE switch OFF by placing the EQ-99-RC Remote Control switch in the "down" position.



2. If the system will not be used for some time, turn the power supply off.

Note: To minimize wear on the ignition components, it is best to avoid frequently starting and stopping the EQ-77X system. It is recommended to run the system continuously rather than turn the system off and on several times in one day.

Chapter 6. Maintenance

6.1 Lamp Bulb Replacement

If a bad lamp bulb is suspected in the EQ-77X system, contact Energetiq for more information on having the lamp bulb replaced.

Chapter 7. Troubleshooting

As shown in the figure [LDLS Controller LED Lights](#) below, there are five LED lights on the side of the LDLS controller that indicate the current status of the EQ-77X system.



Figure 20. LDLS Controller LED Lights

During normal operation, the three green LED lights (POWER ON, LASER ON, LAMP ON) should be turned **ON**. The red LED light (SYSTEM FAULT!) should be turned **OFF**.

In the event that a green LED light turns **OFF** or a red LED light turns **ON** during normal operation, see the following section for a list of potential issues and remedies.

7.1 Issues and Remedies

See below for a list of possible issues that may be encountered while operating the EQ-77X system and the potential steps to resolve those issues.

Table 10. Possible Issues and Remedies

LED Light Name and Status	Possible Issues	Troubleshooting Steps
LAMP MODULE FAULT is ON	<p>One of the following has occurred in the lamp head:</p> <ol style="list-style-type: none"> 1. A control cable is not connected. 2. The lamp head has overheated (above 85 °C). 3. The laser subminiature assembly (SMA) is not connected. 4. The lamp bulb is not properly installed. 5. There was a failure to ignite the plasma inside the lamp bulb, or the plasma inside the lamp bulb has been extinguished after ignition. This also causes the LAMP ON light to turn OFF and LASER ON light to turn OFF. 	<ol style="list-style-type: none"> 1. Clear the fault lights by toggling the EQ-99-RC Remote Control between the ON and OFF positions. The EQ-77X system will not start if a fault condition exists. 2. Confirm that the black jumper plug is fully inserted into the back of the EQ-99-RC Remote Control (or, if using another remote control, confirm that the external interlock contact is closed). 3. Check that the bulb and laser fiber optic cable are properly connected to the lamp head. 4. If either the LAMP MODULE FAULT or CONTROLLER FAULT light will still not clear, contact Energetiq.
CONTROLLER FAULT is ON	<p>One of the following has occurred in the LDLS controller:</p> <ol style="list-style-type: none"> 1. An external interlock is open. 2. The LDLS controller printed circuit board has overheated (above 82 °C). 3. The laser has overheated (above 66 °C). 4. There is a regulation error with the laser current. 5. There is a regulation error with the laser temperature. 6. There is a laser failure. 	

LED Light Name and Status	Possible Issues	Troubleshooting Steps
LAMP ON is OFF	The plasma inside the lamp bulb has been extinguished after ignition. This also causes the LAMP MODULE FAULT light to turn ON and LASER ON light to turn OFF .	If the lamp bulb fails to ignite after several attempts, contact Energetiq.
LASER ON is OFF	There was a failure to ignite the plasma inside the lamp bulb. This also causes the LAMP MODULE FAULT light to turn ON and LAMP ON light to turn OFF .	

Appendix A. RS-485 Interface Commands and Pin Assignments

The RS-485 serial interface is provided for user adjustment of laser operating power, in order to increase or decrease light output. The EQ-77X system lamp head 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-77X system via a terminal emulation program, or the user's control system. Response from the EQ-77X system will be a string of ASCII characters, format depending on the command issued.

The following table describes the serial commands and their functions.

Table 11. Serial Commands and Functions

Command Character	Function	Reply from EQ-77X system
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-77X system is interrupted.	Calibration data copied to FLASH Memory.
H	Queries the bulb operating hours	XXXX.X hours
Z	Zeroes the bulb operating hours	Send 'z' within 10 sec. to confirm
z	(Confirm zero within 10 sec)	Bulb hours zeroed & flash saved

Command Character	Function	Reply from EQ-77X system
?	Displays a help menu listing the available 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 H – Query bulb operating hours Z – Zero bulb operating hours z – (Confirm zero within 10 sec) ? – This help menu

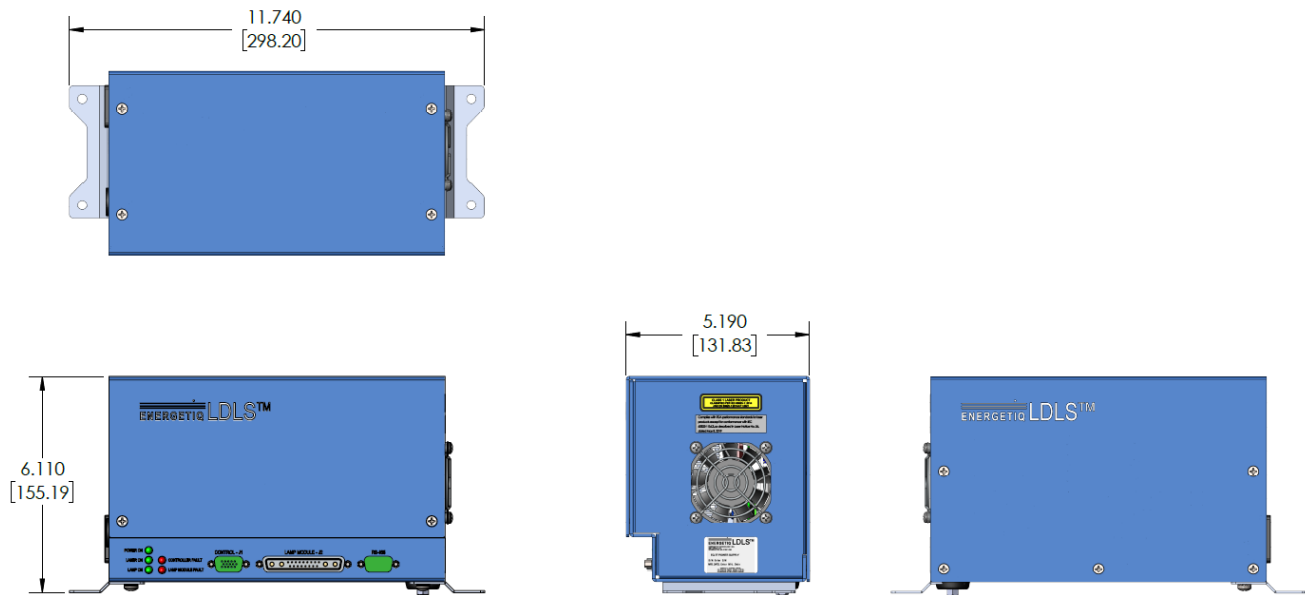
The following table provides pin assignments for the RS-485 interface.

Table 12. RS-485 Interface Pin Assignments

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

Appendix B. Dimensional Drawings

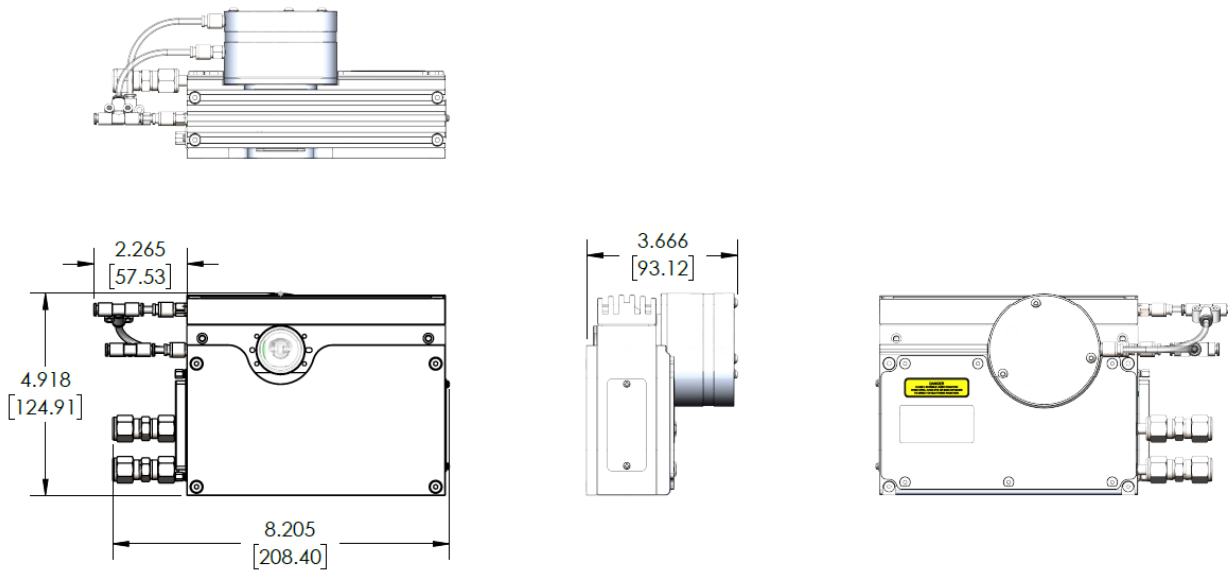
LDLS Controller Drawings



Units in brackets are millimeters. Units outside of brackets are inches.

Figure 21. LDLS Controller Dimensional Drawing

Lamp Head Drawings



Units in brackets are millimeters. Units outside of brackets are inches.

Figure 22. Lamp Head Dimensional Drawing

Appendix C. Revision History

Table 13. Revision History

Date	Revision No.	Author	Description
09/15/2022	1	Eric Burz	Initial release.
03/06/2023	2	Eric Burz	Updated the chapter "Safety and Compliance." Added section on EMC compliance standards. Changed nitrogen purge gas from "required" to "recommended." Minor edits.
06/23/2023	3	Eric Burz	Compliance label updates. Updated Declaration of Conformity. Updated cooling fluid temperature range. Minor edits.
09/05/2023	4	Eric Burz	Updated chiller flow rate.
11/11/2024	5	Eric Burz	Revised layout of product manual to match other existing Energetiq product manuals. Added EQ-77 model system to manual. Updated "Installation" and "Troubleshooting" chapters. Updated product dimensions and dimensional drawings. Added chiller operation instructions. Minor edits.