Laser-Driven Light Source (LDLS®)

Models: EQ-9 & EQ-9-HP



Operation Manual

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ENERGETIQ

A HAMAMATSU Company

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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-9 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-9 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-9 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-9 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-9 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-9 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-9 system.**

The EQ-9 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-9 system uses a patented (U.S. Patent #7435982, others pending) laser drive system to excite a plasma that radiates in the UV as well as the visible bands. A class 4 laser is located in the lamp head enclosure. The optical configuration of the lamp head ensures that the direct laser beam cannot exit the unit. The EQ-9 system laser product is designated as Class 1 during all normal operation.

The parameters of the non-accessible internal laser are given below in 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 mW via 7mm measurement aperture	~25 mm at aperture	>100 mRad	Diffuse

No regular maintenance is required for the EQ-9 system. Any service to the system must be performed only by factory authorized and trained technicians. To avoid injury, under no circumstances should the user open or modify the lamp head or LDLS controller enclosure.

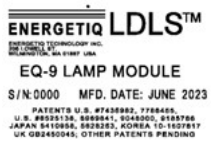
The unit must not be operated if the covers are removed or it is defective in any way. Contact Energetiq if any problems with the equipment are suspected.

1.4 Labels and Safety Notifications

The following safety labels appear on the EQ-9 system. The figure EQ-9 and EQ-9-HP Safety Label Locations shows the location of each label on the system.



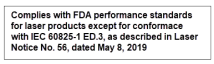
UV Hazard Warning Label – indicates hazardous levels of UV light are present.



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



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



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



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



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

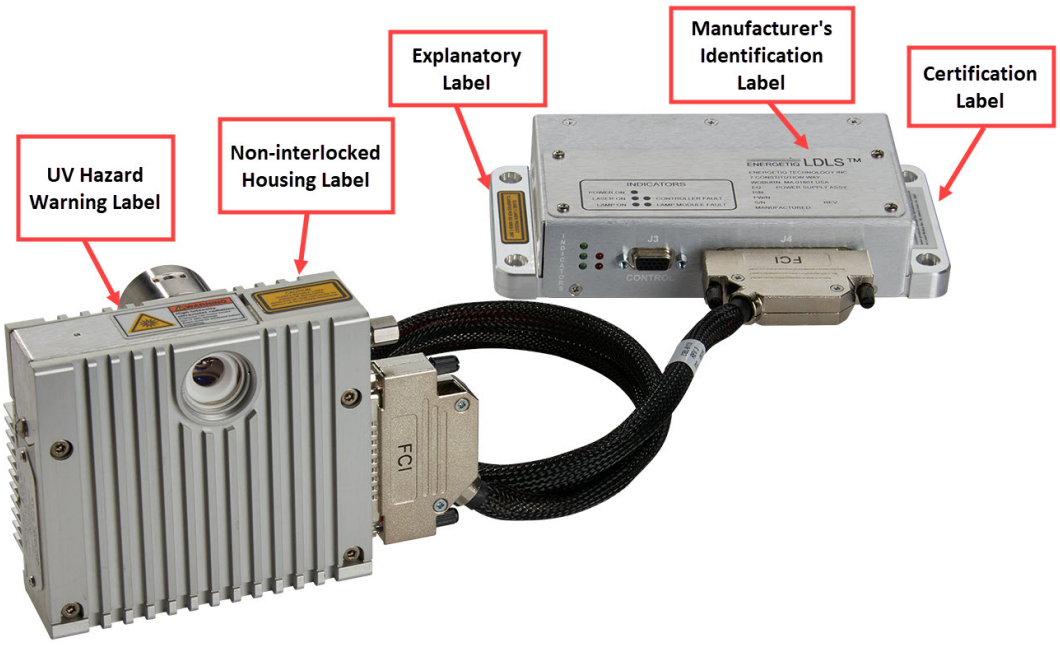


Figure 1. EQ-9 and EQ-9-HP Safety Label Locations

1.4.1 Definition of Equipment and Document Symbols

The following symbols are found on the EQ-9 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-9 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-9 system's warranty, contact your local distribution representative.

1.7 Correct Disposal of the Unit

When the EQ-9 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

This manual describes both the standard EQ-9 and high-power EQ-9-HP models of the EQ-9 Laser-Driven Light Source (LDLS®). Unless otherwise noted, these products will be collectively referred to as the EQ-9 system.

The EQ-9 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-9 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-9 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. See Chapter 4. Installation for connection details.

2.2 Description of System Components

The EQ-9 system consists of an LDLS controller, lamp head, and interconnecting cable. Power and I/O interface connections (not shown) are either provided by the user or by Energetiq upon request.

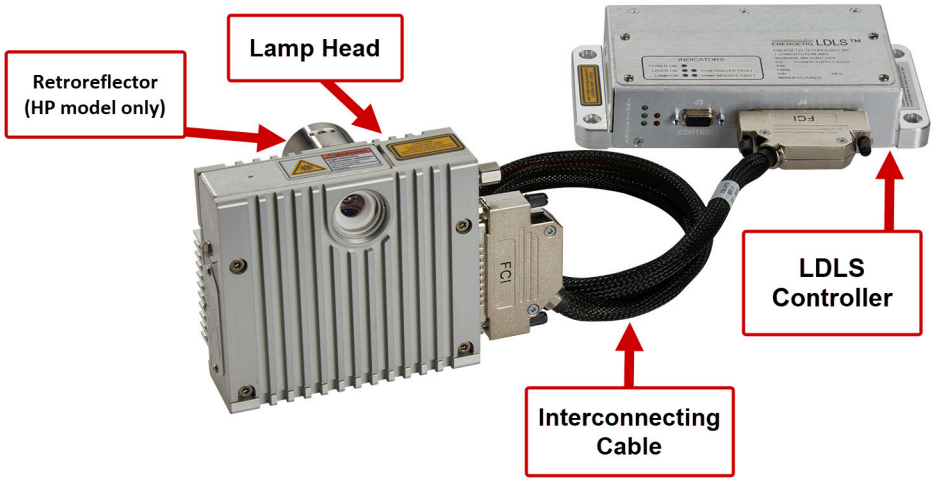


Figure 2. EQ-9 System

The following sections 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
- Lamp Head Port
- Power Input Port
- RS-485 Port
- Laser Power Supply (internal, not shown)
- Thermoelectric Laser Cooler (internal, not shown)
- Control Electronics (internal, not shown)

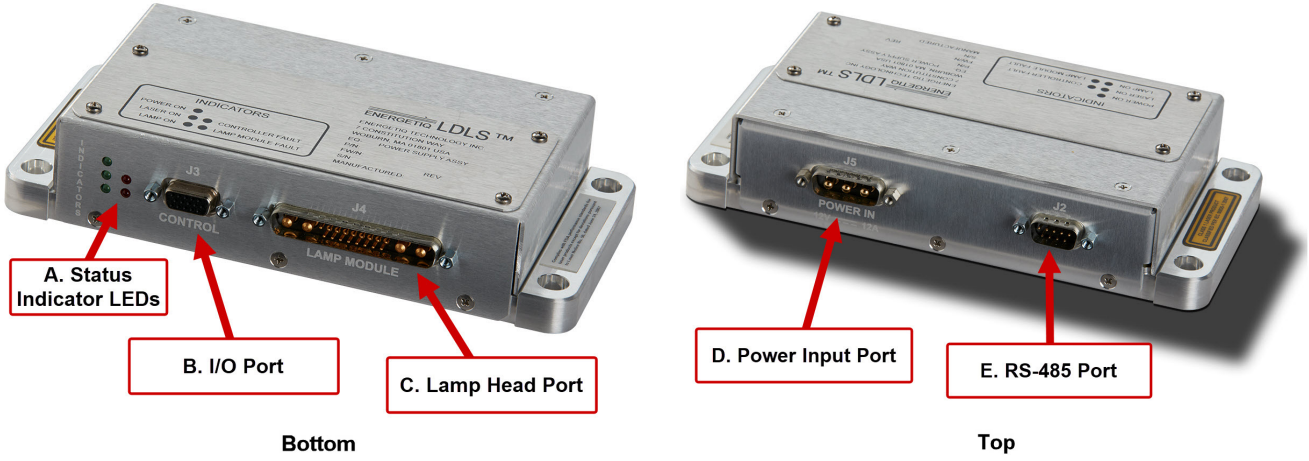


Figure 3. LDLS Controller

A. Status Indicator LEDs

These five LED lights 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 produced within the lamp head
CONTROLLER FAULT	One of the following has occurred in the LDLS controller: 1. External interlock open 2. Controller internal temperature is too high 3. Laser power not reaching setpoint 4. Laser temperature fault
LAMP MODULE FAULT	One of the following has occurred in the lamp head: 1. Control cable not connected properly 2. Lamp head internal temperature is too high 3. Ignition failure

B. Input/Output (I/O) Port

The I/O port is used to connect a remote control to the EQ-9 system. This is the only operator interface for the system – there are no local controls. You can either use the EQ-99-RC Remote Control provided with the system, or another remote control. See 4.3.2 Installing Alternative Remote Control for pin assignments and functions.

C. Lamp Head Port

The lamp head port provides various power and control signals to and from the lamp head. No other connector or cable may be used with the EQ-9 system other than the supplied cable.

D. Power Input Port

The power input port is a jack-screw-secured input port for 12V DC power. Power can be provided using the included 12V DC power supply. Alternatively, the EQ-9 system can be powered directly from a customer-provided 12V DC power supply. See 4.3.1 Installing Alternative Power Supply for detailed information.

E. RS-485 Port

The RS-485 port allows for an optional RS-485 interface to be connected. See Appendix A. RS-485 Interface Commands and Pin Assignments for more information about using the RS-485 interface.

2.2.2 Lamp Head

The lamp head contains the following components:

- Lamp Output Windows (front and rear)
- Nitrogen Inlet Purge Port
- Laser ON Indicator
- LDLS Controller Port
- Retroreflector (HP model only)
- Lamp Bulb (internal, not shown)
- Igniter (internal, not shown)
- Laser (internal, not shown)
- Thermoelectric Cooler (internal, not shown)
- IR Pumping Optics (internal, not shown)

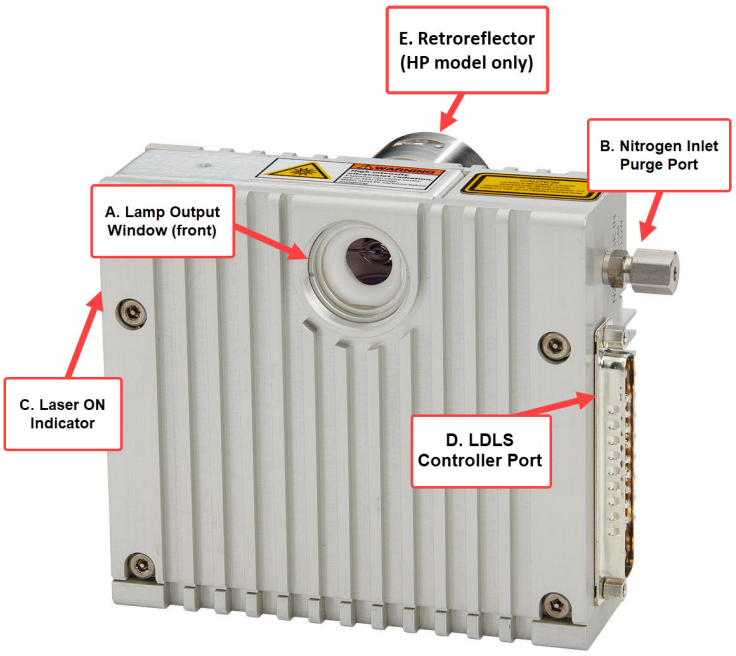


Figure 4. Lamp Head

A. Lamp Output Windows

The lamp output windows on the front and rear of the lamp head provide protection from the high-pressure bulb inside the lamp head. The lamp output windows accommodate light output of 0.56 NA. An internally-threaded SM1 adapter is provided for connection of optical hardware. See Appendix B. Dimensional Drawings for mechanical layout of the lamp head.

B. Nitrogen Inlet Purge Port

This port is the inlet fitting for nitrogen purge gas. Purge gas is optional but strongly recommended for best performance. For optimal product performance, nitrogen gas purging of the EQ-9 system is required.

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

C. Laser On Indicator

This LED light is illuminated when the laser is ON.

D. LDLS Controller Port

The LDLS controller port provides various power and control signals to/from the LDLS controller. No other connector or cable may be used with the EQ-9 system other than the one supplied.

E. Retroreflector

The retroreflector is included with the EQ-9-HP model of the EQ-9 system only. The retroreflector increases the output brightness and limits the light output to one side. Contact Energetiq for more information.

Chapter 3. System Specifications and Requirements

3.1 Optical Performance

See the figure Typical Output Spectrum below for the typical output spectrum.

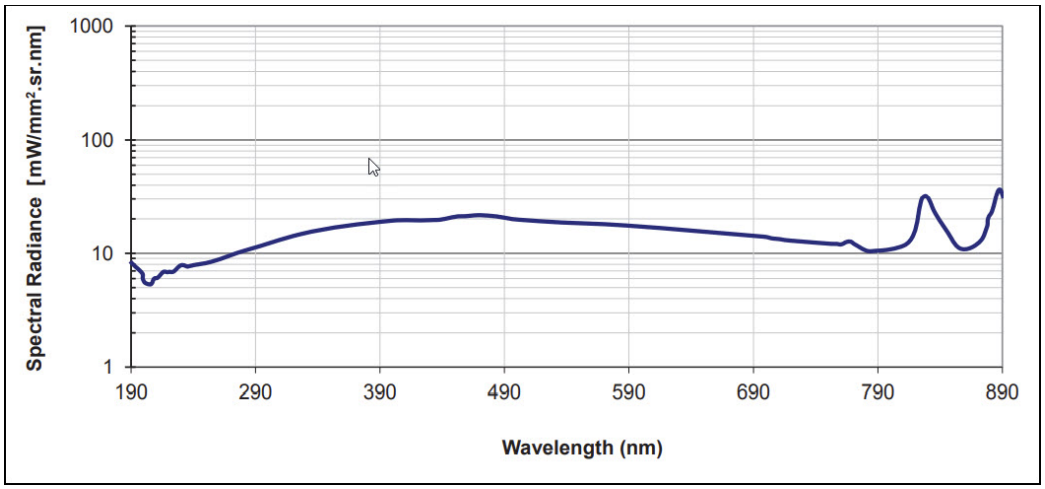


Figure 5. Typical Output Spectrum

3.2 Physical Specifications

EQ-9 Model

Dimensions (H x W x D)

- **Lamp Head**: 108 x 124 x 52 mm (4.3 x 4.9 x 2.1 in)
- **LDLS Controller**: 42 x 197 x 103 mm (1.7 x 7.8 x 4.1 in)

Weight

- **Lamp Head**: 0.91 kg (2 lb)
- **LDLS Controller**: 0.68 kg (1.5 lb)

EQ-9-HP Model

Dimensions (H x W x D)

- **Lamp Head**: 108 x 124 x 60 mm (4.3 x 4.9 x 2.4 in)
- **LDLS Controller**: 42 x 197 x 103 mm (1.7 x 7.8 x 4.1 in)

Weight

- **Lamp Head**: 0.91 kg (2 lb)
- **LDLS Controller**: 0.68 kg (1.5 lb)

3.3 Remote Interface Specifications

Digital Inputs

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

Digital Outputs

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

Power

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

Serial Interface

- **Type**: RS-485 2-wire (half-duplex)
- **Connnector**: Male 9-pin d-sub
- **Termination**: 120 ohm termination across the data lines
- **Port Settings**: 9600 bps, 8 data bits, 1 stop bit, no parity, no handshaking

3.4 Utility Requirements

- **Electrical**: 12VDC at 11.7A minimum (140W rating). Power consumption is approximately 100W during normal operation. Some OEM versions have higher current requirements.
    - **Optional AC Adapter**: 100-240V ~ ± 10%, 2.5A, 50-60Hz.
- **Purge Gas**: Optional (strongly recommended). Clean dry nitrogen, filtered to 5 um 20 psig (0.14 MPa) supply pressure.
    - **Fittings**: Push-to-connect type, sized for 1/8" tubing
    - 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-9 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.

- **Cooling**: Fan (30 CFM forced air cooling) – Provided with EQ-9 system

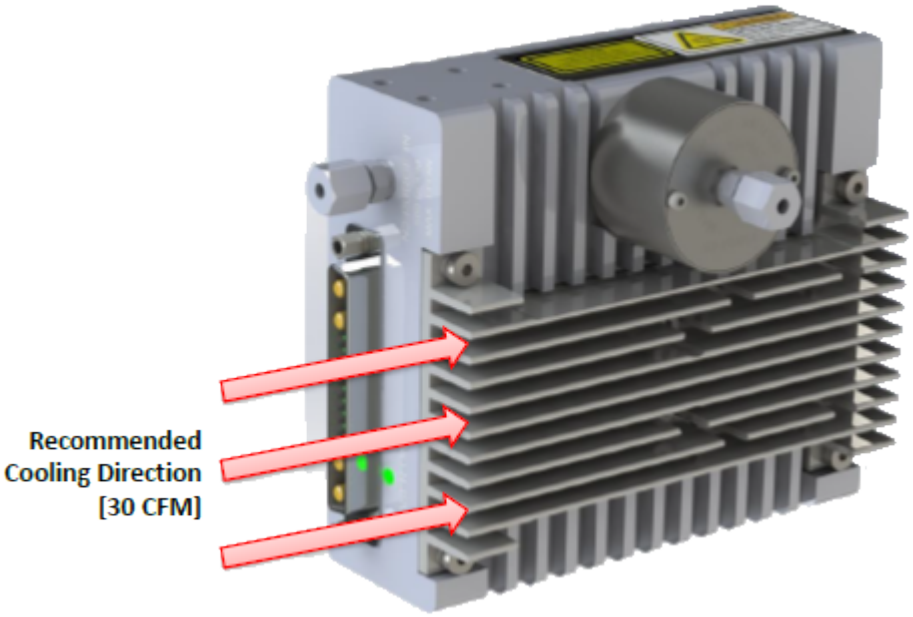


Figure 6. Recommended Cooling Direction

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 Adapater**: 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-9 system for completeness and damage incurred in shipping.

If any part is missing or appears damaged, contact Energetiq immediately. Do not attempt to substitute any parts. There are no user-serviceable parts inside the EQ-9 system lamp head or LDLS controller.

At a minimum, the EQ-9 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 **Note**: Retroreflector shown in photo is only included with the EQ-9-HP model system.	

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

4.1.2 Optional Accessories

The EQ-9 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	

Qty	Item Description	Picture
1	12V DC power supply with custom connector	

4.2 Installation Procedure

The following section details how the install the EQ-9 system.

> **Note**: The instructions below depict an EQ-9 system. If you are installing an EQ-9-HP system, your system may appear slightly different.

> **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 performance problems. Consult Energetiq for applications information and suggested configurations.

To install the EQ-9 system:

1. Mount the LDLS controller to an optical breadboard plate or other suitable mounting structure using the four mounting holes and the appropriate hardware.

   > **Note**: The surface where the LDLS controller is mounted should be near ambient temperature (preferably 20 °C to 30 °C) and capable of dissipating 25W of heat.

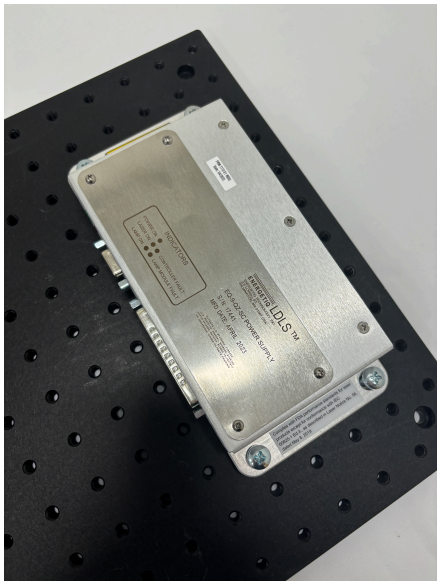


Figure 7. Mounting the LDLS Controller

2. Mount the lamp house in the orientation shown below, with the output windows on the side and the bulb oriented horizontally. Four M4-threaded holes are available on the bottom of the EQ-9 system for mounting. Four M4-threaded holes are also available on the top surface of the lamp head.

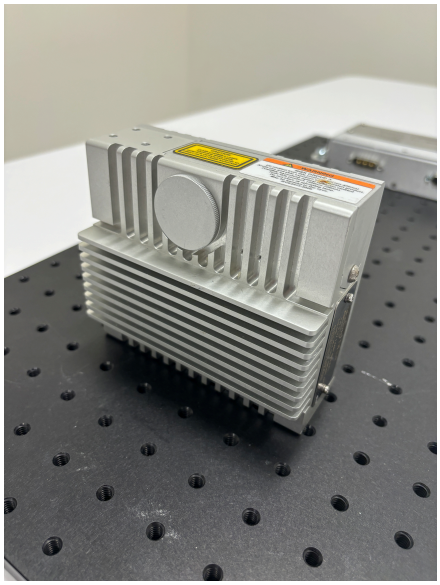


Figure 8. Mounting the Lamp Head

3. Remove the lamp output window covers from the lamp head.



Figure 9. Removing the Lamp Output Window Covers

4. Set up the cooling fan so that it is blowing on the EQ-9 system lamp head in the recommended direction as shown below.

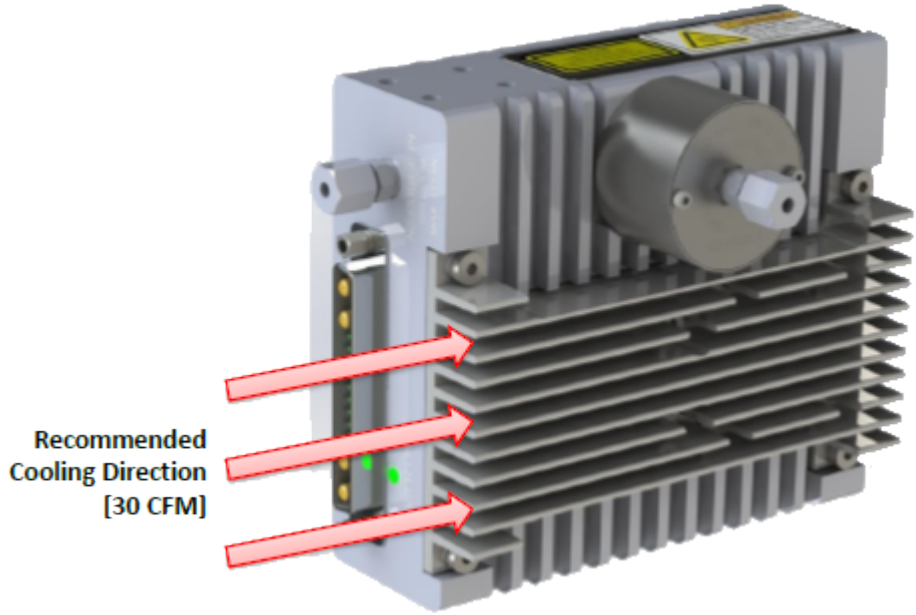


Figure 10. Recommended Cooling Fan Direction

5. Connect the lamp head to the user equipment. Set up the lamp head with the appropriate ultraviolet safety measures and laser light safety measures in place. It is recommended that any enclosure or aperture-blocking hardware utilizes switches wired to the EQ-9 system external interlock circuit.
6. Connect the black 21-pin mixed D-sub interconnect cable from the LDLS controller to the lamp head.

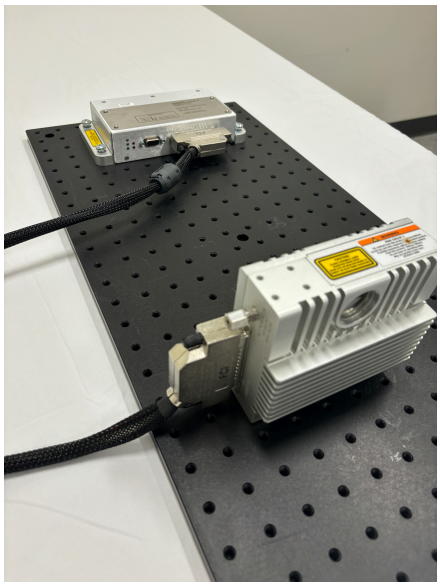


Figure 11. Connecting the Interconnect Cable

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.
8. 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.

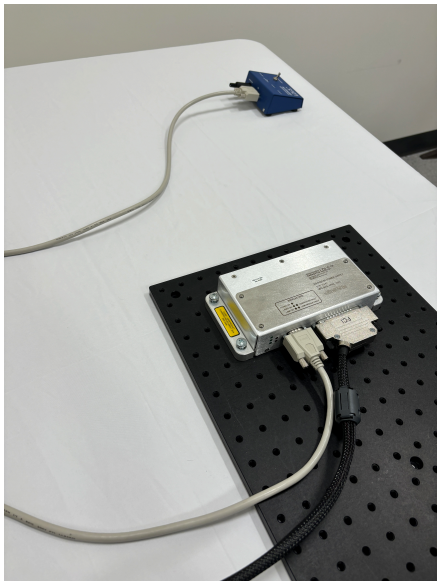


Figure 12. Connecting the I/O Cable to Remote Control

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

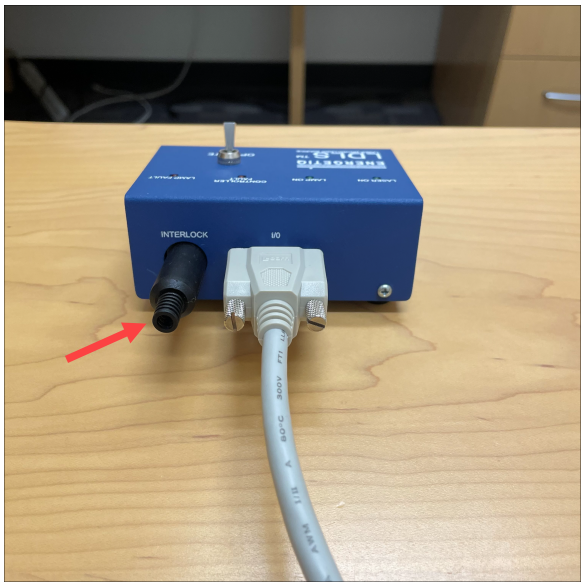


Figure 13. Inserting the Interlock Jumper Plug

Alternatively, if using another remote control system, see 4.3.2 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.

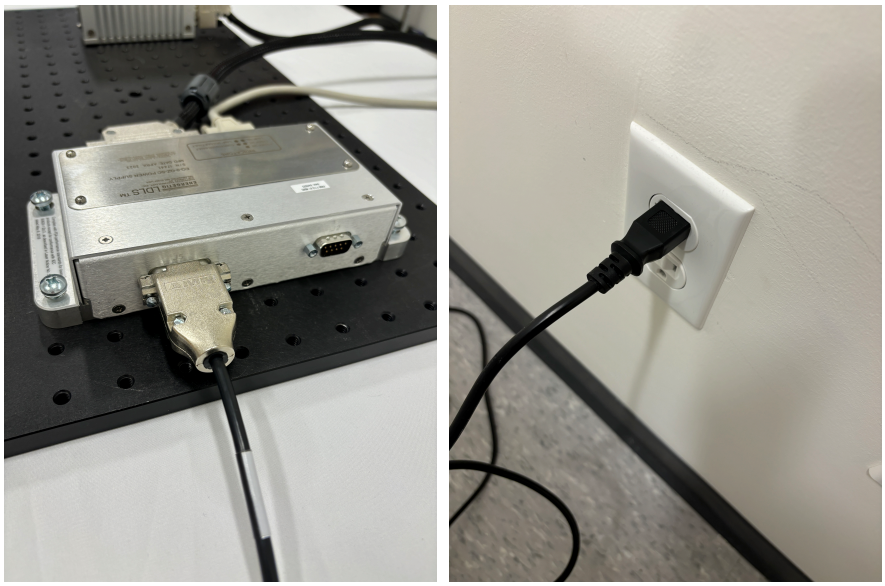


Figure 14. Connecting the 12V DC Input Power Source

Alternatively, if using a power supply other than the internal power supply in the LDLS controller, see 4.3.1 Installing Alternative Power Supply for more information.

10. If using the optional RS-485 interface, connect the host computer to the RS-485 port on the LDLS controller.
11. The system is now ready to operate.

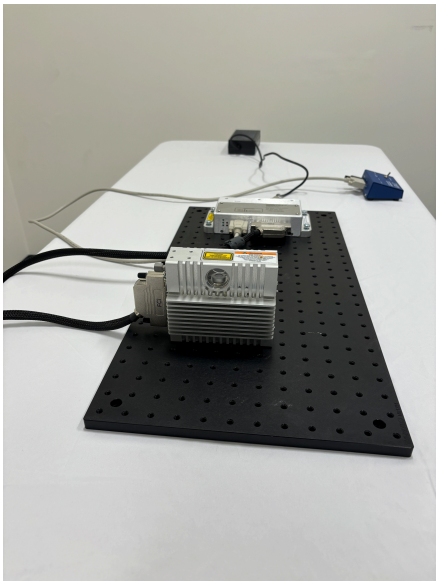


Figure 15. EQ-9 System Installed

4.3 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-9 system.

4.3.1 Installing Alternative Power Supply

The EQ-9 system requires 12V DC ± 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-9 system is a jack screw 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 5. Types of Connectors

Connector	FCI DA3W3SA00LF
Pin A1	+12V DC
Pin A2	-12V DC return
Pin A3	Safety Ground

4.3.2 Installing Alternative Remote Control

The EQ-9 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 6. 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-9 system internal isolated power supply, or an external supply.

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

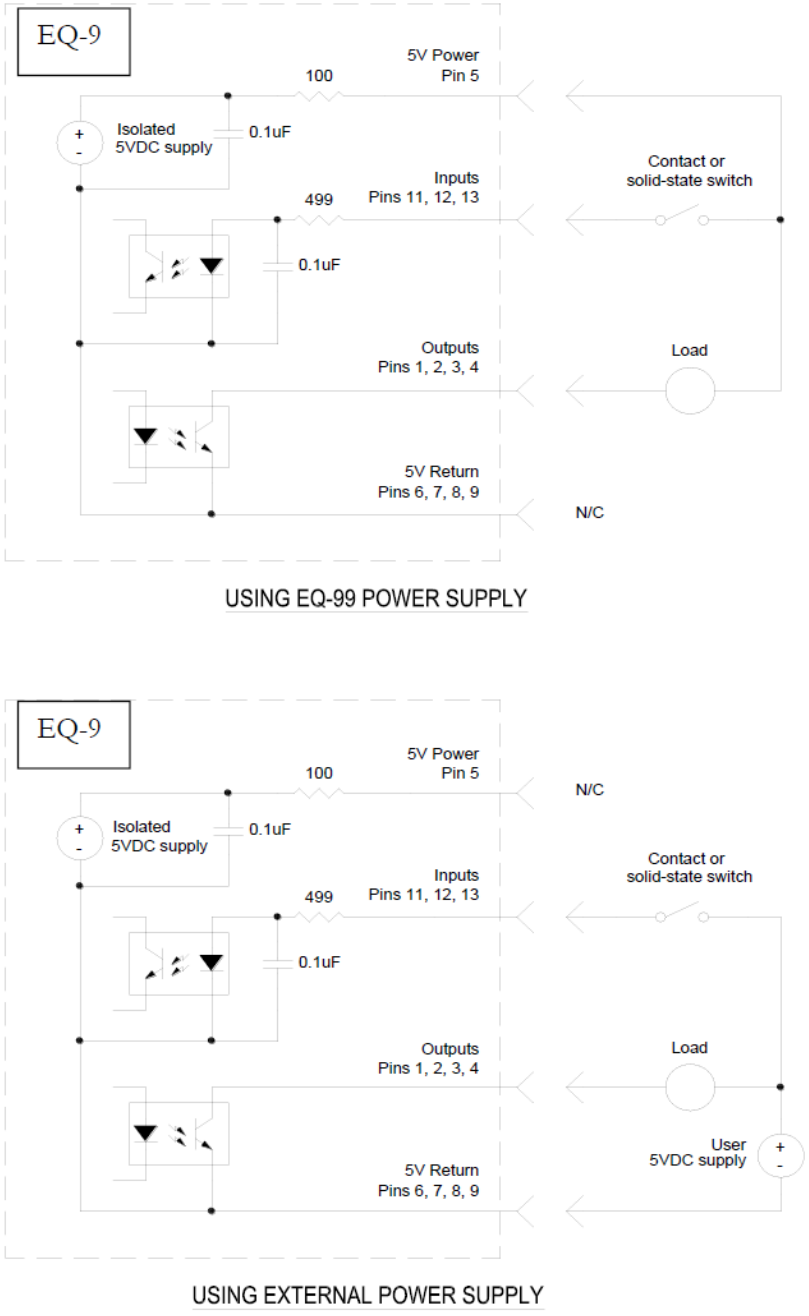


Figure 16. Remote Interface Schematic

Chapter 5. Operating the System

5.1 Starting the System

> **Caution**: Once the EQ-9 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-9 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 17. 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.

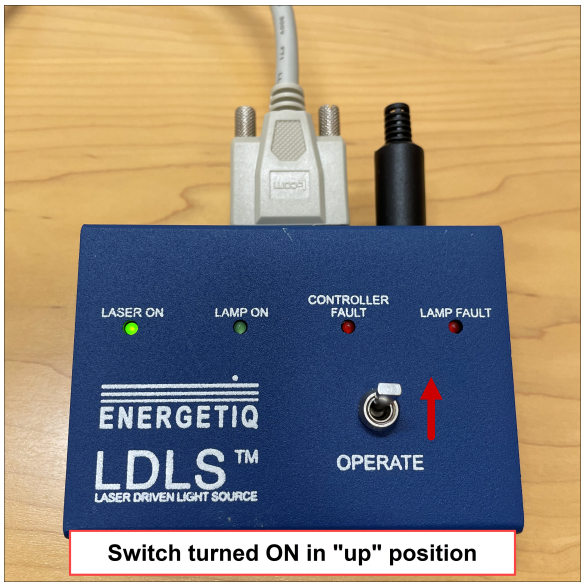


Figure 18. LASER ON LED Illuminated

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



Figure 19. LAMP ON LED Illuminated

4. Allow the EQ-9 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-9 system. The EQ-9 system will automatically detect when the unit

has reached the optimum conditions for ignition.

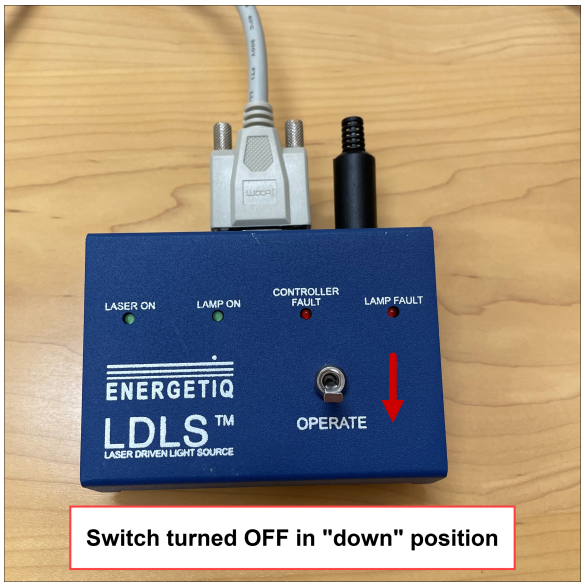
– If a bulb fails to ignite, 150 seconds after the OPERATE switch is turned ON:

- 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 or contact Energetiq's Service department.

5.2 Stopping the System

1. To turn the EQ-9 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-9 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-9 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-9 system.

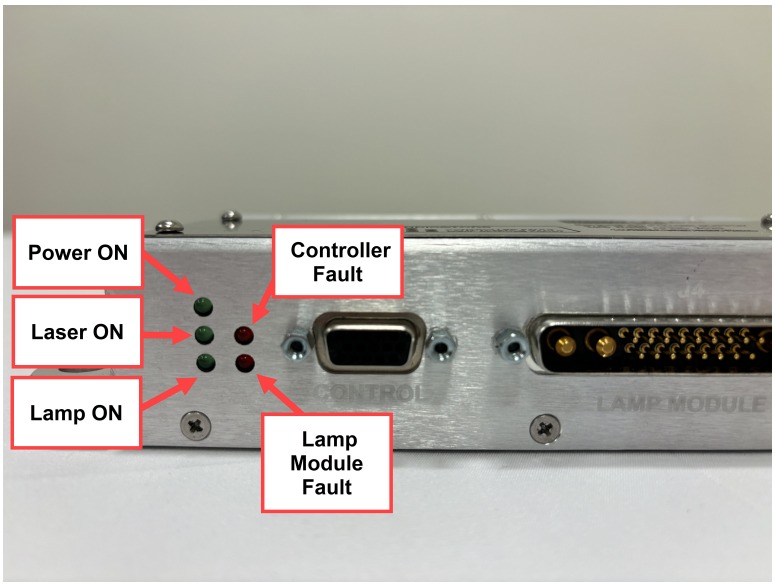


Figure 20. LDLS Controller LED Lights

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-9 system and the potential steps to resolve those issues.

Table 7. Possible Issues and Remedies

LED Light Name and Status	Possible Issues	Troubleshooting Steps
LAMP MODULE FAULT is **ON**	One of the following has occurred in the lamp head: 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**.	1. Clear the fault lights by toggling the EQ-99-RC Remote Control between the ON and OFF positions. The EQ-9 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**	One of the following has occurred in the LDLS controller: 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 lamb 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-9 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 80% and 100% of full scale in 0.5% increments.

Commands consist of a single ASCII character, case-sensitive. This can be transmitted to the EQ-9 system via a terminal emulation program, or the user's control system. Response from the EQ-9 system will be a string of ASCII characters, format depending on the command issued.

The following table describes the serial commands and their functions.

> **Note**: The RS-485 port supports Logwatch.

Table 8. RS-485 Commands

Command Character	Function	Reply from EQ-9
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-9 system is interrupted.	Calibration data copied to FLASH Memory
H	Query bulb operating hours	Bulb time = XXXX.X hrs
Z	Zero bulb operating hours	Send "z" within 10 sec. to confirm.
z	Confirm zeroing of bulb hours	Bulb hours zeroed & flash saved

Command Character	Function	Reply from EQ-9
L	Query laser operating hours	Laser time = XXXX.X hrs
T	Query lamp head 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	EQ-9 firmware vXXX build date mm/dd/yy (c) Energetiq Technology, Inc. • U/D – Inc/Dec laser pwr (by 0.5% full scale) • Q – Query laser pwr setpoint • F – Reset laser pwr to default • B –Burn settings to flash memory • H – Query bulb operating hrs • Z – Zero bulb operating hrs • z – (confirm above within 10 sec) • L – Query laser operating hrs • T – Query lamp head temp • S – Query system status • ? – This menu

System Status Word

Table 9. 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	Laser status: 1 = on, 0 = off
3	Laser temperature: 1 = overtemperature, 0 = OK

Bit #	Definition
4	Reserved – always 0
5	Reserved – always 0
6	Lamp head temperature: 1 = overtemperature, 0 = OK
7	Reserved – always 0
8	Lamp head interlock: 1 = open, 0 = OK
9	External interlock: 1 = open, 0 = OK
10	Reserved – always 0
11	Lamp photodiode signal: 1 = low, 0 = OK
12	Lamp photodiode signal: 1 = low, 0 = OK
13	Ignition status: 1 = failed to ignite, 0 = OK
14	Reserved – always 0
15	Reserved – always 0

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

Table 10. RS-485 Interface Pin Assignments

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

Appendix B. Dimensional Drawings

EQ-9 System Drawings

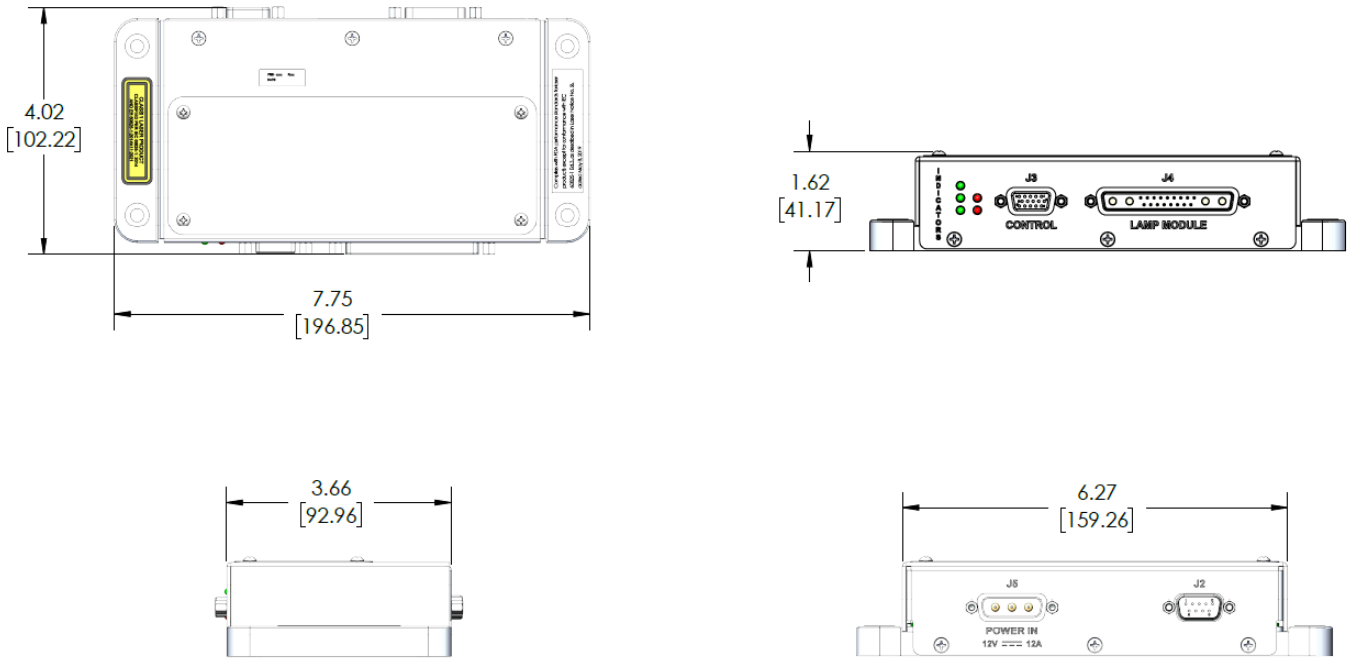


Figure 21. EQ-9 LDLS Controller Dimensional Drawing

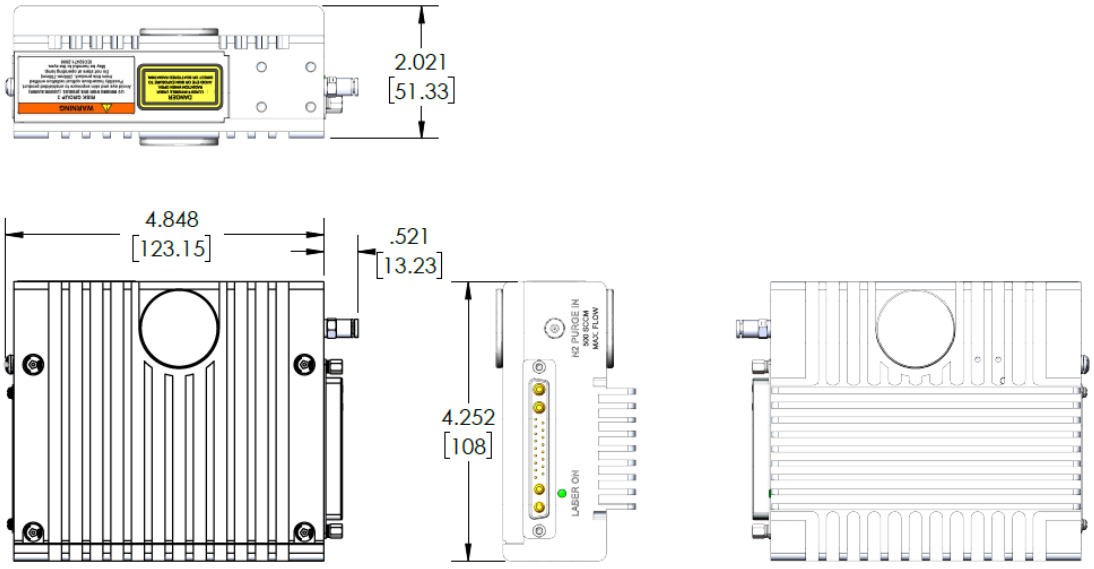
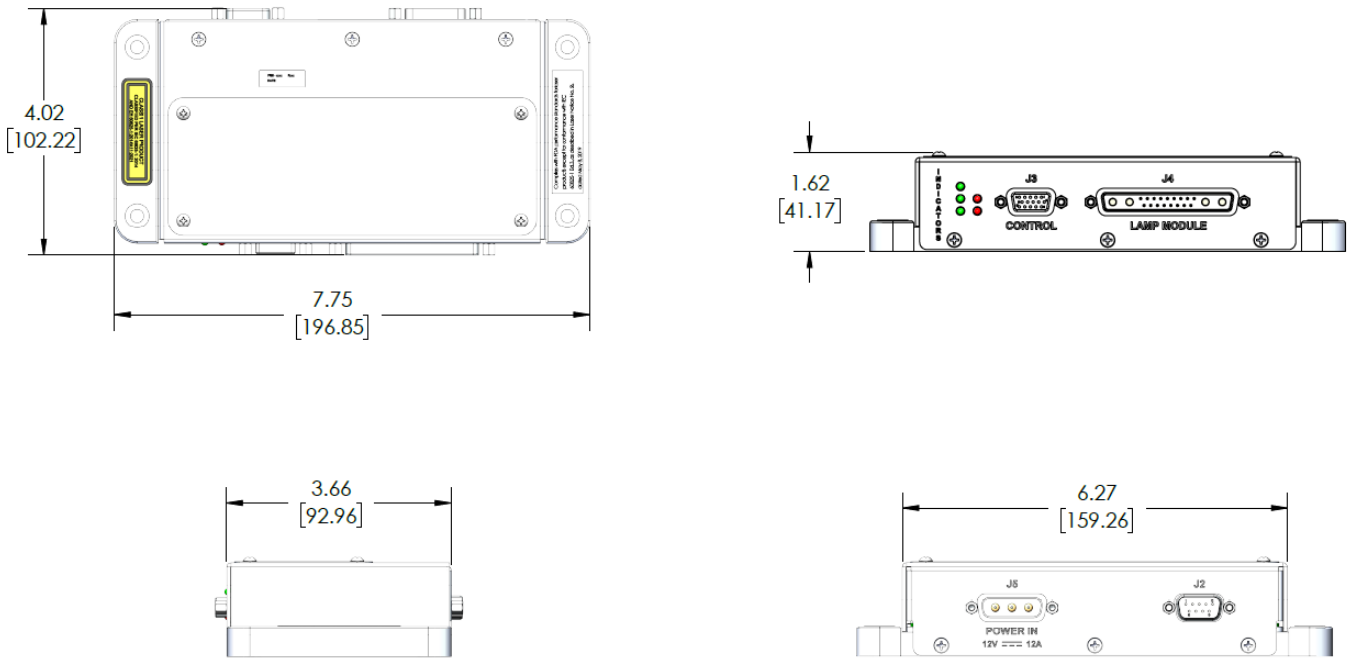


Figure 22. EQ-9 Lamp Head Dimensional Drawing

EQ-9-HP System Drawings



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

Figure 23. EQ-9-HP LDLS Controller Dimensional Drawing

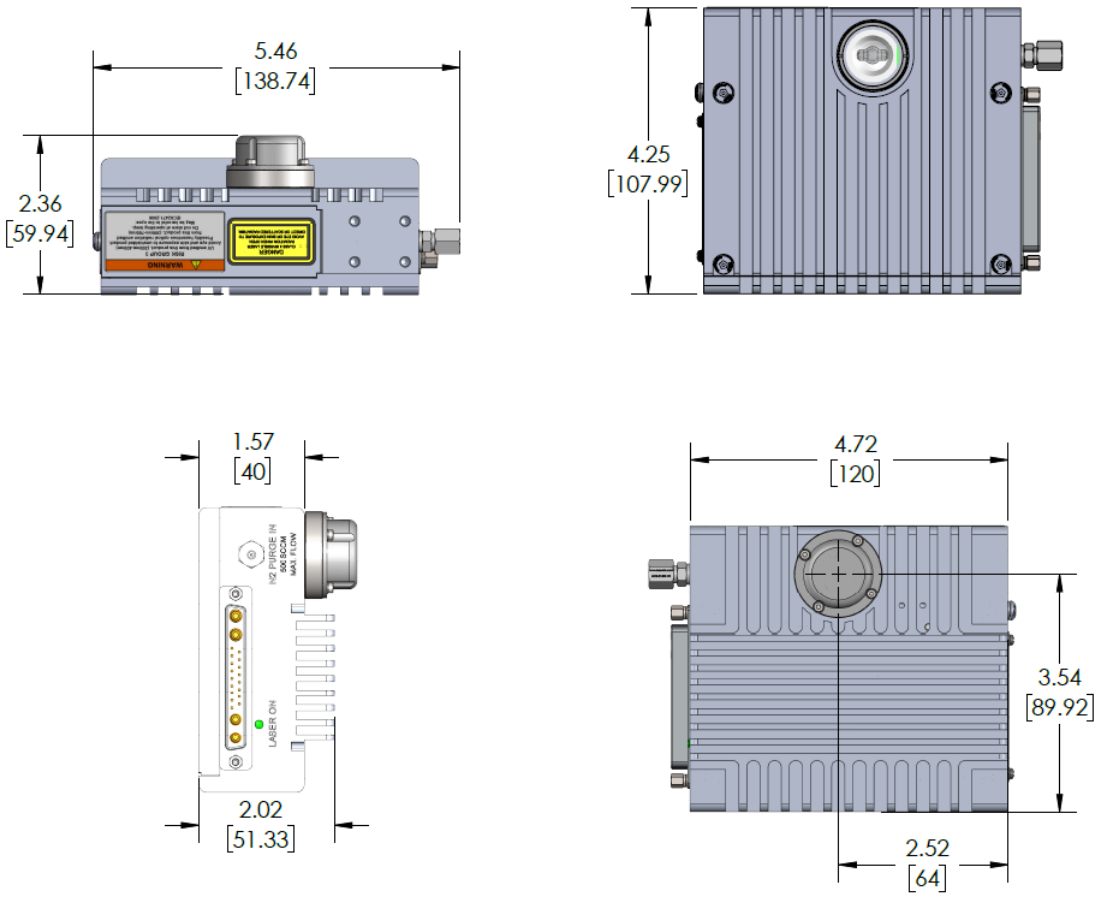


Figure 24. EQ-9-HP Lamp Head Dimensional Drawing

Appendix C. Revision History

Table 11. Revision History

Date	Revision No.	Author	Description
April 2018	3	Mae Steinberg	Updated CE Certificate of Compliance, laser safety labels, and manufacturer label. Added Appendix "Revision History."
August 2019	4	N/A	N/A
June 2022	5	Lai Chan	Updated: • Declaration of Conformance to latest electrical safety standards • Laser safety labels to reflect latest standards date.
June 2023	6	Eric Burz	Compliance label updates. Updated Declaration of Conformity. Minor edits.
11/11/2024	7	Eric Burz	Updated formatting and layout of product manual to align with existing Energetiq product manuals. Added "EQ-9-HP" model to manual. Updated "Troubleshooting" and "Installation" chapters. Minor edits.