

# Model EQ-400

## LDLS<sup>®</sup>

### Laser-Driven Light Source



## Operation Manual

Revision 12

November 2024

DOC-7388



Copyright © 2024 Energetiq Technology Inc. All rights reserved.

For a list of Energetiq product patents, visit [www.energetiq.com/patents](http://www.energetiq.com/patents).

All technical information, including drawings, schematics, and specifications contained in this manual are the property of Energetiq and shall not be reproduced in whole or in part without the written consent of Energetiq. The content of this manual is subject to change without notice.

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](http://www.energetiq.com/compliance).

## Manufacturer Information

Energetiq Technology Inc.  
205 Lowell St., Wilmington, MA 01887 USA  
Phone: +1 (781) 939-0763  
Email: [service@energetiq.com](mailto:service@energetiq.com)  
Web: [www.energetiq.com](http://www.energetiq.com)

## Contents

Contents.....	3
Chapter 1. Safety and Warranty Information .....	5
1.1 Safety Warnings.....	5
1.2 General Precautions .....	6
1.3 Laser Information .....	7
1.4 Labels and Safety Notifications .....	8
1.5 Safety Interlocks .....	9
1.5.1 External Interlock.....	9
1.6 Warranty .....	9
1.7 Correct Disposal of the Unit .....	10
1.8 EMC Compliance Standards .....	10
Chapter 2. System Description .....	11
2.1 System Overview .....	11
2.2 Description of System Components .....	11
2.2.1 Controller.....	12
2.2.2 Lamp Head.....	15
Chapter 3. System Specifications and Requirements .....	17
3.1 Physical Specifications .....	17
3.2 Remote Interface Specifications.....	17
3.3 Utility Requirements.....	17
3.4 Environmental Requirements .....	18
Chapter 4. Installation .....	19
4.1 Unpacking the System .....	19
4.1.1 Required Contents.....	19
4.3 Installation Procedure.....	21
4.3 Installing Remote Control System .....	22
4.4 Chiller Information .....	25
Chapter 5. Operating the System .....	26
5.1 Starting the System.....	26
5.2 Stopping the System .....	26
5.3 Manually Resetting the System.....	26
Chapter 6. Maintenance .....	28
6.1 Lamp Bulb Replacement .....	28

**Chapter 7. Troubleshooting ..... 29**

**Appendix A. RS-485 Interface Commands and Pin Assignments ..... 31**

**Appendix B. Dimensional Drawings ..... 34**

**Appendix C. Revision History ..... 36**

## Chapter 1. Safety and Warranty Information

### 1.1 Safety Warnings

The EQ-400 system 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 system 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.lia.org](http://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-400 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-400 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-400 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.

## 1.2 General Precautions

The output beam from the EQ-400 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-400 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-400 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-400 system.**

**The EQ-400 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-400 system uses a patented laser drive system to excite a plasma that radiates in the ultraviolet as well as the visible bands. Visit [www.energetiq.com/patents](http://www.energetiq.com/patents) for a list of Energetiq product patents. A Class 4 laser is located in the LDLS controller. The optical configuration of the lamp head ensures that the direct laser beam cannot exit the unit. The EQ-400 system is designated as Class 4 during all normal operation.

*Nominal Ocular Hazard Distance (NOHD) based on 400W 1070 nm 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.*

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
1070 nm	CW	400W	5 mm	0.3 mRad	Single Mode

## 1.4 Labels and Safety Notifications

The following safety labels appear on the product. The figure [EQ-400 System Label Locations](#) shows the location of each label on the EQ-400 system.



**1. Manufacturer's Identification Label** – gives the manufacturer's name and address, and the model, serial number, and date of manufacture of the system.



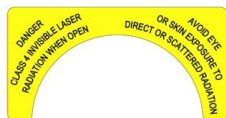
**2. Hazard Warning Label** – indicates that a laser hazard is present.



**3. Aperture Label** – indicates the outlet aperture for laser radiation.



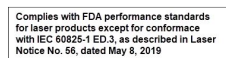
**4. UV Hazard Warning Label** – indicates hazardous levels of UV light are present.



**5. Protective Housing Label** – indicates hazardous levels of heat are present.



**6. Explanatory Label** – states the classification of the laser product. Class 1 is the lowest hazard level classification.



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



**8. Protective Housing Label** – warns of an enclosed laser radiation hazard located inside chassis on laser module.



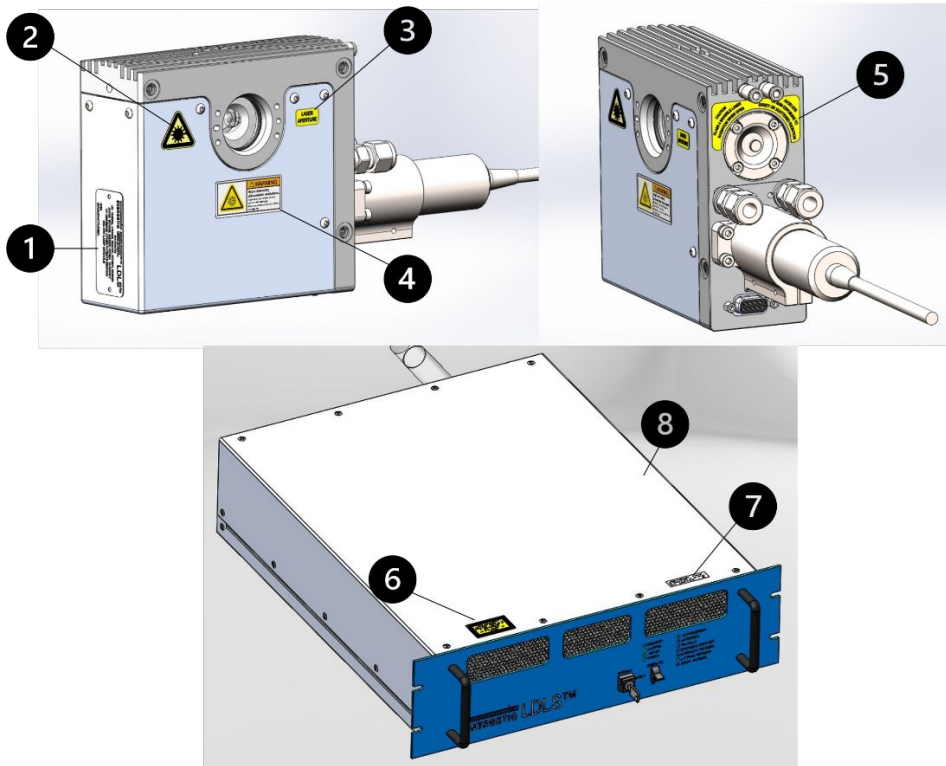


Figure 1. EQ-400 System Label Locations

## 1.5 Safety Interlocks

The EQ-400 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 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-400 system's warranty, [contact your local distribution representative](#).

## 1.7 Correct Disposal of the Unit

When the EQ-400 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.
--------------	---

- **Criteria B**

Light output	Light output remains above 50% and does not turn off.
--------------	---

- **Criteria C**

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

## Chapter 2. System Description

### 2.1 System Overview

The EQ-400 system is a broadband lamp system for use in a wide variety of applications. The lamp bulb produces high brightness, broadband light from deep ultraviolet (UV) wavelengths through visible and beyond. The output is very stable, and the system has a long lifetime before any service is required. A simple control interface ensures ease of use.

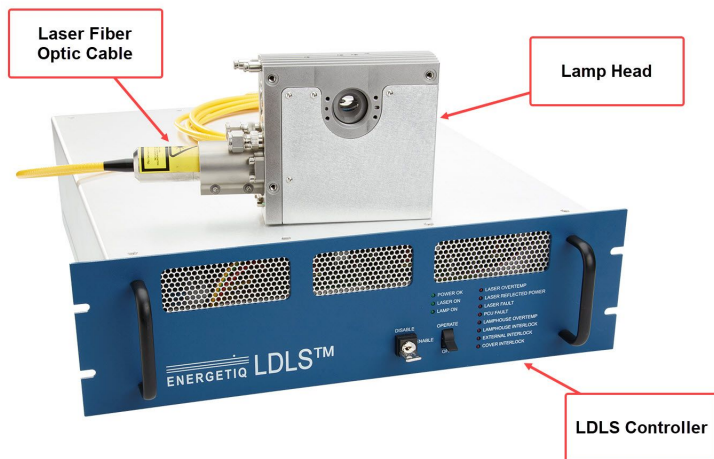
Some of the advantages of the EQ-400 system include:

- 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-400 system consists of an LDLS controller, lamp head, and interconnecting cable. Connection to AC power is required for operation. Connections to nitrogen purge gas and cooling water are required. For connection details, see [4.3 Installation Procedure](#).

### 2.2 Description of System Components

The EQ-400 system consists of an LDLS controller, lamp head, laser fiber optic cable, and power input cable (not shown). Laser light is generated in the controller and transmitted to the lamp head by an optical fiber permanently attached to the controller.



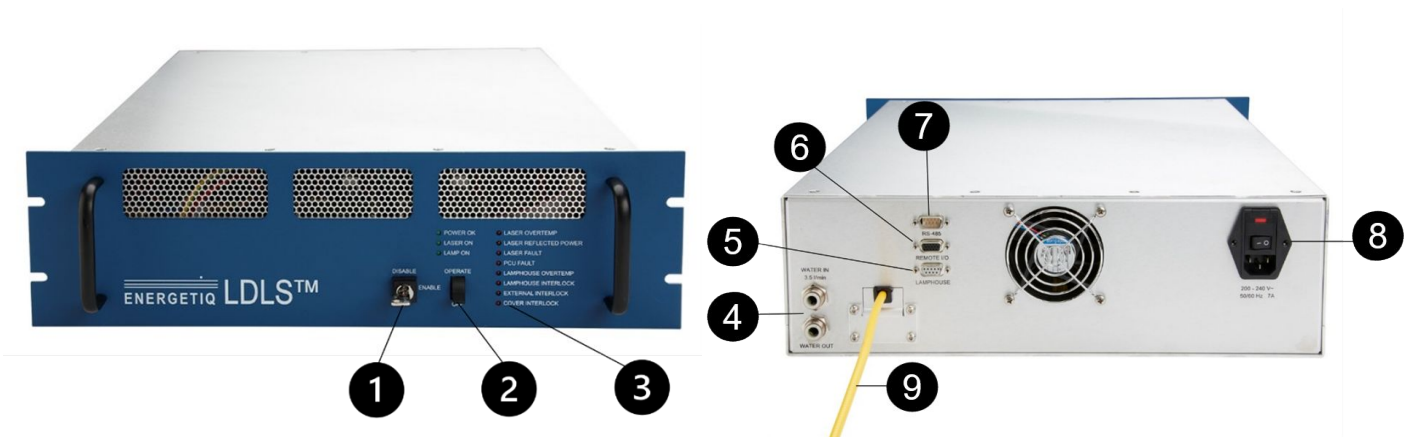
**Figure 2. EQ-400 System**

The following subsections provide descriptions of the system components and controls and give an overview of their functions.

### 2.2.1 Controller

The controller contains the following components:

- Key Switch
- Operation Switch
- Status Indicator LEDs
- Water Inlet/Outlet Fittings
- Lamp House Control Port
- Remote I/O Port
- RS-485 Port
- Power Input Port
- Laser Fiber Optic Cable



**Figure 3. Controller Components**

## 1. Key Switch

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

## 2. Operation Switch

The operation switch turns the EQ-400 system on or off.

## 3. Status LED Indicators

These LEDs indicate the system status. The function of these indicators is shown below in the table [Status Indicator LED Functions](#).

**Table 2. Status Indicator LED Functions**

LED Label	Meaning (when lit)
POWER OK	AC power is connected to the EQ-400 LDLS controller
LAMP ON	UV Light is on
LASER ON	Laser power is ON and laser light is being produced within the lamp head
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 LDLS controller: <ol style="list-style-type: none"> <li>1. External interlock open</li> <li>2. Controller internal temperature too high</li> <li>3. Laser power not reaching setpoint</li> <li>4. Laser temperature fault</li> <li>5. Failure in laser delivery fiber</li> </ol>
LAMPHOUSE OVERTEMP	Lamp head internal temperature too high

LED Label	Meaning (when lit)
LAMPHOUSE INTERLOCK	<p>One of the following has occurred in the lamp head:</p> <ol style="list-style-type: none"> <li>1. Control cable not connected properly</li> <li>2. Lamp head internal temperature too high</li> <li>3. Laser fiber not correctly connected</li> <li>4. Lamp bulb not correctly installed</li> <li>5. Ignition failure</li> </ol>
EXTERNAL INTERLOCK	External interlock open
COVER INTERLOCK	LDLS controller cover(s) not in place

#### 4. Cooling Fluid Water Inlet/Outlet Fittings

The cooling fluid inlet/outlet fittings are for cooling fluid for the internal laser module.

#### 5. Lamp Head Control Port

This port provides various power and control signals to/from the lamp head. No other connector or cable may be used with the EQ-400 system other than the one supplied.

#### 6. Remote I/O Port

This port provides access to control and status signals. This connector also functions as the remote interlock connector. Control signals are only active when the system is in remote control mode. See [4.3 Installing Remote Control System](#) for more information.

#### 7. RS-485 Port

The RS-485 Port is for the optional RS-485 interface. See [Appendix A. RS-485 Interface Commands and Pin Assignments](#) for more information.

#### 8. Power Input Port

This port is a fused IEC 320 inlet connector for AC power input. Fuses are 5x20 mm, 10 A, 250 V, time delay type.

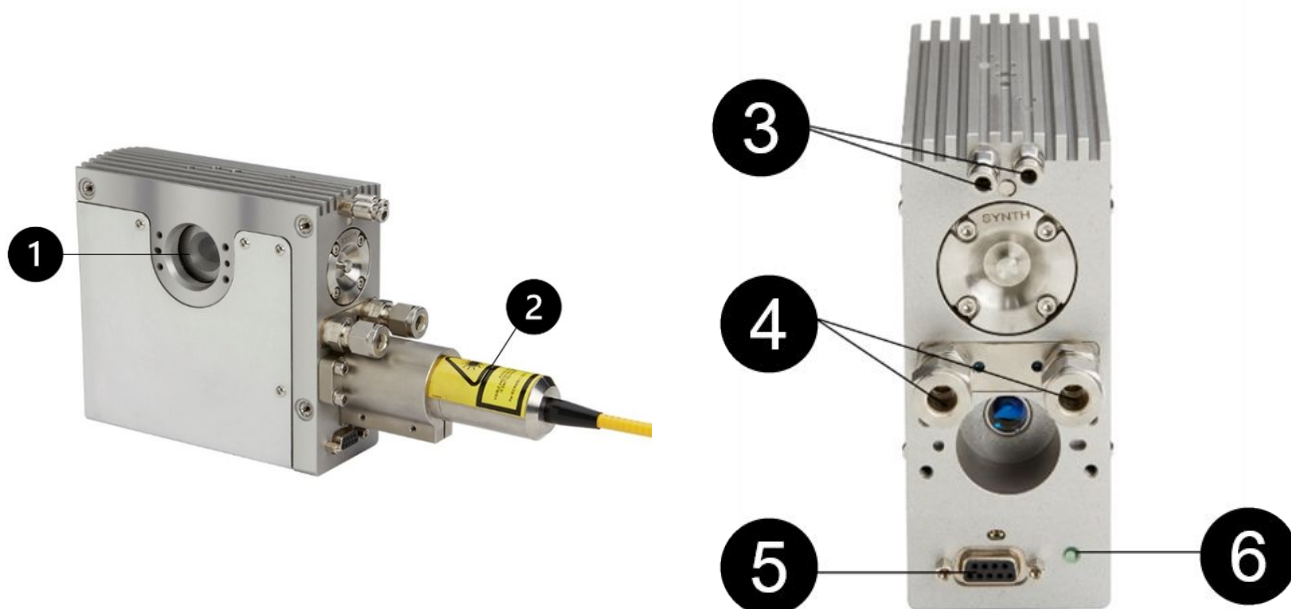
#### 9. Laser Fiber Optic Cable

The laser fiber optic cable transmits laser energy from the controller to the lamp head.

## 2.2.2 Lamp Head

The lamp head contains the following components:

- Lamp Output Window
- Laser Collimator
- Nitrogen Purge Inlet/Outlet
- Cooling Fluid Inlet/Outlet
- Lamp Head Control Port
- Laser ON Indicator



**Figure 4. Lamp Head Components**

### 1. Lamp Output Window

The lamp window at the optical output provides protection from the high-pressure bulb inside the lamp head. An internally-threaded SM30 adapter is provided for easy connection of optical hardware. A retroreflector is installed on the output window on one side of the lamp head. In addition to the light output, invisible laser radiation exceeding Class 1 emission limits is emitted from the output aperture. See [Appendix B. Dimensional Drawings](#) for more information.

### 2. Laser Collimator

The laser collimator is a device that narrows the beam of light.

### **3. Nitrogen Purge Inlet/Outlet**

The nitrogen purge inlet/outlet fittings are for the required nitrogen purge gas.

### **4. Cooling Fluid Inlet/Outlet**

The cooling fluid inlet/outlet fittings are for the required cooling fluid.

### **5. Lamp Head Control Port**

This port is used to provide various power and control signals to/from the LDLS controller. No other connector or cable may be used with the EQ-400 system other than the one supplied.

### **6. Laser ON Indicator**

This LED is illuminated when the laser is ON.



## Chapter 3. System Specifications and Requirements

### 3.1 Physical Specifications

#### Dimensions (H x W x D)

- **Lamp Head:** 151 x 149 x 157 mm (6 x 5.9 x 6.2 in)
- **Controller:** 133 x 483 x 583 mm (5.3 x 19.0 x 23.0 in)

#### Weight

- **Lamp Head:** 2.7 kg (6.0 lbs)
- **Controller:** 18.8 kg (41.5 lbs)

### 3.2 Remote Interface Specifications

#### Digital Inputs

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

#### Digital Outputs

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

#### User Power

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

### 3.3 Utility Requirements

- **Electrical:** 200-240 V~, 50/60 Hz, 7A, 1700 W max.
- **Purge Gas:** Required. Clean dry nitrogen, filtered to 5 um 20 psig (0.14 MPa) supply pressure.
  - 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-400 system will consume approximately 1 slm of flow.
- **Cooling Fluid:** Required.
  - **Flow Rate:** 3-4 liters/minute.
  - **Temperature:** 18 – 24 °C.
  - **Controller Fittings:** 8 mm push-to-connect.

- **Lamp Head Fittings:** 8 mm 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.
- **Indoor/Outdoor Use:** Indoor use only.
- **Overvoltage Categories:** Overvoltage Category II.
- **Operating Altitude:** 2,000 m max.
- **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-400 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-400 system shipping box contains the following required items:

### 4.1.1 Required Contents

Table 3. Required Contents of Shipping Box

Qty	Item Description	Picture
1	LDLS Controller	
1	Lamp head	

Qty	Item Description	Picture
1	Interconnecting cable from lamp head to LDLS controller (9 pin mini D-sub)	
1	AC Power Cable	—
1	AC Power Plug (differs by country)	—
1	Chiller Tubing Kit	—

## 4.3 Installation Procedure

The following section details how to install the EQ-400 system.

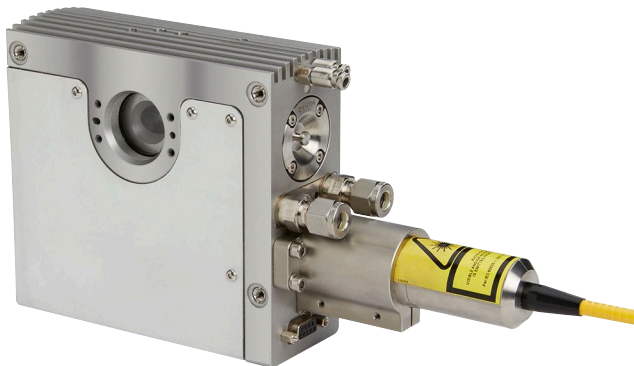
**Caution:** It is recommended the lamp be connected to a beam pipe. For any other use, configuration shielding is strongly recommended. The beam should always be enclosed in an appropriate beam pipe, tube, or enclosed space and purged with nitrogen. Operating the source without any output target or beam transport is not recommended and may lead to unsafe operating conditions. Consult Energetiq for applications information and suggested configurations.

To install the EQ-400 system:

1. Place the LDLS controller in a standard 19-inch rack or on a stable surface. The controller must be placed within three (3) meters of the lamp head due to the length of the interconnecting cable.

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

2. Connect the lamp head optical output to the user equipment.
3. Mount the lamp head in the orientation shown below, with the output window on the side and the lamp head mounting surface oriented horizontally.



**Figure 5. Mounting the Lamp Head**

**Note:** 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.

4. Connect the laser fiber optic cable from the LDLS controller to the lamp head as follows:
  - a. Remove the plastic cap from the end of the laser collimator.
  - b. Inspect the collimator lens for dust or contamination.
  - c. Carefully insert the collimator and bracket into the socket in the lamp head.
  - d. Secure the bracket to the lamp head using the four socket head screws and a 3 mm hex driver. Torque the screws to 20 in-lbs.
5. Connect the 9-pin mini D-sub interconnect cable from the LDLS controller to the lamp head.
6. Connect a source of nitrogen purge gas to the nitrogen inlet 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.
7. Connect cooling fluid to the 8 mm Swagelok fittings on the lamp head.
8. Connect cooling fluid to the 8 mm Swagelok fittings on the LDLS controller.
9. Connect an interlock switch to the interlock pins of the remote I/O port (functions as remote interlock connector).

If using remote control mode, connect user's control system to the remote I/O connector using a suitable cable. [4.3 Installing Remote Control System](#) 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 system internal isolated power supply, or an external supply. [4.3 Installing Remote Control System](#) 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 controller. Mating connector is a standard 9-pin female d-sub (for example, AMP part no. 205203-3 with contacts 1-66504-0). See [Appendix A. RS-485 Interface Commands and Pin Assignments](#) for pin connections.
11. Connect an AC input power source to the standard IEC 320 style port on the rear of the controller.

The system is now ready to operate.

## 4.3 Installing Remote Control System

The following section details how to install a remote control system for the EQ-400 system.

The EQ-400 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).

Table 4. I/O Port Pin Assignments

Description	Pin #	Details
<b>Commands (Inputs)</b>		
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
<b>Status Indicators (Outputs)</b>		
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	50 mA 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

The user's remote I/O port can be powered either by the EQ-400 system internal isolated power supply, or an external supply.

The figure Remote Interface Schematic below shows connection schematics for both configurations.

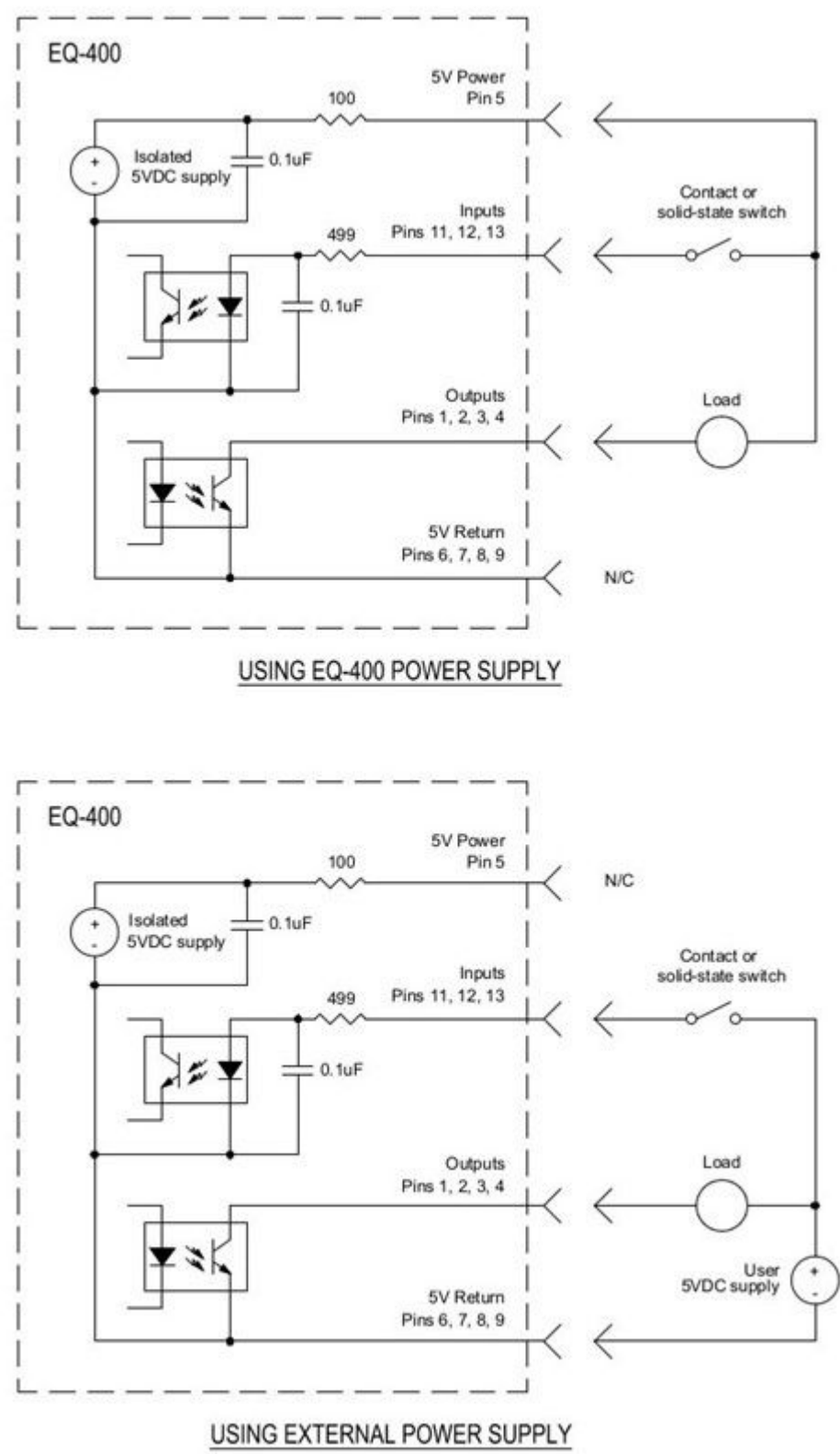


Figure 6. Remote Interface Schematic



### 4.4 Chiller Information

The EQ-400 system system requires a chiller to maintain the cooling requirements in [3.3 Utility Requirements](#). For your convenience, Energetiq offers a suitable chiller produced by SMC Corporation. You may also choose to procure a chiller directly through your local SMC Corporation representative (SMC PN HRS018-A-10-T).

Table 5. Energetiq Chiller Kit Details

PN	Description
EQ-400-CHILLER-KIT	EQ-400 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-400 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-400 system is safely being used.

1. Review the status LEDs on the controller. The POWER OK LED should be lit, and neither the LASER FAULT or PCU FAULT LEDs should be lit.
2. Place the keyswitch in the ENABLE position as shown below.
3. Turn on the OPERATE Switch by placing the switch in the "up" position.

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

4. Within several seconds, the LASER ON LED will illuminate. Laser light is now present in the lamphouse.
5. Within several seconds, the igniter automatically turns back on and the plasma ignites. The LAMP ON LED illuminates. To avoid thermal shock to the lamp components, the EQ-400 system starts with the laser at half power. After 20 seconds, the laser will switch to full power.

The system is now ready to be used.

### 5.2 Stopping the System

1. To turn the EQ-400 system 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.
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-400 system. It is recommended to run the system continuously rather than turn the system off and on several times in one day.

### 5.3 Manually Resetting the System

If any fault occurs during operation of the EQ-400 system lamp (including actuation of the remote interlock), the laser is immediately shut off, and light output ceases. When the fault condition is cleared, the EQ-400 system will not automatically restart. The EQ-400 system must be manually reset by turning the OPERATE switch to the OFF position.

Assuming that the fault or interlock condition no longer exists, the EQ-400 system can then be restarted by turning the switch to the OPERATE position.

If a fault occurs while the EQ-400 system 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 back to OPERATE.

## Chapter 6. Maintenance

### 6.1 Lamp Bulb Replacement

If a bad lamp bulb is suspected in the EQ-400 system, contact Energetiq for more information on having the lamp bulb replaced.

## Chapter 7. Troubleshooting

If any errors are detected, an LED indicator will be lit on the front panel indicating the source of the fault. The below table describes the fault conditions and possible remedies.

**Table 6. Troubleshooting**

Indicator	Fault Condition	Possible Remedies
LASER OVERTEMP	Laser internal temperature too high	<ol style="list-style-type: none"> <li>1. Check for sufficient controller cooling water flow.</li> <li>2. Ensure that cooling water temperature is between 18 and 24° C.</li> </ol>
LASER FAULT	Laser module internal fault	<ol style="list-style-type: none"> <li>1. Cycle power to the LDLS controller.</li> <li>2. Contact Energetiq if condition persists.</li> </ol>
PCU FAULT	Controller internal temperature too high	<ol style="list-style-type: none"> <li>1. Confirm that cooling fan is operating.</li> <li>2. Ensure that fan opening and front panel vents are not obstructed.</li> </ol>
PCU FAULT	Laser power not reaching setpoint	Contact Energetiq.
PCU FAULT	Internal power supply voltage low	Contact Energetiq.
PCU FAULT	Lamp failed to ignite	<ol style="list-style-type: none"> <li>1. If lamp head was previously running, allow to cool for 5 minutes and then try again.</li> <li>2. Contact Energetiq if condition persists.</li> </ol>
LAMPHOUSE OVERTEMP	Lamphouse internal temperature too high	<ol style="list-style-type: none"> <li>1. Check for sufficient lamp head cooling water flow.</li> <li>2. Ensure that cooling water temperature is between 18 and 24° C.</li> </ol>

Indicator	Fault Condition	Possible Remedies
LAMPHOUSE INTERLOCK	Control cable not connected properly	1. Ensure that the cable is plugged in and retaining screws are tightened at both ends (lamp head and controller).
LAMPHOUSE INTERLOCK	Laser fiber not connected properly	1. Ensure that the collimator bracket is seated in the lamp head, and the screws are properly tightened.
LAMPHOUSE INTERLOCK	Lamphouse cover loose or missing	1. Tighten or replace cover. 2. NEVER attempt to operate the unit with the lamp head cover removed.
EXTERNAL INTERLOCK	External interlock open	1. Ensure that pins 5 and 13 of the remote I/O connector are jumpered, or that pin 13 receives +5 VDC from an external supply. 2. Check any external interlock switches that may be connected.
COVER INTERLOCK	Controller cover(s) not in place	1. Ensure that covers are in place and screws are properly tightened. 2. NEVER attempt to operate the unit with the controller covers removed.

Additionally, if the bulb fails to ignite within 6 seconds after the OPERATE switch is activated, the LASER ON LED will dim, the PCU FAULT LED will illuminate, and the LAMP ON LED will remain off. If this occurs, turn the OPERATE switch to the "off" position (down) and begin at Step 1 of [5.1 Starting the System](#) again. If this occurs multiple times, contact Energetiq service.

## 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-400 system is shipped with the laser power set to a factory default value of 100% of full scale power. The user has the ability to adjust the actual operating power between 40% and 100% of full scale in 0.5% increments. 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 system via a terminal emulation program, or the user's control system. Response from the EQ-400 system 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 table describes the serial commands and their functions.

**Table 7. RS-485 Commands**

Command Character	Function	Reply from EQ-400 system
U	Increases the present laser power setpoint by 0.5% of full scale	Power = XXX.X %
D	Increases 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 system is interrupted.	Calibration data copied to FLASH Memory
H	Query bulb operating hours	Bulb time = XXXX.X secs
Z	Zero bulb operating hours	Send "z" within 10 sec. to confirm.
z	Confirm zeroing of bulb hours	Bulb hours zeroed & flash saved
L	Query laser operating time	Laser time = XXXX.X secs

Command Character	Function	Reply from EQ-400 system
T	Query lamphouse 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.	00000 to 65535
?	Displays a help menu listing the available commands	EQ400 firmware vXXX build date mm/dd/yy (c) Energetiq Technology, Inc. <ul style="list-style-type: none"> <li>• U/D – Inc/Dec laser pwr (by 0.5% full scale)</li> <li>• Q – Query laser pwr setpoint</li> <li>• F – Reset laser pwr to default</li> <li>• B –Burn settings to flash memory</li> <li>• H – Query bulb operating hrs</li> <li>• Z – Zero bulb operating hrs</li> <li>• z – (confirm above within 10 sec)</li> <li>• L – Query laser operating hrs</li> <li>• T – Query lamphouse temp</li> <li>• S – Query system status</li> <li>• ? – This menu</li> </ul>

## System Status Word

**Table 8. System Status Word**

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



Bit #	Definition
5	Laser current source: 1 = fault, 0 = OK
6	Lamphouse temperature: 1 = overtemperature, 0 = OK
7	PCU temperature: 1 = overtemperature, 0 = OK
8	Lamphouse 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

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

**Table 9. RS-485 Interface Pin Assignments**

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

## Appendix B. Dimensional Drawings

### Lamp Head

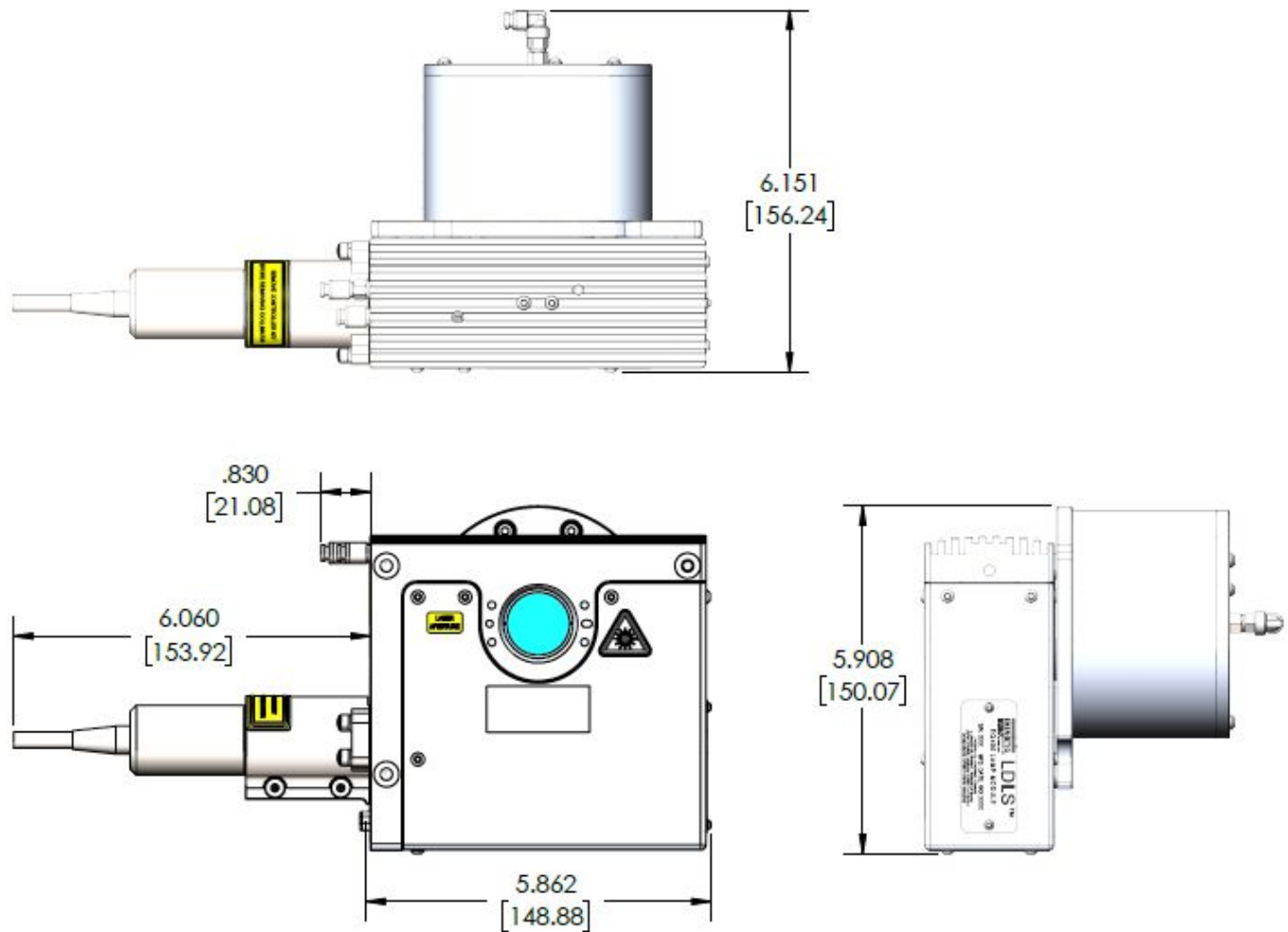
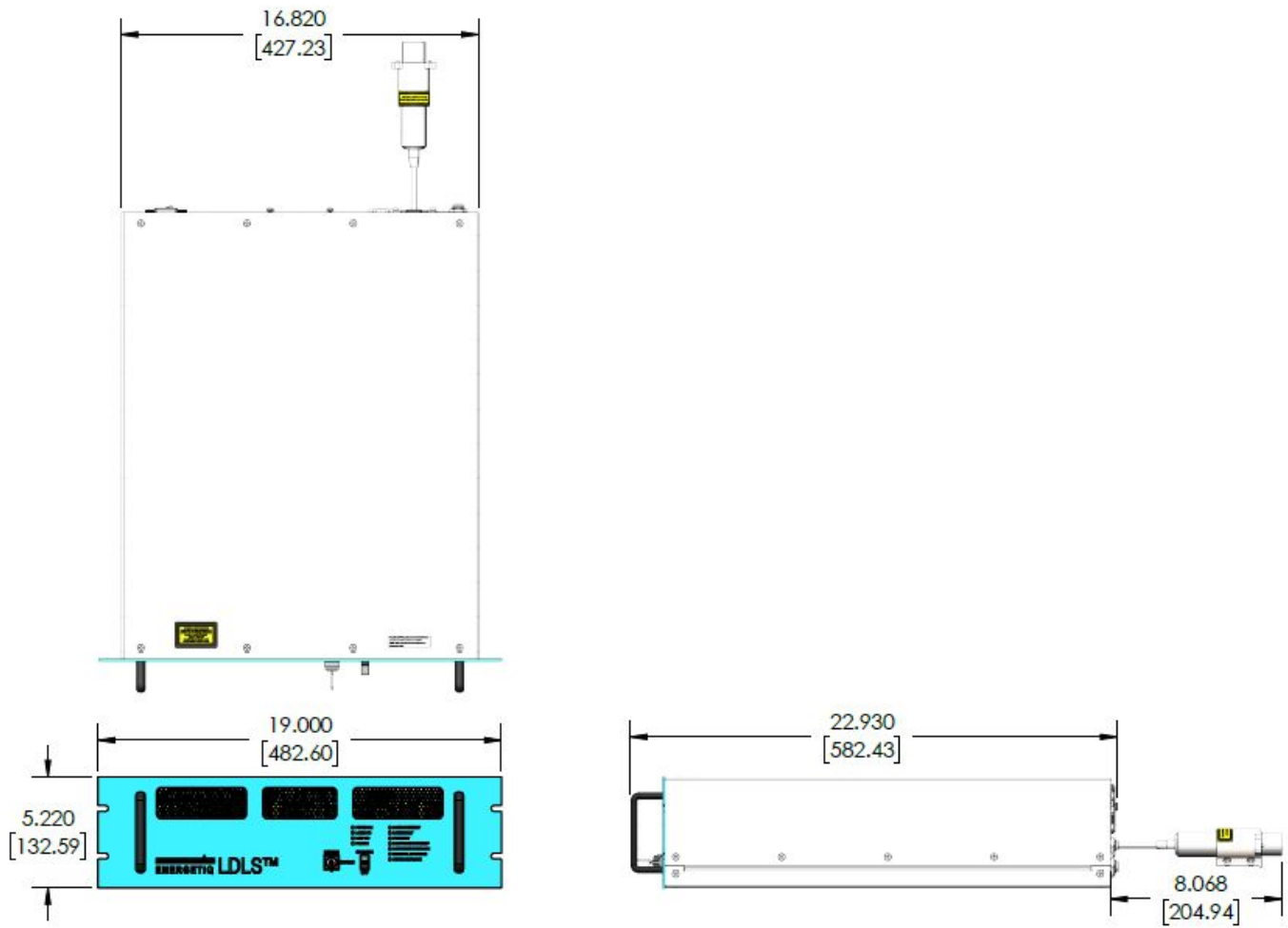


Figure 7. Lamp Head Drawing

**LDLS Controller****Figure 8. LDLS Controller Drawing**

## Appendix C. Revision History

**Table 10. Revision History**

Date	Revision No.	Author	Description
06/23/2023	11	Eric Burz	Compliance label updates. Updated Declaration of Conformity. Minor edits.
11/11/2024	12	Eric Burz	Reformatted document using new template for Energetiq product manuals.