

Model EQ-99X

LDLS[®]

Laser-Driven Light Source



Operation and Maintenance Manual

Revision 9

November 2024

DOC-6521



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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-99X 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-99X 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-99X 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.
- When using the optional AC power adapter, never use a power supply voltage other than the one specified.
- If using the optional AC power adapter, you must use the associated AC power cord provided by Energetiq.

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-99X 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-99X 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.

Other than the lamp bulb and output window, there are no user-serviceable parts inside the EQ-99X 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-99X system.**

The EQ-99X 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-99X 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 for a list of Energetiq product patents. A Class 4 laser is located in the LDLS controller. Laser energy is delivered to the lamp head via a laser fiber optic cable and connected with an SMA-type connector. Safety interlocks shut down the laser power if the SMA connector is removed from the lamp head. The optical configuration of the lamp head ensures that the direct laser beam cannot exit the unit. The EQ-99X system laser product is designated as Class 1 during all normal operation in accordance with IEC 60825-1.

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	<8.7 mW via 12 mm measurement aperture at a distance of 300 mm	29 mm at aperture	>100 mRad	Diffuse

No regular service is required for the EQ-99X system. Any service to the system must be performed only by factory authorized and trained technicians. All lamp head bulb replacements must be performed at the factory. To avoid injury, under no circumstances should the user open or modify the lamp head or LDLS controller.

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.

1.4 Labels and Safety Notifications

The following safety labels appear on the product. The figures [EQ-99X LDLS Controller Label Locations](#) and [EQ-99X Lamp Head Label Locations](#) show the location of each label on the EQ-99X system.



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



Heat Warning Label – indicates hazardous levels of heat are present.



Laser Label – indicates that a laser light is present.



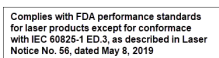
Manufacturer's Identification Label (LDLS Controller) – gives the manufacturer's name and address, and the model, serial number, and date of manufacture of the LDLS controller.



Manufacturer's Identification Label (Lamp Head) – gives the manufacturer's name and address, and the model, serial number, and date of manufacture of the lamp head.



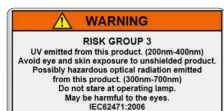
Explanatory Label – states the classification of the laser product. Class 1 is the lowest hazard level classification.



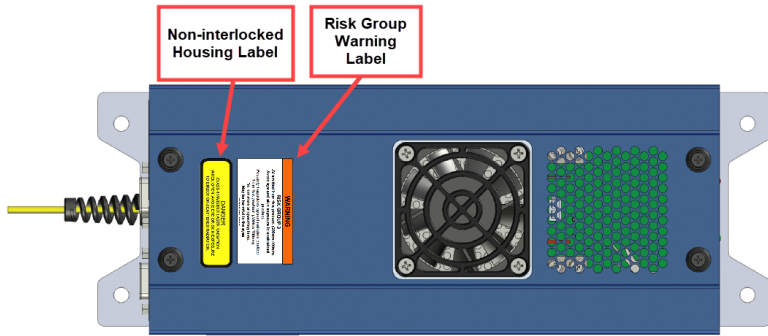
Certification Label – states that the equipment has been tested and verified to meet the standards indicated.



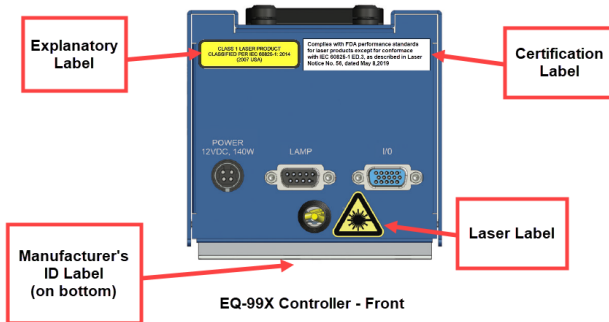
Non-interlocked Housing Label – notifies of a potential hazard when covers are removed.



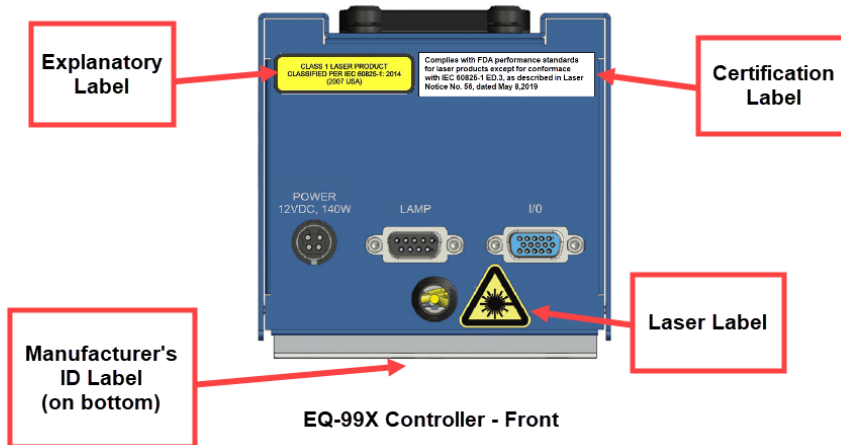
Risk Group Warning Label – states the classification of the source per IEC 62471, Photobiological Safety of Lamps and Lamp Systems.



EQ-99X Controller - Top



EQ-99X Controller - Front



EQ-99X Controller - Front

Figure 1. EQ-99X LDLS Controller Label Locations

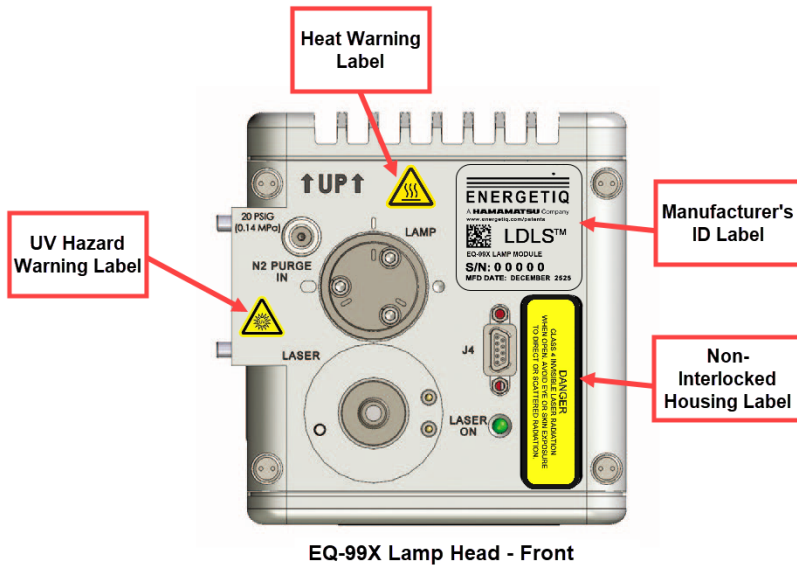


Figure 2. EQ-99X Lamp Head Label Locations

1.4.1 Definition of Equipment and Document Symbols

The following symbols are found on the EQ-99X system and in this document. The meaning of each symbol is listed below:



CAUTION: Controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.



WARNING: Invisible laser radiation. Avoid eye or skin exposure to direct or scattered radiation from Class 1 laser product.



Alternating current

1.5 Safety Interlocks

The EQ-99X 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-99X system's warranty, [contact your local distribution representative](#).

1.7 Correct Disposal of the Unit

When the EQ-99X 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 Overview

The EQ-99X system is a broadband lamp system for use in a wide variety of applications. The lamp bulb produces high brightness, broadband light from DUV 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-99X system include:

- Very high brightness across complete spectrum
 - 170 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-99X system consists of an LDLS controller, lamp head, and interconnecting cables. Connection to DC power is required for operation. Connection to nitrogen purge gas is optional but strongly recommended for best performance. For connection details, see [Chapter 4. Installation](#).

2.2 Description of System Components

The EQ-99X system consists of an LDLS controller, lamp head, laser fiber optic cable, and lamp head signal cable (not shown). Power and Input/Output (I/O) interface connections (also not shown) are provided by the user.

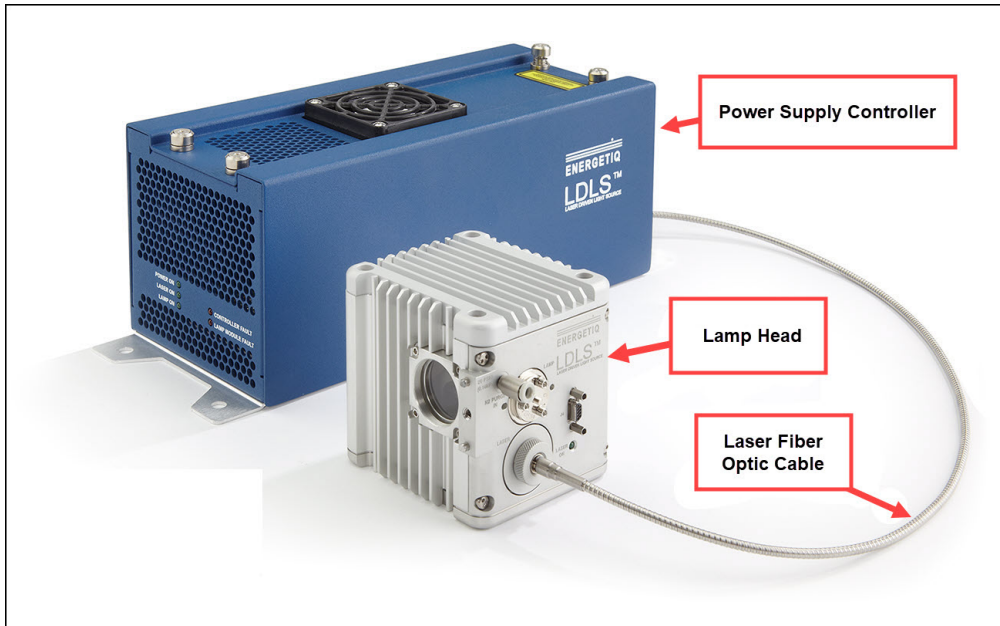


Figure 3. EQ-99X System Components

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

2.2.1 LDLS Controller

The LDLS controller contains the following components:

- Status Indicator LEDs
- I/O Port
- Power Port
- Lamp Head Signal Port
- Laser Fiber Optic Cable (permanently attached)
- IR Diode Laser (internal, not shown)
- Laser Power Supply (internal, not shown)
- Thermoelectric Laser Cooler (internal, not shown)

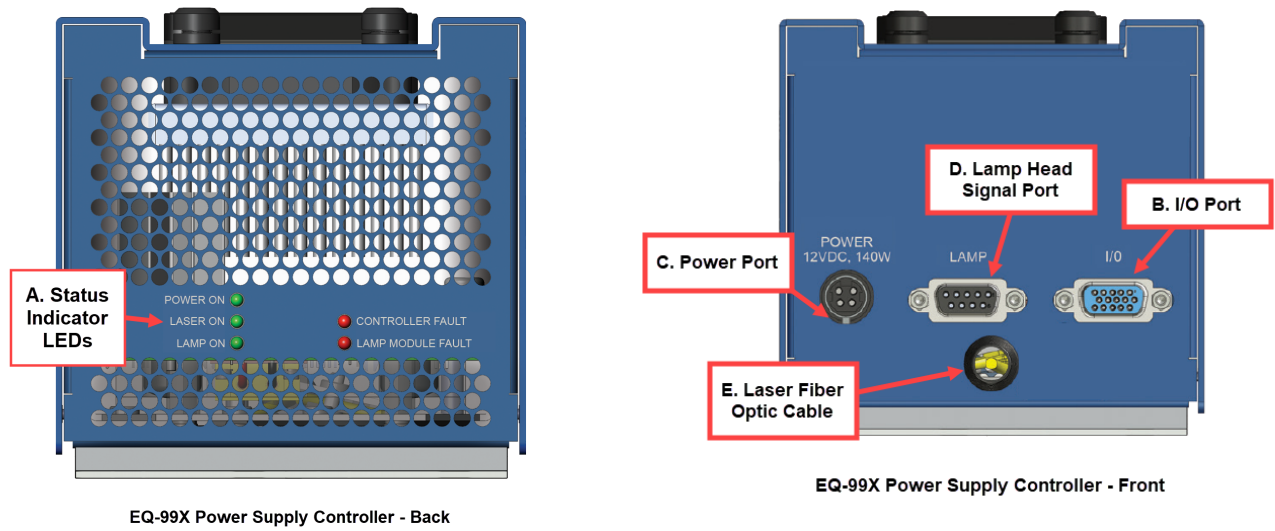


Figure 4. LDLS Controller Components

A. Status Indicator LEDs

These five 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 ON	DC power is connected to the LDLS controller
LAMP ON	UV Light is on
LASER ON	Laser power is ON and laser light is being delivered to the lamp head
CONTROLLER FAULT	One of the following has occurred in the LDLS controller: <ol style="list-style-type: none"> 1. External interlock open 2. Controller internal temperature too high 3. Laser power not reaching setpoint 4. Laser temperature fault 5. Failure in laser delivery fiber

LED Label	Meaning (when lit)
LAMP MODULE FAULT	<p>One of the following has occurred in the lamp head:</p> <ol style="list-style-type: none"> 1. Control cable not connected properly 2. Lamp head internal temperature too high 3. Laser fiber not correctly connected 4. Lamp bulb not correctly installed 5. Ignition failure

B. Input/Output (I/O) Port

The I/O port is used to connect a remote control to the EQ-99X system. You can either use the EQ-99-RC Remote Control provided with the system, or another remote control. See [4.4.2 Installing Alternative Remote Control](#) for pin assignments and functions.

C. Power Port

This is the power port for 12V DC power. Power can be provided using the included 12V DC power supply. Alternatively, the EQ-99X system can be powered directly from a customer-provided 12V DC power supply. See [4.4.1 Installing Alternative Power Supply](#) for detailed information.

D. Lamp Head Signal Port

This port is used to provide various power and control signals to/from the lamp head. No other connector or cable may be used with the EQ-99X system other than the one supplied.

E. Laser Fiber Optic Cable

The laser light is delivered from the LDLS controller to the lamp head via a fiber optic cable with armored protection. The fiber is permanently attached to the LDLS controller and connects to the lamp head via an SMA-type connector.

It is critical that this armored fiber be treated with care and inspected for any abnormalities prior to operation. Avoid sharp bends which can permanently damage the fiber. The minimum bend radius is 30 mm (1.18 in). Avoid crimping or compressing the fiber. See [Chapter 4. Installation](#) for more information on installation and [Chapter 6. Maintenance](#) for more information on fiber end-face cleaning.

2.2.2 Lamp Head

The lamp head contains the following components:

- Lamp Output Window
- Laser ON Indicator
- Nitrogen Purge Inlet
- Laser Input
- J4 Signal Port
- Lamp Bulb (internal, not shown)
- Igniter (internal, not shown)
- IR Pumping Optics (internal, not shown)

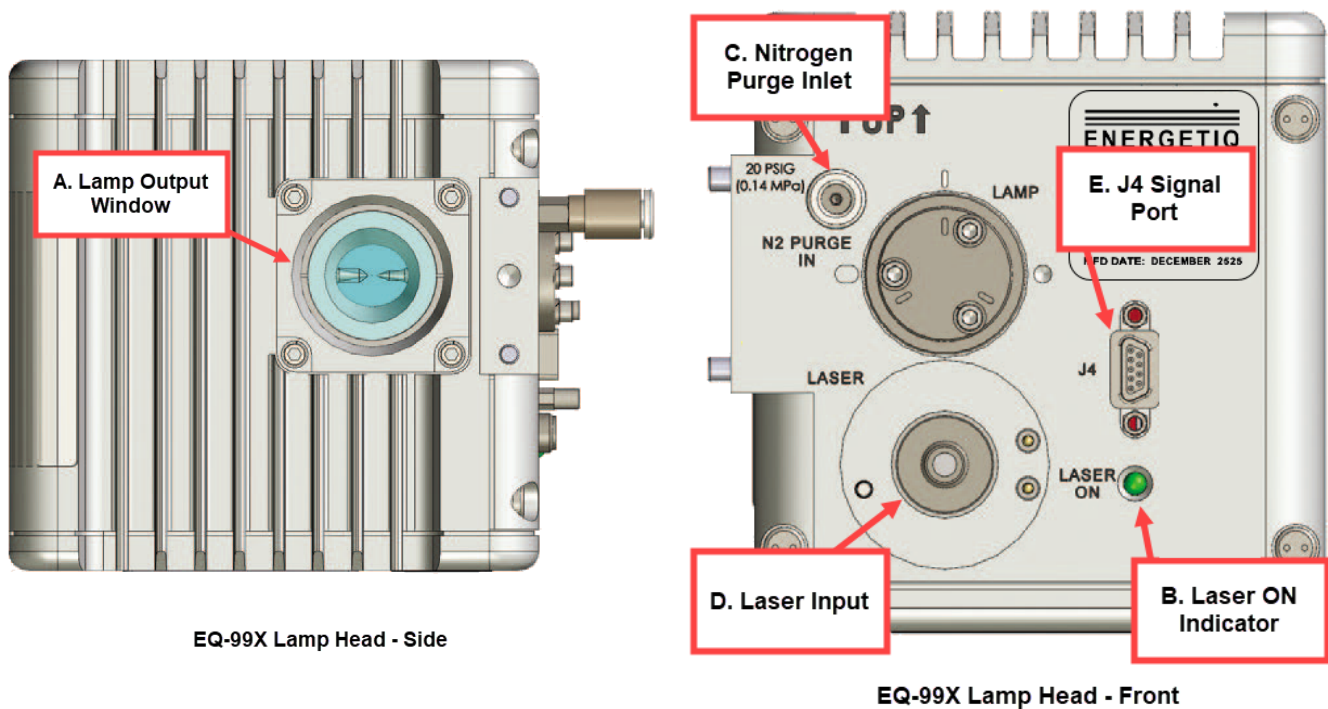


Figure 5. Lamp Head Components

A. Lamp Output Window

The lamp window at the optical output provides protection from the high-pressure bulb inside the lamp head. The lamp output window accommodates a light output of 0.47 NA. An internally-threaded SM1 adapter is provided for easy connection of optical hardware. See [Appendix A. Dimensional Drawings](#) for more information.

B. Laser ON Indicator

This LED is illuminated when the laser is ON.

C. Nitrogen Purge Inlet

This is the inlet fitting for nitrogen purge gas. See [3.4 Utility Requirements](#) for more details.

D. Laser Input

This is the inlet for the laser fiber optic cable from the LDLS controller. It contains a set of interlock pins that disable the laser when the SMA connector is not properly in place.

E. J4 Signal 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-99X system other than the one supplied.

Chapter 3. System Specifications and Requirements

3.1 Optical Performance

See the figure [Typical Output Spectrum](#) below for the typical output spectrum.

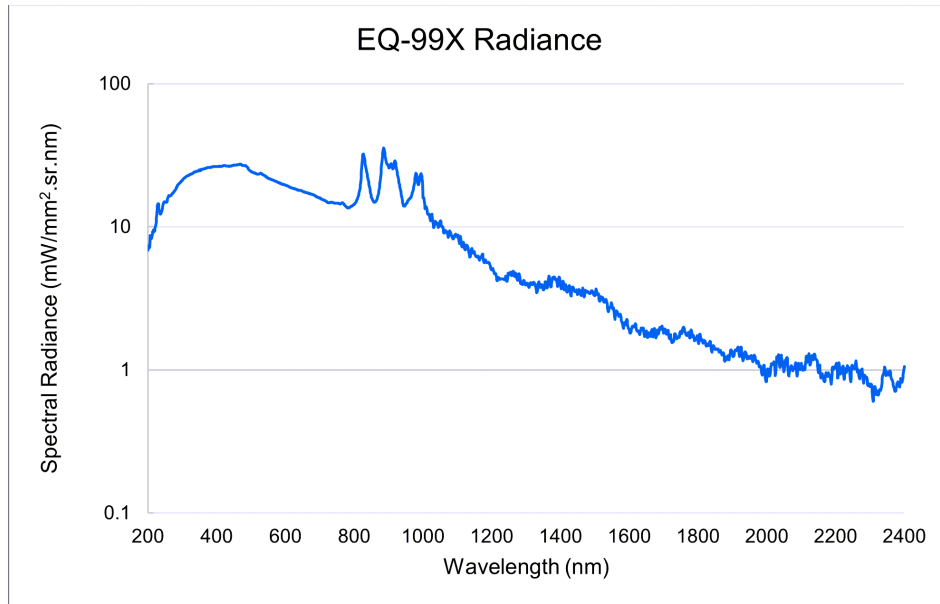


Figure 6. Typical Output Spectrum

3.2 Physical Specifications

Dimensions (H x W x D)

- **Lamp Head:** 83 x 83 x 92 mm (3.3 x 3.3 x 3.6 in)
- **LDLS Controller:** 108 x 112 x 301 mm (4.3 x 4.4 x 11.9 in)

Weight

- **Lamp Head:** 0.7 kg (1.5 lbs)
- **LDLS Controller:** 1.4 kg (3.0 lbs)

3.3 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:** 30 mA max.

User Power

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

3.4 Utility Requirements

- **Electrical:** 12VDC \pm 5% at 11.7A minimum (140W rating). Power consumption is approximately 100W during normal operation.
 - **Optional AC Adapter:** 100-240V \sim \pm 10%, 2.5A, 50-60Hz.
- **Purge Gas:** Optional (strongly recommended). Clean dry nitrogen, filtered to 5 μ m 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-99X system will consume approximately 1 slm of flow.
 - There is no return fitting for the purge nitrogen. The purge flow normally escapes within the lamp head enclosure, and then to the atmosphere.

3.5 Environmental Requirements

Operating

- **Ambient Temperature:** 15–35 °C.
- **Relative Humidity:** Non-condensing, 80% max. for temperatures up to 31 °C, decreasing linearly to 50% max. at 40 °C.
- **Pollution Degree:** 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:**
 - **DC Input:** Category I.
 - **Optional AC Adapter:** Category II.
- **Operating Altitude:** 2,000 m max.

- **IP Code:** IP20.

Transport

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

Chapter 4. Installation

4.1 Unpacking the System



Upon arrival, inspect all parts of the EQ-99X 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-99X 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)	

4.1.2 Optional Accessories

The EQ-99X system shipping box may also contain the following optional accessories available from Energetiq:

Table 4. 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	<ul style="list-style-type: none"> • 12 VDC Power Supply (universal input voltage) – TDK Lambda model no. DT150PW120D <ul style="list-style-type: none"> ◦ NA AC Cable – Assmann model no. AK500/U-1 ◦ EU AC Cable – Qualtek model no. 364002-D01 <p>Note: If using the 12 VDC power supply, you must use the associated AC cable provided by Energetiq.</p>	

4.2 Attaching the Laser Fiber from the Controller to the Lamp Head

The EQ-99X system is typically delivered with the laser fiber optic cable connected to the lamp head. This is done to minimize the possibility of debris or particles contaminating the end of the laser fiber. If the LDLS controller of your EQ-99X system is shipped separately from the lamp head, follow the procedure below to attach the laser fiber optic cable from the LDLS controller to the lamp head.

4.2.1 Tools Required

Table 5. Required Tools

Description	Quantity
Nitrile Safety Gloves	1 pair
Complete EQ-99X system (LDLS Controller and Lamp Head)	1
Fiber Inspection Microscope	1

4.2.2 Procedure

To attach the laser fiber optic cable from the LDLS controller to the lamp head:

Notes:

- The lamp head pictured in this procedure may appear slightly different than the lamp head included with your EQ-99X system.
- Use care when handling the fiber optic cable to avoid sharp bends, which will permanently damage the cable. Minimum bend radius for the cable is 30 mm (1.18 in).

1. Put on nitrile safety gloves.



Figure 7. Putting On Nitrile Gloves

2. On the laser fiber optic cable attached to the controller, remove the protective cap.

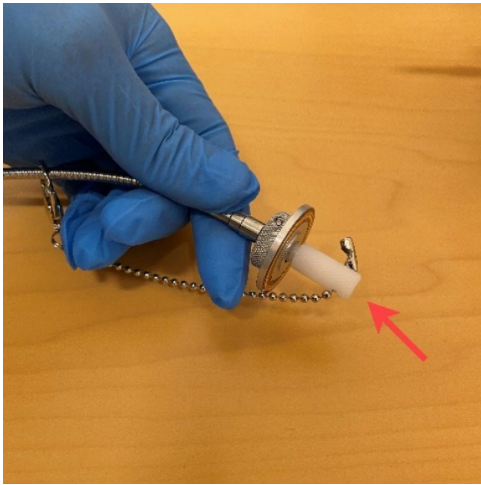


Figure 8. Removing the Protective Cap

3. Using the fiber inspection microscope, inspect the laser fiber optic cable for contamination as outlined in the section [6.1 Fiber Cleaning Process](#). If contaminated, clean the fiber optic cable as described.
4. On the lamp head, remove the SMA cap covering the Laser Input port.



Figure 9. Removing the SMA Cap

5. Carefully insert the laser fiber optic cable into the laser input port of the lamp head. Insert the fiber optic cable at a slight angle until the fiber tip is inside the port on the lamp head.



Figure 10. Inserting the Laser Fiber Optic Cable

Caution: Ensure the output fiber tip does not contact any surface (table, lamp head exterior, etc.) to avoid scratching or damaging the cable.

6. Screw in the laser fiber connector to tighten the connector to the lamp head. Rotate the laser output fiber to ensure the thick black line on the fiber optic cable is on top at the 0-degree position.

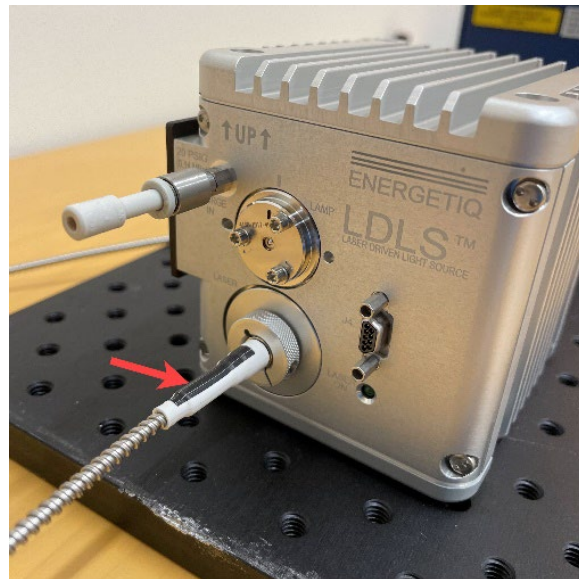
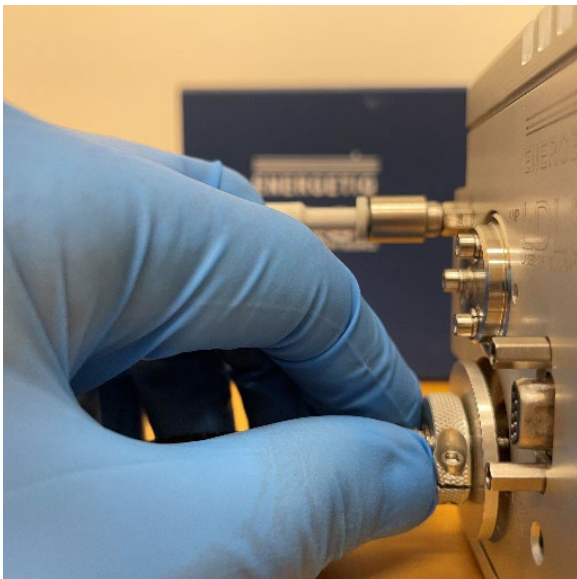


Figure 11. Screwing In the Laser Output Fiber Connector

7. Continue setting up your LDLS system as outlined in the product manual.

4.3 Installation Procedure

The following section details how to install the EQ-99X system.

Note: The EQ-99X system is typically delivered with the laser fiber optic cable connected to the lamp head. This is done to minimize the possibility of debris or particles contaminating the end of the laser fiber. Energetiq strongly recommends leaving the laser fiber optic cable connected unless it is necessary to disconnect it for installation or routing of the laser fiber. If the laser fiber optic cable must be disconnected, immediately apply an SMA cap to the end of the cable and another cap to the end of the lamp head. Then, follow the directions to inspect and clean the laser fiber as described in [Chapter 6. Maintenance](#).

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-99X system:

1. If not already connected, attach the laser fiber optic cable from the LDLS controller to the lamp head laser input. For instructions on attaching the laser fiber optic cable, see [4.2 Attaching the Laser Fiber from the Controller to the Lamp Head](#).

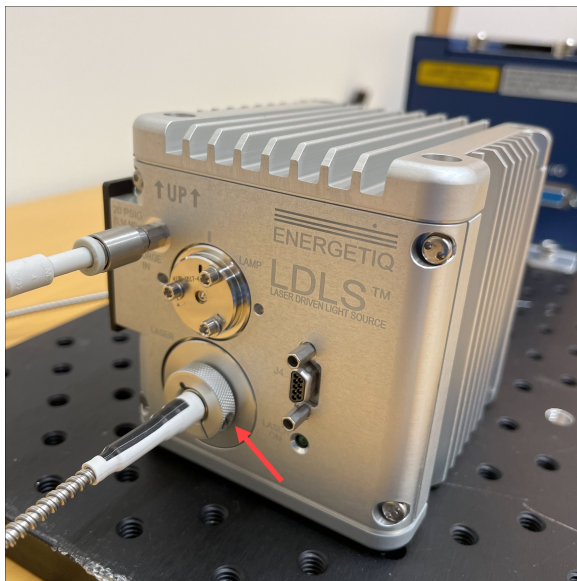


Figure 12. Connecting the Laser Fiber Optic Cable to Lamp Head

Note: Use care when handling the fiber optic cable to avoid sharp bends, which will permanently damage the cable. Minimum bend radius for the cable is 30 mm (1.18 in).

2. 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 exhaust fan on the top of the LDLS controller is facing up. Ensure the inlet and outlet air vents of the LDLS controller are not blocked and are at least 6 inches away from any obstacles.



Figure 13. 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.

3. Remove the lamp output window cover from the lamp head using an Allen wrench.

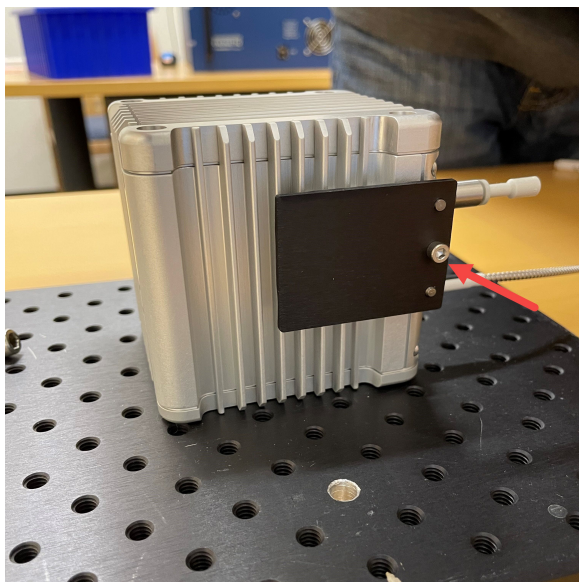


Figure 14. Removing the Lamp Output Window Cover

4. Connect the lamp head output to the user equipment. Mount the lamp head so that the lamp output window is facing outward as shown in the figure below. A pair of pins and a 6-32 threaded hole on the bottom of the lamp head are available for mounting.

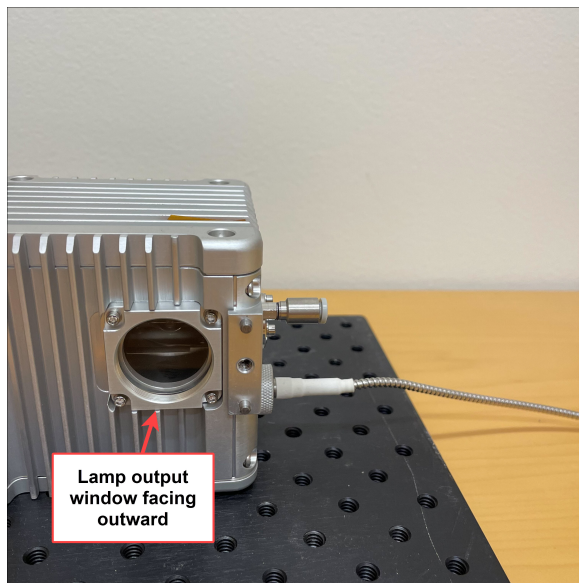


Figure 15. Mounting the Lamp Head

5. 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-99X system external interlock circuit.
6. Connect the black 9-pin mini D-sub interconnect cable from the LDLS controller (labeled TO LAMP) to the lamp head (labeled J4).

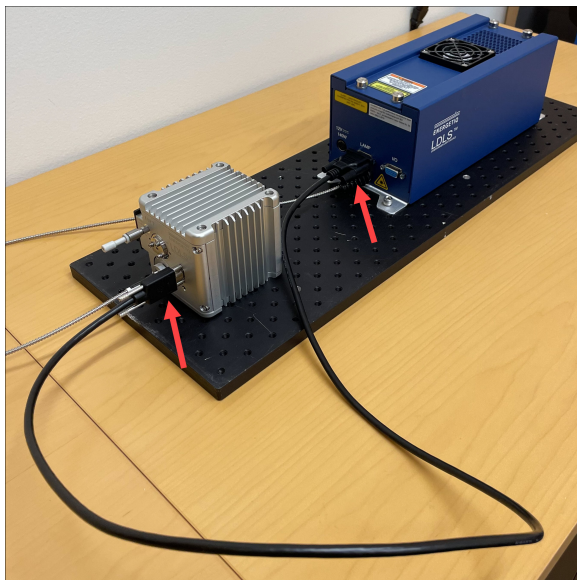


Figure 16. Connecting the Lamp Interconnect Cable

7. 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 [3.4 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.

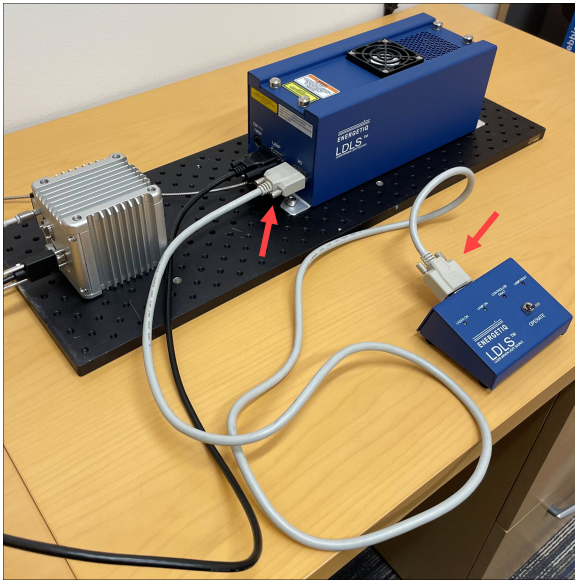


Figure 17. Connecting the I/O Cable to Remote Control

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

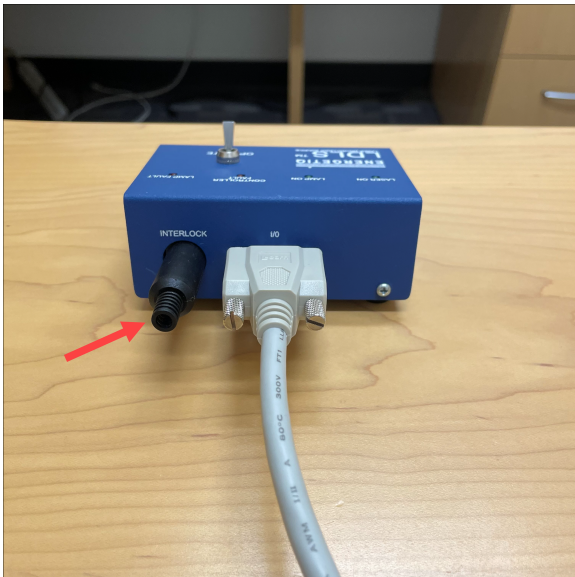


Figure 18. Inserting the Interlock Jumper Plug

Alternatively, if you are integrating the EQ-99X system into your own interlock system, connect a remote contact or solid-state switch across pins 1 and 3 in the interlock port.

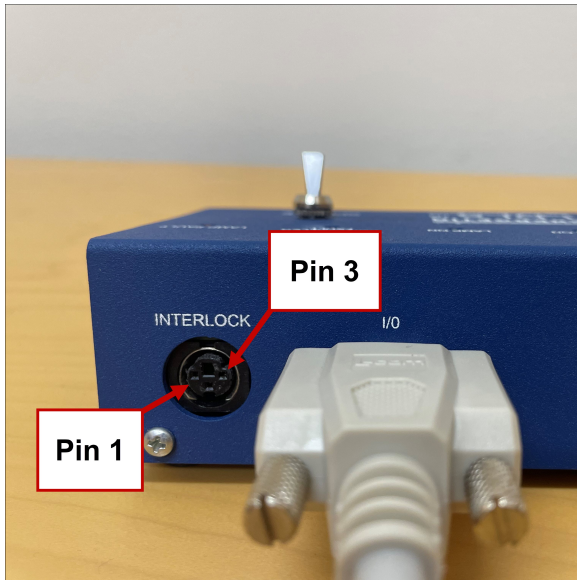


Figure 19. Interlock Pin Locations

If using another remote control system, see [4.4.2 Installing Alternative Remote Control](#) for more information.

9. Connect the 12V DC input power source to the LDLS controller and a power outlet. Position the AC adapter so that the AC inlet and power cord are readily accessible.

Note: Never use a power supply voltage other than the one specified. Use only the supplied AC cable for the power connection.

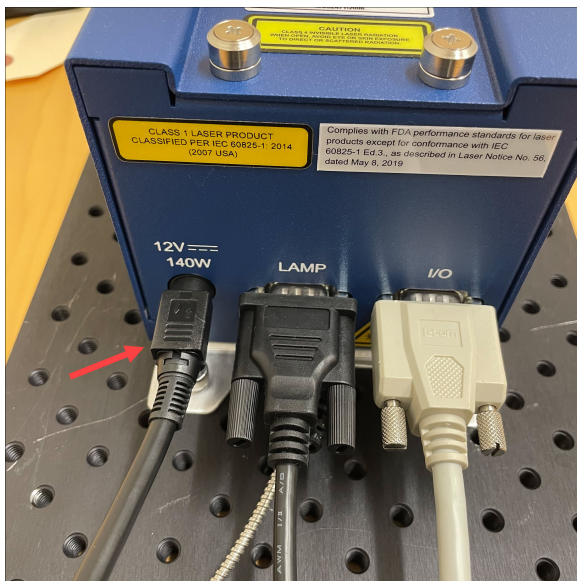


Figure 20. Connecting the 12V DC Input Power Source

Alternatively, if using another power supply, see [4.4.1 Installing Alternative Power Supply](#) for more information.

The system is now ready to operate.

4.4 Installing Alternative Power Supply or Remote Control

If you are using a power supply other than the included 12V DC power supply, or if you are using a or a remote control other than the EQ-99-RC Remote Control, the following subsections detail how to install an alternative power supply or remote control for the EQ-99X system.

4.4.1 Installing Alternative Power Supply

The EQ-99X system requires 12V DC \pm 5% at 11.7A minimum (140W rating). Power consumption is approximately 100W during normal operation.

Power can be provided using the included 12V DC power supply. Alternatively, power can be provided directly via a user-supplied 12V DC power supply. The power port on the EQ-99X system is a latching port. Once fully inserted, the power cable will not release unless the body of the cable is pulled first. This protects from accidental removal of power if the power cable is pulled. Connect to a 12V DC source as follows:

Table 6. Types of Connectors

Connector	Kycon KPPX-4P
Pins 3 & 4	+12V DC
Pins 1 & 2	12V DC return

4.4.2 Installing Alternative Remote Control

The EQ-99X 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 7. 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
CONTROLLER FAULT	4	Pulled to digital common when OK, float on FAULT
ISOLATED +5V SUPPLY	5	50mA 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-99X system internal isolated power supply, or an external supply.

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

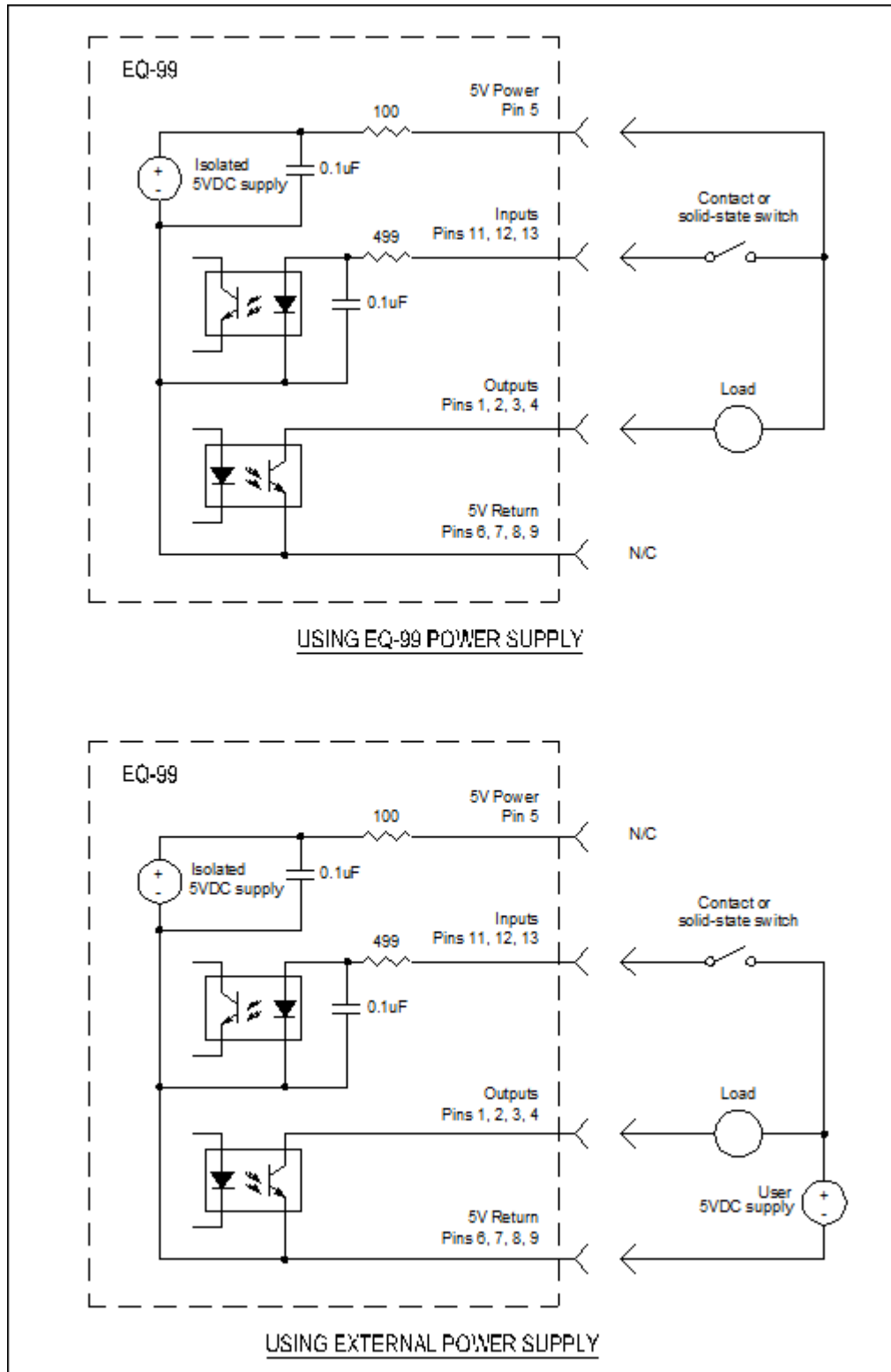


Figure 21. Remote Interface Schematic

4.5 Cooling Fluid Components for EQ-99 CAL

Note: The following procedure *only* applies to the EQ-99-CAL model of the EQ-99X system.

The following section details how to connect the cooling fluid components that come packaged with the EQ-99-CAL system.

To properly complete the cooling fluid installation, you must have the items listed below:

1. Calibrated EQ-99 Lamp Head
2. Swagelok Fittings [$\frac{1}{4}$ " OD to $\frac{1}{4}$ " OD] (Qty: 2)
3. $\frac{1}{4}$ " OD Tubing [8ft length individually] (Qty: 2)
4. Solid State Cooling Systems UC160-190 Chiller (not shown)

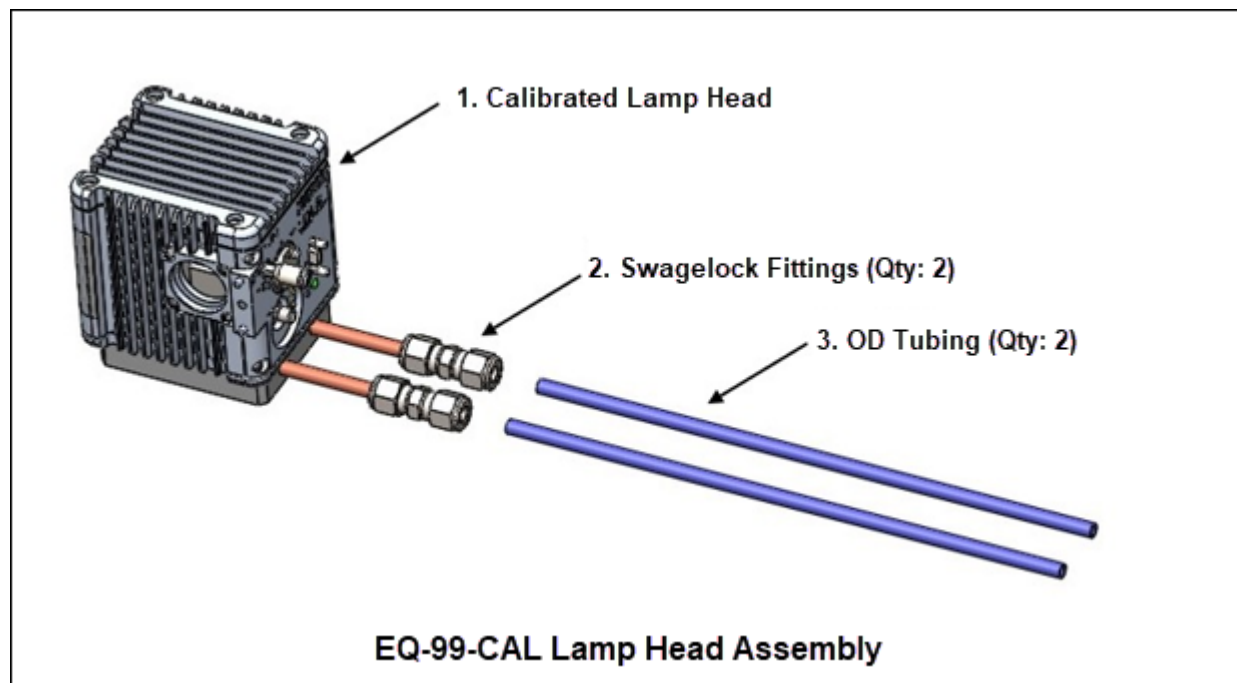


Figure 22. EQ-99-CAL Lamp Head Assembly

4.5.1 EQ-99 CAL Cooling Fluid Specifications

The specifications of the cooling fluid to be used with the EQ-99 CAL system are as follows:

- **Fluid Temperature:** 37° C
- **Fluid Flow Rate:** ~0.45 LPM at 10 PSI

4.5.2 EQ-99 CAL Cooling Fluid Installation Procedure

To assemble the cooling fluid components of the EQ-99-CAL system:

1. Attach the Swagelok fittings to the two pieces of copper tubing as shown in the figure [EQ-99-CAL Lamp Head Assembly](#).
 - a. The $\frac{1}{4}$ " end of the fitting will mate to the copper tubing.
 - b. A $\frac{9}{16}$ " and $\frac{1}{2}$ " wrench are required in order to complete the attachment.
2. The $\frac{1}{4}$ " end of the Swagelok fitting will connect to the two pieces of $\frac{1}{4}$ " OD tubing as shown in the figure [EQ-99-CAL Lamp Head Assembly](#).
 - a. A $\frac{9}{16}$ " and $\frac{1}{2}$ " wrench are required in order to complete the connection.
3. Connect the open ends of the $\frac{1}{4}$ " tubing to the "inlet" and "outlet" ports on the Solid State Cooling Systems UC160-190 Chiller.
 - a. The ports on the chiller are "quick disconnect" fittings. To create a good seal, press the tubing in.
 - b. There are no designated ports for the two pieces of tubing. Either piece of tubing can fit in either port.

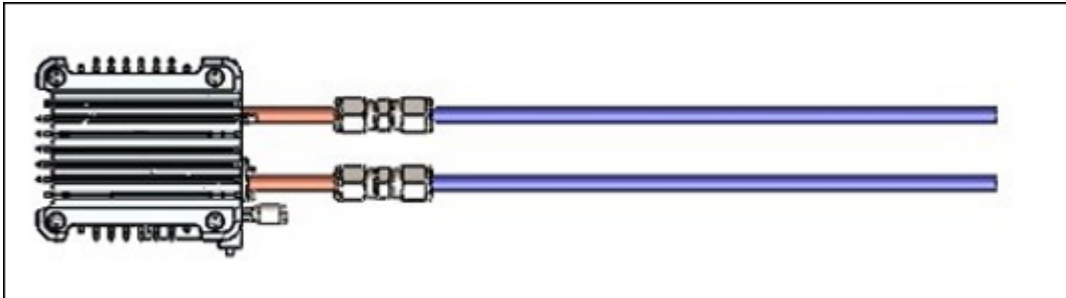


Figure 23. Assembled EQ-99-CAL Lamp Head

Chapter 5. Operating the System

5.1 Starting the System

Caution: Once the EQ-99X 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-99X 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. 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.

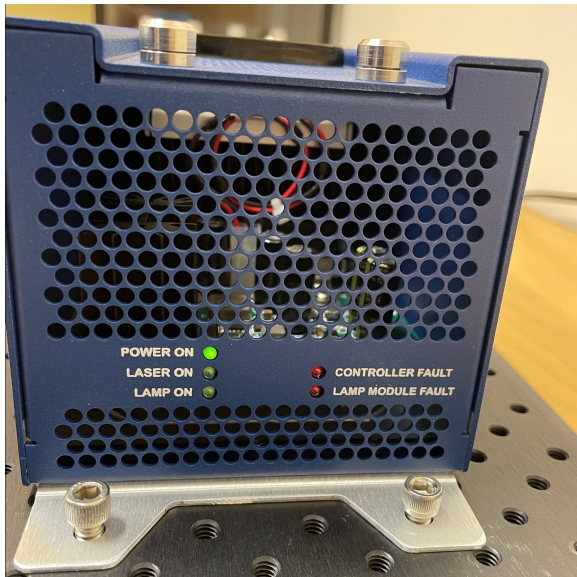


Figure 24. LDLS Controller "POWER ON" LED Illuminated

2. 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.

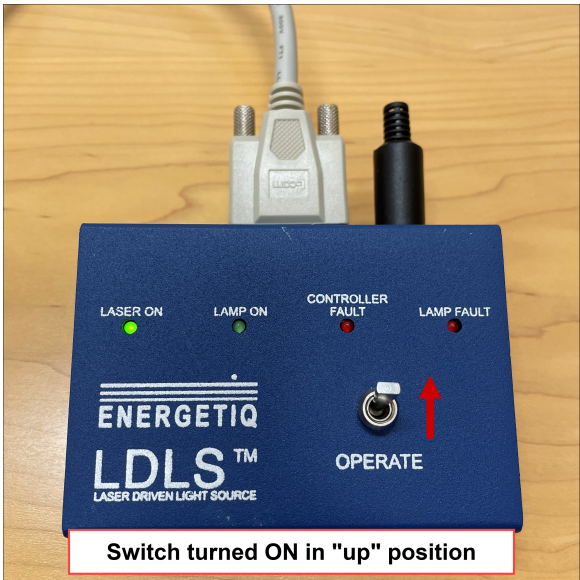


Figure 25. LASER ON LED Illuminated

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



Figure 26. LAMP ON LED Illuminated

- 4. Allow the EQ-99X 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-99X system. The EQ-99X system will automatically detect when the

unit has reached the optimum conditions for ignition.

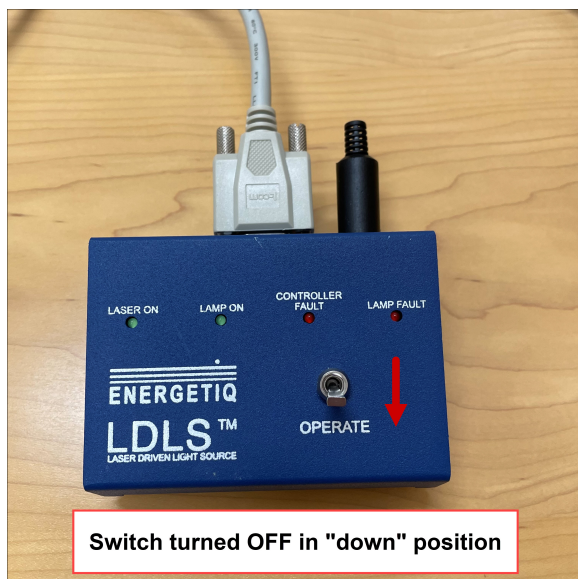
– If a bulb fails to ignite, 150 seconds after the OPERATE switch is turned ON:

- 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-99X 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-99X 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 Fiber Cleaning Process

Fiber Cleaning Basics

Caution: Prior to installing any fiber optic cable on the EQ-99X system, the fiber end-face **MUST** be cleaned and inspected at 200x magnification to ensure that contamination has been removed. Failure to properly clean and inspect fibers will significantly increase the risk of power loss and eventually cause laser failure.

- Operating the LDLS with a contaminated fiber introduces the risk of decreased performance or damage to the unit.
- A fiber is considered clean when there are no particles on the fiber core or cladding that are detectable with >200X magnification.
- Follow the fiber inspection and cleaning process shown in the figure Fiber Cleaning Process Flowchart before making a laser fiber SMA connection. As shown in the figure, inspecting and cleaning is an iterative process. The final step of the cleaning should **always** be a successful inspection. Sometimes, the cleaning action redistributes particles from an area that is not visible with the inspection scope (and not problematic) to an area that *is* visible (and *is* problematic). Because of this, Energetiq recommends that the first step is removing any loose particles or debris with pressurized nitrogen.

Fiber Caps

- If the SMA fiber must be disconnected, always use a white Delrin cap on the laser fiber end and a red cap on the lamp head.
- Store caps open-side down when possible.
- The threads on the caps can store and migrate or transfer metal particles, which are particularly problematic to the laser fiber. Blow out caps with clean dry air (CDA) or nitrogen (N2) prior to use.
- Never leave the fiber disconnected without a cap.

6.1.1 Fiber Inspection Tools

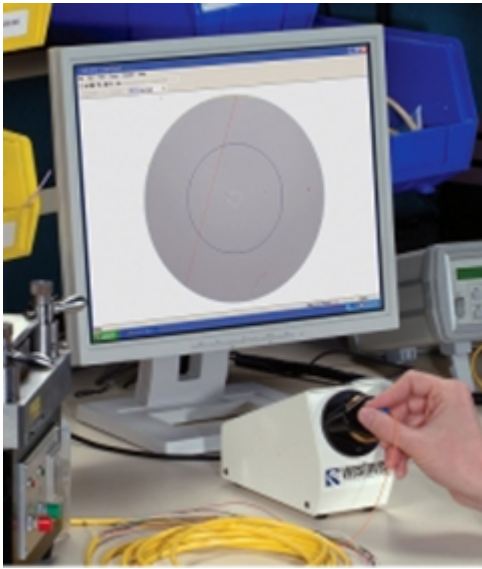


Figure 27. JDS Uniphase/Westover FVD-2400 Benchtop USB/PC Operated Fiber Viewer



Figure 28. FS-201 Handheld Fiber Inspection Scope

Note: A special SMA adapter must be used with either the FS201 handheld inspection scope or the Westover Digital inspection scopes. This custom adapter allows the scope to be used with the laser fiber and integral interlock ring. The custom adapter may not be compatible with other fiber inspection equipment.

The following fiber inspection equipment can be purchased from Energetiq:

Table 8. Energetiq Parts for Purchase

Energetiq Part Number	Description	Use
MW-00518	FS201 Fiber Inspection Scope with Custom SMA Adapter	Standalone Fiber Inspection
MW-00516	Custom Adapter from FS201 to EQ-99X system Fiber	For use with an existing FS201 Fiber Inspection Scope
MW-6537	Custom Adapter from Westover Digital Microscope to EQ-99X system Fiber	For use with an existing Westover Digital Microscope

6.1.2 Fiber Cleaning Tools

1. Clean Dry Air or Pressurized Nitrogen
2. Dust Off (or similar clean, compressed air)
3. Isopropyl Alcohol
4. QbE Cleaning Platform (www.chemtronics.com/qbe-cleaning-platform-3)

Table 9. Chemtronics QbE Cleaning Platform

Part Description	Manufacturer Part Number	UPC
Chemtronics QbE Cleaning Platform	QbE	32599094887

6.1.3 Fiber Inspection and Cleaning Procedure

Caution: Disconnect power from the LDLS controller before performing fiber inspection.

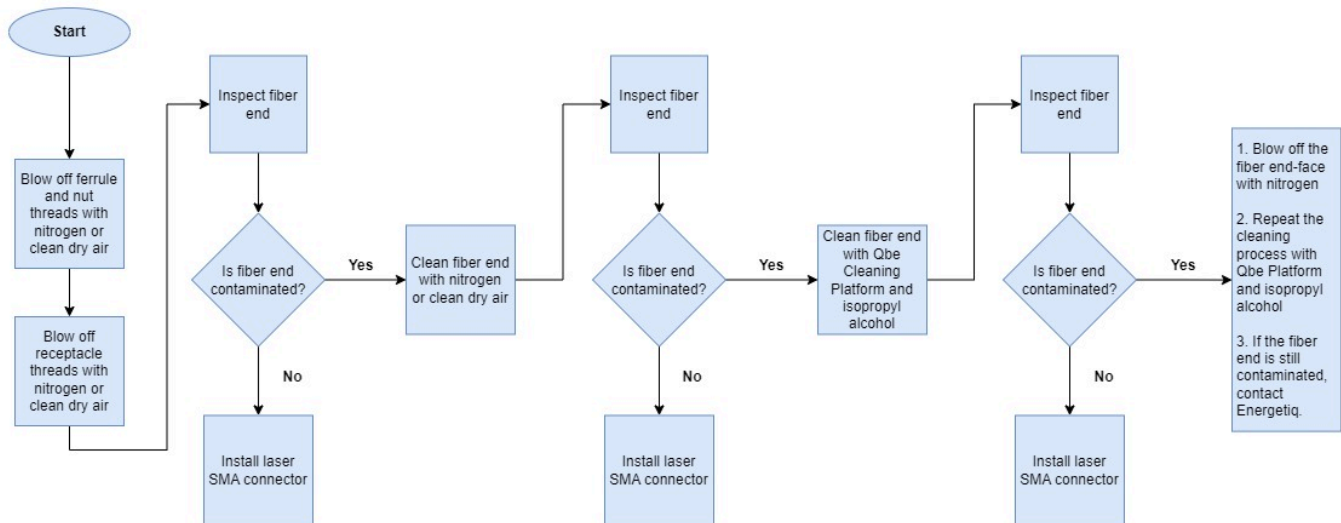


Figure 29. Fiber Cleaning Process Flowchart

- To clean with the QbE Cleaning Platform, gently press the fiber end-face into the cleaning cloth or wipe and rotate it in place several times. Then, reduce pressure and drag the fiber 1-2 cm across the cleaning cloth or wipe.
- The fiber end-face must not have any particles on the core or cladding that are detectable with >200X magnification. For visual examples of a contaminated fiber and a clean fiber, see the figure [Contaminated and Clean Fiber End Examples](#) below.

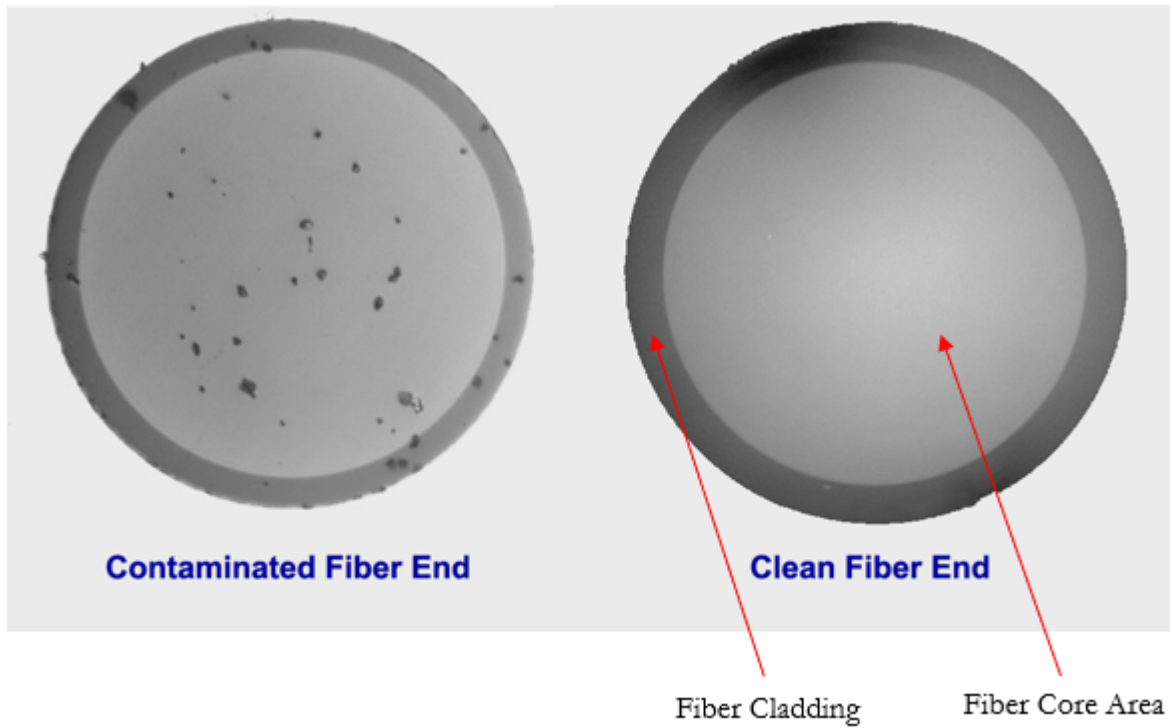


Figure 30. Contaminated and Clean Fiber End Examples

6.2 Lamp Bulb Replacement

If a bad lamp bulb is suspected in the EQ-99X 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-99X system.

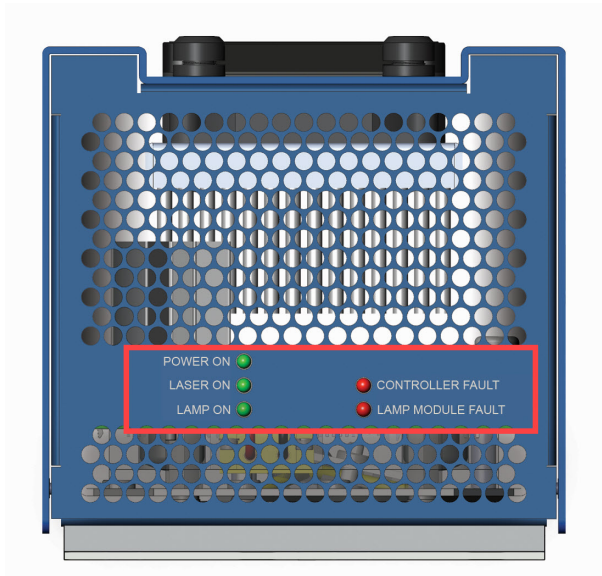


Figure 31. LDLS Controller LED Lights

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

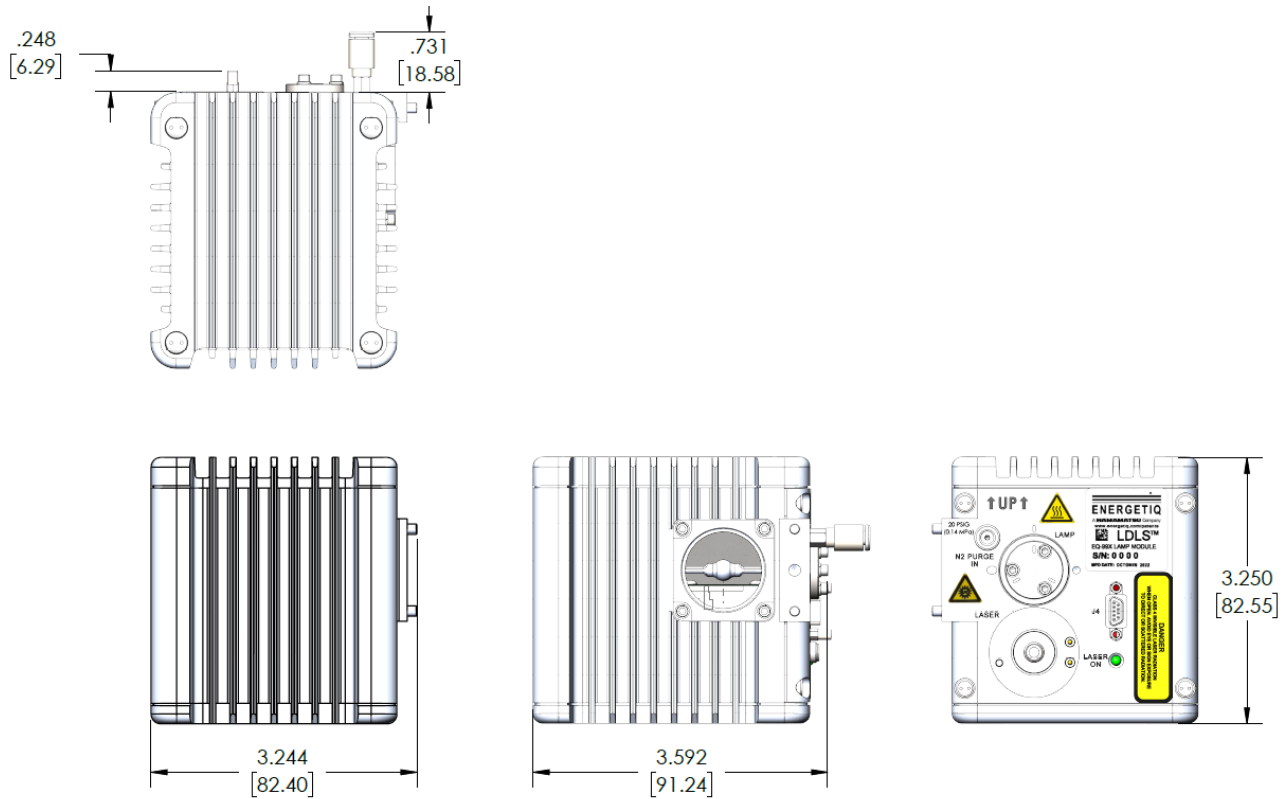
See below for a list of possible issues that may be encountered while operating the EQ-99X system and the potential steps to resolve those issues.

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-99X 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).
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. 	<ol style="list-style-type: none"> 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.

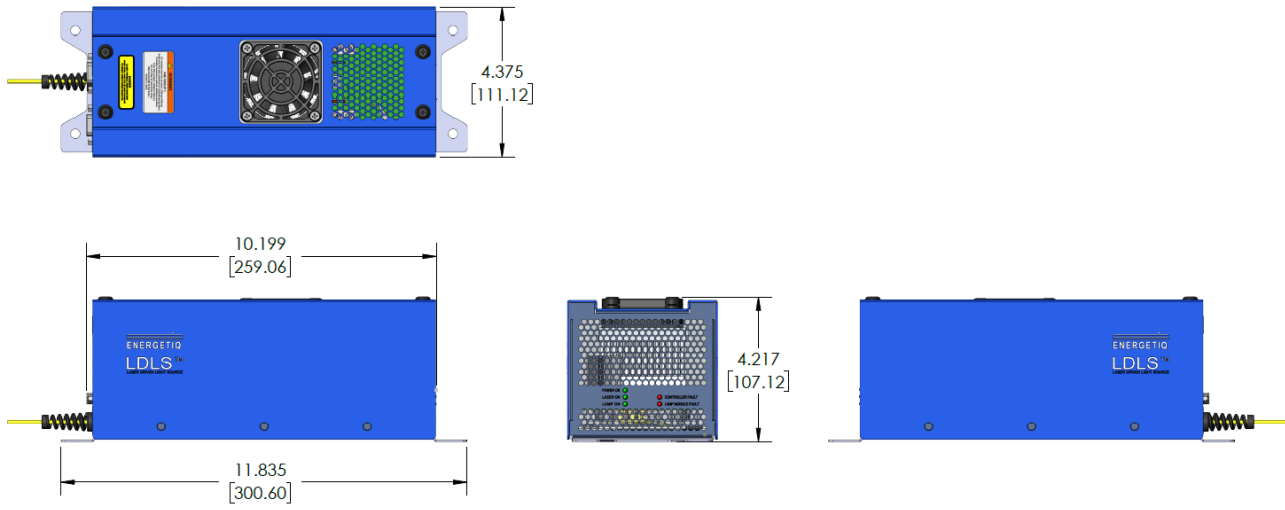
LED Light Name and Status	Possible Issues	Troubleshooting Steps
LAMP ON is OFF	The plasma inside the lamp bulb has been extinguished after ignition. This also causes the LAMP MODULE FAULT light to turn ON and LASER ON light to turn OFF .	If the lamp bulb fails to ignite after several attempts, contact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



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

Figure 32. Lamp Head Dimensional Drawing



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

Figure 33. LDLS Controller Dimensional Drawing

Appendix B. Revision History

Version Number	Modified By	Modifications Made	Date Modified
Rev. 4	M. Steinberg	Updated CE Mark, Logo, Page footer format, Fiber Cleaning Procedure, added Appendix A	March 2018
Rev. 5	L. Chan	Updated: <ol style="list-style-type: none"> 1. Declaration of Conformance with latest standards 2. Laser safety labels to reflect latest standards' dates 3. Manuf. Label to reflect correct Energetiq address 4. Fig. 2 Typical Output Spectrum. 5. Water Cooling Installation for EQ-99-CAL section. 6. Energetiq Address on document 	June 2022
Rev. 6	E. Burz	Reformatted document using new template for Energetiq product manuals. Compliance label updates. Updated Declaration of Conformity.	June 2023
Rev. 7	E. Burz	Compliance updates. Updated the following sections: "Safety Warnings," "Utility Requirements," "Environmental Requirements," "Unpacking the System," "Installing Alternative Power Supply or Remote Control," "Installation Procedure," "Cooling Fluid Components for EQ-99 CAL." Added the following sections: "Correct Disposal of the Unit," "EMC Compliance Standards." Minor edits.	November 2023
Rev. 8	E. Burz	Minor compliance updates.	04/05/2024
Rev. 9	E. Burz	Updated product dimensions and dimensional drawings. Minor edits.	11/11/2024