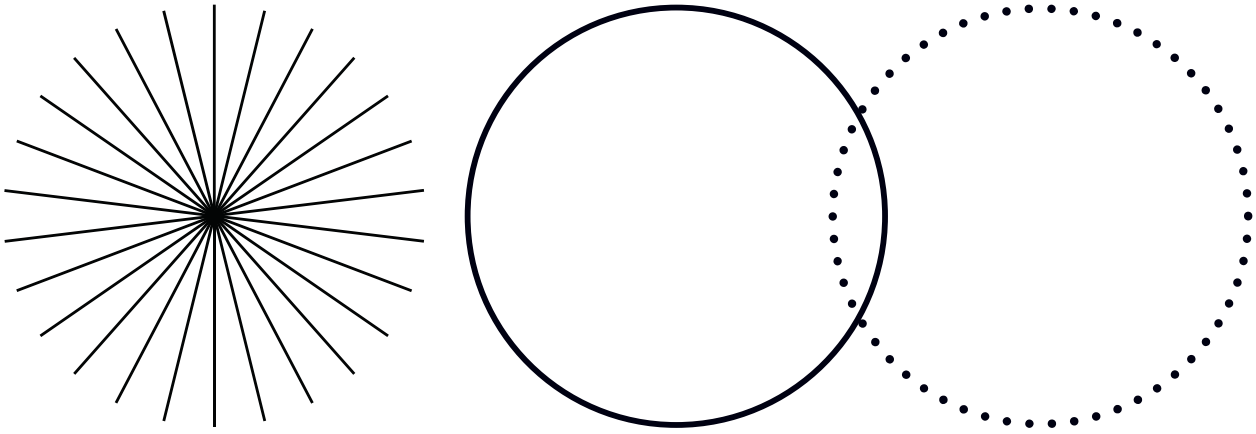
Axon™ Laser Systems

Operator's Manual



INNOVATIONS THAT RESONATE

COHERENT

Operator's Manual
Axon™ Laser Systems

COHERENT

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1 Introduction

1.1 Signal Words and Symbols in this Manual

This documentation may contain sections in which particular hazards are defined or special attention is drawn to particular conditions. These sections are indicated with signal words in accordance with ANSI Z-535.6 and safety symbols (pictorial hazard alerts) in accordance with ANSI Z-535.3 and ISO 7010.

1.1.1 Signal Words

Four signal words are used in this documentation: **DANGER**, **WARNING**, **CAUTION** and ***NOTICE***.

The signal words **DANGER**, **WARNING** and **CAUTION** designate the degree or level of hazard when there is the risk of injury:

DANGER!
Indicates a hazardous situation that, if not avoided, will result in death or serious injury. This signal word is to be limited to the most extreme situations.

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

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

The signal word "***NOTICE***" is used when there is the risk of property damage:

NOTICE
Indicates information considered important, but not hazard- related.

Messages relating to hazards that could result in both personal injury and property damage are considered safety messages and not property damage messages.

1.1.2 Symbols

The signal words **DANGER**, **WARNING**, and **CAUTION** are always emphasized with a safety symbol that indicates a special hazard, regardless of the hazard level:

This symbol is intended to alert the operator to the presence of additional information.

This symbol is intended to alert the operator to the presence of important operating and maintenance instructions.

This symbol is intended to alert the operator to the danger of exposure to hazardous visible and invisible laser radiation.

This symbol is intended to alert the operator to the presence of dangerous voltages within the product enclosure that may be of sufficient magnitude to constitute a risk of electric shock.

This symbol is intended to alert the operator to the danger of Electro-Static Discharge (ESD) susceptibility.

This symbol is intended to alert the operator to the danger of crushing injury.

This symbol is intended to alert the operator to the danger of a lifting hazard.

1.2 Preface

This manual contains user information for the Axon Laser

NOTICE
Read this manual carefully before operating the laser for the first time. Failure to follow the instructions and safety precautions in this manual can result in serious injury or death. Special attention must be given to the material in “Laser Safety” (p. 61), that describes the safety features built into the laser. Keep this manual with the product and in a safe location for future reference.

DANGER!
Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

1.3 Export Control Laws Compliance

It is the policy of Coherent to comply strictly with U.S. export control laws.

Export and re-export of lasers manufactured by Coherent are subject to U.S. Export Administration Regulations, which are administered by the Commerce Department. In addition, shipments of certain components are regulated by the State Department under the International Traffic in Arms Regulations.

The applicable restrictions vary depending on the specific product involved and its destination. In some cases, U.S. law requires that U.S. Government approval be obtained prior to resale, export or re-export of certain articles. When there is uncertainty about the obligations imposed by U.S. law, clarification must be obtained from Coherent or an appropriate U.S. Government agency.

Products manufactured in the European Union, Singapore, Malaysia, Thailand: These commodities, technology, or software are subject to local export regulations and local laws. Diversion contrary to local law is prohibited. The use, sale, re-export, or re-transfer directly or indirectly in any prohibited activities are strictly prohibited.

1.4 The Operator's Manual

This Operator Manual is designed to familiarize the user with the Axon Laser system and its designated use. It contains important information on how to install, operate, and troubleshoot the laser system safely, properly, and most efficiently. Observing these instructions helps to avoid danger, reduce repair costs, and downtimes and increase the reliability and lifetime of the laser system.

This Manual:

- describes the physical hazards related to the laser system, the means of protection against these hazards, and the safety features incorporated in the design of the laser system
- briefly describes the purpose and operation as well as the primary features, system elements, subsystems, and fundamental laser control routines of the laser system
- describes the fundamental operation of the laser system
- describes the maintenance procedures for the laser system which can be performed by the end user. This includes a time schedule for all periodic routine replacement procedures and a basic troubleshooting section.

The screenshots in this manual are only examples and may show configurations or parameter settings which do not apply to Axon Laser system. Changing parameter settings to correspond with screenshots may reduce laser performance or even damage the laser system!

1.4.1 Intended Audience

The Operator's Manual is intended for all persons that are to work on or with the laser system. It assumes that the reader has participated in an introductory training course which has taught them the safe operation of the laser system.

None of the procedures described in this manual requires the defeating of safety interlocks. Where specific training is required to perform procedures, this is clearly indicated at the beginning of the corresponding section.

1.4.2 Availability and Use

This Operator's Manual must always be available wherever the laser system is in use. Keep this manual in a safe location for future reference. It must be read and applied by any person in charge of carrying out work with and on the laser system, such as

- operation (including setting up, troubleshooting in the course of work, removal of production waste, care and disposal of consumables,
- service (maintenance, inspection, repair) and/or
- transport.

1.4.3 Numbering of Sections, Pages, and Instructions

The sections are numbered continuously. The name of the section appears in the upper outside corner of every odd page. Each section ends with an even page number. Consequently, certain even pages at the ends of sections will be intentionally left blank.

The pages of this manual are numbered continuously by section. The page number appears in the bottom center of every page.

Each step within a procedure is sequentially numbered. Each procedure starts with the step number one.

1.4.4 Cited Standards

Unless otherwise stated, all technical standards cited in this manual relate to the latest version of the standard that is applicable at the date of the publication of this manual.

This information is in compliance with the Performance Standards for Laser Products,' *United States Code of Federal Regulations*, 21 CFR 1040.10(d). In many cases, the international standards (ISO and IEC standards) have been adopted wholly or in part by national or regional standards authorities and are known locally under the designation assigned by this authority. For instance, the IEC 60825-1 has been adopted by the European Committee for Standardization as the standard
EN 60825-1 and, in turn, by various national standards authorities as standards such as DIN EN 60825 (Germany) and BS EN 60825 (United Kingdom). The exact content, number and revision date of the national standard may, however, vary from that of the corresponding international standard. For further information, please contact the publisher of the respective national standard.

1.5 Laser Terminology

ISO 11145 ("Optics and Optical Instruments - Lasers and Laser Related Equipment - Vocabulary and Symbols") contains a list of laser terminology.

To prevent misunderstandings, the Axon Laser documentation strictly differentiates between "laser" and "laser system"?. Thus "start laser system" means that the power is off and shall be turned on. To "start the laser" means to switch on the laser beam and start laser operation.

Laser	Consists of an amplifying medium capable of emitting coherent radiation with wavelengths up to 1 mm by means of stimulated emission.
Laser System	A laser, where the radiation is generated, together with essential additional facilities that are necessary to operate the laser (e.g. cooling, power, and gas supply).

In addition to the terminology used by ISO 11145, IEC 60825-1 uses the term "laser product". This term relates to any product or assembly of components which constitutes or is intended to incorporate a laser. In other words, the term "laser product" can be used in conjunction with any of the definitions contained in ISO 11145.

1.6 Units of Measurements

In this manual, units of measurement are used according to the metric system (international system of units (SI)), e.g. meter, millimeter, square meter, cubic meter, liter, kilogram, bar, pascal; and imperial system, e.g. tons, pounds, and ounces; gallons and quarts; miles, yards, feet, and inch.

Temperatures are primarily indicated in degrees Celsius (°C) and Fahrenheit (°F).

1.7 Feedback Regarding Documentation

If there are any comments regarding the documentation provided, please contact the Coherent Documentation Department.

In any correspondence, please provide the following:

- the document part number, revision, and date of issue,
- the section number, page number and, where applicable, the procedure step number,
- a description of any errors,
- a proposal for improvements.

1.7.1 Feedback Address

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Santa Clara, CA. 95054
USA

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2 Laser Safety Table

This laser safety information must be reviewed thoroughly prior to operating the Axon Laser system. Safety instructions presented throughout this manual must be followed carefully. See “Laser Safety” (p. 61) for additional laser safety information and guidelines.

Table 2-1. Laser Safety Reference Table

Item	Description
Scope	This user information is in compliance with the following standards for Light-Emitting Products IEC 60825-1 “Safety of laser products - Part 1: Equipment classification and requirements” and CDRH 21 CFR Title 21 Chapter 1, Subchapter J, Part 1040 “Performance standards for light-emitting products” except for conformance with IEC 60825-1 Ed. 3 and IEC 60601-2-22 Ed. 3.1, as described in Laser Notice No. 56, dated May 8, 2019.
Hazards	
Biological/Optical	Exposure to laser radiation may damage the eyes or skin. Wear appropriate laser safety eyewear for protection against the specific wavelengths and laser energy being generated. See “Optical Safety” (p. 62) for additional information/guidelines.
Electrical	Laser uses AC and DC voltages that are potentially hazardous. The rules for electrical safety must be strictly followed. See“Electrical Safety” (p. 65) for additional information/guidelines.
Chemical	Contact of the laser beam with volatile or flammable substances, or released as a result of laser material processing.
Laser Classification	The Axon Laser is classified as Class 4 based on 21 CFR, Subchapter J, Part 1040, section 1040.10 (c) and IEC/EN 60825-1. In this manual, the classification will be referred to as Class 4.
Control Measures	Laser incorporates protective housing, safety interlocks, remote interlock connector, key switch, laser emission indicators, beam attenuator, operator’s controls, display, and manual reset mechanism in accordance with CFR 1040.10 (f)(6)/IEC 60825-1. See “Safety Features and Compliance with Government Requirements” (p. 65) for additional information.
Warning Labels	Refer to Table A-3, “Axon Laser Safety Features and Labels,” (p. 71) for the location of all safety labels.

WARNING!

Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

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3 Description and Specifications

3.1 Axon Laser System

Axon and Axon Total Power Control (TPC) femtosecond lasers are a family of discrete wavelength, ultrafast sources. Compact design ideal for life sciences and instrumentation applications.

Multiphoton excitation microscopy applications are served by key wavelengths at 780 nm, 920 nm, and 1064 nm, with dispersion precompensation included to optimize short pulses at the sample plane. Built-in modulation (with TPC version) is optional for fast power control and fly-back blanking.

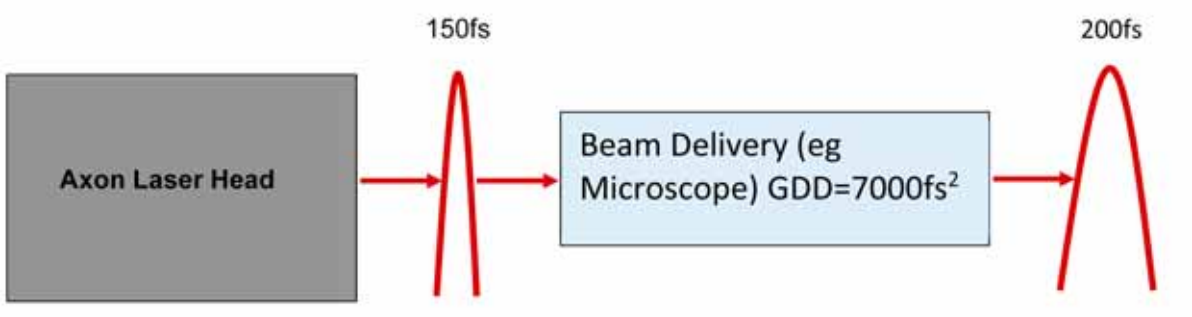
Integrators benefit from a common, plug-and-play interface with the same form factor for each wavelength. Systems are completely air-cooled with no maintenance requirements, enabling a low cost of ownership and long lifetimes.

Figure 3-1. Axon Laser Head

3.1.1 Dispersion Precompensation

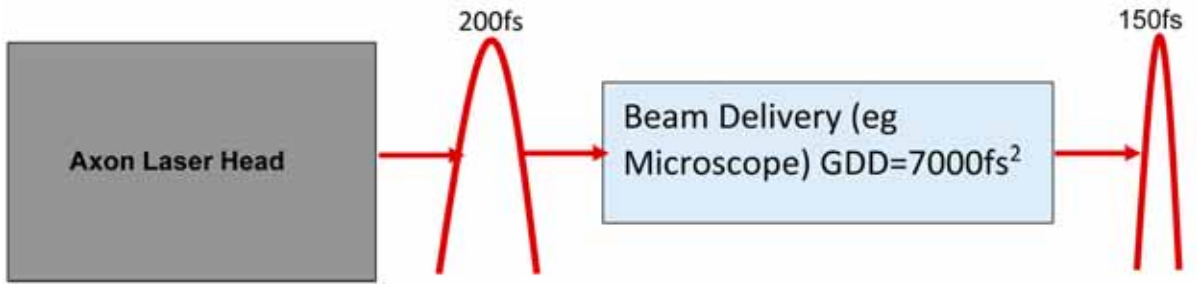
In applications that require ultra-short pulses, pulse duration at the workpiece is of great importance. This is particularly relevant to multi-photon microscopy, where a shorter pulse duration leads to an improved signal-to-noise ratio. One issue in achieving this is that beam delivery optics, such as microscopes, are often highly dispersive. The effect of second-order disper-

sion, caused by dispersive media is to effectively stretch the duration of the pulse, meaning that the output pulse duration is no longer achievable at the sample or workpiece. However, the Axon laser family is equipped with dispersion precompensation, which acts to impart negative second-order dispersion on the pulses before the laser output window. If this is tuned to match the positive dispersion imparted by the dispersive media in the beam path, the shortest possible pulses are once again achievable at the sample or workpiece. Refer to the diagram Figure 3-2.



The Axon pulses have no dispersion compensation applied. The microscope system applies a group delay of 7000 fs^2. As a result the pulse duration at the sample or workpiece has increased to 200 fs.

Figure 3-2. Pulse Width Example without Dispersion Compensation



The Axon pulses have dispersion compensation applied at -7000 fs^2. The microscope system applies a group delay of 7000fs^2. As a result the pulse duration at the sample or workpiece remains at the minimum 150 fs.

Figure 3-3. Pulse Width Example with Dispersion Compensation

3.1.2 Key Features & Benefits

The Axon Laser system includes:

- Maintenance free

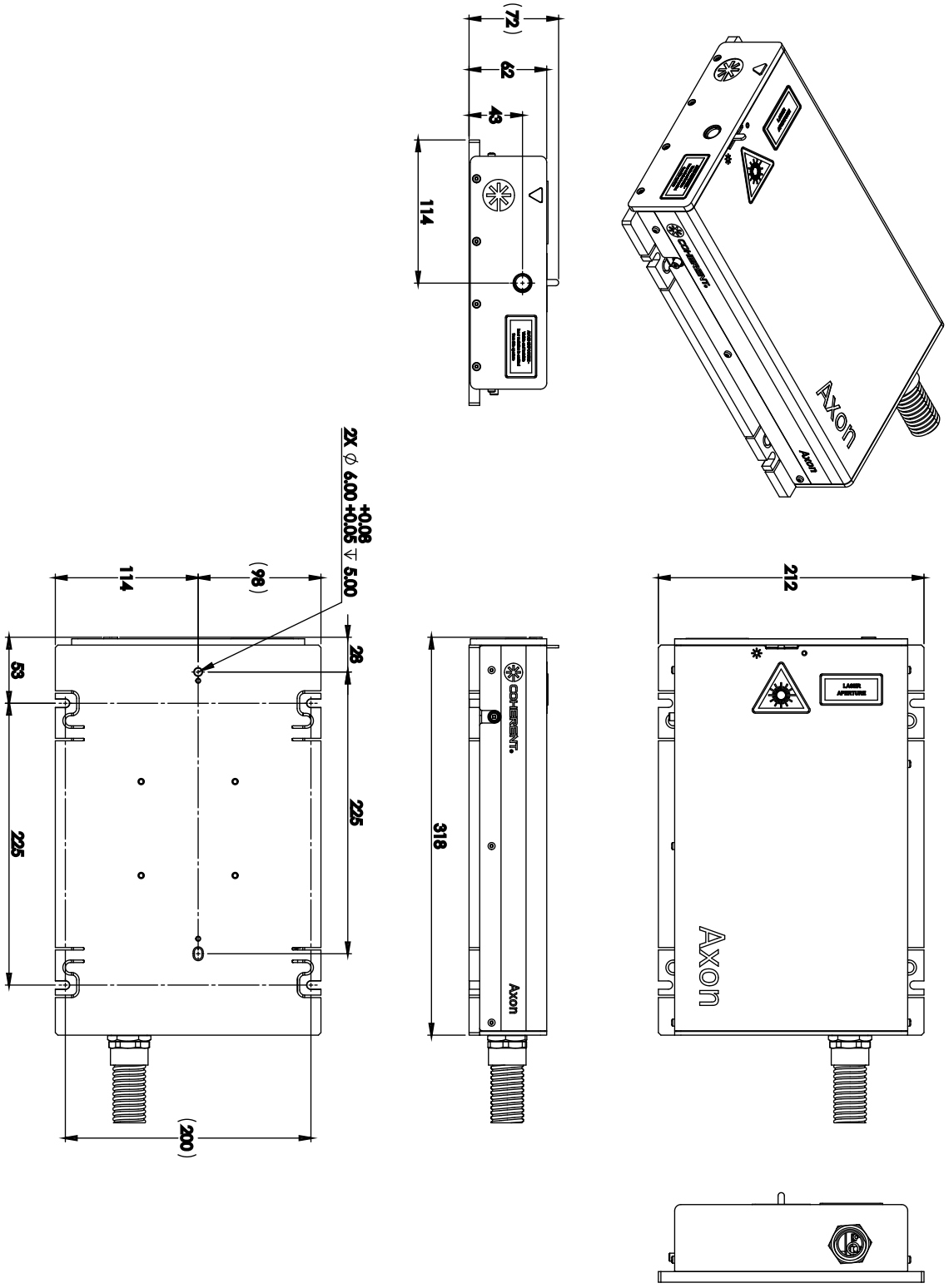
- Air-cooled design
- < 150 fs pulse duration
- Adjustable dispersion precompensation for short pulse delivery at the sample or work piece
- Total Power Control (TPC), optional
- HASS/HALT tested for greatest reliability and stability

3.2 Specifications

Review the data sheet on the Coherent website at: https://www.coherent.com/lasers/oscillators/axon, for general details on your laser system.

Check the customer data sheet shipped with each Axon Laser for a detailed description of system performance.

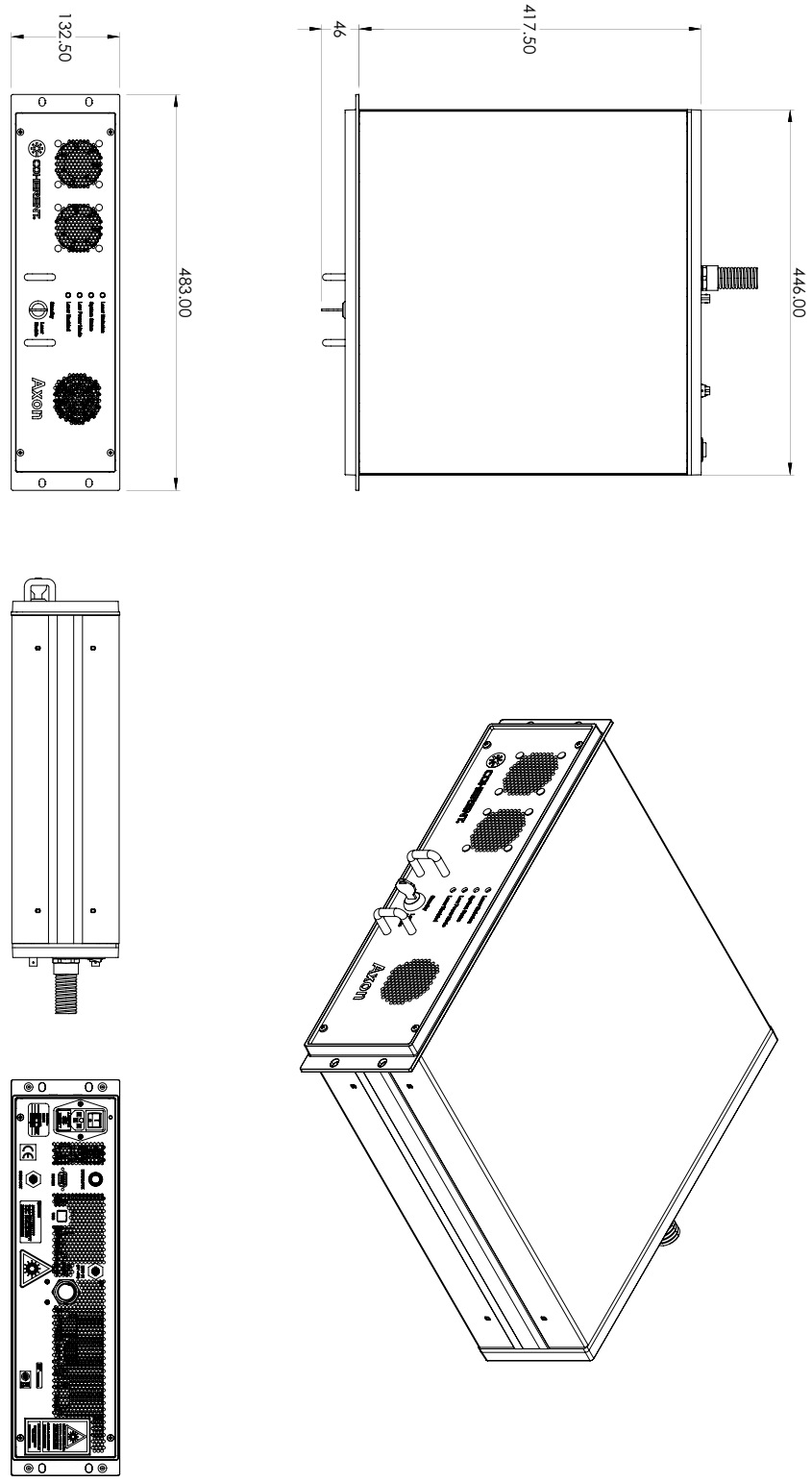
3.3 Laser Head Dimensions



All dimensions are in millimeters (mm)

Figure 3-4. Axon Laser Head

3.4 Power Supply Dimensions



All dimensions are in millimeters (mm)

Figure 3-5. Axon Power Supply

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4 Installation

NOTICE
The Axon laser system is customer installable. If additional support is required, contact the local Coherent representative for details.

4.1 Receiving and Inspection

Inspect shipping containers for signs of rough handling or damage. Indicate any such signs on the bill of lading. Immediately report any damage to the shipping carrier and to the Coherent Order Administration Department or authorized representative.

NOTICE
Keep shipping containers and all foam and shipping bags. The containers are required if the system is returned to the factory for service. The containers may also be needed to support a shipping damage claim.

The items below are included with a Axon Laser laser system:

- Laser system
- External interlock connector
- Power supply key
- Mains cable
- USB cable
- Operator manual

NOTICE
The Axon Laser is a sealed cavity, hands-free laser system. DO NOT break or remove the warranty seals. Doing so will void the warranty as stated in the warranty section of this manual.

NOTICE
The umbilical is attached to the head and power supply during manufacturing. DO NOT disconnect the umbilical! Doing so will damage the laser and void the warranty!

4.2 Unpacking

CAUTION!
When unpacking and transporting the Axon laser system, keep fingers and hands away from the bottom of the laser head while placing and positioning on the install surface.

1. Remove the items from their packaging and set up in your allocated work space. See "Packing Procedure" (p. 53) for packing instructions and details.

NOTICE
The head is very light compared to the umbilical and power supply. It is possible to pull the head from its location while unpacking the umbilical and power supply. Verify the head is in a secure location while removing and repacking the system.

2. Inspect the protective housing (controller, umbilical, and head) for any damage. The laser system must not be used if any part of the protective housing is damaged.
3. Position and secure the laser head on an optical table. Carefully route the cables to prevent snagging or presenting a tripping hazard.
4. Place a beam block, such as an optical power meter, at the end of any optical arrangement.

WARNING!
Ensure that the output port is blocked by a beam block. Beam block must be able to dissipate up to 5 W average optical power.

4.3 System Connections

Figure 4-1 provides a diagram of all required system connections.

1. Confirm mains power is off.
2. Verify fuse rating for correct operating voltage. See “Verify Operating Voltage” for steps to change the fuses as needed.
3. Make the **electrical connections** as shown in Figure 4-1.

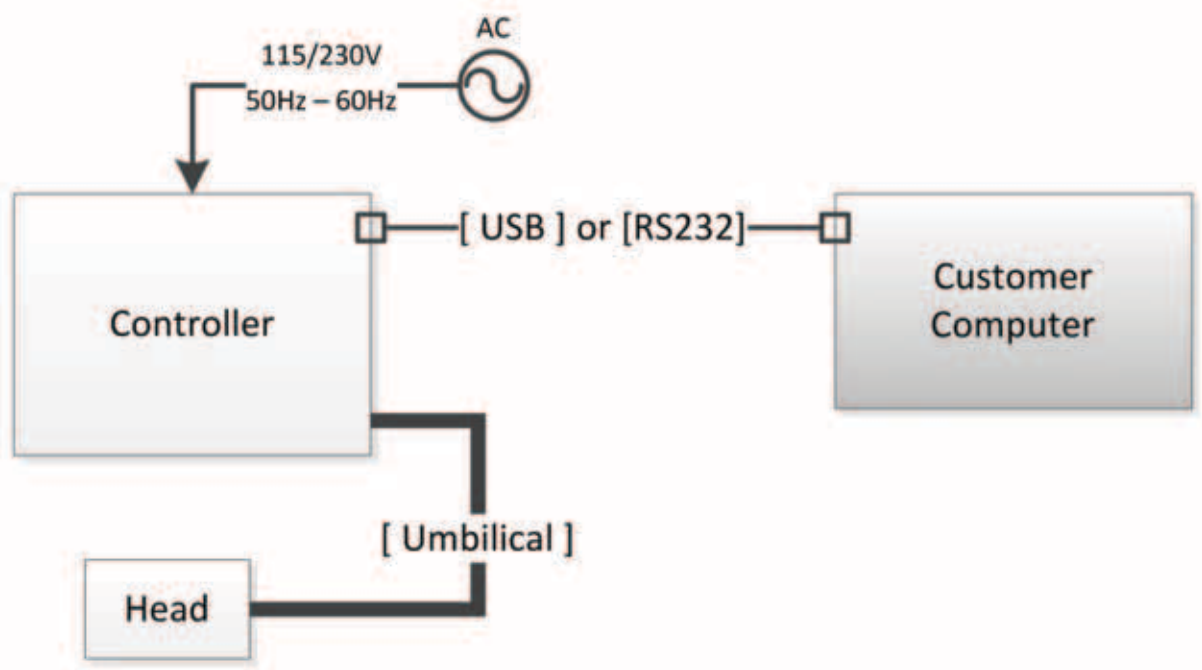


Figure 4-1. Axon System Connections

NOTICE

Do not replace the detachable mains cable with a cable that is not rated for this laser system.

4. Confirm that the power supply module and any PCs connected use the same ground voltage (AC source).

If the system installation is in an area with unstable AC mains supply, Coherent recommends the use of a suitable surge protector for the Axon system.

NOTICE

The mains plug on the socket-outlet of the building must be accessible at all times.

4.3.1 Verify Operating Voltage

The laser can operate on 100-240 VAC. The user must verify the correct voltage is selected at the fuse module located at the power supply rear panel. See Figure 5-2 (p. 30) for the location of the fuse module.

1. Confirm the operating voltage by checking that the white arrow is pointed toward the white mark. See Figure 4-2 for an operating voltage range of 220-240VAC.

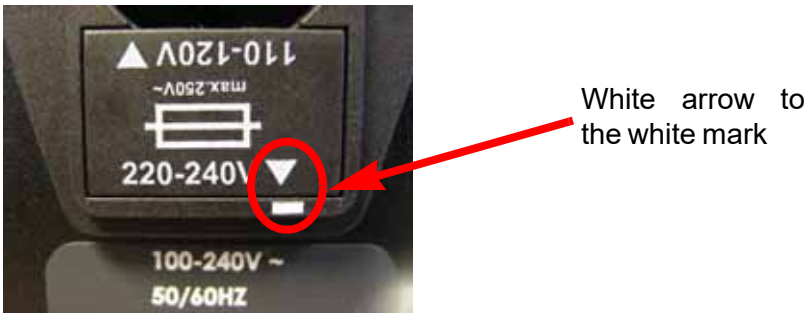


Figure 4-2. Fuse Holder Voltage Verification

2. Insert a small flathead screwdriver into the slot behind the cover and carefully press out to remove the fuse holder.
3. Remove the cover fully with fingers. See Figure 4-3.

Figure 4-3. Fuse Holder Removal

4. Remove all fuses from the fuse clip.
5. Confirm the replacement fuse is of the correct type for the mains supply voltage to be selected. See Figure 4-4.

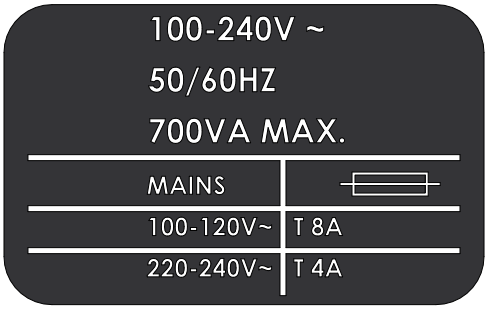


Figure 4-4. Fuse Rating for Voltage Input

6. Secure the fuse in the correct clip for the mains supply voltage selected.
   - **Input Voltage 110-120 V:** With the 110-120 V arrow indicator pointing down, verify the 8 A fuse in the right clip holder.

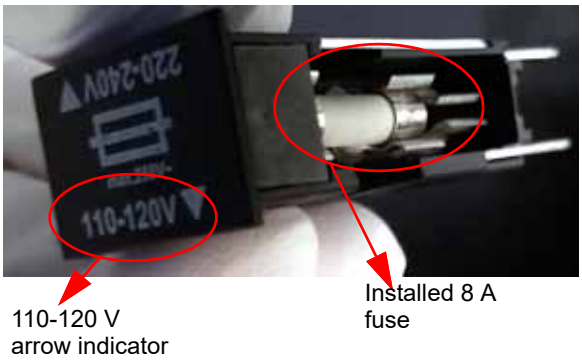


Figure 4-5. Fuse Location in the Clip Holder for 110-120 V

   - **Input Voltage 220-240 V:** With the 220-240 V arrow indicator pointing down, verify the 4 A fuse in the right clip holder.

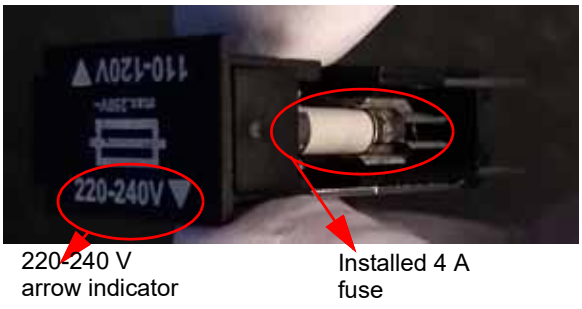


Figure 4-6. Fuse Location in the Clip Holder for 220-240 V

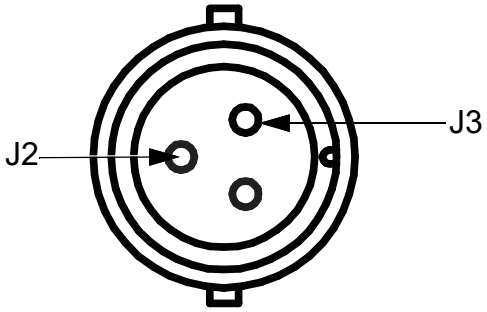
7. Reinstall the fuse holder by pressing in with fingers. See Figure 4-7.

Figure 4-7. Fuse Holder Installation

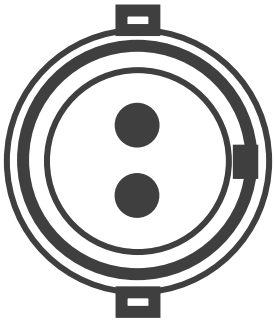
4.4 External Interlock

An interlock connector is located on the power. There are two possible styles of interlock connectors depending on your system type and manufacture date, see Figure 4-8 on page 22.

The Axon Laser accessory kit contains an interlock defeat which can be installed to close the interlock loop. Alternatively, the interlock connector can be connected to an external circuit, for example a door switch. The switch must have its contacts closed when it is safe to operate the laser and open when it is not safe.



Three Female Contacts - Only J2 and J3 Used (Old Style)



Two Male Contacts (New Style)

Figure 4-8. External Interlock Connectors - Two Styles

To incorporate an external interlock circuit into the laser system, perform the following steps:

1. Confirm that the laser is in the “OFF” or “STANDBY” state (see Table 6-1 (p. 32)). Perform the “Turn-off (Daily Use)” (p. 36) procedure if necessary.
2. Remove the interlock defeat from the back of the power supply. Attach a user-furnished, external interlock circuit to the connector.
   a.) **Three Female Contacts:** Use pins 2 and 3 for the input signal to the external interlock. A short (< 500 Ω) between pins 2 and 3 allows normal operation while an open (> 60 kΩ) prevents laser emission.
   b.) **Two Male Contacts:** Use the two pins for the input signal to the external interlock. A short (< 500 Ω) between the pins allows normal operation while an open (> 60 kΩ) prevents laser emission.

NOTICE

Any external interlock circuit must be equivalent to a mechanical closure of the circuit. Under no circumstances should an external voltage or current source be connected to this circuit. External interlock circuitry must be isolated from all other electrical circuits or grounds.

In the event of an interlock fault during normal operation, the laser system will enter the fault state (shut down and the status LED light on the front panel will illuminate red). Once the interlock circuit is closed, cycle the keyswitch on the power supply to clear the fault (see “Key-Switch Transition Behavior” (p. 31)). The system can then resume operation.

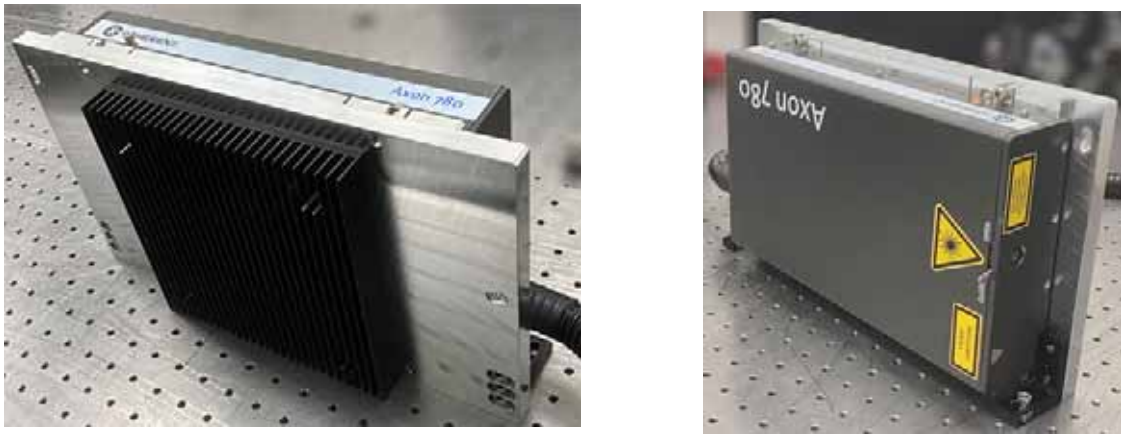
4.5 Laser Head Mounting

The mounting points (x4) and dowel locations (x2) are shown in Figure 3-4 (p. 14).

There are many possibilities for mounting the laser head. In reviewing mounting options the user should consider:

- Access to the GDD (Group Delay Dispersion) adjustment screw may be required at setup
- Heatsinking of the laser head is recommended for the Axon 780 version, and where ambient temperature conditions may be variable, for optimum performance

Figure 4-9 shows an example of how the Axon head can be mounted with a suitable heatsink on the rear mounting plate. This mounting assembly (PN 2254360) is available to purchase from Coherent.



Rear View **Front View**

Figure 4-9. Axon Heatsink Mounting

Contact your Coherent representative for instructions on cleaning the laser head output window.

Use a slightly damp cloth followed by a soft, dry cloth for external cleaning of the protective housing. Avoid chemical products.

4.6 Power Supply Installation

Install the power supply so that air flow to the front and back sides is not obstructed. If installing the power supply in a 19 in.(48 cm) equipment rack, allow a minimum horizontal clearance of 18 in. (46 cm) for the front panel of the power supply.

This product is intended for indoor use, in an office or laboratory environment, with pollution degree 2.

It must be installed in a location with overvoltage category 2 or better, limiting transients seen by the mains input to a maximum of 2500 V. The mains input voltage range is 100-240 Vac ±10%.

Use a slightly damp cloth followed by a soft, dry cloth for external cleaning of the protective housing. Avoid chemical products.

4.7 GDD (Group Delay Dispersion) Adjustment

The following is offered as general advice in order to give users a reference for adjustment of the dispersion precompensation module built into the Axon laser head. Although it is anticipated that the precompensation will not be adjusted frequently, if regular access to the 2mm hex screw is expected then bear this in mind when deciding on mounting options.

The system is shipped with the precompensation screw set fully clockwise. To compensate for positive dispersion in the customer beam delivery and experiment, the precompensation adjustment adds negative dispersion to the pulse - see “Dispersion Precompensation” (p. 11).

Note that the advice below is offered as a guide in order to assist customers quickly and easily set up their experiment – these are *not* specifications.

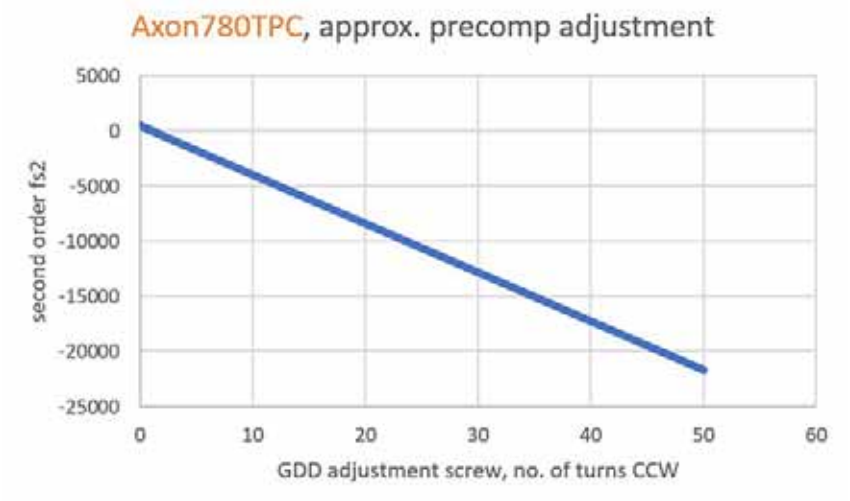
- The Axon laser system has a 2 mm hex key that can be used to manually adjust the desired level of precompensation for the system. See Figure 5-1 (p. 29) #5 for the GDD (Group Delay Dispersion) the screw location and “Precompensation Screw” (p. 28) for guidance on adjusting the screw.

- Note that adjustment scale on the x-axis of the graphs is defined as number of turns, CCW (Counter-Clockwise), i.e. moving the adjuster outwards from the laser head.

- Also note the very different adjustment scales appropriate for the different Axon models – the Axon 920 (see Figure 4-11) requires relatively few turns to make large changes to the precompensation, while the Axon 780 (see Figure 4-10) and Axon 1064 (see Figure 4-12) requires greater numbers of turns to impart a similar chirp to the pulse.

See the data sheet shipped with the laser for specified precompensation ranges.

Non-TPC



TPC

Figure 4-10. Axon 780 Precomp Adjustment Graph

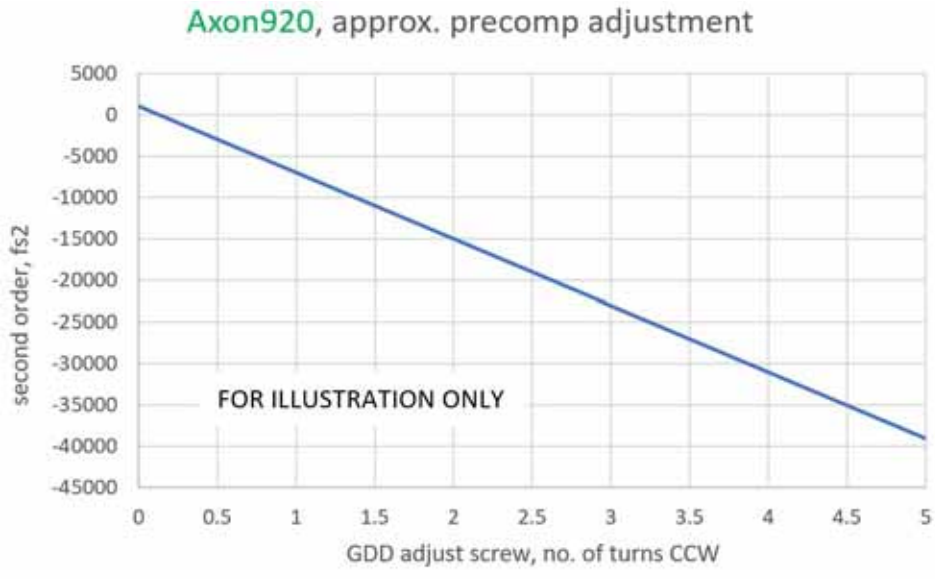


Figure 4-11. Axon 920 Precomp Adjustment Graph

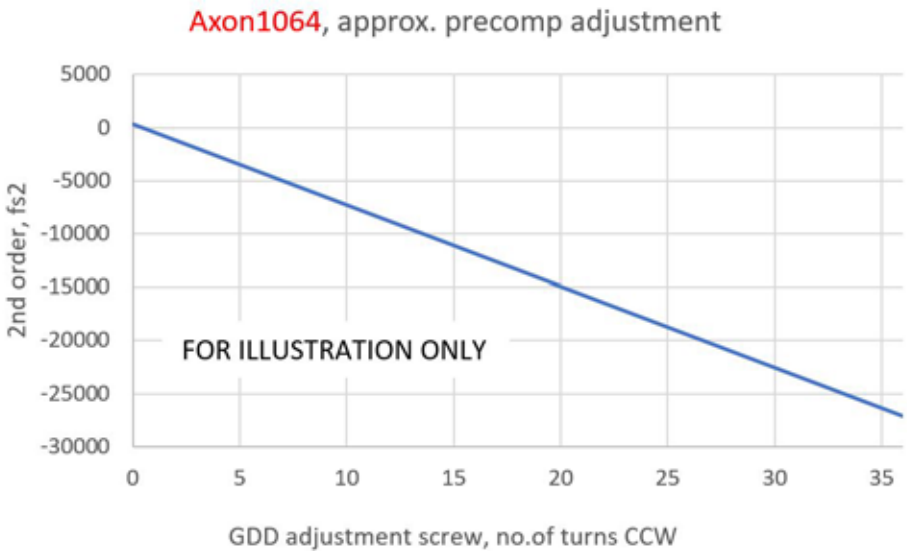


Figure 4-12. Axon 1064 Precomp Adjustment Graph

4.7.1 Precompensation Screw

The precompensation screw is installed with two lock rings that are marked with a factory set reference point at the 12 O'clock position.

Figure 4-13. Lock Rings' Reference Mark

The lock rings must never be adjusted; otherwise, the reference point will be lost. Only the precompensation screw can be adjusted.

Figure 4-14. Precompensation Screw with Lock Rings

At the factory, the screw is set fully clockwise until resistance is met. The initial adjustment of the precompensation screw will only be in the counter-clockwise position. The shortest pulse width is two full revolutions counter-clockwise from the shipment position.

Prior to shipping laser system, reference "Shipping Position of Precompensation Screw" (p. 53).

4.8 Axon TPC Systems

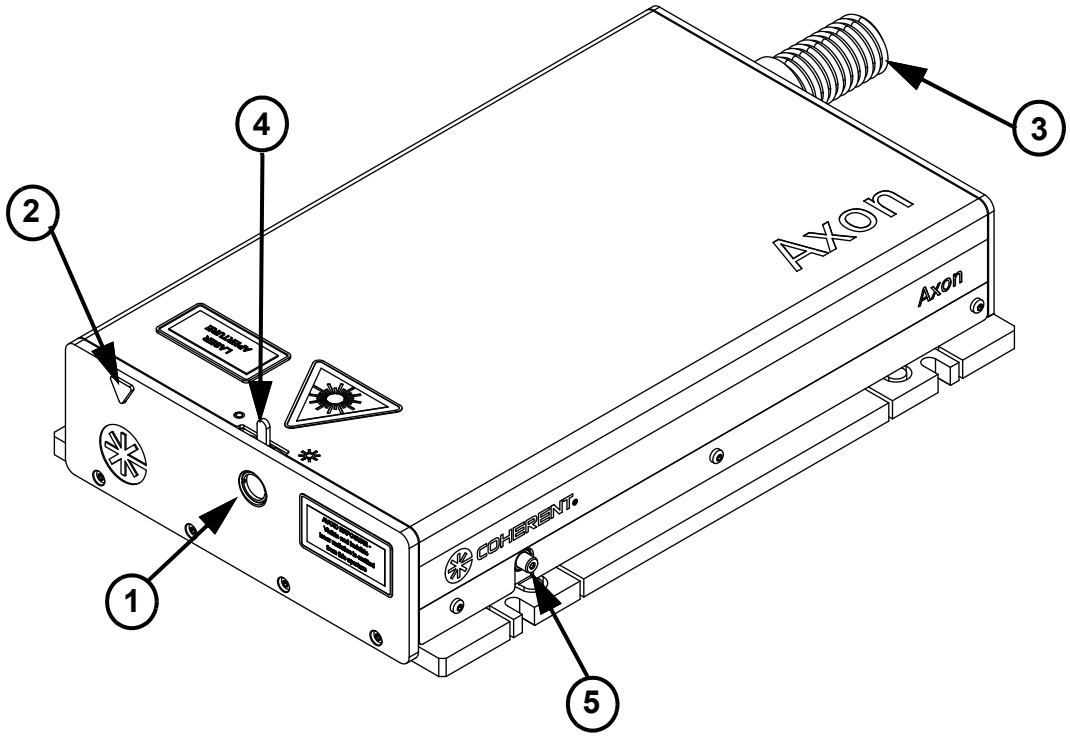
For the TPC version of the Axon systems, see "TPC Modulator Control" (p. 45) for additional details.

5 Controls, Indicators and Features

5.1 Axon Laser

The following figures show the locations and features of the Axon Laser laser head and power supply.

5.1.1 Laser Head

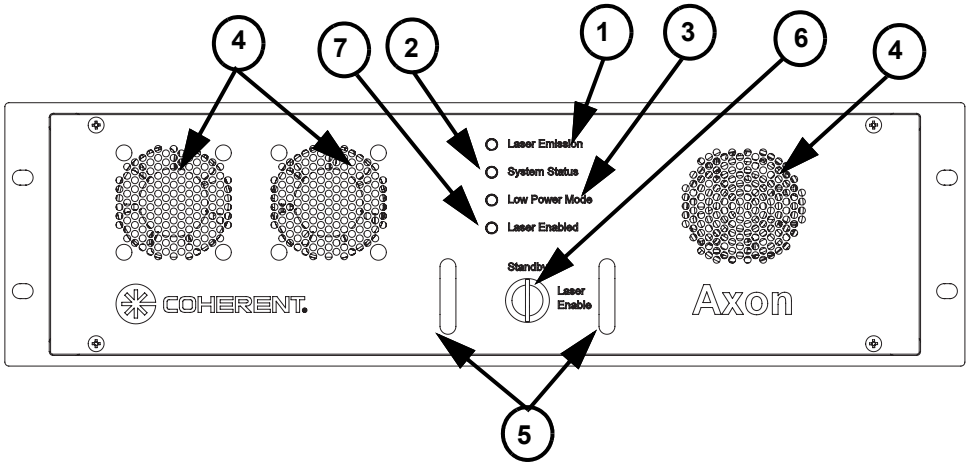


Laser Head-Isometric View

1.Laser Exit Port
2.Emission Indicator
3.Umbilical
4.Manual Shutter Switch
5.GDD Adjuster

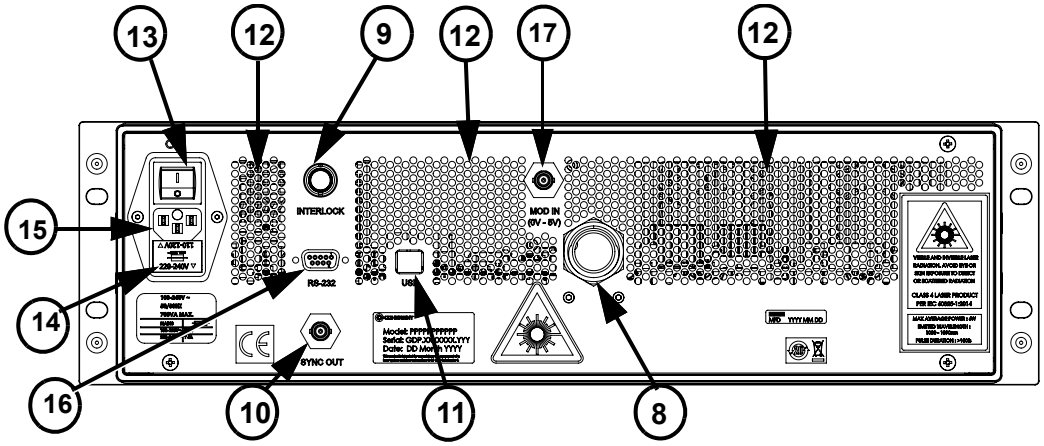
Figure 5-1. Laser Head Features, Controls and Indicators

5.1.2 Power Supply



POWER SUPPLY-FRONT PANEL

1.Laser Emission Indicator
2.System Status Indicator
3.Low Power Mode Indicator
4.Air Flow Vents
5.Key Switch Protectors
6.Key Switch
7.Laser Enabled Indicator



POWER SUPPLY-REAR PANEL

8.Umbilical Socket
9.Interlock
10.SYNC OUT
11.USB Port
12.Air Flow Vents
13.Mains Power Switch
14.Fuse Location
15.Mains Input
16.RS-232
17.Modulation Input

Figure 5-2. Power Supply Front and Rear Panel Features, Controls and Indicators

6 Operation

WARNING!
All personnel in the area must wear laser safety eye wear to protect against laser radiation. Read "Laser Safety" (p. 61) and know the proper laser safety practices.

The Axon Laser must be operated with the laser head and power supply covers in position. The Axon Laser is not customer serviceable. There is no reason to remove any part of the protective housings on any part of the system. Should the protective housing become damaged then cease operations immediately, power off the laser system and contact your Coherent representative. Unintended exposure to laser radiation could occur if the laser is operated with a damaged housing.

NOTICE
Do not open the Axon laser head or power supply. Opening any cover voids the warranty.

6.1 System Operating States and Behaviors

Table 6-1 describes the system operating states for the hardware key-switch. In addition, the laser has software key-switch states which interact with the hardware key states. The interaction is described below in “Key-Switch Transition Behavior”.

The LED states and behaviors are described in “LED States and Behaviors”.

6.1.1 Key-Switch Transition Behavior

The system has a physical hardware key-switch (HKEY) and a software key-switch (SKEY). The laser can never be enabled if the physical key-switch is inactive. The software key-switch can be used to disable and enable the laser while the physical key-switch is active. This facilitates a remote enable/disable. The laser must always be considered energized if the physical key-switch is active.

Table 6-1. Axon Laser Operating States

State	Switch Positions	Status
OFF	• Main power switch: OFF	• All functions off • No laser output
STANDBY	• Main power switch: ON • Keyswitch: STANDBY	• Pump diodes: temperature stabilized, zero current • No laser output
ON	• Main power switch: ON • Keyswitch: ENABLE	• Pump diodes: ON (See Operating Mode below) • Laser output
Operating Mode	• High Power Mode: Normal diode operating current • Low Power Mode: Low diode operating current for lower output power and beam alignment to work surface.	

NOTICE

The power modes can only be accessed through software commands. See "Communication" (p. 39) for more information on the external-communication requirements and the software commands.

The system shall be described as having a hard-key and soft-key. The hard-key is the physical key-switch control that exists on the front panel of the laser. The soft-key is enabled/disabled via software and works in conjunction with the hard-key. The hard-key can be in the ON position or Standby position. If the hard-key is in the ON position, it is Active, and if it is in the standby position it is Inactive.

The system will power on with the soft-key inactive regardless of hard-key position.

Hard-key transitions will only be acted upon once all software modules are initialized.

Only two conditions can allow the software key to transition from inactive to active.

1. If the hard-key transitions from inactive to active, then the soft-key will be set to active ONLY if conditions allow (e.g. a fault would not allow the soft-key to transition).
2. If the hard-key is currently active and the software command `SKEY=1` is received then, the soft-key will be set to active ONLY if conditions allow (e.g. a fault would not allow the soft-key to transition).

The transition of the software key from inactive to active will cause the laser to start the Diode-Turn-On sequence.

If the hard-key transitions to Inactive the soft-key will be forced inactive - this overrides any user setting.

The hardware is connected to the key-switch such that the laser diodes are disabled by the key-switch without the involvement of software. Hardware faults are likewise connected to the laser diode enable. The hardware can shut-down the diodes without the involvement of software.

If a fault occurs in the system (e.g., If the external interlock has been removed) then information about the fault can be found via the query `?FINFO`. The status LED will be solid red if the system is in a fault condition. If the fault condition has been corrected then faults can be cleared via the software using the command `FCLEAR`. Faults can also be cleared from the front panel by turning the hard-key from off-on-off. If the system is in fault and the hard-key is turned from off-on then the status LED will flash red to show that enabling the laser was inhibited due to a fault. Turning the key off when the status LED is flashing red will cause the system to clear faults.

6.1.2 LED States and Behaviors

The system has 4 LEDs on the controller:

- Laser Enabled
- System Status
- Laser Emission
- Low Power Mode

The system has 1 LED on the head:

- Head Laser Emission

The System Status LED will initialize to red while software is booting. This will then flash green while temperature controllers stabilize (system is warming). The system will display solid green when ready or laser is enabled. If a system fault occurs then the System Status LED will become solid red. It flashes red as part of the fault-reset operation.

The Laser Enabled LED will flash green while the laser is ramping and illuminate solid green when the laser is running.

6.2 System Activation

6.2.1 Turn-on (Cold Start)

WARNING!
Class 4 radiation may be emitted from the head after this point. Use extreme caution and make sure the correct safety eye wear is worn by all personnel in the area of the laser system.

Use the cold start procedure when mains power is disconnected from system components (the system is in the OFF state). See Table 6-1 for the different descriptions of the operating states.

1. Verify the key is in Standby
2. Switch ON from rear of PSU
3. After switching the power supply ON, LEDs will be in the following condition:

Laser Emission LED	System Status LED	Laser Enabled LED
Constant ON	Flashing (green)	OFF

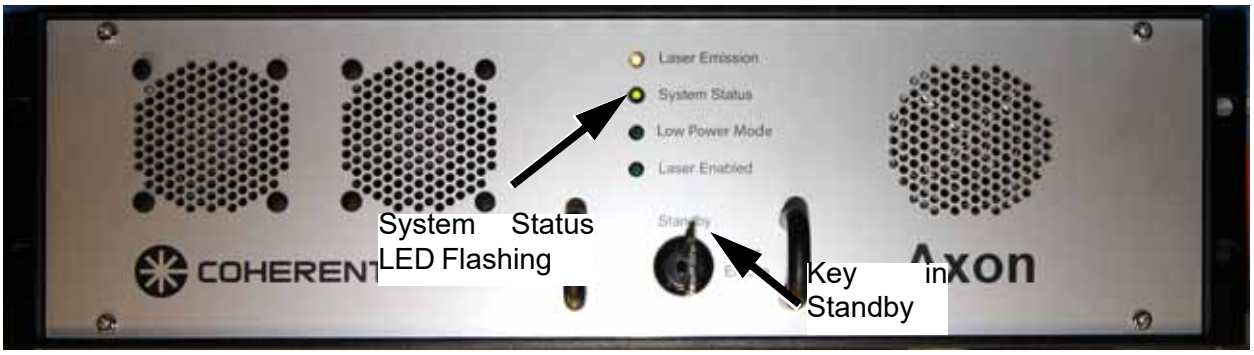


Figure 6-1. LED Status in Standby

4. Status LED will be constant ON after a period no longer than 2 minutes

5. Turn key to Laser Enable, the LEDs will be in the following condition:

Laser Emission LED	System Status LED	Laser Enabled LED
Constant ON	Constant ON (green)	Flashing (green)

Figure 6-2. LED Status in Laser Enable during Initial Diode Ramp

6. Laser Enabled will be constant ON after approximately 1 minute.
7. Open shutter by moving the lever from the left side to the right side.

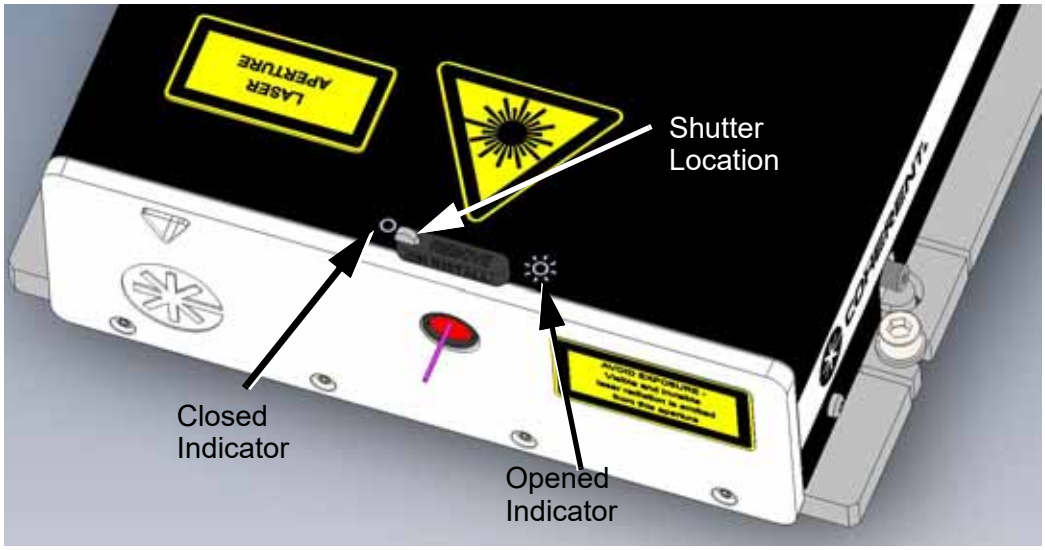


Figure 6-3. Shutter Indicators

6.2.2 Turn-on (Standby-State)

Use the turn-on procedure below when AC mains power is already on and the laser is in the Standby state as described in Table 6-1 Axon Laser Operating States.

1. Confirm the key switch on the power supply front panel is in the STANDBY position.

CAUTION!
Make sure that all personnel in the area wear laser safety eye wear. Make sure that the laser output is pointed at an intended target, beam block or power meter.

2. Select Low Power Mode or High Power Mode with software command `LPMODE=X`, where X is 1 = low power or 0 = high power.

NOTICE
The controller can be turned on in the Low Power Mode or High Power Mode. Initially, use the Low Power Mode to confirm the beam is contained.

3. Turn the keyswitch to the ENABLE position.
4. When the Laser Status LED is continuously illuminated, the laser is ready for operation.
5. Open the shutter to let the beam exit the output port
6. Use IR CARD to confirm the laser beam is pointed to the intended target. **Only use the IR CARD if the laser is in LOW POWER MODE.**
7. Disable the laser output with command `SKEY=0`.
8. Switch to High Power Mode.
9. Enable the laser output with command `SKEY=1`.
10. Wait five minutes for the system to stabilize.

6.3 System Turn-off

6.3.1 Turn-off (Daily Use)

When use of the Axon occurs throughout the day, turn-off consists of the following:

1. Turn the key switch to STANDBY. The key switch can be removed to prevent accidental turn-on.

The system is now in the STANDBY state described in Table 6-1.

6.3.2 Turn-off (Complete Shutdown)

This procedure removes all power from the Axon Laser. It is recommended to use this procedure if no operation is anticipated for a long period of time.

1. Turn the key switch to STANDBY.
2. Turn OFF the power switch on the rear panel of the power supply.

6.4 Modes of Operation

The Axon Laser has two modes of operation and a user adjusted GDD control. The modes can only be accessed through software commands. See “Communication” (p. 39) for more information on the external-communication requirements and the software commands.

6.4.1 Low Power Mode

Access low power mode with the software command `LPMODE=1`. This mode is intended to help the user align the laser output to the work surface. All safety precautions and warnings still apply as described in “Laser Safety” (p. 61).

WARNING!
The laser is a Class 4 system in Low Power Mode. All safety precautions and warnings still apply as described in “Laser Safety” (p. 9).

6.4.2 High Power Mode

The high power mode applies the normal diode current to operate the system. Use this mode once the laser beam is aligned to an intended target. The high power mode is accessed through software command `LPMODE=0`.

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7 External Control

7.1 Communication

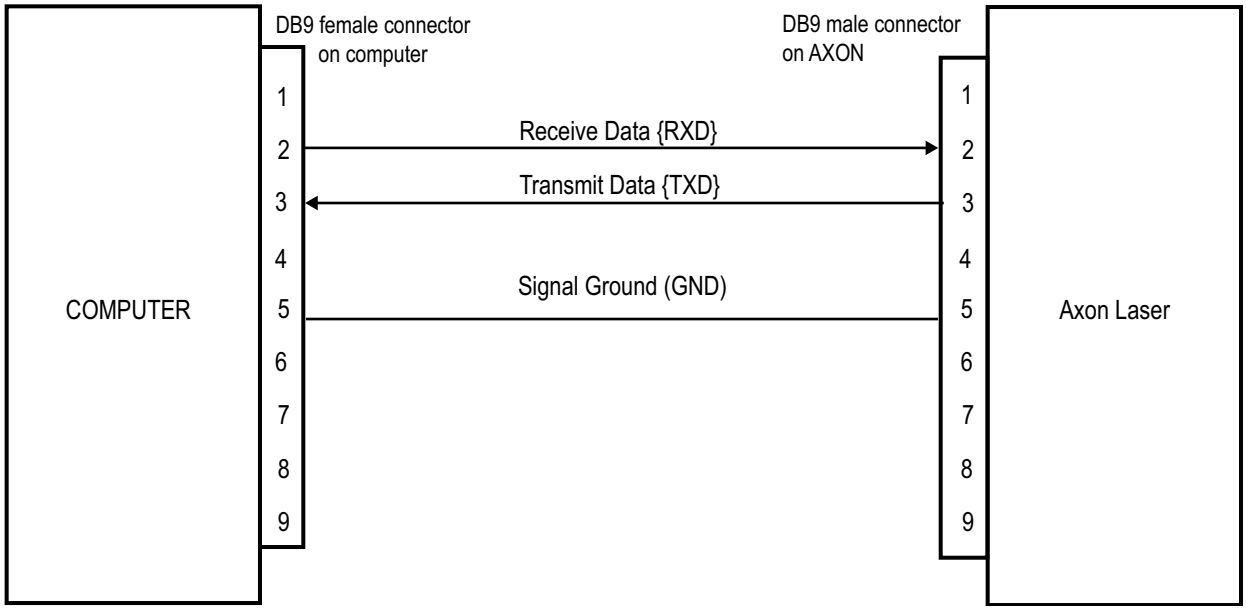
The Axon Laser is designed to be operated by the RS-232 serial connection or the USB port using a command terminal such as Tera Term. The communication connections are located at the rear panel of the power supply, see “Power Supply” (p. 30) for locations.

7.1.1 Communication via RS-232

The Axon port configuration is described below.

Table 7-1. Port Configuration

Property	Value
Data bits	8
Parity	none
Stop bits	1
Flow control	none
Baud rate	115200



Male-to-Female Standard Serial Cable Required Pins. Pins 4, 6, 7, 8 and 9 Are Not Used.

Figure 7-1. RS-232 Pin Configuration Between a Computer and the Axon Power Supply

7.1.2 Communication via USB

The USB port is a standard Type-B connection.

This port provides a high-speed communication connection. The advantage is that the data transfer rate of the interface is noticeably increased over the RS232 port.

No driver is required to be installed for Windows 10. The USB port requires a Coherent software driver to be installed for Windows 8 or older.

The USB interface appears as a COM port in the windows system and can communicate within the same way as COM port.

The settings of the COM port can be set to match the RS-232 Serial Port. Note that although the baud rate is set to 115200, this does not determine the data rate of the port, which is handled by the driver.

7.1.3 Communication Protocol

Table 7-2. Character List

Name	Shorthand	Hexadecimal	Decimal
Carriage Return	<CR>	0x0D	13
Linefeed	<LF>	0x0A	10
End of text	<ETX>	0x03	3
Tab	<TAB>	0x09	9

Always terminate a command string sent to the Axon Laser with the characters <CR><LF> to make the laser parse and reply. If the system echo is on, then each character except <CR><LF> is echoed. See "Echo Examples".

The laser responds to a command with one or more lines. If the reply has only one line, it ends with <ETX><CR><LF>. If the response has multiple lines, each line except the last ends with <CR><LF>. The last line of the response end with <ETX><CR><LF>. Automated software should wait for this end sequence before sending the next command/query.

It is recommended that the initial command to set is PROMPT=0<CR><LF>. This will remove the AXON> prompt on all future replies which will make parsing easier.

To send a command, enter a command from Table 7-3. The laser will first reply with an echo of the sent command and then append any errors or warnings. If the command was a query, then the laser will reply with the query and append any results. Some commands will reply with multiple lines.

7.1.3.1 Echo Examples

The echoing of the command can be enabled by issuing `ECHO=1`. As an example, the response to the query `?HKEY` with echo enabled and the prompt disabled is shown in detail below.

Command: `?HKEY<CR><LF>`

Response: `?HKEY<TAB>1<ETX><CR><LF>`

The echoing of the command can be disabled by issuing `ECHO=0`. As an example, the response to the query `?HKEY` with echo disabled and the prompt disabled is shown in detail below.

Command: `?HKEY<CR><LF>`

Response: `1<ETX><CR><LF>`

7.2 Commands and Replies

The command set is given in the following information.

Table 7-3. Commands and Replies

Command	Example Response	Comments
AOM:EXT=[value]		1. Enabled external modulation input 2. Disable external modulation input. Laser will use internal drive value.
?AOM:EXT	1	1. External modulation active 2. Internal modulation active
AOM:DRIVE=100		Set internal AOM drive to 100%. Range is 0 to 100. External modulation overrides this value. NB: If external modulation exceeds limits system will use internal drive value to protect the system.
?AOM:DRIVE	55	Read AOM drive value from 0 to 100%.
?HKEY	1	1 – physical hardware key is enabled. 0 – physical hardware key is disabled. See “Key-Switch Transition Behavior” (p. 31) for full explanation.

Table 7-3. Commands and Replies (Continued)

Command	Example Response	Comments
?SKEY	1	1 – software key state is enabled. 0 – software key state is disabled. See "Key-Switch Transition Behavior" (p. 31) for full explanation.
SKEY=[value]		1 - Enable software key. 0 – disable software key. See "Turn-off (Daily Use)" (p. 36) for full explanation.
PROMPT=[value]		1- Enable 0- Disable
?PROMPT		1- Enabled (default) 0- Disabled
ECHO=[value]		1- Enable Echo (default) 0- Disable Echo
?ECHO	1	1- Echo is enabled 0- Echo is disabled
?STATE	LASING	
LPMODE=[value]		1 - Low power 0 - High power
?POWER	1000	The power in milliwatts internal to the laser head. Note that the internal sensor is placed before the AOM cell in a TPC system and is unaffected by AOM:DRIVE.
?NAME	COHERENT AXON	
NAME=[string]		A user settable name to identify the system.
?SYS:SN	12345	
?SYS:TIME		Date is stored on the system in a battery backed up device.
?SYS:DATE		Date is stored on the system in a battery backed up device.

Table 7-3. Commands and Replies (Continued)

Command	Example Response	Comments
?SYS:LIFETIME	106d 02:25	The length of time that the system has been ON since manufacture. It is returned as days hours minutes e.g. 5d 02:55 would be 5 days 2 hrs and 55 minutes.
?SYS:UPTIME	14d 05:18:55	Time since system was powered ON. It is returned as days hours minutes seconds e.g. 5d 02:55:18 would be 5 days, 2 hrs, 55 minutes and 18 seconds.
FCLEAR		This command will clear any faults that are no longer active.
?FCODE	1-2-3	Return codes of active faults
?FINFO		Display detailed information of active faults.
?FHIST		Show history of any faults that have occurred.

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8 TPC Modulator Control

8.1 Introduction

The Axon TPC laser systems are controllable over the GUI or the “MOD-IN” BNC connection located at the rear of the power supply. The two modes of operation for Axon TPC:

- Internal (software power control)
- External (analog power control)

8.2 AOM Operational Modes

The various functionalities and requirements of the two operational modes available to the user:

- Internal (software power control)
- External (analog power control)

8.2.1 Internal Mode

Internal mode is the easy mode of operation for likely use at initial installation or for users configuring external optics on an optical table.

It enables slow power control only. This function can be accessed easily from a terminal program or the Coherent GUI.

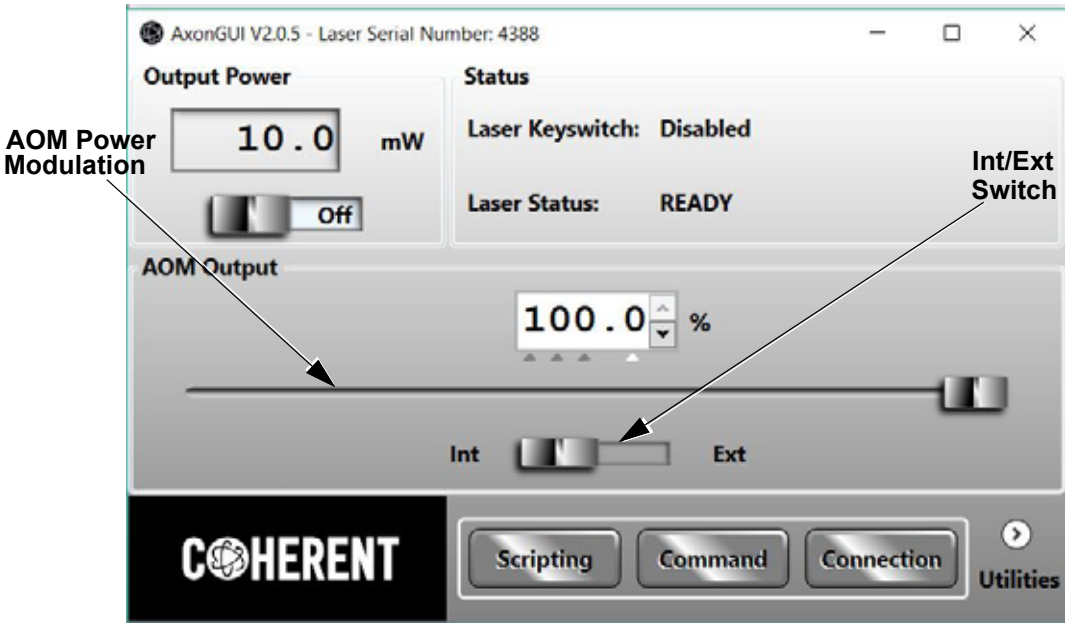

Figure 8-1. AOM GUI Control

8.2.2 External Mode

The external mode is available via the "MOD-IN" at the rear of the power supply. See Figure 5-2 (p. 30) for location details.

External mode is likely to be used in daily operation by most home-builders and some users of OEM equipment. This mode allows slow and fast power control as well as fast modulation. See Figure 8-2 for an example of external control of the AOM.

A user-supplied 0-5 Vdc signal is required to set the laser output power level.

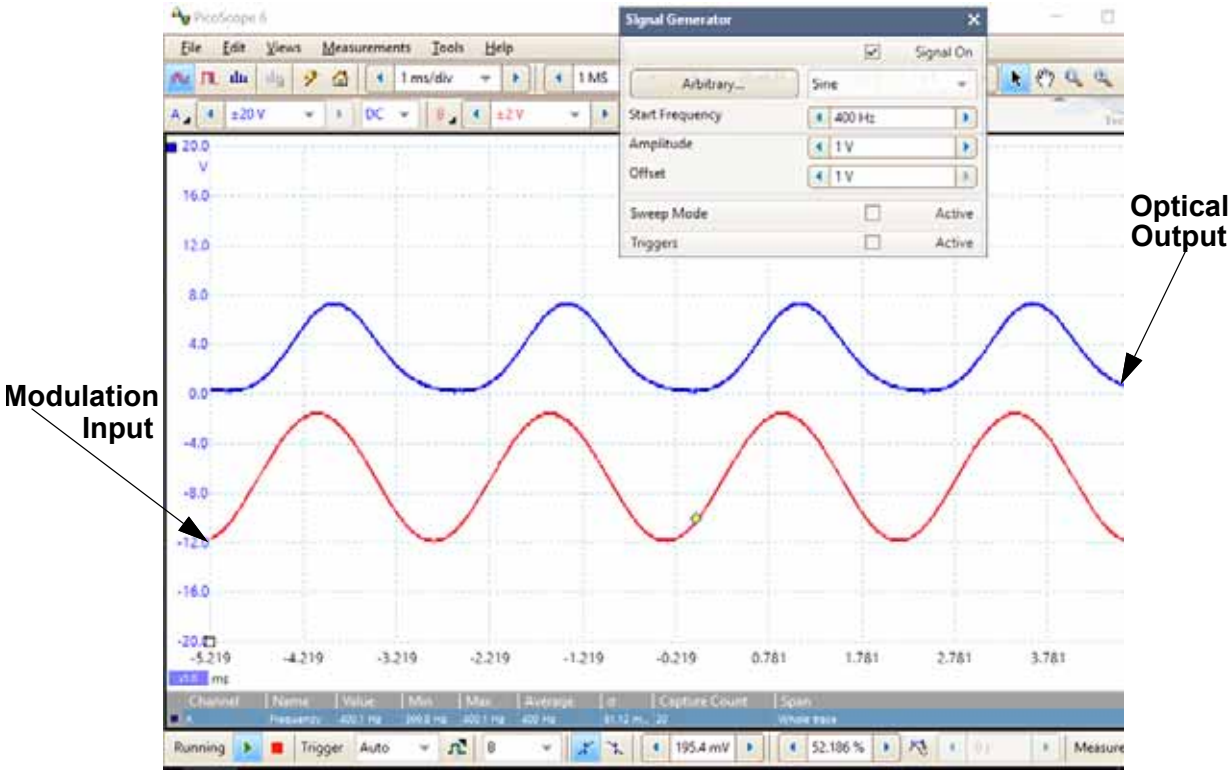

Figure 8-2. Example of External AOM Control

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9 Graphical User Interface

9.1 Description and Installation

The Axon GUI is a PC based application which can connect to various DPSS laser systems using RS-232 or USB. For the latest version of the GUI, visit the Coherent website at http://www.coherent.com/products/.

9.2 Establishing Connection

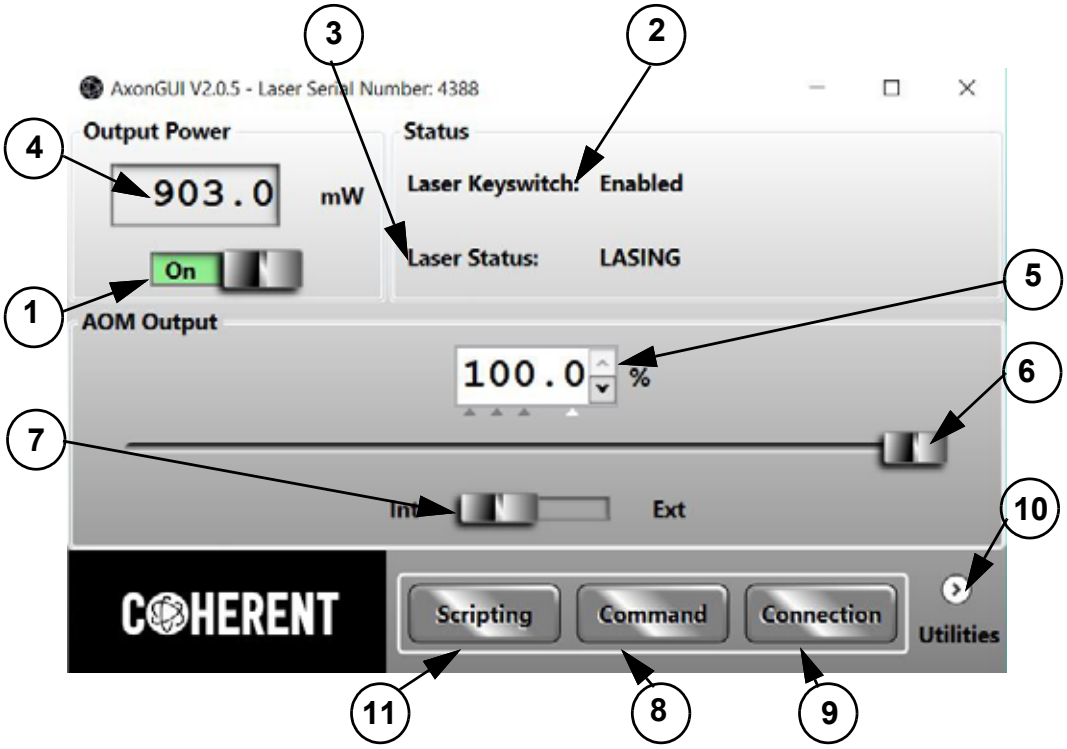
Once the GUI has been installed on the user PC, a connection will need to be established to the laser head using an RS-232 or USB cable.

Upon execution of the Axon GUI the main interface will be visible and present.

This opens the “Connection Options” window which provides users with different connection modes. Coherent recommends using the USB connection with the supplied USB cable.

9.3 Axon GUI Features

The GUI features are shown below in Figure 9-1.



1.Laser Enable Control
2.Laser Keyswitch Status
3.Laser Status
4.Output Power Level (mW)
5. AOM Modulation Level[a]
6.AOM Modulation Adjustment Slide[a]
7.Internal/External Switch[a]
8.Command Menu
9.Connection Menu
10.Utilities Menu
11.Scripting Menu

Figure 9-1. GUI Features

a.Only available on the TPC versions of the Axon Laser Systems.

10 Troubleshooting

Use the following checklists if you are experiencing problems with the Axon laser systems. Should the problem persist, or if you need further assistance, contact your regional Coherent Representative group.

10.1 System Issues

10.1.1 System Status Red (Fault)

[ ] Record Fault codes via a computer connection. Take a note of the fault code(s) and consult further below. Alternatively use the query `?FINFO` and make a note of the fault code(s).

[ ] Clear fault status. Try and clear the fault with the key-switch sequence Standby→Laser Enable→Standby. If the Status LED is now green then the fault has been cleared.

[ ] Try to turn the system off and on again.

[ ] Fault codes are logged in the system EEPROM. You can query faults with `?FHIST`.

10.1.2 Low Light Levels with System Status Green

If the system is a TPC then check that the AOM is configured correctly. Running in internal mode (`AOM:EXT=0`) with a drive value of 100 will give the most power from the system.

[ ] 1. Confirm physical keyswitch is in the enabled position

[ ] 2. Enable software key with `SKEY=1`.

[ ] 3. If the system is a TPC then check that the AOM is configured correctly. `AOM:DRIVE=100` and `AOM:EXT=0` will give the most power from the system.

[ ] 4. Disable `LPMODE=0` too see if this is causing low light.

10.1.3 Low Light Levels in Low Power Mode

If no light is visible in low power mode, contact your Coherent Representative.

10.2 Fault Codes

If the laser is experiencing a fault code not listed below, contact your local Coherent Representative.

10.2.1 Fault Code 2

External Interlock is not detected as being connected.

[ ] Check external interlock connection located at the rear of the power supply (see Figure 5-2 (p. 30) for location) with Coherent supplied interlock plug.

[ ] If fault still occurs, then contact your Coherent Representative.

10.2.2 Fault Code 4

Keyswitch detected in an undefined position.

[ ] The system will fault if the keyswitch is turned too slowly or is left in an undefined position. If this was the cause then reset the fault by turning the keyswitch Standby->Laser Enable->Standby.

[ ] If the keyswitch fault persists, then contact your Coherent Representative.

10.2.3 Fault Codes 7,8, and 9

These fault codes indicate a problem with the LEDs on the front panel of the power supply. Contact your Coherent Representative.

10.2.4 Fault Code 101

The "SYNC Output" BNC connection is not terminated in 50 ohm impedance.

[ ] Disconnect any external connections. If this resolves the fault, then replace external hardware.

[ ] If the issue persists, contact your Coherent Representative.

11 Packing Procedure

The following is the factory recommended packing procedure for the Axon Laser system. This procedure should be followed if the Axon Laser system is to be shipped to another location after initial installation.

NOTICE

Include all accessories and modules when returning a system. Only return parts associated with the serial corresponding with the laser.

NOTICE

The head is very light compared to the umbilical and power supply. It is possible to pull the head from its location while packing the umbilical and power supply. Verify the head is in a secure location while moving and repacking the system.

11.1 Shipping Position of Precompensation Screw

Prior to packing or shipping the laser system, the precompensation screw must be placed into the shipping position.

1. Locate a 2 mm hex 3.5 N-m torque wrench.
2. Turn the precompensation screw fully clockwise until resistance is met at 3.5 N-m.

CAUTION!

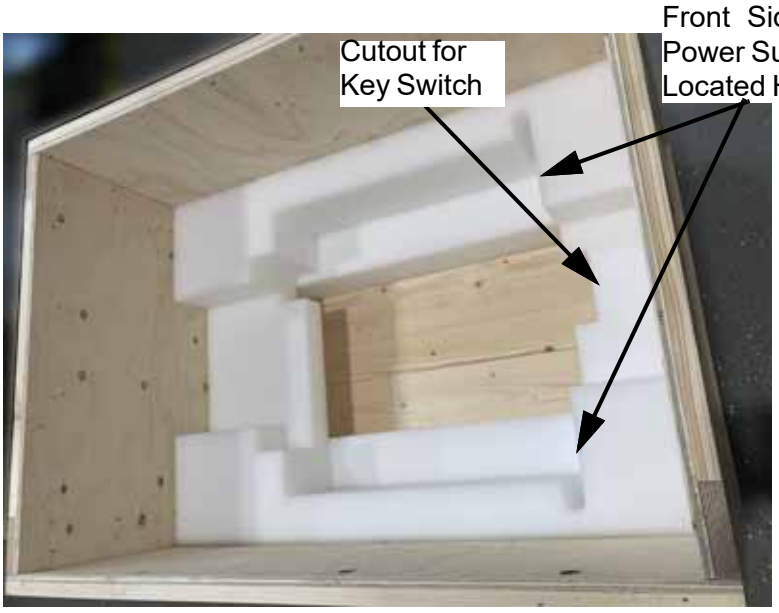
***DO NOT* adjust the lock rings. The reference position will be lost. See “Precompensation Screw” (p. 28).**

11.2 Packing the System

1. Locate the original Axon packaging.

Figure 11-1. Axon Packing Material

2. Place the bottom and side inserts into the Axon box with ESD foil placed on top of the inserts.



Bottom Power Supply Insert

Figure 11-2. Power Supply Insert with ESD Foil

Power Supply ESD Foil

Figure 11-2. Power Supply Insert with ESD Foil (Continued)

3. Place the power supply into the box with front panel tight against the insert.

Figure 11-3. Power Supply Placement in Packaging

4. Wrap the ESD foil around the power supply.

Figure 11-4. Power Supply Wrapped in ESD Foil

5. Place the oval shaped insert on top of the power supply.

Figure 11-5. Laser Head Oval Insert

6. Wrap the umbilical around the oval foam in a counter clockwise direction starting from the power supply. Take care of the head! The weight of the umbilical may pull it off the table or trolley cart if not safely secured.

Figure 11-6. Umbilical Handling

7. Place the ESD foil on top of the oval insert.

Figure 11-7. Laser Head Insert with ESD Foil

8. Set the head on top of the oval foam and wrap the ESD foil around the head.

Figure 11-8. Laser Head Wrapped in ESD Foil

9. Place the top insert over the system.

Figure 11-9. Top Insert Placement

10. Place the accessories box in with the system, see Figure 11-1 (p. 54).
11. Close the crate with the crate lid.
12. Secure top lid to the crate with the six crate clips.

Figure 11-10. Close and Secure the Crate

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Appendix A: Laser Safety

This user information is in compliance with the following standards for Light-Emitting Products IEC 60825-1 / EN 60825-1 *"Safety of laser products - Part 1: Equipment classification and requirements"* and CDRH 21 CFR Title 21 Chapter 1, Subchapter J, Part 1040 *"Performance standards for light-emitting products"* except for conformance with IEC 60825-1 Ed. 3 and IEC 60601-2-22 Ed. 3.1, as described in Laser Notice No. 56, dated May 8, 2019.

WARNING!
LASER RADIATION - AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION CLASS 4 LASER PRODUCT!

WARNING!
Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

This laser safety section must be reviewed thoroughly prior to operating the Axon Laser system. Safety instructions presented throughout this manual must be followed carefully.

A.1 Hazards

Hazards associated with lasers generally fall into the following categories:

- Biological hazards from exposure to laser radiation that may damage the eyes or skin
- Electrical hazards generated in the laser power supply or associated circuits

- Chemical hazards resulting from contact of the laser beam with volatile or flammable substances, or released as a result of laser material processing

The above list is not intended to be exhaustive. Anyone operating the laser must consider the interaction of the laser system with its specific working environment to identify potential hazards.

A.1.1 Optical Safety

Laser light, because of its optical qualities, poses safety hazards not associated with light from conventional light sources. The safe use of lasers requires all operators, and everyone near the laser system, to be aware of the dangers involved. Users must be familiar with the instrument and the properties of coherent, intense beams of light.

The safety precautions listed below are to be read and observed by anyone working with or near the laser. At all times, ensure that all personnel who operate, maintain or service the laser are protected from accidental or unnecessary exposure to laser radiation exceeding the accessible emission limits defined in the laser safety standards.

WARNING!
Direct eye contact with the output beam from the laser may cause serious eye injury and possible blindness.

The greatest concern when using a laser is eye safety. In addition to the main beam, there are often many smaller beams present at various angles near the laser system. These beams are formed by specular reflections of the main beam at polished surfaces such as lenses or beamsplitters. While weaker than the main beam, such beams may still be sufficiently intense to cause eye damage.

Laser beams are powerful enough to burn skin, clothing, or combustible materials, even at some distance. They can ignite volatile substances such as alcohol, gasoline, ether, and other solvents, and can damage light-sensitive elements in video cameras, photomultipliers, and photodiodes. The user is advised to follow the control measures below.

A.1.1.1 Recommended Precautions and Guidelines

1. Observe all safety precautions in the preinstallation and operator's manuals.
2. The protective housing includes the controller chassis, the umbilical, and the laser head. It is the user's responsibility to make sure these are free from damage.
3. Check the protective housing routinely for damage. Especially after installation or moving.
4. Always wear appropriate eyewear for protection against the specific wavelengths and laser energy being generated. See "Laser Safety Eyewear" (p. 64) for additional information.
5. Avoid wearing watches, jewelry, or other objects that may reflect or scatter the laser beam.
6. Stay aware of the laser beam path, particularly when external optics are used to steer the beam.
7. Provide enclosures for beam paths whenever possible.
8. Use appropriate energy-absorbing targets for beam blocking.
9. Block the beam before applying tools such as Allen wrenches or ball drivers to external optics.
10. Limit access to the laser to trained and qualified users who are familiar with laser safety practices. When not in use, lasers should be shut down completely and made off-limits to unauthorized personnel.
11. Terminate the laser beam with a light-absorbing material. Laser light can remain collimated over long distances and therefore presents a potential hazard if not confined. It is good practice to operate the laser in an enclosed room.
12. Post laser warning signs in the area of the laser beam to alert those present.
13. Exercise extreme caution when using solvents in the area of the laser.
14. Never look directly into the laser light source or at scattered laser light from any reflective surface, even when wearing laser safety eyewear. Never sight down the beam.
15. Set up the laser so that the beam height is either well below or well above eye level.
16. Avoid direct exposure to the laser light. Laser beams can easily cause flesh burns or ignite clothing.
17. Advise all those working with or near the laser of these precautions.

CAUTION!
Laser safety eyewear protects the user from accidental exposure to laser radiation by blocking light at the laser wavelengths. However, laser safety eyewear may also prevent the operator from seeing the beam or the beam spot. Exercise extreme caution even while wearing safety glasses.

A.1.1.2 Laser Safety Eyewear

Always wear appropriate laser safety eyewear for protection against the specific wavelengths and laser energy being generated. The appropriate eye protection can be calculated as defined in the "EN 207 Personal eye protection equipment - Filters and eye-protectors against laser radiation (laser eye-protectors)", in other national or international standards (e.g. ANSI, ACGIH, or OSHA) or as defined in national safety requirements.

CAUTION!
Laser safety eyewear protects the user from accidental exposure to laser radiation by blocking light at the laser wavelengths. However, laser safety eyewear may also prevent the operator from seeing the beam or the beam spot. Exercise extreme caution even while wearing safety glasses.

A.1.1.3 Viewing Distance

The Axon Laser produces optical power levels that are dangerous to the eyes and skin if exposed directly or indirectly. This product must be operated only with proper eye and skin protection at all times. Never view directly emitted or scattered radiation with unprotected eyes.

DANGER!
Class 4 should never be viewed directly!

A.1.2 Electrical Safety

Axon Laser use AC and DC voltages. There are no user serviceable components in the controller or laser head. All units are designed to be operated as assembled. Warranty will be voided if the laser head, the controller, or the cable is disassembled.

DANGER!
Normal operation of the Axon Laser should not require access to the power supply circuitry. Removing the power supply cover will expose the user to potentially lethal electrical hazards. Contact an authorized service representative before attempting to correct any problem with the power supply.

A.2 Maximum Accessible Radiation Level

The AXON lasers produce visible and invisible radiation over the range 750 nm to 1090 nm, with a maximum power of 6 W and with pulse duration of typically 120 fs to 150 fs. The specific outputs of the different models are displayed in Table A-1.

Table A-1. Emitted Wavelengths

Laser Type	Emitted Wavelengths
Axon 780	**750 nm to 810 nm**
Axon 920	**890 nm to 950 nm**
Axon 1064	**1030 nm to 1090 nm**

A.3 Safety Features and Compliance with Government Requirements

The following features are incorporated into the instrument to conform to several government requirements:

United States of America:
The applicable United States Government requirements are contained in 21 CFR, Subchapter J, Part 1040 administered by the Center for Devices and Radiological Health (CDRH).

Europe:
The European Community requirements for product safety are specified in

the Low Voltage Directive (LVD) (published in 2014/35/EU). The Low Voltage Directive requires that lasers comply with the standard EN 61010-1: 2010/IEC 61010-1 "Safety Requirements For Electrical Equipment For Measurement, Control and Laboratory Use" and EN 60825-1/IEC 60825-1 "Safety of Laser Products". Compliance of this laser with the European requirements is certified by the CE mark.

A.3.1 Laser Classification

Governmental standards and requirements specify that the laser must be classified according to the output power or energy and the laser wavelength. The Axon Laser is classified as Class 4 based on 21 CFR, Subchapter J, Part 1040, section 1040.10 (c) and/or IEC/EN 60825-1, Clause 5. In this manual, the classification will be referred to as Class 4.

A.3.2 Protective Housing

The Axon Laser system is enclosed in a protective housing that prevents human access to radiation in excess of the limits of Class radiation as specified in the 21CFR, Part 1040 Section 1040.10 (f)(1) and EN 60825-1/ IEC 60825-1 Clause 6.2 except for the output beam, which is Class 4. The protective housing includes the controller chassis, the umbilical, and the laser head,

A.3.3 External Interlock Connector

The Axon Laser system is equipped with an external interlock connector on the rear panel of the power supply, see "External Interlock" (p. 22) for operation details and "Power Supply" (p. 30) for location. The terminals of this connector must be electrically joined for the laser to operate [CFR 1040.10 (f)(3)/ EN 60825-1/IEC 60825-1, Clause 6.4].

A.3.4 Key Control

Operation of the Axon Laser requires that the power supply keyswitch be in the ON position. The key is removable and the system cannot be operated when the key is removed [CFR 1040.10 (f)(4)/EN 60825-1/IEC 60825-1, Clause 6.6].

A.3.5 Laser Radiation Emission Indicators

The LASER EMISSION indicators on both the power supply and the laser head illuminate approximately a few seconds before laser emission can occur. The indicators are visible without exposing the operator to laser emission. Lights are used which are visible while wearing the proper type of safety glasses [CFR 1040.10(f)(5)/ EN 60825-1/IEC 60825-1, Clause 6.7].

A.3.6 Beam Attenuator

An internal beam block prevents exposure to all laser radiation above Class 1 without removing power from the system [CFR 1040.10 (f)(6)/EN 60825-1/ IEC 60825-1, Clause 6.8].

A.3.7 Operating Controls

The laser controls are positioned so that the operator is not exposed to laser emission while manipulating the controls [CFR 1040.10(f)(7)/ EN 60825-1/IEC 60825-1, Clause 6.9].

A.3.8 GUI Display

The GUI display screen may be viewed without exposing the operator to laser emission [CFR 1040.10(f)(8)/EN 60825-1/IEC 60825-1, Clause 6.10].The GUI can provide a visual indicator of the laser performance.This is viewable without exposing the operator to laser emission. Additionally the controller has indicator LED's that allow the operator the determine the current laser status without exposure to laser radiation

A.3.9 Manual Reset Mechanism

Following an interlock fault or unexpected loss of electrical power, laser operation is manually reset by turning the key switch on the power supply front panel or by sending the appropriate control commands via the software interface [CFR 1040.10(f)(10)/ EN 60825-1/IEC 60825-1, Clause 6.5].

WARNING!
Use of controls or adjustments or performance of procedures other than those specified in the manual may result in hazardous radiation exposure.

NOTICE
Use of the system in a manner other than that described herein may impair the protection provided by the system.

A.4 Electromagnetic Compatibility

The European Community requirements for Electromagnetic Compliance are specified in the Electromagnetic Compatibility (EMC) Directive (published in 2014/30/EU). Conformance to the EMC requirements is achieved though compliance with EN 61326-1/IEC 61326-1 (Electrical Requirements for measurement, control and laboratory use). Compliance of this Laser with the European requirements is certified by the CE mark.

A.5 Environmental Compliance

This section describes compliance with various environmental regulatory directives to identify hazardous substances.

A.5.1 RoHS Compliance

Coherent products conform to all applicable requirements of the EU-RoHS Directive (2011/65/EU) and subsequent Amendment Directives including Directive (EU) 2015/863. Compliance Declarations are available upon request.

Compliance of this Laser with the European requirements is certified by the CE mark.

A.5.2 China-RoHS Compliance

This section details compliance with the China RoHS (Restriction of Hazardous Substances) Regulation SJ/T 11364-2014.

This Regulation restricts the use of certain hazardous substances in electrical and electronic equipment. The China RoHS Regulation applies to the production, sale, and import of products into the Peoples Republic of China.

- Any hazardous substances in the Axon Laser laser systems are listed in the table.
- The environmental-friendly use period is 20 years as indicated by the number 20 inside the circle.

The China RoHS Regulation also requires that the date of manufacture be identified (in Chinese characters) on the product label

PN: 1260938rAG	产品中有害物质的名称及含量						
部件名称 Part Name	有害物质 Hazardous Substances						
	铅 (Pb)	汞 (Hg)	镉 (Cd)	六价铬 (Cr(VI))	多溴联苯 (PBB)	多溴二苯醚 (PBDE)	
印刷电路板组装 Printed Circuit Board Assembly	X	O	O	O	O	O	
电缆装配 Cable Assembly	O	O	O	O	O	O	
光学部件装配 Optic Assembly	X	O	O	O	O	O	
板金组装 Sheet Metal Assembly	O	O	O	O	O	O	
电源 Power Supply	X	O	O	O	O	O	
组装二极管激光器 Laser Diode Assembly	O	O	O	O	O	O	
本表格依据 SJ/T 11364 的规定编制 O: 表示该有害物质在该部件所有均质材料中的含量均在 GB/T 26572 规定的限量要求以下。 X: 表示该有害物质至少在该部件的某一均质材料中的含量超出 GB/T 26572 规定的限量要求。							

A.5.3 REACH

Coherent product(s) conform to all applicable requirements of the EU-REACH Regulation, (1907/2006). Compliance Declarations are available upon request.

A.5.4 Waste Electrical and Electronic Equipment

Coherent products conform to all applicable requirements of the EU Waste Electrical and Electronic Equipment (WEEE)- Directive (2012/19/EU). WEEE management also covers EU Directive 2006/66/EC-EU Battery Directive and Directive 94/62/EC on Packaging and Packaging Waste. Do not dispose of these products or packaging as unsorted municipal waste.

Coherent joins approved compliance organizations to meet its collection and recycling obligations. For further information, please contact:

Email: info@rene-europe.com
Phone: +49 (0) 8266-869806
Website: www.rene-europe.com

A.5.4.1 Battery Directive

The batteries used in this product are in compliance with the EU Directive 2006/66/EC ("EU Battery Directive").

Table A-2. Batteries Contained in this Product

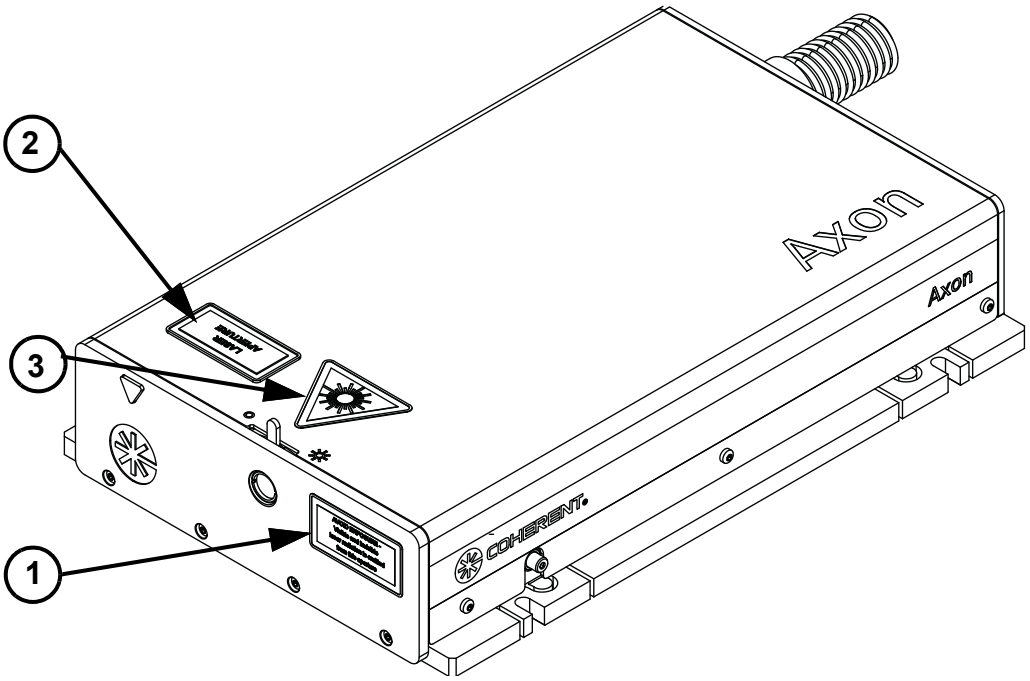
Description	Type
3 volt coin cell	Lithium

Do not dispose as normal waste.For further information, please contact:

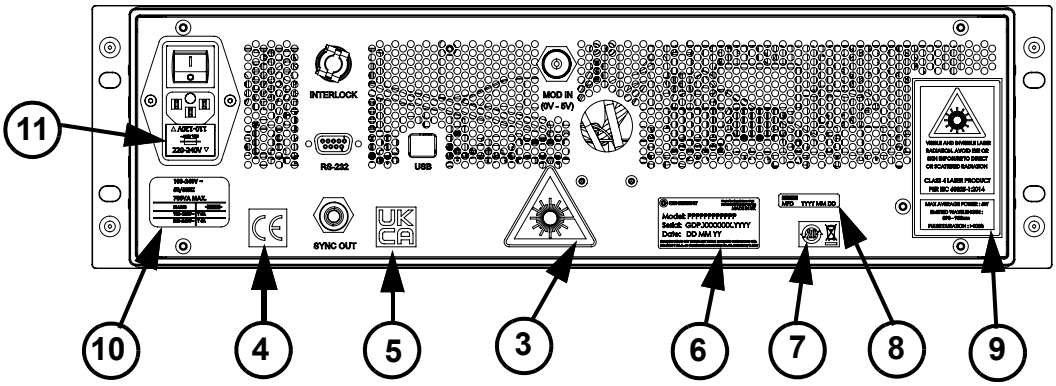
Email: info@rene-europe.com
Phone: +49 (0) 8266-869806
Website: www.rene-europe.com

A.6 Location of Safety Labels

Refer to Table A-3 for the location of all safety labels. These include warning labels indicating removable or displaceable protective housings, apertures through which laser radiation is emitted, and labels of certification and identification [21 CFR § 1040.10(g), 21 CFR § 1010.2, and 21 CFR § 1010.3/ EN 60825-1/IEC 60825-1, Clause 7].



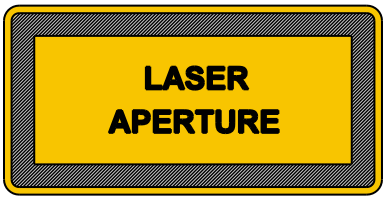
Laser Head - Isometric View



Power Supply - Rear View

1. Aperture Warning Label

Table A-3. Axon Laser Safety Features and Labels (Sheet 1 of 4)

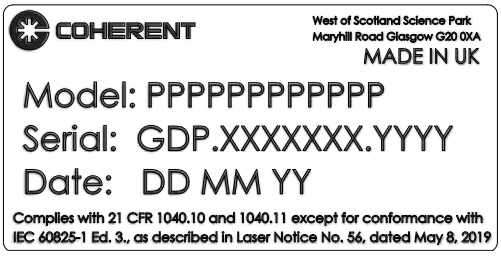


2. Laser Aperture Indicator Label

3. Hazardous Radiation Warning Label

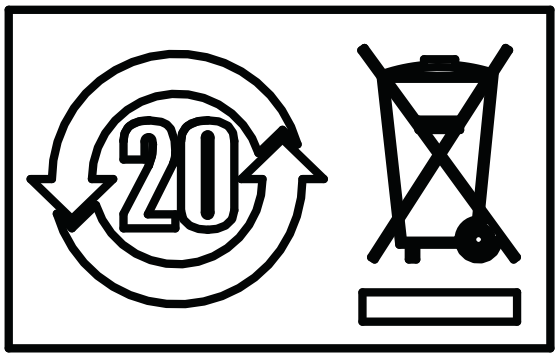
4. CE Certification Label

5. UKCA Certification Label

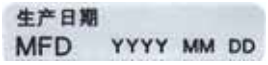


6. Serial Number Label

Table A-3. Axon Laser Safety Features and Labels (Sheet 2 of 4)



7. China RoHS & Wheelie Bin Disposal Label

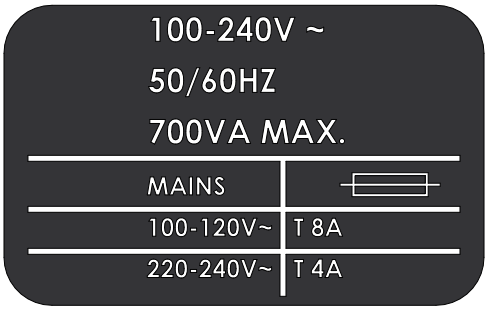


8. Manufacture Date Label

780 nm **920 nm** **1064 nm**

9. Maximum Radiation Label

Table A-3. Axon Laser Safety Features and Labels (Sheet 3 of 4)



10. Maximum Power Rating Label

11. AC Mains Input Rating and Fuse Type/Position

Table A-3. Axon Laser Safety Features and Labels (Sheet 4 of 4)

A.7 Sources of Additional Information

The following are sources for additional information on laser safety standards and safety equipment and training.

A.7.1 Laser Safety Standards

American National Standard for Safe Use of Lasers
ANSI Z136 Series
American National Standards Institute (ANSI)
www.ansi.org

Performance standards for light-emitting products
21 CFR Title 21 Chapter 1, Subchapter J, Part 1040
U.S. Food and Drug Administration
www.fda.gov

A.7.2 Publications and Guidelines

Safety of laser products - Part 1: Equipment classification and requirements
IEC 60825-1 / EN 60825-1

Safety of laser products - Part 14: A user's guide
IEC 60825-1 / EN 60825-1

Safety Requirements For Electrical Equipment For Measurement, Control and Laboratory Use
IEC 61010-1 / EN 61010-1

International Electrotechnical Commission (IEC)
www.iec.ch

Safety of laser products - Part 1: Equipment classification and requirements
BS EN 60825-1
British Standard Institute
www.bsigroup.com

A Guide for Control of Laser Hazards
American Conference of Governmental
and Industrial Hygienists (ACGIH)
www.acgih.org

Laser Safety Guide
Laser Institute of America
www.lia.org

A.7.3 Equipment and Training

Laser Focus Buyer's Guide
Laser Focus World
www.laserfocusworld.com

Photonics Spectra Buyer's Guide
Photonics Spectra
www.photonics.com

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Appendix B: Warranty

Coherent, Inc. warrants the Axon laser systems to the original purchaser (the Buyer) only, that the laser system, that is the subject of this sale, (a) conforms to Coherent's published specifications and (b) is free from defects in materials and workmanship.

Laser systems are warranted to conform to Coherent's published specifications and to be free from defects in materials and workmanship for a period stated in the sales agreement.

B.1 Responsibilities of the Buyer

The buyer is responsible for providing the appropriate utilities and an operating environment as outlined in the product literature. Damage to the laser system caused by failure of buyer's utilities or failure to maintain an appropriate operating environment, is solely the responsibility of the buyer and is specifically excluded from any warranty, warranty extension, or service agreement.

The Buyer is responsible for prompt notification to Coherent of any claims made under warranty. In no event will Coherent be responsible for warranty claims made later than seven (7) days after the expiration of warranty.

B.2 Limitations of Warranty

The foregoing warranty shall not apply to defects resulting from:

- Components and accessories manufactured by companies, other than Coherent, which have separate warranties,
- Improper or inadequate maintenance by the buyer,
- Buyer-supplied interfacing,
- Operation outside the environmental specifications of the product,
- Unauthorized modification or misuse,
- Improper site preparation and maintenance, or
- Opening the laser head housing.

Coherent assumes no responsibility for customer-supplied material. The obligations of Coherent are limited to repairing or replacing, without charge, equipment which proves to be defective during the warranty period. Replacement sub-assemblies may contain reconditioned parts. Repaired or replaced parts are warranted for the duration of the original warranty period only. Our warranty does not cover damage due to misuse, negligence or accidents, or damage due to installations, repairs or adjustments not specifically authorized by Coherent.

Warranty applies only to the original purchaser at the initial installation point in the country of purchase, unless otherwise specified in the sales contract. Warranty is transferable to another location or to another customer only by special agreement which will include additional inspection or installation at the new site. Coherent disclaims any responsibility to provide product warranty, technical or service support to a customer that acquires products from someone other than Coherent or an authorized representative.

THIS WARRANTY IS EXCLUSIVE IN LIEU OF ALL OTHER WARRANTIES, WHETHER WRITTEN, ORAL OR IMPLIED, AND DOES NOT COVER INCIDENTAL OR CONSEQUENTIAL LOSS. COHERENT SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

Glossary

°C	Degrees centigrade or Celsius
°F	Degrees Fahrenheit
µ	Microns
µrad	Microradian(s)
µsec	Microsecond(s)
$1/e^2$	Beam diameter parameter
AC	Alternating current
Amp	Amperes
CDRH	Center for Devices and Radiological Health
CFR	Code of Federal Regulation
cm	Centimeter(s)
DC	Direct current
EEPROM	Electrically erasable programmable read only memory
EMC	Electromagnetic Compliance
ESD	Electrostatic Discharge
fs	Femtosecond (1fs= 10^{-15}s)
fs^2	Femotsecond^2. Unit of measure for the GDD.
FSR	Free spectral range
GDD	Group Delay Dispersion. the frequency dependency of the group delay, or (quantitatively) the corresponding derivative with respect to angular frequency
Hz	Hertz
I/O	Input/output
kg	Kilogram(s)
kHz	Kilohertz
LED	Light emitting diode
LVD	Low Voltage Directive
m	Meter(s)
mAmp	Milliampere(s)
MHz	Megahertz
mm	Millimeter(s)
mrad	Milliradian(s)
msec	Millisecond(s)
mV	Millivolt(s)
mW	Milliwatt(s)

nm	Nanometer(s)
OEM	Original equipment manufacturer
rms	Root mean square
TEM	Transverse electromagnetic (cross-sectional) mode
VAC	Volts, alternating current
VDC	Volts, direct current
W	Watt(s)

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Axon™ Laser Systems Operator’s Manual
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COHERENT

INNOVATIONS THAT RESONATE

Axon™ Laser Systems Operator's Manual
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