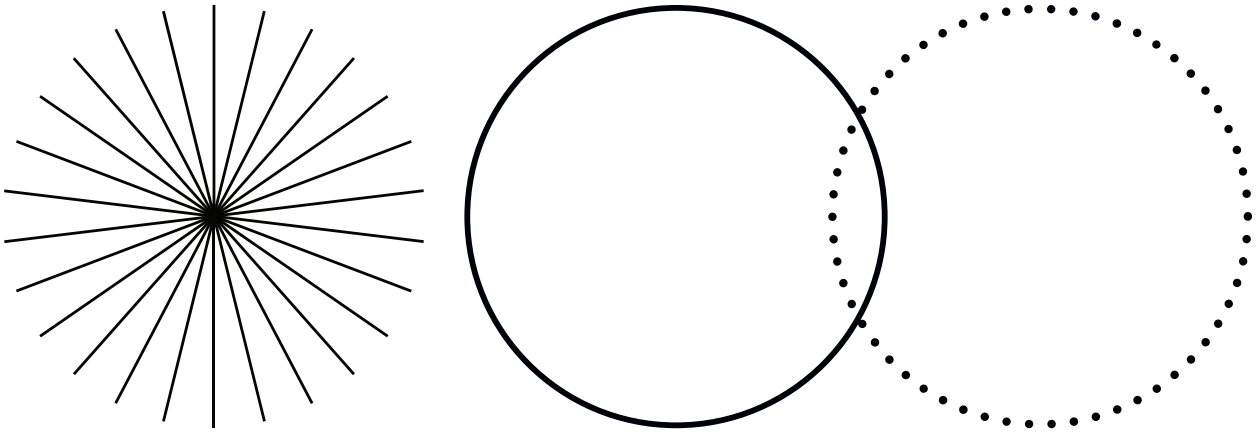
Matrix Laser System

Operator’s Manual



INNOVATIONS THAT RESONATE

COHERENT

Operator's Manual
Matrix Laser System

COHERENT

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23560 Lübeck, Germany

Patents referenced in this manual are active when the manual is printed (see last page for the date). You are advised to check if the patents are still active www.coherent.com/legal/patents.

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Should you experience any difficulties with your laser or need any technical information, please go to our web site www.Coherent.com. Should you need further assistance, please contact Coherent Technical Support by e-mail customer.support@coherent.com or telephone, +1-734-456-3100. Please be prepared to supply the model and laser head serial number of your laser system, the description of the problem, and any attempted corrective steps to the Product Support Engineer responding to your request.

Telephone coverage is available Monday through Friday (except U.S. holidays and company shutdowns). Inquiries received outside of normal office hours will be captured by our automatic answering system and will be quickly returned the next business day.

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1 Introduction to the Manual

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 Matrix.

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 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 and China: 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 Matrix 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. Installation, deinstallation, servicing, and detailed troubleshooting are only to be performed by formally trained and instructed personnel.

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.

1.4.1 Intended Audience

The Matrix 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.

1.5 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.

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

1.6 Feedback Regarding Documentation and/or Matrix Laser System

If there are any comments and feedback regarding the documentation and/or the Matrix Laser System, please contact the Coherent Product Support Team.

In any correspondence, please provide the following (if relevant to your feedback):

- 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.
- the model and laser head serial number of your laser system
- the description of the problem

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2 Laser Safety

2.1 Warning Information

Refer to the Safety Section in the Operator's Manual before installation or operation. Failure to follow the safety section can cause accidental exposure to laser radiation which may result in severe bodily injuries and/or damage to the laser.

NOTICE

Use of the system in a manner different from described in this guide or the operator's manual can impair the protection provided by the system.

WARNING!

Direct and indirect eye contact with the output beam from the laser will cause serious damage and possible blindness.

WARNING!

Wear appropriate laser safety glasses to protect against the radiation generated from the laser. It is expected that the operator has read the Matrix Operator's Manual Safety Section and knows laser safety practices and the possible danger. Make sure all personnel in the area are wearing appropriate laser safety glasses.

This laser device does not comply with:

US FDA CFR 21 requirements for certified laser products,

US FDA CFR 21, section 1040.10 and 1040.11,

IEC 60825-1:2014.

The laser can only be used as an OEM component of a certified laser product. Refer to the Matrix Operator's Manual Safety Section for more information on compliance..

2.2 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.

2.2.1 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.

DANGER!
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 beam-splitters. 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.

2.2.1.1 Recommended Precautions and Guidelines

- Observe all safety precautions in the preinstallation and operator's manuals.
- Always wear appropriate eyewear for protection against the specific wavelengths and laser energy being generated.
- Avoid wearing watches, jewelry, or other objects that may reflect or scatter the laser beam.
- Stay aware of the laser beam path, particularly when external optics are used to steer the beam.
- Provide enclosures for beam paths whenever possible.
- Use appropriate energy-absorbing targets for beam blocking.
- Block the beam before applying tools such as Allen wrenches or ball drivers to external optics.
- 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.
- 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.
- Post laser warning signs in the area of the laser beam to alert those present.
- Exercise extreme caution when using solvents in the area of the laser.
- 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.
- Set up the laser so that the beam height is either well below or well above eye level.

- Avoid direct exposure to the laser light. Laser beams can easily cause flesh burns or ignite clothing.
- Advise all those working with or near the laser of these precautions.

2.2.1.2 Laser Safety Eyewear

Always wear appropriate laser safety eyewear for protection against the specific wavelengths and laser energy being generated. The appropriate eye protection must be determined by your Laser Safety Officer.

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.

The Matrix Laser produces optical power levels that are dangerous to the eyes and skin if exposed directly or indirectly. This product must be always operated only with proper eye and skin protection. Never view directly emitted or scattered radiation with unprotected eyes. Avoid direct viewing into the laser beam even while wearing sufficient eye protection. Eye protection is for protection against accidental short-term exposure and protection against stray light only. Eye protection is not for intentional viewing into the beam.

2.2.2 Electrical Safety

The Matrix uses 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 Matrix 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.

2.2.2.1 Recommended Precautions and Guidelines

The following precautions must be observed by everyone when working with potentially hazardous electrical circuitry:

DANGER!

When working with electrical power systems, the rules for electrical safety must be strictly followed. Failure to do so could result in the exposure to lethal levels of electricity.

- Disconnect main power lines before working on any electrical equipment when it is not necessary for the equipment to be operating.
- The main power supply connection cord shall be rated for the maximum equipment current and no longer than 3 m.
- Do not short or ground the power supply output. Protection against possible hazards requires proper connection of the ground terminal on the power cable, and an adequate external ground. Check these connections at the time of installation, and periodically thereafter.
- Never work on electrical equipment unless there is another person nearby who is familiar with the operation and hazards of the equipment, and who is competent to administer first aid.
- When possible, keep one hand away from the equipment to reduce the danger of current flowing through the body if a live circuit is touched accidentally.
- Always use approved, insulated tools.
- Special measurement techniques are required for this system. A technician who has a complete understanding of the system operation and associated electronics must select ground references.

2.3 Safety Features and Compliance with Government Requirements

This laser product is to be sold to an original equipment manufacturer (OEM) of electronic products for use as a component (or replacement component) in electronic products. As such, this product is exempt from DHHS performance standard for laser products in accordance with paragraph 1040.10(a)(1).

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 standard IEC 61010-1 "Safety Requirements For Electrical Equipment For Measurement, Control and Laboratory Use". Compliance of this laser with the European requirements is certified by the CE mark.

2.3.1 OEM Requirements

This laser device does not comply with

US FDA CFR 21 requirements for certified laser products,
US FDA CFR 21, section 1040.10 and 1040.11,
IEC 60825-1:2014.

The laser can only be used as an OEM component of a certified laser product.

To comply with the safety regulations according to IEC 60825-1:2014 the integrator must:

- Ensure the system is single fail-safe
- Install an interlock
- Install a key switch. The key switch must be able to disconnect all live conductors
- Install a shutter
- Install a laser emission warning
- Ensure the laser head and controller labels are accessible to view according to IEC 60825-1:2014.

The list may not be complete. The integrator is responsible for verifying the necessary compliance requirements for applicable safety regulations.

2.3.2 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 Matrix is classified as Class 4 based on 21 CFR, Subchapter J, Part 1040, section 1040.10 (c) and IEC/EN 60825-1:2014, Clause 4. In this manual, the classification will be referred to as Class 4.

2.3.2.1 Wavelength and Power Levels

The primary radiation of the system is emitted from the laser output window at the front of the laser head.

For the 355 nm model, it is INVISIBLE LASER RADIATION with a wavelength of 0.35 to 0.36µm. Its maximum average power does not exceed 15W.

Furthermore, the Matrix laser head can additionally emit the following laser radiation wavelengths and power levels from the aperture at the front of the laser head. See below for the location of emitted light.

- INVISIBLE LASER RADIATION of 1.064µm wavelength. The maximum average power does not exceed 2W.
- INVISIBLE LASER RADIATION of 0.85 to 0.90µm. The maximum average power does not exceed 10W.
- VISIBLE LASER RADIATION of 0.532µm wavelength. The maximum average power does not exceed 2W.
- INVISIBLE LASER RADIATION of 0.355µm wavelength. The maximum average power does not exceed 15W.

Figure 2-1. Laser Product Label

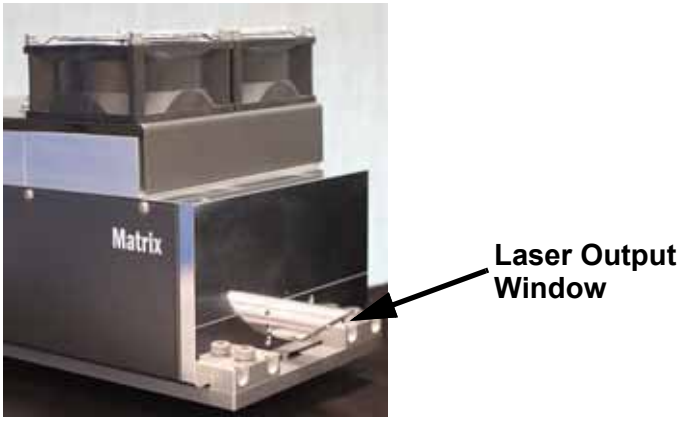


Figure 2-2. Laser Output

2.3.3 Protective Housing

The laser head 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.

WARNING!
Any opening to break the sealing of the laser head is not permitted. Do not remove any item from the protective housing. Opening or breaking the laser head sealing will void the manufacturer's warranty.

2.3.4 Remote Interlock Connectors

See "External Interlock 1 & 2 Connector" (p. 36) for more details.

The Matrix Laser System is equipped with two external interlock connectors on the rear panel of the laser head. The terminals of this connector must be electrically joined for the laser to operate.

To incorporate an external safety interlock circuit into the laser, turn off the laser and remove the jumper from the interlock connector of the rear panel of the laser head. Attach a user furnished external interlock circuit to each of both connectors. Any external interlock circuit must be equivalent to 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 to avoid potential damages.

Both interlock loops are established as 12 mA current loops and should be designed with less than 1 Ohm resistance, that must be closed to enable laser radiation. Do not connect the loops with each other.

2.4 Electromagnetic Compatibility

The European requirements for Electromagnetic Compliance (EMC) are specified in the EMC Directive (published in 2014/30/EU).

Conformance to EMC requirements is achieved through compliance with the harmonized standards.

Emission: EN IEC 61326-1:2021

Immunity: EN IEC 61326-1:2021

The laser meets the emission requirements for Class A, Group 1, as specified in EN IEC 61326-1:2021.

Compliance of this laser with the EMC requirements is certified by the CE mark.

2.5 Environmental Compliance

2.5.1 RoHS Compliance

The RoHS directive restricts the use of certain hazardous substances in electrical and electronic equipment. Coherent can provide RoHS certification upon request for products requiring adherence to the RoHS Directive.

2.5.2 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.

Table 2-1 specifies the following:

- Any hazardous substances in the laser system
- Environmental-friendly use period of 20 years, indicated by the number 20 inside the circle
- Date of manufacture be identified in Chinese characters

2.5.3 EU REACH

REACH (Registration, Evaluation, Authorization and Restriction of Chemicals) is a European Union Commission (EUC) Regulation on chemicals and their safe use (EC 1907/2006) entered into force on 01 June, 2007.

Coherent products are "articles" as defined in REACH Article 3(3) and do not release substances under their normal use. Suppliers of articles must provide recipients with information on Substances of Very High Concern (SVHC) if those are present above a concentration limit of 0.1% on an article level. As Coherent's duty to communicate information on substances in articles, the delivered product(s), based on Coherent's knowledge, may contain the listed chemical substance(s) included on the REACH Candidate List at this link: https://edge.coherent.com/assets/pdf/reach_article_33_statement.pdf. The current Candidate List of SVHCs can be found on the ECHA website https://echa.europa.eu/home.

Table 2-1. China-RoHS 2 Compliant Components

PN:1362052 & 1410152	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	
装配电缆 Cable Assembly	X	O	O	O	O	O	
硬件 Hardware	X	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。							

Laser Head Chart
All Head Models

PN: 1365951	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)	
板金组装 Sheet Metal Assembly	X	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。							

The current Candidate List of SVHCs can be found on the ECHA website https://echa.europa.eu/home.

Coherent will post information on SVHCs to our website as the information becomes available and assures its customers that our products are in full compliance the EU REACH requirement. For detailed information on SVHC and Coherent products, please visit https://www.coherent.com/company/environmental.

2.5.4 Waste Electrical and Electronic Equipment (WEEE)

The European Waste Electrical and Electronic Equipment (WEEE) Directive (2012/19/EU) is represented by a crossed-out garbage container label. The purpose of this directive is to minimize the disposal of WEEE as unsorted municipal waste and to facilitate its separate collection.

The WEEE Directive applies to this product and any peripherals marked with this symbol. Do not dispose of these products as unsorted municipal waste. Contract the local distributor for procedures for recycling this equipment.

2.5.5 Location of Safety Labels

Refer to Figure 2-3 below 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].

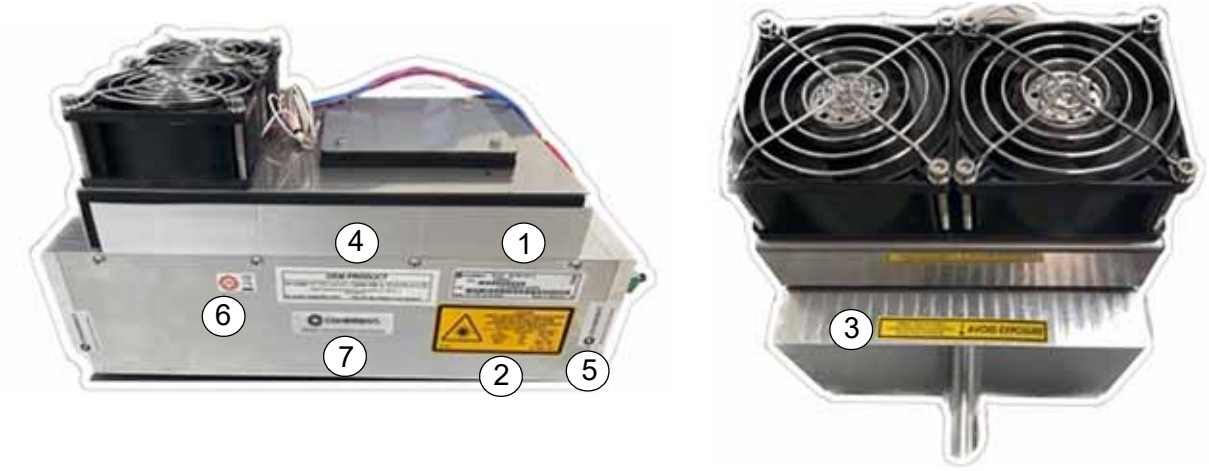


Figure 2-3. Location of Safety Labels

Table 2-2. Label Descriptions- Laser Head

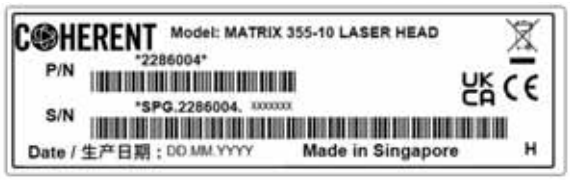
Item	Label	Description
1		**Product Identification Label:** This label states the compliance to DHHS Performance Radiation Standards 21 CFR Ch. I, EN 60825-1 for this product. It also contains the model, serial number, manufacturing date, part number and product origin. Contains the European Waste Electrical and Electronic Equipment (WEEE) Directive Label (lower right corner). See “Waste Electrical and Electronic Equipment (WEEE)”.
2		**Laser Product Label:** This label describes the specific wavelength and output power level capabilities of the laser head. It also includes the laser class of the product. For more information, refer to “Laser Classification” (p. 13).
3		**Avoid Exposure Label:** This label identifies the location of the output beam.
4		**OEM Product Label:** This label states the non-compliance with DHHS Performance Radiation Standards 21 CFR Ch. I, EN 60825-1 for this product. It is described in both English and German. See “OEM Requirements” (p. 14) for more information on OEM requirements.
5		**Warranty Void Label:** Warns that the warranty of the product will be void if the seal is broken. This is commonly used to prevent unauthorized access to internal components. Refer to “Warranty” (p. 87) of the warranty section for more information.

Table 2-2. Label Descriptions- Laser Head (Continued)

Item	Label	Description
6		**China RoHS Label:** Standardized label which meets substance labeling requirements for China RoHS. States 20 year Environment-Friendly Use Period (EFUP) warning for Lead (Pb) shown in Table 2-1.
7		**Patent Label:** This label provides the website address for the current Coherent patents.

2.6 Sources of Additional Information

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

2.6.1 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

2.6.2 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

2.6.3 Equipment and Training

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

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

3 DESCRIPTION AND SPECIFICATIONS

3.1 System Description

The Matrix Laser System is offered in various models for the flexibility in application requirements.

The Matrix is a compact diode-pumped, solid-state, Q-switched laser that provides ultraviolet output with a wide range pulse repetition rates.

The complete laser system consists of a laser head and the Coherent Web User Interface (WUI) for user control. The user may purchase optional accessories for integration:

- Air-Cooling Assembly
- DC Power Supply
- Kinematic Mounting Plate

Figure 3-1. Matrix Laser System Laser Head with Optional Air-cooling Assembly and Kinematic Mounting Kit

3.1.1 Features of the Matrix Laser

Several features contribute to the Matrix Laser System's superior performance and reliability.

3.1.1.1 Pulse Control

Gated Trigger Mode delivers constant pulse energy across a wide range of rapidly varying pulse repetition rates. Refer to "Gated Trigger Mode" (p. 43) for more details.

PulseTrack Control Mode allows pulse energy adjustment of each individual pulse with constant or changing pulse repetition rates in External Trigger mode. Refer to "PulseTrack Control Mode" (p. 44) for more details.

3.1.1.2 Crystal Shifter

The third harmonic generation (THG) crystal function utilizes a motor-driven stage indexed to a series of predefined site positions. The THG crystal can be moved to any of the ten positions with a typical lifetime of 1500 hours per site. A crystal site can be used until the laser output performance no longer meets the application requirements or the site reaches the spot hour limit of 2000 hours. Refer to "Matrix Crystal Shifter Function" (p. 53) for details on the crystal shifter's operation.

3.1.1.3 CW Alignment Mode

When the RF-power to the Q-switch is disabled, the Matrix laser can emit a UV CW-beam, typically < 5mW. Refer to "Start-up in CW Mode" (p. 52) for more details.

3.2 Specifications

The general specification on an MATRIX are available at: https://www.coherent.com/lasers/nanosecond/matrix.

The Customer Test Data Sheet shipped with each Matrix laser provides a detailed description of system performance.

3.2.1 Environmental Specifications

The Matrix environmental specifications are provided in Table 3-1.

Table 3-1. Environmental Specifications

Parameter	Value
Temperature (Non-Condensing): Laser Head, operational (°C) Non-operation (storage) (°C)	 15 to 40 (59 to 104 °F) -20 to 60 (-4 to 140 °F)
Relative Humidity	5 to 80%
Altitude: Operational Non-Operational	 Up to 2000 m (6561 ft) Below 13716 m (45000 ft)

3.2.2 Power Supply Requirements

A power supply is not included, but may be purchased from Coherent. The laser system must be installed with a power supply that meets the general requirements listed in Table 3-2.

If a non-Coherent power supply is used, contact Coherent to determine if the power supply can be used with the laser system.

Table 3-2. General Power Supply Requirements

Parameter	Requirement
DC Output	
Electrical Power	48 VDC ± 5%
Electrical Power Consumption	< 400 W typical 500 W maximum
Noise	< 350 mV
Current	< 12 A
Electrical Safety Requirement	Safety Extra Low Voltage, SELV

3.3 Matrix and Assemblies Dimensions

The dimensions for the Matrix laser head are shown below.

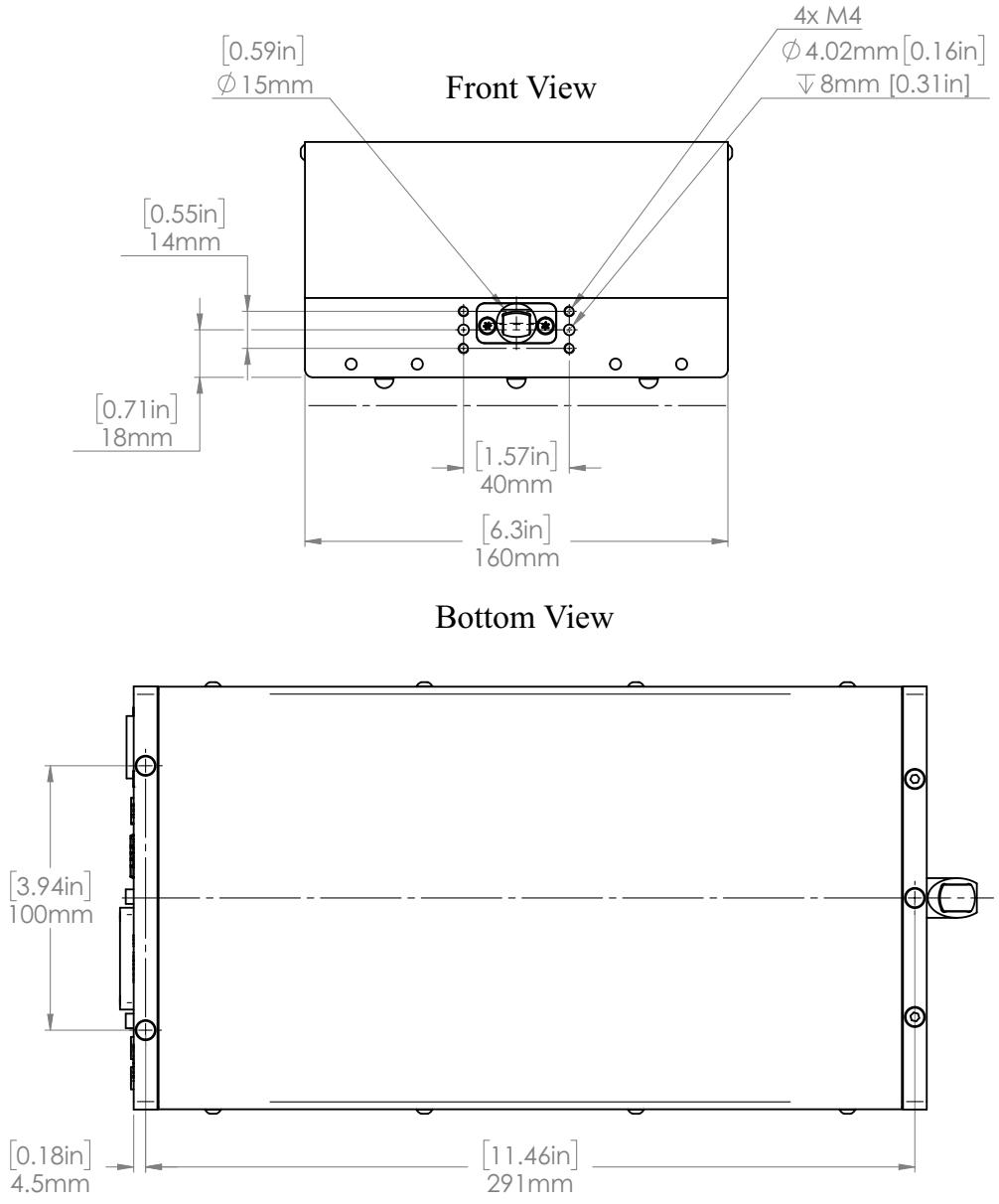


Figure 3-2. Matrix Laser Head Dimensions

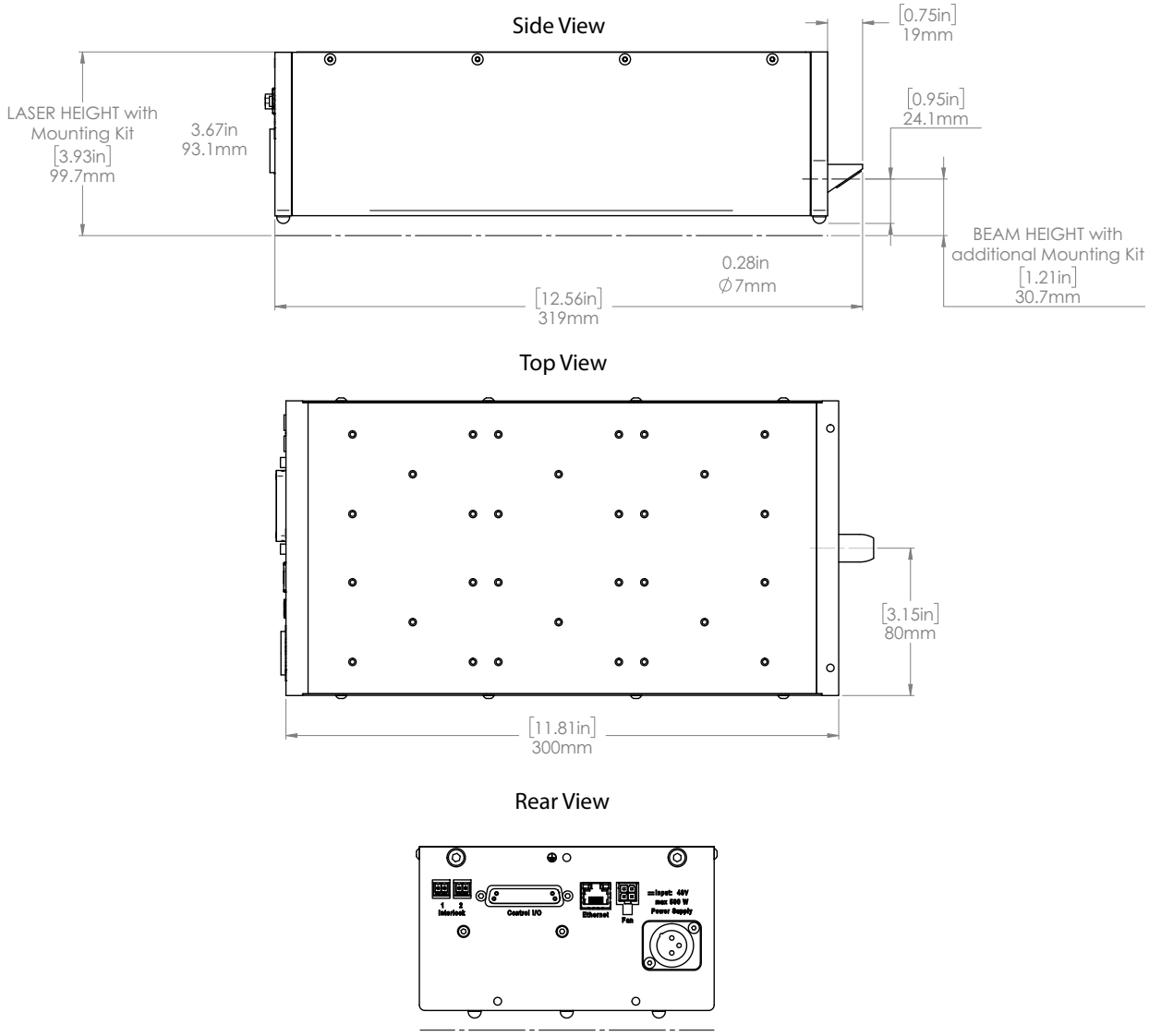


Figure 3-2. Matrix Laser Head Dimensions (Continued)

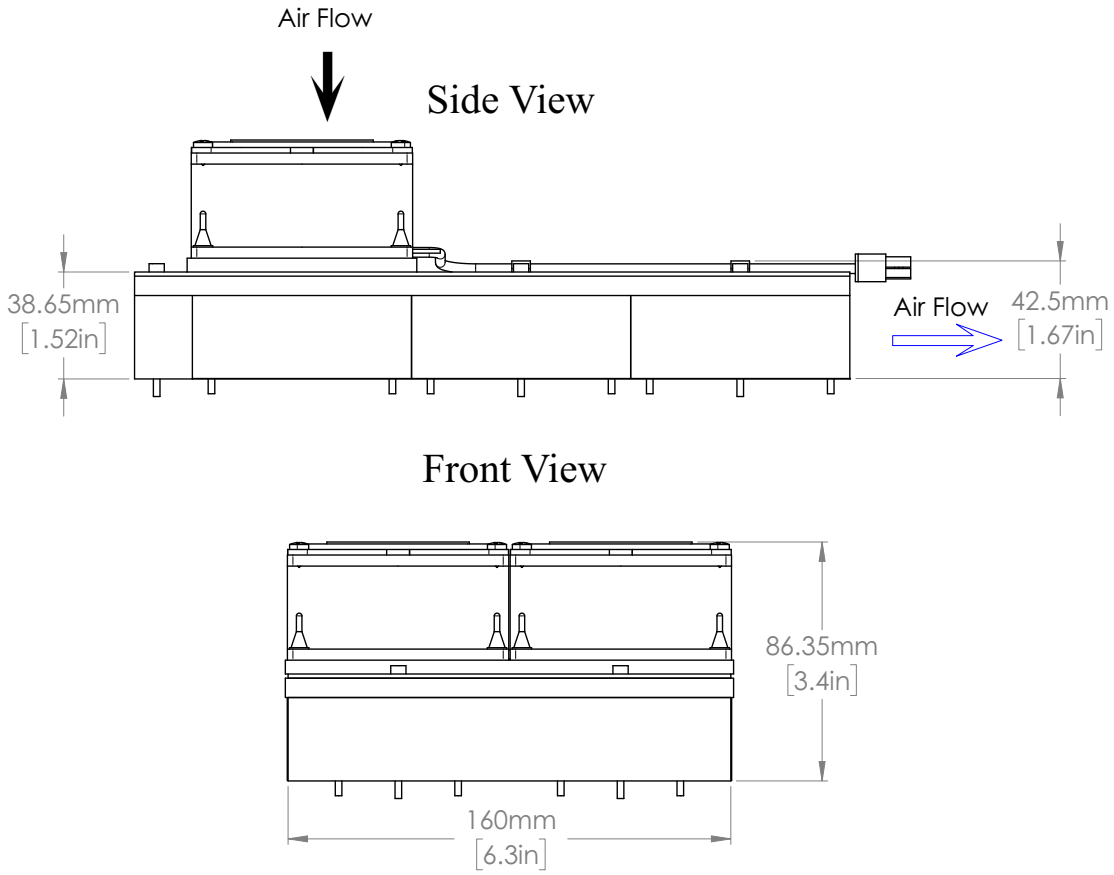


Figure 3-3. Matrix Fan Assembly

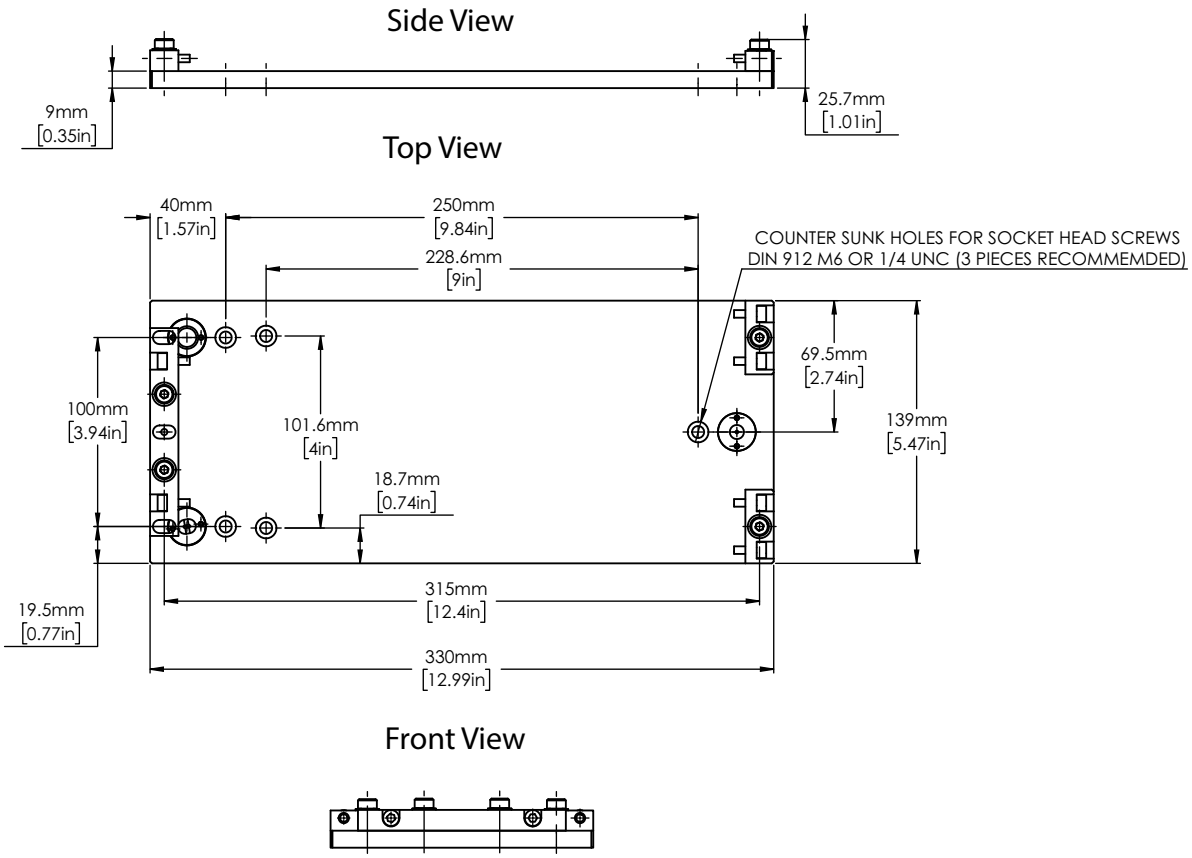


Figure 3-4. Kinematic Mounting Plate

4 Installation

4.1 Receiving and Inspection

When the product is received, examine the shock-watches (if any), shipping container, and contents for damage caused during shipment and complete contents. Record signs of damage on the bill of lading. If damage has occurred, immediately contact the shipping carrier and your local Coherent technical support center. Contact centers can be found at: www.coherent.com/support.

NOTICE

Keep the original shipping containers and packing materials. In the case of an event in which the laser must be returned, the laser system will need to be returned to Coherent in the original packaging.

To prevent condensation, let the laser system stabilize for 4 hours in the environment where it will be installed, before opening the shipping containers.

4.2 Installation

To keep the factory warranty, the installation procedure below must be followed before operating the laser.

Remove the laser head from its shipping crate, and check for any physical damages. Record any signs of damages by taking photos and report immediately.

For installation of optional equipment, see the relevant sections for the integration of the below optional parts.

- Air-Cooling Assembly, see Figure 3-3 (p. 29)
- DC Power Supply
- Kinematic Mounting Plate, see Figure 3-4 (p. 30)

4.2.1 Preparation for First Time Installation

Install the laser system on an appropriate optical surface. The Matrix laser head is recommended to be installed with the air-cooling assembly facing up and the laser head is sitting on the optional Matrix kinematic mounting plate for best performances.

Arrange the power supply and the laser head in their operating positions:

- In an accessible location
- Away from heat sources

4.2.1.1 Power Supply

If the power supply was supplied by the user, it must meet the requirements in "Power Supply Requirements" (p. 25). If the power supply was from Coherent, please follow the instructions below.

Note: There are two power points on the power supply connector (please see Figure 5-2 (p. 37)).

- **LD Supply:** This point controls the power supply to the laser diode. User may connect this point to the power supply linked to the emergency stop circuit of their tool, so that the power of the diode can be cut off upon activation of emergency stop. This will result as a fault to the laser.

- **Housekeeping:** This point controls the power supply of the electronics of the laser. User may connect this point to the power supply linked to the non-emergency circuit of their tool, so that the power may not be cut off upon activation of emergency stop. This will allow the user to retain communication to the laser upon de-activation of the emergency stop.

Alternatively, the user may connect both points to the power supply linked to the emergency stop circuit of their tool. This will result in the power to the laser being cut off completely upon activation of emergency stop.

NOTICE

***DO NOT* connect facility power before connecting 48 V laser head cable between the laser head and power supply. If the connections are not made in sequence, possible damage could occur to the laser system.**

NOTICE
The "AC power input" or "DC power output" of the power supply must have a device for separating any electrical energy source. These devices must disconnect all live conductors.

DANGER!
To prevent injury or damage, the laser output must be blocked or pointed at a specified target. All personnel in the area must wear laser safety eyewear.

4.2.1.2 Communication Setup

1. Connect a RS232 cable to the RS232 interface.
2. Connect the other end of the RS232 cable to a PC. **OR**
3. Connect an ethernet cable to the "ETHERNET" interface.
4. Connect the other end of the ethernet cable to a device with ethernet capabilities.
   NOTE: The WebUI of the Matrix laser system can only be accessed by ethernet connection.

CAUTION!
Position the computer so the operator is not exposed to hazardous laser radiation.

4.2.1.3 Finalize Installation

1. Remove the protective cap from the output window.
2. Proceed to "Operation" (p. 41) to operate the Matrix Laser System.

4.3 Connection Diagram

The diagram below shows the different types of connections necessary to control and operate the Matrix Laser System. See "Controls, Connectors and Functions" (p. 35) for locations and descriptions.

The user must supply the components below to operate the laser:

- Power Supply - available as an option
- Air-cooled fan module - available as an option
- Computer installed with a web browser and ethernet connector
- All relevant cables
- I/O control, External Interlock control, Sync Out and Trigger IN control devices

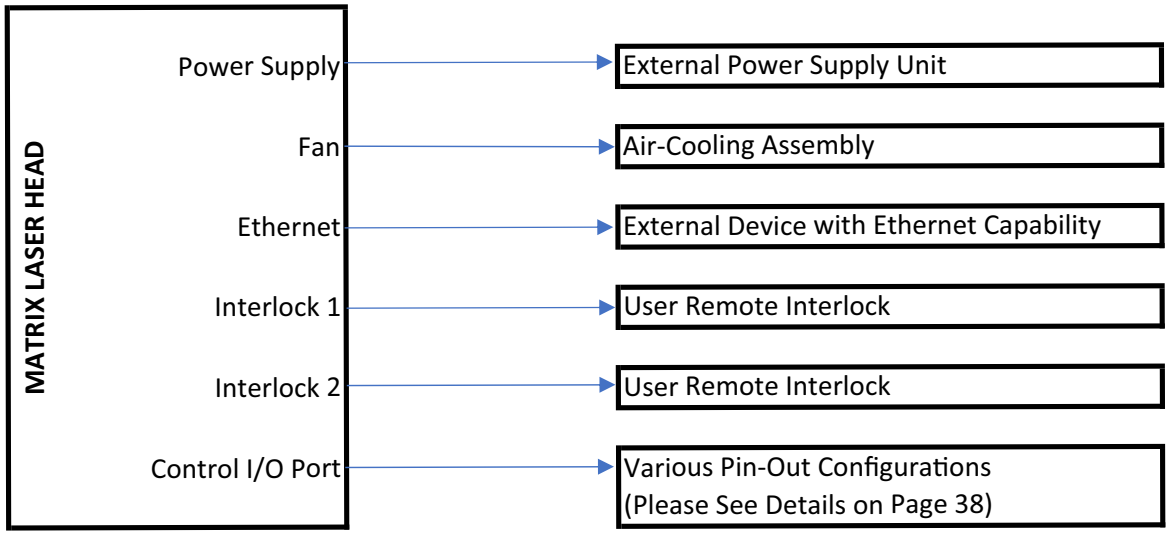
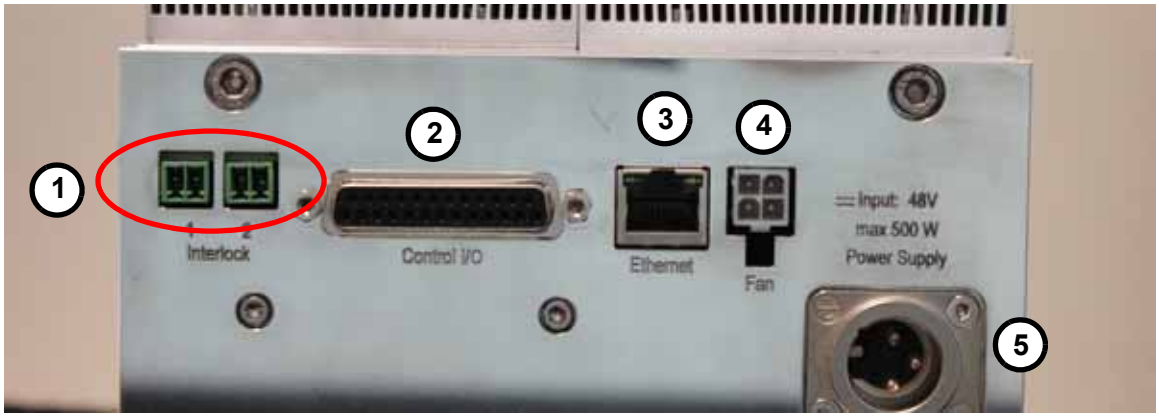


Figure 4-1. Connection Diagram

5 CONTROLS, CONNECTORS AND FUNCTIONS

5.1 Controls, Connectors and Functions

The information in this section gives a description of the controls, indicators, functions and connectors used on the Matrix Laser System.



1. Interlock 1 & 2

2. Control I/O (details at "External Interface Connector" (p. 38))

3. Ethernet connection

4. Fan module connection

5. Power supply connection at laser head

Figure 5-1. Connections Diagram

5.2 Matrix Connectors

There are electrical connectors on the back of the Matrix laser head to connect equipment. Figure 4-1 (p. 34) provides a general hardware setup for the connectors. Refer to the figure on p. 35 for the location of the connectors.

5.2.1 External Interlock 1 & 2 Connector

The external interlock connectors must be engaged to operate the Matrix laser head. The system will not operate with an interlock circuit open. If an interlock circuit is opened, the system defaults to the Standby state.

The external interlock connectors are supplied together with the laser. The customer can interlock the Matrix to doors or access panels for laser safety. Both interlock loops are established as 12 mA current loops and should bedesigned with less than 1 Ohm resistance, that must be closed to enable laser radiation. Do not connect the loops with each other.

5.2.2 Ethernet Connector

The Ethernet connector uses the industry standard receptacle for an RJ45 connector (also called an 8P8C connector). It can be connected to a switch, router, or PC using a Cat5 cable. A PC connection may require crossover cable wiring for older systems. Once the IP address of the laser is known, the WebUI for the Matrix can be established by opening the web browser using the IP address.

Laser behavior upon communication loss: The laser will not react to a lost communication connection but continue working as set.

WARNING!
If both RS232 and Ethernet are connected, the laser will accept commands from both sources. No exclusive control is implemented.

5.2.3 Power Supply Connector

The power supply connector provides 48V to the laser head. Connect this connector to the external power supply providing the power source for the laser head. The power supply must be connected with ground or protective earth via the power cord.

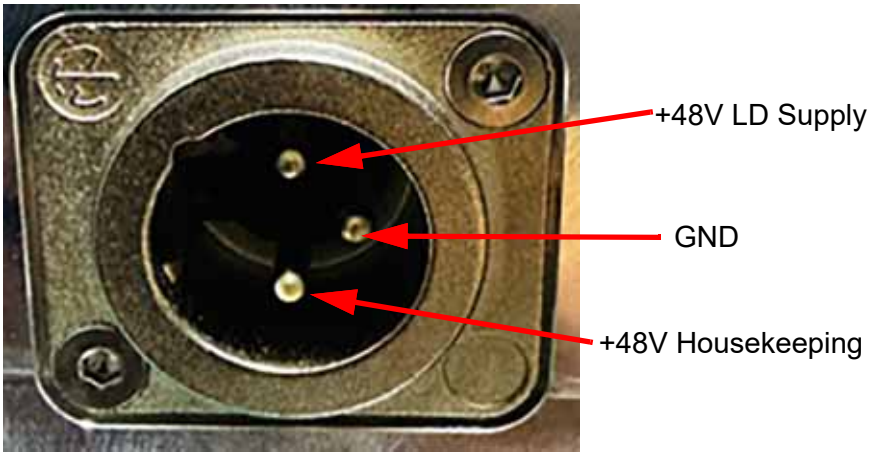


Figure 5-2. Power Supply Connector

Note: There are two power points on the power supply connector (please see Figure 5-2).

- **LD Supply**: This point controls the power supply to the laser diode. User may connect this point to the power supply linked to the emergency stop circuit of their tool, so that the power of the diode can be cut off upon activation of the emergency stop. This will result as a fault to the laser.
- **Housekeeping**: This point controls the power supply of the electronics of the laser. User may connect this point to the power supply linked to the non-emergency circuit of their tool, so that the power may not be cut off upon activation of the emergency stop. This will allow the user to reset the laser fault and turn the diode on upon de-activation of the emergency stop. Alternatively, the user may connect both points to the power supply linked to the emergency stop circuit of their tool. This will result in the power to the laser being cut off completely upon activation of the emergency stop.

Table 5-1. Power Supply Connector Type

Manufacturer	Order Number	Description	Qty
Neutrik	NC3FXX-14-D	XLR 3-pole power connector	1

5.2.4 External Interface Connector

The Control interface connector uses a 25-pin DSUB connector to provide an OEM customer interface.

Table 5-2 describes how each signal should be managed.

WARNING!
If both RS232 and Ethernet are connected, the laser will accept commands from both sources. No exclusive control is implemented.

Laser behavior upon communication loss: The laser will not react to a lost communication connection but continue working as set.

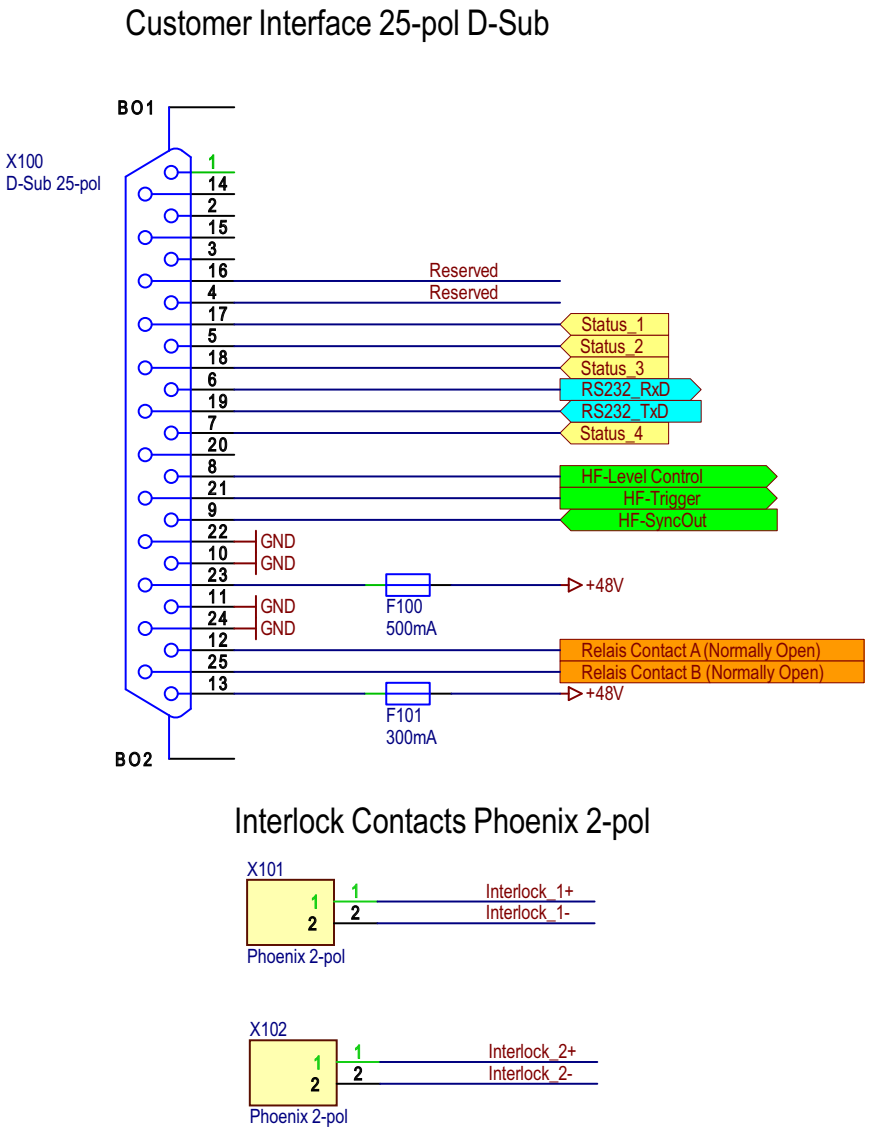


Figure 5-3. External Interface Connector

Table 5-2. Control D-sub 25-pin Connector Signal Descriptions

Pin	Signal Name	Description
1	–	Do not connect
2	–	Do not connect
3	–	Do not connect
4	–	Do not connect
5	Status 2	Laser Warm-Up Status Indicator (+3.3V TTL, active High)
6	RS232 RXD	RS232 Laser Receive -> Connect to PC RS232 Transmit
7	Status 4	Laser Emission Status Indicator (+3.3V TTL, active High)
8	APEC Control	Enables User to control APEC by applying 0-3.3V in APEC pulsing mode (100 Ohm Input Series Resistor)
9	Sync-Out	Output Signal synchronisation (+3.3V TTL). Falling Edge of the Signal indicates Laser Pulse (to be enabled later)
10	GND	Ground
11	GND	Ground
12	Relay Contact A	Relay Contact A. Relay contact between Terminal A and B is closed, when Laser is emitting
13	+48V Output	+48V Output (300mA Max Current)
14	–	Do not connect
15	–	Do not connect
16	–	Do not connect
17	Status 1	Laser Error Status Indicator (+3.3V TTL, active High)
18	Status 3	Laser Standby Status Indicator (+3.3V TTL, active High)
19	RS232 TXD	RS232 Laser Transmit -> Connect to PC RS232 Receive
20	–	Do not connect
21	Trigger	Trigger Input (+3.3V TTL, active High) with 100 Ohm Input Series Resistor
22	GND	Ground
23	+48V Output	+48V Output (500mA Max Current)
24	GND	Ground
25	Relay Contact B	Relay Contact B. Relay contact between Terminal A and B is closed, when Laser is emitting

5.2.5 Fan Module Connector

The fan module connector provides power to the optional air-cooling assembly of the Matrix. It will provide the necessary power to the fans via the PWM signals as programmed by the Matrix to regulate the temperature of the Matrix laser head.

WARNING!
This connector should only be used with the optional air-cooling assembly (Coherent part number 2302876). Attaching other equipment might result in unexpected behavior and insufficient cooling.

The detail of the pin out is shown in diagram below.

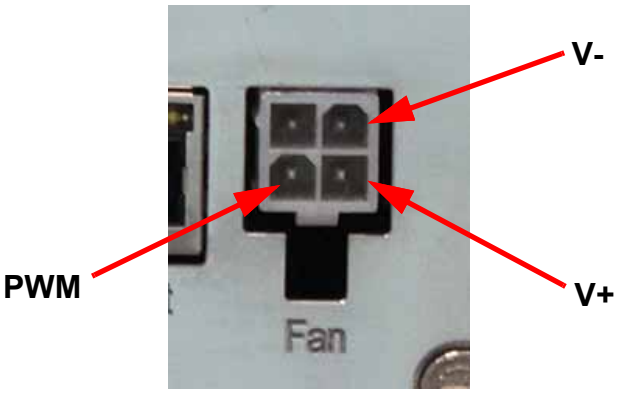


Figure 5-4. Fan Module Pin Out

5.2.6 Other Cooling Options

For other cooling options, the temperature behavior of the laser system below needs to be referenced:

- Housing temperature: 50°C
- Protection limits:
  - +/- 2°C: normal deviation
  - +/- 5°C: first protection interval will give a warning, with a time interval to get back into the normal range
  - below 3°C and above 60°C the laser will go into an error state and the temperature must be corrected by the user
  - humidity (non-condensing) conditions must be observed

6 Operation

CAUTION!
If the laser is in an operating mode (i.e. diode is ON) in which the Q-Switch is blocked and no laser radiation is emitted, a laser-safe operation is not guaranteed. As a result of faulty functions, e.g. in the software or if a signal cable is disconnected during operation, an unexpected laser emission may occur. In an operational state, personal laser safety equipment must be used, and protective precautions for the work environment must also be followed.

NOTICE
Read the entire manual before operation. Incorrect operation can cause damage to the Matrix Laser System.

NOTICE
The Matrix Laser System is designed for system implementation. The laser should only be operated by trained personnel.

DANGER!
To prevent injury or damage, the laser output must be blocked or pointed at a specified target. All personnel in the area must be wearing laser safety eyewear.

DANGER!
To prevent injury or damage, never move the laser head while the laser diodes are ON or the power supply is enabled.

This laser device does not comply with

**US FDA CFR 21 requirements for certified laser products,
US FDA CFR 21, section 1040.10 and 1040.11,
IEC 60825-1:2014.**

The laser can only be used as an OEM component of a certified laser product.

6.1 Introduction

Before operating the laser system, it is recommended to review "Controls, Connectors and Functions" (p. 35) to identify all necessary connections and functions necessary for operation.

Instructions for first time start-up of the Matrix Laser System is on p. 45 System shutdown is on p. 54. Read and understand the procedures before operating the laser system.

The Matrix has different configurations of pulse and trigger modes. The information in this section provides instructions on the configurations and operation available in for the Matrix Laser Systems.

The table below shows the available configurations on the Matrix.

Table 6-1. Matrix Configurations

Pulse Control	External Trigger	Pulsing Parameters	Details on Page
Internal Continuous	Not Required	Internal Rep Rate	p. 43
Gated	Required	Internal Rep Rate Triggered by Gate Signal	p. 43
PulseTrack	Required	External Trigger with Adjustable Pulse Width	p. 44
CW	Not Required	Not Applicable	p. 44

6.2 Matrix Pulse Control Modes

There are four pulsing control options available for operating the Matrix Laser System: Internal Continuous Mode, Gated Trigger Mode, and PulseTrack Control Mode. There is also a CW Mode for alignment purposes.

6.2.1 Internal Continuous Mode

The Matrix laser can be operated at a steady pulse repetition rate (PRF) for the given model. The current internal repetition rate can be queried by the SCPI command:
SOURce:PULSe:CONFiguration:REPRate?
and it can be specified through the SCPI command:
SOURce:PULSe:CONFiguration:REPRate nnnnn (nnnnn=rep rate in Hz)

In Internal Continuous Mode both the pulse trigger and gate (enable) signals are supplied internally with a pulse repetition rate for the given model. The External Enable function, which accepts a gate signal, is disabled. The external pulse control options have no effect on laser operation when the laser is in Internal Continuous Mode.

6.2.2 Gated Trigger Mode

In Gated Trigger Mode, the pulse trigger signal is supplied internally, and the gate (enable) signal is supplied externally through the HF Trigger input lines on the External Interface connector (see Table 5-6, “Control D-sub 15-pin Connector Signal Descriptions,” on page 47).

The external gate signal should have a gate width greater than the period of the internal pulse trigger to properly gate Table 5-6, “Control D-sub 15-pin Connector Signal Descriptions,” on page 47internally-triggered laser pulses. To keep the gate pulsing on, drive the HF Trigger lines on the External Interface connector to high.

The laser output pulse repetition rate can be gated from the external gate signal, where the internal generated pulse rate can be specified through the SCPI command
SOURce:PULSe:CONFiguration:REPRate nnnnn (nnnnn=rep rate in Hz).

6.2.3 PulseTrack Control Mode

PulseTrack allows pulse energy adjustment of each individual pulse in External Trigger Mode by adjusting the width of the trigger input signal (Pin 21 of the Control I/O interface, see Table 5-2 (p. 39)). The high-level width of the trigger pulse (Tw) determines the laser pulse energy independent of repetition rate. The greater the pulse width, the higher the pulse energy up to a maximum value determined by an internal time constant (Tmax). Where Tmax is defined as Tmax= (1/f)-300 ns.

The falling edge of the input signal triggers the release of a laser pulse. In normal operation for trigger width Tw < Tmax, the falling edge of the input signal will trigger the release of a laser pulse within approximately 2 µs. If the trigger width Tw > Tmax, the laser pulse is released at approximately Tmax+ 2 µs following the rising edge of the trigger pulse.

PulseTrack provides the greatest flexibility for controlling timing and laser output pulse energy but requires accurate and sophisticated control of the width and edges of the trigger signal. The PulseTrack control range of operation is limited to the minimum and maximum allowed RF Off/On Time, which varies with repetition rate.

Depending on the desired process pulse repetition rate, the maximum trigger signal rectangular pulse width is limited as shown below:

Table 6-2. Maximum Trigger Signal Pulse Width

Rep Rate/ kHz	Duty Cycle %	T_w / µs
50	≤ 98	≤ 19.6
100	≤ 95	≤ 9.5
200	≤ 90	≤ 4.5
300	≤ 80	≤ 2.66

6.2.4 CW Alignment Mode

This mode is for alignment purposes and is not for any operations.

6.3 Current Settings

The current value is designated as a percentage (%) of the diode current in each laser system, each system is normalized to achieve the specified output power at 100% of current. You can check the diode current by specifying the following SCPI commands:
SOURce:CURRent:LEVel? (in amperes)
SOURce:CURRent:LEVel? LD_DRIVER (in amperes)
CONFiguration:DIODe:CURRent:SET? LD_DRIVER (in percentage)

6.4 Start-Up in Internal Continuous Mode

This section is intended to illustrate the essential steps for successful initial operation of the laser system in internal continuous mode.

6.4.1 First Time or Cold Start-Up Procedure in Internal Continuous Mode

This start-up procedure must be used for first time start-up or after the power has been shut off. For first time start-up, it is recommended to run the laser in internal continuous mode as described below.

From cold start or after performing a “Complete System Shutdown” (see p. 54), the warm up time will take at least 20 minutes while the crystal temperatures stabilize to their set values and may take up to 45 minutes for the laser system to reach equilibrium.

1. Turn ON the power supply to the Matrix laser head.
2. Wait a minimum 20 minutes for the temperature servos to reach operating temperature.
3. Turn ON the PC connected to the Matrix laser head via the RS-232 cable and open the dedicated terminal program used to control the Matrix Laser System.
4. Follow the “Warm Start-Up Procedure” below to start the laser.

6.4.2 Warm Start-Up Procedure

For normal operation of the Matrix laser, Coherent recommends using the Warm Start-up procedure to turn on the laser. After a Warm Shutdown, the Warm Start-up is performed when the power is switched ON and all

crystal temperatures are locked and stable. Use the serial commands in "Serial Commands Warm Start-Up" or the WebUI interface for the warm start-up process.

6.4.3 Serial Commands Warm Start-Up

For Warm Start-up of the Matrix Laser System, enter the following SCPI commands in the order listed.

1. Set up the following parameters:

- **SOURce:PULSe:MODe CONTinuous** to set the pulse control mode to Internal Continuous

- **SOURce:PULSe:CONFiguration:REPRate 50000** to set the repetition rate to 50KHz

2. Enable laser emission using the following command:
   SOURce:AM:STATe ON
3. Wait at least 5 minutes for the laser to stabilize.
4. Confirm that laser meets power specifications by querying following command: **SERVice:DETector:POWer:SCALed?**

6.4.4 Internal Continuous Mode Pulsing Diagram

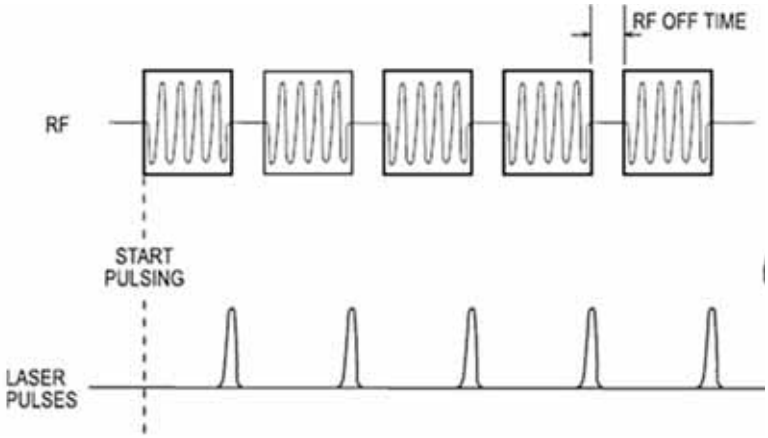


Figure 6-1. Internal Continuous Mode Pulsing Diagram

Overview	The output of pulses is continuous at the selected repetition rate.
Gate / Trigger	For Internal Trigger mode, the Trigger In input does not need to be connected. Gated or external trigger operation is not possible.

6.5 Start-up in External Gated Trigger Mode

It is recommend to start the laser in Internal Continuous mode for first time start-up.

1. Follow the cold start up procedures if needed.
2. Follow the warm start up procedures to start the laser.
3. Enter the following SCPI commands in the order listed.
4. Set up the following parameters:

- **SOURce:PULSe:MODe GATed** to set the pulse control mode to gated Trigger Mode
- **SOURce:PULSe:CONFiguration:REPRate nnnnn** (nnnnn in Hz) to set the repetition rate to the preferred frequency.

5. Enable laser emission by the following command:
   SOURce:AM:STATe ON
6. Wait at least 5 minutes for the laser to stabilize.
7. Start modulating the pulse emission via the external signal.

Refer to "Controls, Connectors and Functions" (p. 35) for trigger connection options

6.5.1 Gated Trigger Mode Pulsing Diagram

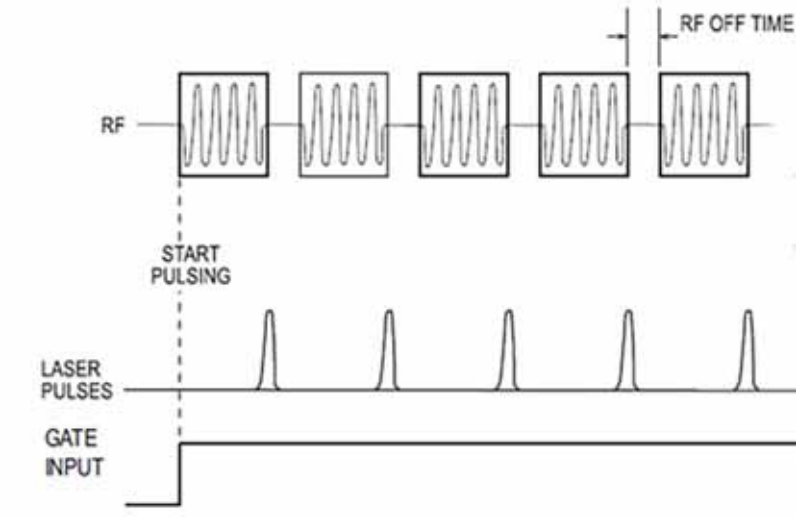


Figure 6-2. Gated Trigger Mode Pulsing Diagram

Overview	The output of pulses is continuous at the selected repetition rate during the external gate signal phase/duration.
Gate / Trigger	A gate signal will provide accurate timing of the pulse start and stop times. For Gated Trigger mode, an external trigger signal is required. Active high-signal is the default setting for now. Before executing the command, make sure that the existing external signal will not lead to immediate laser pulsing

6.6 Start-up in PulseTrack Control Mode

It is recommend to start the laser in Internal Continuous mode for first time start-up.

1. Follow the cold start up procedures if needed.
2. Follow the warm start up procedures to start the laser.
3. Enter the following SCPI commands in the order listed.
4. Set up the following parameters:

- **SOURce:PULSe:MODe PULSetrack** to set the pulse control mode to pulsetrack control

5. Enable laser emission by the following command:
   SOURce:AM:STATe ON
6. Wait at least 5 minutes for the laser to stabilize.
7. Start modulating the pulse emission via the external signal.

Refer to "Controls, Connectors and Functions" (p. 35) for trigger connection options

6.6.1 Pulse Track Control Mode Pulsing Diagram

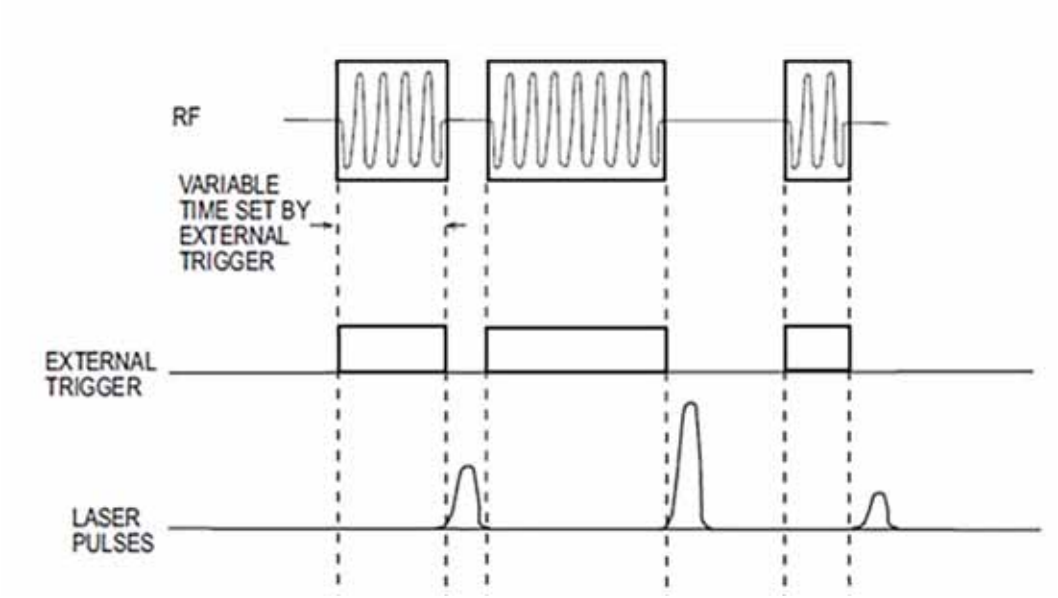


Figure 6-3. Pulse Track Control Mode Pulsing Diagram

Overview	The energy per pulse is controlled by the length of the trigger signal. This produces a single pulse for each input of an external trigger pulse.
Gate / Trigger	PulseTrack requires an external trigger with a variable time square wave signal.

6.7 Start-up in CW Mode

It is recommend to start the laser in Internal Continuous mode for first time start-up.

1. Follow the cold start up procedures if needed.
2. Follow the warm start up procedures to start the laser.
3. Enter the following SCPI commands in the order listed.
4. Set up the following parameters:

- **SOURce:PULSe:MODe CW** to set the pulse control mode to CW mode

5. Enable laser emission by the following command:
   SOURce:AM:STATe ON
6. Wait at least 5 minutes for the laser to stabilize.

This mode is for alignment purposes and is not for any operations.

Overview	In this mode the laser emits a continuous wave (CW) at very low levels. Turning off the laser diodes will stop CW operation.
Gate / Trigger	The status of the external Gate/Trigger is not relevant to CW operation.

6.8 Matrix Crystal Shifter Function

The THG crystal is a component that degrades over time, the Matrix has a crystal shifter to maintain beam parameters and power over the lifetime. When the spot reaches its end of life, the crystal shifter lets the operator move from one spot on the THG crystal to the next spot. There are 10 good spots on a new laser.

Each spot has a recommended lifetime of 1500 usage hours. Usage hour is defined as when the diode is ON and the laser is pulsing. When the laser is in standby mode, the usage hour is not calculated.

The operation sequence for the THG shifter is as follows:

- Start operating on a good spot (new or used).
- After 90% of the spot lifetime the laser will indicate the First Spot Warning flag. The laser will continue to operate on this spot.
- After 100% of the spot lifetime the laser will indicate the Second Spot Warning Flag. The laser will continue to operate on this spot.
  Coherent recommends changing to the next spot at this time.
  Each spot can be used to an additional maximum of 500 UV hours at the user's risk. After the spot has reached the maximum UV hours the laser will stop operation and cannot be restarted until a good spot is selected.

Use the SCPI terminal command:
SOURce:STEPper:SPOT:MOVe
to move the THG crystal to the next spot. The laser must be in stand-by to move the crystal.

Note: The shifter will shift back to the first good spot available after the shifter has shifted to the end of the crystal spots.

It is recommended to use the crystal spots in sequence, starting from the first spot.

6.9 Shutdown

Warm Shutdown and Complete Shutdown of the Matrix Laser System are described in the following sections.

6.9.1 Warm Shutdown

During frequent operation, the Matrix Laser System can be put into Ready mode through the serial commands. Standby mode reduces the time necessary for the system to warm up during the start-up procedure. Perform the following SCPI commands for the laser to be in standby mode:

- **SOURce:AM:STATe OFF** to stop the internal pulsing.
- The power supply should remain ON.

6.9.2 Complete System Shutdown

"Complete System Shutdown" is recommended when performing system maintenance or repair. To perform the "Complete System Shutdown", please follow the steps below:

1. Make sure "Warm Shutdown" is completed.
2. Disconnect facility power by disconnecting the facility power from the power supply.
3. Disconnect the 48 V laser head cable from the laser head and or power supply, if needed.

NOTICE

DO NOT disconnect 48 V laser head cable before facility power has been removed from the power supply. If the facility power and head cable are not disconnected in sequence, possible damage could occur to the laser system.

NOTICE

To start the system after a complete shut down, use the "Start-Up in Internal Continuous Mode". Do not start in "Gated Trigger Mode" or "PulseTrack Control Mode".

7 External Laser Control

7.1 Instruction Syntax

To operate and control the Matrix laser a computer must be connected to the laser head using RS-232 from the PC to the 25-pin DSUB connection or ethernet connection on the laser head. Please refer to the “External Interface Connector” (p. 38) for details of the connection.

Commands and queries are sent via a terminal program or the WebUI.

7.1.1 Syntax

The Matrix uses the SCPI command set to control the laser functions and parameters. The command syntax is based on root word separated by a colon followed with keywords.

Example:

SOURce	**:**	**AM**	**:**	**STATe**		**SET**
Rootword	Colon	Keyword	Colon	Keyword	Space	Setting

Below are examples of frequently used root and keyword terms for the Matrix Laser System. The complete command set is given in section 7.4.

SOURce:AM:STATe OFF

SOURce:PULSe:MODe PULSetrack

NOTICE

The short form of commands using the letters in capitals can be used. For example: SOUR:PULS:MOD PULS

Any instruction to the laser consists of a string of ASCII characters and is terminated by a carriage return and line feed <CR LF>. A space must be present between the command and the numeric value for the command to be valid. Commands can be entered in upper or lower case.

Example Commands:

SOURce:PULSe:MODe GATed <CR LF>

SOURce:PULSe:CONFiguration:REPRate 50000 <CR LF>

To query the settings, type in the query command and press ENTER. See Syntax for command / query structure.

Example Queries:

SOURce:AM:STATe? <CR LF>
SOUR:AM:STAT? <CR LF> (short form)
SOURce:CURRent:LEVel? LD_DRIVER <CR LF>

NOTICE
An accepted command will be responded to with 'OK"; otherwise the reply will be 'ERR'..

7.2 RS-232 Connection

The RS-232 interface does not support either hardware or software flow control. Any instruction to the laser consists of a command or query written as a string of ASCII characters and terminated by a carriage return (<CR>) and linefeed (<LF>). For proper handshaking, communication programs should wait until <CR><LF> has been returned from the laser before sending the next instruction.

Although RS-232 is a common industry standard, it is an unbalanced connection that is more susceptible to noise and is not robust in a factory environment. When using RS-232, the following are required to maintain good signal integrity:

- Use only shielded cables. The shield must be connected between the two ends of the cable.
- Keep cable length to 15 meters or less. The shorter it is, the better.
- Make sure the equipment at both ends of the cable is very well grounded.

Because the RS-232 connection is unbalanced, a small voltage difference between equipment can be interpreted as a different value at the receiver. Avoid running the cable in a way that magnetic coupling can occur with other equipment..

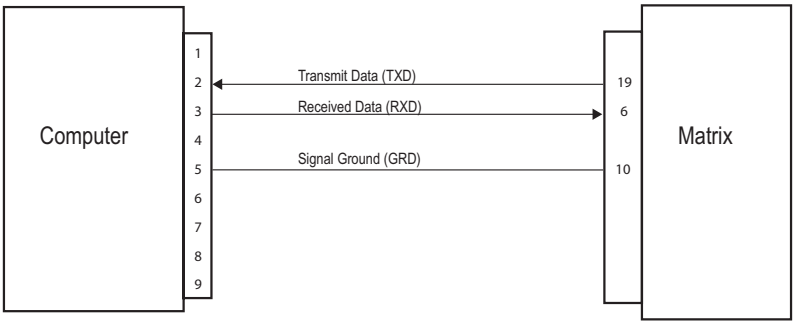


Figure 7-1. RS-232 Pin Configuration

Table 7-1. RS232 Port Descriptions

Configuration	DCE, No Handshaking
Data Bits	8
Stop Bits	1
Parity	None
Baud Rate	115200 (fixed setting)
Flow Control	None

7.3 Commands and Queries

Table 7-2 "Commands and Queries" describes the language used to communicate with the Matrix Laser System Systems.

Table 7-2. Commands and Queries (Sheet 1 of 6)

Commands & Queries	Instance	Parameter	Access Level	Description (Unit)
General Category				
?ALL			USER	See Description in Table 7-3 (p. 64)
*IDN?			USER	Query Laser Identification.
*RST			USER	Reset Laser
SCPI?			USER	Query all SCPI Commands possible in actual Access Level
V?			USER	Query the Firmware Version
BV?			USER	Query the Bootloader Firmware Version.
T?			USER	Query Firmware Type Identifier
LIBRary?			USER	Query used cohrembm library version
CALibration:PASSword			USER	Set Password in order to obtain a higher Access Level USER -> Normal User ENHANCED USER -> User with more privileges
SYSTem:HOURmeter:LIST?			USER	Query List of all available Hourmeters
SYSTem:HOURmeter:GET?	OPERATION 2F_3F HOUSING LASERDIODE	FULL	USER	Query specific Hourmeter count No Parameter -> Resetable Counter Value FULL -> Non Resetable Counter Value (hour:min:sec)
SYSTem:INFormation:IDENtification?			USER	Query the silicon Serial Number

Table 7-2. Commands and Queries (Sheet 2 of 6)

Commands & Queries	Instance	Parameter	Access Level	Description (Unit)
SYSTem:INFormation:ID?			USER	Query the silicon Serial Number
SYSTem:INFormation:FIRMware?			USER	Query the Firmware Version.
SYSTem:STATe?			USER	Query actual System State Startup -> System initializing Warmup -> Temperature Stages active, Set-Temperatures not reached yet Standby -> Temperatures ready, waiting for enabling emission Rampup -> Laser enabled (LD, HF), LD Current is ramping up Emission -> Laser enabled, LD Current ready, Pulsing enabled Rampdown -> Laser still enabled , Current is ramping down, Pulsing and HF are disabled Error -> Laser in Fault State; LD, HF, Pulsing and Temperature Stages will be disabled
SOURce:AM:STATe?			USER	Query Laser Emission Enable/Disable State
SOURce:AM:STATe		ON OFF	USER	Set Laser Emission Enable/Disable.
SYSTem:INFormation:COMPonent:LIST?			USER	Query a List of all available Components.
SYSTem:INFormation:SERialnumber?	SYSTEM CONTROLLER HF-DRIVER		USER	Query the Serial Number of the specific Component.
SYSTem:INFormation:PARTnumber?	SYSTEM CONTROLLER HF-DRIVER		USER	Query the Part Number of the specific Component
SYSTem:INFormation:MANufacturing:DATe?	SYSTEM CONTROLLER HF-DRIVER		USER	Query the Manufacturing Date of the specific Component
SYSTem:INFormation:CALibration:DATe?	SYSTEM CONTROLLER HF-DRIVER		USER	Query the Calibration Date of the specific Component
SYSTem:FLAGs:STATus?			USER	32-bit hex Value, see Status Codes

Table 7-2. Commands and Queries (Sheet 3 of 6)

Commands & Queries	Instance	Parameter	Access Level	Description (Unit)
SYSTem:FLAGs:STATus:DETails?			USER	Text form of actual Status
SYSTem:FLAGs:WARNings?			USER	32-bit hex Value, see Warning Codes
SYSTem:FLAGs:WARNings:DETails?			USER	Text form of actual Warnings
SYSTem:FLAGs:FAULts?			USER	32-bit hex Value, see Fault Codes
SYSTem:FLAGs:FAULts:DETails?			USER	Text form of actual Faults
SYSTem:HARDware:REVision?			USER	Query Controller Hardware Revision
Temperature Category				
SOURce:TEMPerature:APRobe?			USER	Query if Temperature Module is enabled/disabled
CONFiguration:TEMPerature:SAVe?			ENHANCED USER	Query whether new entries of temperature configuration parameters are saved automatically or not.
CONFiguration:TEMPerature:SAVe		MANUAL AUTOMATIC	ENHANCED USER	AUTOMATIC -> New Inputs of Parameters will be save automatically MANUAL -> New Inputs of Parameters will not be saved, but executed. After Reboot, last saved Parameter Settings will be utilized.
SOURce:TEMPerature:LEVel:SET?	TEMP_STAGE_SHG TEMP_STAGE_THG		USER	Qyery the Set-Temperature of the specific instance (°C)
SOURce:TEMPerature:LEVel:SET	TEMP_STAGE_SHG TEMP_STAGE_THG	<float>	ENHANCED USER	Set the Set-Temperature of the specific instance (°C)
CONFiguration:TEMPerature:LIMit:HIGH?	TEMP_STAGE_SHG TEMP_STAGE_THG		ENHANCED USER	Query the upper Set-Temperature Limit of the specific instance (°C)

Table 7-2. Commands and Queries (Sheet 4 of 6)

Commands & Queries	Instance	Parameter	Access Level	Description (Unit)
CONFiguration:TEMPerature:LIMit:LOW?	TEMP_STAGE_SHG TEMP_STAGE_THG		ENHANCED USER	Query the lower Set-Temperature Limit of the specific instance (°C)
Package Conditioning Category				
CONFiguration:PACKage:COOLing?			USER	Query the actual Package Cooling Option. Changes will become valid after restart.
CONFiguration:PACKage:COOLing		AIR WATER	USER	Set the actual Package Cooling Option. Changes will become valid after restart
Fan Category				
CONFiguration:FAN:ENABle?			USER	Query if the Fan is enabled/disabled
Laser Diode Category				
SOURce:CURRent:LEVel?	LD_DRIVER		USER	Query the actual Current of the specific instance (A)
SOURce:AM:INTerlock?			USER	Query if Interlock is OPEN or CLOSED
Q-Switch Category				
SOURce:PULSe:MODe?			USER	Query the actual Pulse Mode
SOURce:PULSe:MODe		CONTinuous GATed PULSetrack CW	USER	Set the actual Pulse Mode
SOURce:PULSe:CONFiguration:REPRate?			USER	Query the actual Repetition Rate (Hz)
SOURce:PULSe:CONFiguration:REPRate			USER	Set the actual Repetition Rate (Hz)
Detector Category				
SERVice:DETector:POWer:SCALed?			USER	Query the measured Power (Measured Voltage x Scaling Factor (W)

Table 7-2. Commands and Queries (Sheet 5 of 6)

Commands & Queries	Instance	Parameter	Access Level	Description (Unit)
Stepper Category				
SOURce:STEPper:SPOT:LIST?			USER	Query all available Spots (All unlocked Spots)
SOURce:STEPper:SPOT:GET?			USER	Get the actual Spot
SOURce:STEPper:SPOT:MOVe			USER	Move forward to the next available Spot
SOURce:STEPper:SPOT:HOURmeter:GET?	SPOT_0 … SPOT_15	- FULL	USER	Query hour meter of Spot instance No Parameter -> Resettable Counter FULL -> Not Resettable Counter (hour:min:sec)
SOURce:STEPper:SPOT:HOUR-meter:GET:RAW?	SPOT_0 … SPOT_15	- FULL	USER	Query raw hour meter of Spot instance No Parameter -> Resettable Counter FULL -> Not Resettable Counter (sec)
SOURce:STEPper:SPOT:HOUR-meter:ACTual?		- FULL	USER	Query the hour meter of actual Spot No Parameter -> Resettable Counter FULL -> Not Resettable Counter (hour:min:sec)
SOURce:STEPper:SPOT:HOUR-meter:REMain?		SPOT CRYStal	USER	Query the remaining Lifetime of actual Spot or Crystal (hour:min:sec)
SOURce:STEPper:SPOT:FLAGs:STATus?			USER	Query the actual Spot Status Flags
SOURce:STEPper:SPOT:FLAGs:WARNings?			USER	Query the actual Spot Warning Flags
SOURce:STEPper:SPOT:FLAGs:FAULTs?			USER	Query the actual Spot Fault Flags
CALibra-tion:STEPper:SPOT:WARNing:TRIGger:FIRst?			USER	Query the Spot first Warning Trigger (in % of Spot Lifetime)
CALibra-tion:STEPper:SPOT:WARNing:TRIGger:FIRst		<uint32>	USER	Set the Spot first Warning Trigger (in % of Spot Lifetime)

Table 7-2. Commands and Queries (Sheet 6 of 6)

Commands & Queries	Instance	Parameter	Access Level	Description (Unit)
Syslog Category				
SERVice:SYSLog:MORe?			ENHANCED USER	Query the next message from the internal volatile buffer
SERVice:SYSLog:MASK?			ENHANCED USER	Query the syslog severity mask for direct output 0 -> EMERG: System is unusable 1 -> ALERT: Action must be taken immediately 2 -> CRIT: Critical Condition 3 -> ERR: Error Condition 4 -> WARNING: Warning Condition 5 -> NOTICE: Normal, but significant Condition 6 -> INFO: System Info 7 -> DEBUG: Debug Messages 255 -> ALL: All Messages
SERVice:SYSLog:MASK		<uint8>	ENHANCED USER	Set the syslog severity mask for output filtering 0 -> EMERG: System is unusable 1 -> ALERT: Action must be taken immediately 2 -> CRIT: Critical Condition 3 -> ERR: Error Condition 4 -> WARNING: Warning Condition 5 -> NOTICE: Normal, but significant Condition 6 -> INFO: System Info 7 -> DEBUG: Debug Messages 255 -> ALL: All Messages

Table 7-3. SCPI Command ALL?

Returning Parameter Sequence	Returning Parameter Name	Equivalent SCPI Command
1	Status	SYSTem:FLAGs:STATus?
2	Warnings	SYSTem:FLAGs:WARNings?
3	Faults	SYSTem:FLAGs:FAULts?
4	Actual Housing Temperature	SOURce:TEMPerature:ACTual? TEMP_MONITOR_HOUSING
5	Actual Laserdiode Temperature	SOURce:TEMPerature:ACTual? TEMP_MONITOR_LD
6	Actual SHG Temperature	SOURce:TEMPerature:ACTual? TEMP_STAGE_SHG
7	Actual THG Temperature	SOURce:TEMPerature:ACTual? TEMP_STAGE_THG
8	Operation Hours	SYSTem:HOURmeter:GET? OPERATION
9	Laserdiode Hours	SYSTem:HOURmeter:GET? LASERDIODE
10	THG Crystal Hours	SOURce:STEPper:SPOT:HOURmeter:CRYStal?
11	Acutal THG Spot Hours	SOURce:STEPper:SPOT:HOURmeter:ACTual?
12	Actual THG Spot Number	SOURce:STEPper:SPOT:GET?
13	Actual THG Spot Status	SOURce:STEPper:SPOT:FLAGs:STATus?
14	Sealed UV-Power	SERVice:DETector:POWer:SCALed?

8 Troubleshooting

8.1 Status Codes

Use a terminal program to check for the current status by entering the SCPI command: **SYSTem:FLAGs:STATus?**. The laser system will return a 32-bit hex value.

Alternatively, use a terminal program to check for current status by entering the SCPI command: **SYSTem:FLAGs:STATus:DETails?**. The laser system will return the current status in text form.

Table 8-1. Controller Status Register

Bit	Mask	Label	Description
0	0x00000001	Laser Fault	Laser is in Fault State
1	0x00000002	Laser Startup	Laser is in Startup State
2	0x00000004	Laser Warmup	Laser is in Warmup State
3	0x00000008	Laser Standby	Laser is in Standby State
4	0x00000010	Laser Emission	Laser is in Emission State
5	0x00000020	-	-
6	0x00000040	-	-
7	0x00000080	-	-
8	0x00000100	Warnings Present	There are Warning present, see Warning Register Table 8-2 (p. 66)
9	0x00000200	Faults Present	There are Faults present, see Fault Register Table 8-3 (p. 67)
10	0x00000400	-	-
11	0x00000800	-	-
12	0x00001000	-	-

8.2 Warning Codes

Use a terminal program to check for current warnings by entering the SCPI command: **SYSTem:FLAGs:WARNings?**. The laser system will return a 32-bit hex value.

Alternatively, use a terminal program to check for current warnings by entering the SCPI command: **SYSTem:FLAGs:WARNings:DETails?**. The laser system will return the current warnings in text form.

Table 8-2. Controller Warning Register

Bit	Mask	Label	Description
0	0x00000001	Interlocks Open	Interlocks are open. See "External Interlock 1 & 2 Connector" (p. 36) for more information.
1	0x00000002	Current Spot EOL	Current Spot is End of Life. See "Matrix Crystal Shifter Function" (p. 53) for more information.
2	0x00000004	LD Supply Voltage not present	LD Supply Voltage is not present (Voltage below 48V(± 10%))
3	0x00000008	-	-
4	0x00000010	-	-
5	0x00000020	-	-

8.3 Fault Codes

Use a terminal program to check for current faults by entering the SCPI command: **SYSTem:FLAGs:FAULt?**. The laser system will return a 32-bit hex value.

Alternatively, use a terminal program to check for current faults by entering the SCPI command: **SYSTem:FLAGs:FAULt:DETails?**. The laser system will return the current faults in text form.

Table 8-3. Controller Fault Register

Bit	Mask	Label	Description
0	0x00000001	Housing Temperature Protection	Housing Temperature out of Protection Range
1	0x00000002	Vanadate Temperature Protection	Vanadate Temperature out of Protection Range
2	0x00000004	Reso Temperature Protection	Reso Temperature out of Protection Range
3	0x00000008	Laserdiode Temperature Protection	Laserdiode Temperature out of Protection Range
4	0x00000010	SHG Temperature Protection	SHG Temperature out of Protection Range
5	0x00000020	THG Temperature Protection	THG Temperature out of Protection Range
6	0x00000040	SHG Temperature Control Failure	SHG Actual-Temperature could not reach Set-Temperature
7	0x00000080	THG Temperature Control Failure	THG Actual-Temperature could not reach Set-Temperature
8	0x00000100	Housing Temperature Sensor Fault	Broken or Shorted Housing Temperature Sensor
9	0x00000200	Vandate Temperature Sensor Fault	Broken or Shorted Vanadate Temperature Sensor
10	0x00000400	Reso Temperature Sensor Fault	Broken or Shorted Reso Temperature Sensor
11	0x00000800	Laserdiode Temperature Sensor Fault	Broken or Shorted Laserdiode Temperature Sensor
12	0x00001000	SHG Temperature Sensor Fault	Broken or Shorted SHG Temperature Sensor
13	0x00002000	THG Temperature Sensor Fault	Broken or Shorted THG Temperature Sensor
14	0x00004000	-	-
15	0x00008000	-	-
16	0x00010000	Laserdiode Current Protection	Laserdiode Current above Protection Limit

Table 8-3. Controller Fault Register

Bit	Mask	Label	Description
17	0x00020000	Laserdiode Current Control Failure	Laserdiode Actual-Current does not match Set-Current
18	0x00040000	Laserdiode Current Sensor Fault	Laserdiode Current could not be measured
19	0x00080000	-	-
20	0x00100000	Laserdiode Over Voltage Protection	Laserdiode Voltage above Protection Limit
21	0x00200000	Laserdiode Under Voltage Protection	Laserdiode Voltage below Protection Limit
22	0x00400000	Laserdiode Voltage Sensor Fault	Laserdiode Voltage could not be measured
23	0x00080000	-	-
24	0x00100000	General Temperature Fault	Failure in Temperature Module
25	0x02000000	General Laserdiode Fault	Failure in Laserdiode Module
26	0x04000000	-	-
27	0x08000000	-	-
28	0x10000000	Internal Hardware Fault	Internal Hardware Failure
29	0x20000000	Deviation 2f/3f	2f/3f Temperature Deviation Fault during Operation State
30	0x40000000	Deviation Housing	Housing Temperature Deviation Fault during Operation State
31	0x80000000	-	-

9 Graphical User Interface

9.1 Matrix Web User Interface (WebUI)

The WebUI for the Matrix laser system is provided through an external computer linked to the laser head via the ethernet connection, and using a web browser to access the WebUI.

This section provides information on how to connect to that computer and how to use the WebUI to operate the Matrix laser system. Instructions are sent to the laser through the WebUI using an Ethernet connection.

The simplest and most intuitive way to interact with the Matrix laser is by using the WebUI. The WebUI is a web-based application that uses commands and queries to interact with the Matrix laser. The instructions below explain how to access the WebUI on an external computer.

9.2 Connecting to the WebUI Through Ethernet Connection

A device (computer, laptop, tablet) with a pre-installed web browser (Google Chrome, Mozilla Firefox, Microsoft Edge, Safari, etc.) is required to access the WebUI.

The device must have an ethernet port. An ethernet cable (RJ-45) is required to connect the device to the laser head.

The following resolution for the device is recommended:

- Recommended screen or browser resolution:1280x900
- Minimum screen or browser resolution: 900x650

The laser will need to be assigned an IP address by a DHCP server. The ethernet port of the laser can be connected either to a network or directly to a computer using the ethernet cable.

9.3 Accessing the WebUI

1. Check the IP address assigned to the laser by the DHCP server by typing the command **SYSTem:IP:ADDRess?** into a terminal program while connected through RS232.
2. Open a web browser on your device.
3. Type the Matrix laser's assigned IP address in the address bar:
4. Press Enter to see the WebUI login screen.

Figure 9-1. WebUI Login Screen

5. Enter the login password (if any) if using the laser at a higher access level.
6. Click on "Log In" to see the WebUI main screen.

9.4 WebUI Menu Tabs Overview

The WebUI for the Matrix laser has the following menu tabs: Overview, System Info and Settings (indicated by the gear icon).

1. Overview - Contains the command panels for primary information and operation of the laser system, including status, warnings and faults
2. System Info - Contains general information regarding the laser system
3. Settings – Option to log out of the laser system

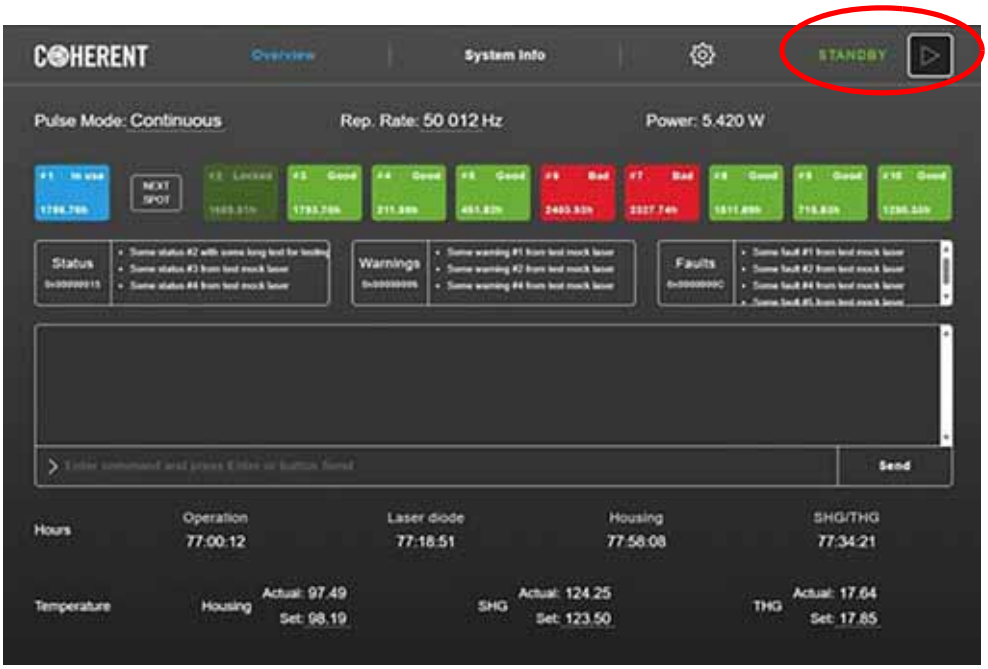
Figure 9-2. WebUI Menu Tabs

9.5 Laser Status Icon

The laser status icon reflects the current status of the connected Matrix laser.

Users can click on the  icon to start emission after the laser has ramped up and on standby.

User can click on the  icon to stop emission when the laser has started emission.



Laser has completed Warmup, and is ready for Rampup.

Laser is ramping up to the required current and temperature settings for Emission.

Laser is emitting.

Figure 9-3. Laser Status Icon

9.6 Overview Tab

The overview tab of the WebUI provides an overview of the laser status. It provides selection of the laser pulse mode as well as the internal repetition rate (if applicable). This tab also provides information of the status of each crystal spot and can be used to switch to the next available spot. There is also a prompt menu to enter commands and queries into the system. Lastly, it provides information regarding the total hours used and temperature settings for the Matrix laser connected.

1. Shows current pulse mode. Click to change.
2. Shows current repetition rate. Click to change
3. Shows the internal measured average power for the laser during laser emission.
4. Shows the list of crystal spots, status of each spot, and the number of hours used at each spot. Click on “next spot” to shift to the next available spot.
5. Shows the current status and list any active faults or warnings of the laser.
6. Provides space to enter commands or queries into the laser (details on p. 58).
7. Shows the current total hours of laser operation and the laser diode.
8. Shows the current set and actual temperatures of the housing, SHG, and THG crystals.

Figure 9-4. WebUI Overview Tab

9.7 System Info Tab

The system Info tab shows detailed information on the connected Matrix laser.

Figure 9-5. WebUI System Info Tab

9.8 Settings Tab

The settings tab allows the user to log out of the laser system.

Figure 9-6. WebUI Settings Tab

A Parts List

The following parts can be ordered by contacting our regional Technical Support Groups. Visit our website for contact information in your region. When communicating with our Technical Support Department, via telephone or E-mail, the model and laser head serial number of your laser system will be required by the Support Engineer responding to your request.

Table A-1. Parts List

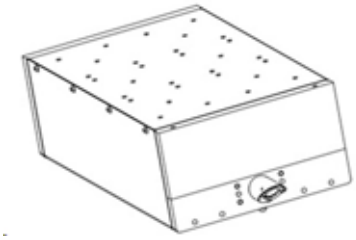
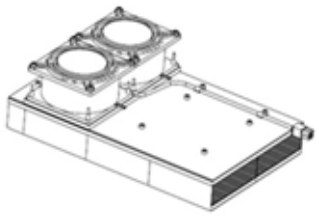
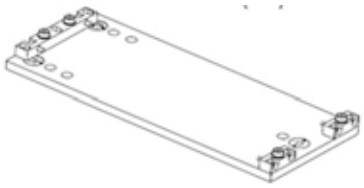
Description	Coherent Part Number	Content	Image
Matrix 355-10 LASER HEAD Matrix 355-5 LASER HEAD	**2286004** **2285577**	**Laser head only**	
Matrix Air-Cooling Assembly	**2302876**	**Fan module for air-cooled laser head**	
Matrix Kinematic Mounting Kit	**2302879**	**Adapter plate to enable the mounting and quick repositioning of the laser**	

Table A-1. Parts List (Continued)

Description	Coherent Part Number	Content	Image
AVIA LX PS with Inverse Polarity Protection	2217743	48 V Power supply, AVIA LX High Power Cable	
NOTICE **This power supply is intended for initial testing and integration only. It is highly recommended that the end user supply their own power supply.**			
Matrix DC Power Adapter for AVIA LX PS	2302878	Power adapter for the Matrix laser head	

B Accessories for Integration

B.1 Matrix Kinematic Mounting Plate

Coherent provides an adaptation kit for direct integration.

B.1.1 Kinematic Mounting Plate Setup

1. Locate the mounting plate and hardware.

Figure B-1. Mounting Plate and Hardware

2. Position the kinematic mounting plate in the installation location.
3. Screw the plate to the installation location; e.g. an optical breadboard.
   a.) At the front of the plate there is one screw hole location, this opening will always be utilized.
   b.) At the rear of the plate, there are two sets of screw openings. One set is for imperial breadboards and the other set is for metric breadboards. Align the screw opens to your breadboard type.

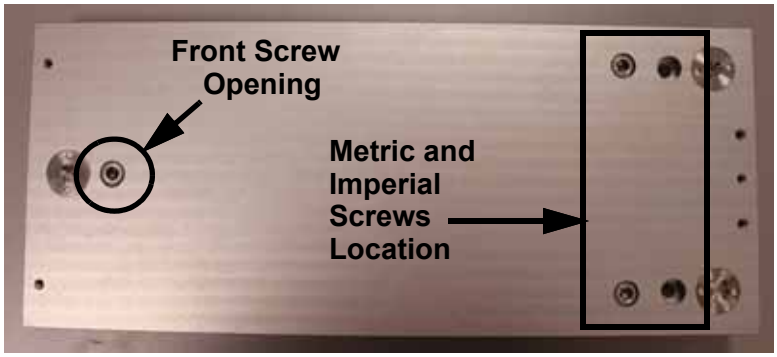
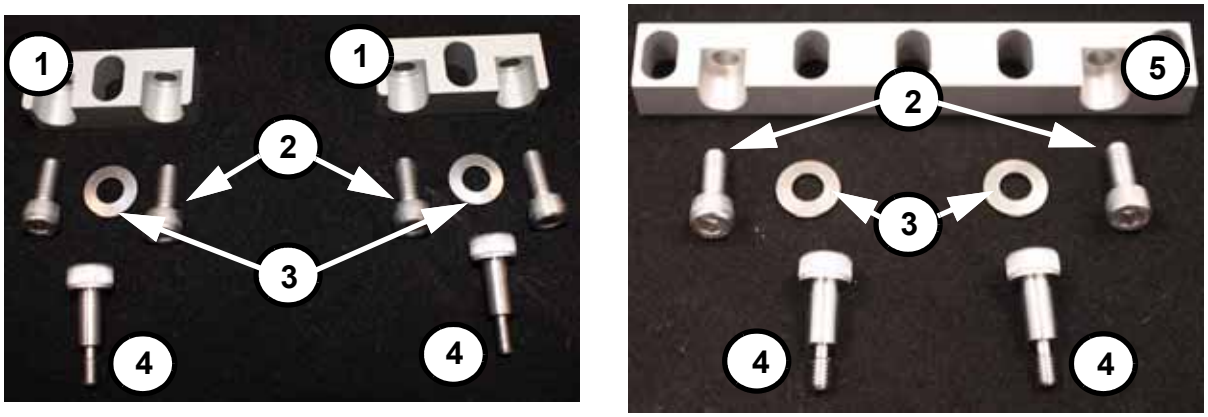


Figure B-2. Kinematic Mounting Plate Screw Openings

4. Position the laser on the mounting plate, align the three laser feet to the three kinematic mounts. The front of the laser head has one foot and the rear of the head has two feet.



1. Front Bracket
2.M5x25 Screws
3. Disc Springs
4. M5 Shoulder Screws
5. Rear Bracket

Assembled Front Brackets (2 sets)

Assembled Rear Brackets

Figure B-3. Mounting Plate Hardware

5. Use the M5x25 screws and attach the brackets to the laser.
   a.) At the front the screw head will rest in the recess. **Hand tighten only**.
   b.) At the rear the screw head will sit flush on the surface of the bracket. **Hand tighten only**.
6. Attach the brackets to the Mounting plate with the M5 shoulder screw and the disc spring, with the base of the disc springs conus pointing towards the bracket, use a torque of 2.5 Nm.
7. Tighten the M5x25 screws with 2.5 Nm torque to the laser.

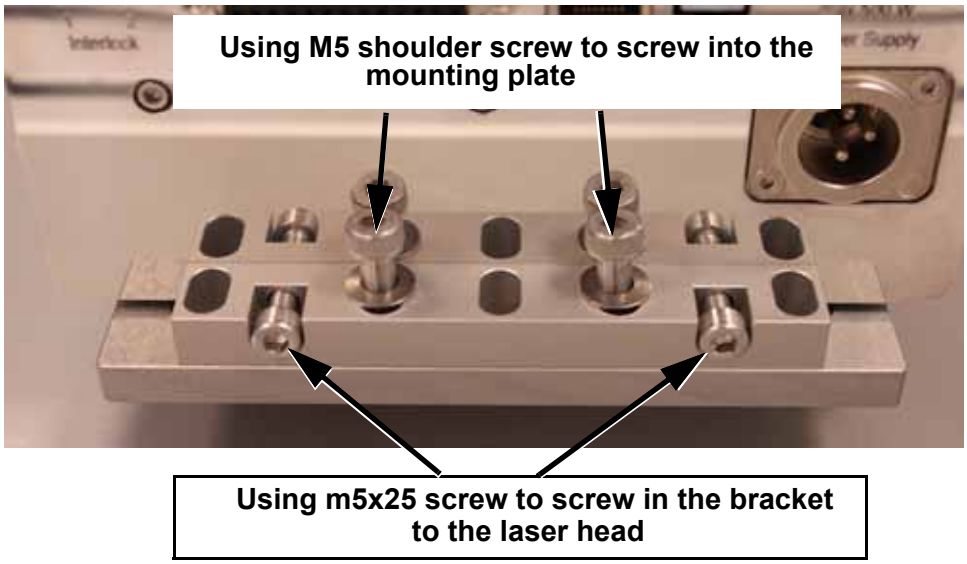


Figure B-4. Laser Rear Bracket Installation

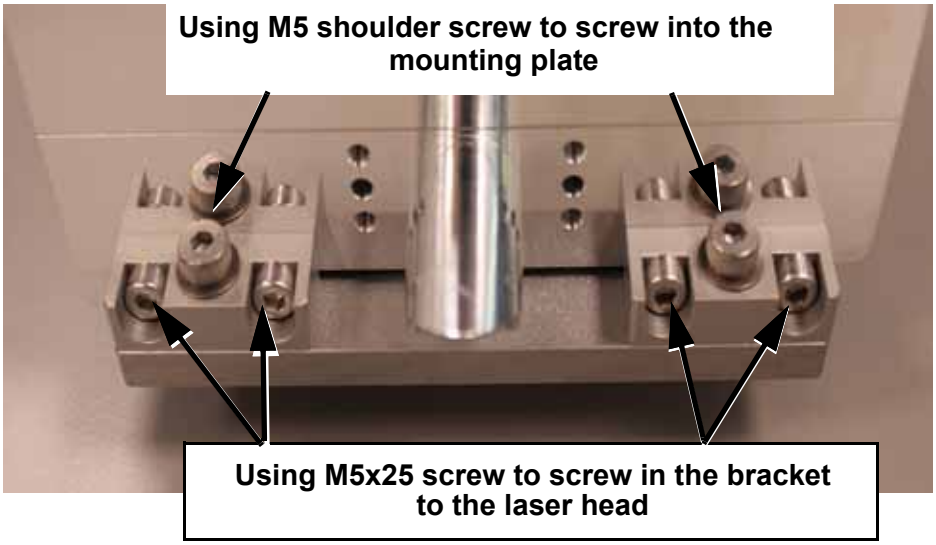


Figure B-5. Laser Front Brackets Installation

C Environmental Guidelines

C.1 Introduction

A very important contributing factor to the long-term operational reliability of lasers such as the Matrix is to ensure that once it is installed in a tool it is operated in a suitably controlled and non-hostile environment. This includes proper management of dust, debris from laser material processing, VOC's, airborne contaminants, ambient temperature, humidity, vibrational shocks, back reflections, and electrical noise or RF EMI that the laser may be exposed to.

Under certain circumstances where lasers may be operated in less-than-ideal environments, like machine shops, air testing is recommended.

C.1.1 Airborne Contamination

Airborne contaminants such as dust or volatile organic compounds (VOC's) can be very harmful to lasers, beam delivery optics and sensitive control electronics. The high intensity pulsed light, especially in the UV range, from a laser such as the Matrix can photo-chemically interact with airborne contaminants present in the beam path, causing the formation of harmful deposits or films on the laser's output optics or the tool's beam delivery optics. Over time, depending on the severity of the contamination, this will reduce the performance of the laser and degrade the optics and optical quality of the delivered beam, negatively impacting applications. In addition if excessive dust or other material processing debris settles on the control electronics, it could cause shorts or damage that would not be covered by the warranty.

Typically in a micromachining system the majority of the contaminants come from the ablated material that is ejected from the work piece, but sometimes dust, debris, or volatile chemicals may also come from "dirty" outgassing assemblies in the machine system, an adjacent process, or environment in the factory. Below are some guidelines for managing such contamination.

NOTICE

Typically, the primary source of contaminants in a micromachining system is debris ejected from the work piece.

- Effective fume and debris extraction, together with proper purging of the optics, is critical to the long-term reliable operation of laser micro-machining systems. Its importance should not be overlooked.

- Suction positioned near the interaction zone at the work piece should be employed to minimize the amount of debris released into the environment and onto the workpiece. This technique works well with confined scan fields or fixed optics. However, it may not be suitable for scanning systems where the area can be too large to make capturing the ejected material with suction effective. In these cases positive air pressure through a nozzle close to the final beam delivery optic can be used to protect it from processing debris (a suitable collection fixture for the rejected debris will also be required).

- The use of beam tubes to enclose the entire beam path, and positive clean dry air pressure within these tubes, may be required to protect the optical system from processing debris and other contamination sources within the machine tool (such as airborne lubricants) and in the general ambient environment.

There are several important points to note in the design of beam tubing with positive air pressure:

- The beam tubing and opto-mechanics of the system should be very clean and use non-outgassing materials.

- Only qualified adhesives should be used, and these should be used sparingly and thoroughly cured.

- The beam enclosures must have adequate seals that can keep out contaminants. Hermetic seals should be used if possible.

- If positive pressure is utilized in the optical system, the effects of airflow on the laser beam must be tested. Too much flow or turbulence may cause beam pointing instability that may negatively impact the process.

C.1.2 Temperature and Humidity

High performance lasers such as the Matrix Laser Systems are designed to operate best in environments with limited temperature excursions and relatively low humidity. Coherent recommends that end user facilities have heating and air conditioning systems that maintain stable temperature and remove excess moisture from the atmosphere to limit temperature swings and any risk of damage to the laser from humidity.

The laser should be mounted outside the work cell when possible, and beam tubes used to convey the beam to the final work piece.

Most importantly care must be taken to avoid condensation. If water vapor condenses it may collect on the electronic boards and the risk of malfunction or damage is increased. This may result in rusting, corrosion, short circuiting, electrical and electronic component breakdowns, or premature deterioration of laser parts.

The best way to prevent issues from condensation is to operate the laser in a low humidity, air conditioned environment. Alternatively, the system developer can fully enclose the laser system and employ temperature and humidity control systems within. Building/installing enclosures that are large enough to permit airflow and are tightly sealed from the outside environment can help reduce instances of condensation.

Relative humidity refers to the water vapor content in air at a specific temperature. This is a ratio that is expressed as a percentage of the maximum amount of water vapor that the air can hold without condensing. In high relative humidity environments (>50%) leaving the chiller on when the diodes are off could result in condensation forming on the laser's internal components, causing damage as mentioned above. To avoid this, the user must maintain the laser head temperature above the dew point at all times. Faults and warnings have been incorporated into the Revolution laser to alert users of situations that could lead to condensation inside the electronic compartment of the laser head. For example, warning #807 indicates when the laser temperature is too low; faults #10 and #11 will also alert when the laser temperature is out of range or too low, respectively. All faults and warnings are accompanied by text describing the issue.

C.1.3 Excessive Vibration

The Matrix Laser contains motorized micro-positioning stages that are used to optimize the cavity and shift the THG crystal from spot to spot. (TBD) Excessive mechanical shock or vibration while the laser is in operation may cause unwanted displacement to the internal optics mounted on these stages and induce fault messages, errors, or performance problems. Severe shock or vibration may cause permanent laser damage. Ideally the operating environment should be vibration free, though not always practical. The user should ensure that the laser and optical beam delivery are mounted to effectively isolate them from sources of shock or vibration such as large fans, robots, motors, etc. to ensure minimal disturbance to the system and laser.

C.1.4 EMI Sources

The ideal environment should be free of active electromagnetic interference (EMI, also called RFI or radio frequency interference) sources and passively immune to external disturbances.

The task of minimizing active sources is often easier than protecting against interference. Common techniques to minimize EMI are line filtering, power-supply design, proper layout, and shielding the enclosure.

Electrical disturbances can be conducted by the power lines or conveyed through the air by magnetic field or electromagnetic radiation. Typically, the interference conducted over signal lines connected to the equipment is the most difficult to manage. In any case, one must balance between the need to protect against damage or malfunction and the need to prevent signal or data distortion. The first problem is handled with hardware design, the second with software algorithms.

Consider these basic rules:

- EMI protection should be considered while designing equipment, not added afterwards.
- Block disturbances as near to the source as possible, preferably before they enter the equipment and redirect them to ground.
- As all sections, even electrically isolated sections, are susceptible to EMI disturbance, EMI sources should be located as far as possible from the equipment.

C.1.5 Back Reflection

In a properly designed laser application, the laser beam exits the beam aperture and very little of the light is scattered or sent back into the laser exit aperture.

NOTICE

***Back reflection* (also referred to as *retroreflection*) occurs when a part of the laser beam is sent back into the laser's exit aperture. Back reflection can be caused by any object in front of the laser and may result in instability, noise, and even damage the laser.**

The amount of back reflection that can be damaging varies from system to system. Damage from back reflection can be immediate or subtle and slowly decrease the service life of the laser. A laser that shows symptoms such as low output power, no output power, or high noise, indicates a possibility of back reflection to the laser.

To prevent damage, reduce noise and increase the life of the laser:

- Review the objects in front of the laser and identify what surfaces are a possible hazard for back reflections. Change the objects to be less reflective whenever possible. Adding Anti-Reflective (AR) coatings to optics and more diffuse surfaces to mounts or beam shutters can help.

- If possible, add an angle to the object so that the reflection does not enter the laser exit aperture.

- Take precautions when moving objects that can create a back reflection in front of the laser.

- Decrease the risk from any possible back reflections by starting the laser at lower output power—for example, <10% output power—to identify and eliminate potential hazards.

- *Using proper safety precautions,* monitor where the reflections from objects are returning to make sure the reflections are not at or near the laser exit aperture. Always use the appropriate eyewear protection.

- Take precautions when using a laser power meter. Consider how close the measurement is being taken to the laser and the angle at which the beam can reflect off the sensor so that it does not reflect back into the laser.

- Add an optical isolator in front of the laser exit aperture for applications where significant back reflections cannot be corrected.

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Warranty

Coherent, Corp. warrants the Matrix 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.

I.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.

I.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
- Opening the 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 Celsius or centigrade
°F	Degrees Fahrenheit
µm	Microns = (10^{-6} Meters)
µJ	MicroJoules = (10^{-6} Joules)
µrad	Microradians = (10^{-6} radians)
µs	Microseconds = (10^{-6} seconds)
µsec	Microseconds = (10^{-6} seconds)
$1/e^2$	Beam diameter parameter
A	Amperes
AC	Alternating current
Amp	Amperes
CDRH	Center for Devices and Radiological Health
cm	Centimeters = (10^{-2} Meters)
CPU	Central processing unit
CW	Continuous wave (operating mode)
DAC	Digital-to-analog converter
DC	Direct current
DCE	Data communications equipment
ESD	Electrostatic discharge
gpm	Gallons per minute
Hz	Hertz or cycles per second (frequency) (= 1/pulse period)
I/O	Input/output
IR	Infrared (wavelength)
kg	Kilogram(s) = (10^3 grams)
kHz	Kilohertz = (10^3 hertz) or (1000 Hertz)
kV	Kilovolt(s) = (10^3 Volts)
K	Kelvin
LCD	Liquid crystal display
LD	Laser diode
LED	Light emitting diode
LPM	Liters per minute
m	Meters
mA	Milliamperes = (10^{-3} Amperes)
mAmp	Milliamperes = (10^{-3} Amperes)
mm	Millimeters = (10^{-3} Meters)
mrad	Milliradians = (10^{-3} Radians)
msec	Milliseconds = (10^{-3} Seconds)

mV	Millivolts = (10^{-3} Volts)
mW	MilliWatts = (10^{-3} Watts)
nm	Nanometers = (10^{-9} m) (wavelength)
OEM	Original equipment manufacturer
PRF	Pulse repetition frequency
psi	Pounds per square inch
QS	Q-switch
RF	Radio frequency
RH	Relative humidity
RMA	Return material authorization
rms	Root mean square
RXD	Receive Data
SHG	Second harmonic generation
TEC	Thermoelectric cooler
TEM	Transverse electromagnetic mode
THG	Third harmonic generator
TTL	Transistor-to-Transistor Logic
TXD	Transmit Data
UV	Ultraviolet (wavelength at 355 nm)
V	Volts
VAC	Volts, alternating current
VDC	Volts, direct current
W	Watts

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INNOVATIONS THAT RESONATE

2336892 AA

Matrix Laser System Operator's Manual

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