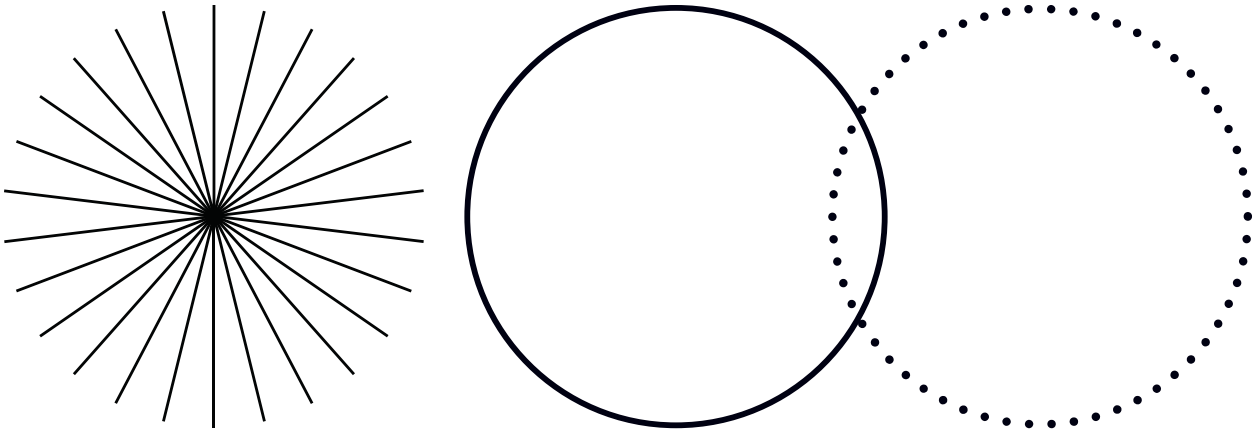
Diamond C-70 Air-Cooled OEM Lasers

Preinstallation Manual



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COHERENT

Preinstallation Manual
Diamond C-70 Air-Cooled OEM Lasers

COHERENT

1280 Blue Hills Avenue
Bloomfield, CT 06002

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1 Introduction

1.1 Signal Words and Symbols in this Manual

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

1.1.1 Signal Words

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

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

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

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

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

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

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

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

1.1.2 Symbols

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

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

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

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

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

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

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

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

1.2 Preface

This is the preinstallation manual for the Diamond C-70 OEM/Industrial laser manufactured by Coherent. These lasers are OEM systems; they are designed as components which are to be inserted by the original equipment manufacturer (OEM) prior to delivery to the end user. Coherent requires that the user read “Laser Safety” (p. 9), before operating the laser.

NOTICE

Read this manual carefully before operating the laser for the first time. Failure to follow the instructions and safety precautions in this manual can result in serious injury or death. Special attention must be given to the material in “Laser Safety” (p. 9), that describes the safety features built into the laser. Keep this manual with the product and in a safe location for future reference.

DANGER!

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

1.3 Export Control Laws Compliance

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

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

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

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

1.4 Notice Concerning Regulatory Status of Diamond Series Lasers

This laser component does not include all safety features that are required by the United States Food and Drug Administration (FDA), Center for Devices and Radiological Health (CDRH) in laser systems sold to end users. It is sold solely to qualified manufacturers who in their end product, supply interlocks, indicators, and other required safety features, in full compliance with 21 CFR 1040, Subchapter J and/or other applicable national and local regulations.

1.5 Notice Concerning Warranty

Operation or handling of this laser component, inconsistent with this manual, may void the warranty.

1.6 The Preinstallation Manual

This preinstallation manual is designed to familiarize the user with the C-70 system and its designated use. It contains important information on how to install the laser system safely, properly, and most efficiently. Observing these instructions helps to avoid danger, reduce repair costs, and downtimes and increase the reliability and lifetime of the laser system.

This manual describes the physical hazards related to the laser system, the means of protection against these hazards, and the safety features incorporated in the design of the laser system.

1.6.1 Intended Audience

The preinstallation manual is intended for all persons that are to work on or with the laser system.

1.6.2 Numbering of Sections, Pages and Instructions

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

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

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

1.6.3 Cited Standards

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

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

1.7 Laser Terminology

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

To prevent misunderstandings, the C-70 documentation strictly differentiates between "laser" and "laser system". Thus "start laser system" means that the power is off and shall be turned on. To "start the laser" means to switch on the laser beam and start laser operation.

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

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

1.8 Units of Measurements

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

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

The water hardness is indicated in parts per million (ppm; American Hardness).

1.9 Feedback Regarding Documentation

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

In any correspondence, provide the following:

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

1.9.1 Feedback Email Address

Email documentation.support@coherent.com

2 Laser Safety

This user information is in compliance with the following standards for Light-Emitting Products IEC 60825-1 / EN 60825-1 *"Safety of laser products - Part 1: Equipment classification and requirements"* and CDRH 21 CFR Title 21 Chapter 1, Subchapter J, Part 1040 *"Performance standards for light-emitting products"*.

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

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

This laser safety section must be reviewed thoroughly prior to operating the C-70 laser system. Safety instructions presented throughout this manual must be followed carefully.

2.1 Hazards

Hazards associated with lasers generally fall into the following categories:

- Biological hazards from exposure to laser radiation that may damage the eyes or skin
- Electrical hazards generated in the laser power supply or associated circuits
- Chemical hazards resulting from contact of the laser beam with volatile or flammable substances, or released as a result of laser material processing

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

2.1.1 Optical Safety

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

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

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

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

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

2.1.1.1 Recommended Precautions and Guidelines

1. Observe all safety precautions in the preinstallation and operator's manuals.
2. Always wear appropriate eyewear for protection against the specific wavelengths and laser energy being generated. See "Laser Safety Eyewear" (p. 11) for additional information.
3. Avoid wearing watches, jewelry, or other objects that may reflect or scatter the laser beam.
4. Stay aware of the laser beam path, particularly when external optics are used to steer the beam.
5. Provide enclosures for beam paths whenever possible.

6. Block the beam before applying tools such as Allen wrenches or ball drivers to external optics.
7. 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.
8. 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.
9. Post laser warning signs in the area of the laser beam to alert those present.
10. Exercise extreme caution when using solvents in the area of the laser.
11. 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.
12. Set up the laser so that the beam height is either well below or well above eye level.
13. Avoid direct exposure to the laser light. Laser beams can easily cause flesh burns or ignite clothing.
14. Advise all those working with or near the laser of these precautions.

2.1.1.2 Laser Safety Eyewear

Always wear appropriate laser safety eyewear for protection against the specific wavelengths and laser energy being generated. The appropriate eye protection can be calculated as defined in the “EN 207 Personal eye protection equipment - Filters and eye-protectors against laser radiation (laser eye-protectors)”, in other national or international standards (e.g. ANSI, ACGIH, or OSHA) or as defined in national safety requirements. Anyone working with or near the C-70 laser must wear laser safety eye-wear with an OD rating 5 eye protection.

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.

2.1.2 Viewing Distance

C-70 lasers produce optical power levels that are dangerous to the eyes and skin if exposed directly or indirectly. These products must be operated only with proper eye and skin protection at all times. Never view directly emitted or scattered radiation with unprotected eyes. When viewing the laser during operation, the operator must maintain the Nominal Ocular Hazard Distance (NOHD) between the laser or scattered radiation and the operator's eyes. Figure 2-1 summarizes the NOHD for the power range of the C-70 for direct viewing of the collimated beam along with two other common configurations. The NOHD in this figure is based on the Maximum Permissible Exposure (MPE = 0.1 W/cm^2) level for each power condition as specified in ANSI Z136.1 and IEC 60825-1.

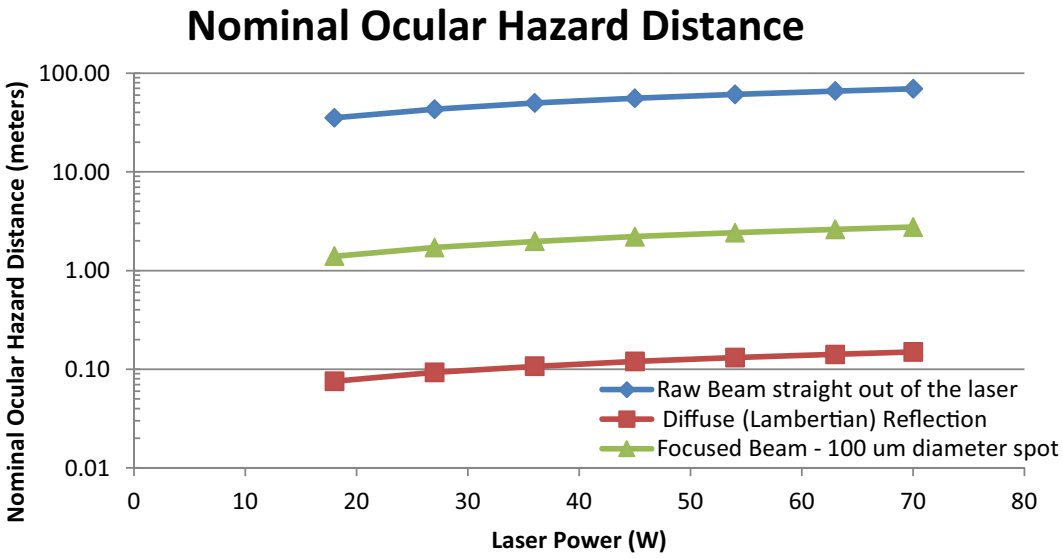


Figure 2-1. Nominal Ocular Hazard Distance (NOHD) for indicated conditions calculated per ANSI Z136.1

2.1.3 Electrical Safety

All C-70 laser systems, which consist of the laser head and the RF power module, require high current at + 48 VDC to operate. This voltage is sourced from commercially available power supplies from various manufacturers. The typical input voltage to these power supplies is 208 or 480 VAC. These voltages can be lethal. Every portion of the electrical system should be treated as if it is at a dangerous voltage level.

High RF power levels are present in the RF power module compartment and laser resonator compartment when the power is on. There is no RF radiation exposure hazard to personnel so long as all protective covers are not removed.

DANGER!
Normal operation of the C-70 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.

2.1.3.1 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.

1. Disconnect main power lines before working on any electrical equipment when it is not necessary for the equipment to be operating.
2. 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.
3. 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.
4. 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.
5. Always use approved, insulated tools.

2.2 Safety Features and Compliance with Government Requirements

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

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

Integrators who incorporate a C-70 laser into other products that they introduce into United States commerce are defined in the law as manufacturers who are thus required to manufacture their products to conform to the Federal standard, certify them, and submit product reports to the CDRH.

For jurisdictions outside of the United States, it is the responsibility of the buyer of this laser device to ensure that it meets the local laser safety requirements.

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

United Kingdom (England, Wales, and Scotland):
The United Kingdom requirements for product safety are specified in the Electrical Equipment (Safety) Regulations 2016 (published in SI 2016/ 1101). The Electrical Equipment (Safety) regulations requires that lasers comply with the standard EN 61010-1/IEC 61010-1 “Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use” and EN 60825-1/ IEC 60825-1 “Safety of Laser Products”. Compliance of this laser with the United Kingdom requirements is certified by the UKCA mark.

2.2.1 Laser Classification

Governmental standards and requirements specify that the laser must be classified according to the output power or energy and the laser wavelength. The C-70 is classified as Class 4 based on 21 CFR, Subchapter J, Part 1040, section 1040.10 (c) and/or IEC/EN 60825-1;2007, Clause 8 and IEC/EN 60825-1:2014, Clause 4. In this manual, the classification will be referred to as Class 4.

2.2.2 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.

2.2.3 Protective Covers (Safety Interlocks)

The laser's protective covers are not interlocked and should only be removed by trained service technicians.

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

DANGER!
To avoid potentially fatal electrical shock hazards from electrical equipment, follow all applicable electrical codes such as (in the U.S.) the National Electrical Code.

2.3 Compliance to Standards Relevant to CE and UKCA Mark

The C-70 of lasers are OEM products, and are sold as components for integration into complete laser systems by a system integrator. These products are tested and marked as independent products in the European Community (CE) and the United Kingdom (UKCA). For specific details regarding what applicable compliance directives and standards the products have been tested to, refer to the EU Declaration of Conformity and/or the UKCA Declaration of Conformity which are available upon request from Coherent, per contact information on p. ii of this manual.

Compliance to applicable standards for a particular laser tool incorporating C-70 lasers must be demonstrated by the manufacturer of the complete system. The primary issue for the system integrator is to design covers, shielding, grounding, routing of electrical cable assemblies, and control elements with the proper safety features so that during subsequent testing the system meets the appropriate standards.

2.4 Environmental Compliance

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

2.4.1 Electromagnetic Compatibility

Compliance of this laser with the Electromagnetic Compatibility (EMC) requirements is certified by the CE mark and the UKCA mark. For more information about the CE/UKCA marks see “Compliance to Standards Relevant to CE and UKCA Mark” (p. 16).

Each application and installation is unique, and in some cases, the user may experience Electromagnetic Interference (EMI) noise being emitted from various electronic components. This laser uses high-frequency RF (100 MHz). While adequate countermeasures have been taken to suppress this emission to meet the requirements stated on the Declaration of Conformity, the user may wish to employ additional measures to suppress the EMI to reduce the emissions further. Standard methods of reducing the EMI are:

1. Use of shielded control cables grounded on both ends
2. Addition of appropriate ferrite beads to cables connected to the beam source.

2.4.2 RoHS Compliance

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

2.4.3 China-RoHS Compliance

Coherent product(s) conform to all applicable requirements of Restriction of Hazardous Substances Regulation SJ/T 11364-2014 commonly referred to as China-RoHS.

The China RoHS Hazardous Substance Marking Table is located in the shipping document packet shipped with the product (or laser system).

2.4.4 REACH Compliance

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

2.4.5 Waste Electrical and Electronic Equipment

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

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

Email: info@rene-europe.com
Phone: +49 89 490 491 00
Website: www.rene-europe.com

2.5 Location of Safety Labels

Refer to Figure 2-2, “Location of Safety Labels,” (p. 18) and Figure 2-3, “Labels,” (p. 19) for a description and location of all required 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]

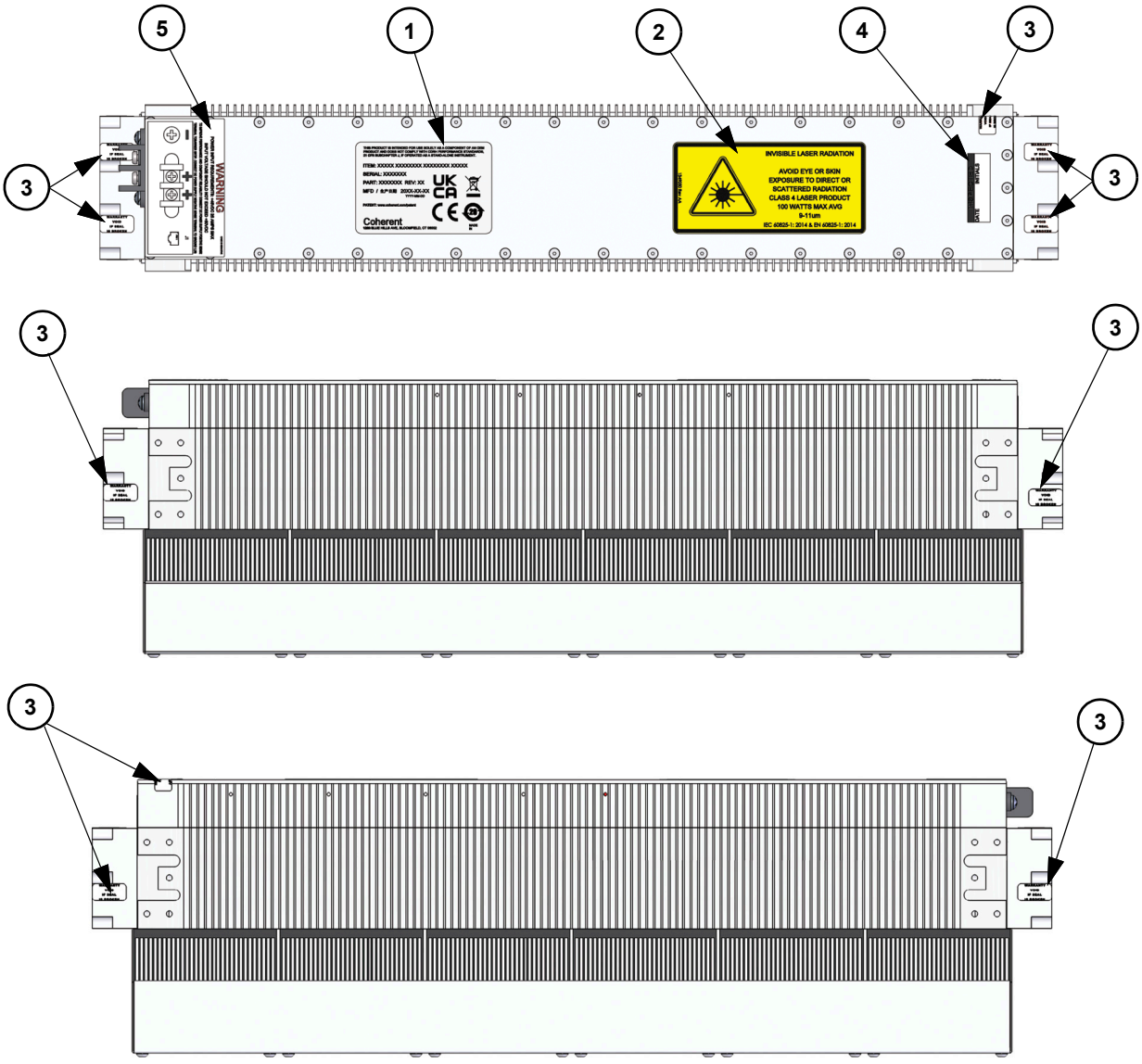


Figure 2-2. Location of Safety Labels (Sheet 1 of 2)

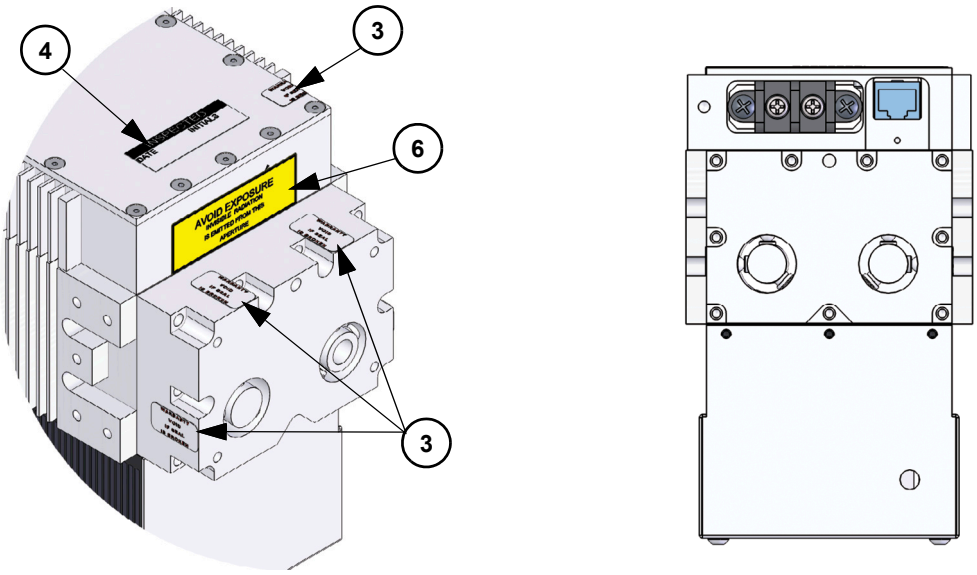
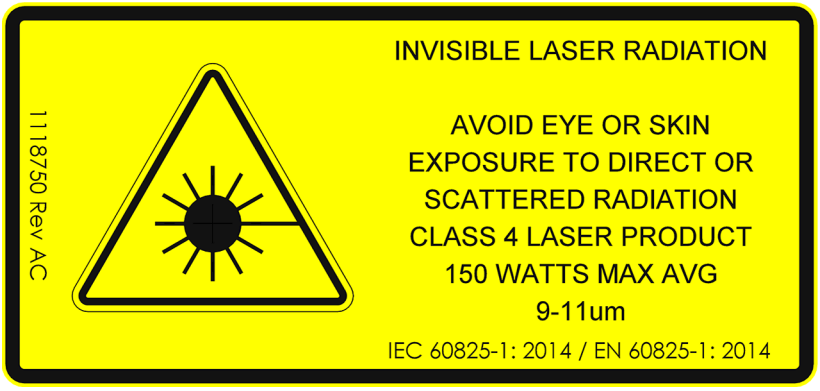


Figure 2-2. Location of Safety Labels (Sheet 2 of 2)

1. Identification Label

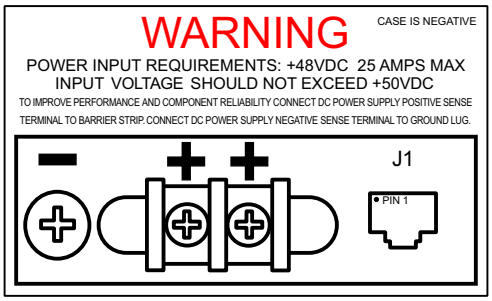
Figure 2-3. Labels (Sheet 1 of 2)



2. Danger of Laser Radiation Label

3. Tamper Proof Label

4. QC Approval Label



5. Voltage Warning Label

6. Warning Aperture Label

Figure 2-3. Labels (Sheet 2 of 2)

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 Standard

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

Safety of laser products - Part 14: A user's guide
IEC 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

Coherent Web Site
Laser Safety Page, Laser Safety Awareness Training Video
www.coherent.com

3 Description and Specifications

3.1 Introduction

This section details specifications and characteristics (including mechanical, thermal, electrical, and optical interfaces; environmental requirements, and limitations) of the C-70 laser.

The C-70 laser is a sealed-off, RF-excited CO_2 laser, capable of continuous wave (CW) or modulated operation. From the laser safety point of view, this laser is considered to be a component and must be integrated into a system by a qualified original equipment manufacturer (OEM) prior to delivery to the end user. See the “Laser Safety” (p. 9) for a complete discussion of laser safety issues.

3.2 Purpose of This Manual

This manual is designed to assist the original equipment manufacturer (OEM) during the integration of the C-70 OEM laser. It contains information about the performance and operation of the laser as well as installation and control methods.

Figure 3-1. C-70 Air-Cooled Laser

3.3 Specifications and Input Requirements

Table 3-2 (p. 27) provides specifications and requirements for power inputs for the C-70 laser.

Figure 3-1 illustrates the baseline configurations (i.e., without any optional hardware additions or deletions) of the C-70 laser. Each laser system consists of a laser head assembly and an integrated radio frequency (RF) power supply. The RF power module converts 48 VDC, ≤ 25 A (35 A peak for 1 ms) power to radio frequency power.

Connection of the customer-supplied DC power supply to the C-70 is via a barrier strip with screw terminals on the RF power module. These terminals should also be used for the connection of wires for remote voltage sensing. Such sensing is recommended to control the voltage at the input to the RF power module more precisely.

3.4 Hardware Overview

The C-70 laser is a waveguide, carbon dioxide (CO_2) laser. RF electric fields provided by the RF power module excite the CO_2 gas mixture. The standard configuration of this laser operates at a wavelength near 10.6 μm in the infrared region of the electromagnetic spectrum.

3.4.1 DC Input Power

DC input power is provided by the user through customer-supplied bus wiring, which goes to the RF power module. The RF power module converts this DC electrical power into RF power, which is used to excite the gas in the laser head. The DC power supply requirements are discussed in detail in the subsection entitled “DC Power Supply Requirements” (p. 38).

3.5 Cooling Requirements

Total heat dissipation for the laser is specified in Table 3-2. The laser head typically dissipates 700 W from its base surface while the RF power module typically dissipates 300 W, for a total typical heat dissipation of 1000 W (maximum total heat dissipation is 1200 W). The C-70 must be provided adequate cooling to keep the laser operating temperature within acceptable limits. The cooling method that is used must not induce stresses that will result in misalignment of the laser resonator. The C-70 heat sinks are designed so the assembled structure remains free of excessive stress. Installation requirements related to cooling the air-cooling version of the Diamond C-70 laser are discussed in detail in the subsection titled “Air Cooling” (p. 35).

3.5.1 Comparison of Air-Cooling and Liquid-Cooling (Reference)

Air-cooling and liquid-cooling each have distinct advantages. Table 3-1 describes the factors that should be taken into consideration when choosing a cooling system for a laser module.

One should also consider if condensable vapors are present and take suitable measures to purge sensitive areas, such as optical surfaces, with a suitable gas.

Table 3-1. Comparison: The Benefits of Air-Cooling vs. Liquid-Cooling Methods

Air Cooling	Liquid Cooling
• Low in cost • Low in complexity • Low service requirements • Easier to install	• Offers the highest process stability • Can yield the most compact arrangement • Suitable for applications in which the ambient air temperature exceeds 40ºC • Better for applications in which the ambient air is laden with particulates; it will result in a maintenance requirement of cleaning of air-cooling system and in general lower heat transfer, more performance instability and shorter product life time if air-cooled laser is used • Easier to make a hermetically sealed system

NOTICE

To avoid damage to the laser, never operate the laser without adequate air cooling.

3.6 Laser Head

The laser head takes RF input power and converts some of it to laser radiation. The rest of the RF input power is exhausted as waste heat. For the C-70 Air-Cooled laser, the waste heat is exhausted into the ambient air. The laser head consists of the folded optical waveguide resonator, the all-metal gas envelope structure, and RF power module. Infrared laser radiation is emitted from the optical aperture. Pictures and dimensions drawings for the C-70 Air-Cooled laser are shown in Figure 3-1 and Figure 4-2.

3.7 RF Power Module

The C-70 RF power module converts DC input power to RF energy which is sent to the laser head. Heat from the RF power module flows into the integrated laser assembly and is exhausted into the surrounding air. An RJ-45-type connector is used to control the laser system. All of the user interfaces (DC power and signal interface) are on one panel of the RF power module.

3.8 Configuration and Facility Requirements

Table 3-2 describes the configuration and facility requirements for C-70 Air-Cooled lasers. Laser performance specifications are provided in the C-70 Air-Cooled lasers datasheet available online at www.coherent.com and in the test report provided with each laser.

Table 3-2. C-70 Configuration and Facility Requirements

Parameter	Value
Weight	10.2 kg (22.5 lbs.)
Dimensions (L x W x H)	604.9 x 92.5 x 154.5 mm (23.8 x 3.64 x 6.08 in.)
Input Power[1]	48 VDC < ± 2% regulation, < ± 1% P-P Noise/Ripple 25 A Max avg, with 35 A peak for 1 msec minimum, measured at input terminals
Heat Dissipation (W)	< 1200 W
Maximum Case Temperature	< 60ºC (140ºF)
Operating Environment	
Temperature	5ºC to 40ºC (41ºF to 104ºF)
Altitude	< 2,000 m (6,500 ft.)
Humidity	Non-Condensing
Shipping/Storage Environment	- 10ºC to 60ºC (14ºF to 140ºF), Non-condensing
[1] Power measured @ 25ºC & derated by 1%/ºC for higher laser head temperatures	

4 Utility Requirements and System Installation

4.1 Introduction

This section covers unpacking and installation of the C-70 laser. Operating instructions are detailed in "Laser Operation" (p. 43).

4.2 Unpacking and Inspection

Before unpacking the laser components, inspect the shipping carton for evidence of rough handling, and note any damage. If damage to the shipping carton is evident, request that the carrier's agent be present when the unit is unpacked. Inform the shipping carrier and Coherent of any evidence of damage in shipment. The Buyer and shipping carrier is responsible for any damage which might occur during shipment.

4.2.1 Verifying Delivery

The shipping container contains the following:

- Laser head and integral RF power module
- Final test sheet

If any items are missing, report this to Coherent immediately.

4.2.2 Protective Shipping Tape

The front of the C-70 laser head is protected by a blue adhesive film or tape (Figure 4-1). This tape is designed to protect the optics during shipping and must be removed prior to operating the laser.

To avoid damage, the blue protective tape must be removed BEFORE operating the laser.

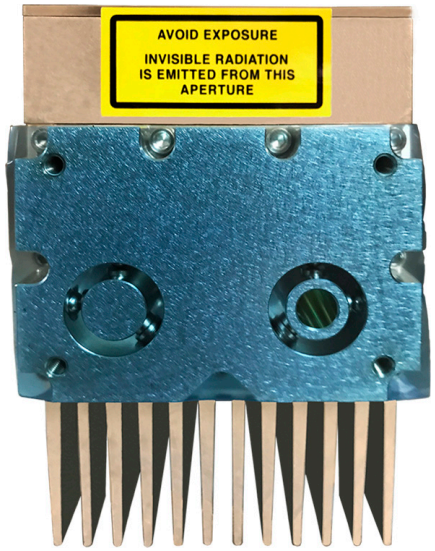


Figure 4-1. Protective Shipping Tape

4.2.2.1 Tape Removal

To remove the protective tape:

1. Pinch one corner of the tape between the thumb and index fingers.
2. Gently pull the tape off of the laser.

Discard the tape and do not place the tape anywhere near or on the laser.

4.3 Safety Issues in Laser Installation

Installation of the C-70 laser must comply with all applicable electrical safety and laser safety laws and regulations. Review Laser Safety for important information relating to safety.

The negative (return) side of the DC input connection to the C-70 RF power module is connected internally to the chassis. The user must ensure that the system into which the C-70 is built protects against the possibility that the C-70 laser head or RF power module chassis could be at a hazardous voltage and that personnel could be exposed to these voltages.

DANGER!

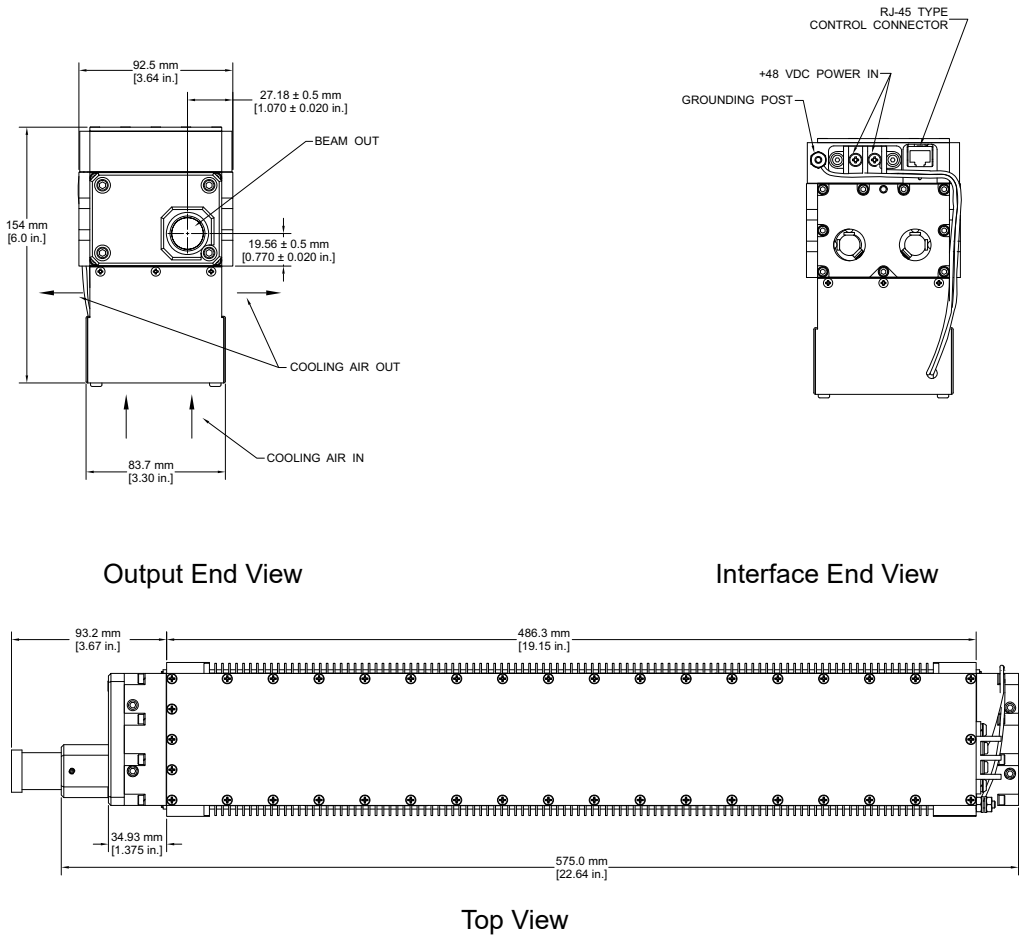
To avoid potentially fatal electrical shock hazards from electrical equipment, be sure to follow all applicable electrical codes such as (in the U.S.) the National Electrical Code.

The laser must be secured properly to avoid the possibility of the laser shifting unexpectedly during operation, creating a hazardous condition. The location of the output beam of the C-70 laser head is shown in Figure 4-2 (p. 32). The laser output is emitted from the aperture shown in the referenced figures and propagates within a full cone angle up to 5°. The acceptance angle of the system aperture must intercept all of the output of the laser.

It is also extremely important to understand the direction, divergence, and magnitude of all reflections that will occur from optical surfaces. Infrared (IR) beams, such as those from C-70 lasers, can also be located with commercially available IR screens, such as those produced by Macken Instruments, Inc. [tel. (707) 566-2110]. Coherent recommends that all beam propagation paths be enclosed and that personnel operating the laser be qualified optical technicians who are familiar with this type of hardware.

4.4 Mechanical Mounting

The dimensions for the C-70 laser head is shown in Figure 4-2. Mechanical mounting of the C-70 laser head must result in no distortion or stress the laser head is in any way. Otherwise, optical alignment and power stability could be adversely affected.



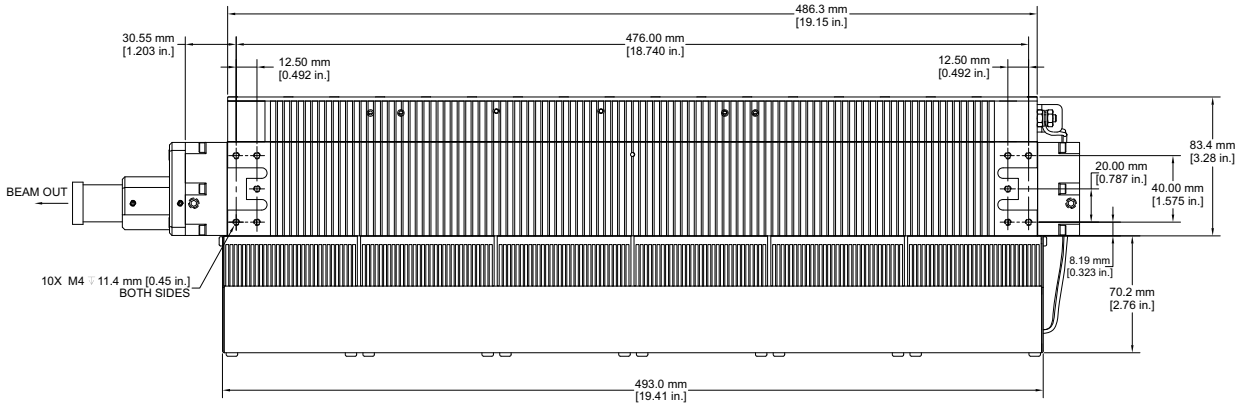
Output End View

Interface End View

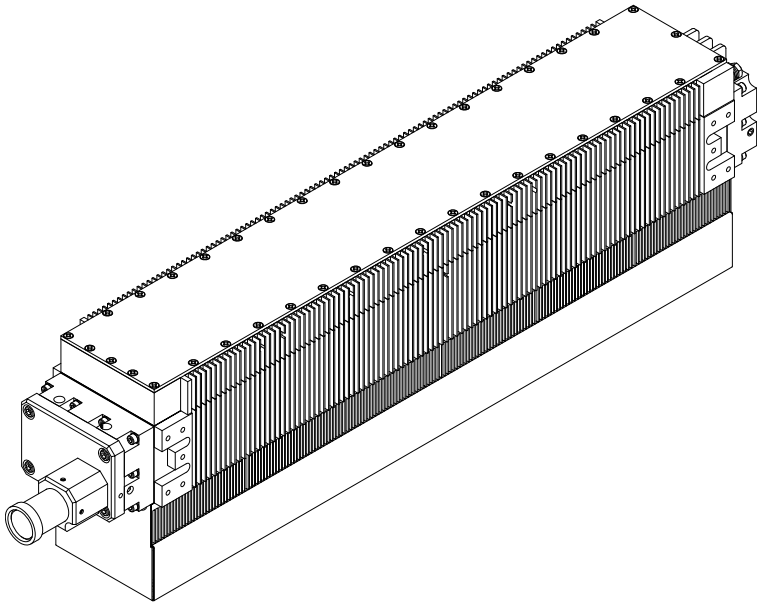
Top View

NOTES:
1. Allow proper clearance around heatsinks to insure sufficient cooling air flow.

Figure 4-2. C-70 Air-Cooled Laser Head Dimensions



Side View



Isometric View

NOTES:
1. Allow proper clearance around heatsinks to insure sufficient cooling air flow.

Figure 4-2. C-70 Air-Cooled Laser Head Dimensions (Continued)

4.4.1 Mounting Considerations for C-70

Certain aspects of specific customer applications may preclude absolute interchangeability of laser heads. For example, for certain applications, the sensitivity of the application to optical beam pointing errors may require external optical realignment after the laser head is replaced in the customer's integrated system. Depending on the method of mounting and the sensitivity of the integrated customer system to beam pointing errors, even removing a laser head from the customer's system, then replacing the same laser head back into the customer's system may require external optical realignment. This external alignment would be a repositioning of the head itself or adjustment of beam delivery mirrors (positions and angle). Consult Coherent if there is any question about such interchangeability issues. Consult Coherent if there is any question about such interchangeability issues.

Coherent recommends using optional brackets (part number 1101-12-0016 for a set of 4) that are designed for mounting the laser safely without inducing any stress onto the laser. Care must be taken not to induce stress onto the laser head, as optical mis-alignment of the laser resonator can occur, which would require the laser to be returned to Coherent for service. A mechanical drawing for this bracket is provided in Parts List. Coherent strongly encourages use of this bracket or one of similar design in order to accommodate the temperature changes in operation while providing secure mounting.

4.4.2 Ambient Air Cleanliness

The C-70 laser heads are designed for use in a dust-free or nearly dust-free environment. They should be installed in a protective housing that prevents dust or debris from contaminating the optical output window. Do not turn the laser on if there is water, dust, or dirt on the output element; otherwise, damage to the coating on this optical element may occur. To prevent such optical damage, never allow the output window to become contaminated.

Do not allow the fins on the heat sinking elements to become clogged with dirt, dust, or debris. They must be cleaned periodically, as indicated in Maintenance and Troubleshooting.

NOTICE

In the case of the C-70 Air-Cooled laser, a dust- and particle- free environment must be maintained around the heat sinks. Dust or particles can clog the fans and heat sinks, and degrade their performance significantly. Coherent recommends that the OEM set up a regular preventive maintenance schedule to clean these cooling fins every 6 months or as needed in the OEM's operating environment.

The Coherent warranty covers defects in material and workmanship relating to the output optical element, but this warranty does not cover damage to the external output optical surface that is the result of contamination to the surface, or abrasion of the surface.

4.5 Air Cooling

The C-70 Air-Cooled laser incorporates heat sinks cooled by forced air (blown by fans). The six fans draw 1.6 A of current when supplied with the required 48 VDC electrical power. Running the fans at higher voltages will reduce the operating life and is strongly discouraged. The user must provide the correct voltage polarity to the fans in order for the airflow direction and resulting volume to be sufficient to cool the laser adequately.

4.5.1 Air Flow

Open-air flow for the laser system is critical. Therefore, Coherent requires clear access to free air within 60 mm of the cooling fans and fins for the laser system. The air used to cool the C-70 must be clean and free of contaminates. This requirement can be fulfilled by filtering the air at the input to the laser cavity or system equipment.

4.5.2 Signal Interface

Coherent uses a temperature interlock to ensure that the fans are operating and supplying sufficient air cooling. It is recommended that both Modulation and Control Enable be commanded to the OFF state when the airflow interlock system detects an over-temperature fault. The system also provides a temperature warning that should be used to alert the user to a need for maintenance of the cooling system to return the performance to the normal full cooling capacity. Failure to take action regarding the temperature warning will result in poorer product performance (outside specifications) and lesser product life time. These signals are listed in Table 4-1 (p. 39) and further discussed in subsections of “Laser Operation”.

4.6 Electrical Power Connection

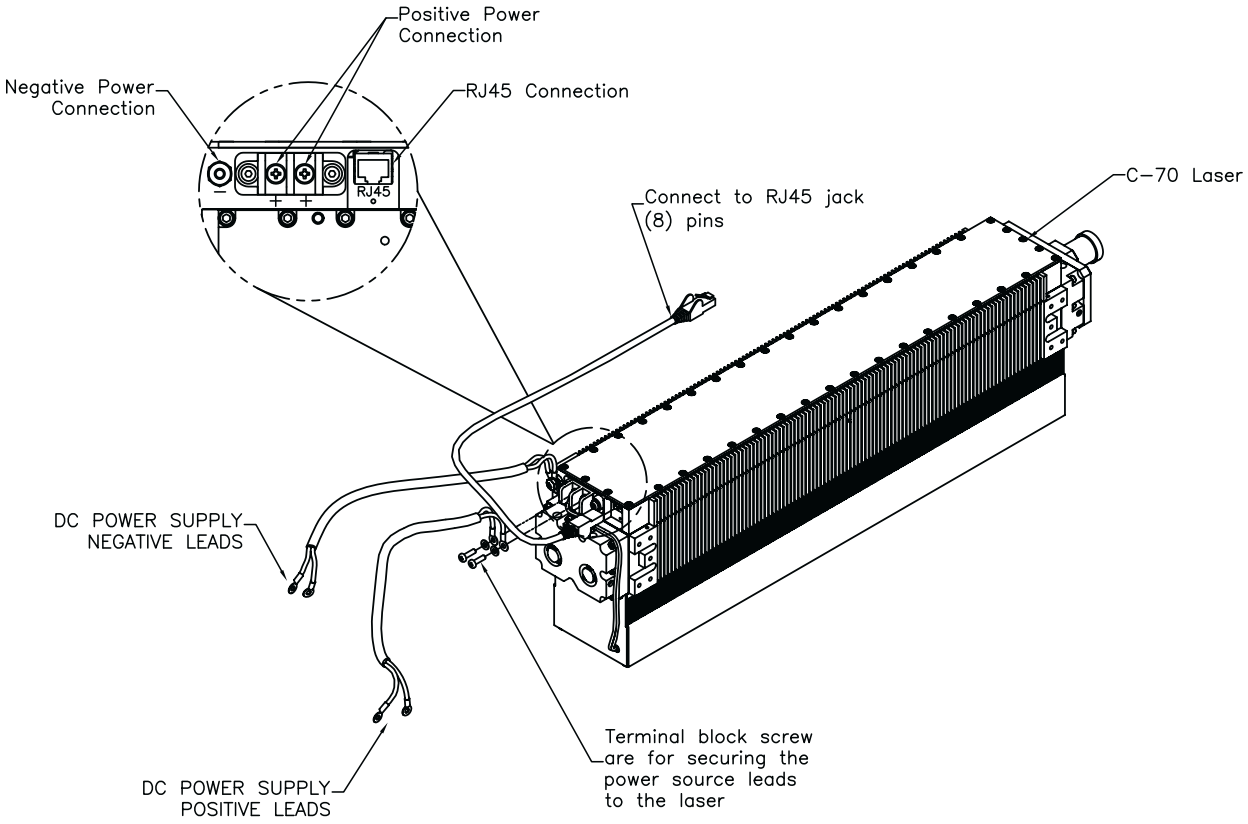
The C-70 laser requires 48 VDC input DC power. This power is carried from the power source to the system through the terminal block on the C-70. The maximum current required is 25 A.

The negative (return) side of the DC input connection to the C-70 RF power module is connected internally to the chassis. The user must assure that the system into which the C-70 is built protects against the possibility that the C-70 chassis could be at a hazardous voltage and that personnel could be exposed to these voltages.

DANGER!

To avoid potentially fatal electrical shock hazards from electrical equipment, be sure to follow all applicable electrical codes, such as (in the U.S.) the National Electrical Code.

Coherent requires that the user review the precautions described in Laser Safety regarding electrical safety before using the C-70 laser. It is the user’s responsibility to provide circuit breakers and/or fusing of the AC power source, in accordance with all applicable laws and regulations.



Note: Pin #1 of RJ45 control interface is on the left as viewed.

NOTICE

To avoid damage to the system, connect leads to the user-supplied power source last after other connections are made.

Figure 4-3. Electrical Connections to C-70

4.6.1 DC Power Supply Requirements

Requirements for the customer-supplied DC power supplies include standards regarding DC power supply cabling and over-voltage tripping.

DC Voltage	48 VDC measured at the terminals.
Peak Current	<35 A for a minimum of 1 msec with a maximum voltage drop of 1.5 V
Regulation	< ± 2%
Regulation Sensing	Remote at load
Ripple and Noise	< 1% p-p (20 MHz BW limit)
Overload Protect	Automatic Recovery
Short-circuit Protect	Automatic Recovery

4.6.1.1 DC Power Supply Cabling Requirements

Coherent requires the use of remote voltage sense/regulation at the C-70. This requires a 4-wire cable (2 supply currents and 2 voltage senses).

The following requirement minimizes the voltage loss from the supply to the C-70:

Wire length (in Meters)	AWG
0 to 2	2 x 17 or 14
2 to 3	2 x 15 or 12
3 to 5	2 x 13 or 10
Note: Typically, doubling the wire at a give length will reduce the AWG by 3.	

4.6.1.2 DC Power Supply Over-Voltage Tripping

In the event that the DC power supply trips because of the current, there are two countermeasures that can be applied:

- Remote sensing, in which four wires are used to sense the regulation of the DC power supply
- Increased capacitance at the laser connection; to do this, add a capacitor at the DC power supply connection of the laser, using a capacitor of 470 µF or greater, rated at > 60 VDC

4.7 Control Signal Connection

Electrical control of the C-70 laser is achieved via a RJ-45 connector built into the system. The signals carried on each of the pins are indicated in Table 4-1. Details about controlling the laser through the signal interface are discussed in “Laser Operation” (p. 43).

Table 4-1. Signal Interface Description and Connector Pinout

Pin No.	Signal Description
1	Modulation TTL logic input; 1=RF ON, 0=RF OFF; 1 kΩ impedance This input turns on the laser. See also Pin 7, Control Enable, below
2	+ 15 VDC ± 0.5 VDC, 0.25 Amps maximum output for customer use
3	LASER OK TTL logic output; 1=LASER OK, 0=LASER Fault; I_{OH} = – 0.4 mA, I_{OL}= 8 mA Output is asserted when no faults (SWR, Temp. or Volt.) are detected Indicates that the temperature of the laser head is < 80°C
4	Temperature OK TTL logic output; 1=Temp OK, 0=Temp Fault; I_{OH} = – 0.4 mA, I_{OL}= 8 mA Output is asserted when the temperature of the laser head is < 60ºC
5	Voltage OK TTL logic output; 1=Voltage OK, 0=Voltage Fault; I_{OH} = – 0.4 mA, I_{OL}= 8 mA Output is asserted when DC supply voltage (V_{DD}) is between 43 VDC < V_{DD} < 55 VDC
6	Internal Coherent use. Must be grounded
7	Control Enable TTL logic input; 1=Laser Control Enabled, 0=Laser Control Disabled This input must be asserted before Modulation can be used to turn on laser
8	Customer Logic Ground for all interface signals

1) Connector used is RJ-45 type.
2) These specifications are subject to change.

NOTICE

Coherent requires use of shielded interface cables. The interface cable shield must connect to the chassis ground of the controller. In addition to proper shielding, this shield provides a secondary connection for the signal ground (Pin 8).

A floating ground connection (use of un-shielded interface cable or no return path between the host control electronics and the laser) can present an unsafe condition and result in unstable or unexpected operation of the laser. This condition can arise when the control signal ground connection (Pin 8) is lost and the Control Enable (Pin 7) and Modulation (Pin 1) remain high. Therefore, Coherent requires that a second safety ground be provided either via a shielded control cable or common potential chassis mounting between the laser head and the control electronics. Inadequate or nonexistent grounding between the laser and the external control system can result in loss of control of the laser and damage to the laser electronics or the external control electronics.

4.8 Beam Propagation

The C-70 delivers a 3.6 ± 0.5 mm diameter beam with a < 5 mRad divergence. The typical beam diameter as a function of distance from the laser is shown in Figure 4-4.

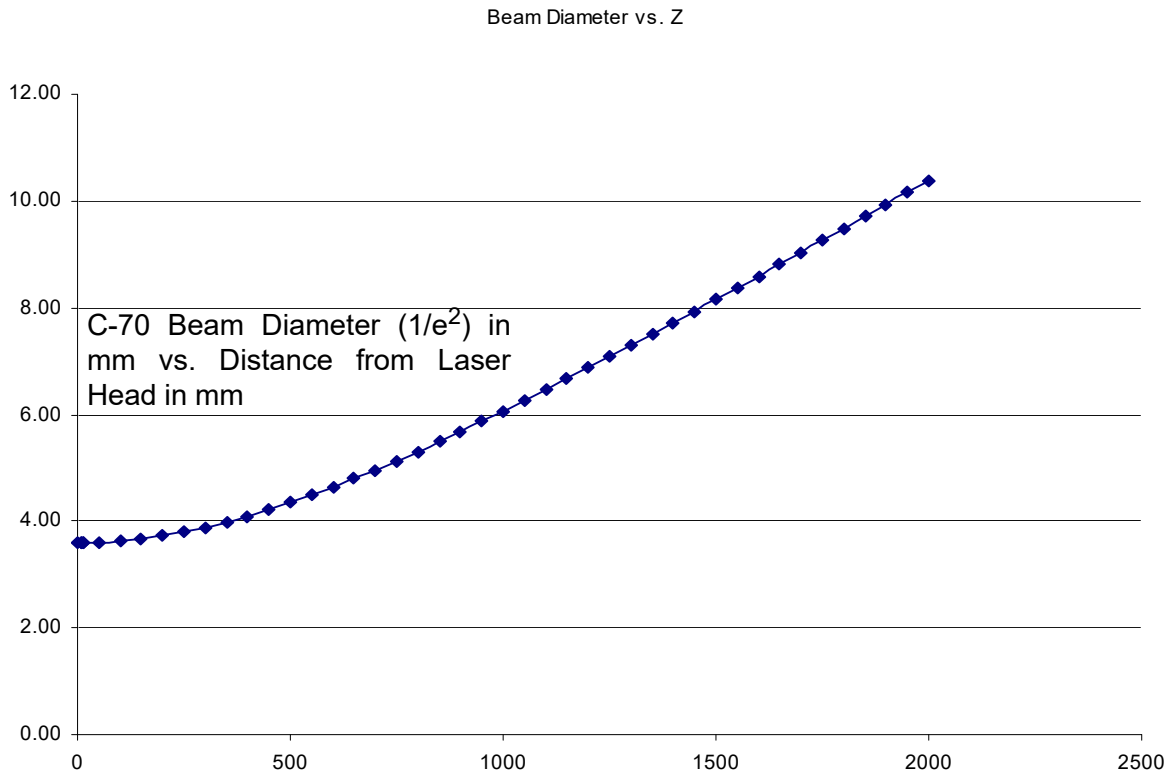


Figure 4-4. Beam Diameter vs. Distance From Laser Head

5 Laser Operation

5.1 Signal Interface Connectors

For all C-70 lasers, the signal interface between the C-70 laser and the customer's equipment is through a RJ-45 connector that is built into the RF power module. The pin assignments for the interface are indicated in Table 4-1, "Signal Interface Description and Connector Pinout," (p. 39). The signal interface and its use are discussed in detail in this section.

NOTICE
To avoid damage to the RF power module, ensure that the electronic controller is compatible with the interface described in Table 4-1 (p. 39).

As noted in the Laser Safety section of this manual, the signal interface is designed to provide a high degree of reliability in the control of laser output.

WARNING!
"Laser Safety" must be reviewed for guidance on any use of the signal interface in safety interlock subsystems, or in any other subsystem which affects personnel safety.

5.2 Operating Modes

All C-70 lasers can be operated in continuous wave (CW) mode or Gated CW mode. Each mode is described in the following sections; details about how to operate the laser in each mode are also discussed.

In the following sections, the assumption is that the laser has been initially started and the laser is now ready for operation.

5.2.1 Typical Waveform

Figure 5-1 illustrates a typical periodic-pulsed laser waveform. The RF input to the laser will generally follow the “Modulation” signal (Table 5-1). The laser output will generally follow the RF input, but will be distorted. The pulse repetition frequency is

$$PRF = \frac{1}{T}$$

T = period of the waveform

The duty cycle is

$$DC = \left(\frac{t}{T}\right)100$$

t = the pulsewidth

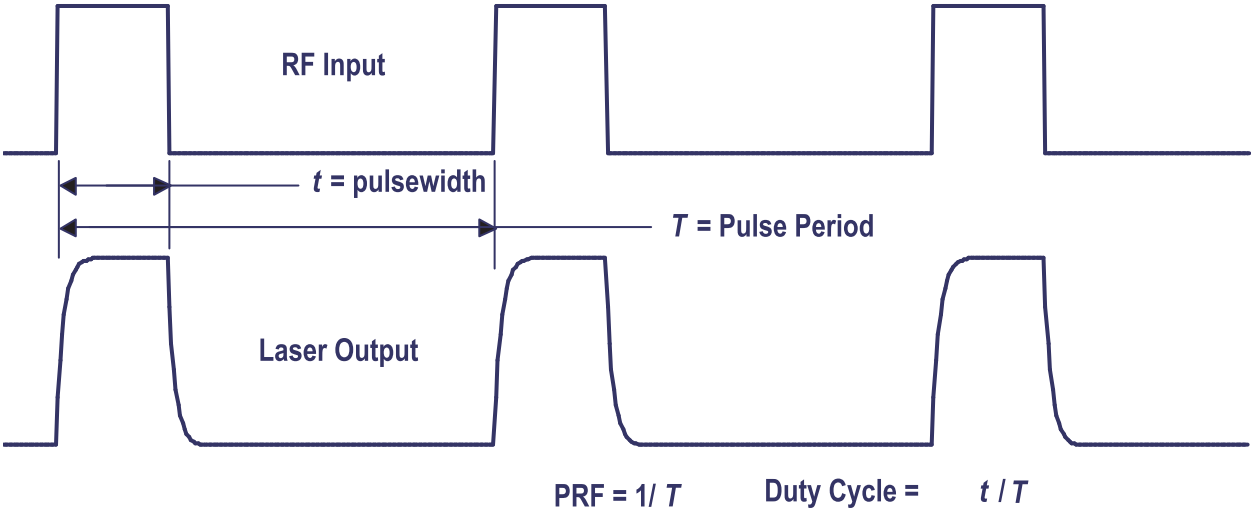


Figure 5-1. RF Input Waveform and Laser Output Waveform

5.2.2 CW Mode

To command the laser to operate in CW mode, “RF Enable” must be set continuously to Logic Level 1 (high), as shown in Figure 5-1.

5.2.3 Power Stability

Figure 5-2 illustrates the C-70 power stability over the course of a 30-minute warm-up from a cold start.

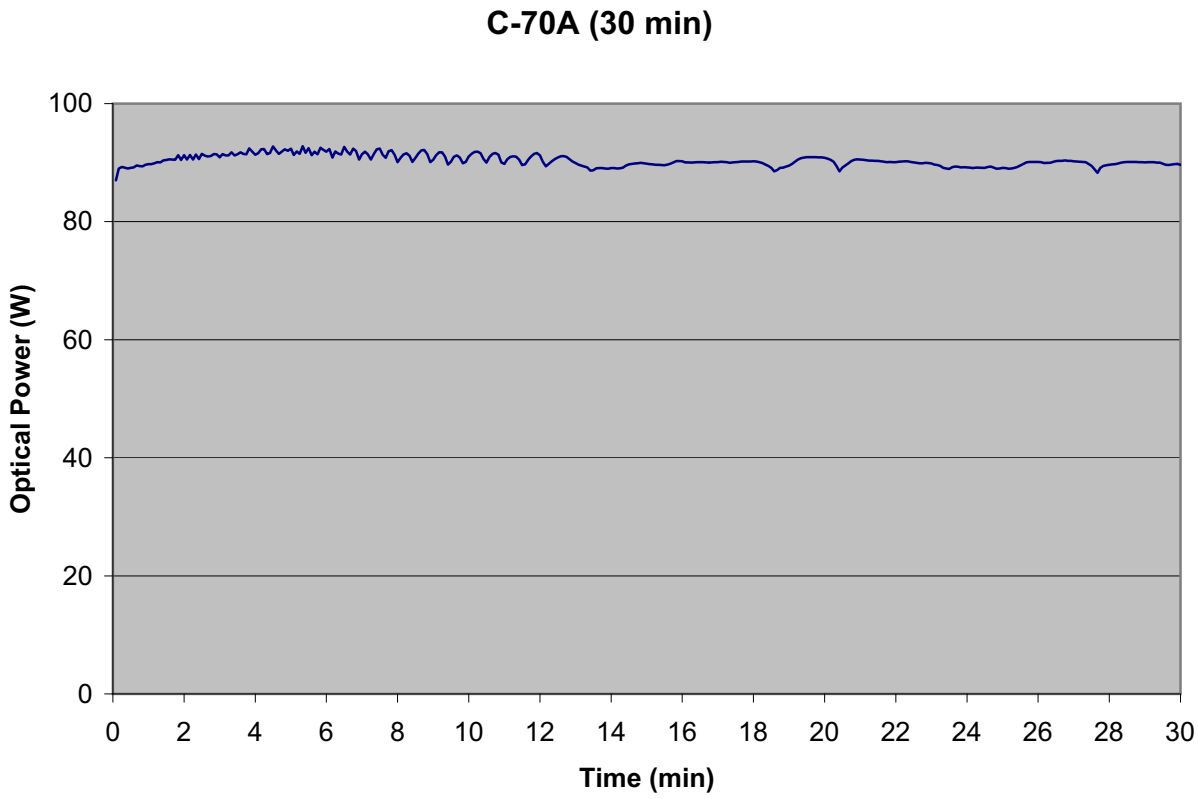


Figure 5-2. Typical Warm-Up Behavior from a Cold Start

5.2.4 Gated CW Mode

The C-70 laser is capable of producing a wide range of pulse repetition frequencies (PRFs), pulse widths, and duty cycles in Gated CW mode. “Modulation” pulse widths of less than 1 µs and/or PRFs greater than 25 kHz are not advisable. With the exception of these restrictions for pulse widths and PRFs, the RF power module will support any duty cycle from zero to 100% in Gated CW mode.

5.2.5 Variable Output, Power Capability and Pulsewidth Variation

All C-70 lasers provide the capability to vary the average laser output power continuously from near zero to at least the Optical Output Power specified on the datasheet. The user can alter the average output power by adjusting the pulsewidth of the input command “Modulation”.

5.2.5.1 Optical Pulse Shape

When the pulsewidth of the input digital signal “Modulation” is varied, the pulsewidth of the RF input to the laser’s electric discharge is also varied. Because of the complex dynamics of the electric discharge and the laser resonator, the optical output from the laser will be a somewhat altered version of the RF input waveform.

To vary the laser output power, adjust the RF pulsewidth in Gated CW mode, with the recommended lower limit on pulsewidth at 1 µs.

5.2.6 Complex Modulation Waveforms

The laser is capable of responding to more complex modulation waveforms. There are a variety of potentially useful modulation waveforms that offer advantage over the simple periodic waveforms with a single pulse per period.

5.2.6.1 Varying the Pulsewidth

Some users may require pulsed output with fixed pulsewidth but variable pulse energy. It is possible to approximate this desired optical output by pulsing the laser at a relatively high PRF (e.g., 25 kHz), then envelope-modulating at a lower PRF (e.g., 1 kHz). Variation of the pulsewidth of the 25 kHz modulation would provide the ability to vary the pulse energy of the 1 kHz pulses continuously.

5.2.6.2 Protection from Unacceptable Inputs

The C-70 laser easily accommodates complex modulation waveforms, and it will protect itself from damage due to inappropriate inputs.

5.3 Turning the Laser On and Checking Output Power

The following steps detail the method to turn a C-70 laser on and to perform an output power check.

1. Ensure that the laser output aperture is clear and free of packing material.
2. Place a laser power meter head in a position to intercept the output beam, and turn on the power meter.
3. Verify that the system does not have condensation on its outer surfaces.
4. If the C-70 laser is built into a system with safety interlocks, verify that all required laser safety interlocks are positioned for laser operation.
5. Verify that other safety features, such as equipment covers, shutters, and warning lights, are functional and operating properly.
6. Verify the solid electrical connection between the negative DC input terminal on the system and earth ground.
7. Ensure that all safety procedures detailed in Laser Safety are observed.
8. Turn AC power to the DC power supply on.
9. Turn DC power to the system on.
10. Set the user-supplied control equipment to activate the laser in CW Mode, in accordance with the instructions below.
11. After a few seconds of laser operation, read and verify the power level. The laser output should meet or exceed the laser output power specification given on the datasheet.
12. Set the user-supplied control equipment to deactivate the laser.
13. Turn DC power off.
14. Turn AC power off.

5.4 Electronic Control

The C-70 laser is controlled through the electronic interface described in Table 4-1, “Signal Interface Description and Connector Pinout,” (p. 39). In this section, additional information is provided regarding the use of this control interface. This section supplements the section in the paragraph titled “Operating Modes” (p. 43) and its subsections.

Use of the control interface in any strategy for assuring personnel safety must comply with the design guidelines discussed in Laser Safety.

NOTICE

Coherent requires use of shielded interface cables. The interface cable shield must connect to the chassis ground of the controller. In addition to proper shielding, this shield provides a secondary connection for the signal ground (Pin 8).

A floating ground connection (use of un-shielded interface cable or no return path between the host control electronics and the laser) can present an unsafe condition and result in unstable or unexpected operation of the laser. This condition can arise when the control signal ground connection (Pin 8) is lost and the Control Enable (Pin 7) and Modulation (Pin 1) remain high. Therefore, Coherent requires that a second safety ground be provided either via a shielded control cable or common potential chassis mounting between the laser head and the control electronics. Inadequate or nonexistent grounding between the laser and the external control system can result in loss of control of the laser and damage to the laser electronics or the external control electronics.

5.4.1 Electronic Signals Required to Turn the Laser On

The laser can be commanded electronically to turn on any time during which DC power is applied to the RF power module and the RF power module is properly connected to the laser head. Coherent recommends that all the control signals be set to their OFF condition until DC power is applied to the RF power module.

5.4.1.1 Start-up Sequence

The following steps detail how to turn the laser on in CW Mode.

1. Apply DC power to the laser.
2. Set “Control Enable” (Pin 7) to “TTL high” (logic 1). This enables the RF power module. Note that this signal should not be used to modulate the laser.
3. After the “Laser OK” has been asserted, the laser is ready for operation.
4. Set “Modulation” to logic 1 (Pin 1). This activates the RF output of the RF power module.

5.4.2 Response Times of Laser to Modulation and Control Enable

The response time of the RF power module to “Control Enable” (Pin 7), and to “Modulation” (Pin 1) are quite different. The response to “Modulation” is on a microsecond time scale, whereas the response to “Control Enable” is on a time scale of milliseconds.

This difference is not significant if the objective is to use the power supply only in CW mode. However, if it is desired to use the power supply in gated CW mode, it is important to take into account the response time of the power supply.

In general, it is best to assert “Control Enable” and leave it on while modulating “Modulation” as required.

5.4.3 Signals Used for Fault Detection

Several of the signals listed in Table 4-1, “Signal Interface Description and Connector Pinout,” (p. 39) may be used at the customer’s discretion for diagnosing faults in the laser system. The approach that provides the easiest access to these signals is to provide indicators, such as light-emitting diodes (LEDs), on the customer’s system control console for three of these signals. One way to use these signals as shown schematically in Figure 5-3 to sink the current for one LED on the operator’s control panel with each of the following three signal leads:

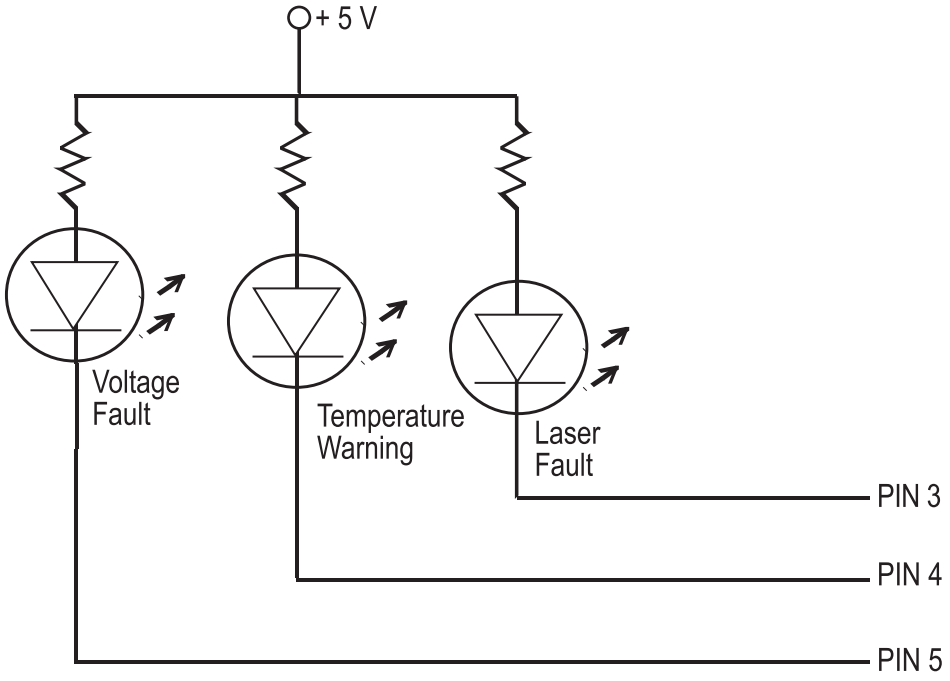


Figure 5-3. Fault Detection Circuit

- Laser OK (Pin 3): This signal indicates a composites fault if either SWR, over temperature, or voltage are at fault. The temperature fault will trip at a laser case temperature of approximately 80ºC. Once it trips it will be latched on even after the laser is cooled down. To restart the laser, the Control Enable signal has to be reset after the laser cools down.

- Temperature OK (Pin 4). This signal indicates an over-temperature warning. This will trip at a laser head temperature of approximately 60°C. This temperature warning signal will be reset automatically when the laser cools down with a hysteresis of 2ºC.

- Voltage OK (Pin 5). This signal will indicate a fault if V_{DD} exceeds 55 VDC or drops below 43 VDC.

See “Maintenance and Troubleshooting” (p. 57) for guidance about how to interpret and use indications by the above signals of faults in the laser.

NOTICE

Do not ignore indications of faults in the laser system, even if the laser seems to be working normally. Continued operation in the presence of a fault may result in damage to the laser system.

5.4.4 VSWR Faults During Initial Turn-On

The electric discharge in the laser head is more difficult to start after extended non-operational periods. As a result, the laser may not start immediately when it is first commanded to do so after more than a few hours of being turned off (not lasing). This may occasionally result in the signal “Laser OK” becoming Low. This would indicate a VSWR fault (i.e., high standing wave ratio in the RF supply due to failure of the electric discharge to light) if “Voltage OK” and “Temperature OK” are still asserted. Such transient indications when the laser is first turned on do not indicate any failed component in the laser. To avoid an unwarranted system response to this occurrence, Coherent recommends that the VSWR fault is logically qualified to “true” in the system controller for 1.0 seconds after laser “Modulation” and “Control Enable” have been active.

If the VSWR Fault Indicator signal indicates VSWR faults for longer than a couple of seconds during the first operation of the laser on any given day, this may indicate a genuine fault in the laser. In this case, the operator should proceed to Maintenance and Troubleshooting.

5.4.5 C-70 Microcontroller, I/O Signal Operation

The sequence shown in Figure 5-4 is the normal sequence when the microcontroller comes out of power-on reset (POR). Timing starts with the supply voltage (+ 48 VDC) going into regulation at t_0. Laser OK then signals the ability for normal laser operation to start. The laser can be commanded first by asserting Control Enable (at t_1) and then modulating RF Enable (at t_2). Modulation of Control Enable is not recommended for modulation frequencies above 200 Hz.

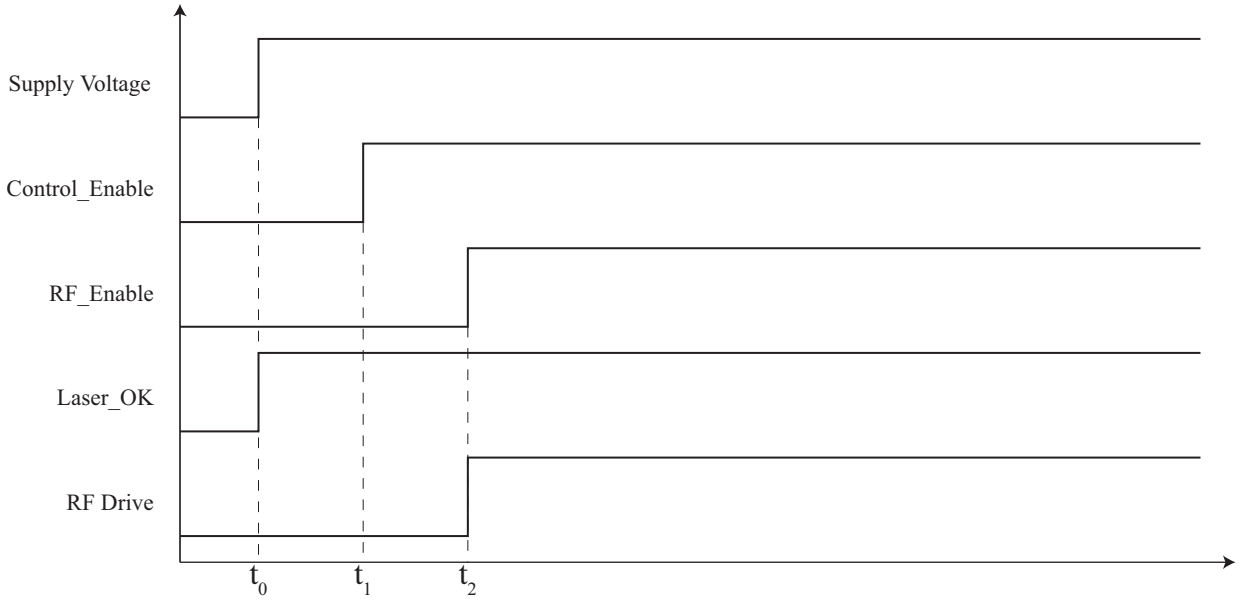


Figure 5-4. Normal Start Sequence

If the laser has been off for a significant amount of time (longer than four days), it may not ignite when first commanded to do so. In this case, the control electronics will detect high-reflected voltage and will issue a standing wave ratio (SWR) fault. Modulation duty cycles of less than 20% (< 25 kHz) are considered safe and will not trip the SWR circuitry.

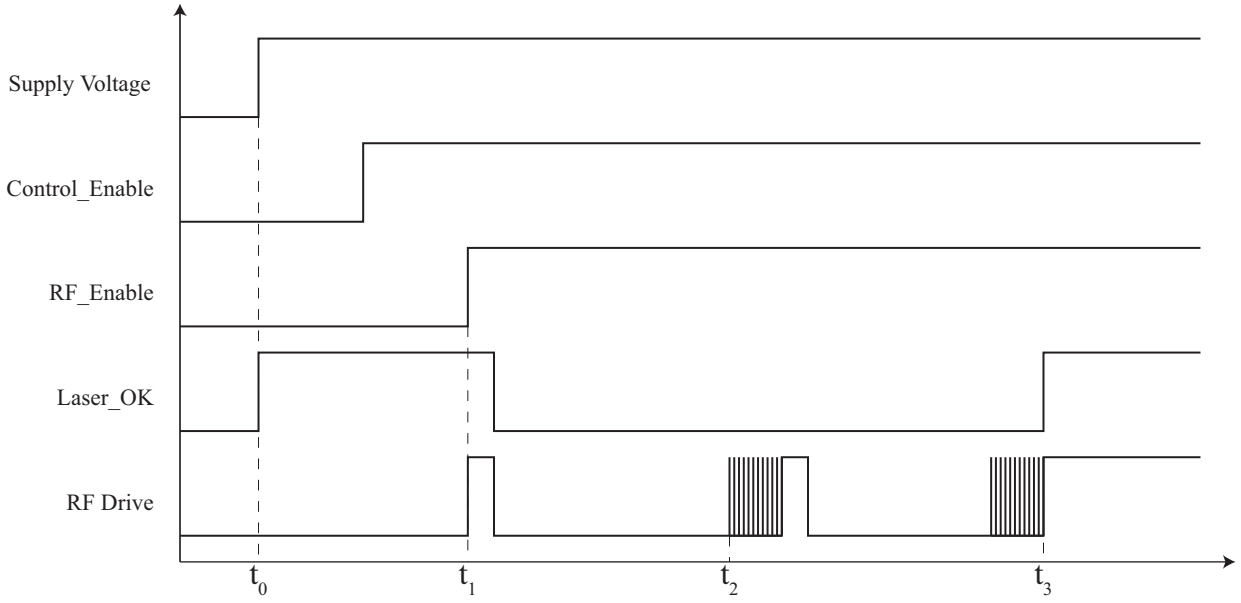


Figure 5-5. SWR Fault Detected

If an SWR Fault is detected, Laser OK will be de-asserted and the laser will enter a cool-down period (at time, t_1, of Figure 5-5). Immediately following this period, reduced modulation pulses are issued by the control electronics to help start the laser (t_2). During this time, Coherent recommends that the customer leave the modulation on RF Enable to increase the effectiveness of this process.

This sequence will repeat until the laser tube reaches proper operation (t_3). At that point, Laser OK will be asserted and customer modulation can proceed.

5.4.5.1 Temperature Fault

High temperature warnings are issued with the Temperature OK signal. In the event that cooling to the laser head is impaired, the Temperature OK signal will de-assert at time, (t_1) of Figure 5-6, but the laser head will continue to function normally. If the temperature continues to rise as shown, the laser head will shut down and Laser OK will drop at t_2 of Figure 5-6; see Table 4-1, “Signal Interface Description and Connector Pinout,” (p. 39) for trip points. To restart the laser, Control Enable has to be reset after laser case temperature drops below warning level with hysteresis of 2ºC. At t_3, resetting the laser failed because the laser case temperature is still too high. At t_4, when Temperature OK becomes true, the laser is reset successfully. Coherent requires that action be taken immediately upon the issuance of the temperature warning signal.

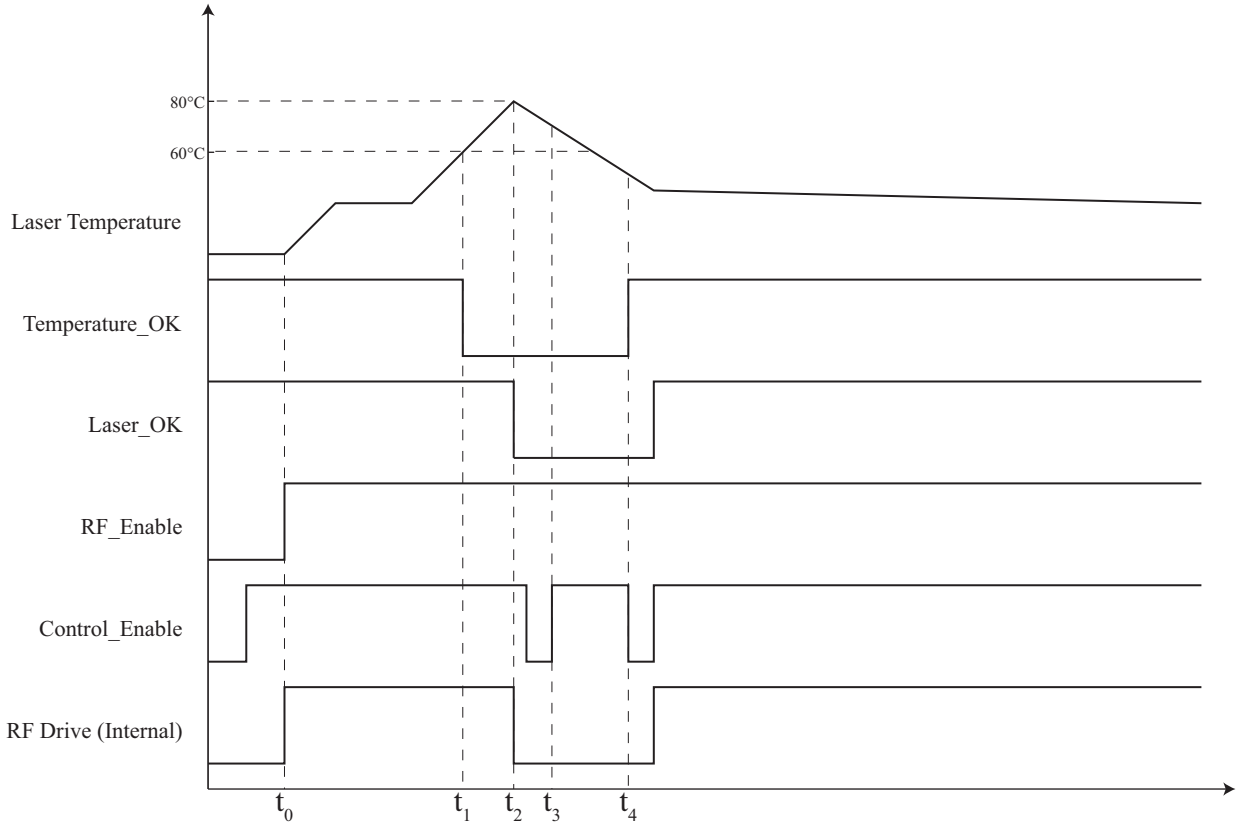


Figure 5-6. Temperature OK Signal Operation

5.4.5.2 Voltage Fault

Voltage OK is a window comparator function (see Figure 5-7). The signal is asserted only when the supply voltage is within regulation limits. The trip points are widened significantly to allow for transient conditions; see Table 4-1, “Signal Interface Description and Connector Pinout,” (p. 39) for trip points.

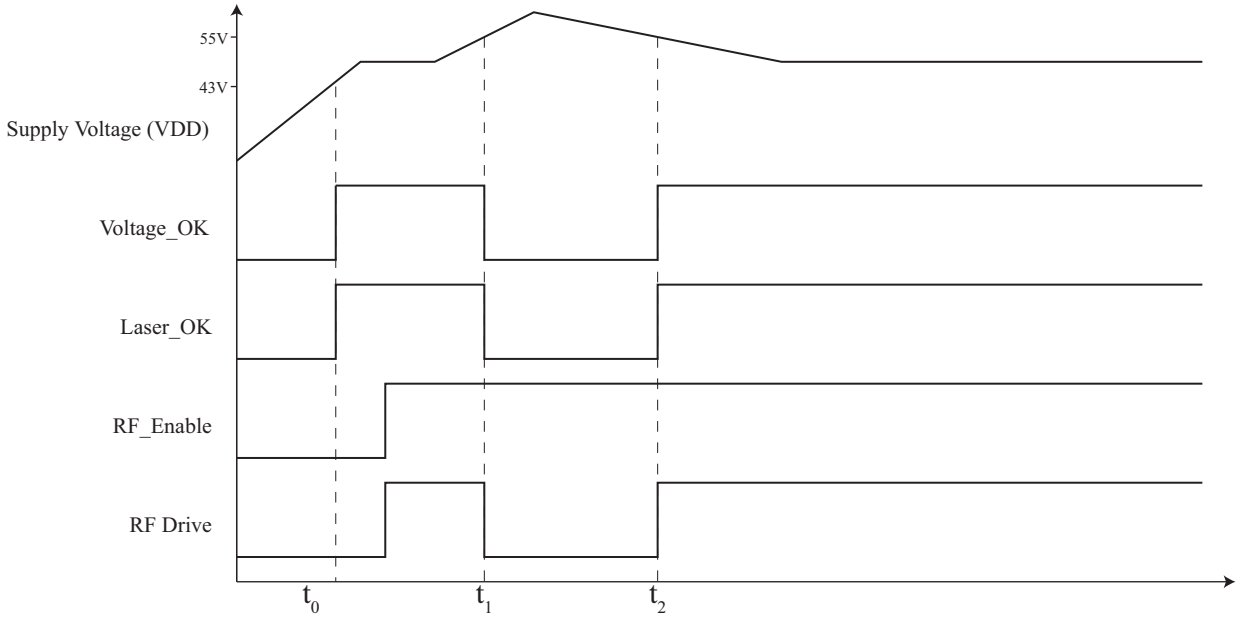


Figure 5-7. Voltage OK Signal Operation

Note that the control electronics do not provide a crowbar function for supply voltages rising without bound. The customer is responsible for ensuring that the supply voltage never exceeds 55 VDC.

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