Operator's manual

ALX100-AO-9.6 Laser

ACCESS LASER
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Contents

1 Laser Safety

1.1 FDA & International Regulations

Access Laser products are designed, tested, and certified to comply with United States (US) and European Union (EU) regulations. For commerce within the US, laser safety requirements are governed by the Center for Devices and Radiological Health (CDRH) as set forth by United States Radiation Control for Health and Safety Act of 1968. For International commerce outside the US, laser safety is commonly governed by IEC Standards.

Original Equipment Manufacturers (OEMs) that manufacture laser products sold in the US or imported into the US are required to file a Product Report with the CDRH, prior to entering commerce in the US, that demonstrates compliance to 21 CFR 1040.10. OEMs that operate and sell outside of the US typically follow IEC 60825-1 for laser safety compliance. It is the responsibility of the OEM or system integrator to assure complete compliance with all applicable regulations when integrating Access Laser products into their systems. Per United States regulatory requirements, Access Laser has filed an OEM Product Report with the CDRH for the ALX100-AO-9.6 laser.

1.2 General Safety Information

The ALX100-AO-9.6 is a Class 4 laser subsystem intended exclusively for integration into OEM (Original Equipment Manufacturer) equipment. It is not intended for standalone operation or direct end-user use without additional protective measures implemented by the system integrator.

This laser emits high-power infrared radiation capable of causing serious injury, fire, or equipment damage if used improperly.

The purchaser, system integrator, or manufacturer of the final equipment is responsible for ensuring that the completed system complies with all applicable regional regulations, directives, and safety standards.

All personnel involved in installation, integration, operation, or service must read and understand this manual before working with the laser.

Failure to follow the safety instructions in this manual may result in:

- Permanent eye injury or blindness
- Severe skin burns
- Electrical shock
- Fire hazards
- Equipment damage
- Personal injury or death

Only trained and qualified personnel familiar with high-power laser systems and associated hazards are permitted to install, operate, or service this equipment. Unauthorized or untrained individuals must not operate or attempt to service the laser.

1.3 OEM Integration Responsibility

The ALX100-AO-9.6 laser is intended as an OEM subsystem, designed to be incorporated into laser processing equipment. As supplied by Access Laser, the product does not meet the laser safety requirements outlined by the Center for Devices and Radiological Health (CDRH) in 21 CFR, Sub Chapter J without additional safeguards. The integrator or manufacturer of the final equipment is responsible for implementing all safety measures required for safe operation of the completed system.

Responsibilities include, but are not limited to:

- Providing a protective housing or beam enclosure preventing human access to hazardous radiation
- Implementing safety interlocks and emission indicators
- Performing system-level hazard analysis and risk assessment
- Ensuring compliance with applicable electrical and machinery safety standards
- Providing appropriate safety labeling and user documentation
- Certification of the final product where required by regulatory authorities

Operation of the laser outside a properly engineered enclosure is hazardous and may violate applicable regulations.

1.4 Equipment Safety Standards

The ALX100-AO-9.6 laser subsystem has been designed and tested for compliance with the following applicable standards and directives.

Applicable EU Directives

- Electromagnetic Compatibility (EMC) Directive 2014/30/EU
- Restriction of Hazardous Substances (RoHS) Directive (EU) 2015/863 with allowed exemptions

Applicable Harmonized Standards

- EN 60825-1:2014 + A2:2020 /A11:2021
  Safety of laser products, Part 1: Equipment classification and requirements
- IEC 61000-6-2:2016
  Immunity standards
- EN 55011:2016 + A1
  Radio frequency disturbance — Group 2, Class A
- EN IEC 63000:2018
  Technical documentation for RoHS assessment

EMC Test Methods

- EN 55011 — Radiated and conducted emissions
- EN 61000-4-2 — Electrostatic discharge immunity
- EN 61000-4-3 — Radiated RF immunity
- EN 61000-4-4 — Electrical fast transient/burst immunity
- EN 61000-4-6 — Conducted RF disturbances

CE Marking

The CE marking has been affixed to the device according to Article 17 of Directive 2014/30/EU.

1.5 Symbols & Signal Words

DANGER
Indicates a hazardous situation, which if not avoided will result in serious injury or death. Use limited to only the most extreme situations.

WARNING
Indicates a hazardous situation, which if not avoided could result in serious injury or death.

CAUTION
Indicates a hazardous situation, which if not avoided could result in minor or moderate injury.

NOTICE
Non-hazard related information regarding the operation or use of the laser

This symbol is used to alert the operator to important operational or use information

This symbol is used to alert the operator to the presence of dangerous voltages that may result in an electrical shock hazard

This symbol is used to alert the operator to the danger of exposure to hazardous radiation (visible and/or invisible).

1.6 Optical Safety Precautions

WARNING
Laser radiation—this class 4 laser product emits invisible laser radiation in the 9-11µm wavelength range. Avoid eye and skin exposure from both direct and scattered beams.

- Always wear laser safety eyewear rated for the laser's wavelength and power
- Verify that all optical components (mirrors, lenses, beam guides) are clean, properly mounted, and rated for the power output of the laser
- Never place reflective or flammable materials in the beam path
- Take care to prevent specular reflections, which can redirect the beam unpredictably

1.7 Electrical Safety Precautions

DANGER
Follow all applicable electrical codes to avoid potentially fatal electrical shocks from electrical equipment.

- Disconnect electrical power before servicing the laser
- Do not bypass interlocks or safety circuits
- Do not remove or tamper with external covers on the laser—doing so could expose hazardous voltages
- All electrical cables should be inspected for wear and damage prior to use
- Use appropriate grounding and shielding to prevent electrical shock and electromagnetic interference
- Only qualified personnel should access or modify electrical connections

1.8 Safety Features & Compliance

Feature	Use Case	Required By:		Available on ALX100-AO-9.6?
		CDRH	IEC 60825-1	
Key Switch	On/Off Key Switch controls power to laser electronics. The key cannot be removed when it is in the “On” position	Yes	Yes	No—OEM must implement key switch at the system level
Remote Interlock	Disables the laser when protective equipment or panel door is open	Yes	Yes	Yes
Laser Shutter	User can close the shutter when servicing the unit	Yes	Yes	No—OEM must add external shutter
Laser Ready Indicator	Indicates power is applied and laser is ready to operate	Yes	Yes	Yes—LED on laser indicates DC power is applied
Delay at Power Up	Laser is not enabled when powered up or Key Switch is cycled for about 5 seconds	Yes	Yes	No—OEM must implement power-up delay
Power Fail Lockout	The RF driver is disabled when the power comes back on after an intermittent failure	Yes	Yes	No—OEM must implement lockout system
Warning Labels	Labels attached to various locations on laser housing to warn users of potential danger.	Yes	Yes	Yes

Table 1.8-1 Laser Safety Features

As documented in the table above, if the ALX100-AO-9.6 is integrated into an OEM system, the system manufacturer must add additional features to meet CDRH and IEC 60825-1 requirements.

1.9 Safety Labels & Placement

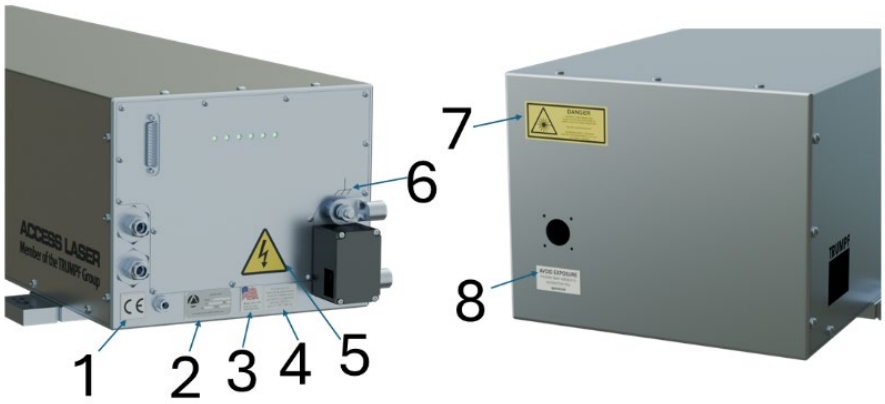


Figure 1.9-1 Safety Label Placement

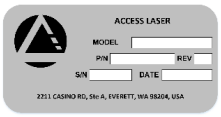
Location	Label	Description
1		CE Compliance Label – indicates that the laser is CE compliant
2		Product Identification label – Indicates model, serial number, and date of manufacture
3		Made in USA Label
4	**This device is a laser component which must be installed and operated in compliance with IEC 60825-1 and 21 CFR 1040.10**	Safety Compliance Label – Indicates the standards that the OEM must comply with when integrating into a system
5		Electric Shock Danger Label – Indicates that there is an electrical shock hazard
6		Chassis terminal – Indicates the location of ground terminal to be connected to system ground
7		Danger Label – Indicates laser class and includes explanatory data such as power and wavelength. It also calls out the edition of IEC 60825-1 used for label compliance
8	**AVOID EXPOSURE** Invisible laser radiation is emitted from this **aperature**	Avoid Exposure label – Indicates the location of the beam aperture

Table 1.9-1 Safety Label Descriptions

2 General Description

2.1 Overview

The ALX100-AO-9.6 is a stabilized 100-watt CO_2 laser with an integrated Acousto-Optic Modulator (AOM), optimized for high-throughput processing of sensitive materials. The laser resonator is engineered for highly stable continuous-wave (CW) output, maintaining power stability within ±2% during both short- and long-term operations.

The output of the laser resonator is passed through an internally mounted AOM which functions as an output gate, enabling fast rise and fall times (<400 ns) to reduce melting and minimize heat-affected zone (HAZ) issues on thin films and other delicate materials. When the customer supplied AOM Digital Modulation Input signal is low, the output beam is diverted into an internal beam dump. When the signal is high, the beam is transmitted through the laser exit window.

In addition to fast pulse rise and fall time, the AOM gating capability allows the laser beam output to be suppressed during initial warm-up, ensuring excellent power stability before material processing begins.

2.2 Basic Function

When 48 Volts DC is applied to the laser, the control systems will power on and prepare the laser for operation. The behavior of the laser will then depend on the state of the System Interlock circuit and the AOM Digital Modulation Input signal. **To ensure safe startup conditions, the System Interlock should be verified to be in the open state, and the AOM Digital Modulation Input signal should be removed prior to applying DC voltage.**

2.2.1 System Interlock Open

WARNING
Laser radiation—this class 4 laser product emits invisible laser radiation in the 9-11µm wavelength range. Avoid eye and skin exposure from both direct and scattered beams.

If the System Interlock is in an open state when DC voltage is applied, the control system will power on, and the laser will remain in an idle state until the System Interlock circuit is closed.

2.2.2 System Interlock Closed

If/when the System Interlock is closed, the control system will go through a short diagnostic check (10-15 seconds). If all checks are normal, the laser RF drive will be set to 100% power and laser beam will begin transmitting through the internal AOM. If a command signal is applied to the AOM

Digital Modulation Input, the laser beam will output from the exit aperture. If no digital modulation signal is applied, the output beam will be directed into the internal beam dump.

2.3 Specifications

Laser Specifications	
Wavelength	9.55 ± 0.05 µm
Peak/CW Power	>100 W
Power Stability[1]	± 2%
Beam Quality (M^2)	<1.2
Beam Diameter[2]	5.5 ± 1.0 mm
Divergence	2.7 ± 0.3 mrad, full angle
Ellipticity[3]	< 1.2
Pointing Stability[1]	< 400 µrad
Polarization	Linear, Vertical
Rise/Fall Time	<400 ns
Pulse Frequency[4]	0-1 MHz
Pulse Duty Cycle	0-100%
Pulse Amplitude Range	0-100%

Electrical Specifications	
Voltage	48 ± 1.0 VDC
Current Draw	< 50 A
Heat Load	< 2.8 kW

Cooling Requirements	
Coolant Type	Distilled Water + Corrosion Inhibitor
Min Flow Rate	9.8 L/min (2.6 GPM)
Typical Differential Pressure at Min Flow Rate	1.2 bar (17 psi) @ 9.8 L/min (2.6 GPM)
Max Pressure	5.5 bar (80 psi)
Coolant Temperature	20 ± 1.0 C
Max Coolant Temperature[5]	25 C

Dimensional Specifications	
Dimensions (L x W x H)	855mm x 260mm x 205mm (without mounting feet)
Weight	49kg

Table 2.3-1 Laser Specifications

All specs measured at 20 kHz, 50% duty cycle

[1] Measured after 20-minute warmup for duration of 60 minutes. Coolant temperature stability ± 0.1 °C. Power stability calculated as (Pmax - Pmin) / (Pmax + Pmin). Pointing Stability is measured under the same conditions. Pointing stability defined as max peak-to-peak angular deviation, after the warmup period

[2] Beam diameter measured at a distance of 20 cm from the face plate of the laser, using D4σ width criteria

[3] Ellipticity calculated as maximum of the ratio of the divergence of X and Y axes: max (div X / div Y, div Y / div X)

[4] Specifications not guaranteed across entire frequency range

[5] Laser will function up to 25 C, but performance is not guaranteed outside coolant temperature range of 20 ± 1.0 C

3 Unpacking

The ALX100-AO-9.6 is shipped in a reusable crate, designed to protect the laser through a range of shipment conditions. The crate should be retained for reuse in future shipments.

3.1 Removal From Crate

Open the crate's outer and inner lid. Inspect the laser for any visible damage caused during shipment. Using a 5mm hex, loosen and remove the M6 mounting hardware securing the laser to the crate as shown below.

Figure 3.1-1 Laser Mounting Hardware

Check that all four (4) fasteners are completely removed. **Using the attached eyebolts and lifting equipment, lift straight upward.**

CAUTION

The approximate weight of the laser is **49** kg. Two-person lift is advised.

If lifting equipment is not available, reach under the laser body with one worker on each end and lift by the base of the laser only. **Do NOT lift with the protective bag, connectors, fittings, or side panels.**

NOTICE
Lifting the laser by the protective bag, connectors, fittings, or side panels may cause damage to the system.

Remove the plastic bag in an environment free of dust and inspect the laser output window for scratches or debris. Inspect the water, nitrogen (N_2), and electrical connections on the back of the laser for damage and or loose fittings. Finally inspect the side panels for dents or damage that may disrupt laser performance.

Save the packaging, including the crate and all mounting hardware.

4 Installation

4.1 Mounting

The ALX100-AO-9.6 laser should be mounted on a flat surface (≤100 µm over the mounting area) and secured using appropriate mounting hardware. There are three mounting options for the laser:

(1) top-mounted using the provided mounting feet using imperial hardware, as in Figure 4.1-1

(2) top-mounted using the provided mounting feet using metric hardware, as in Figure 4.1-2

(3) bottom-mounted using the tapped holes on the bottom side of the laser, as in Figure 4.1-3

NOTICE
Should the bottom mounting option be chosen, the provided mounting feet must first be removed. Customer-designed mounting feet may also be used

4.1.1 Top Mounting

Using either Imperial or Metric socket head cap screws (¼"-20 or M6 respectively), use the mounting hole locations shown to secure the laser to a flat mounting platform. Recommended torque values:

M6: 6-10 Nm (53-88.5 in-lbs)

¼"-20: 7.7-12.2 Nm (68-108 in-lbs)

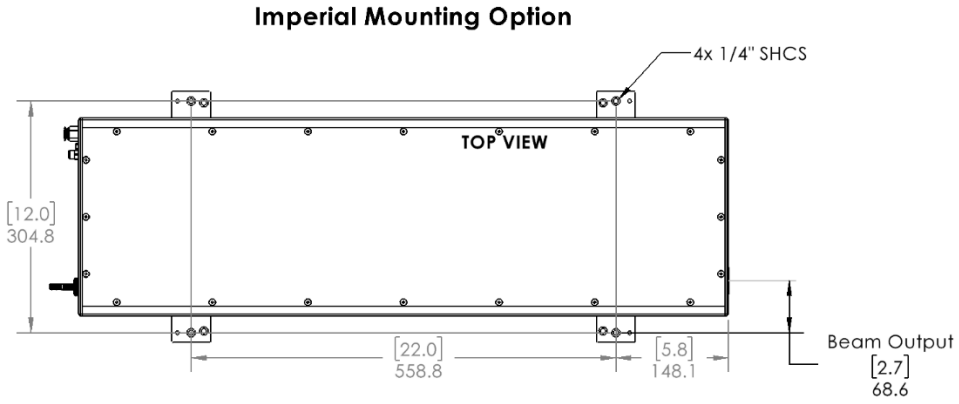


Figure 4.1-1 Top Mounting - Imperial

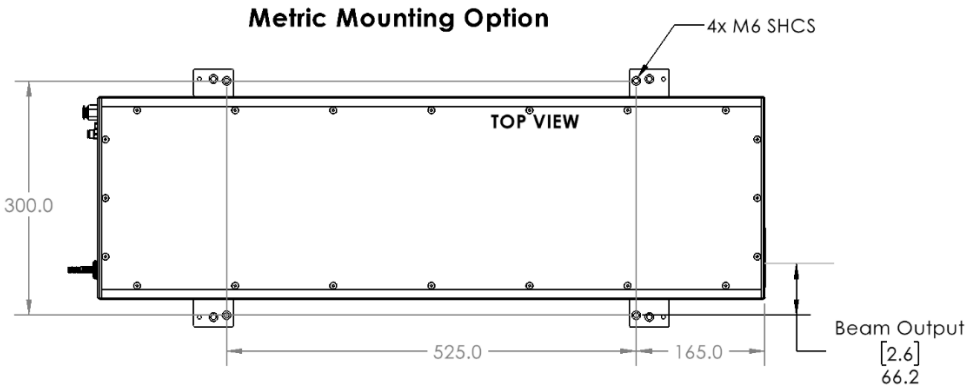


Figure 4.1-2 Top Mounting - Metric

4.1.2 Bottom Mounting

Securely place the laser on its base plate such that the mounting feet hardware is accessible. Loosen the (6x) ¼”-20 mounting bolts on each foot and remove them from the laser. The laser can now be mounted using the hole pattern shown.

NOTICE
the threaded mounting holes on the laser are tapped to a depth of 6.35mm—bolt lengths should be chosen such that they don’t bottom out in the tapped holes

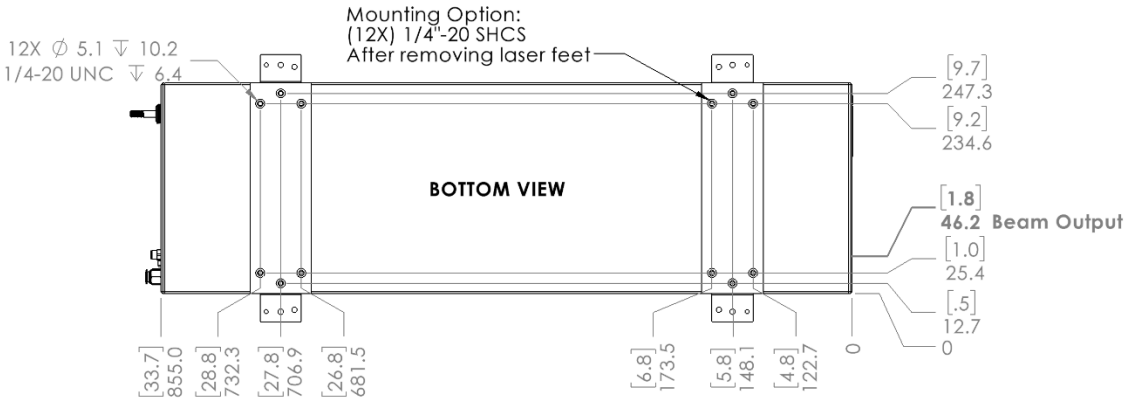


Figure 4.1-3 Bottom Mounting

4.2 Cooling

The ALX100-AO-9.6 is a water-cooled laser, and proper cooling system performance is essential for safe and reliable operation. The control system includes internal monitoring of coolant flow rate to help ensure adequate cooling conditions. To prevent condensation from forming inside the laser, the coolant temperature set point must always be maintained above the ambient dew point. The table below provides the minimum allowable coolant temperature set points required to avoid condensation under various ambient temperature and relative humidity conditions. Cells marked with "–" indicate that the dew-point-based minimum coolant temperature exceeds the maximum permissible coolant input temperature for the laser. The laser must not be operated under these environmental conditions.

Relative Humidity	Ambient Temperature [C] 20	25	30	35	40
45%	19	19	19	24	-
50%	19	19	20	25	
55%	19	19	21	-	
60%	19	19	22	-	
65%	19	19	23	-	
70%	19	19	24	-	
75%	19	20	25	-	
80%	19	21	-		
85%	19	22	-		
90%	19	23	-		
95%	19	24	-		

Minimum Chiller Setpoint

Table 4.2-1 Dew Point Minimum Chiller Set Point

Using the 8mm OD tube compression style fittings on the back of the laser, connect the cooling lines as shown in **Figure 4.2-1 Cooling Connections.** Finger tighten the compression nut until it contacts the tube ferrule. Then tighten the nut an additional 1 ¼ turns to complete the compression seal without over-torquing the soft brass fitting. **Do not exceed 45 Nm torque on the compression nut.** Apply cooling liquid and ensure that the connections are leak-free.

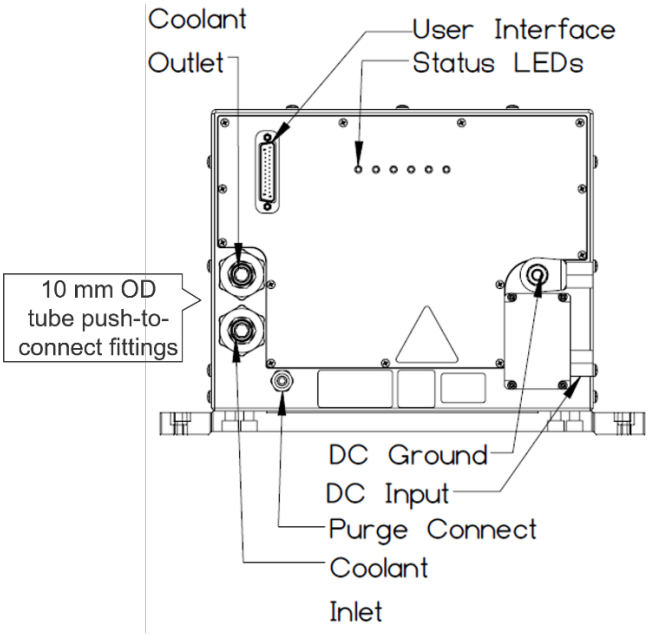


Figure 4.2-1 Cooling Connections

4.3 Electrical

4.3.1 DC Power Requirements

The DC voltage requirements for the ALX100-AO-9.6 laser are shown in the table below. It is critical that the selected DC power supply can meet the laser's electrical requirements.

Electrical Requirements	
DC Voltage	48 VDC at laser terminal
Maximum DC Current Draw	< 55 A
Heat Load	< 2800 Watts
Regulation	+/- 0.5%
Ripple and noise	<1% p-p 20 MHz BW limit

Table 4.3-1 Electrical Requirements

4.3.2 DC Power Cabling Requirements

The DC supply cables should be sized such that the maximum voltage drop across the cables is less than 160 mV with a 55A load. In addition, total loop inductance must not exceed 10 uH. Table 4.3-2 below shows the typical recommended wire gauge for various DC cable lengths.

Cable Length	**Recommended Gauge**
1.5 meters	4 AWG
3 meters	2 AWG

Table 4.3-2 Typical Recommended Wire Gauge and Length

4.3.3 Power Supply Connections

WARNING
The negative (GND) side of the DC input is internally connected to the chassis. The user must ensure that the host system includes appropriate protection to prevent hazardous voltages from appearing on the chassis and thus protect personnel from potential exposure.

To access the positive DC terminal, remove the 4x Torx T10 cover screws securing the protective cover. **The protective cover should only be removed once DC power has been verified to be off.** Once the cover is removed, loosen and remove the M8 bolt, lock washer, and flat washer on the **bottom** of the bus bar. **Warning: Do not loosen or remove the hardware on the top of the bus bar.**

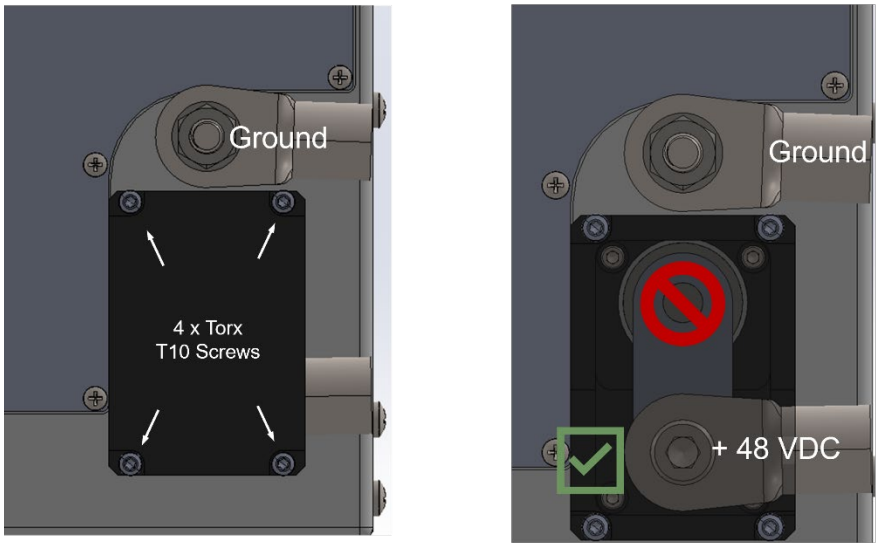


Figure 4.3-1 DC Power Connections

Using appropriately sized wire gauge, connect the +48 VDC cable to the bus bar using the previously removed hardware. Reinstall the protective cover with 4x Torx T10 screws prior to powering on the power supply.

To connect the ground cable, remove the M8#1 nut and washer on the ground terminal of the laser and reinstall with the cable terminal as shown below. **Warning: Two wrenches must be used to secure the mounting hardware at the laser terminals. Do not remove the second M8 nut or washer, closer to the laser body.**

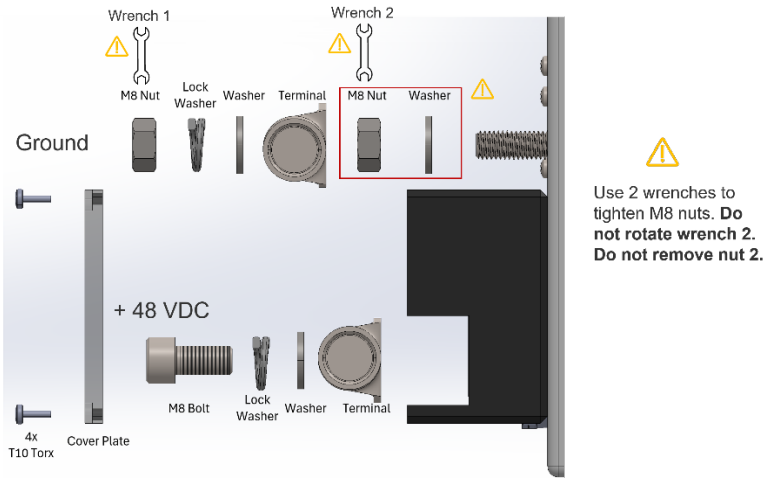


Figure 4.3-2 Ground Terminal Hardware Installation

Be sure to match the +48 VDC terminal and GND terminal to the appropriate terminal on the DC power supply.

4.4 Control Connections

The ALX100-AO-9.6 is controlled through the 25-pin connector located on the rear panel of the laser. The pinout for this connector is shown in Table 4.4-1 below and includes interlock, control, status, and diagnostic signals.

Pin	Function	Description
1	Not Connected	This pin is not connected.
2	Laser OK Output	Master fault status. All other faults will trigger this fault. Output HIGH=normal, LOW=fault. Signal input impedance > 100kΩ.
3	System Interlock Input	This line must be tied to the laser system I/O GND to enable laser output.
4	24 VDC Power Input	OPTIONAL input for 24 VDC control signal level implementation. Required source current capacity >30mA. **This input is not required if the 5 VDC output scheme is being used.**
5	AOM Digital Modulation Input	This signal is used to command modulation of the AOM and output of the laser. Connect the return to I/O GND. LOW: -0.5V to +0.5V. HIGH: 4.5V to 24V (5 V typical). Switching frequency: 0 to1MHz.
6	Not Connected	This pin is not connected.
7	AOM RF Overtemperature Fault Output	AOM RF module overtemperature fault. Output HIGH=normal, LOW=fault. User interface input impedance > 100kΩ.

8	AOM Cell Overtemperature Fault Output	AOM module overtemperature fault. Output HIGH=normal, LOW=fault. User interface input impedance > 100kΩ.
9	AOM VSWR Fault Output	AOM RF module VSWR fault. Output HIGH=normal, LOW=fault. Signal input impedance > 100kΩ.
10	Laser Overtemperature Fault Output	Laser overtemperature fault. Output HIGH=normal, LOW=fault. User input impedance > 100kΩ.
11	Laser VSWR Fault Output	Laser RF module VSWR fault. Output HIGH=normal, LOW=fault. Signal input impedance > 100kΩ.
12	Internal Use	Do Not Connect
13	Internal Use	Do Not Connect
14	Not Connected	This pin is not connected.
15	I/O GND	Signal ground for all input and output signals.
16	AOM RF Power OK Output	AOM RF Module fault status. Output HIGH=normal, LOW=fault. User input impedance > 100kΩ.
17	Not Connected	This pin is not connected.
18	Not Connected	This pin is not connected.
19	I/O GND	Signal ground for all input and output signals.
20	Not Connected	This pin is not connected.
21	Not Connected	This pin is not connected.
22	AOM Analog Modulation Input	Once the modulation function is enabled, apply 0–10 V (current capacity > 30 mA) between this pin I/O GND, as shown in Figure (d) Otherwise, leave the pin floating.
23	I/O GND	Signal ground for all input and output signals.
24	AOM Analog Modulation Enable	Tie this pin to I/O GND to enable the AOM analog modulation function, as shown in Figure (d). Otherwise, leave the pin floating.
25	Internal Use	Do not connect

Table 4.4-1 Control Interface Pinout

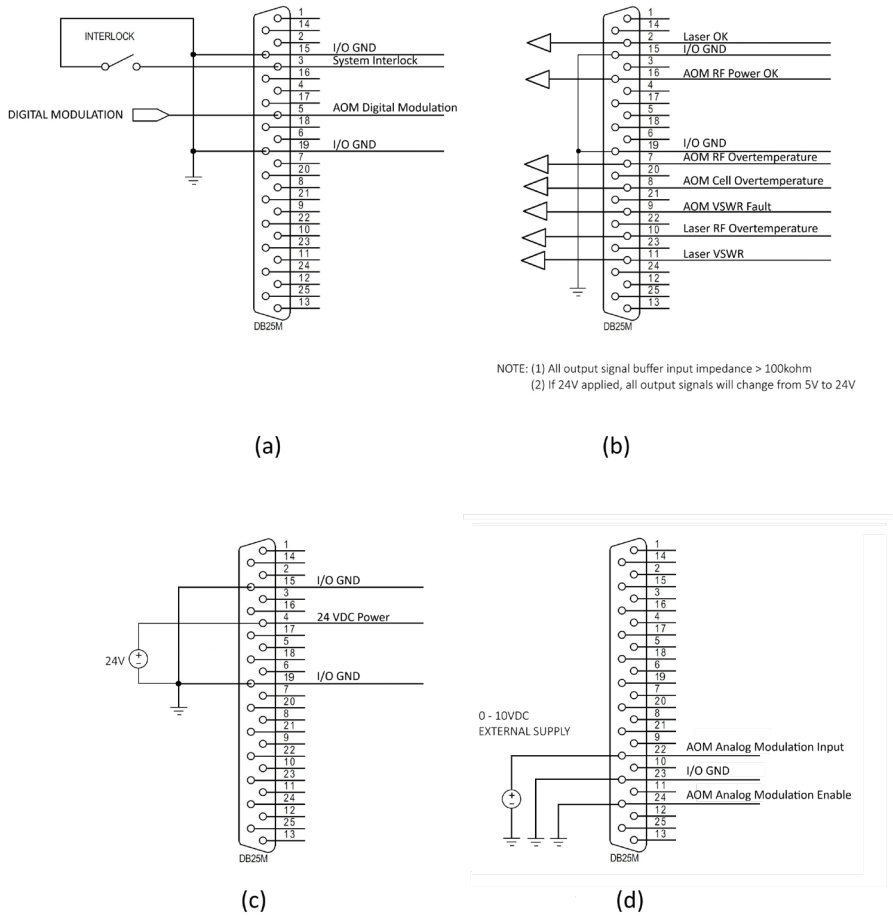


Figure 4.4-1 Interface Connector Diagram (a) minimum connection requirement for operation (b) optional system status information connections (c) optional 24 VDC control signal level (d) optional external pulse amplitude control connections

4.4.1 Basic & 24V Connections

The minimum control connections for basic operation are shown in Figure (a). This includes an external System Interlock circuit switch, ground, and AOM Digital Modulation Input which is used to control the laser output. The basic connection uses 5-volt logic signals levels for modulation and control.

If 24-volt signal levels are desired, the connections shown in Figure (c), including 24 VDC supply, must also be added to the basic connection configuration.

4.4.2 Output Diagnostic Signals

The ALX100-AO-9.6 laser also transmits operational status and fault diagnostic information through the 25-pin connector as shown in Figure (b). These signals can be used to remotely determine faults and take action on other processing system components. A description of these signals is provided in Table 4.4-1.

4.4.3 External Analog Modulation Control

In the basic connection scheme described in section 4.4.1, the output pulse duty cycle and frequency are controlled using AOM Digital Modulation Input signal. When the control signal level is LOW, the laser output is off and when the control signal level is HIGH, the laser output is at the maximum power level.

It is also possible to control the output pulse *amplitude* of the ALX100-AO-9.6 laser by adding the control connection scheme shown in Figure (d) to the basic connection. In this configuration the AOM Digital Modulation Input signal will still control the pulse frequency and duty cycle, but the pulse amplitude will be controlled by the analog voltage level between the AOM Analog Modulation Input and AOM Analog Modulation GND pins. Using a 0-10 VDC signal, the output laser pulse amplitude can be adjusted from 0-100% power. Example output pulses at full amplitude and 50% amplitude are shown below.

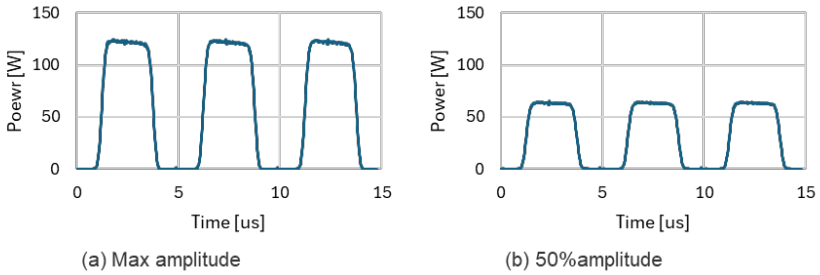


Figure 4.4-2 Pulse amplitude modulation (a) max amplitude (b) 50% amplitude

Figure 4.4-3 below shows the typical peak output power (relative) versus AOM Analog Modulation Input voltage.

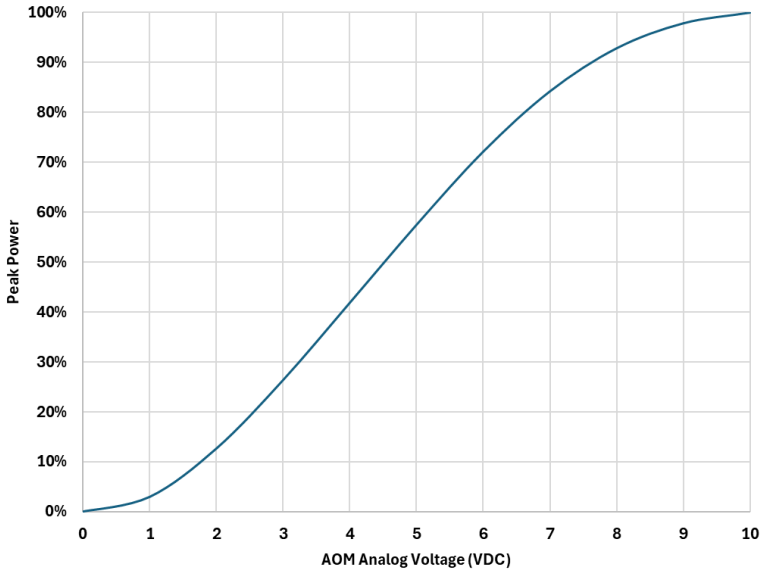


Figure 4.4-3 Typical Relative Peak Power as a Function of Analog Voltage Input

5 Startup & Operation

5.1 Setup

Prepare the laser for operation by following the guidelines in the above sections for:

4.1 Mounting

4.2 Cooling

4.3 Electrical

4.4 Control Connections

Ensure that the beam path is free of any obstructions, cooling systems are operational, and the workspace is safe before applying electrical power.

5.2 Operation

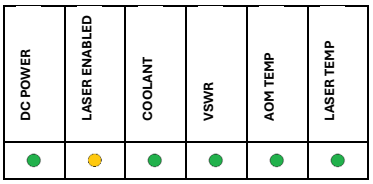
WARNING
Laser radiation—this class 4 laser product emits invisible laser radiation in the 9-11µm wavelength range. Avoid eye and skin exposure from both direct and scattered beams.

Step 1

Turn on the DC power supply to laser & wait ~10sec for DC power startup sequence to complete. The status LEDs should match the pattern shown below. If the DC Power LED is red, the voltage is not within the acceptable range and should be checked at the laser terminals.

Step 2

Close the System Interlock & wait ~10sec for the laser startup sequence to complete. The status LEDs should indicate as below—refer to section 6 Diagnostics & Troubleshooting if different.



WARNING
Laser radiation—this class 4 laser product emits invisible laser radiation in the 9-11µm wavelength range. Avoid eye and skin exposure from both direct and scattered beams.

Step 3

When ready for laser output, apply a PWM signal to the AOM Digital Modulation Input. The laser will now output based on the PWM signal level.

Optional – if using pulse amplitude control, an additional application 0-10V DC into the AOM analog modulation input is required for laser output as described in section 4.4.3 External Analog Modulation Control.

6 Diagnostics & Troubleshooting

6.1 LED status indicators

The ALX100-AO-9.6 prototype includes LED indicators on the rear panel of the laser to provide a visual indication of the status of the laser and any faults. The behavior of the LED is described in Table 6.1-1 below.

LED Signal	Description	Pattern					
		DC POWER	LASER ENABLED	COOLANT	VSWR	AOM TEMP	LASER TEMP
All LEDs [Green/Amber]	Normal operation	●	●	●	●	●	●
LASER ENABLED [Off]	System Interlock is open	●	○	●	●	●	●
DC POWER [Solid Red]	DC power is out of range	■	●	●	●	●	●
COOLANT [One Red Flash]	Coolant flow rate is below the required level	●	●	✳1	●	●	●
COOLANT [Two Red Flashes]	Inlet coolant overtemperature condition	●	●	✳2	●	●	●
COOLANT [Solid Red]	Low coolant flow and coolant overtempt condition	●	●	■	●	●	●
VSWR [One Red Flash]	Laser RF driver VSWR fault	●	●	●	✳1	●	●
VSWR [Two Red Flashes]	AOM RF driver VSWR fault	●	●	●	✳2	●	●
VSWR [Solid Red]	Laser and AOM RF driver VSWR fault	●	●	●	■	●	●
AOM TEMP [One Red Flash]	AOM RF driver overtemperature	●	●	●	●	✳1	●
AOM TEMP [Two Red Flashes]	AOM modulator overtemperature	●	●	●	●	✳2	●
AOM TEMP [Solid Red]	AOM RF driver and modulator overtemperature	●	●	●	●	■	●
LASER TEMP [One Red Flash]	Beam dump overtemperature condition	●	●	●	●	●	✳1

Table 6.1-1 LED Status

6.2 Fault Behavior

There are two basic types of faults for the laser: latching faults that cause a system shutdown and require a reset by cycling the System Interlock circuit, and non-latching faults that may or may not interrupt laser operation but will clear once the fault condition is removed and do not require a system reset. Table 6.2-1 describes the possible fault conditions, their trip point, and reset procedure.

Fault	Latching?	Fault Value	Action	Reset Procedure
DC Power [DC Power LED]	Yes[1]	<45V, >55V	Check the DC voltage level at the laser terminals	Cycle the System Interlock after the fault is corrected
Low Coolant Flow [Coolant LED]	Yes	<6.4 L/min (1.7 GPM)	Increase coolant flow as required	Cycle the System Interlock after the fault is corrected
Coolant Temperature [Coolant LED]	Yes	>26°C	Check input coolant temperature	Cycle the System Interlock after the fault is corrected
Laser VSWR [VSWR LED]	Yes[1]	-	Attempt system reset - contact Access Laser service if fault persists	Cycle the System Interlock after the fault is corrected
AOM VSWR [VSWR LED]	Yes[1]	-	Attempt system reset - contact Access Laser service if fault persists	Cycle the System Interlock after the fault is corrected
AOM Driver Overtemperature [AOM Temp LED]	Yes	-	Check laser coolant flow and temperature - contact Access Laser service if fault persists	Cycle the System Interlock after the fault is corrected
AOM Modulator Overtemperature [AOM Temp LED]	Yes	-	Check laser coolant flow and temperature - contact Access Laser service if fault persists	Cycle the System Interlock after the fault is corrected
Laser Beam Dump Overtemperature [Laser Temp LED]	Yes	>120°C	Contact Access Laser Service	Do not attempt reset—contact Access Laser Service

Table 6.2-1 Laser Faults

[1] Latching during operation, non-latching during system startup

7 Technical Drawing