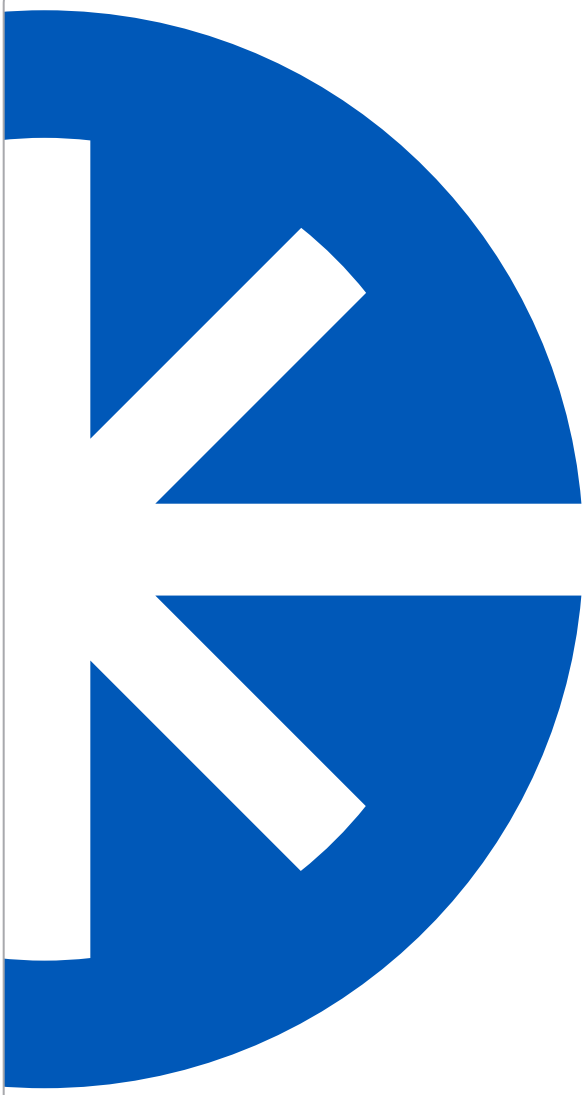

Monaco IR Lasers

Operator's Manual

COHERENT®
Superior Reliability & Performance

Operator's Manual
Monaco IR Lasers

COHERENT.
5100 Patrick Henry Drive
Santa Clara, CA 95054

Patents referenced in this manual are active when the manual is printed (see last page for the date). You are advised to check to see if the patents are still active **http://portal.uspto.gov/external/portal/pair**.

Every effort was made to make sure that the data shown in this document is accurate. The information, figures, tables, specifications, part numbers, and schematics contained in this manual are subject to change without notice. Coherent makes no warranty or representation, either expressed or implied, related to this document. In no event will Coherent be liable for any direct, indirect, special, incidental, or consequential damages caused by any defects in its documentation.

Technical Support

In the U.S.:

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 **Product.Support@Coherent.com** or telephone, 1-800-367-7890 (1-408-764-4557 outside the U.S.). Please be prepared to supply the model and laser head serial number of your laser system also 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.

Outside the U.S.:

If you are located outside the U.S., please visit **www.Coherent.com** for technical assistance, or contact your local Service Representative. Service Representative telephone numbers and addresses can be found on the Coherent web site.

Coherent provides telephone and web-based technical assistance as a service to its customers and assumes no liability for any injury or damage that can occur at the same time with such services. Under no conditions do these support services effect the terms of any warranty agreement between Coherent and the buyer. Operation of any Coherent laser with any of its interlocks defeated is always at the operator's own risk.

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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.

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.

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 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.

Preface

This manual contains user information for the Monaco laser.

WARNING!
Read this manual carefully before operating the laser for the first time. Special attention should be given to the material in "Section One: Laser Safety" that describes the safety features built into the laser.

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

U.S. 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 should be obtained from Coherent or an appropriate U.S. Government agency.

SECTION ONE: LASER SAFETY

NOTICE!
This user information is in compliance with section 1040.10 of the CDRH Performance Standards for Laser Products from the Health and Safety Act of 1968.

DANGER!
The use of controls or adjustments or performance of procedures different from those specified herein may result in hazardous radiation exposure.

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

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

Hazards

Hazards associated with lasers generally fall into the following categories:

- 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.

Optical Safety

Laser light, because of its special qualities, can cause safety hazards beyond that of light from conventional sources. The safe use of lasers requires all operators and all persons near the laser system to know the dangers involved. Users must understand the laser system and the properties of coherent, intense beams of light.

The safety precautions shown below must be read and monitored by all persons operating or near the laser. At all times make sure 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 listed in "Performance Standards for Laser Products," *United States Code of Federal Regulations*, 21CFR1040 10(d).

DANGER!
Direct eye contact with the output beam from the laser will cause serious damage 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 from 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 paint 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 precautions below.
Table for Direct Beam Exposure and Diffuse Reflection
Nominal Ocular Hazard Distance (NOHD)

Recommended Optical Precautions and Guidelines

1. Observe all safety precautions in this operator's manual.
2. All personnel should wear laser safety glasses rated to protect against the specific wavelengths being generated. Protective eyewear vendors are listed in the *Laser Focus World, Lasers and Optronics,* and *Photonics Spectra* buyer's guides. Consult the ANSI, ACGIH, IEC and LIA standards listed at the end of this section for guidance.

3. Table for Optical (OD) for 100 Second Exposure
4. Avoid wearing watches, jewelry, or other objects that may reflect or scatter the laser beam.
5. Stay aware of the laser beam path, particularly when external optics are used to steer the beam.
6. Provide enclosures for beam paths whenever possible.
7. Use appropriate energy-absorbing targets for beam blocking.
8. Block the beam before applying tools such as Allen wrenches or ball drivers to external optics.
9. Limit access to the laser to 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.
10. 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.
11. Post warning signs in the area of the laser beam to alert those present.
12. Exercise extreme caution when using solvents in the area of the laser.
13. Never look directly into the laser light source or at scattered laser light from any reflective surface. Never sight down the beam.
14. Set up the laser so that the beam height is either well below or well above eye level.
15. Avoid direct exposure to the laser light. Laser beams can easily cause flesh burns or ignite clothing.
16. Advise all those working with or near the laser of these precautions.

DANGER!
Laser safety glasses protect the user from eye damage by blocking light at the laser wavelengths. Exercise extreme caution even while wearing safety glasses.

Electrical Safety

Recommended Electrical Precautions

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

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.
6. 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.

Safety Features and Compliance with Government Requirements

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

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

Europe:
The European Community requirements for product safety are specified in the Low Voltage Directive (LVD) (published in 2014/35/EU). The Low Voltage Directive requires that lasers comply with the standard EN 61010-1/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.

CDRH/IEC 60825-1 Compliance

When used with the Monaco power supply, the Monaco laser head complies with the CDRH (21 CFR 1040.10 and 1040.11).

NOTICE
To be CDRH compliant, you *must* use the Coherent power supply with the laser head—the laser head alone is *not* CDRH compliant.

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 Monaco 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.

Protective Housing

The laser head is enclosed in a protective housing that prevents human access to radiation in excess of the limits of Class 1 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!
There are NO serviceable items in the laser head or power supply except those shown in the desiccant replacement procedure. Any opening to break the sealing of the laser head or power supply is not permitted. Do not remove any item from the protective housing except those shown in the desiccant replacement procedure. Opening or breaking the laser head sealing, except as specified in the desiccant replacement procedure, will void the manufacturer's warranty.

Remote Interlock Connector

The Monaco system is equipped with an external interlock connector on the rear panel of the power supply. The terminals of this connector must be electrically joined for the laser to operate [CFR 1040.10 (f)(3)/ EN 60825-1/IEC 60825-1, Clause 6.4].

Key Control

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

Laser Radiation Emission Indicators

The LASER EMISSION indicators on both the power supply and the laser head illuminate approximately 30 seconds before laser emission can occur. The indicators are visible without exposing the operator to laser emission. Amber lights are used which are visible while wearing the proper type of safety glasses [CFR 1040.10(f)(5)/ EN 60825-1/IEC 60825-1, Clause 6.7].

The Monaco laser system is classified by the United States National Center for Device and Radiological Health (CDRH) as a CLASS 4 laser product. It may emit visible or invisible laser radiation wavelengths of 0.9 to 1.1 µm from the aperture in the front of the laser head.

Beam Attenuator

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

Operating Controls

The laser is controlled remotely through its Ethernet, RS232, or USB port. Position the control computer so that the operator has no exposure to laser emission while manipulating the controls. [CFR 1040.10(f)(7)/EN 60825-1/IEC 60825-1, Clause 6.9].

Manual Reset Mechanism

Following an interlock fault or unexpected loss of electrical power, the shutter automatically closes, the laser diodes turn off, and any internally triggered pulsing is disabled. To resume operation clear the fault, turn on the laser diodes, and enable pulsing through the laser's USB, Ethernet, or RS232 interface. The shutter can be reopened through the laser's USB, Ethernet, RS232, or I/O interface or by pressing the SHUTTER OPEN button on the power supply front panel [CFR 1040.10(f)(10)/ EN 60825-1/IEC 60825-1, Clause 6.5].

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

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

Electromagnetic Compatibility

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

Conformance (EMC) concerning emission and immunity is achieved through compliance with the harmonized standard EN 61326-1:2013 (Electrical Requirement for Measurement, Control and Laboratory) for Class A.

The laser meets the emission requirements for Class A, Group 1, as specified in EN55011:2009.

Compliance of this laser with the EMC requirements is certified by the CE mark. Note that CE compliance is dependent on operating the Monaco laser head in conjunction with the Coherent power supply.

Environmental Compliance

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. Coherent is compliant with EN50581:2012 for the RoHS Directive.

China-RoHS Compliance

The China-RoHS Regulation restricts the use of certain hazardous substances in electrical and electronic equipment and applies to the production, sale, and import of products in the Peoples Republic of China. Refer to Figure 1-1 below for product components that are China-RoHS compliant.

China RoHS Substance Table for Laser Heads

PN: 1323912AA	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
光学部件装配 Optic Assembly	X	O	O	O	O	O
组装二极管激光器 Laser Diode 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。

China RoHS Substance Table for Power Supplies and Controllers

PN 1323913AA	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
组装二极管激光器 Laser Diode 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。

China RoHS Substance Table for Systems Products

PN: 1324027AA	产品中有害物质的名称及含量					
部件名称 Part Name	有害物质 Hazardous Substances					
	铅 (Pb)	汞 (Hg)	镉 (Cd)	六价铬 (Cr(VI))	多溴联苯 (PBB)	多溴二苯醚 (PBDE)
印刷电路板组装 Printed Circuit Board Assembly	X	O	O	O	O	O
电缆装配 Cable Assembly	X	O	O	O	O	O
光学部件装配 Optic Assembly	X	O	O	O	O	O
板金组装 Sheet Metal Assembly	X	O	O	O	O	O
组装二极管激光器 Laser Diode 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。

Figure 1-1. China-RoHS Compliant Components

X-Ray Radiation

Plasma X-ray radiation can be generated when exposing a target with laser radiation of high peak intensity. The operator must check if and how X-ray radiation can be produced with the present installation. Figure 1-2 shows an example of X-ray plasma emissions spectra observed in air during the laser ablation of a molybdenum target with a target to detector distance of 12 cm[1] and two peak intensities around 10^{14} W/cm^2. For typical peak intensities of up to 10^{15} W/cm^2 that can be generated with a focused Monaco laser beam, the X-ray spectra will exhibit a peak at around 3-5 keV, with the tail of the emission reaching photon energies of up to 30 keV.

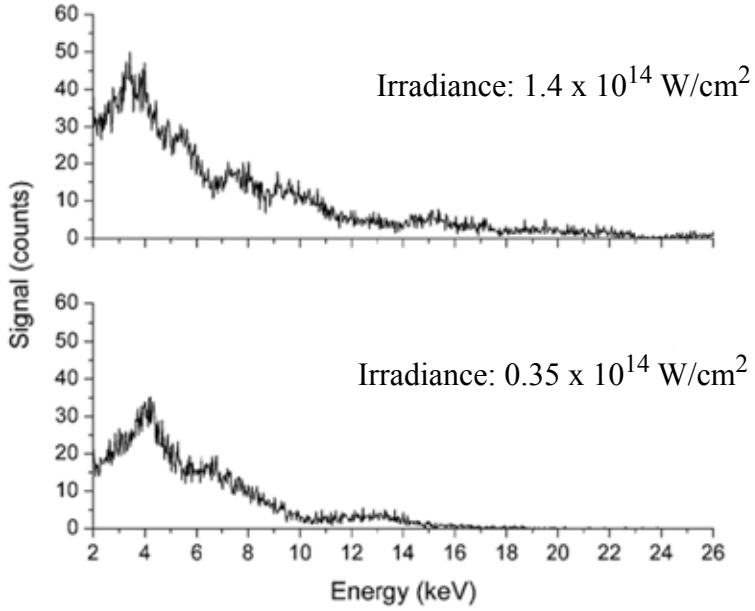


Figure 1-2. Measured X-ray Spectrum of Molybdenum for Different Peak Intensities of the Focused Beam[1] (800 nm, 35 fs, 1 kHz)

WARNING!
If X-ray radiation is generated, it must be checked whether it is subject to notification duty. If so, the regionally competent authority must be informed.

The peak intensity of the focused laser beam can be calculated using:

$$I = 255 \frac{P}{f\ d^2\ \Delta t}\ x\ 10^{15}\ \frac{W}{cm^2}$$

1. M.J. Wesolowski et al. IEEE Transactions on Nuclear Science, Vol. 64, No. 9, September 2017

where P is the average laser power in W, f is the pulse repetition rate in MHz, d is the focus spot diameter in µm, and Δt is the pulse duration in fs. For example, for 100 W of laser power, at a repetition rate of 1 MHz, a pulse duration of 300 fs, and a focus diameter of 20 µm, the peak intensity is 2.12 x 10^{14} W/cm^2.

The biological effect of exposure of the human body to X-ray radiation is referred to as Dose Equivalent H, given in millisieverts (mSv). The Dose Equivalent H is defined by the absorbed X-ray energy in Joules per kg of tissue times a dimensionless weighting factor that varies with the type of tissue and describes the specific sensitivity of the tissue. One Sievert is equal to 1 J of absorbed radiation per kg of tissue. Figure 1-3 shows typical values for the Dose Equivalent H. The recommended annual upper dose limit for the average person is 1 mSv. For occupations with X-ray exposure, this limit is set to 50 mSv.

Chest X-ray	**0.02 mSv**
Plane Flight from Los Angeles to New York	**0.04 mSv**
Annual Dose from Potassium in the Body	**0.39 mSv**
Annual Public Dose Limit	**1 mSv**
Annual Natural Radiation (Average)	**2.4 mSv**
Annual Occupational Dose Limit	**50 mSv**

Figure 1-3. Examples of Dose Equivalent Levels for the Human Body

The Dose Equivalent Rate dH/dt in mSv per hour at 0.2 m distance from a laser beam that is focused on a target with peak intensity I, pulse energy E and repetition rate f can to a good approximation be calculated using[1]:

$$\frac{dH}{dt} = 9\,x\,10^{-14.5} * (I\lambda^2)^{0.65} * E * f$$

where I is the peak intensity in W/cm^2, λ is the laser wavelength in µm, E is the pulse energy in µJ and f is the repetition rate in kHz. This equation holds for peak intensities between 10^{13} and 10^{16} W/cm^2. Figure 1-4 shows the X-ray dose equivalent per hour (in units of mSv/h) for various pulse energies and spot diameters of the Monaco laser with an assumed pulse duration of 300 fs, repetition

1. R. Qui et al. Chinese C, Vol. 38, No. 12, 2014

rate of 400 kHz, and distance from the target of 0.2 m. The Dose Equivalent, H, is proportional to the repetition rate and pulse energy, and inversely proportional to the pulse duration and the square of the distance.

Dose Equivalent H in mSv/h	Pulse Energy in µJ					
Spot Diameter in µm	20	40	60	80	100	120
100						0.44
90					0.37	0.50
80				0.30	0.43	0.58
70			0.22	0.36	0.51	0.69
60		0.14	0.27	0.43	0.63	0.85
50		0.18	0.34	0.55	0.80	1.08
40	0.07	0.23	0.46	0.74	1.06	1.44
30	0.11	0.34	0.67	1.07	1.55	2.09
20	0.18	0.58	1.13	1.81	2.62	3.54
10	0.45	1.42	2.78	4.46	6.45	8.71

Figure 1-4. Calculated Dose Equivalent for Monaco

As a rule of thumb, the Dose Equivalent Rate should be kept below 1 µSv per hour by using proper shielding between the laser focus and the operator. Figure 1-5 shows X-ray absorption data for a variety of materials. This information can be used to help determine barrier effectiveness in shielding from X-rays generated. In general, the X-ray photons below 3 keV are very strongly absorbed in air. The higher energy photons, however, need to be blocked by metal or glass shields. Figure 1-6 shows the X-ray spectrum with and without a 5mm glass view port shield at T=4.6 keV.

NOTICE!
It is recommended that a thickness of at least 5mm of glass, 10 mm of aluminum, or 1 mm of steel be used to shield against X-rays in the plasma spectrum typically emitted by the Monaco laser during laser ablation.

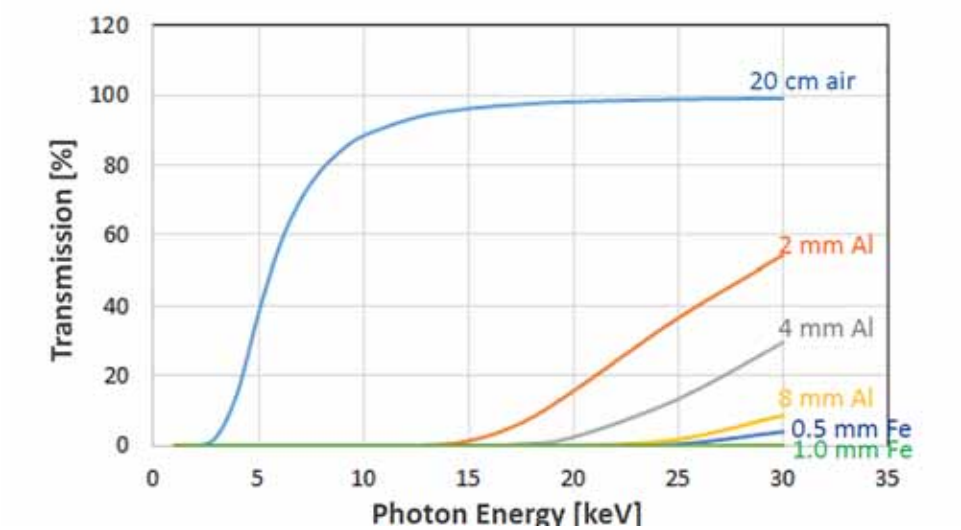


Figure 1-5. Calculated X-Ray Transmission for Various Materials[1]

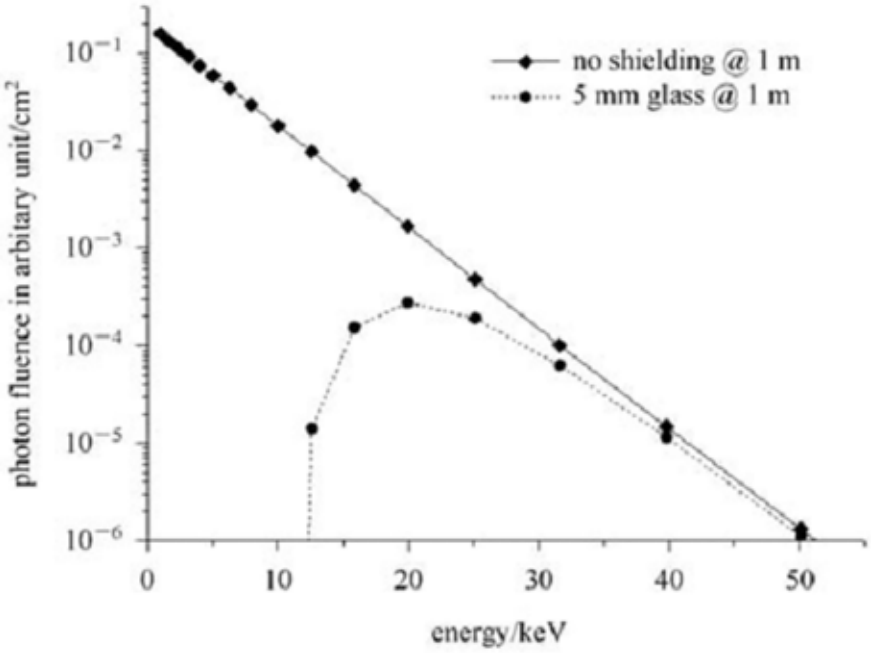


Figure 1-6. X-ray Spectrum With and Without 5 mm Glass Shield[2]

1. X-Ray Absorption Calculator: https://web-docs.gsi.de/~stoe_exp/web_programs/x_ray_absorption/index.php
2. R. Qui et al. Chinese Physics C, Vol. 38, No. 12, 2014

Backreflection

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 to 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 a laser:

- A quarter waveplate that can be mounted at the output of the Monaco laser is included in the accessory kit. It is recommend users make use of the waveplate for polarization insensitive applications.
- 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, particularly when working with metal or reflective surfaces.

EU REACH

On June 1, 2007 the European Union REACH regulation (EC) No 1907/2006 went into force. The REACH regulation deals with the Registration, Evaluation, Authorization, and Restriction of Chemical substances.

Coherent products are classified as "articles" according to EU REACH definition as follows:

Article means an object which during production is given a special shape, surface or design which determines its function to a greater degree than its chemical composition. (REACH, Article 3(3))

Articles as defined by REACH regulations are exempt from registration as long as they are not intended to release a chemical substance.

To the best of our knowledge, all Coherent product meet the definition of "article" according to REACH.

The information here after is provided per article 33 of REACH regulation 1907/2006 from European Commission:

1. Substance name: 1,2 DimethoxyEthane

2 Content: may be above 0,1% weight by weight in batteries.

3. EGMDE use description: Incorporated in Lithium Primary Batteries as electrolyte solvent, is not released during normal or reasonably foreseeable conditions of use of batteries.

4. Conditions of use of batteries remain unchanged: Do not open, do not disassemble, do not damage, do not expose to fire, do not charge, do not insert incorrectly, keep out of reach of children, do not short circuit, do not mix types.

In addition, to the best of our knowledge, Coherent products do not contain any other substances of very high concern (SVHC) above the legally mandated thresholds included in the REACH SVHC list which is updated every six months. The current SVHC list is available on-line at https://echa.europa.eu/candidate-list-table.

Waste Electrical and Electronic Equipment (WEEE, 2002)

The European Union 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. Return the equipment to Coherent or contact the local distributor on procedures for recycling it.

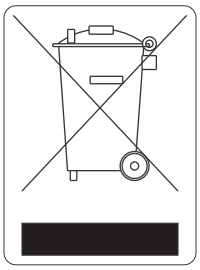


Figure 1-7. Waste Electrical and Electronic Equipment Label

Battery Directive

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

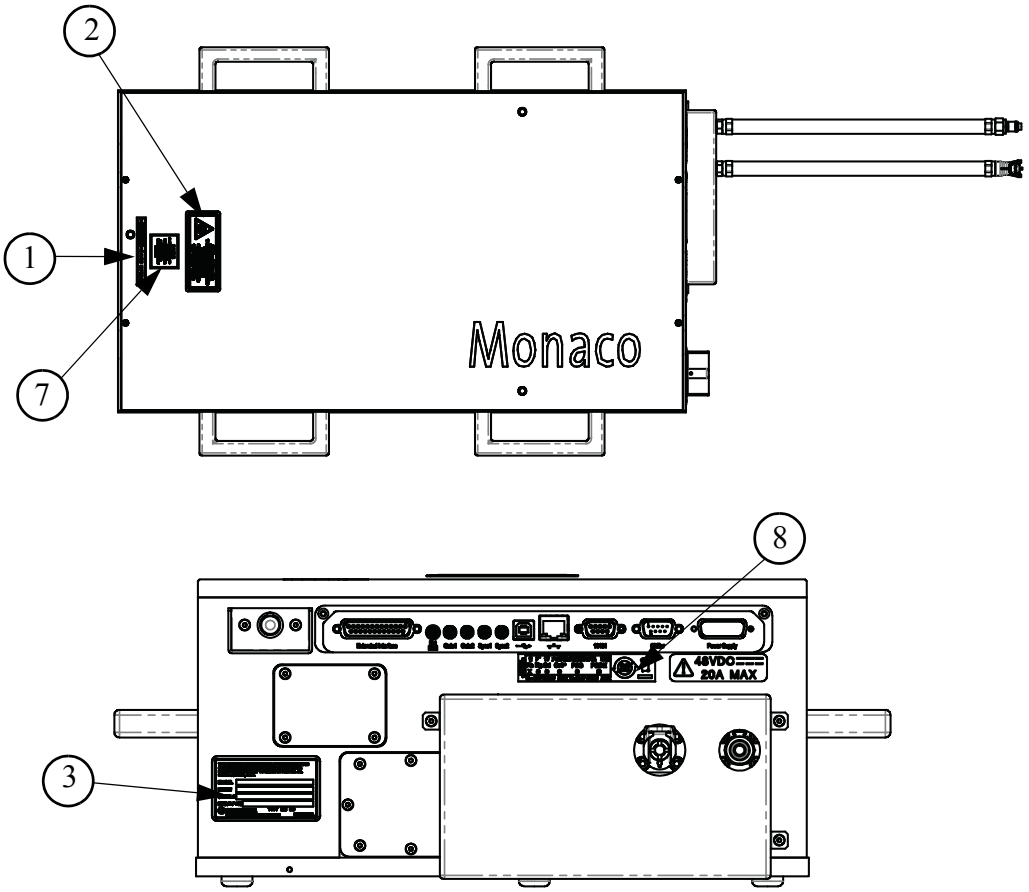
Table 1-1. Batteries Contained in this Product

DESCRIPTION	TYPE
3V Memory Backup Coin Cell	Lithium

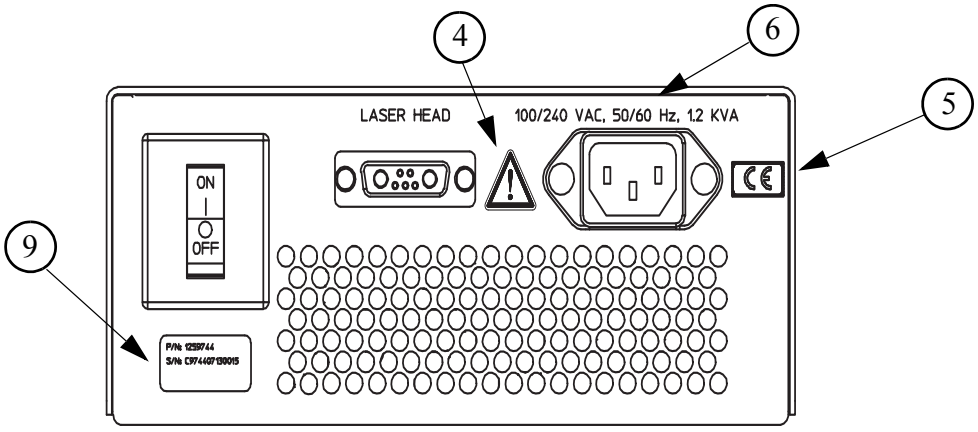
Dispose of batteries according to local regulations. Do not dispose as normal waste. Consult your local waste authorities for guidance.

Location of Safety Labels

Refer to Figure 1-8 for the descriptions and locations of all safety labels. These include warning labels indicating removable or displaceable protective housings, apertures through which laser radiation is emitted, and labels of certification and identification [21 CFR § 1040.10(g), 21 CFR § 1010.2, and 21 CFR § 1010.3/ EN 60825-1/IEC 60825-1, Clause 7].



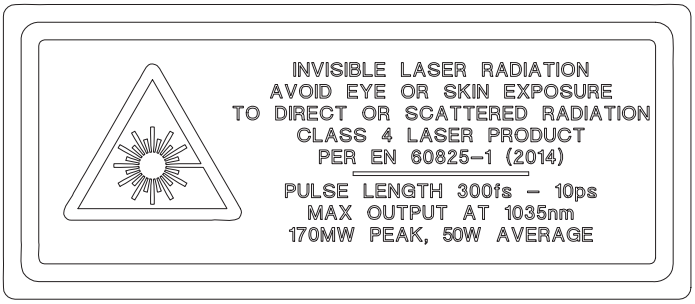
LASER HEAD



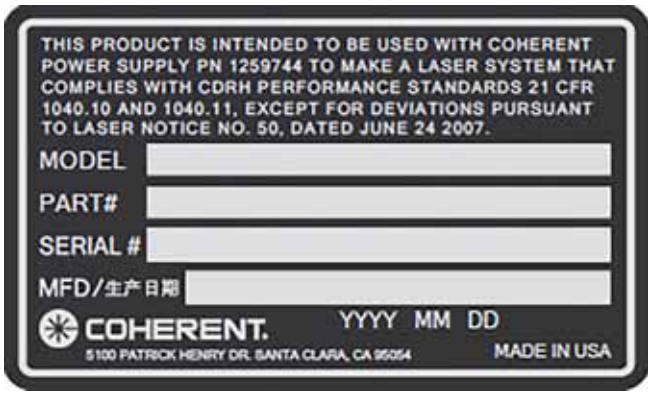
POWER SUPPLY

Figure 1-8. Safety Features and Labels (Sheet 1 of 3)

1. APERTURE WARNING



2. RADIATION WARNING



3. LASER HEAD SERIAL NUMBER IDENTIFICATION

4. CAUTION MARK

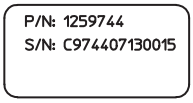
5. CE CERTIFICATION

Figure 1-8. Safety Features and Labels (Sheet 2 of 3)

6. VOLTAGE RATING

7. RADIATION WARNING

8. CHINA ROHS



9. POWER SUPPLY SERIAL NUMBER IDENTIFICATION

Figure 1-8. Safety Features and Labels (Sheet 3 of 3)

Sources of Additional Information

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

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.govl

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 (British Standard)
IEC TR 60825-14

Safety Requirements For Electrical Equipment For Measurement, Control and Laboratory Use
IEC 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

Equipment and Training

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

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

SECTION TWO: DESCRIPTION AND SPECIFICATIONS

System Description

The Monaco laser system is an ultrafast diode-pumped fiber laser with pulse repetition rates from single shot to 50 MHz.

Monaco possesses superior levels of reliability and cost of ownership, unmatched by other femtosecond lasers. The unique headboard electronics interface reduces all laser management to a single head board.

Monaco's compact laser head is machined from a single block of stress-relieved aluminum. This monolithic structure ensures an optical alignment that is kept during the life of the laser. This head encases all of the optical, electrical, and control elements. There are no umbilicals, no cumbersome wiring harnesses between power supply boards, and no remotely located pump diodes. Furthermore the laser head acts as its own clean room environment, thanks to the onboard PureFemto^{TM} cleaning engine ensuring that the interior stays as clean as it was when the laser was built.

The Monaco design and assembly is done under the industry's most stringent test benchmarks. HALT (Highly Accelerated Life Test) and HASS (Highly Accelerated Stress Screen) standards are the hallmarks of the design philosophy behind the Monaco. All components, as well as the full system, are tested to environmental levels well beyond normal application conditions. This attention to vigorous testing ensures that the Monaco quality and reliability levels are beyond that of any other femtosecond laser.

Figure 2-1. Monaco Laser System

Monaco Laser Head

The optical elements of the laser head include a seed laser, seed acousto-optic modulator (AOM), amplifier, and output acousto-optic modulator (AOM).

The Monaco features several modes of operation for precise control over the output pulses. See "Operating Modes" on page 4-13 for a complete description of seed laser and amplifier functionality. See Figure 2-2 below for the seed laser and amplifier block diagram.

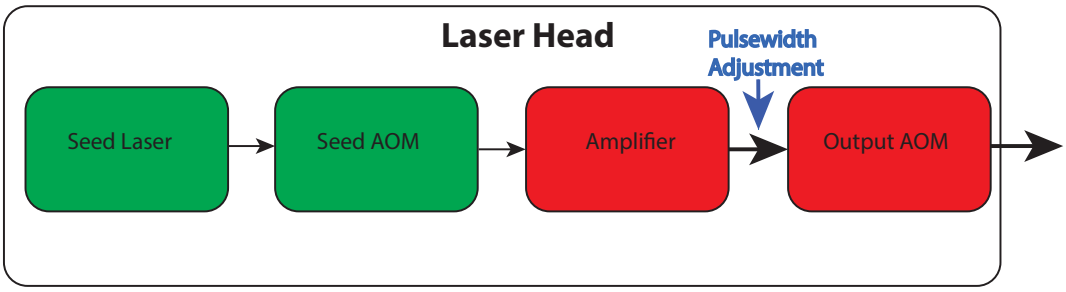


Figure 2-2. Laser Head Block Diagram - Seed Laser, Amplifier, and AOM

Seed AOM & Seeder Burst

A modelocked seed laser provides a high repetition rate pulse train for subsequent pulse picking and amplification. A fast AOM on the seed laser output allows the pulse train to be divided-down to achieve lower repetition rates, and suitable gating of the seed AOM offers single or bursts of pulses in the reduced repetition rate pulse-train. The pulse train is then delivered to the amplifier.

User settings allow control of the reduced repetition rate from the seed AOM and the number of pulses in each seeder burst. This seeder burst allows pulses to be delivered separated by approximately 20 ns. An example of a seeder burst containing 5 pulses is shown in Figure 2-3.

Output AOM

The pulse train from the seed AOM is further amplified in a high-gain amplifier, which exits the laser through an output AOM. The output AOM allows a wide range of gating, power tuning and pulse selection options. For a full description of these options see "Operating Modes" on page 4-13. The user has multiple options with the seed AOM in conjunction with output AOM.

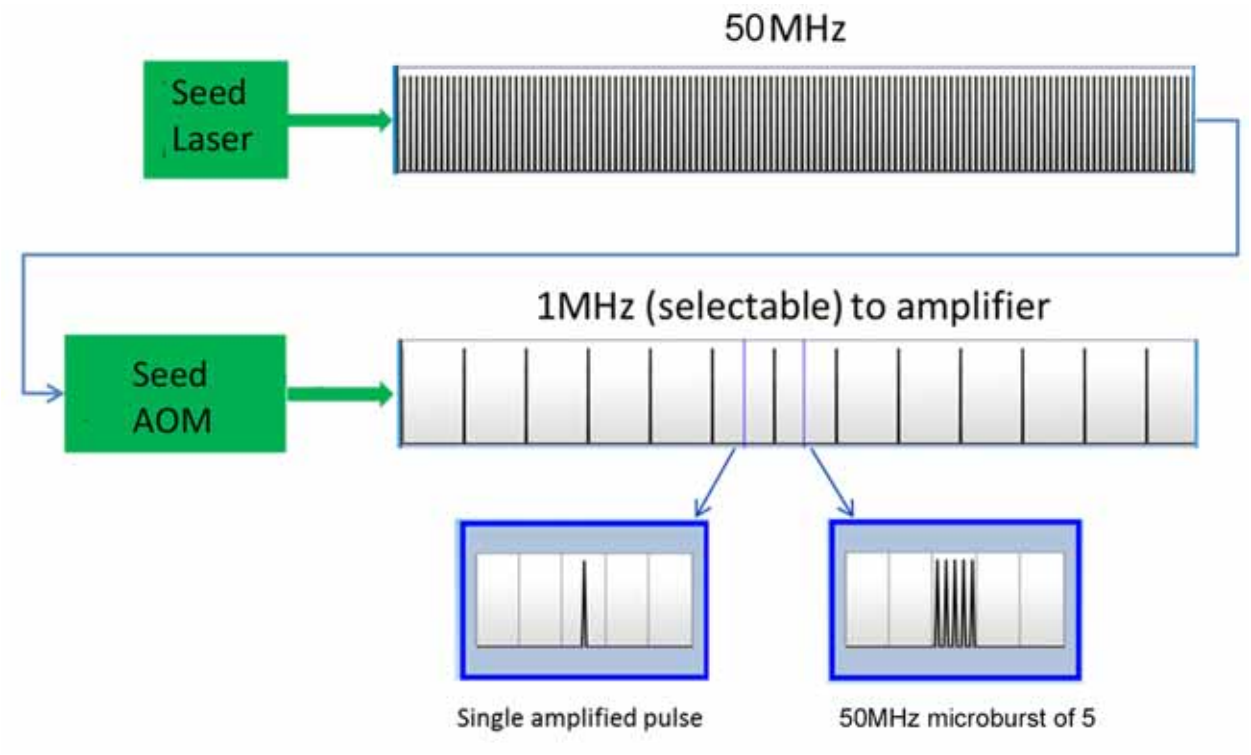


Figure 2-3. Seed Laser AOM & Seeder Burst Example

Specifications

The specifications for the Monaco laser are summarized below. Full specifications for all Coherent products can be found at **www.Coherent.com.**

Table 2-1. Monaco Specifications

SPECIFICATIONS[A]	MONACO 1035-40	MONACO 1035-80
Wavelength (nm)	1035 +/- 5	1035 +/- 5
Average Output Power (W)	40	40
Energy per Pulse (µJ)	40 @ 1 MHz	80 @ 500 kHz
Pulse Repetition Rate Range	Single Shot to 1 MHz. Higher rep rates without AOM pulsepicking 1-50 MHz	
Pulsewidth (fs)	<350 fs[b]	
Pulsewidth Tuning Range	<350 fs to >10 ps	
Spatial Mode	TEM_{00} (M^2 <1.2)	
Beam Divergence (mrad, 2F)	<1.0	
Beam Diameter $1/e^2$ (mm)	2.7 ± 0.3[c]	
Beam Circularity (%)	>85	
Polarization Ratio[d]	>100:1 Vertical	
Beam Pointing Stability (µrad/°C)	<25	
Pulse Energy Stability (%, RMS)	<2	
Power Stability (%, RMS, 2σ)[e]	<2	
Warm-up Time (minutes) Cold Start Warm Start	 <45 <15	
Long-term Beam Pointing Stability (µrad, at fixed rep-rate)	±25 over 8 hours	
Power Consumption[f] (typical)	48VDC, <500W	
All specifications are subject to change without notice.		

a. All specifications at full energy and repetition rate.
b. Based on $sech^2$ deconvolution factor of 0.65 times autocorrelation width.
c. Measured at 1m from laser output window.
d. External isolation required depending on application.
e. Measured at 100% power.
f. Optional 110-240VAC power supply available.

Table 2-2. Environmental Specifications

PARAMETER	VALUE
OPERATING SPECIFICATIONS	
Temperature (Non-Condensing): Laser Head Power Supply Relative Humidity (%):	 +10 to 30°C (50 to 86°F) -20 to +60°C (-4 to 140°F) <90, non-condensing
NON-OPERATING SPECIFICATIONS	
Temperature (Non-Condensing): Storage Shipping	 +5 to 65°C (41 to 149°F) -20 to +60°C (-4 to 140°F)

Table 2-3. Laser System Dimensions

	POWER SUPPLY	LASER HEAD
Length	37.8 cm (14.9 in.)	66.9 cm (26.3 in.)
Width	19.2 cm (7.6 in.)	36.0 cm (14.2 in.)
Height	8.3 cm (3.3 in.)	18.1 cm (7.1 in.)
Weight	4.5 kg (10 lb)	48.6 kg (107 lb)
POWER SUPPLY CABLE LENGTH: 3 m (10 ft.)		
Note that the crated laser dimensions are 74 x 132 x 94 cm (29 x 52 x 37 in.), and the approximate crated weight will be 136 kg (300 lbs).		

SECTION THREE: INSTALLATION

Receiving and Inspection

Inspect the shipping containers for indication of rough handling or damage. Record any signs of damage on the bill of lading. Report any damage immediately to the shipping carrier and to Coherent Order Administration Department (800-438-6323) or to an authorized Coherent representative.

NOTICE!
Keep the original shipping containers. The container is necessary if the system is returned to the factory for service. The containers may also be needed to support a shipping damage claim.

DANGER!
To prevent injury, Coherent recommends that at least two people unpack and transport the Monaco laser system.

Installation

This section describes the Monaco electrical interface and provides quick-start instructions with commands to control the laser. The Monaco continues to be refined before production and any information in this document is subject to change. Refer to future revisions of this manual for updated descriptions of the interface.

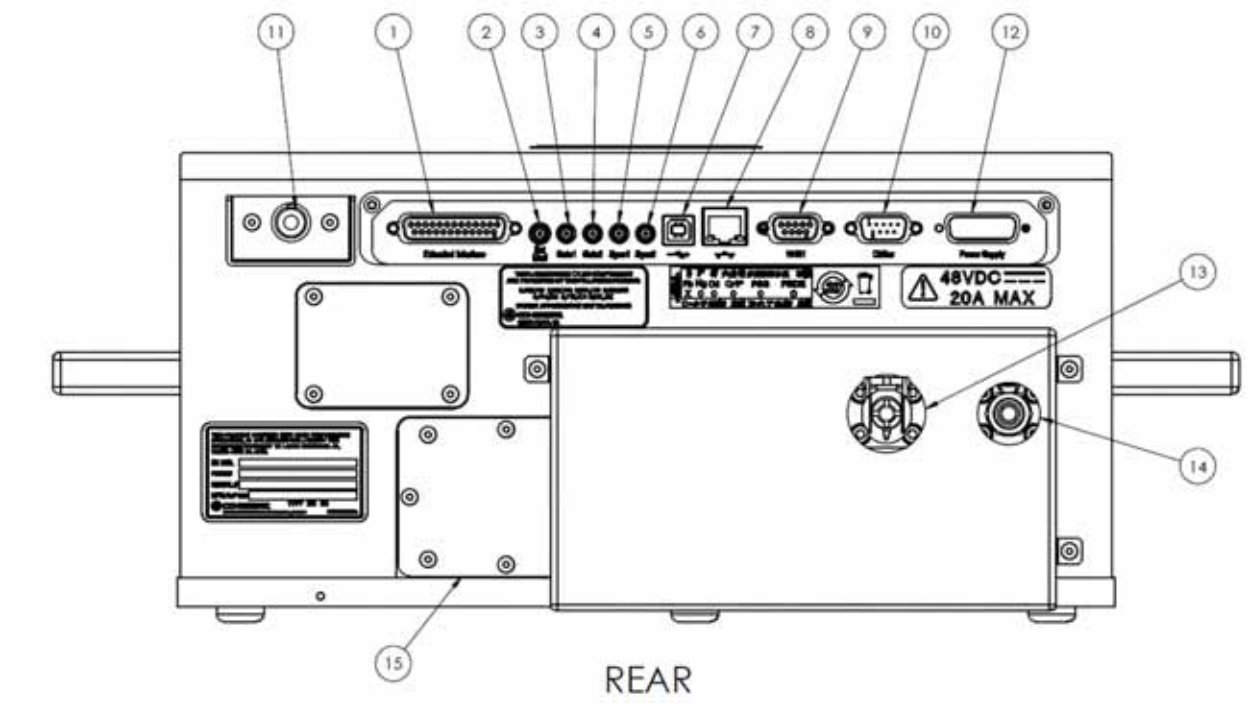
NOTICE!
It is the customer's responsibility to comply with IEC60825 safety standards during any use of the signals described in this document.

Hardware Setup

Remove the laser head, power supply and chiller from their shipping crates.

1. Coherent recommends that at least two people unpack and transport the Monaco laser system. The power supply weight is approximately 4.5 kg (10 lb) and the laser head weight is approximately 48.6 kg (107 lb).
2. Arrange the chosen power supply and the laser head into their operating positions in an accessible location, preferably away from heat sources. The laser head must be mounted flat and horizontal with feet down. Confirm the power supply cooling air intake and exhaust (front and back) are not blocked or obstructed (refer to Figure 4-14 and Figure 4-15). Coherent recommends using a kinematic alignment plate to enhance the mounting repeatability of the laser head. A mounting plate can be procured from by Coherent (part number 1303793).
3. Remove the protective plate mounted to the front of the laser over the aperture.
4. Block the laser beam using a beam stop.

5. Refer to Figure 3-1 while performing the following instructions.

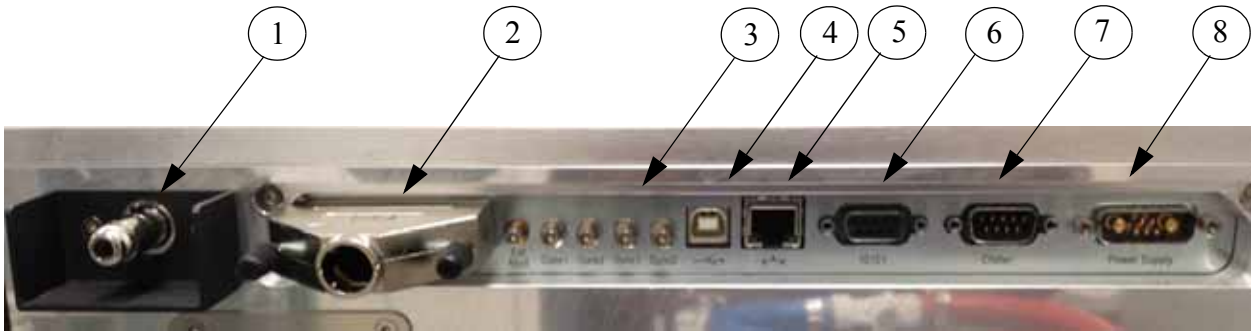


1. Extended Interface
2. EXT MOD Input
3. Gate 1
4. Gate 2
5. Sync 1
6. Sync 2
7. USB Connector
8. Ethernet Connector
9. RS-232 Connector
10. Chiller RS232
11. External Interlock
12. Power Supply Cable
13. Coolant In
14. Coolant Out
15. Desiccant Access

Figure 3-1. Laser Head Connections Diagram

6. Connect the power supply cable to the laser head and to the power supply. When connecting cables to the laser head, press them firmly into place before tightening with the jack screws. Do not overly tighten the screws or use them to pull the connector into place.
7. Insert the Chiller cable, Extended Interface defeat plug, and External Interlock defeat plug into the applicable connectors on the laser head.
8. Connect the AC power cord to the rear of the power supply.

9. Connect the power supply AC power cord to building power. See Figure 3-2 below.



1. External Interlock defeat plug
2. Extended Interface defeat plug
3. Synch BNC connector
4. USB connector
5. Ethernet connector
6. RS-232 connector
7. Chiller RS-232 connector
8. Power cable

Figure 3-2. Laser Head Connections Photograph

Chiller Setup

NOTICE!
If additional external coolant plumbing lines or fittings are required for the chiller, use only plastic fittings and opaque high-quality hose (such as food grade) with no stop valves. To prevent damage, DO NOT use any metal materials (for example brass, stainless steel, or copper).

To minimize the pressure drop and maximize the chiller efficiency through the connecting hoses, the chiller should be put as close as possible to the laser head. Coolant lines are best run at or near the same level as the cooling system. For more information, refer to the chiller product manual and "Appendix B: Thermal Management" on page B-1. **Do not start the chiller or laser before reading the chiller instructions. Only chillers authorized by Coherent are to be used with the laser head.**

1. Connect the coolant lines between the chiller and the laser head. Inlet and outlet connections for the coolant hoses must match with the label.

2. Check that fittings are tight to prevent leaks.

NOTICE!
To avoid damage to the Monaco system, use ONLY distilled water (with 28% CoolFlow DTX) in the chiller's closed loop system. DO NOT use facility tap or deionized water. Refer to "Appendix B: Thermal Management" on page B-1.

3. Fill the chiller reservoir with the coolant specified in the appendix section "Thermal Management."
4. Remove the left side panel of the TermoTek P307 chiller carefully and unplug the ground lead.
5. Check that the correct voltage plug is attached to the internal connector (see Figure 3-3 below). To change the input voltage detach the plug from the internal connector, detach the female protection connector from the selected voltage plug, and re-insert it for protection into the previous plug. Connect the selected voltage plug with the internal connector.

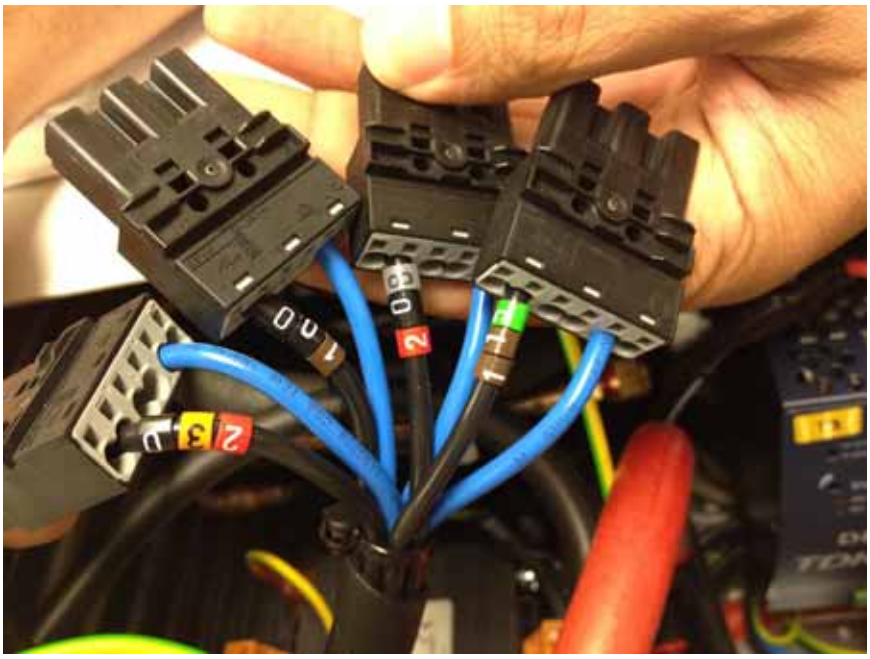


Figure 3-3. P307 Chiller Voltage Inputs (230VAC plug shown connected)

6. Connect the ground lead to the left side panel, and re-install the panel.

7. Attach the AC power cord.
8. Connect the chiller AC power cord to facility power.
9. Note that chiller flow rate should initially be set to >5.0 lpm, and should be checked during laser operation referencing the chiller front panel display or by using the serial command ?CHF to ensure that it stays above 4.0 lpm. The flow rate can be adjusted using the bypass valve on the front of the chiller (see Figure 3-4 below). Once the chiller is operating, loosen the bypass valve locking nut and twist the knob to adjust the flow rate.

Figure 3-4. P307 Chiller Bypass Valve

NOTICE!
To avoid damage to the Monaco system, ensure the chiller flow rate remains constant while power is being supplied to the laser head (even when the system is in the Standby state).

Chiller RS-232

Coherent uses a custom cable to connect between the TermoTek P307 chiller and Monaco head. The TermoTek P307 chiller is recommended for the Monaco laser. Other chillers can be used, but need to be approved by Coherent. Please contact Coherent for details about electrical connections to other chillers.

Monaco Connectors

There are twelve connectors on the back of Monaco laser head to connect equipment. Figure 3-1 shows the location of the connectors.

Computer Interface

A Windows computer is the user interface necessary to operate the Monaco laser system. The Monaco can be connected to the computer through an Ethernet, USB, or RS-232 interface.

RS-232 Connector

The customer RS-232 connection is a standard female 9-pin D-sub (DE-9) connector. A cable with a male connector is required to use this interface. The RS-232 pins shown in Table 3-1 must be connected. The only data rate supported is 19200 Baud.

Table 3-1. RS-232

PIN	SIGNAL NAME	DESCRIPTION
3	TxD	Transmit data (RX into laser).
2	RxD	Receive data (TX from laser).
5	GND	Common ground
1,4,6,7, 8,9		No connection.

USB Connector

This connection uses a standard USB connector on a PC for computer control of the laser. The USB connector uses the industry standard type B receptacle. The USB uses industry standard signal levels and Microsoft's RNDIS protocol.

Ethernet Connector

The Ethernet connector uses the industry standard receptacle for an RJ45 connector (sometimes called an 8P8C connector). It connects to a switch, router or PC using a Cat 5 cable. Once the IP address of the laser is known, a Telnet session can be established to the Monaco using the same commands as the RS-232 or USB connections.

The laser automatically acquires an IP address from a DHCP server, if one is provided on the Ethernet network.

If the network does not have a DHCP server (for example, in a tool with a private network), then by default the laser will scan from 192.9.200.1 to 192.9.200.255 to find an unused IP address. This range can be changed with the IPMIN and IPMAX commands, respectively.

The laser can be assigned a static IP address by setting AUTOIP=0 and IP=nn.nn.nn.nn. There are other commands that can be useful to a network administrator for unusual configurations. Type the queries ?HELP NET or ?HELP DHCP into the command prompt to see them all.

The Coherent GUI can display the IP address of the laser as long as the computer is on the same subnet as the laser. To see the IP address, from the GUI Main menu press the CONNECTION button, then the SEARCH button. The Ethernet Discovery screen appears, where the laser IP address can be identified with the corresponding laser serial number in the list. To connect a laser, select the laser you want to connect and press the CONNECT button. This establishes GUI connection with the selected laser and returns the GUI to the Main tab.

Lockout Function

Because Monaco lasers allow multiple connections to the laser, there is a safety concern about unintended control of the laser by unauthorized operator(s). The Lockout function ensures that only one connection can have control of the laser at any given time and locks out other remote devices or connections from controlling the laser. The laser can be monitored from multiple connections or remote control devices, but it can be controlled from only one connection. Note that multiple Ethernet control sessions with the same IP address from one computer are considered as one connection and therefore allow parallel control of the laser.

When a LOCKOUT=0 command is issued from the current control connection (or toggle off the Lockout button on the GUI menu), it unlocks the laser to release control to other remote control devices. The next remote device issuing a command to the laser will obtain exclusive control, which sets LOCKOUT=1 for that device.

Interlocks

The system will not operate with an interlock circuit open. The fault can be cleared when the interlock is closed. The fault must be cleared to restart the laser. The laser has two interlock defeat plugs in the Accessory Kit to close the interlocks when they are not used by the customer (see Figure 3-2 on page 3-4).

Interlock Connector

The interlock connector may be connected to customer equipment for safety, such as to switches on access doors. As long as the interlock connection is made, the laser will operate. A 12 mA current loop supplies power to this connection. A 3-pin ITT connector is used on the Monaco head with the following connections.

Table 3-2. Interlock Connector

PIN	SIGNAL NAME	NOTES
1	EXT_INTERLOCK+	Short to pin 2 to enable diode current; 24 V 12 mA. Short must be less than 100 ohms. Open must be greater than 10 k ohm.
2	EXT_INTERLOCK-	
3	N/C	Reserved. Do not connect

The recommended mating plug is ITT Cannon M-XL-3-11M.

Extended Interface

The extended interface connector provides an additional customer interface. Table 3-4 describes how each signal should be managed. Coherent provides an interface defeat connector that is configured to allow the laser to operate without using these interface inputs. If the user does not use this interlock defeat the appropriate voltage levels must be maintained for the laser to operate (see Table 3-4 below).

Table 3-3. Extended Interface Connector

Connector	Tyco Electronics 207464-7
Connector Pins	Tyco Electronics 1658539-1
Connector Back Shell	Framatome Connectors (FCI) 8655MH2501BLF

Table 3-4. Extended Interface/RS-232 Connector Pinouts

PIN	SIGNAL NAME	SIGNAL	DIR	DESCRIPTION
1	GND	Ground	–	
2	+24V	+24 V	Out	4 A fuse - Monaco is able to drive 0.5 A max
3	EXT_INTERLOCK+	Current loop	Out	Pins 3 and 4 must be connected for the laser to operate. These signals should be connected to customer equipment for safety, such as switches on access doors.
4	EXT_INTERLOCK-	Current loop	In	
5	LASER_READY	TTL	Out	High when laser is ready to pulse.
6	SYSTEM_STATUS	TTL	Out	High when status is OK. Low when Fault occurs.

Table 3-4. Extended Interface/RS-232 Connector Pinouts (Continued)

PIN	SIGNAL NAME	SIGNAL	DIR	DESCRIPTION
7,8,9, 10	Reserved			
11	Laser Shutdown	TTL	In	High to operate the laser. Hold low for 2-3 seconds to shut down the laser. Pulled down through 10 k ohm to Ground.
12	FF-Interlock	TTL	In	Pulled down through 10 k ohm resistor to ground. Connecting to ground disables laser. The FF-Interlock is a fast shutdown and hard wired to immediately turn off AOM2 and the diodes.
13	Shutter Status: OPEN	TTL	Out	Direct connection to shutter (5 V = open)
14	Shutter Status: CLOSED	TTL	Out	Direct connection to shutter (5 V = closed)
15	Pulse Energy Control	0-5 V / 10 kΩ	In	Analog Input pulse energy control via AOM2 (note output power is not linear with voltage). See "Beam Modulation Modes" below for details on how to set the mode to use this pin.
16	GND Pulse Energy Control	Ground	–	
17	Shutter Control	TTL	In	Pulled down through 10 k ohm resistor to ground. Ground closes shutter.
18	GND Shutter Control	Ground	–	
19	Pulse Picker Enable	TTL	In	Pulled down through 10 k ohm to ground. High to allow control of the AOM2 pulse picker. Low to disable the AOM2 pulse picker. Output laser pulses stop when the AOM2 pulse picker is disabled.
20	GND Pulse Picker Enable	Ground	–	
21	(No Signal)			In the interlock defeat plug, this provides +5V to enable high active pins 11,12,15,17,19. Not to be used for any other purpose.
22	Reserved			Not to be used for any other purpose.
23, 24, 25	Reserved	No connection.		

Beam Modulation Modes

The Monaco allows for several different ways to modulate the pulse energy as shown in Table 3-5 below. The laser parameters can be adjusted manually or through Coherent's GUI.

Table 3-5. Beam Modulation Modes and Inputs

		Beam Modulation Operating Mode		
		Internal Mode	**External Mode Using EXT MOD Connector**	**External Mode Using Extended Interface Connector (pin 15)**
Laser Parameters	**Query / Commands to Set the Parameter**			
External Modulation	?EM; EM=0; EM=1	0	1	Doesn't matter
Pulse Energy (%)	?RL; RL=xx.xxx (0.000 to 100)	0.000-100.000	Doesn't matter	0
Analog Inputs	**Analog Input Range (V)**			
EXTENDED INTERFACE connector - pulse energy control (pin 15)	0.00 - 5.00	Must be 0 V or no connection	Must be 0 V or no connection	0.00 - 5.00 V
EXT MOD connector	0.00 - 5.00	Doesn't matter	0.00 - 5.00 V	Must be 0 V or no connection

EXT MOD Input

The EXT MOD connection allows modulation of the output beam when in the external modulation mode. External modulation through the EXT MOD BNC connector is enabled from the GUI Triggering tab (see Figure 4-4 on page 4-7), or by using the serial command EM=1. The laser will provide analog modulation to vary pulse energy corresponding to the input wave form. Note this does not serve as a trigger input as it does not affect pulse repetition rate or timing. The fastest modulation possible is approximately a 1 MHz square wave. The output power is not linearly proportional to the input applied, and may require some testing to get the desired response. Also note that if there is a signal to pin 15 of the External Interface (see Table 3-4 above) it will override the input to the EXT MOD BNC connector.

Signal Levels/Impedance: 0 to 5 V waveform/500 ohm series resistor. The signal must not have any negative or positive offsets.

NOTICE!

To avoid damage to the Monaco system, note that the load on the external modulation is approximately 500 Ohms and the input voltage should never exceed 5V.

Table 3-6. External Modulation Connector

Connector	HD-BNC Amphenol 034-1030
Mating connector	Amphenol 034-5017
HD-BNC to BNC Adaptor	APH-BNCJ-HDNBNCP
HD-BNC to BNC cable 12"	Amphenol 095-666-44815

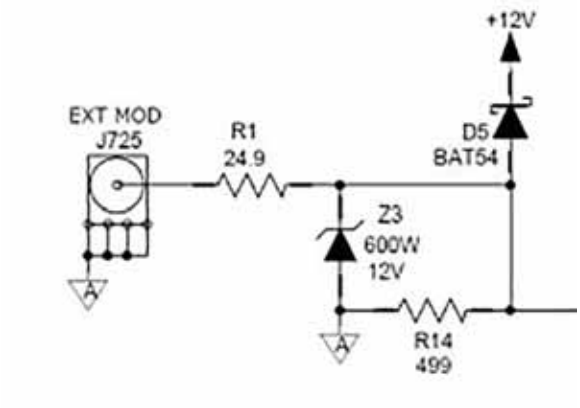


Figure 3-5. External Modulation Diagram

Sync 1 and Sync 2

The sync connections allow for synchronizing external events with the laser output by providing output signals which are synchronous with the laser pulses. The output signals are a fixed delay from laser pulses and approximately 50 ns wide. Sync 1 follows the AOM1 signal and is a fixed delay and width from the actual seed pulse out of AOM1 (should be measured as it varies from laser to laser). Sync 2 is a representation of the drive signal for AOM2 and will follow the pulse mode selected. For example, for a 1MHz laser in Divided Mode with RRD=2 then Sync2 will have 500kHz output (see "AOM Pulse Modes" on page 4-16 for more information). Adapters for connecting the HD-BNC connectors with standard BNC connectors are included in the Accessory Kit for the laser.

Table 3-7. Sync Connection

Connector	HD-BNC Amphenol 034-1030
Mating Connector	HD-BNC Amphenol 034-5017
HD-BNC to BNC Adaptor	APH-BNCJ-HDBNCP
HD-BNC to BNC Cable 12"	Amphenol 095-666-44815
Signal levels/Impedance. Source is four parallel 74ACT541 drivers at 5.0 V. Designed to drive a 75 ohm line.	

Gate 1 and Gate 2

The gate input connection provides external pulse control. Gate 1 is used to control the duration of a string of pulses. If the Pulse Mode is set to 1 (PM=1 or by clicking the Enable External Gate button on the Triggering tab of the GUI), laser pulses will be produced as long as the Gate 1 signal is high. Gate 2 is a spare for future use. Adapters for connecting the HD-BNC connectors with standard BNC connectors are included in the Accessory Kit for the laser.

Table 3-8. Gate Connector

Connector	HD-BNC Amphenol 034-1030
Mating Connector	HD-BNC Amphenol 034-5017
HD-BNC to BNC Adaptor	APH-BNCJ-HDBNCP
HD-BNC to BNC Cable 12"	Amphenol 095-666-44815
Signal levels/Impedance: 3.3 V to 5.0 V is a high input, 0 to 0.5 V low input. 10 kohm series resistor.	

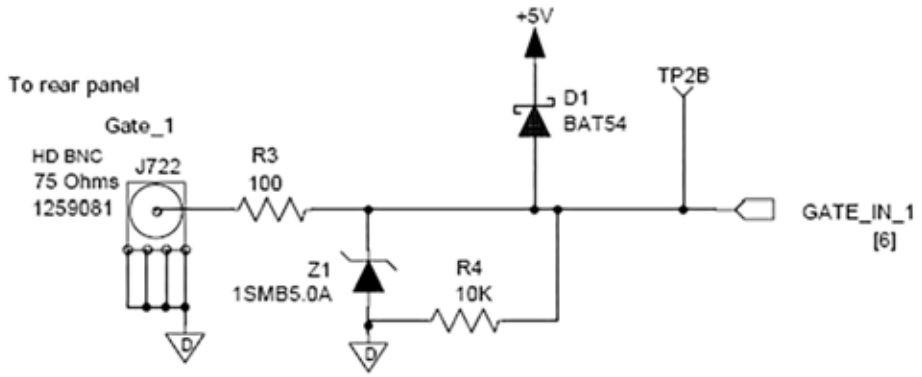


Figure 3-6. Gate Diagram

Power Supply Connector

The cable connection between the power supply and head uses a 7W2 D-sub connector with the pinout shown in Table 3-10 below. The power supply has a receptacle, the laser has a plug. One or two LEDs may be wired in series with the key switch to provide an emission indication.

Table 3-9. Power Supply Connector

Connector	Norcomp 680S7W2203L401
Mating Connector	Norcomp 680S7W2103L401

Table 3-10. Power Supply Connector Pinouts

PIN	SIGNAL NAME	DESCRIPTION
1	KEY_SW+	CDRH keyswitch input and emission indicator drive. Short to pin 5 indicates key is in the enabled position. Open indicates key off. Short must be less than 100 ohm. Open must be greater than 100 k ohm, 12 mA and 24 V.
2	SHUTTER LED+	Shutter position indicating LED is on when the shutter is open. Drive is 12 V at 3 k ohm when shutter is open. This is the LED anode connection.
3	SHUTTER BUTTON	Short this pin to pin 4 to request a change in the shutter state from open to close or close to open. 10 k ohm pull-up to 3.3V, 511 ohm series resistance.
4	GND	Shutter indicating LED cathode connection and reference for the shutter button.
5	KEY_SW-	Key_SW- signal passes through an optocoupler to ground. This is used to sense the position of the keyswitch. The optocoupler output signal is then passed on to the microcontroller and safety circuits.
A1	48V	10 AWG wire recommended for connecting directly to the +48 V output of the power supply.
A2	GROUND_RETURN	10 AWG wire recommended for connecting directly to the Ground return of the power supply.
Shield	Chassis GND	Chassis connection for shielding.

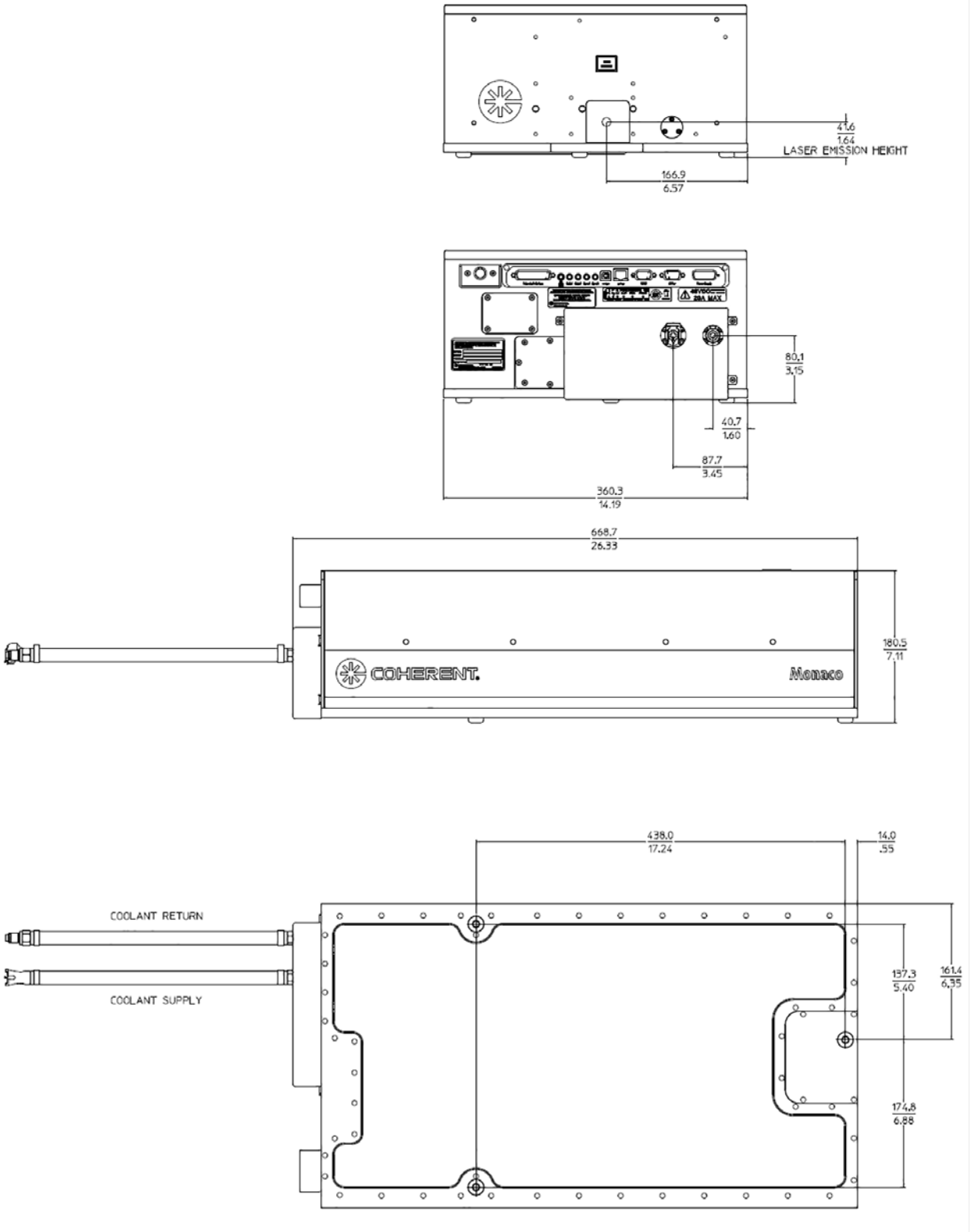
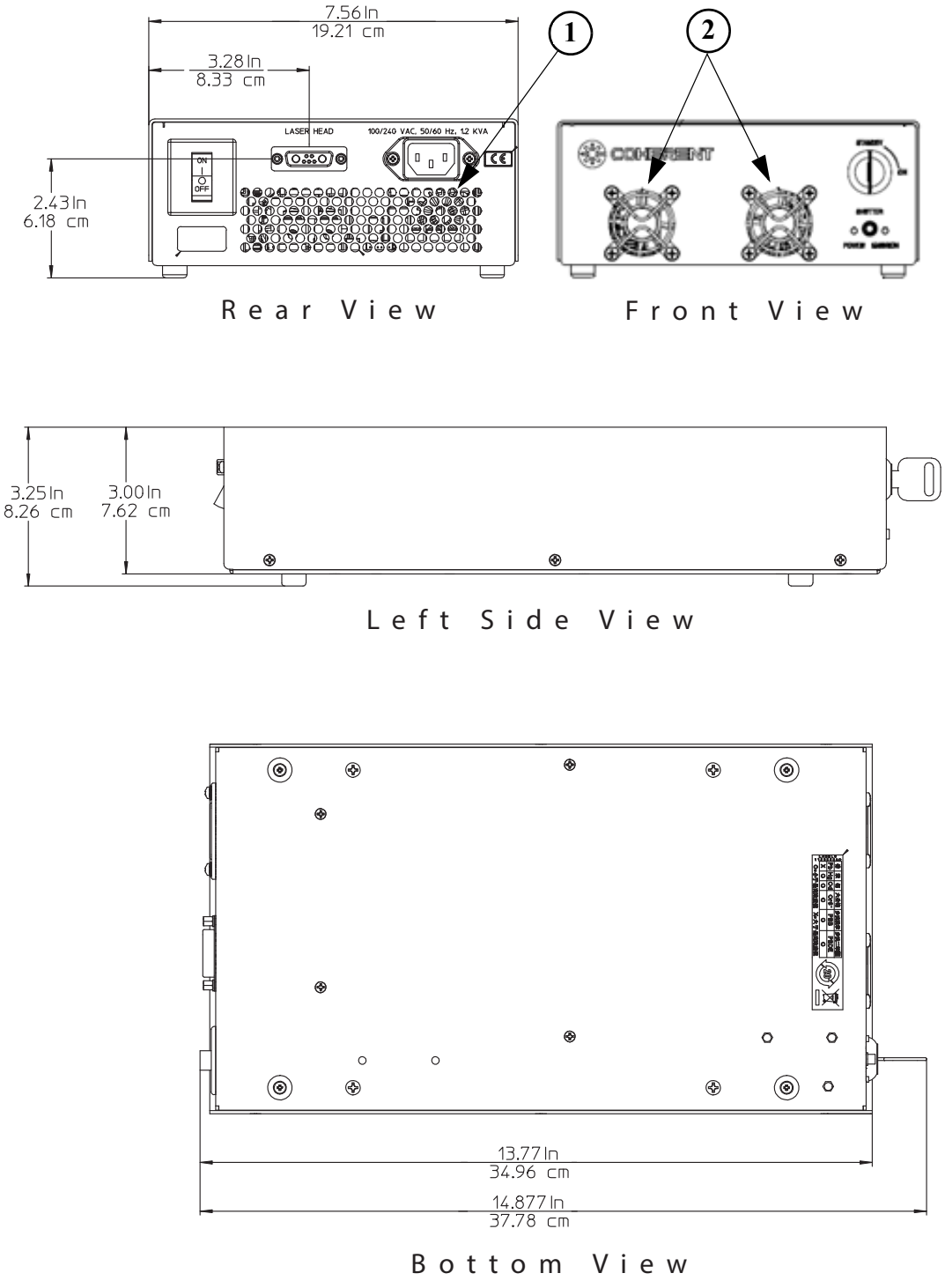


Figure 3-7. Monaco Laser Head Dimensions



1. Exhaust Holes
2. Air Intake

Figure 3-8. Monaco Power Supply Dimensions

SECTION FOUR: OPERATION

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 keyswitch on the power supply is enabled.

Operating States

This section describes the operation of the laser through the Coherent GUI program. The program is supplied on a USB drive included in the accessory kit. Refer to "Coherent GUI Installation" on page 5-1 for instructions on installing the program on the computer. Table 4-1 summarizes the operating states of the Monaco laser system.

Table 4-1. Operating States

STATE	SWITCH POSITION	STATUS
OFF	• Power Switch (rear panel): Off. • All other switches: Any position.	All functions off.
STANDBY	• Power Switch (rear panel): On. • Key switch: STANDBY.	Temperature servos on. Current to laser diodes off.
LASER ENABLED	• Power Switch (rear panel): On. • Key switch: LASER ENABLE.	Temperature servos on. Current to laser diodes can be on or off. Pulsing can be on or off.

Laser Control Coherent GUI

WARNING!
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.

Initial Start-up Procedure

To start the Monaco laser system, follow each of the steps in the order listed. If the power switch on the rear panel has been shut off, the Initial Start-up procedure must be used. Refer to Table 4-1 for more information.

After a complete shut down, the warm up time may take up to 45 minutes while the chiller temperature stabilizes to the set values. If a fault or system message occurs during either startup or operation, refer to "Fault Handling" on page 4-26.

Preliminary Steps

1. The chiller reservoir must be filled with distilled water mixed with Coolflow at 28% volume, the coolant lines are connected, the chiller AC switch is in the ON position, and the coolant is flowing.
2. Set the power supply keyswitch to the Standby position.
3. Set the power switch on the power supply rear panel to the ON position. The AC power indicator will illuminate.[1]
4. Install/open the Coherent Monaco GUI on a PC.
5. Wait for the emission LED to light on the power supply front panel.

After the preliminary steps of the Initial Start-up procedure have been completed, perform the Standby Start-up procedure below to complete the Initial Start-up.

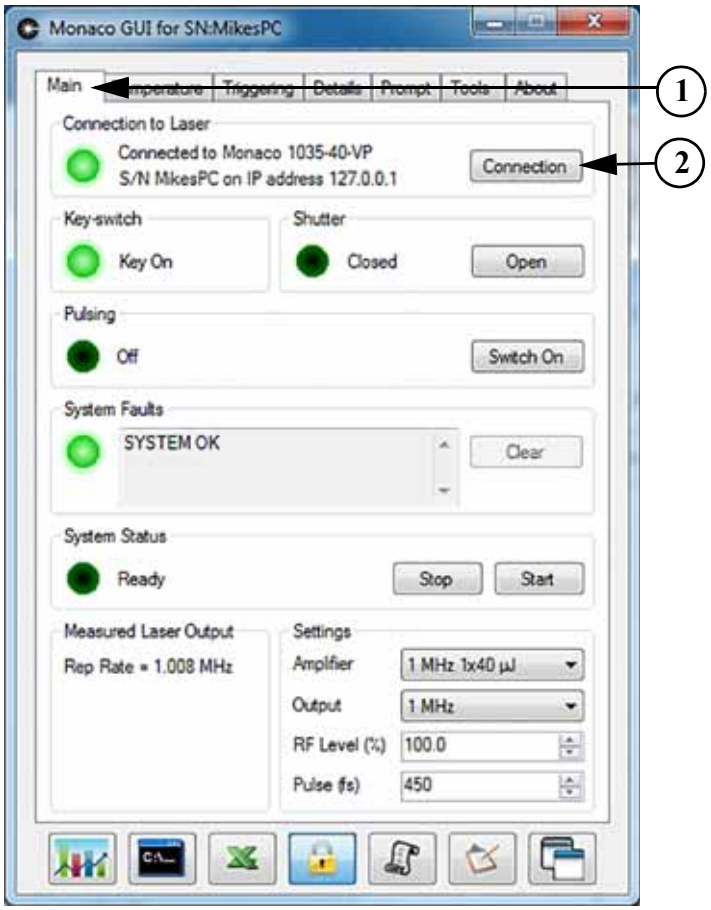
1. If the indicator does not illuminate, refer to "Section Seven: Service and Maintenance" for more information.

Standby Start-up Procedure

For normal operation of the Monaco, Coherent recommends using the Standby Start-up procedure listed below to turn on the laser. Before restarting the laser after a Standby Shut-down has been performed, the rear panel power switch must be in the ON position and chiller temperature must be locked and stable[1].

Refer to "Heartbeat Function" on page 4-24 if a fault message occurs during the start-up or normal operation.

1. Check that the coolant level in the chiller reservoir is full.
2. Block the laser beam using an appropriate beam attenuator.
3. Set up Communication (see Figure 4-1). On the GUI **Main menu tab,** in the Connection to Laser panel, select the CONNECTION button to open the Connection Options window.



1. Main menu tab on the Coherent Monaco GUI
2. CONNECTION button

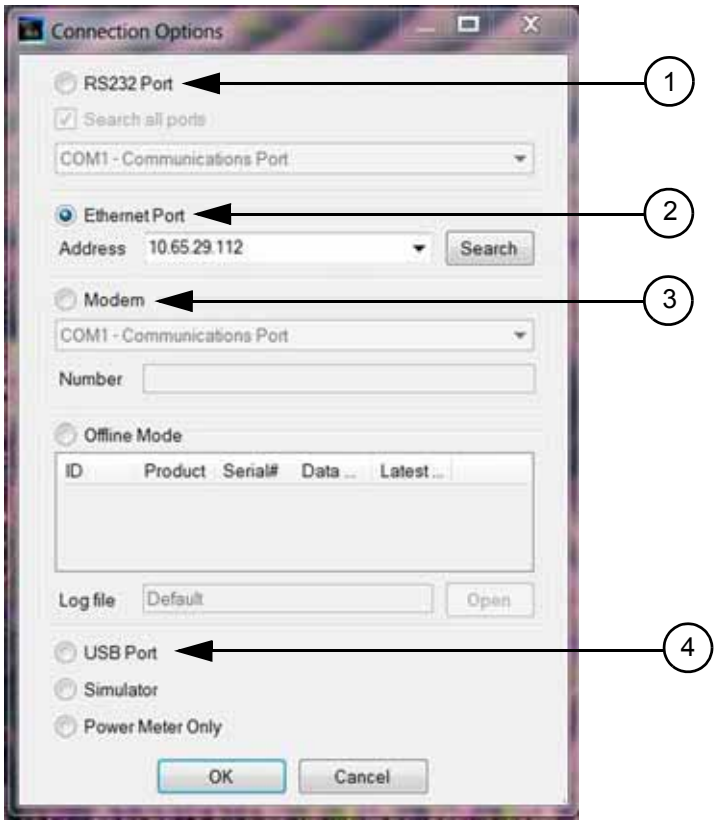
Figure 4-1. Connecting GUI to Laser

1. Laser in the standby state with main AC power on as described in Table 4-1.

4. In the Connection Options window select one of the following methods to set up the laser communication connection, then click the OK button[1] (see Figure 4-2):

   - RS232 Port or
   - Ethernet Port or
   - Modem port or
   - USB Port

The Offline Mode enables review of Logdata files (see "Logging" on page 5-18). Choosing Power Meter Only mode allows communication with only a power meter - you will not be communicating with the laser. If you wish to collect data from an external meter while connected to the laser, see "Power Meter" on page 5-19.

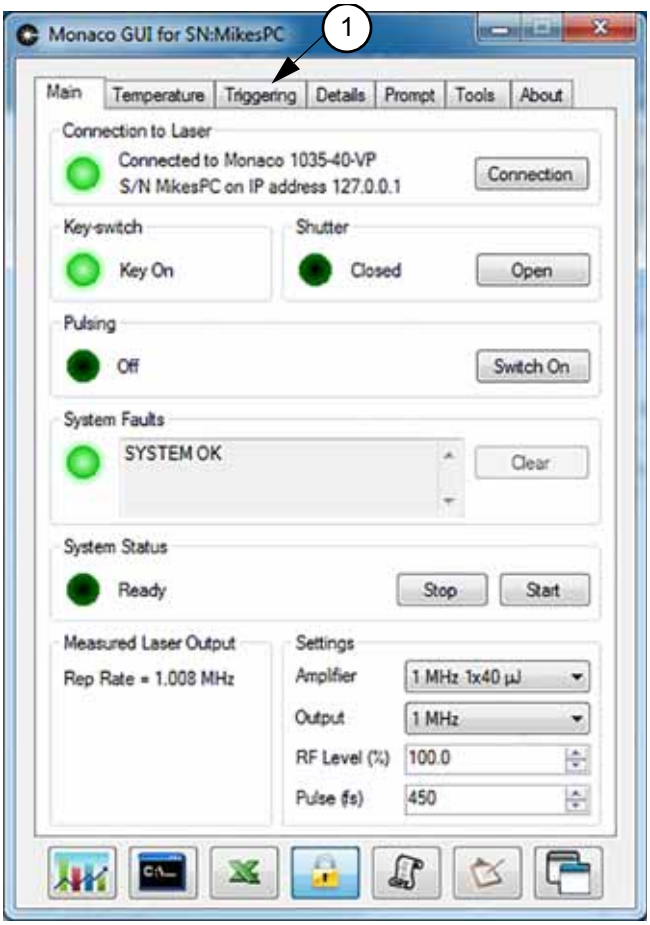


1. RS232 Port
2. Ethernet Port
3. Modem Port
4. USB Port

Figure 4-2. Connection Options Screen Selections

1. For example, if an RS232 cable is used between the control computer and the laser, select RS232. The specific COM port can be selected from the menu if it is known, or check "Search All Ports."

5. Set the power supply keyswitch to the ON position.
6. From the Main menu tab, select the Triggering tab to set up the preferred AOM Pulse Mode (see "AOM Pulse Modes" on page 4-16).



1. Triggering tab

Figure 4-3. Triggering Tab on Coherent GUI Menu Screen

7. On the Triggering tab, in the Triggering Setup panel, make the following selections (see Figure 4-4):

   a.) Select Enable Pulsing (this is a duplicate function to the Pulsing On/Off button on the Main tab).

   b.) Select the Enable External Gate button if Gated or Burst Mode is desired (see "Gated Mode" on page 4-16). This allows the user to enable/disable pulsing by applying a TTL signal externally through the Gate 1 port on the rear of the laser head.

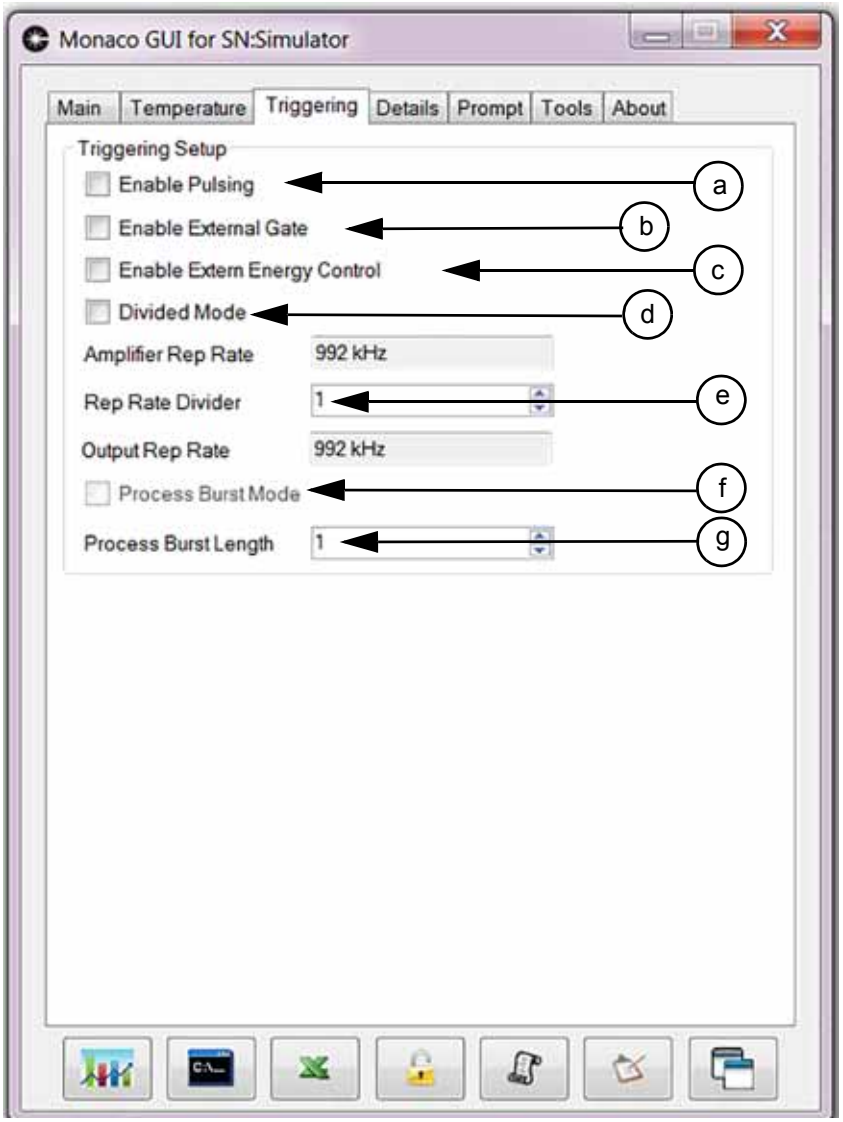
   c.) Select the Extern Energy Control button to adjust pulse energy. This allows modulation of the output beam through the EXT MOD Input connection on the rear of the laser head (see Figure 4-13 on page 4-27).

   d.) Select the Burst Mode button if Burst Mode is desired (see "Process Burst Mode" on page 4-17). This button is not available if the Enable External Gate button is not selected. This allows the laser to emit a number (1–1,000,000) of laser pulses (or seeder bursts) in a burst configuration at a specified repetition rate when triggered by an external signal through the Gate 1 port on the rear of the laser head.

   e.) Select the Divided Mode button if Divided Mode is desired (see "Divided Mode" on page 4-17). This enables laser output at lower pulse repetition rates.

   f.) Enter a Burst Length value (only takes effect if Burst Mode is selected and enabled). In Burst Mode, the number of pulses emitted in a burst is controlled by the Burst Pulses (BP) setting.

   g.) Enter a Rep Rate Divider value (only takes effect if Divided Mode is selected and enabled). In Divided Mode, the repetition rate is reduced by the Rep Rate Divider value (RRD).



a. Pulsing

b. External Gate
(enables Gated/Burst Modes)

c. External Energy Control

d. Divided Mode enable

e. Rep Rate Divider
(requires Divided Mode)

f. Process Burst Mode enable
(requires External Gate)

g. Process Burst Length
(requires Process Burst Mode)

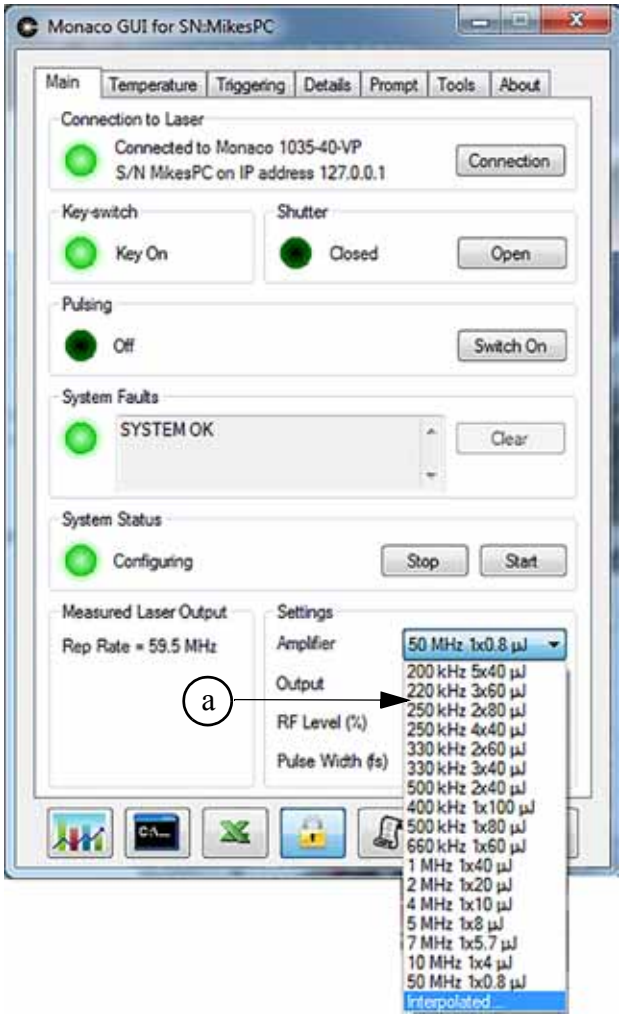
Figure 4-4. Triggering Tab Selections

8. On the Main menu tab, in the Laser Output panel at the bottom of the screen, make the following selections (see Figure 4-5):

   a.) From the Amplifier Rep Rate (kHz) drop down menu select the amplifier repetition rate (in kHz) and number of pulses in each seeder burst (see "Seeder Burst Mode" on page 4-14).

   b.) Select the Pulse Width in femtoseconds (or picoseconds) as applicable from the drop down menu.

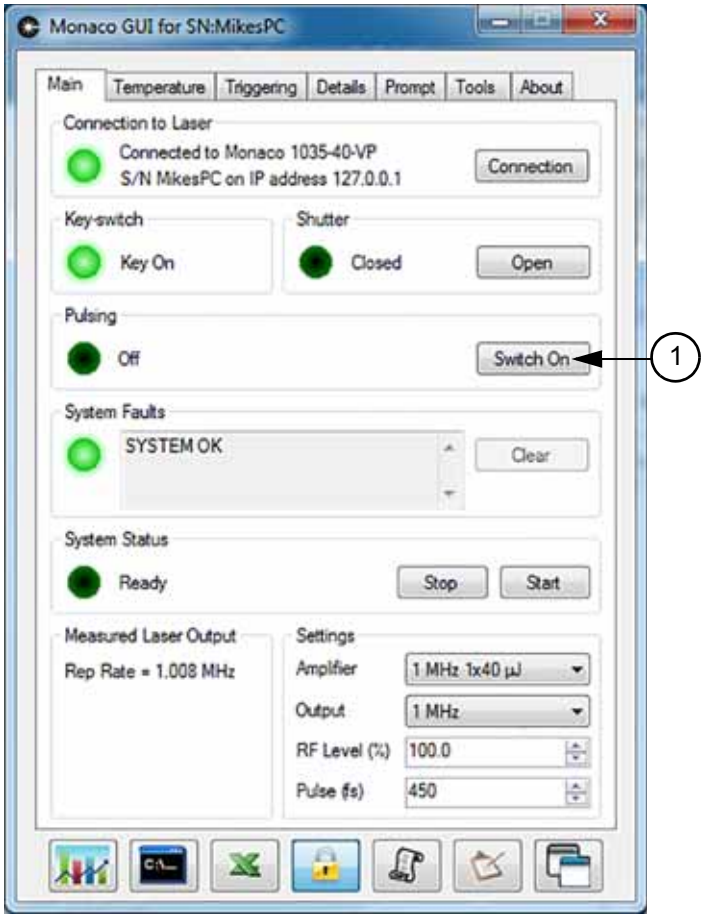
   NOTE: The choices available under the drop down menus will change depending on the particular laser model and configuration.



a. Select Amplifier Repetition Rate/Seeder Burst Pulses

Figure 4-5. Laser Output Panel Selections

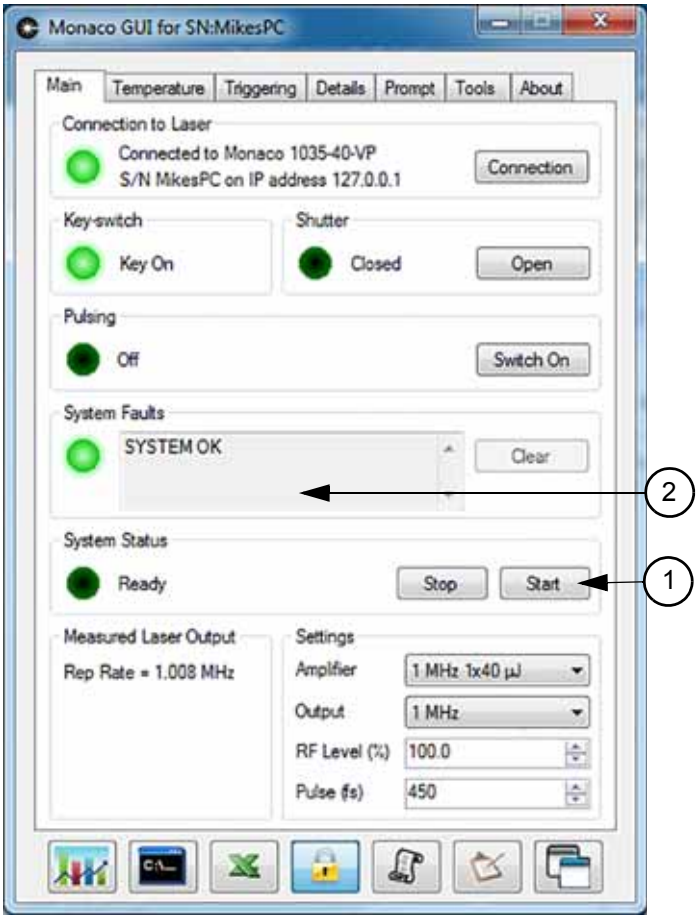
9. Check that pulsing is turned on. On the Main menu tab, in the Pulsing panel, select the Switch On button (see Figure 4-6). Note that when pulsing is turned off, there is no laser output as the Amplifier AOM is closed. This function allows output to be quickly switched on and off without requiring the laser to go through start-up.



1. Pulsing SWITCH ON button

Figure 4-6. Pulsing SWITCH ON Button

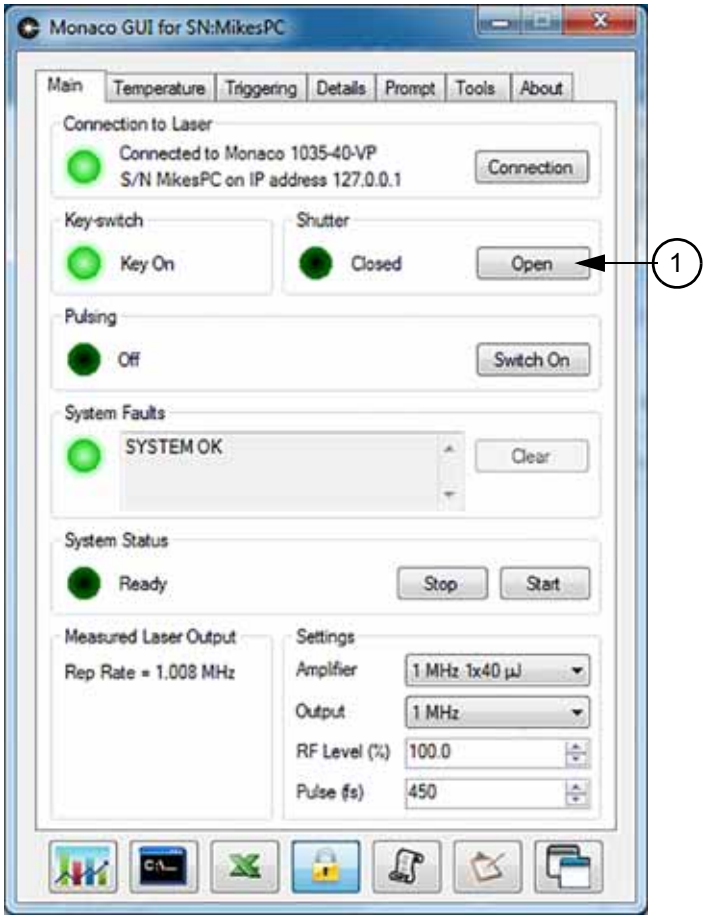
10. Start the laser. On the Main menu tab, in the System Status panel, select the START button and wait for the System Status message "On" to appear (see Figure 4-7). Allow at least 40 minutes for the temperature servos and the chiller to achieve operating temperature.
    Note that the system will not start if there is a red FAULT condition, but it will continue to operate normally if there is a yellow WARNING condition shown in the System Faults panel.



1. START button
2. System Faults Indication

Figure 4-7. START (the Laser) Button

11. Open the shutter. On the Main menu tab, in the Shutter panel, select the OPEN button (see Figure 4-8). A message asks you to confirm that you want to open the shutter, and gives the option of not being asked again.



1. Shutter OPEN button

Figure 4-8. Shutter OPEN Button

12. Select the OK button. The status changes to “Shutter Open” and the shutter indicator lights.

Standby/ Shut Down

During normal operation, the Monaco system can be put in Standby mode through the Coherent GUI. Using Standby mode eliminates the time necessary for warm up during the Initial Power-up procedure. To put the laser into Standby mode, do the following:

1. **Disable the AOM.** On the Main menu tab, in the Pulsing panel, change to OFF. The pulsing status indicator light goes out.
2. **Stop lasing.** On the Main menu tab, in the System Status panel, select the STOP button. The status reads "Laser Off" and the system status indicator light goes out.
3. Turn the keyswitch to the STANDBY position. (The key can be removed for safety.)
4. Leave the AC Main Power switch on the back of the laser power supply in the ON position. The chiller can remain in the ON position and running (as long as you are using a Coherent approved chiller that is communicating with the laser).

Complete System Shut Down

Use this procedure when doing system maintenance or repair. To remove all electrical power from the Monaco, complete the previous Standby/Shut-down procedure, then do the following additional steps:

1. **Monaco laser:** Turn off the AC Main Power switch on the power supply rear panel.
2. **Chiller:** Turn off the coolant flow from the chiller. Complete shut down of the laser can take up to two minutes. After complete shut down there is no connection to the Coherent GUI.

Operating Modes

The Monaco laser system makes available several operating modes that can be used in different combinations. Through control of the Monaco's seed AOM and output AOM components, the pulse repetition rate, pulse width, and pulse energy can be adjusted from the Coherent GUI or by serial command. Table 4-2 below is a summary of the Monaco Operating Modes and the user selectable parameters to configure them.

Monaco lasers use patented techniques to maintain thermal equilibrium for the laser gain media and other optical components.

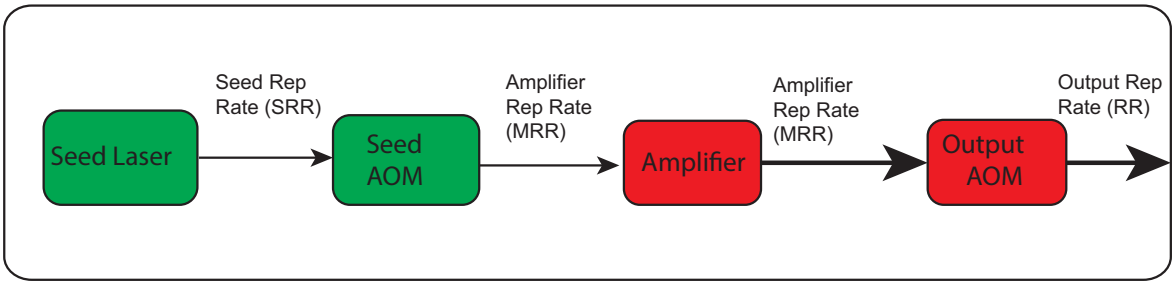


Figure 4-9. Laser Schematic and Laser Repetition Rates

Table 4-2. Monaco Operating Modes

PULSE MODE	SEED AOM	OUTPUT AOM	PULSING PARAMETER REQUIRED SET UP
Continuous/ Seeder Burst Figure 4-10 & Figure 4-11	Sets MRR and number of pulses in seeder burst	Not used	Amplifier Repetition Rate (MRR) Seeder Burst Pulses
Gated Figure 4-12	Sets MRR and number of pulses in seeder burst	Gates output On and Off	Amplifier Repetition Rate (MRR) Seeder Burst Pulses
Divided	Sets MRR and number of pulses in seeder burst	Divides down MRR by factor RRD	Amplifier Repetition Rate (MRR) Seeder Burst Pulses Repetition Rate Divisor (RRD)
Divided and Gated	Sets MRR and number of pulses in seeder burst	Divides down MRR by factor RDD Gates output On and Off	Amplifier Repetition Rate (MRR) Seeder Burst Pulses Repetition Rate Divisor (RRD)

Table 4-2. Monaco Operating Modes (Continued)

PULSE MODE	SEED AOM	OUTPUT AOM	PULSING PARAMETER REQUIRED SET UP
Process Burst	Sets MRR and pulse number in seeder burst	Sets BP pulses in process burst output	Amplifier Repetition Rate (MRR) Seeder Burst Pulses Process Burst Pulses Setting (BP)
Burst and Divided	Sets MRR and pulse number in seeder burst	Sets BP pulses in burst output Divides down MRR by factor RDD	Amplifier Repetition Rate (MRR) Seeder Burst Pulses Process Burst Pulses Setting (BP) Repetition Rate Divisor (RRD)

Seeder Burst Mode

Seeder Burst mode groups multiple pulses into a short time window. The separation between pulses in the seeder burst is determined by the seed laser repetition rate (SRR) and is approximately 20 nsec (see Figure 4-9 on page 4-13). The exact separation between pulses can be calculated from 1/SRR, where the seed repetition rate can be found by using the query ?SRR from the Command Prompt (see "Prompt Menu Tab" on page 5-10). For example, with a seed repetition rate of 50MHz the pulse separation would be 20nsec. The maximum output power in Seeder Burst Mode is still limited to 40W in a 1035-40 system. The number of pulses in each seeder burst can be chosen from the values in the Coherent GUI Amplifier Rep Rate drop down menu (see "Laser Output Panel Selections" on page 4-8). If a seeder burst contains only one pulse it is simply a continuous stream of single pulses at the amplifier repetition rate (MRR). The amplifier repetition rate is adjusted to maintain the maximum 40 W average power out of the laser. For example, at a 1 MHz amplifier repetition rate, changing the number of seeder burst pulses from 1 to 2 will decrease the amplifier repetition rate to 500kHz while maintaining 40W output power (pulse energy is still 40µJ). The repetition rate and the number of pulses in a seeder burst can be specified using the Coherent GUI drop down table (see Figure 4-5 on page 4-8), or through the serial command SET. If the SET command is used (see "SET Command" on page 6-18 for a detailed description), the amplifier repetition rate and pulses per seeder burst entered must be limited to the values displayed in the GUI drop down menu. See Figure 4-10 below for an illustration of Seeder Burst Mode.

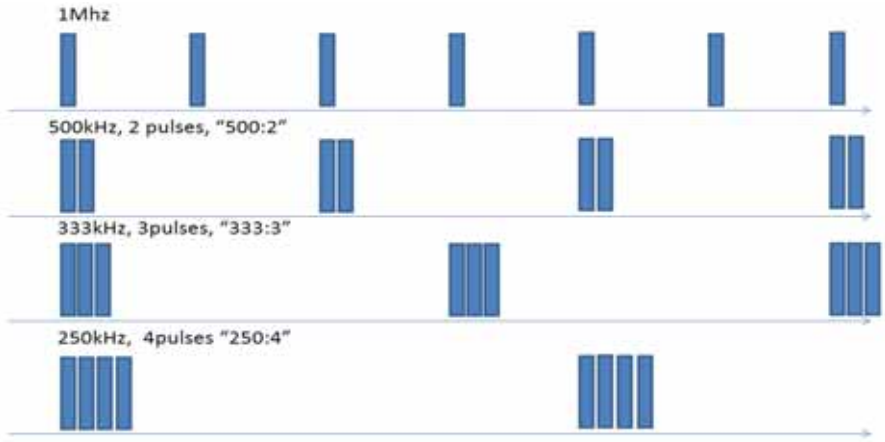


Figure 4-10. Seeder Burst Mode

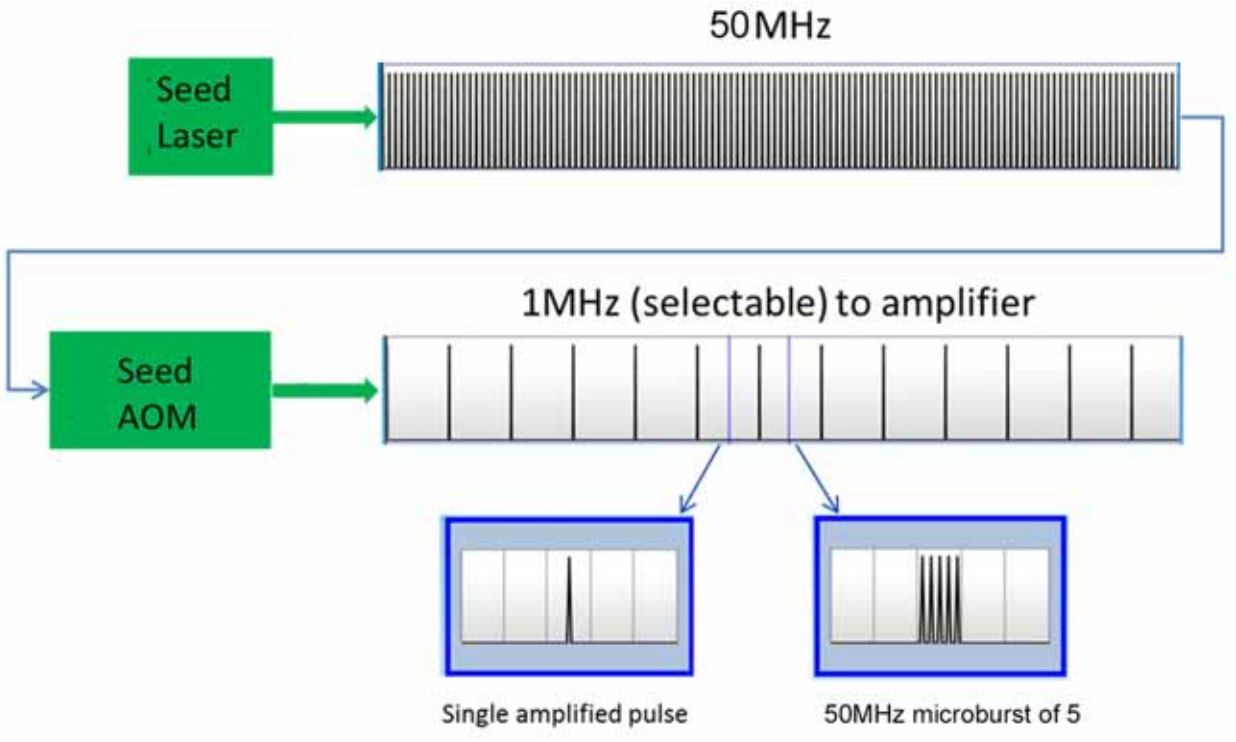


Figure 4-11. Seed AOM & Seeder Burst

AOM Pulse Modes

There are several laser AOM Pulse Mode options available for operating the Monaco laser system. By making use of the output acousto-optic modulator (AOM) the laser output can be adjusted in different ways:

Continuous (Pulse) Mode

The Monaco laser is operated at a steady pulse (or seeder burst) repetition rate set by the amplifier repetition rate (MRR) (see Figure 4-9). The amplifier repetition rate can be selected through the Coherent GUI Main menu (see Figure 4-5 on page 4-8), or through the serial command SET. For systems with Extrapolated mode option, repetition rates between 1-4 MHz can also be entered into the GUI or through the serial command SET.

Gated Mode

Gated Mode enables pulsing by applying a TTL signal externally through the Gate 1 port on the rear of the laser head. (see "Gate 1 and Gate 2" on page 3-13). As in Continuous Mode the amplifier repetition rate can be selected through the Coherent GUI Main menu or through the serial command SET. In Gated Mode, TTL high enables output pulses and TTL low inhibits output pulses (see Figure 4-12). To utilize Gated Mode the Enable External Gate button is selected from the GUI Triggering menu (see Figure 4-4 on page 4-7), or by entering the serial command PM=1.

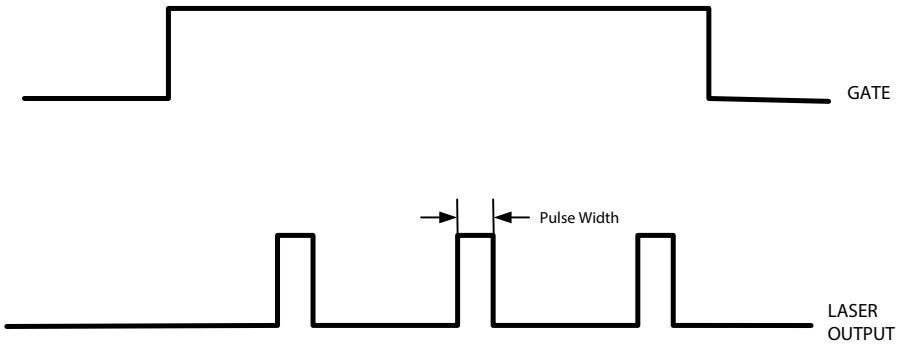


Figure 4-12. Gated Mode

Divided Mode

Divided Mode enables Monaco laser output at lower pulse repetition rates by using the AOM to reduce the output laser pulse (or seeder burst) repetition rate by a frequency/rep rate divisor (RRD) chosen by the user. For example, for an amplifier laser pulse repetition rate of 1MHz and setting the divisor to 4, the output repetition rate would be 250kHz, the average output power would be divided by 4, and pulse energy and pulse width would be unchanged. To utilize Divided Mode, the Divided Mode button is selected from the Triggering Menu (see "Triggering Tab Selections" on page 4-7), or by entering the serial command PM=2. The divisor can be specified by choosing a frequency divider through the GUI Triggering menu (see "Triggering Tab Selections" on page 4-7), or by the serial command RRD. The value for the divisor can be from 1 - 65,535.

Divided and Gated Mode

Divided and Gated Mode enables pulsing by applying a TTL signal externally through the Gate 1 port similar to Gated Mode, and at a lower output pulse repetition rate similar to Divided Mode. To utilize Divided and Gated Mode both the External Triggering button and the Divided Mode button from the GUI Triggering Menu must be selected (see "Triggering Tab Selections" on page 4-7), or by using the serial command PM=3. Again the divisor can be specified by choosing a frequency divider through the GUI Triggering menu, or by the serial command RRD. The value for the divisor can be from 1 - 65,535.

Process Burst Mode

The Monaco laser can emit a number (1–1,000,000) of laser pulses (or seeder bursts) in a burst configuration at a specified repetition rate. In Process Burst Mode the number of pulses emitted in a burst is controlled by the Burst Pulses (BP) setting. To utilize Process Burst Mode the External Triggering and Process Burst Mode buttons are selected from the Triggering Menu (see "Triggering Tab Selections" on page 4-7), or by entering the serial command PM=4. The repetition rate and the number of pulses in a process burst can be specified using the Coherent GUI, or through the serial command SET and BP, respectively. Each process burst is initiated by the transition from TTL low to TTL high similar to Gated Mode shown in Figure 4-12. The process burst will continue until the specified number of pulses is generated if the Gate 1 signal (see "Laser Head Features Drawing" on page 4-27) remains TTL high. A process burst can be shortened by a transition from TTL high back to TTL low. If a process burst is allowed to continue for the specified number of pulses, the Gate 1 signal must be reset from TTL high to TTL low before initiating the next burst.

Process Burst and Divided Mode

In Burst and Divided Mode the number of pulses (or seeder bursts) emitted in a burst is initiated by the Gate 1 TTL signal and controlled by the Burst Pulses (BP) setting similar to Burst Mode, and at a lower output pulse repetition rate similar to Divided Mode. To utilize Burst and Divided Mode the External Triggering, Burst Mode and Divided Mode buttons from the GUI Triggering Menu must be selected (see "Triggering Tab Selections" on page 4-7), or by using the serial command PM=5. As in Divided Mode the divisor can be specified by choosing a frequency divider through the GUI Triggering menu, or by the serial command RRD. The value for the divisor can be from 1 - 65,535. Note that if the gate period (when the TTL signal is high) is not sufficiently long then some pulses in the burst may be cut off. For example if RRD=4 and the output rep rate (RR) is 250kHz with BP set to 10 pulses, then the gate period must be at least 40µs to allow all the pulses to exit the laser.

Basic Serial Commands for Operation

This section contains a subset of Monaco serial commands. They are supplied here as a guide to start using the Monaco. There are two types of instructions to communicate with the Monaco: commands that set the values of laser operating parameters and queries that request the laser to return the value of an operating parameter.

For initial setup of the laser, Coherent recommends use of the Coherent GUI which eliminates the need to type these serial commands.

The ?HELP command supplies a list of all possible commands. To get a sublist of all commands containing a specific key word, enter ?HELP <keyword>.

Table 4-3. Basic Serial Commands (Sheet 1 of 4)

COMMAND	BRIEF DESCRIPTION	NOTES
BP	BURST PULSES	Number of pulses in a process burst
?BP	PRINT BURST PULSES	Returns number of pulses in a process burst
CHEN	CHILLER ENABLE	CHEN=1 turns on the chiller CHEN=0 turns off the chiller
EM	EXTERNAL MODULATION	EM=1 enables external modulation through the EXT MOD Input port EM=0 turns off external modulation
?EM	PRINT EXT MODULATION	Returns external modulation status

Table 4-3. Basic Serial Commands (Sheet 2 of 4)

COMMAND	BRIEF DESCRIPTION	NOTES
?F	PRINT FAULTS	Displays a list of faults, if present Use the ?FNAME command to show a description of a particular fault. If a fault is present, it will turn off the laser.
FACK	ACKNOWLEDGE FAULTS	Send 'FACK=1' to acknowledge faults and return the laser to a ready state if the fault condition is lifted.
?FNAME	PRINT FAULT NAME	For example, send '?FNAME 4' to get the description for fault 4.
?HELP	PRINT HELP	Shows a list of all commands or a subset if a keyword is used For example, '?HELP PULSE' shows all PULSE related commands.
?HV	PRINT HARDWARE VERSION	Displays the internal revision level of major hardware components
?IRE	PRINT IR ENERGY	Returns the laser pulse energy in µJ
?IRPOUT	PRINT IR POWER	Returns laser average power in W
?K	PRINT KEYSWITCH	Returns laser enable keyswitch state 1 = Laser Enabled 0 = Laser in Standby (laser diodes cannot be turned on)
L	LASER ENABLE	L=1 turns on laser L=0 turns off laser
?L	PRINT LASER STATE	Returns laser state. For example: 0 if the laser is in (STANDBY) 1 if the laser is in ON 2 if the laser is in STANDBY because FAULT occurred
?LNAME	PRINT STATE DESCRIPTION	For example, send '?LNAME 1' to get the description of state 1.
?LM	PRINT LASER MODEL INFO	Returns laser model
?MRR	PRINT AMPLIFIER REP RATE	Returns the laser amplifier repetition rate in kHz
PC	PULSE CONTROL	Enable or disable laser pulsing PC=1 enables laser pulsing PC=0 disables laser pulsing
?PC	PRINT PULSE CONTROL	Returns the state of laser pulse control 1 = laser pulsing on 0 = laser pulsing off

Table 4-3. Basic Serial Commands (Sheet 3 of 4)

COMMAND	BRIEF DESCRIPTION	NOTES
PM	PULSE MODE	Sets the AOM Pulse Mode PM=0 for Continuous pulsing. PM=1 for Gated mode PM=2 for Divided mode PM=3 for Divided and Gated mode PM=4 for Process Burst mode PM=5 for Process Burst and Divided mode
?PM	PRINT PULSE MODE	Returns the AOM Pulse mode 0 = Continuous pulsing 1 = Gated mode 2 = Divided mode 3 = Divided and Gated mode 4 = Process Burst mode 5 = Process Burst and Divided mode
RL	SET PULSE LEVEL	Sets pulse energy percent, from 0 to 100
?RL	PRINT PULSE LEVEL	Returns the current pulse energy level percent setting
?RR	PRINT REP RATE	Returns the laser pulse or seeder burst output repetition rate in Hz
RRD	SET REP RATE DIVISOR	Allows the amplifier laser pulse repetition rate (configured using the SET command below) to be divided by an integer For example, to divide the repetition rate by 4, enter RRD=4. Range is from 1 - 65,535.
?RRD	PRINT REP RATE DIVISOR	Returns the laser pulse repetition rate divisor
S	SHUTTER	S=1 opens the shutter S=0 closes the shutter
?S	PRINT SHUTTER	Returns the state of the shutter 1 = shutter is open 0 = shutter is closed
SET	SET LASER PARAMETERS	Sets up to 4 laser parameters simultaneously: amplifier repetition rate (MRR), pulse width (PW), repetition rate divisor (RRD), and number of pulses per seeder burst The command is of the form SET=*w,x,y,z* where *w* is the requested amplifier rep rate in kHz, *x* is the pulse width in femtoseconds , y is the repetition rate divisor (RRD), and z is the number of pulses per seeder burst. Values for the amplifier repetition rate must be chosen from those shown in the GUI Amplifier Rep Rate drop down menu. Missing parameters are left unchanged e.g. "SET=MRR,,RRD," will leave PW and seeder burst pulses unchanged. For a full description of the SET command, see "SET Command" on page 6-18.

Table 4-3. Basic Serial Commands (Sheet 4 of 4)

COMMAND	BRIEF DESCRIPTION	NOTES
?SET	PRINTS THE LASER PARAMETER SETTINGS	Returns the provide the current values for the laser parameters: amplifier repetition rate (MRR) in kHz, pulse width (PW) in femtoseconds, repetition rate divisor (RRD), and number of pulses per seeder burst (e.g. “1000,400,2,1”)
SSP	SESAM SPOT	For example, use ‘SSP=+’ to shift to the next available spot.
?SSP	PRINT SESAM SPOT	Returns current SESAM spot position
?SSPC	PRINT SESAM COUNT	Returns current SESAM spot count/restarts.
?SSPH	PRINT SESAM SPOT HOURS	Returns current SESAM spot hours
?ST	PRINT LASER STATE NAME	Returns the name of the current laser state such as “Standby”, “Ready”, “Fault” or “On” when the laser reaches those steady state conditions It can also return transient laser states, such as diode current ramping up or down. The ?L command is a short form of this command.
?SV	PRINT SOFTWARE VERSION	Displays the revision level of major software components
?W	PRINT WARNINGS	Displays a list of warnings, if present The ?WNAME command can then be used to show a description of a particular warning. Warnings will not turn off the laser.
?WNAME	PRINT WARNING NAME	For example send ‘?WNAME 500’ to get the description for warning 500.

Example Command Sequence

The following are examples of how serial commands can be used to control the laser. This sample is not intended for use without a full knowledge and understanding of commands appropriate for the process being performed by the operator. Changes may be required. It is the customer's responsibility to comply with IEC60825 safety standards when using these commands.

Startup for Normal Operation

The following serial commands are an example to startup the laser for normal operation in Continuous (Pulse) mode. For a description of Pulse Modes, see "AOM Pulse Modes" on page 4-16.

Table 4-4. Startup Commands

COMMAND	LASER RESPONSE	NOTES
CHEN=1		Enables the chiller For the most stable laser operation, the chiller should be enabled several minutes before turning on the laser.
?K	1	Checks if keyswitch is on (1 = keyswitch on)
?F	SYSTEM OK	Checks if there are faults
?W	SYSTEM OK	Checks if there are warnings
S=0		Closes shutter
?S	0	Checks if shutter is closed (0 = closed)
PM=0		Sets up Continuous pulsing
?PM	0	Checks the AOM pulse mode (0 = Continuous mode)
L=1		Turns on diodes They will typically ramp to their set current within 30 seconds.
?ST	ON	This query may be repeated until "On" is returned, which indicates the diodes have completed ramping to their set point. This query may also return the descriptions of other intermediate states. Note that if the laser is cold from a power off state, it may take some time to become thermally stable and reach a steady state.
PC=1		Turns on pulses
S=1		Opens the shutter
?S	1	Checks the shutter state (1 = open)

Monitoring While Operating

The following commands can be issued periodically while the laser is operating.

Table 4-5. Periodic-Issue Commands

COMMAND	EXPECTED REPLY	NOTES
?F	SYSTEM OK	This command replies with a list of numbers if a fault exists. The *?FNAME n* command can be used to describe the fault condition "n" if it exists. The laser will automatically go to a standby state whenever there is a fault condition. Most faults are cleared with the FACK=1 command if the fault condition is lifted.
?W	SYSTEM OK	Same as ?F except for warnings Warnings do not change the state of the laser. It continues to operate.

Shutdown

The following commands can be issued to shut down the laser.

Table 4-6. Laser Shutdown Commands

COMMAND	EXPECTED REPLY	NOTES
S=0		Closes the shutter and turns off pulsing
?S	0	Checks the shutter state (0 = closed)
L=0		Turns off diodes
?ST	Ready	Repeat this command every few seconds while diodes are turning off and wait for the 'Ready' reply. This command will also return the descriptions of other intermediate states.

Heartbeat Function

The Heartbeat (HB) function is a new safety feature that automatically shuts off the laser diodes when remote control of the laser is lost. This protects the user from a situation in which the laser is running at full power and the computer controlling the laser fails, or the connection (through Ethernet, USB, or RS-232) between the controlling device and the laser fails. In which case, the only way to turn off the laser would be through the keyswitch on the laser power supply or another hardware interlock. By default the HB function is not active (HB=0), but it can be enabled with an HB=n command, where n is a positive integer in seconds and specifies the timeout period to trigger a HB fault (Dropped Connection fault) if the communication condition is not satisfied.

Note that the HB timeout is not a permanent or global setting - it returns to the off state (HB=0) after each AC power cycling of the laser. Each laser control connection can establish its own HB state and timeout period that can be different from, and independent of, any other connection.

In order to use the HB feature for a specific control line, the user must send a HB=n (n>5) command each time the control connection has been established.

Heartbeat Enabled

When the Heartbeat (HB) function is enabled with HB=n, the laser generates a HB fault if it does not receive a command or query from the controlling device within n seconds (allowable range of n: 0, or 5 to 300, where n=0 disables the function). The fault condition may occur if the communication between the laser and the controlling device is lost, which includes, but is not limited to, scenarios such as 1) the control device or PC goes into Standby mode, Hibernate mode, or crashes, or 2) the network connection to the laser system has failed or is interrupted for longer than the timeout period defined by HB=n, or 3) the cable becomes disconnected.

If the user disconnects the control session with HB already enabled, the laser will generate a HB fault within the timeout period of n seconds unless a HB=0 command is sent to the laser prior to disconnection.

Activation of Heartbeat by the Coherent GUI

The GUI does not enable the Heartbeat (HB) function when it establishes connection to the laser. However, it automatically enables HB when the user presses the START button on the GUI Main Tab in the System Status window. There are three different scenarios involving HB activation by the GUI:

1. If the HB function has not been enabled by explicitly issuing a HB=n command (n is a positive integer 5 to 300) from the

GUI, the START button enables HB function with HB=30 for the time period the laser is on. Turning the laser off by pressing the STOP button returns the HB state to disabled (HB=0).

2. If the HB function is enabled with n<30 before the START button is pressed, the START button will enable HB function with HB=30 during the time period the laser is on. The STOP button will turn off the HB function (HB=0).

3. If the HB function has been enabled with n=30 or n>30, the START and STOP buttons will not change the HB state or setting. The HB=n state and timeout period will remain the same before, during, and after these buttons are pressed.

Note that, unlike using the START button, a diodes-on/off command (L=1 or L=0) issued from the command prompt within the GUI does not change the HB state regardless of whether or not the HB function has been enabled. For example, if the HB function is not currently enabled, the L=1 command to switch on the diodes will not automatically enable the HB function even for the time period the diodes are on. Similarly, for scenarios 1 and 2, above, if the L=0 command is issued to turn off the diodes (instead of pressing the STOP button), the HB function stays enabled with HB=30 (which is different from HB being disabled again or set back to HB=n by pressing the STOP button) until the next time the STOP button is pressed to return the HB function to the original state. The HB function can be switched on or off in scenarios 1 and 2 by entering the L=1 or L=0 (respectively) commands.

When the laser is controlled by the Coherent GUI, the GUI automatically sends periodic queries to satisfy the HB timeout requirement. In cases where other types of remote control are used, the user must send a command or query at least once within the HB timeout to avoid fault. It is highly recommended for users controlling the laser through their own software to incorporate the HB function.

Changing the SESAM Spot

A modelocked seed laser provides the pulse train for subsequent pulse picking and amplification and contains a SESAM (semiconductor saturable absorber mirror). The SESAM has referenced spots that are periodically changed to prevent long term degradation. After 600 laser restarts on a particular spot, the Monaco laser will automatically shift to a different spot at the next laser start. If a particular spot is within one week of maximum recommended usage (5,000 hours) the Monaco system will provide a warning that the spot limit will be reached and the laser should be restarted. At 5,000 hours the laser will issue a fault that will stop laser operation in order to change the spot. To change the SESAM spot:

- If the laser is running, from the GUI Main tab push "STOP" in the System Status panel (see Figure 5-4 on page 5-4).
- Open up the command prompt (see "Prompt Menu Tab" on page 5-10) and enter the command "SSP=+" to move to the next available spot.
- From the GUI Main tab push "START" in the System Status panel and wait for the System Status message "On" to appear.

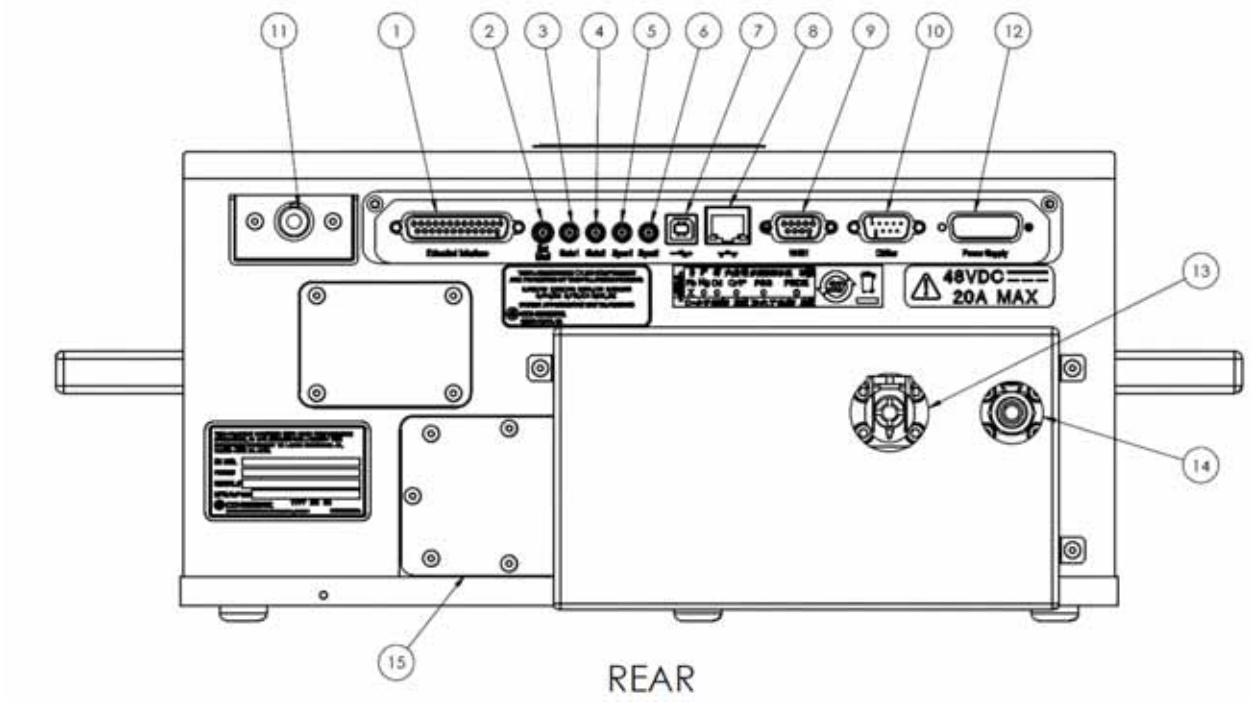
Fault Handling

If a fault condition occurs, the fault indicator on the Main menu tab of the GUI changes from green to red and displays the fault number and description. When a fault occurs, the laser shuts down and goes into Standby state. See Table 7-1 on page 7-2 for a list of system faults and troubleshooting procedures.

To return the system to normal operation, first correct the condition that caused the fault, and then acknowledge the fault condition by clicking the Clear button on the System Fault panel in the Main tab of the GUI (see Figure 4-8 on page 4-11). The fault condition can also be acknowledged using the FACK=1 serial command.

Warning messages are also displayed in the System Faults panel on the Main menu tab of the GUI. Unlike fault conditions, warnings do not shut down the laser. Warnings do not need to be acknowledged to restart or continue normal laser operation.

Controls and Indicators



1. Extended Interface
2. EXT MOD Input
3. Gate 1
4. Gate 2
5. Sync 1
6. Sync 2
7. USB Connector
8. Ethernet Connector
9. RS-232 Connector
10. Chiller RS232
11. External Interlock
12. Power Supply Cable
13. Coolant In
14. Coolant Out
15. Desiccant Cartridge Access

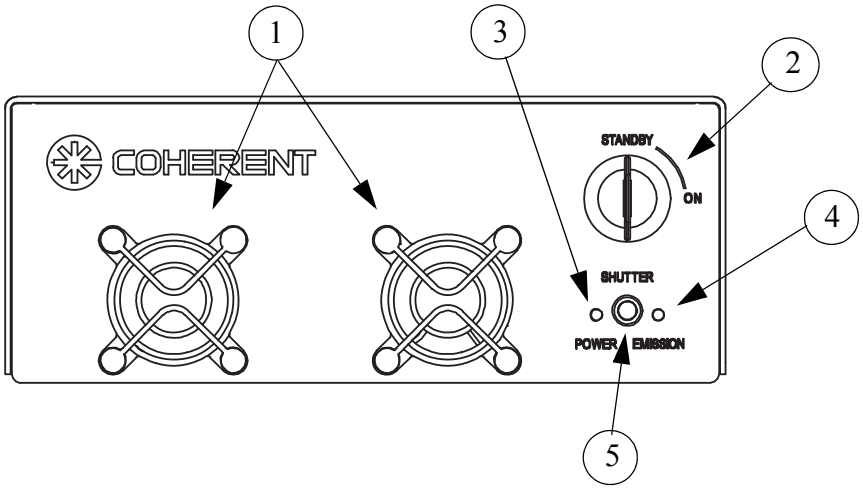
Figure 4-13. Laser Head Features Drawing

Table 4-7. Laser Head Features

ITEM	CONTROL	FUNCTION
1	Extended interface	The extended interface connector provides extra signals that are compatible with OEM systems. This is described in detail in Table 3-4 on page 3-9.
2	Ext MOD Input	Input to modulate output beam when in the external modulation mode (EM=1). See “EXT MOD Input” on page 3-11 for details on how to set the mode to use this signal.

Table 4-7. Laser Head Features (Continued)

ITEM	CONTROL	FUNCTION
3	Gate 1	Input to control pulsing. Gate1 is used to control the duration of a string of pulses. That is, if the AOM Pulse Mode is set to Gated mode (PM=1), laser pulses are produced as long as the Gate 1 signal is high. Gate 1 also has a function in Divided Gate mode (PM=3). That is, a pulse rate is produced that is the fixed amplifier pulse rate divided by an integer.
4	Gate 2	Gate 2 is a spare for future use. It is connected to internal timing circuits but has no function currently.
5	Sync 1	Output signal with a fixed delay from laser pulse and 50 ns wide. Intended to be synchronous with the output laser pulses.
6	Sync 2	Same signal as Sync 1.
7	USB Connector	The USB connector uses the industry standard Type B receptacle. Industry standard USB signal levels and Microsoft's RNDIS protocol are used. It can be connected to a standard USB connector on a PC to control the laser from, for example, the supplied Coherent GUI.
8	Ethernet Connector	The Ethernet connector uses the industry standard receptacle for an RJ45 connector (sometimes called an 8P8C connector). It can be connected to a switch, router or PC using Cat5 cable. Some older computers may require a connection with cross-over cable wiring. Once the IP address of the laser is known, a Telnet session can be established to the laser and the same commands used with the RS232 or USB connections can control the laser.
9	RS-232 Connector	The customer RS232 connection is a standard female 9-pin D-sub (DE-9) connector. A cable with a male connector is needed to use this interface. Only 19200 Baud is supported.
10	Chiller	RS232 communication between the laser and the chiller is required.
11	External Interlock	The interlock connector can be connected to customer equipment for safety, such as to switches on access doors. As long as the interlock connection is made, the laser will operate. A 12 mA current loop supplies power to this connection.
12	Power Supply Cable	Carries power and various signals between the power supply and the laser head.
13	Coolant In	Inlet connector for coolant from the chiller.
14	Coolant Out	Outlet connector for coolant to the chiller.
15	Desiccant Cartridge Access	Access cover to expose the desiccant housing. Check the relative humidity reading on the Temperature menu tab screen and replace the desiccant if >8%.



1. Cooling Fans
2. Keyswitch
3. AC ON Indicator
4. Emission Indicator
5. Shutter Indicator

Figure 4-14. Power Supply Front Panel Controls and Indicators

Table 4-8. Power Supply Front Panel Controls and Indicators

ITEM	CONTROL	FUNCTION
1	Cooling Fans	Inlet for cooling air for the power supply.
2	Keyswitch	Places the laser in either the Standby or On (Enable) state. The key can be removed when in Standby position to prevent unauthorized operation. It cannot be removed when in the On position.
3	Power Indicator (AC On)	LED lights when the AC electrical power is applied to the power supply.
4	Emission Indicator	Lights when laser emission is possible.
5	Shutter Indicator	This LED indicates when the shutter is open. Push the button to change shutter state.

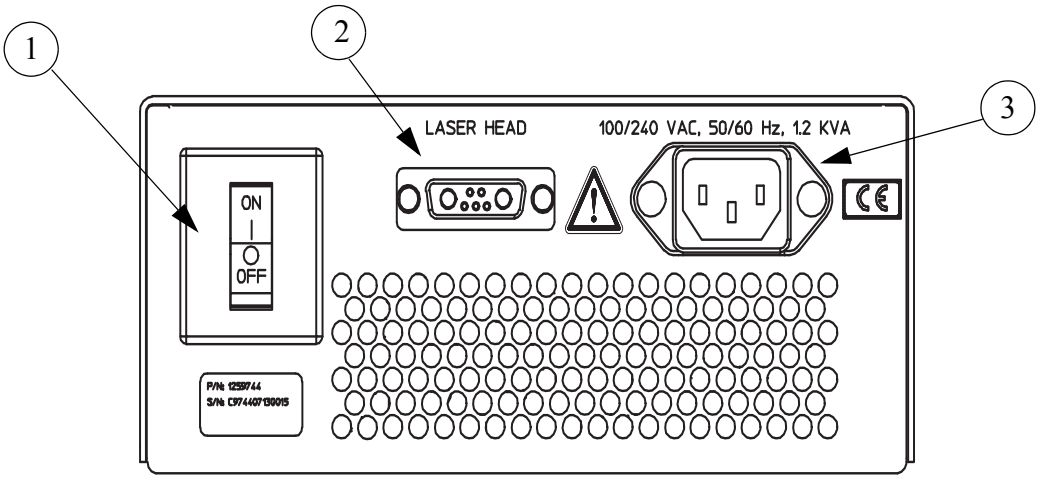


Figure 4-15. Power Supply Rear Panel Controls and Indicators

Table 4-9. Power Supply Rear Panel Controls and Indicators

ITEM	CONTROL	FUNCTION
1	Power On/Off Switch	Applies/removes all AC electrical power to the laser. Refer to "Complete System Shut Down" to avoid possible damage to the system.
2	Power Supply Cable Connection	Carries power and various signals between the power supply and the laser head.
3	AC Mains Power Cord	Connects the power supply to AC facility power.

Power Monitors

A photodiode is used to monitor the power of the laser and report both energy per pulse and average power. It detects light from a beam splitter in the laser path and is useful primarily for diagnostic purposes and relative power measurements. The absolute accuracy is typically better than 5% to 10% depending on power level and pulse repetition frequency, but can be less accurate at low power levels.

An accurate external measurement can be used to update the calibration of the photocell. A power meter and thermopile detector should be used when a more accurate measurement of the output power is required. The correction is easily performed with the power calibration serial commands(??).

For maximum accuracy at a particular operating point, the single point calibration procedure should be used. This procedure changes the calibration at the active operating level and corrects the slope intercept extrapolated to zero power. The two point procedure uses calibration at two operating points to correct the slope of the calibration.

SECTION FIVE: GRAPHICAL USER INTERFACE

Monaco Computer Interface

The user interface for the Monaco laser system is provided through an external computer. This section provides information on how to connect to that computer and how to use the laser control instructions to operate the Monaco laser system. Instructions are sent to the laser through a terminal interface program using an RS-232, USB, or Ethernet connection.

There are two types of instructions used to communicate with the laser: commands that set the values of operating parameters, and queries that return status information to the user. The instruction set is sufficient to support user-written programs.

The simplest and most intuitive way to interact with the Monaco laser is with the Coherent Graphical User Interface (GUI). The Coherent GUI is a PC based application that uses commands and queries to interact with the Monaco. The instructions below explain how to set up the Coherent GUI on an external computer.

NOTICE!
Turning off the GUI application does not turn off or reboot the Monaco laser. Restarting the laser system requires cycling the AC power or using the BOOT=1 command.

Coherent GUI Installation

The required installation file can be obtained from the USB drive included in the accessories kit. Put in the USB drive and select 'Setup.exe' to execute the Coherent GUI installation.

The files can be downloaded on the control Windows PC with an active Internet connection by visiting the Coherent GUI web page at:

http://www.coherent.com/products/?1996/Coherent-GUI

NOTICE!
The Coherent GUI requires 4GB RAM, 2.5GHz CPU, i5 Intel processor, Windows XP (Windows 7 or higher is recommended).

Microsoft Components

Select the "Accept" button as indicated in the menu form, and shown in Figure 5-1.

Figure 5-1. Microsoft Software License

The setup program will install the required files, as shown in Figure 5-2.

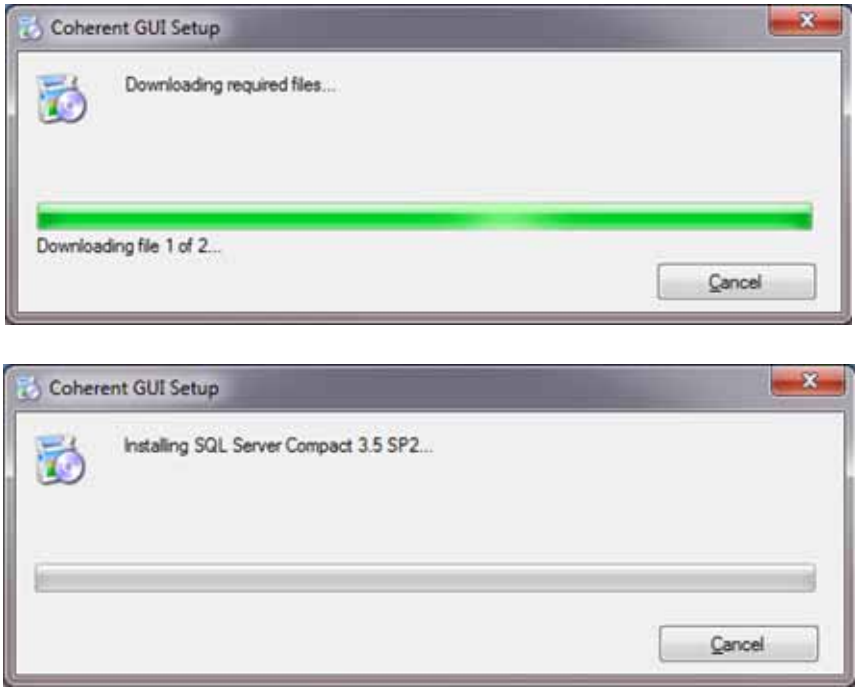


Figure 5-2. Installing SQL

Coherent GUI Setup

The Coherent GUI is installed after the components from Microsoft have been installed. If the required components are already installed on the computer, the Coherent GUI setup program will start at the "GUI Setup Wizard" menu form as shown in Figure 5-3.

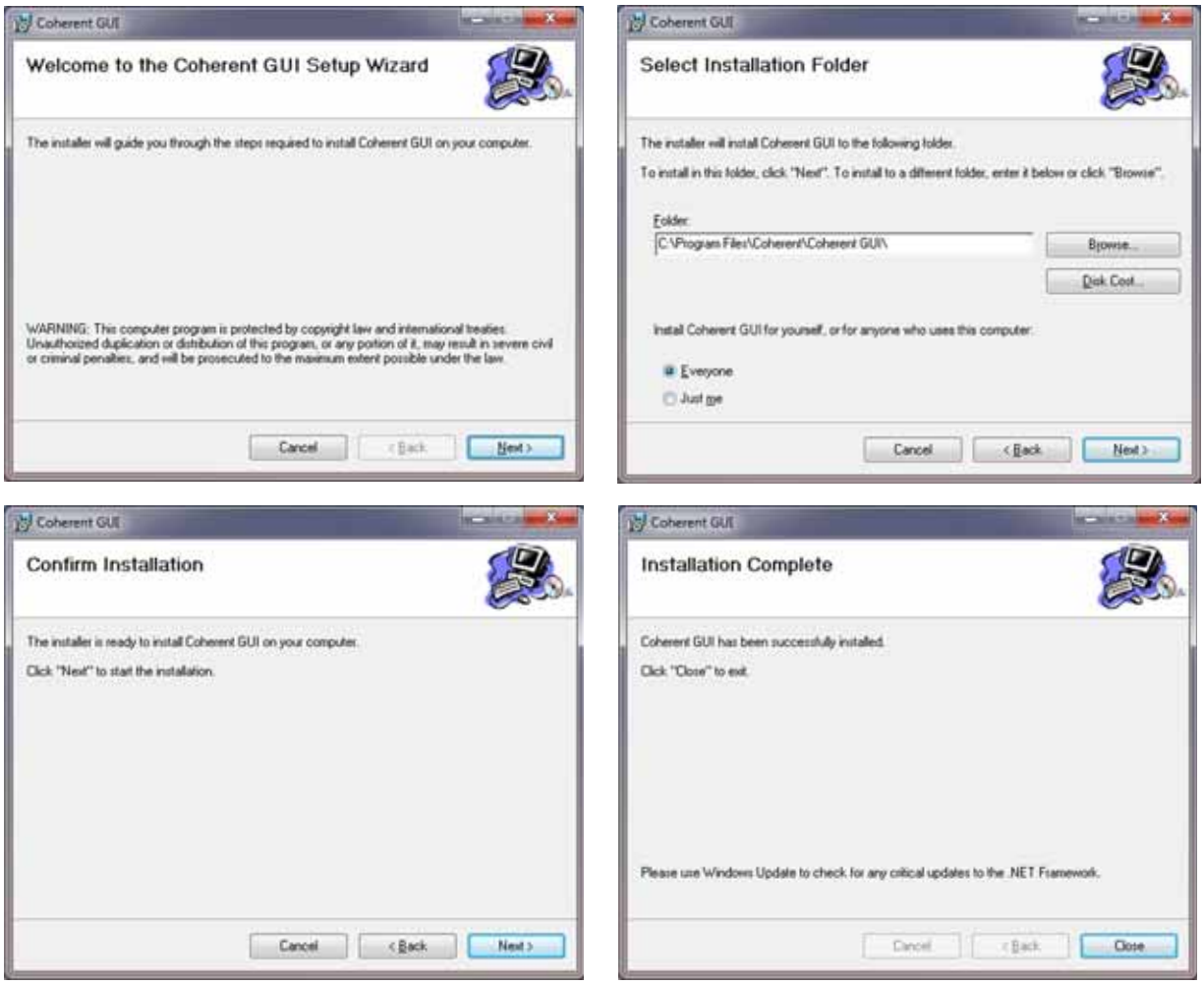


Figure 5-3. GUI Setup Installation

GUI Menu Tabs

The Coherent GUI for the Monaco has seven menu tabs.

- **Main** - Contains the command panels for primary operation of the laser system.
- **Temperature** - Information about the temperature servos and chiller and baseplate temperatures.
- **Triggering** - Configures the laser trigger parameters.
- **Details** - Displays the current status of all data ported through the GUI connection.
- **Prompt** - A COMMAND Prompt window that enables the user to query and send commands.
- **About** - Provides Coherent GUI information, access to the Monaco web page, and other features.

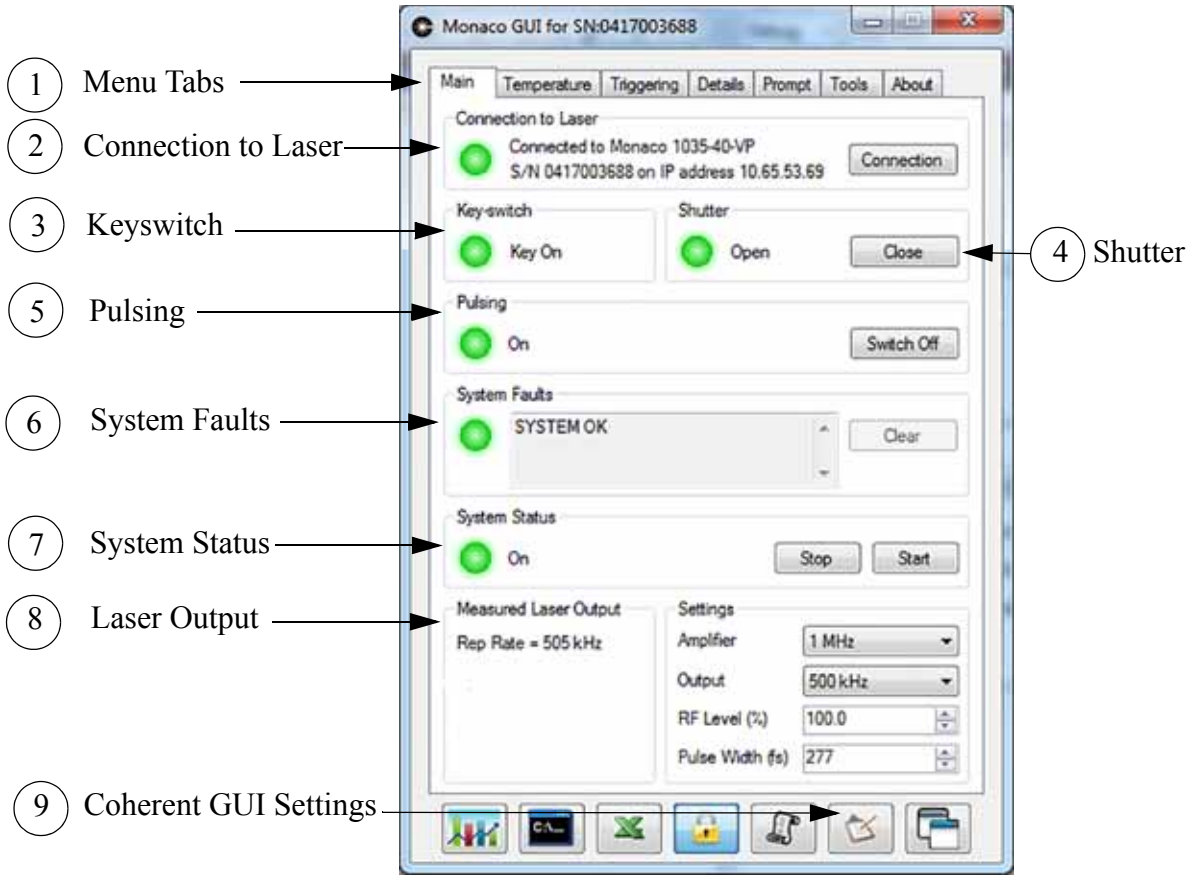


Figure 5-4. Main Menu Tab

Main Menu Tab

The Coherent GUI **Main menu tab** provides an overview of laser status and includes panels for primary operation of the laser system. See Figure 5-4 above.

1. **Menu Tabs -** Name of tab under discussion.
2. **Connection to Laser** Panel **-** Displays the communication status between the control computer and laser, the active communication port, and setting options through the CONNECTION button.
3. **Keyswitch Panel -** Displays the keyswitch status.
4. **Shutter Panel -** Displays the state of the shutter and allows the shutter to be opened or closed.
5. **Pulsing Panel -** Switches the pulses on or off, indicates status.
6. **System Faults Panel -** Lists any active faults or warnings and provides the option to clear faults that have been addressed.
7. **System Status Panel -** Switches the laser on and off, indicates status.
8. **Laser Output Panel -** Displays the average power, pulse energy, enables the pulse parameters, and current adjustments.
9. **Settings Form -** Launches Coherent GUI Settings screen.

GUI Connection Panel

The Connection to Laser panel on the Main tab allows the user to select a connection method between the laser and the control PC. By clicking the CONNECTION button in the panel, a Connection Options screen pops up as shown in Figure 5-5 below.

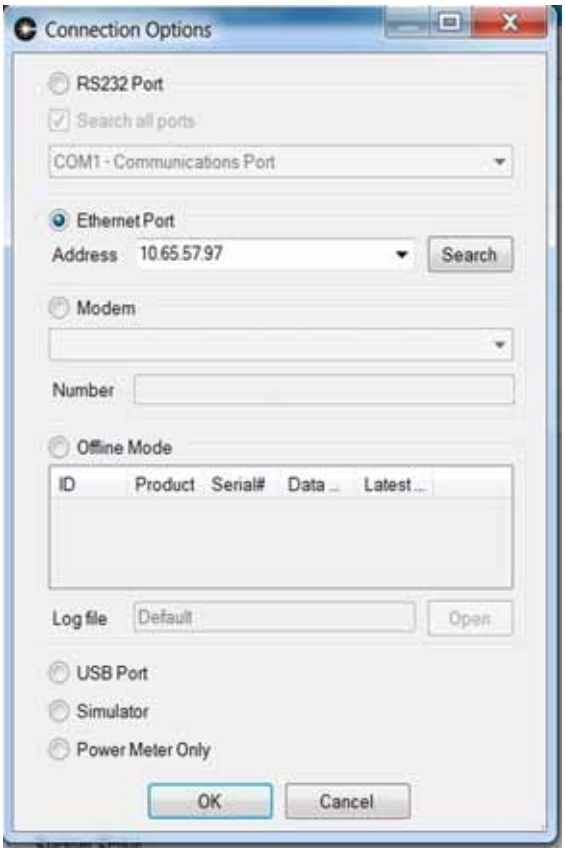


Figure 5-5. Connection Options Screen

There are three available connection options that can be set up from the Connection Options screen: RS-232, Ethernet, and USB. The preferred connection modes are Ethernet and USB, which allow fast connection and data transfer between the laser and GUI (control PC). Check that proper cable connection is established before making selection in the Connection Options screen and clicking the OK button. The connection process may take a few minutes. See "RS-232 Connection" on page 5-12, "Ethernet Connection" on page 5-13, and "USB Connection" on page 5-14 for more information on these connection options.

This panel also provides options to connect the GUI to a simulator or to Offline mode in which no connection to a real laser is required. The GUI can also be connected to a power meter only.

Temperature Menu Tab

The Temperature menu tab displays the chiller temperature, baseplate temperature, and humidity inside the laser head (see Figure 5-6 below).

The chart buttons open new windows to display system parameters in real time. These screens are highly configurable using the buttons on the screens. Configurable features include the graph scale; hiding old data; exporting the graph; showing or hiding the statistics panel; showing older data, more recent data, or the latest data; and zoom out. Using the dropdown menu, the chart can be set to examine a myriad of data captured by the data logger.

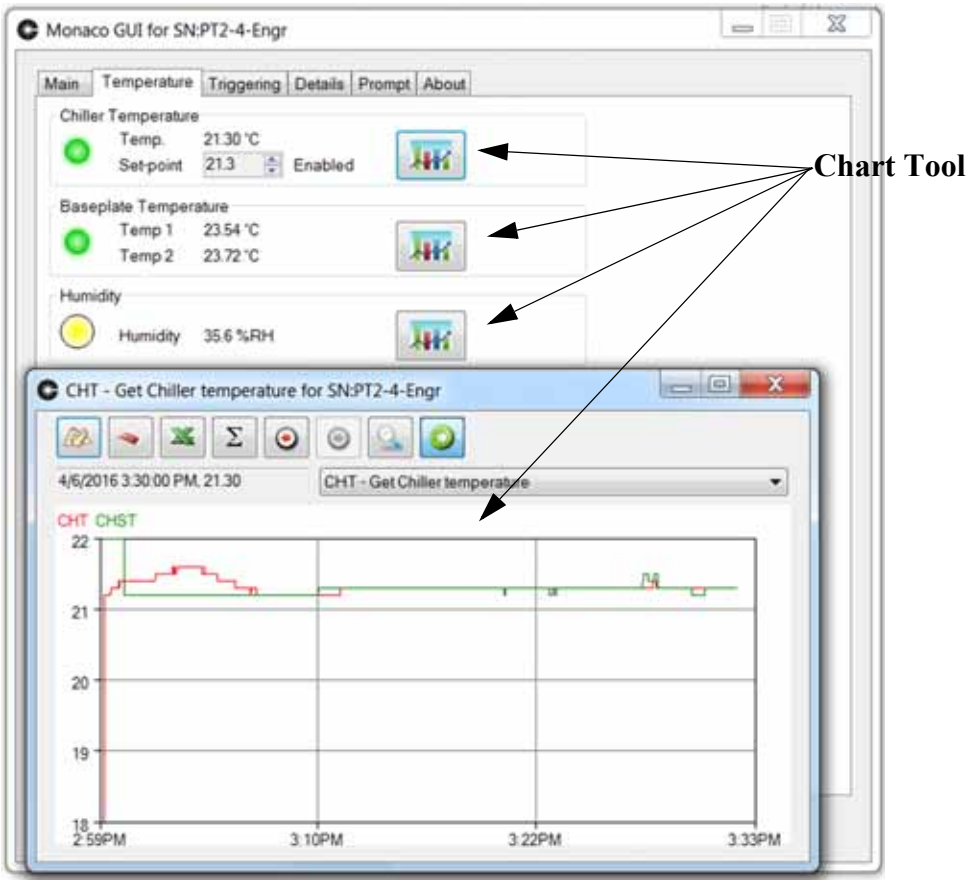


Figure 5-6. Temperature Menu Tab

Triggering Menu Tab

The **Triggering** menu tab, shown in Figure 5-7 below, provides selection and modification of the laser pulse mode. The drop down menus permit the user to select the AOM Pulse Mode and the number of pulses in a process burst (Process Burst Length). The different operating modes supported by the Monaco are described in "Operating Modes" on page 4-13.

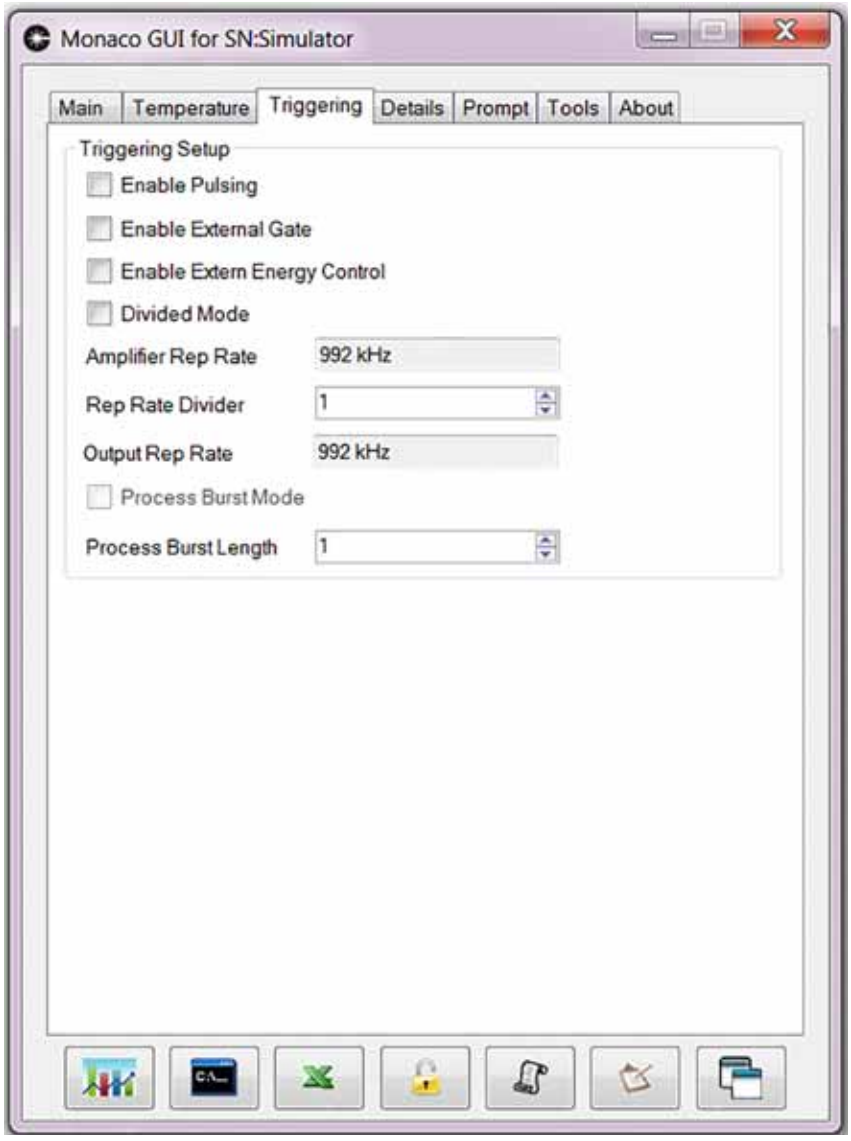


Figure 5-7. Triggering Menu Tab

Details Menu Tab

The **Details** menu tab displays the current status of all the data ported through RS232, USB, or Ethernet. See Figure 5-8 below.

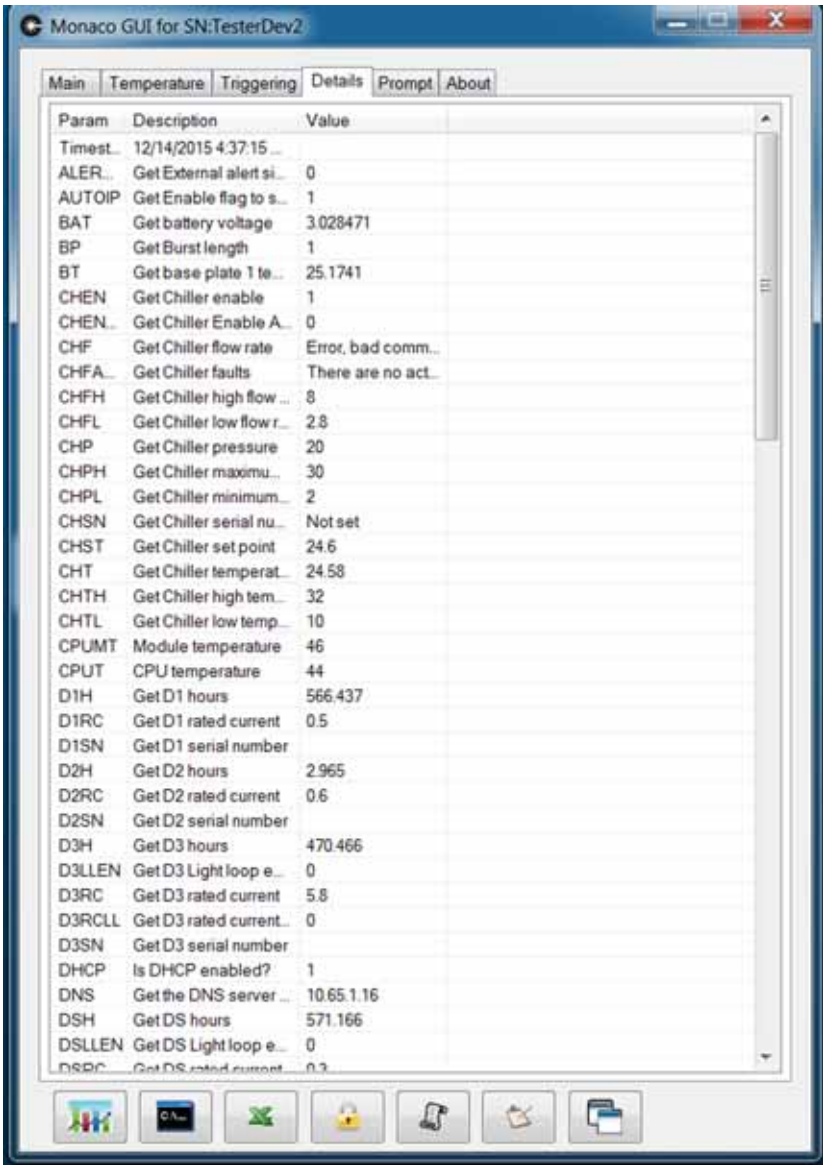


Figure 5-8. Details Menu Tab

Prompt Menu Tab

The **Prompt Menu** tab provides a command line for entering commands into the system. See Figure 5-9 below. Alternatively, a separate command screen can be opened up by pressing the "Open command window" button indicated by the red arrow below. This allows the user to make use of the GUI for monitoring the laser or other functions while entering commands. For a description of available commands, see "RS-232 Commands and Queries" on page 6-7.

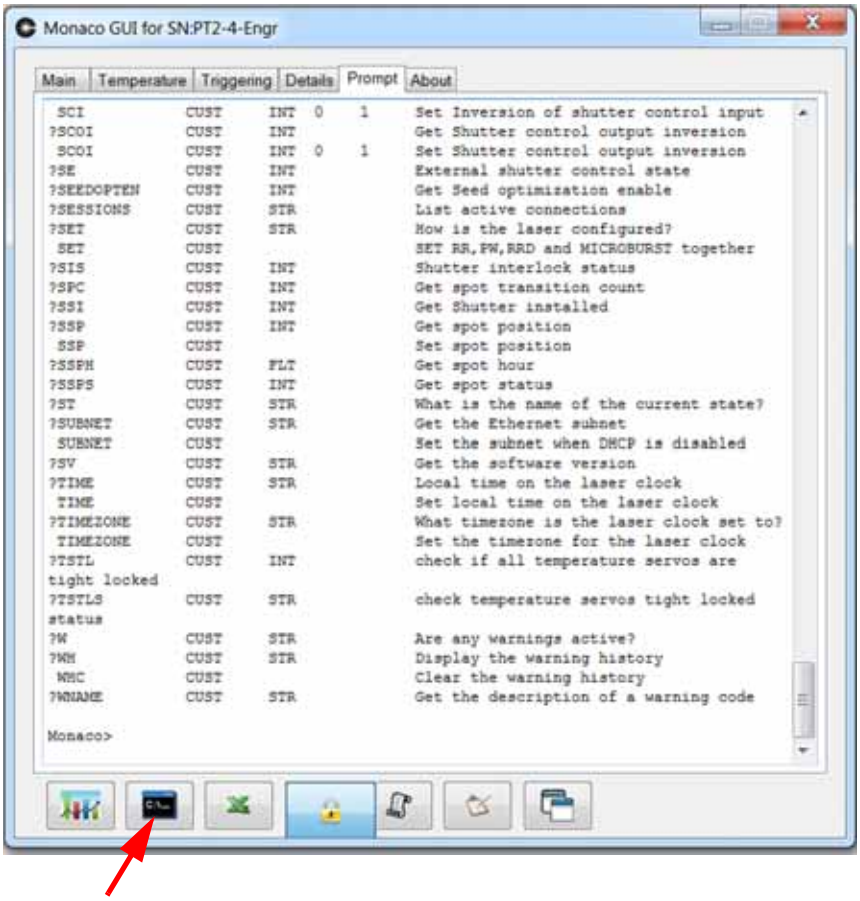


Figure 5-9. Prompt Menu Tab

About Menu Tab

The About menu tab shows the version and build date of the Coherent GUI. It also provides links to the Monaco and Laser web pages, the GUI and Laser Operator's manuals, and direct email access to the GUI developer.

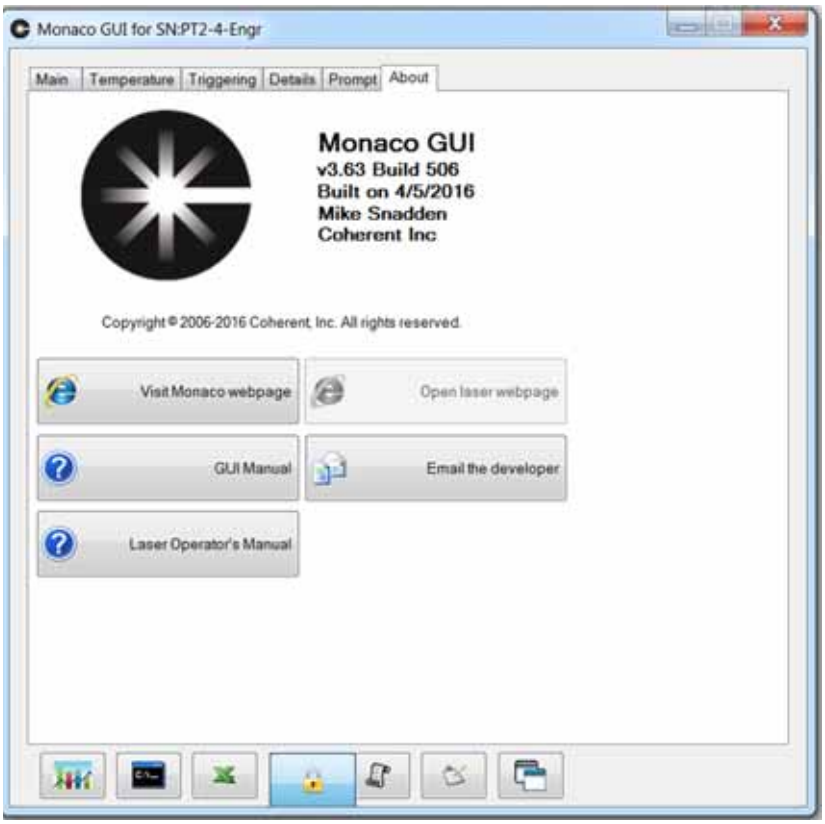


Figure 5-10. About Menu Tab

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>) or a semicolon (;). For proper handshaking, communication programs should wait until the <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:

1. Use only shielded cables. The shield must be connected between the two ends of the cable.
2. Keep cable length to 15 meters or less. The shorter it is, the better.
3. Check that the equipment at both ends of the cable is very well grounded. Because RS-232 is unbalanced, a small voltage difference between equipment can be interpreted as a different value at the receiver.
4. Avoid running the cable in a way that magnetic coupling can occur with other equipment.

The RS-232 connector uses three pins of the 9-pin D-type connector on the rear of the laser head, as shown in Figure 5-11.

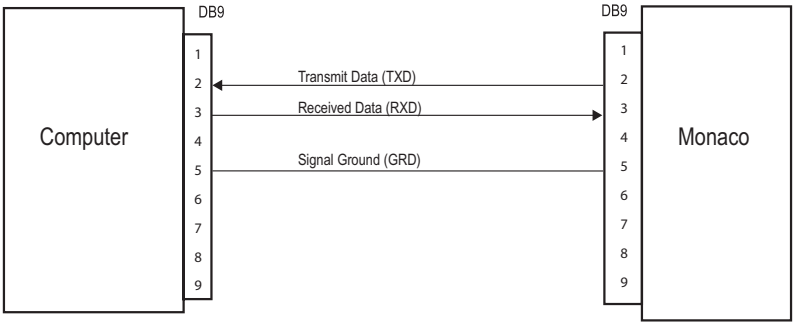


Figure 5-11. RS-232 Pin Configurations

Figure 5-12 shows a basic example of interacting with the Monaco via the RS-232 interface using a serial interface program.

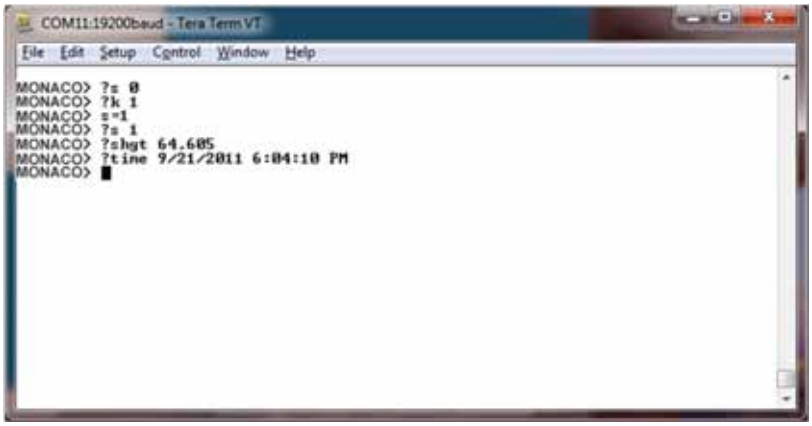


Figure 5-12. Serial Interface Program

Ethernet Connection

The Monaco includes a Telnet server which listens for connections on port 23. The Coherent GUI can use Telnet to interact with the Monaco.

The Monaco Ethernet port can be connected either to a network or it can be connected directly to a computer using an Ethernet cable. The Monaco supports multiple, simultaneous Telnet connections from multiple computers.

The Monaco registers a host name on the network to allow connections to be established. The default host name is the product type, followed by an underscore, followed by the laser serial number. Figure 5-13 below shows an example of a telnet connection being established to Monaco laser serial number 1234.

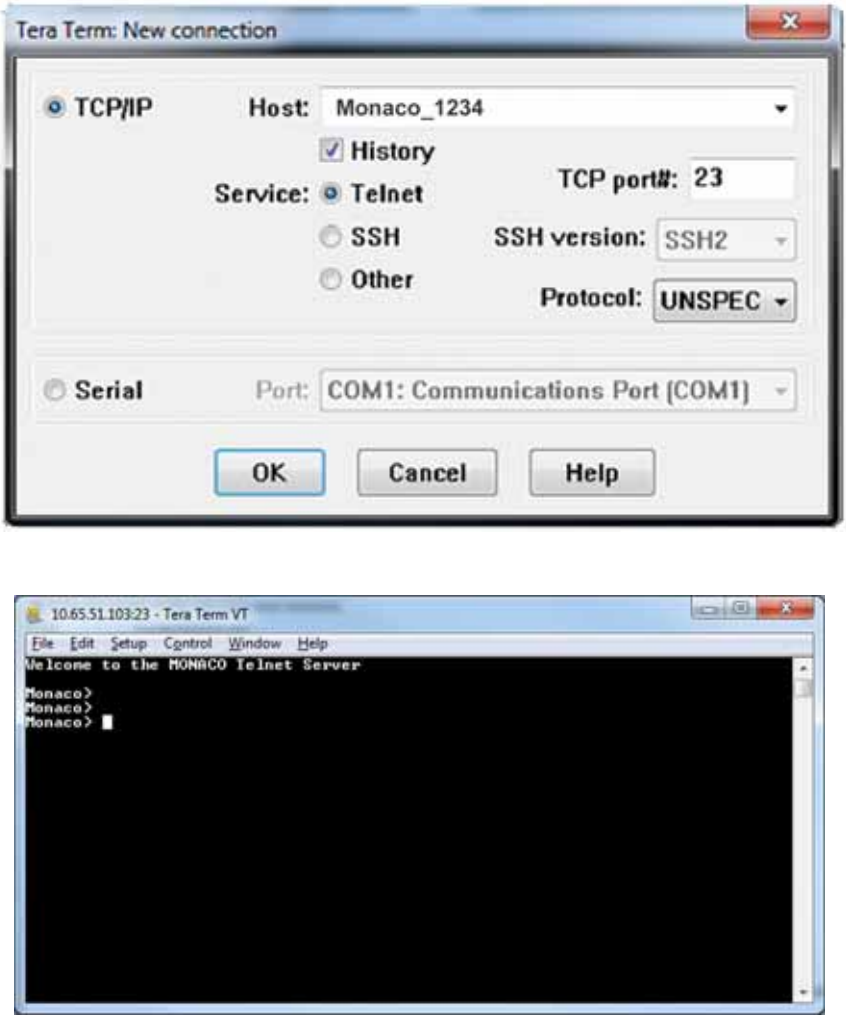


Figure 5-13. Telnet Connection

USB Connection

The USB interface to the laser uses the RNDIS standard. RNDIS is a Microsoft standard that implements a virtual Ethernet connection on top of a USB connection. RNDIS is supported only by Microsoft Windows XP or later.

The Coherent GUI must be installed before using the USB connection to the laser. After plugging in the USB cable, a device called "Coherent Datalogger" should appear on the system, as shown in Figure 5-14 (in Windows 7).

The virtual connection will also appear in the network connections as "Unidentified network", as shown in Figure 5-15.

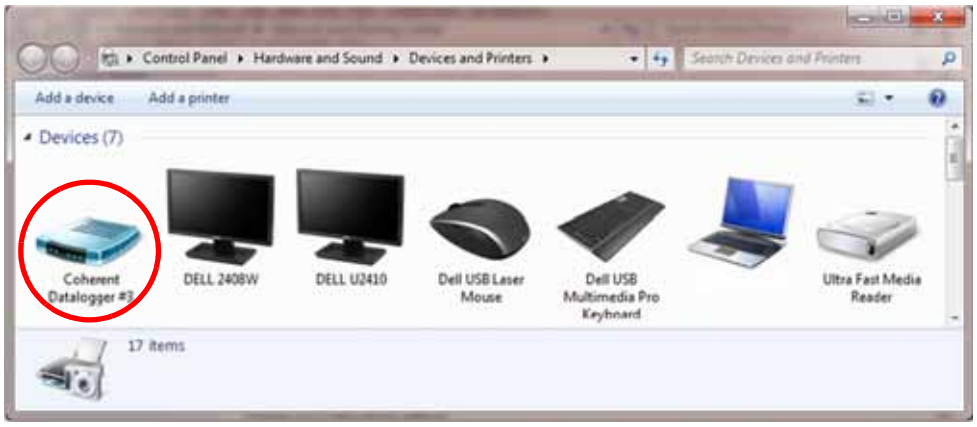


Figure 5-14. Windows Device Manager

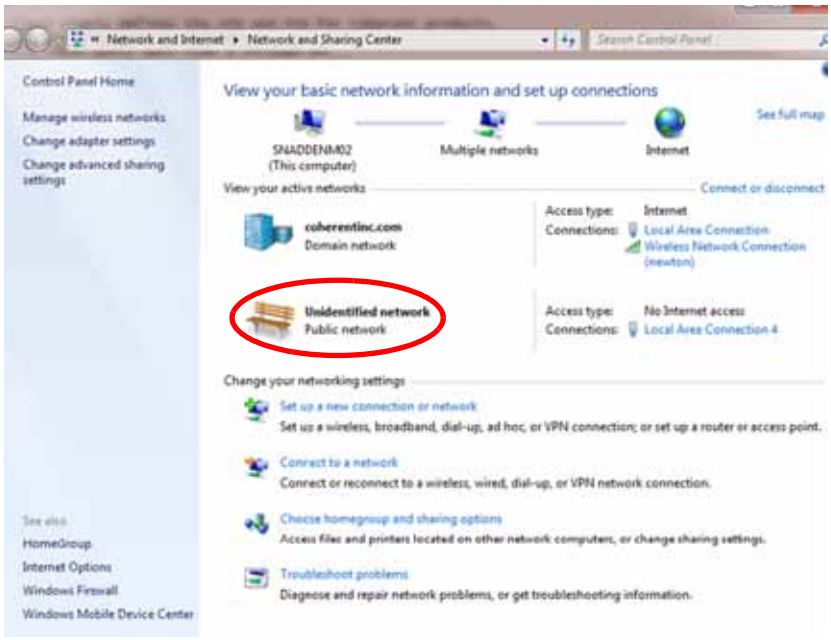


Figure 5-15. Windows Network Connections

Once Windows has configured the USB driver, the Monaco can be accessed on IP address 169.254.21.151 as shown in Figure 5-16.

This IP address can be used to establish telnet connections, as shown in Figure 5-17, or to connect to the Monaco using a web browser.

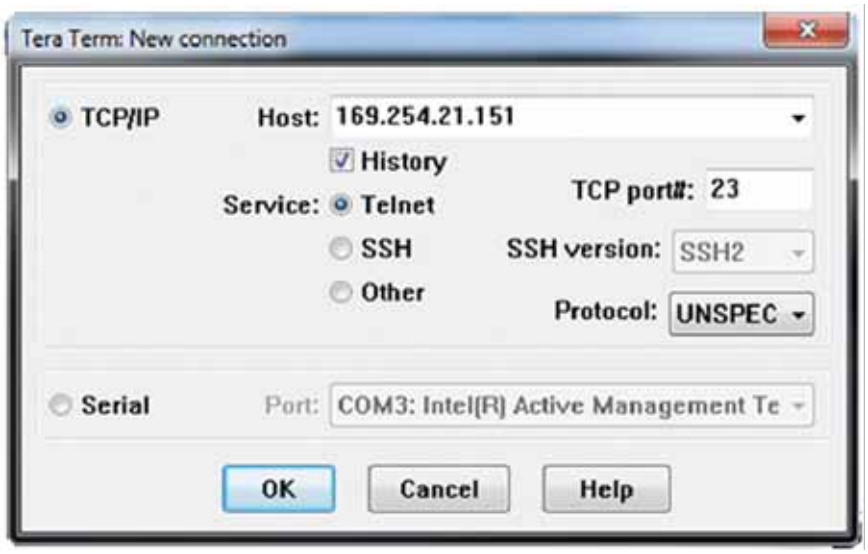


Figure 5-16. IP Address

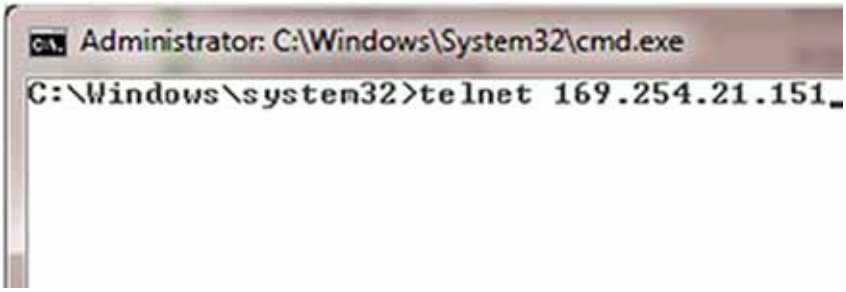
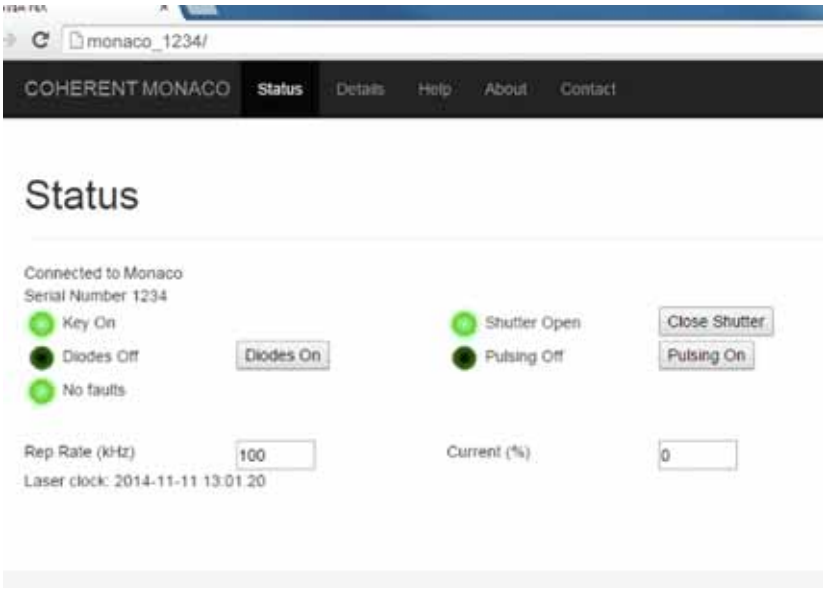


Figure 5-17. Telnet Connection

Web Server

The Monaco laser includes a web server that can be accessed through the Ethernet or USB connections as show in Figure 5-18 below. To access the web server, simply open a web browser and enter either the IP address or host name of the laser into the web server address bar.

The web server allows the basic functions of the laser to be monitored and adjusted.



ETHERNET OR USB

Figure 5-18. Web Server

GUI Settings

To change general settings of the Coherent GUI, click on the Adjust Settings icon at the bottom of the **Main** menu tab (see Figure 5-4).

Logging

The **Logging** menu tab allows you to set the data polling frequency period and the Database period as well as select which data parameters to log.

1. Select Adjust Settings icon at the bottom of the GUI screen.
2. Select the **Logging** menu tab on the Coherent GUI Settings screen.
3. To limit the amount of data stored in the data logger, check the "Trim old data" check box and set the time duration limits accordingly.
4. To save datalogger storage space, check the "Do not log duplicate data" check box as shown in Figure 5-19.

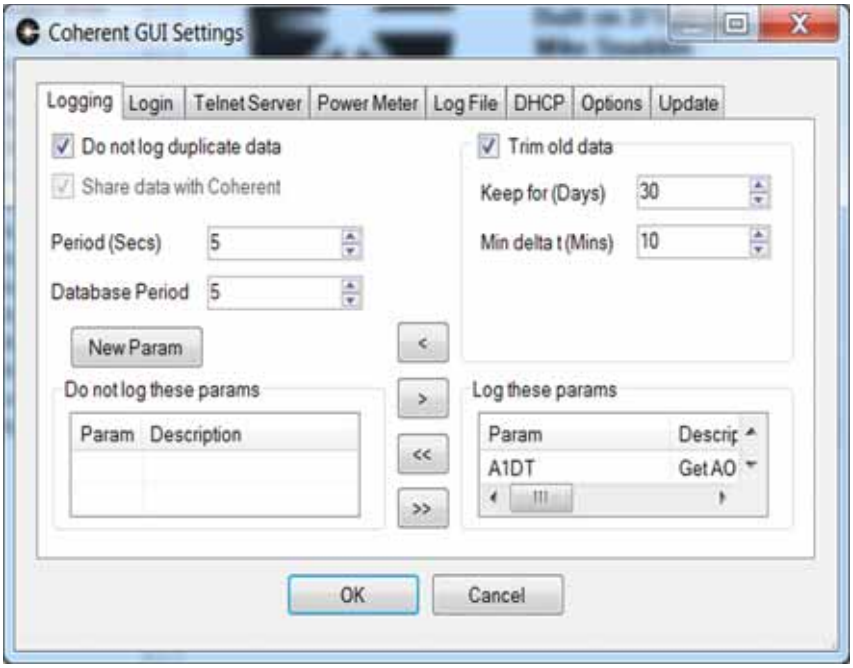


Figure 5-19. Logging Menu Tab

5. Set the data polling frequency by entering a value (m) in the Period (Secs) box. This sets the time period in seconds at which the GUI reads and displays laser parameters. The default value of m is 5. If m is set to zero, the GUI will read the data at the maximum rate.

6. Set the data storing frequency by entering a value (n) in seconds in the Database Period box. This sets the time period in seconds at which the datalogger saves the laser parameters. The default value on n is 30; if n is set to zero, the GUI will save the data at the maximum rate.

   With the data reading period set to m and the database period set to n, the datalogger will store laser parameters at a rate of n*m seconds.

   Low set values of m and n may drastically increase the demand for storage space and slow down the speed of data display; high set values may risk skipping data information for brief or intermittent events.

7. Select the parameters to record and monitor in the "Log these params" panel.

   By default all available laser parameters are logged. To save storage space, the user may choose to log only specific parameters. The DOUBLE ARROW buttons simultaneously transfer all parameters between the "Do not log these params" panel and the "Log these params" panel. The SINGLE ARROW buttons allow only selected laser parameters to be moved between the two panels.

   Note: You can make multiple selections by holding down the CTRL key while making selections or the Shift key for selections in sequence. After making the selection(s), press the SINGLE ARROW button.

Power Meter

The following instructions for establishing communication with the FieldMaster power meter are specific to the FieldMaster. However, the method used to establish communication for other types of power meters is similar to this method.

---

1. Connect an RS-232 cable between the power meter and the computer.
2. Check the power meter is ON.
3. Click on the Adjust Settings icon at the bottom of the GUI screen.
4. Click on the **Power Meter** menu tab.
5. The "Use External Power Meter" check box must be checked as shown in Figure 5-20 below.

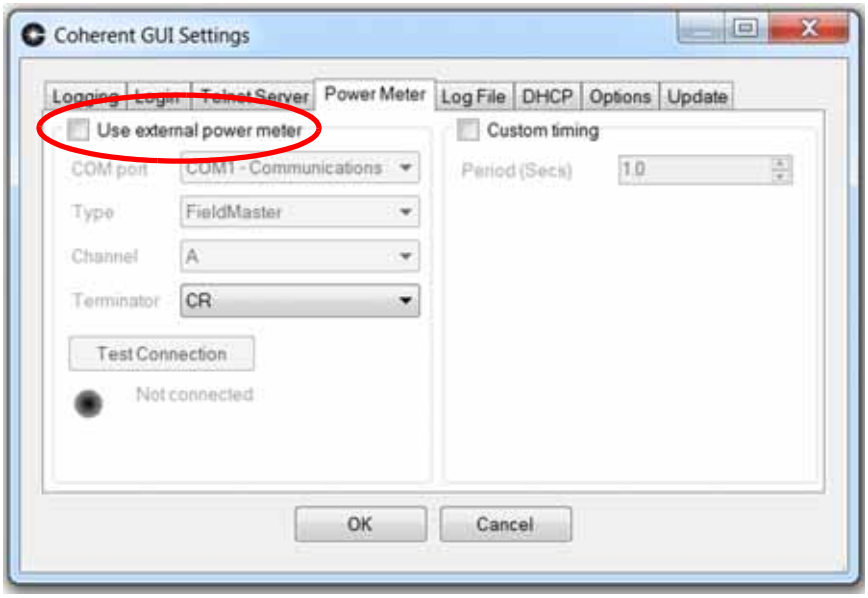


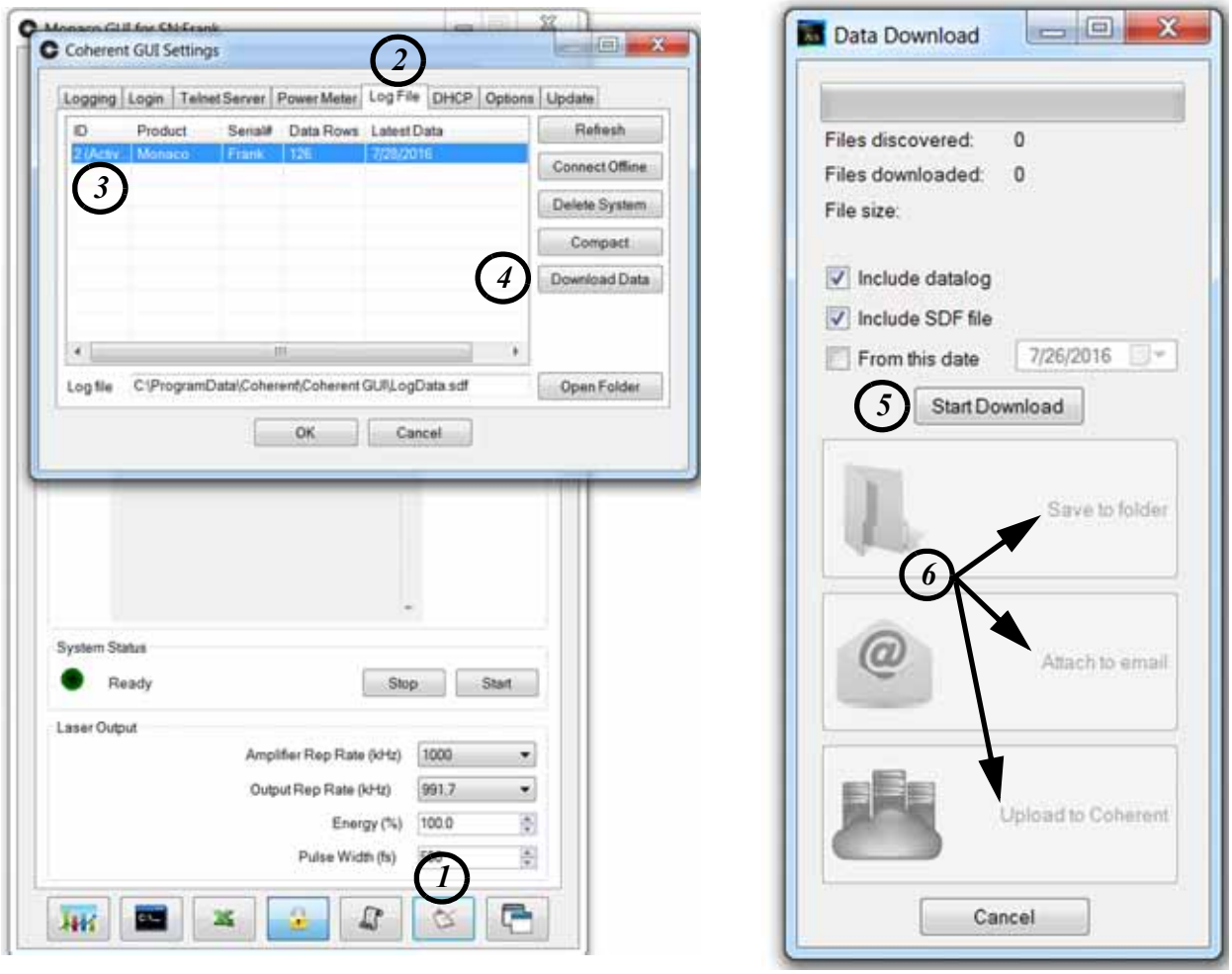
Figure 5-20. Power Meter Settings

6. From the COM port dropdown menu, choose the COM port corresponding to the port you connected to the power meter.
7. From the Type dropdown menu, choose the power meter type corresponding to the power meter you are using.
8. From the Channel dropdown menu, choose the channel corresponding to the power meter channel you are using: A or B.
9. From the Terminator dropdown menu, choose the terminator setting that matches the setting on the power meter console.
10. Determine if communication with the power meter has been established by clicking on the Test Connection button.

Log File

The Monaco stores data that may be retrieved to evaluate performance or assist in diagnosing a potential problem. Log files can be sent to Coherent product support for diagnostic help. To save the log file, proceed as follows:

1. Connect to the GUI using a USB or Ethernet connection. Do not use RS-232.
2. Click on the Adjust settings icon at the bottom of the GUI screen.
3. Click on the Log File tab as shown in Figure 5-21.



1. Adjust Settings
2. Log File
3. Choose Active System
4. Download Data
5. Start Download
6. Save DataLog to Folder, Email, or Coherent Cloud

Figure 5-21. Downloading Datalog File

4. Select the active system from the list.
5. Click the Download Data button.
6. The Data Download window will open (see Figure 5-21 on page 5-21). Click the Start Download button. It may take several minutes to download the file depending on the size. It is preferable to download both the datalog and SDF file, but to reduce the file size the "Include SDF file" button can be de-selected as the datalog is the most important. A message announcing "Done!" will display when the file is finished downloading.

7. Once the file is finished downloading, there are three methods to save the log file - save to a folder, attach to an email, or upload to the Coherent Cloud. Click on the chosen method.

8. To save the log file to a folder, click on the "Save to folder" button, and the Save As window opens. The file name will be populated automatically. Then choose the location the file is to be saved and click on the "Save" button. The folder window will open, and can be closed.

9. To send the log file directly to the Coherent Cloud, you must be connected to the internet as well as the laser. Click the "Upload to Coherent" button. A window will open to ask if you wish to include comments.

   a.) Click Yes, and the Blog Post window will open that will allow for any additional information, symptoms, or data to be typed in or attached as additional files.

   b.) Click the Post button when finished. Be patient, the file will take some time to post depending on how large the file is. A dialog box with a link to the Datalog file opens.

   c.) Click the Email URL button. A message window from your email client will open in the background. Click the message title bar to bring it to the front.

   d.) Send this email to **product.support@coherent.com**, include the symptoms and your contact information in the email, and include the service request number if you have one.

Updates

The **Update** menu tab provides the option of checking for GUI software updates. By default the GUI is set to automatically query the website www.Coherent.com/gui for new versions. You can also get updates by pressing the CHECK NOW button. To prevent the GUI from checking for automatic updates when starting, click on the "Don't check for updates when starting" check box. See Figure 5-22, below.

Figure 5-22. Update Settings

SECTION SIX: SERIAL COMMAND INTERFACE

Instruction Syntax

There are two types of instructions used in serial software command communication with the Monaco lasers:

- Commands which set the values of laser operating parameters
- Queries which request the laser to return the value of an operating parameter

Any instruction to the laser consists of a command or query written as a string of ASCII characters and terminated by a carriage return and line feed (<CR><LF>).

For example:

RL = 50<CR><LF>

Sets the pulse energy to 50 percent.

?HH<CR><LF>

Requests the number of operating hours on the system head.

The laser will always respond to a command with a carriage return and a line feed. It responds to a query with the requested data followed by a carriage return and a line feed. Table 6-1 lists the possible responses from the laser.

For proper handshaking, communication programs should wait until the <CR><LF> has been returned from the laser before sending the next instruction.

ECHO Mode

The Monaco provides an "echo" mode in which each character transmitted to the laser is echoed to the host. This feature can be turned on or off using the ECHO command
(E=0 for off, E=1 for on).

PROMPT Mode

The Monaco provides a "prompt" mode for terminal operation in which the laser returns; "Monaco>" after each command. This feature can be turned on or off using the PROMPT command
(>=0 for off, >=1 for on).

Table 6-1. Computer Interface

INSTRUCTION SENT TO LASER	RESPONSE FROM LASER	
	ECHO OFF PROMPT OFF	**ECHO OFF PROMPT ON**
Command + <CR><LF>	<CR><LF>	Monaco> <CR> <LF>
Query + <CR><LF>	Data + <CR><LF>	Monaco> Data + <CR> <LF>
Command = (bad data) + <CR><LF> (Illegal operand)	Error, bad param(s) + <CR><LF>	Monaco> Error, bad param(s) + <CR><LF>
Command <CR><LF> (Illegal instruction)	Error, bad command + <CR><LF>	Monaco> Error, bad command + <CR><LF>
Bad Query<CR><LF> (Illegal instruction)	Error, bad command + <CR><LF>	Monaco> Error, bad command + <CR><LF>
Multiple items will be separated by the "**&**" character. For example, a list of faults will be returned as "**3&5&6**."		
INSTRUCTION SENT TO LASER	**RESPONSE FROM LASER**	
	ECHO ON PROMPT OFF	**ECHO ON PROMPT ON**
Command + <CR><LF>	Command + <CR><LF>	Monaco> command + <CR><LF>
Query + <CR><LF>	Query + Data + <CR><LF>	Monaco> Query + Data + <CR><LF>
Command = (bad Data) + <CR><LF> (Illegal operand)	Command = (bad data) +Error, bad param(s) + <CR><LF>	Monaco> command= (bad data) +Error, bad param(s) + <CR><LF>
Bad Command + <CR><LF> (Illegal instruction)	(bad command) + Error, bad command + <CR><LF>	Monaco> (bad command) +Error, bad command + <CR><LF>
Bad Query<CR><LF> (Illegal instruction)	(bad query) + Error bad command + <CR><LF>	Monaco> (bad query) +Error, bad command + <CR><LF>
1. Multiple items will be separated by the "**&**" character. For example, a list of faults will be returned as "3&5&6."		

Query

The single character "?" before an instruction to the laser indicates a query. The laser returns information after each query.

Delimiters

The single characters **"="** and **":"** are equivalent delimiters between text and data in all commands. For example:

L = 1 is equivalent to **L: 1**

Enhanced Serial Protocol

The laser is often used near other equipment that can create electrical noise on RS232. This noise can lead to errors in the laser's status or the laser can fault because it received the wrong message. Although a shielded cable should always be used, noise can still interfere with RS232 signals. To solve noise issues, we recommend using the enhanced serial protocol. A comparison between messages with and without this protocol is shown below.

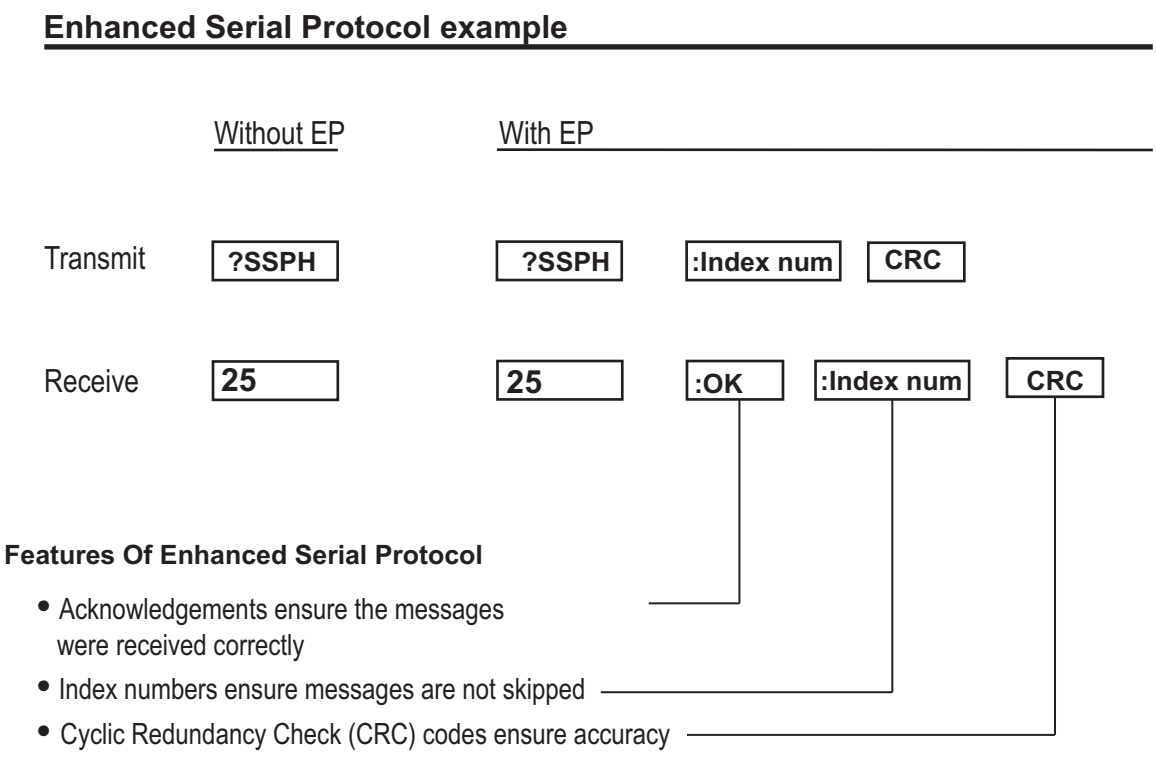


Figure 6-1. Enhanced Serial Protocol

Enhanced Protocol Commands

To start the Enhanced Serial Protocol, use the "EP=1" command. After this, future commands and replies must have the proper suffix added in order to be accepted as error free. The suffix contains:

- Index. This is used as a sequence number so messages don't get out of order when errors occur. The index is decided by the customer equipment. It contains the ":" (colon) character followed by one digit "0" to "9". The digit should change in sequence for each successful message. If the message is not successful, the digit remains the same
- Cyclic Redundancy Check (CRC). This is used to detect bit errors in the message. It contains two hex characters. For example "A9" would represent the hex value "0xA9". The CRC is calculated from the start of the message body up to and including the Index. The CRC is calculated with the polynomial 0x4D. This corresponds to x^8 + x^6 + x^3 + x^2 + 1. Sample code to calculate the CRC or verify contents against a CRC can be found here http://www.codeproject.com/Articles/19059/C-CCITT-8-CRC-Algorithm. Please note however that the polynomial should be changed to 0x4D in this algorithm
- Acknowledgment Token. These are characters that are used to tell if a message was received by the laser correctly. The token precedes the Index and CRC and will have one of the following values:
    - !K The message was successfully received by the laser
    - !R A reply was expected by the customer equipment but not received. The customer equipment uses this to tell the laser to send the reply again
    - !I The message was not correctly received by the laser. The customer equipment must send it again
    - !O The message was partly received by the laser but the UART had overrun errors. The customer equipment must send it again
    - !N This is a notification message sent by the laser on its own (e.g. changes to the chiller temperature). It is not a reply to a command from the customer equipment. This may be used in future product models.

Enhanced Protocol Replies

The laser always replies to every command with an acknowledgment. If the customer equipment does not see the reply, it can assume failure after a time-out and try again using the same index number. In order to minimize chances of errors, messages from customer equipment to laser are not echoed back when the enhanced serial protocol is active.

Commands from the customer equipment always finish with the carriage return character (ASCII 0x0D). This character is not included in the CRC. The laser will use the '!I' acknowledgment token if the carriage return is not received. The Line Feed character (ASCII 0x0A) is optional from customer equipment but will always be sent from the laser in replies.

Enhanced Protocol Example

For example, the following would be a typical exchange when querying SESAM spot hours, assuming no errors. The customer equipment waits for the "!K" acknowledgment token to assume success. If the index is "2", the command and reply look like:

```
Laser                                  Customer Equipment

          <---  ?SSPH:2C1      -------
           ---- 2844:!K:20B -------->
```

In this example, the reply was successfully received by the laser. The CRC of the send command is 'C1' and the CRC on reply is '0B'. A ':' (colon) character is used to separate the reply message from the acknowledgment token.

If the laser did not properly receive the command, it will reply with the '!I' acknowledgment token to ask for the command to be resent. Assuming the index is "7", the command and replies look like:

```
Laser                                  Customer Equipment

          XX     <---      ?SSPH:7B5     -------

          ----   !I:7B8 ---------------------------->
          <---   ?SSPH:7B9     ------------------
          ----   2844:!K:73F ------------------>
```

In this example, the command had an error while initially being transmitted to the laser. The laser asked for it to be resent by using the '!I' acknowledgment token and the customer equipment was able to send it successfully on the second try. Note that the index and CRC are always used, even with the acknowledgment. If the acknowledgment was not successfully received, the customer equipment can ask for the laser's acknowledgment to be resent by sending the '!R' acknowledgment token. The customer equipment should retry at least 6 times.

RS-232 Interface Connection

The Monaco's RS-232 port configuration is in Table 6-2, and typical cable requirements are shown in Figure 6-2. The 9-pin RS-232 port is configured as a data communications equipment (DCE) device using only pins 2 (serial data out), 3 (serial data in) and 5 (signal ground). Handshake lines RTS, CTS, DTR and DSR (pins 4, 6, 7 and 8) are not used and have no connections inside the laser head.

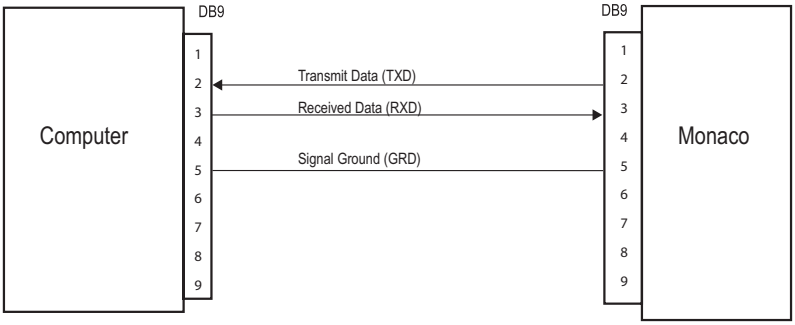


Figure 6-2. RS-232 Pin Configuration

RS-232 Port Configuration

The factory set baud rate is 19200.

Table 6-2. RS-232 Port Description

CONFIGURATION	DCE, NO HANDSHAKING
Data bits	8
Stop bits	1
Parity	none
Baud rate	19200 (factory setting)

Instruction Set

Table 6-3 describes the instructions for use in serial command communication with the Monaco system.

Table 6-3. RS-232 Commands and Queries (Sheet 1 of 9)

COMMANDS & QUERIES	RETURNED INFORMATION
PROMPT=n >=n	n = 0 turns off "Monaco >" prompt n = 1 turns on "Monaco >" prompt
?	Indicates a query
?ALL	Returns the value of every parameter
ALERTFLASH=n	Sets the flash mode of the alert signal output n = 0 disabled (steady output signal); n = 1 enabled (output signal flashes on and off.
?ALERTFLASH	Returns the setting of flash mode for the alert signal output 0 = disabled (stead output signal); 1 = enabled (output signal flashes on and off.
AUTOIP=n	Sets Enable flag to scan for an available IP address: n = 0 disabled n = 1 enabled
?AUTOIP	Returns the AUTOIP function status: n = 0 disabled n = 1 enabled
?BAT	Returns battery voltage, nominal 3V
BOOT=1	Entering the BOOT=1 command will reboot the firmware.
BP=nnnnnn	Sets the number of pulses in a burst. Allowed range is 1 to 1,000,000 pulses.
?BP	Returns the number of pulses in a burst Number of pulses is 1 to 1,000,000
?BT	Returns laser head baseplate measured temperature in °C.
CHEN = n	Set chiller enable: n = 0 turns off the chiller n = 1 turns on the chiller
?CHEN	Returns status of chiller enable
?CHF	Returns chiller flow
?CHFAULT	Returns chiller faults
?CHFH	Returns chiller high flow rate warning
?CHFL	Returns chiller low flow rate warning
?CHP	Returns chiller pressure
?CHPH	Returns chiller maximum pressure

Table 6-3. RS-232 Commands and Queries (Sheet 2 of 9)

COMMANDS & QUERIES	RETURNED INFORMATION
?CHPL	Returns chiller minimum pressure
?CHSN	Returns chiller serial number.
?CHST	Returns chiller set point
?CHT	Returns chiller temperature
?CHTH	Returns chiller high temperature limit
?CHTL	Returns chiller low temperature limit
?CPUMT	Returns CPU package temperature
?CPUT	Returns CPU chip temperature
?D1H	Returns the number of operating hours on laser diode 1
?D1RC	Returns the set maximum current of diode 1 in Amps as nn.nn
?D1SN	Returns serial number of the diode 1
?D2H	Returns the number of operating hours on laser diode 2
?D2RC	Returns the set maximum current of diode 2 in Amps as nn.nn
?D2SN	Returns serial number of the diode 2
?D3H	Returns the number of operating hours on laser diode 3
?D3LLEN	Returns the D3 light loop enable
?D3RC	Returns the D3 rated current
?D3RCLL	Returns the D3 rated current before light loop
?D3SN	Returns the serial number of laser diode 3
?DATA	Return data from the datalogger
DHCP=n	Enables or disables the dynamic host configuration protocol (DHCP): n = 0 DHCP is disabled n = 1 DHCP is enabled
?DHCP	Returns the status of DHCP
DNS=nnn.nnn.n.n	Sets the DNS address when DHCP is disabled
?DNS	Returns the DNS server address
?DSH	Returns the hours of DS
?DSLLEN	Returns DS light loop enable

Table 6-3. RS-232 Commands and Queries (Sheet 3 of 9)

COMMANDS & QUERIES	RETURNED INFORMATION
?DSRC	Returns the DS rated current
?DSSN	Returns the serial number for DS
ECHO=n E=n	Turns the Characters transmitted to the laser (echoed) on or off n = 0 turns off echo n = 1 turns on echo A change in echo mode will take effect with the first command sent after the echo command.
EM	Sets external modulation
?EM	Returns external modulation status
ENHANCED PROTOCOL EP	Enhanced serial protocol
?ENHANCED PROTOCOL ?EP	Returns enhanced serial protocol
EXIT	Closes an Ethernet connection
?F	Displays a list of faults, if present Use ?FNAME command to show a description of a particular fault. If a fault is present, it will turn off the laser.
FACK = 1	Send “FACK=1” to acknowledge faults and return the laser to a a ready state if the fault condition is lifted.
?FAULTS	Returns a list of numbered codes of all active faults. separated by an &, or returns “System OK” if no active faults
?FH	Returns the fault history with index numbers delimited by “&” sign with no spaces Faults are recorded in chronological order since last AC power up or last FHC command. Fault history is limited to the last 20 faults.
FHC	Clears the fault history
?FNAME:nn	Returns the description of fault code or warning code nn
?FV	Returns the FPGA version
GATEWAY =nnn.nnn.n.n	Set the gateway when DHCP is disabled
?GATEWAY	Returns the Ethernet gateway
?GUI	Returns the minimum required GUI version
HB=n	Sets the heartbeat timeout in secs, 0 or 5-300 (0=disabled). For a full description see “Heartbeat Function” on page 4-24.
?HB	Returns the heartbeat timeout in seconds (0=disabled)

Table 6-3. RS-232 Commands and Queries (Sheet 4 of 9)

COMMANDS & QUERIES	RETURNED INFORMATION
HELP	Query commands, with optional filter
?HELP	Shows a list of all commands or a subset if a keyword is used For example, "?HELP PULSE" shows all PULSE related commands.
?HH	Returns the number of operating hours on the system head
?HHL	Returns the set head humidity limit
HOSTNAME	Sets host name for Ethernet connection
?HOSTNAME	Returns host name of Ethernet connection
?HSN	Returns serial number of the laser head
?HSV	Returns firmware version of the laser head as HEAD rev x.xx, date
?HV	Displays the internal revision level of major hardware components
IP = nnn.nnn.n.n	Sets the static IP address. To set a static IP address use the commands below with the IP address (e.g. 192.168.0.32) and subnet (e.g. 255.255.255.0) you've chosen: AUTOIP=0 DHCP=0 IP=192.168.0.32 SUBNET=255.255.255.0 BOOT=1 Note that the SUBNET needs to be set to match the subnet of the PC that you want to control the laser from.
?IP	Returns the IP address for Ethernet
IPMAX	Sets end of range for AutoIP scan
?IPMAX	Returns end of range for AutoIP scan
IP MIN	Sets start of range for AutoIP scan
?IPMIN	Returns start of range for AutoIP scan
?IRE	Returns IR laser pulse energy in µJ
?IREC	Returns uncalibrated IR sensor reading
IREP1	Sets laser pulse energy point 1 calibration, 0-100%
IREP2	Sets laser pulse energy point 2 calibration, 0-100%

Table 6-3. RS-232 Commands and Queries (Sheet 5 of 9)

COMMANDS & QUERIES	RETURNED INFORMATION
?IRPOUT	Returns laser power in W
?K	Returns laser enable keyswitch state: 0 = laser in Standby (laser diodes cannot be turned on) 1 = laser enabled
L	L=0 turns off laser L=1 turns on laser
?L=n	Returns laser state. For example: 0 if the laser is in (STANDBY) 1 if the laser is in ON 2 if the laser is in STANDBY because FAULT occurred
?LASTIP	Returns last used static IP address
?LM	Returns the laser model
?LNAME	Returns name of the specified laser state For example, send "?LNAME 1" to get the description of state 1.
LOCKOUT=n	Sets laser LOCKOUT control state (only one connection can have exclusive control of laser at any given time): n = 0 unlocks laser to release control to other remote control device. The next remote device issuing a command will have exclusive control, which sets LOCKOUT=1 for that device. n = 1 locks out other remote devices from controlling laser; only current control device has exclusive control of laser (default).
?LOCKOUT	Returns LOCKOUT state of laser control: 0 = laser is unlocked from current connection for control by another remote control device or connection. 1 = laser remote control is locked out: only current connection has exclusive control of the laser a = a connection from device X has exclusive control of the laser.
?LPSSN	Returns low power stage serial number
?MAC	Returns the MAC address of the Ethernet interface
?MRR	Returns the laser amplifier repetition rate (in kilohertz)
?NEW	Returns every parameter that has changed
PC=n	Sets pulse control: n = 0 is pulse control off n = 1 is pulse control on

Table 6-3. RS-232 Commands and Queries (Sheet 6 of 9)

COMMANDS & QUERIES	RETURNED INFORMATION
?PC	Returns the status of pulse control: 0 = pulse control off 1 = pulse control on
?PD3T	Returns the PD3 temperature.
?PD4OPTEN	Returns PD4 optimization enable status: 0 = PD4 optimization off 1 = PD4 optimization on
?PDSV	Returns seed photodiode voltage
?PENERGYV	Returns the external pulse energy control voltage
PM=n	Sets the pulse mode: n = 0 for Continuous pulsing n = 1 for Gated mode n = 2 for Divided mode n = 3 for Divided and Gated mode n = 4 for Burst mode n = 5 for Burst and Divided mode
?PM	Returns the pulse mode: 1 = Gated mode 2 = Divided mode 3 = Divided and Gated mode 4 = Burst mode 5 = Burst and Divided mode
PROMPT=n	Displays a prompt before each command: n = 0 to remove the prompt n = 1 to display prompt
?PSSN	Returns the power supply serial number
PW=n	Sets the pulse width in femtoseconds Values for *n* must be within the range of pulse widths tested for the laser as listed on the datasheet provided with the system.
?PWS	Returns the pulse width set point
QUIT	Closes an Ethernet connection
?READY	Returns laser ready status
?RELH	Returns the measured relative humidity % in laser head
REN=n	Enables or disables the recirculator: n = 0 disables the recirculator. n = 1 enables the recirculator.
?REN	Returns recirculator control status

Table 6-3. RS-232 Commands and Queries (Sheet 7 of 9)

COMMANDS & QUERIES	RETURNED INFORMATION
RL	Sets the pulse energy percent, from 0 to 100
?RL	Returns the current pulse energy level percent setting
?RR	Returns the laser pulse or seeder burst output repetition rate in Hz
RRD	Allows the amplifier laser pulse repetition rate (configured using the SET command below) to be divided by an integer For example, to divide the amplifier repetition rate by 4, enter RRD=4. Limit 65,535.
?RRD	Returns the laser pulse repetition rate divisor
S=n	Sets the external shutter state: n = 0 closes external shutter n = 1 opens external shutter
?S	Returns the status of the external shutter: 0 = shutter closed 1 = shutter open
?SC	Returns the shutter cycle counter value
SCI=n	Shutter control inversion: n = 0 disables inversion (default) n = 1 enables inversion
?SCI	Returns inversion of shutter control input value
SCOI=n	Sets shutter control output inversion: n = 0 disables inversion n = 1 enables inversion
?SCOI	Returns shutter control output inversion value
?SE	Returns the external shutter control (pin 17) state: 0 = pin 17 at GND and S = 0 (both are off) 1 = pin 17 at GND and S = 1 2 = pin 17 is high and S = 0 3 = pin 17 is high and S = 1 (both are on) NOTE: This command is seldom used. Using the ?S query is more commonly used to determine if the shutter is open or closed.
?SEEDOPTEN	Returns the seed optimization enable status: 0 = Disabled (default) 1 = Enabled
?SESSIONS	Lists the active connections

Table 6-3. RS-232 Commands and Queries (Sheet 8 of 9)

COMMANDS & QUERIES	RETURNED INFORMATION
SET=*w,x,y,z*	Sets up to 4 laser parameters simultaneously: amplifier repetition rate (MRR), pulse width (PW), repetition rate divisor (RRD), and number of pulses per seeder burst. The command is of the form SET=*w,x,y,z* where *w* is the requested amplifier rep rate in kHz, *x* is the pulse width in femtoseconds , y is the repetition rate divisor (RRD), and z is the number of pulses per seeder burst. Values for the amplifier repetition rate must be chosen from those in the GUI Amplifier Rep Rate drop down menu. Missing parameters are left unchanged e.g. "SET=ARR,,RRD," will leave PW and seeder burst pulses unchanged. For a full description of the SET command, see "SET Command" on page 6-18.
?SET	Returns the current values for the laser parameters: amplifier repetition rate (MRR) in kHz, pulse width (PW) in femtoseconds, repetition rate divisor (RRD), and number of pulses per seeder burst (e.g. "1000,400,2,1")
?SIS	Returns the status of the shutter interlock sense: 0 = shutter interlock closed 1 = shutter interlock open
?SRR	Returns the seed laser pulse repetition rate
?SSI	Returns the status of the shutter installation: 0 = Shutter not installed 1 = Shutter installed
SSP	Sets the SESAM spot position For example, use "SSP=+" to shift to the next available spot.
?SSP	Returns current SESAM spot position
?SSPC	Returns the SESAM spot transition count (i.e. how many system starts on that spot) Note that after 600 starts on a spot, the system will automatically move to a different spot at the next system start-up.
?SSPH	Returns current SESAM spot hours
?SSPS	Returns SESAM spot status
?ST	Returns the name of the current laser state such as "Standby", "Ready", "Fault", or "On" when the laser reaches those steady state conditions It can also return transient laser states, such as diode current ramping up or down. The ?L command is a short form of this command.
SUBNET	Sets the subnet when DHCP is disabled (DHCP=0)
?SUBNET	Returns the Ethernet subnet

Table 6-3. RS-232 Commands and Queries (Sheet 9 of 9)

COMMANDS & QUERIES	RETURNED INFORMATION
?SV	Displays the revision level of major software components
TIME = 'yyyy-mm-dd hh:mm'	Sets local time on the laser clock
?TIME	Returns local time on the laser clock
TIMEZONE	Sets local time zone on the laser clock
?TIMEZONE	Returns local time zone on the laser clock
?TSTL	Checks if all temperature servos are tight locked
?TSTLS	Returns the temperature servos tight locked status: 0 = Not within 0.1ºC 1 = within 0.1ºC
USB	Set the mode for the USB connection
?USB	Returns the USB connection mode
?W	Displays a list of warnings, if present Then use the ?WNAME command to show a description of a particular warning. Warnings will not turn off the laser.
?WH	Displays the warning history
WHC	Clears the warning history
?WNAME	Returns the description of a warning code For example send "?WNAME 500" to get the description for warning 500.

Serial Command Laser Control

WARNING!
To avoid injury or damage, the laser output must be blocked or directed at an intended target. All personnel in the area must be wearing laser safety glasses.

Initial Start-up Procedure

To start the Monaco laser system, perform each of the following steps in the order listed. The Initial Start-up procedure must be used after the power switch on the rear panel has been shut off. Refer to Table 4-1 for more information.

After a complete shut down, the warm up time may take up to 45 minutes while the diode and chiller temperatures stabilize to the set values.

Preliminary

1. Check that the chiller reservoir is full, the coolant lines are connected, and the chiller power switch (if present) is in the <ON> position.
2. Set the keyswitch to the <STANDBY> position.
3. Set the power switch on the power supply rear panel to the <ON> position. The AC power indicator will light.[1]
4. Select which method of communication to set up the laser connection. Connect a Microsoft computer to the system using the RS-232 Connection, Ethernet Connection, or the USB Connection.

After preliminary steps of the Initial Start-up procedure have been completed, perform the Standby Start-up in the following procedure to complete the Initial Start-up.

1. If the indicator does not light, refer to Section Seven: Service and Maintenance for more information.

Standby Start-up Procedure

For routine operation of the Monaco, Coherent recommends using the Standby Start-up procedure to turn on the laser. After a Standby Shut-down the Standby Start-up can be performed whenever the rear panel power switch has been left in the ON position and all diode and chiller temperatures are locked and stable[1].

For Standby Start-up of Monaco laser system, enter the following commands in the order listed.

1. Keyswitch:

- Set the keyswitch to the <ENABLE> position

2. **Set up the Triggering parameters:**

- PM = n to set the pulse mode

3. Set up the repetition rate and pulse width:

- SET = nnnnnn to set the Rep. Rate (Hz) value

4. Open the Shutter:

- S = 1 to open the shutter or press the shutter button on the power supply front panel
- The shutter indicator will light on the power supply front panel

5. Turn on pulsing:

- PC = 1 to turn on pulses

6. Turn on diodes:

- L = 1 to turn on diodes. They will typically ramp to their set current within 30 seconds.
- Allow at least 45 minutes for the temperature servos and the chiller to achieve operating temperature.

1. Laser in the standby state with main AC power on as described in Table 4-1.

Standby Shut-down

When the Monaco laser system is used on a regular routine basis, the system can be powered down to the Standby mode. This method avoids the time necessary to stabilize the system during the Initial Power-up procedure.

1. **Close Shutter:** (this will stop lasing)
   - S = 0 or press the shutter button on the power supply front panel
2. **Turn diodes off:**
   - L = 0 to stop lasing
3. **Keyswitch:**
   - Turn the keyswitch to the <STANDBY> position
   - The key can be removed for safety
4. **Chiller:**
   - The chiller should remain on

Complete System Shut-down

To remove all power from the Monaco, complete the Standby Shut-down procedure before performing these additional steps for a complete shutdown. This procedure is recommended when performing system maintenance or repair. Use the Initial Power-up procedure to turn on the Monaco after a complete system shut-down.

1. **AC mains Power:**
   - Turn off the power switch on the rear panel
2. **Chiller Power:**
   - Turn off the power to the chiller

SET Command

The serial command SET configures up to four laser parameters simultaneously: amplifier repetition rate (MRR), pulse width (PW), repetition rate divisor (RRD), and number of pulses per seeder burst. The command is of the form SET=*w,x,y,z* where *w* is the requested amplifier rep rate in kHz, *x* is the pulse width in femtoseconds, *y* is the repetition rate divisor, and *z* is the number of pulses per seeder burst. If a value for a variable is left blank then the laser parameter remains at its previous setting. For example, entering "SET=500,,,2" would configure the laser for an amplifier repetition rate of 500kHz and set the number of pulses per seeder burst to 2, but would leave the previous values for the repetition rate divisor and pulsewidth unchanged. If the seeder burst value is not used in the SET

command, it is assumed to be set to 1. For example SET=1000 sets the amplifier rep rate to 1MHz, leaves pulse width and repetition rate divisor unchanged, and sets the seeder burst to 1 pulse. Entering the query "?SET" will provide the current values for the laser parameters *w,x,y,* and *z* (e.g. "1000,400,2,1").

Amplifier Repetition Rate (*w*): The SET command allows the user to configure the laser's amplifier repetition rate value. For a repetition rate divisor of one (RRD=1) this will also be the laser's output pulse/seeder burst repetition rate (RR). Values for *w* (in kHz) must be chosen from those in the GUI Amplifier Rep Rate drop down menu (see Figure 6-3). For example, for the laser shown a value of 1000 could be entered for *w* in the SET command to configure the laser for 1MHz operation, "SET=1000". However "SET=600" could not be entered because 600kHz is not a repetition rate value available from the drop down menu. The only exception to this is for lasers with the Interpolated mode option where repetition rates between 1-4MHz can be entered.

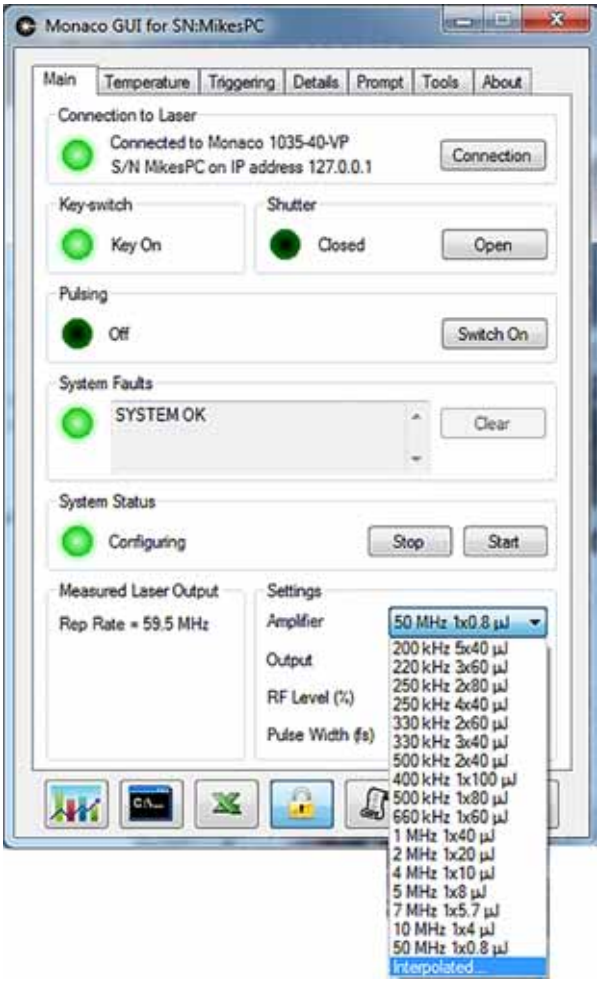


Figure 6-3. Amplifier Rep Rate Drop Down Menu

Pulse Width (*x*): The SET command also allows the user to configure the laser's output pulse width. Values for *x* (in femtoseconds) must be within the range of pulse widths tested for the laser as listed on the datasheet provided with the system. For example if the laser was not tested at 900 fsec pulse width as shown on the datasheet, then "SET=1000,900,," could not be entered as a valid command. Note that a value for the amplifier repetition rate (parameter *w*) must also be entered into the SET command to configure the pulse width.

Repetition Rate Divisor (*y*): The SET command also allows the user to configure the repetition rate divisor (RRD) of the laser. This enables Monaco laser output at lower pulse repetition rates by using the AOM to reduce the amplifier repetition rate (see "Divided Mode" on page 4-17). The laser's output pulse (or seeder burst) repetition rate would be the amplifier repetition rate divided by RRD. Values for *y* can be from 1 to 65535. For example, by using the command "SET=1000,,4," the output repetition rate would be 250kHz.

Number of Pulses per Seeder Burst (*z*): The SET command also allows the user to configure the number of pulses in each seeder burst from the laser (see "Seeder Burst Mode" on page 4-14). Note that *z*=1 (one pulse in each seeder burst) is simply a continuous stream of single pulses. If the seeder burst value is not used in the SET command, it is assumed to be set to 1. Values for the amplifier repetition rate (*w*) and for *z* must be chosen from those in the GUI Amplifier Rep Rate drop down menu (see Figure 6-3). For example in the laser shown, "SET=500,,,2" could be entered to configure the laser for 500kHz repetition rate with 2 pulses per seeder burst, but "SET=400,,,2" is not an available option.

Table 6-4. SET Command Examples

SET COMMAND	LASER OUTPUT
SET=1000,400,1,1	1 MHz output rep rate 400 fsec pulse width
SET=500,450,2,2	250 kHz seeder burst rep rate 450 fsec pulse width 2 pulses per seeder burst
SET=400	Set output rep rate to 400 kHz, pulse width and repetition rate divisor are unchanged, seeder burst set to 1 pulse
SET=400,,4,1	100 kHz output rep rate, pulse width unchanged

SECTION SEVEN: SERVICE AND MAINTENANCE

Introduction

The power supply and laser head are not operator serviceable.

WARNING!
There are NO serviceable items in the laser head or power supply except as detailed in the desiccant replacement procedure. Any opening to break the sealing of the laser head or power supply is strictly not allowed. Opening or breaking the laser head seal, except and only as specified in the desiccant replacement procedure, will void the manufacturer's warranty.

Troubleshooting

Table 7-1 lists some possible problems/error messages with a reference to the associated troubleshooting chart located in this section.

Fault Conditions / Fault Handling

When a fault condition occurs, the fault indicator in the **System Faults Panel** on the **Main menu tab** of the GUI will change from green to red. Most faults will shut down laser operation, and the ramp down typically takes a few seconds to maintain system life. The temperature servos stay on. The laser will not start when a fault is active. See Table 7-1 for a list of common system faults and troubleshooting procedures. For any system faults not listed please contact Coherent service or an authorized Coherent representative.

When a Monaco fault condition occurs, the emission indicators will turn off and the shutter will close.

To return the system to operation, the condition that caused the fault must be corrected. In addition, the fault must be acknowledged by pressing the <Clear> button on the **Main menu tab** in the **System Fault Panel** of the Coherent GUI, or by sending the command FACK = 1.

Warning messages are displayed in the **System Faults Panel o**n the **Main menu tab** of the GUI. Warnings do not shut the laser down. Warnings do not need to be acknowledged to start up or continue laser operation, and are provided for customer information only.

Table 7-1. Troubleshooting/Fault Messages

PROBLEM	TROUBLESHOOTING REFERENCE
AC ON indicator on Coherent power supply front panel does not light when power switch on rear panel is ON.	Chart 1
Laser does not start (no light output).	Chart 2
Laser Emission indicator on Coherent power supply front panel or on the laser head does not light when keyswitch is in the Laser Enable position.	See Note 1
Low output power.	Chart 3
Laser output is unstable.	Chart 4
Laser shuts down (no light output).	Chart 5
FAULT MESSAGES:	
# 1 Emission Lamp Interlock Fault	Contact Coherent
# 2 External Interlock Fault	Chart 8
# 3 Light Loop Fault	Chart 6
# 5 FPGA Fault	Contact Coherent
# 7 Timeout Fault	Contact Coherent
# 8 Rep Rate Noise	Change SESAM Spot (see "Changing the SESAM Spot" on page 4-26)
# 9 HSN on EEPROM Is Not Recognized	Contact Coherent
# 12 Seed Diode Temperature Fault	Contact Coherent
# 13 Diode 1 Temperature Fault	Contact Coherent
# 14 Diode 2 Temperature Fault	Contact Coherent
# 15 Stretcher Temperature Fault	Contact Coherent
# 16 Baseplate Temperature Fault	Chart 7
# 17 Baseplate 2 Temperature Fault	Chart 7
# 18 Seed Servo Stuck Fault	Contact Coherent
# 19 Seed Servo Drive Too Low Fault	Contact Coherent
# 20 Seed Maximum Temp Differential Fault	Contact Coherent
Note 1. Contact Coherent or an authorized representative. The laser emission lamp will not light if an interlock is open. Check interlocks before contacting Coherent or representative.	

Table 7-1. Troubleshooting/Fault Messages (Continued)

PROBLEM	TROUBLESHOOTING REFERENCE
# 21 Diode 1 Servo Stuck Fault	Contact Coherent
# 22 Diode 1 Servo Drive Too Low Fault	Contact Coherent
# 23 Diode 1 Maximum Temp Differential Fault	Contact Coherent
# 24 Diode 2 Servo Stuck Fault	Contact Coherent
# 25 Diode 2 Servo Drive Too Low Fault	Contact Coherent
# 26 Diode 2 Maximum Temp Differential Fault	Contact Coherent
# 27 Stretcher Servo Stuck Fault	Contact Coherent
# 28 Stretcher Servo Drive Too Low Fault	Contact Coherent
# 29 Stretcher Maximum Temp Differential Fault	Contact Coherent
# 30 Diode Seed Over Current Fault	Contact Coherent
# 31 Shutter State Mismatch Fault	Chart 11
# 32 Diode 1 Over Current Fault	Contact Coherent
# 33 Diode 2 Over Current Fault	Contact Coherent
# 34 Diode 3 Over Current Fault	Contact Coherent
# 35 Diode Seed Under Current Fault	Contact Coherent
# 36 Diode 1 Under Current Fault	Contact Coherent
# 37 Diode 2 Under Current Fault	Contact Coherent
# 38 Diode 3 Under Current Fault	Contact Coherent
# 40 Diode 3 Under Voltage Fault	Contact Coherent
# 41 Diode 3 Over Voltage Fault	Contact Coherent
# 50 Chiller Water Level Fault	Chart 13
# 51 Chiller Temperature Fault	Chart 13
# 52 Chiller Comm Fault	Chart 9
# 53 Chiller Flow Fault	Chart 10
# 54 Chiller Delta Fault	Contact Coherent
# 55 Stretcher 2 Temperature Fault	Contact Coherent
Note 1. Contact Coherent or an authorized representative. The laser emission lamp will not light if an interlock is open. Check interlocks before contacting Coherent or representative.	

Table 7-1. Troubleshooting/Fault Messages (Continued)

PROBLEM	TROUBLESHOOTING REFERENCE
# 56 Stretcher 2 Servo Stuck	Contact Coherent
# 57 Stretcher 2 Servo Drive Too Low Fault	Contact Coherent
# 58 Stretcher 2 Maximum Temp Differential Fault	Contact Coherent
# 59 BTEN Enable Fault	Contact Coherent
# 62 Spot Hour Elapsed Fault	Cycle the AC power or issue BOOT=1 command)
# 64 Motor Controller A1 Fault	Contact Coherent
# 68 SESAM Motor Stuck At Home Fault	Contact Coherent
# 69 SESAM Motor Not Find Home Fault	Contact Coherent
# 70 Rotational Motor Communication Fault	Contact Coherent
# 71 Rotational Motor Angle Fault	Contact Coherent
# 72 Pulse Width Motor Fault	Contact Coherent
# 80 Thread Exception Fault	Chart 6
# 90 Fast Shutdown - Photodiode 1 Voltage Fault	Contact Coherent
# 91 Fast Shutdown - Photodiode 2 Voltage Fault	Contact Coherent
# 94 Photodiode 1 Voltage Out of Range Fault	Contact Coherent
# 95 Photodiode 2 Voltage Out of Range Fault	Contact Coherent
# 96 Photodiode 3 Voltage Low Fault	Contact Coherent
# 97 Photodiode 5 Back Reflect High Fault	Contact Coherent
# 98 Configuration Fault	Contact Coherent
# 99 Seed Optimization Fault	Contact Coherent
# 106 Hardware Watchdog Reset Occurred Fault	Contact Coherent
# 107 EE Calibration Values Not Updated Fault	Contact Coherent
# 300 Software Thread Stalled Fault	Contact Coherent
# 301 Communication To Control Computer Lost Fault	Chart 12
# 302 Unable To Read From FPGA Fault	Chart 6
Note 1. Contact Coherent or an authorized representative. The laser emission lamp will not light if an interlock is open. Check interlocks before contacting Coherent or representative.	

Table 7-1. Troubleshooting/Fault Messages (Continued)

PROBLEM	TROUBLESHOOTING REFERENCE
# 303 Wrong FPGA Firmware Installed Fault	Contact Coherent
# 304 Power On Self Test (POST) Fault	Record fault number and contact Coherent
# 305 Unable To Write To FPGA Fault	Chart 6
# 306 DC GOOD Signal Is Bad Fault	Chart 6
# 307 GUI Is Out of Date Fault	Upgrade GUI to the latest version
# 308 Unapproved Chiller Fault	Change to a Coherent certified chiller.
# 309 I2C Failure Fault	Contact Coherent
# 310 Illegal Storage Value Fault	Contact Coherent
# 500 Relative Humidity Warning	Consider change to desiccant (see “Changing the Laser Head Desiccant” on page 7-35)
# 502 Spot Hour Elapsed Warning	Cycle the AC power or issue BOOT=1 command
# 504 State Machine Had A Timeout Warning	If problem persists, Contact Coherent
# 505 Chiller Water Level Warning	Chart 10
# 506 Chiller Flow Warning	Chart 10
# 507 Diode 3 Light Loop Limit Warning	If problem persists, Contact Coherent
# 508 Rotational Motor Angle Warning	If problem persists, Contact Coherent
# 509 Rotational Motor Angle Tolerance Warning	If problem persists, Contact Coherent
# 510 Seed Drive Is Low Warning	If problem persists, Contact Coherent
# 511 Diode 1 Drive Is Low Warning	If problem persists, Contact Coherent
Note 1. Contact Coherent or an authorized representative. The laser emission lamp will not light if an interlock is open. Check interlocks before contacting Coherent or representative.	

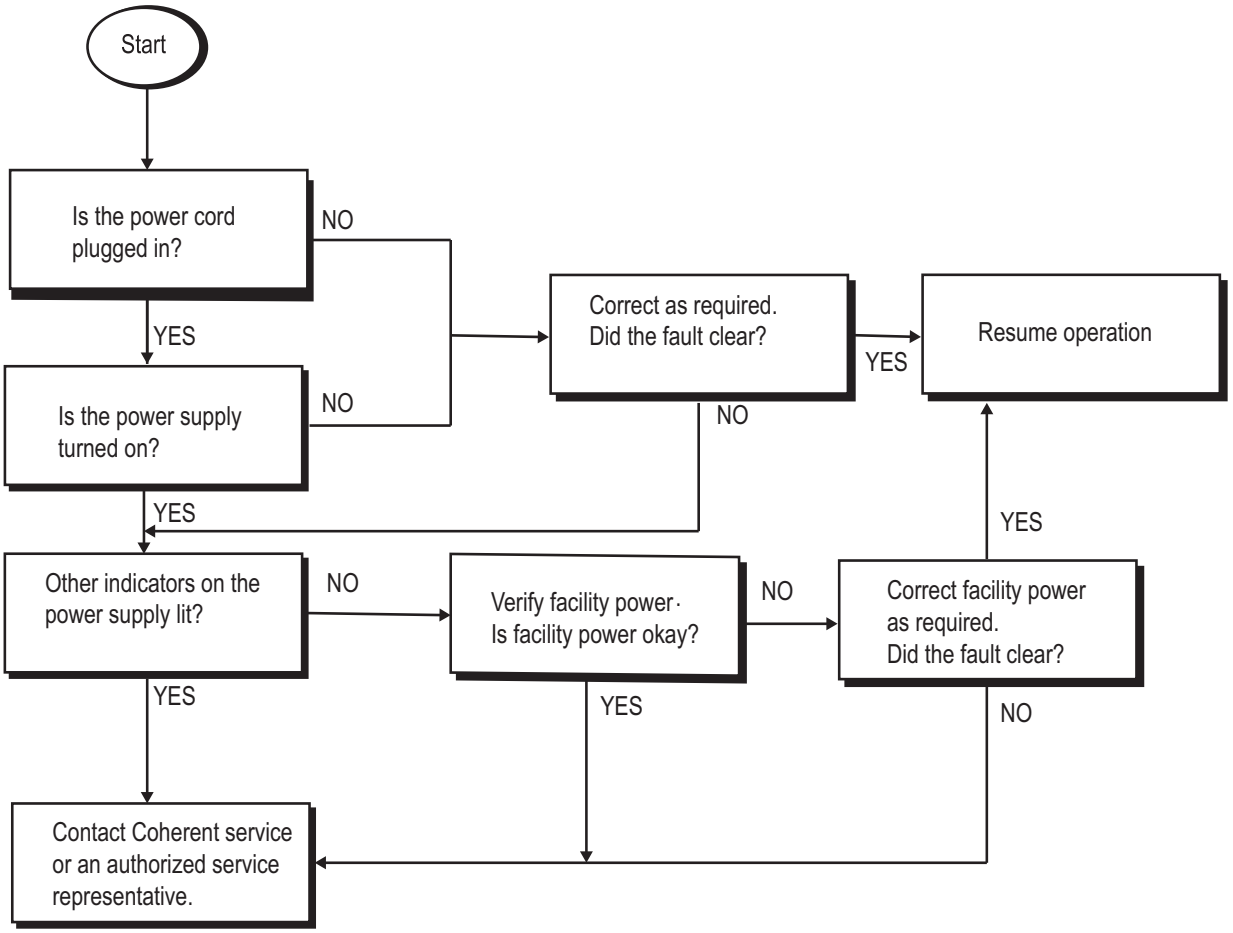
Table 7-1. Troubleshooting/Fault Messages (Continued)

PROBLEM	TROUBLESHOOTING REFERENCE
# 512 Diode 2 Drive Is Low Warning	If problem persists, Contact Coherent
# 513 Stretcher Drive Is Low Warning	If problem persists, Contact Coherent
# 515 Chiller-Baseplate Delta Warning	Chart 10
# 516 Chiller Delta Warning	Chart 10
# 517 Seed Diode Light Loop Limit Warning	If problem persists, Contact Coherent
# 518 Reprate Noise Warning	If problem persists, Contact Coherent
# 519 Rotational Motor Version Warning	If problem persists, Contact Coherent
# 520 Photo Diode 1 Saturated Warning	If problem persists, Contact Coherent
# 521 Photo Diode 2 Saturated Warning	If problem persists, Contact Coherent
# 522 Stretcher 2 Drive Is Low Warning	If problem persists, Contact Coherent
# 523 Diode 4 Light Loop Limit Warning	If problem persists, Contact Coherent
# 524 Diode 3 Calibration Values Exceed Normal Variations Warning	If problem persists, Contact Coherent
# 800 Bootloader Is Below Revision v1.3 Warning	Contact Coherent
# 801 Operating System Image Is Below Revision v1.3 Warning	Contact Coherent
# 802 Operating System Is Not 7.0 Warning	Contact Coherent
# 803 Software Thread Is Too Slow Warning	If problem persists, Contact Coherent
# 804 CPU Temperature Warning	Check ambient temperature is within operating specifications
# 805 Battery Is Low Warning	If problem persists, Contact Coherent
Note 1. Contact Coherent or an authorized representative. The laser emission lamp will not light if an interlock is open. Check interlocks before contacting Coherent or representative.	

Table 7-1. Troubleshooting/Fault Messages (Continued)

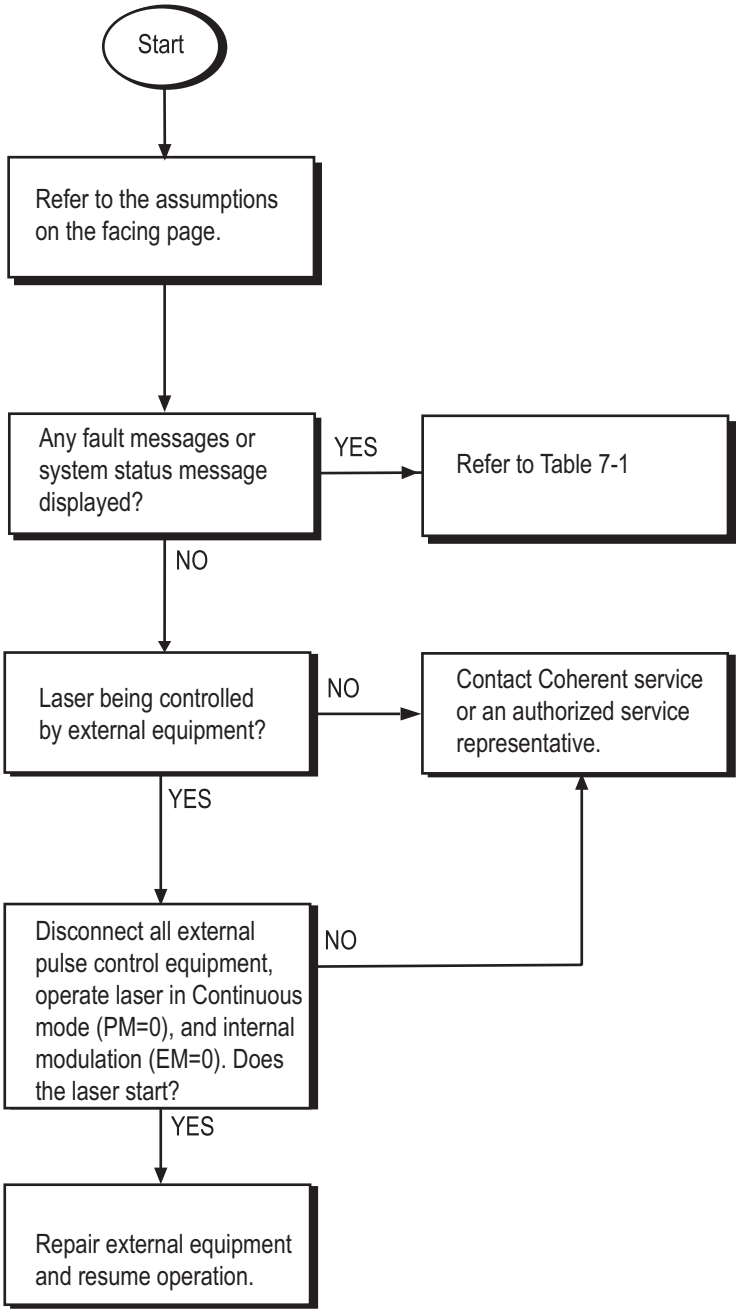
PROBLEM	TROUBLESHOOTING REFERENCE
# 806 Module Temperature Is Too High Warning	Check ambient temperature is within operating specifications
# 807 BasePlate Temperature Too Low Warning	Check ambient temperature is within operating specifications
# 808 Configurable Warning	Per Warning text (can be removed by typing the command "TEST=" in the command prompt)
# 809 Spot Movement Failed Warning	If problem persists, Contact Coherent
# 810 Laser On Last Good Spot Warning	If problem persists, Contact Coherent
# 811 Non Standard Shutdown Warning	If problem persists, Contact Coherent
# 812 Diode Calibration Failed Warning	If problem persists, Contact Coherent
Note 1. Contact Coherent or an authorized representative. The laser emission lamp will not light if an interlock is open. Check interlocks before contacting Coherent or representative.	

Chart 1. AC ON Indicator Does Not Light[1]



1. If the laser system must be returned directly to Coherent, a Return Material Authorization (RMA) number is required. Contact Coherent or an authorized representative.

Chart 2. Laser Does Not Start (No Light Output)[1]



1. If the laser system must be returned directly to Coherent, a Return Material Authorization (RMA) number is required. Contact Coherent or an authorized representative.

Chart 2. Laser Does Not Start (No Light Output) [Continued]

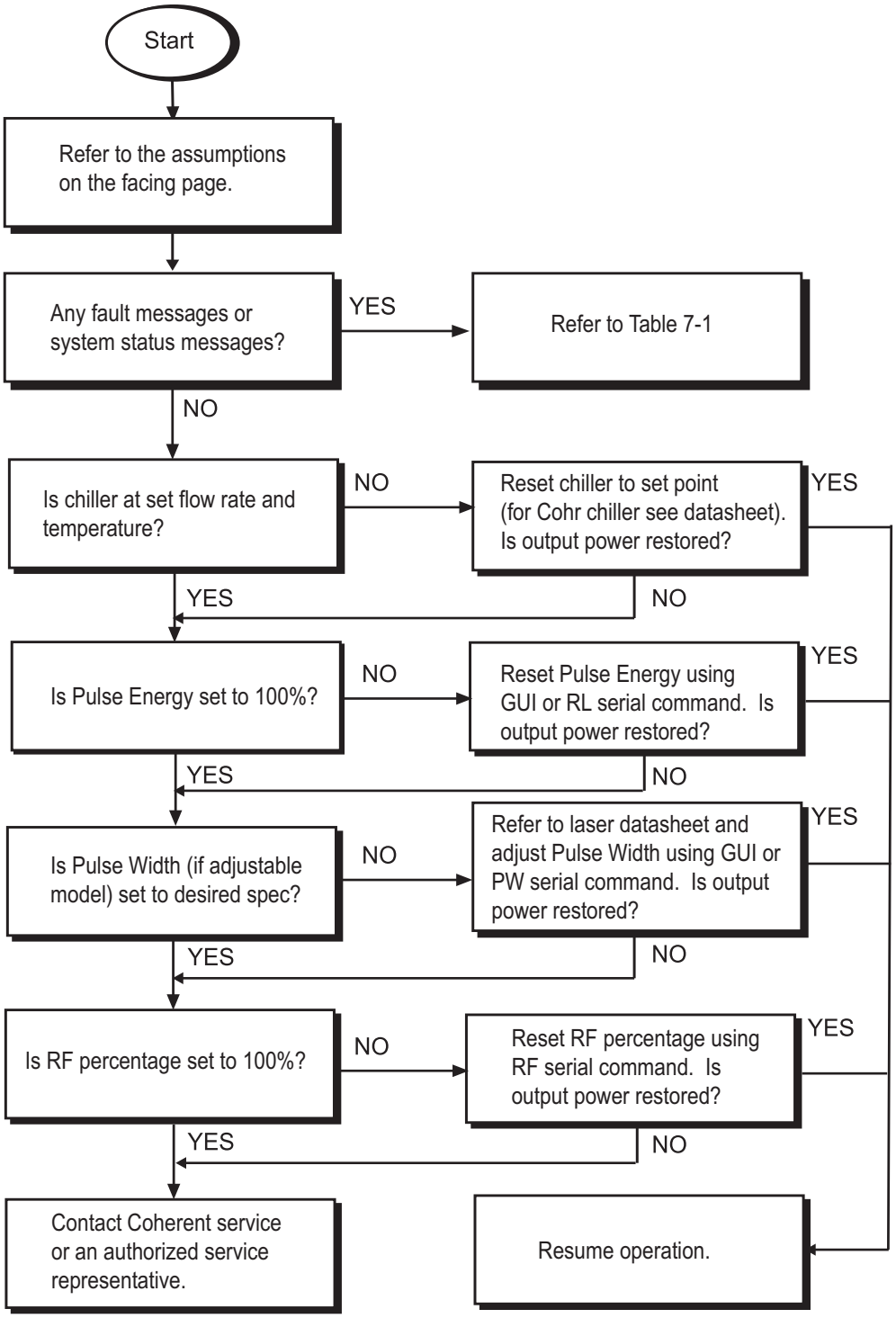
The numbered paragraphs below are keyed to and supplement the flowchart for this chart.

[1] Assumptions:

- The operating parameters are correctly set for the corresponding operating mode as described in "Section Four: Operation".
- The Coherent GUI is connected to the laser in question.
- The Extended Interface and External Interlock connectors are active. It is helpful to verify that the external device supplying this signal is operational. If a user interlock is installed, the user interlock can be verified by temporarily replacing it with the interlock defeat supplied with the system.

[2] If the laser system must be returned directly to Coherent, a Return Material Authorization (RMA) number is required. Contact Coherent or an authorized representative.

Chart 3. Low Output Power[1]



1. If the laser system must be returned directly to Coherent, a Return Material Authorization (RMA) number is required. Contact Coherent or an authorized representative.

Chart 3. Low Output Power [Continued]

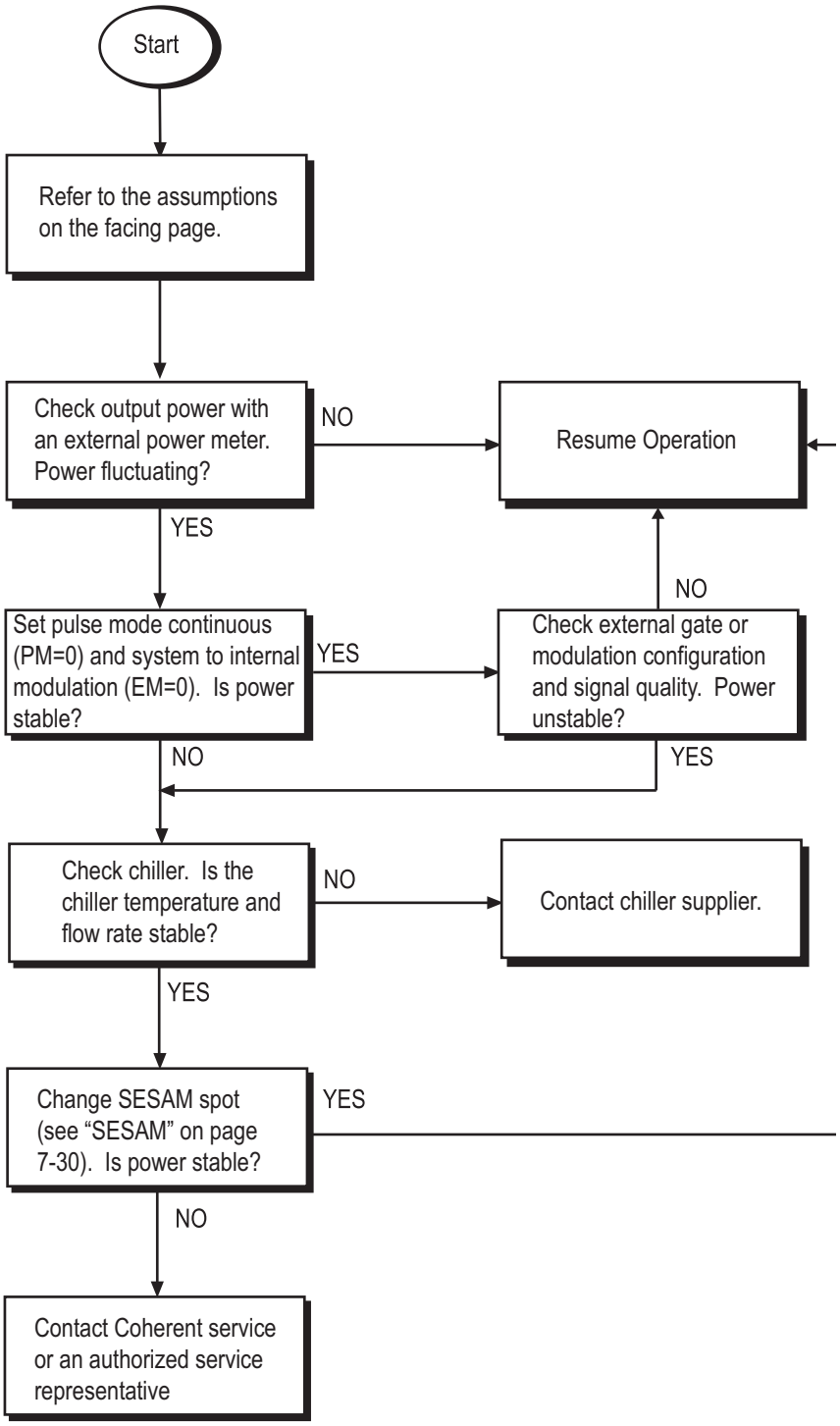
The numbered paragraphs below are keyed to and supplement the flowchart for this chart.

[1] Assumptions:

- The operating mode parameters have the correct settings as described in "Section Four: Operation" on page 4-1.
- The power output level is set properly using the RL command.
- All temperature servos are locked.

[2] If the laser system must be returned directly to Coherent, a Return Material Authorization (RMA) number is required. Contact Coherent or an authorized representative.

Chart 4. Laser Output Unstable[1]



1. If the laser system must be returned directly to Coherent, a Return Material Authorization (RMA) number is required. Contact Coherent or an authorized representative.

Chart 4. Laser Output Unstable [Continued]

The numbered paragraphs below are keyed to and supplement the flowchart for this chart.

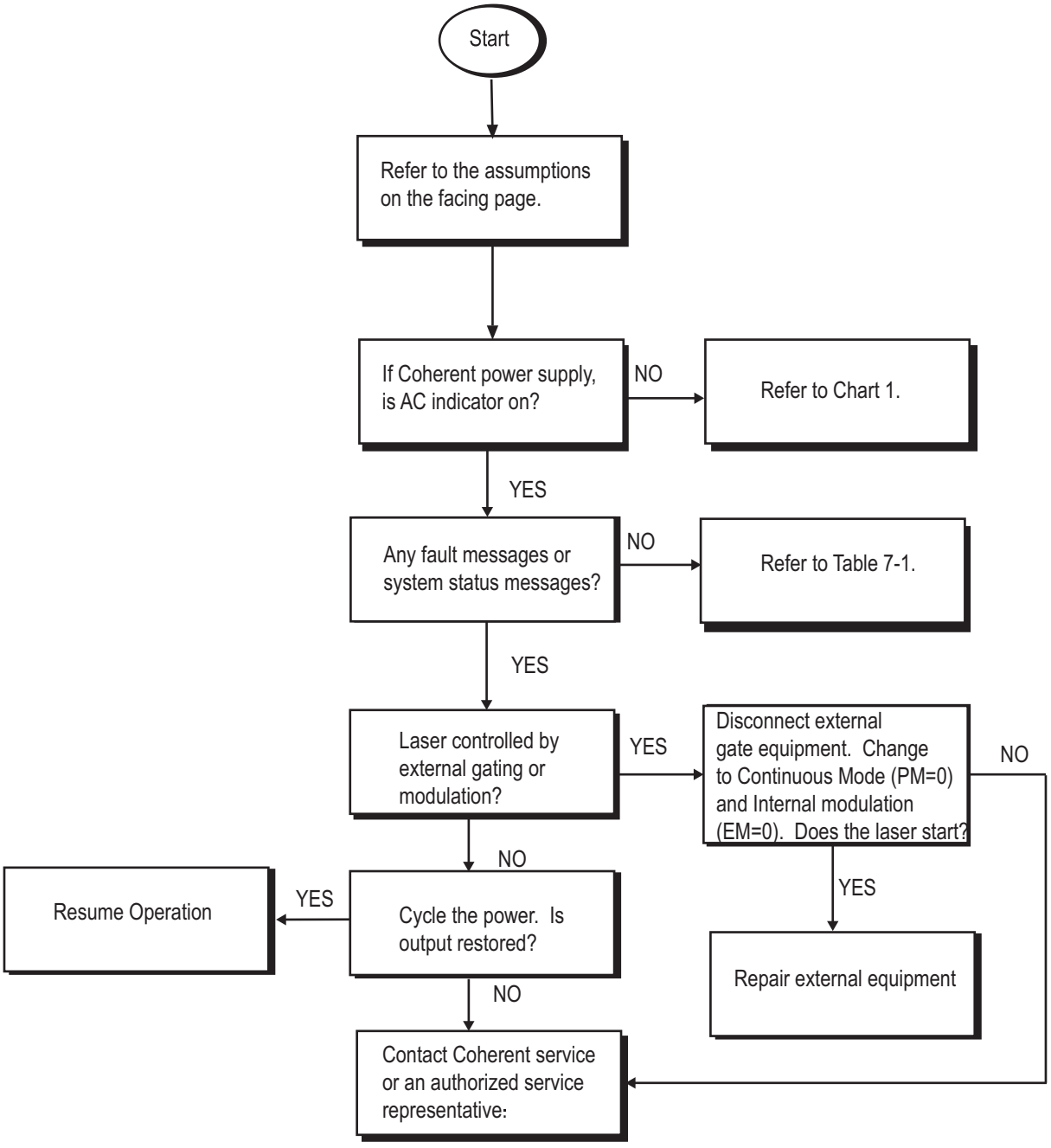
[1] Assumptions:

- The laser system has been installed in accordance with the installation procedures in "Section Three: Installation"
- The laser system has been turned on and set up as described in "Section Four: Operation"
- The laser is in continuous mode (PM=0), or the external gate or modulation configuration is set properly, and signal quality meets the requirement (see "EXT MOD Input" on page 3-11 and "Gate 1 and Gate 2" on page 3-13).

[2] The laser may not function correctly if the external gate or trigger configuration is not set properly.

[3] If the laser system must be returned directly to Coherent, a Return Material Authorization (RMA) number is required. Contact Coherent or an authorized representative.

Chart 5. Laser Shuts Down (No Light Output)[1]



1. If the laser system must be returned directly to Coherent, a Return Material Authorization (RMA) number is required. Contact Coherent or an authorized representative.

Chart 5. Laser Shuts Down (No Light Output) [Continued]

The numbered paragraphs below are keyed to and supplement the flowchart for this chart.

[1] Assumptions:

- The laser system had been operating immediately prior to shut-down.
- The laser is set to Continuous mode.
- The interlocks are closed as described in "Section Three: Installation". The laser will not operate with the interlock circuits open.

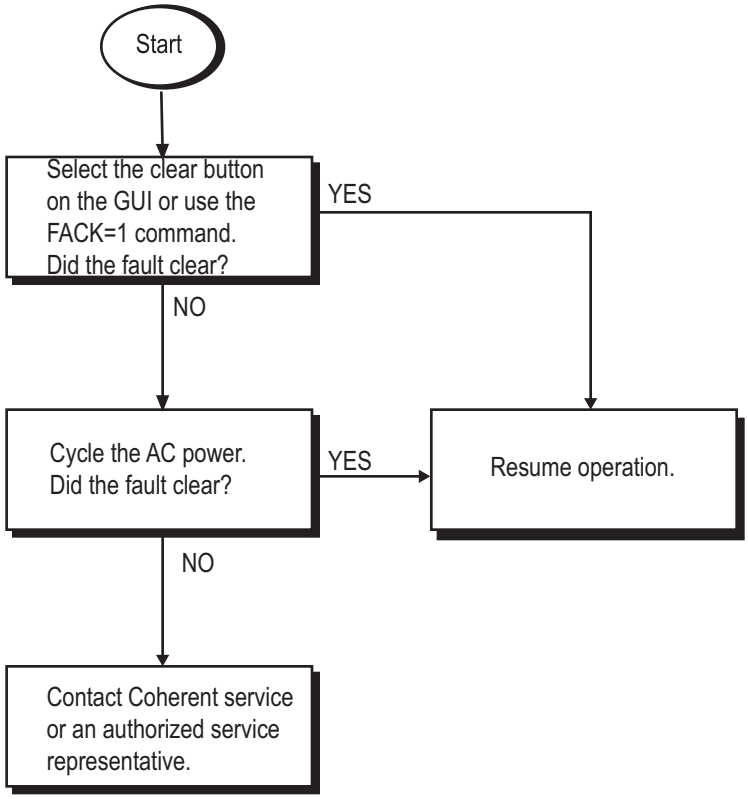
  If a user interlock is installed, the user interlock can be verified by temporarily replacing it with the interlock defeat supplied with the system.
- The operating parameters are correctly set for the operating mode as described in "Section Four: Operation"
- The external enable function is active.

[2] External equipment consists of any equipment connected to the Gate/External Modulation or External Interlock/Chiller Control connector.

[3] The laser will not output pulses unless External Interlock or Extended Interface connector is connected and active. It is helpful to verify that the external device supplying this signal is operational.

[4] If the laser system must be returned directly to Coherent, a Return Material Authorization (RMA) number is required. Contact Coherent or an authorized representative.

Chart 6. Cycle the Power (Light Loop, Thread Exception, FPGA Read/Write, Power On Self Test Faults)[1]



1. If the laser system must be returned directly to Coherent, a Return Material Authorization (RMA) number is required. Contact Coherent or an authorized representative.

Chart 6. Cycle the Power (Thread Exception, FPGA Read/Write, Power On Self Test Faults)

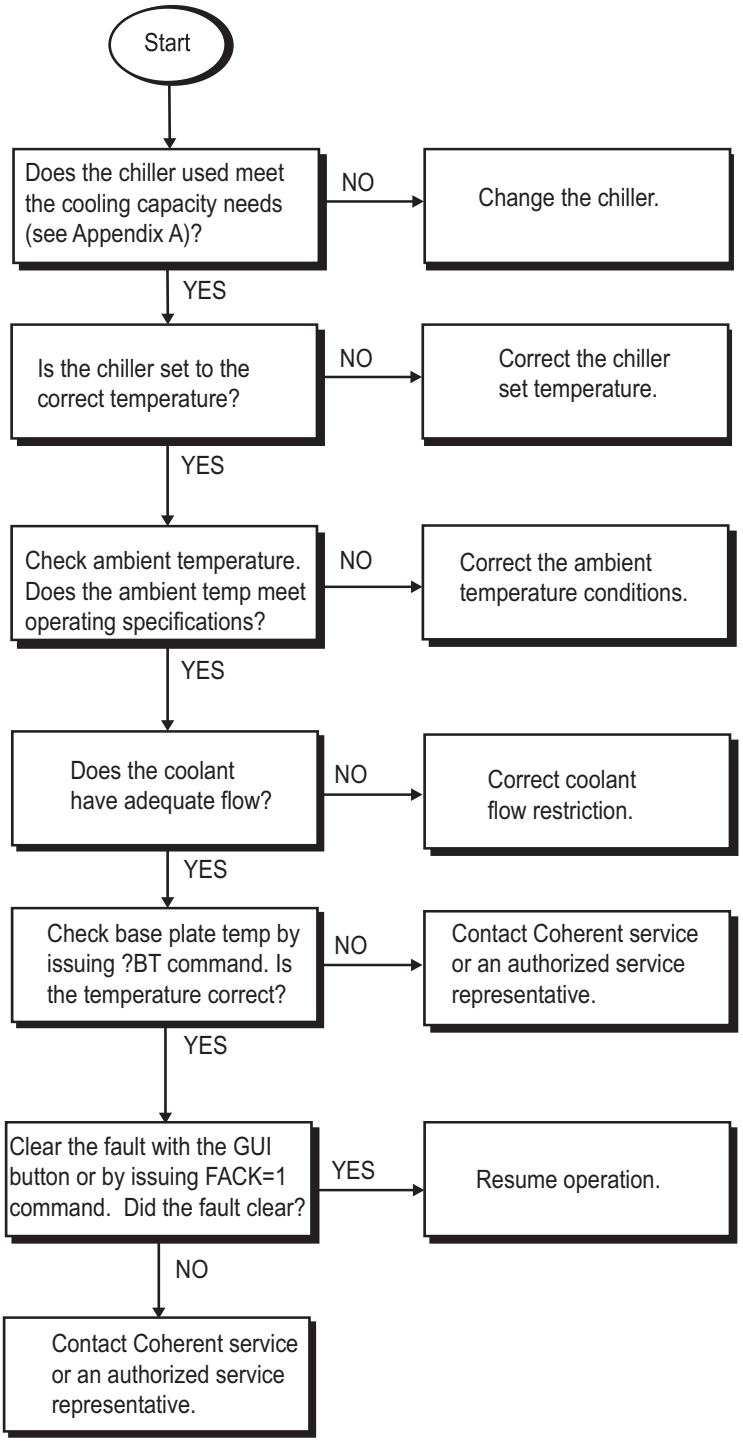
[1] To Clear the fault press the CLEAR button in the System Faults panel of the GUI Main menu tab or send a FACK=1 command. If the fault clears resume operation.

[2] Turn the power switch on the power supply rear panel to OFF for at least 3 seconds. Then turn the switch back to ON.

[3] If the fault persists, contact Coherent or an authorized representative.

[4] If the laser system must be returned directly to Coherent, a Return Material Authorization (RMA) number is required. Contact Coherent or an authorized representative.

Chart 7. Temperature Faults or Warnings[1]



1. If the laser system must be returned directly to Coherent, a Return Material Authorization (RMA) number is required. Contact Coherent or an authorized representative.

Chart 7. Temperature Faults

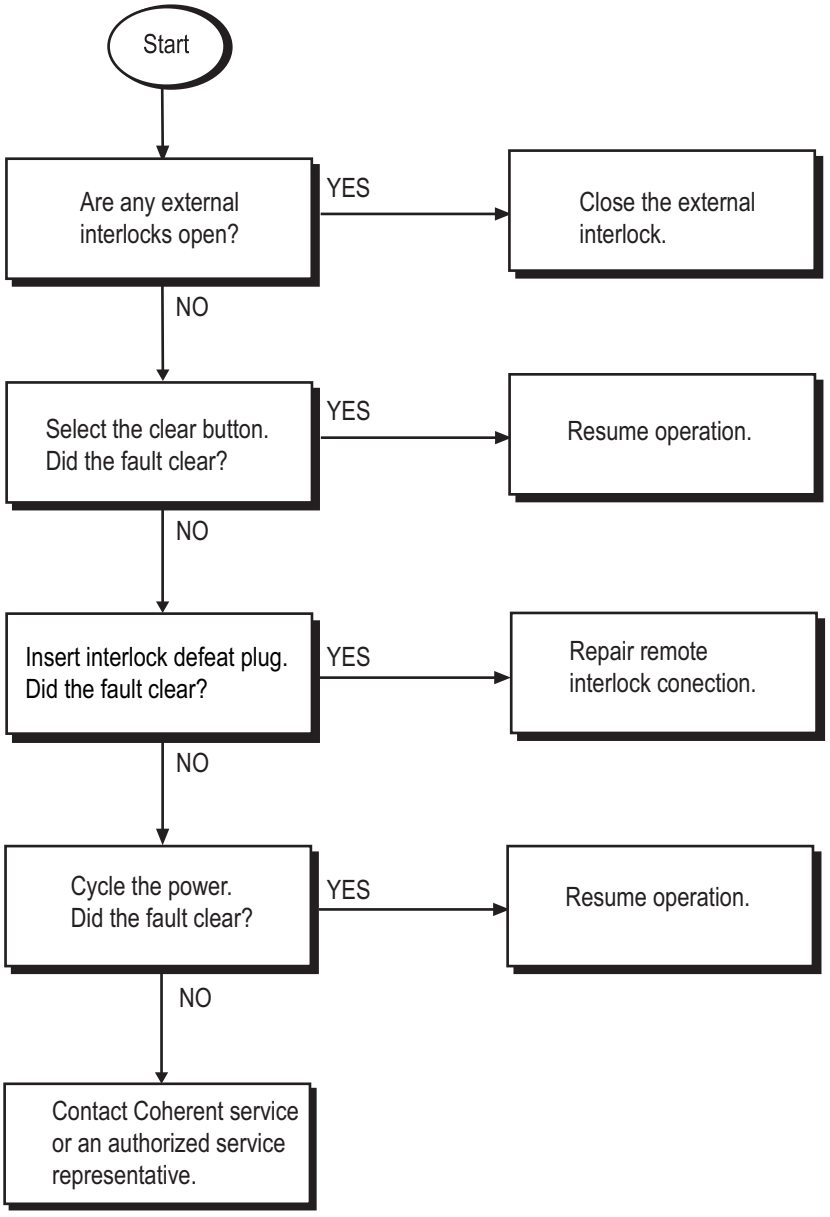
The temperature faults indicate that the allowable ranges of temperature control have been exceeded. The Servo Temperature Fault indicates that a servo drive has been maximized without reaching the control temperature.

[1] To Clear the fault, press the CLEAR button in the System Faults panel of the GUI Main menu tab or send a FACK=1 command.
If the fault does not clear, a message will appear in the System Faults panel on the Main menu tab.
If the fault clears resume operation.

[2] If the fault persists, contact Coherent or an authorized representative.

[3] If the laser system must be returned directly to Coherent, an RMA (Return Material Authorization) number is required. Contact Coherent or an authorized representative.

Chart 8. External Interlock Fault[1]



1. If the laser system must be returned directly to Coherent, a Return Material Authorization (RMA) number is required. Contact Coherent or an authorized representative.

Chart 8. External Interlock Fault

The laser system will not operate with an open interlock circuit. The external interlock supplied with the system or a user-furnished interlock must be installed. Refer to the paragraph titled "Interlocks" on page 3-8.

[1] To Clear the fault, press the CLEAR button in the System Faults panel of the GUI Main menu tab or send a FACK=1 command.
If the fault does not clear, a message will appear in the System Faults panel on the Main menu tab.
If the fault clears resume operation.

[2] Check that the connector that is connected to the External Interlock connector on the laser head rear panel is firmly seated.

[3] If a user interlock is installed, turn the keyswitch to <Standby> and replace the user interlock circuit with the External Interlock supplied with the system. If the fault clears, the user interlock circuit is defective.

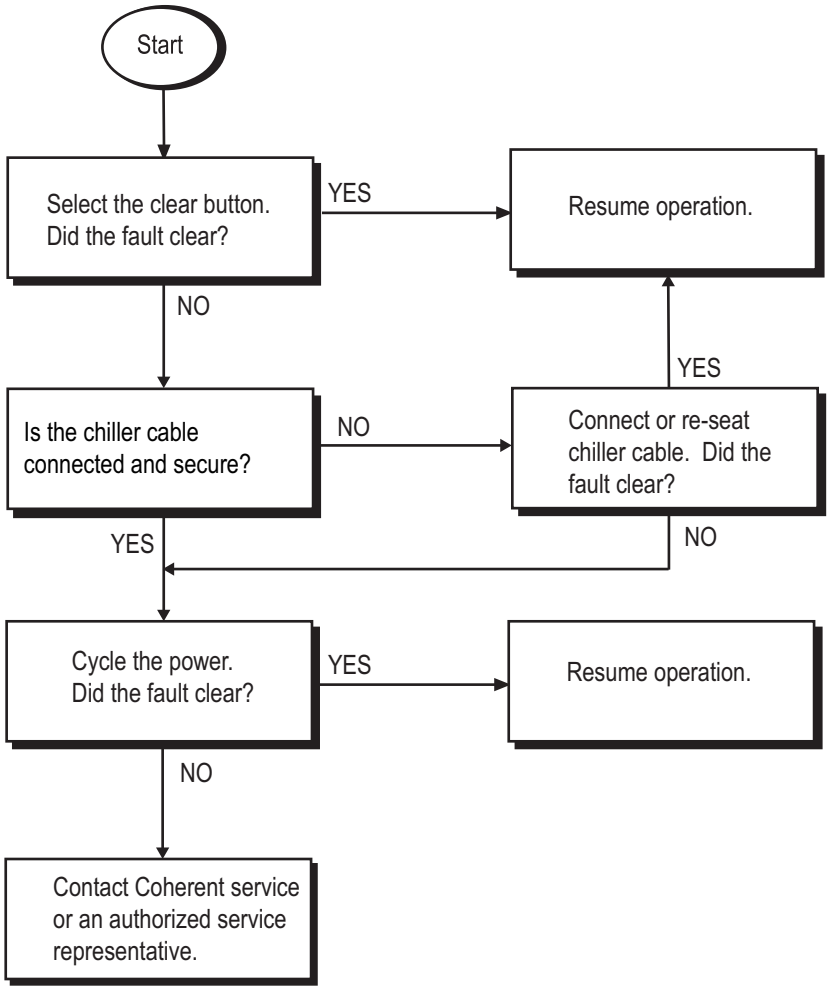
If the fault does not clear, verify continuity of the interlock connector.

If the fault clears, resume normal operation.

[4] If the fault persists, contact Coherent or an authorized representative.

[5] If the laser system must be returned directly to Coherent, an RMA (Return Material Authorization) number is required. Contact Coherent or an authorized representative.

Chart 9. Chiller Comm Fault[1]



1. If the laser system must be returned directly to Coherent, a Return Material Authorization (RMA) number is required. Contact Coherent or an authorized representative.

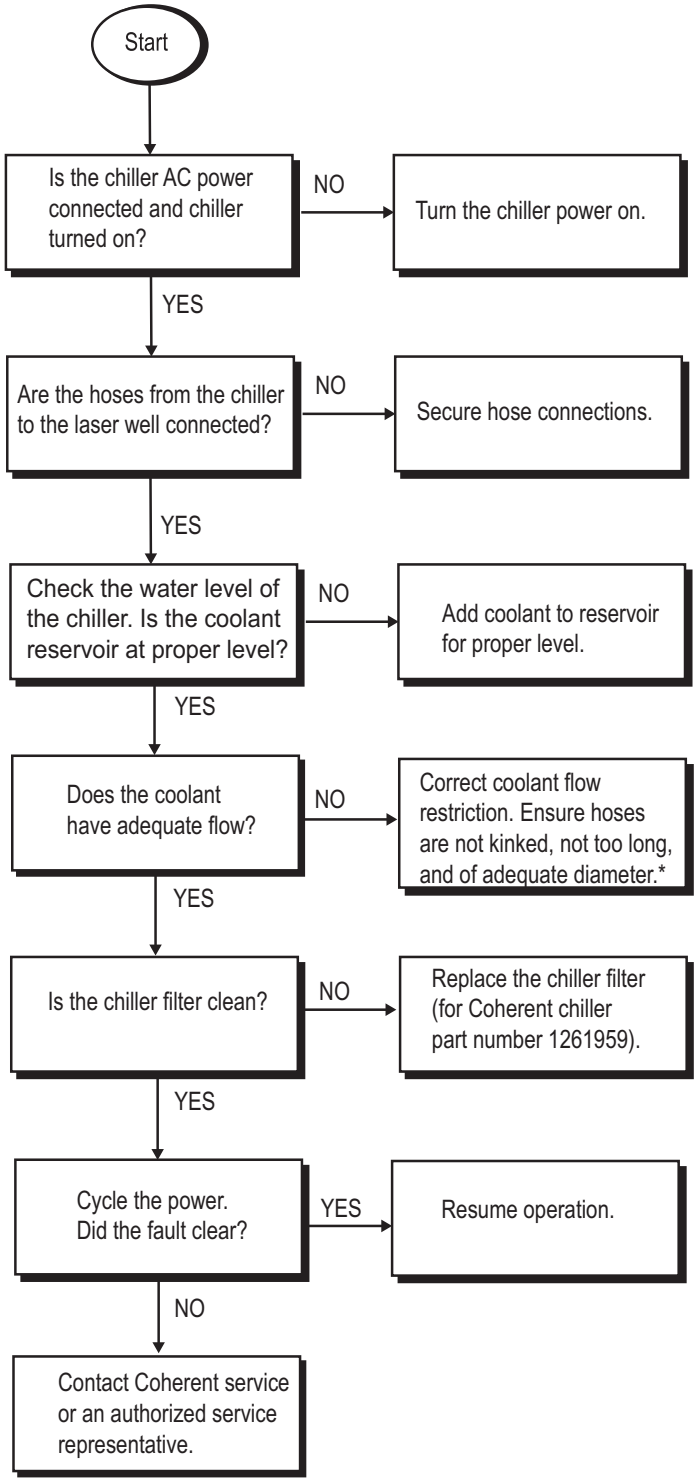
Chart 9. Chiller Comm Fault

[1] To Clear the fault, press the CLEAR button in the System Faults panel of the GUI Main menu tab or send a FACK=1 command.
If the fault does not clear, a message will appear in the System Faults panel on the Main menu tab.
If the fault clears resume operation.

[2] If the fault persists, contact Coherent or an authorized representative.

[3] If the laser system must be returned directly to Coherent, an RMA (Return Material Authorization) number is required. Contact Coherent or an authorized representative.

Chart 10. Chiller Flow Fault[1]



1. If the laser system must be returned directly to Coherent, a Return Material Authorization (RMA) number is required. Contact Coherent or an authorized representative.

* See the note numbers 2-4 next page.

Chart 10. Chiller Flow Fault

[1] To clear the fault, press the CLEAR button in the System Faults panel of the GUI Main menu tab or send a FACK=1 command.
If the fault does not clear, a message will appear in the System Faults panel on the Main menu tab.
If the fault clears resume operation.

[2] The chiller hoses are connected to the laser head rear panel and the hose connectors are firmly seated.

[3] The hoses are not excessively long and have a diameter (ID) equal to or greater than 3/8".

[4] There are no kinks or crimps in the hose to reduce the flow.

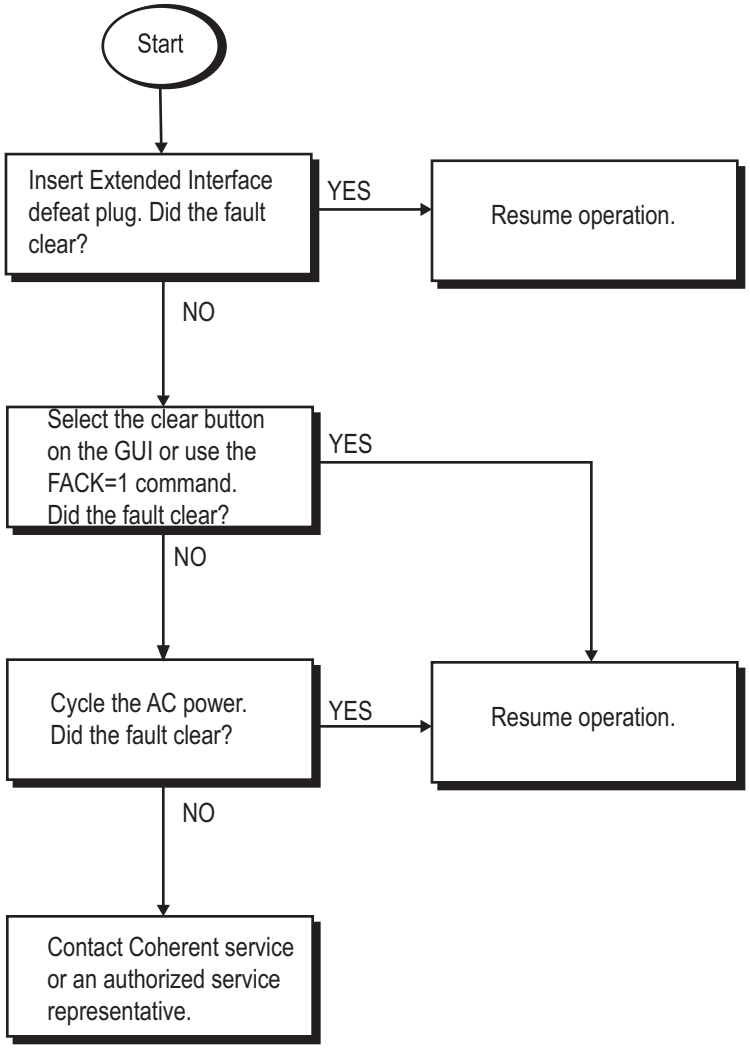
[5] If the system exhibits low flow or suspected possible biological growth, and should maintenance be required:

- Flush with clean distilled water
- Run with a 3-5% solution peroxide for 30 minutes
- Re-fill reservoir with coolant (see "Water Cooling" on page A-2)

[6] If the fault persists, contact Coherent or an authorized representative.

[7] If the laser system must be returned directly to Coherent, an RMA (Return Material Authorization) number is required. Contact Coherent or an authorized representative.

Chart 11. Shutter State Mismatch Fault[1]



1. If the laser system must be returned directly to Coherent, a Return Material Authorization (RMA) number is required. Contact Coherent or an authorized representative.

Chart 11. Shutter State Mismatch Fault

The Shutter State Mismatch Fault indicates that the actual shutter state disagrees with the indicated position.

[1] To Clear the fault, press the CLEAR button in the System Faults panel of the GUI Main menu tab or send a FACK=1 command.
If the fault does not clear, a message will appear in the System Faults panel on the Main menu tab.
If the fault clears resume operation.

[2] If the user has an interface connected to the External Interface connector (see "Laser Head Connections Photograph" on page 3-4), turn the keyswitch to <Standby> and replace the user interface circuit with the Extended Interface Defeat plug supplied with the system. If the fault clears, the problem is with the user's interface wiring and needs to be corrected.

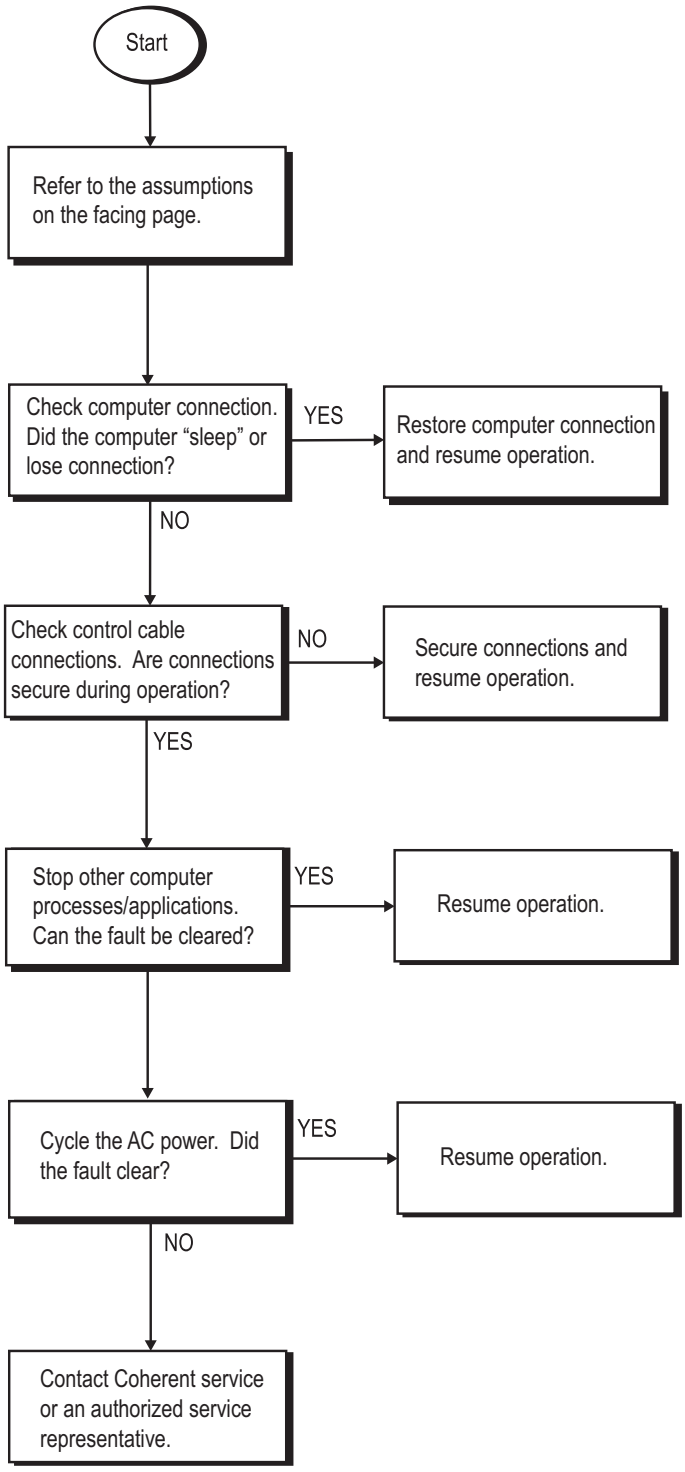
If the fault does not clear, verify continuity of the interlock connector.

If the fault clears, resume normal operation.

If the fault persists, contact Coherent or an authorized representative.

If the laser system must be returned directly to Coherent, an RMA (Return Material Authorization) number is required. Contact Coherent or an authorized representative.

Chart 12. Dropped Connection Fault[1]



1. If the laser system must be returned directly to Coherent, a Return Material Authorization (RMA) number is required. Contact Coherent or an authorized representative.

Chart 12. Dropped Connection Fault

Assumptions:

[1] To clear the fault, press the CLEAR button in the System Faults panel of the GUI Main menu tab or send a FACK=1 command.
If the fault does not clear, a message will appear in the System Faults panel on the Main menu tab.
If the fault clears resume operation.

[2] The connections to the computer (USB, RS-232, or Ethernet) and/or Extended Interface on the laser head rear panel are firmly seated.

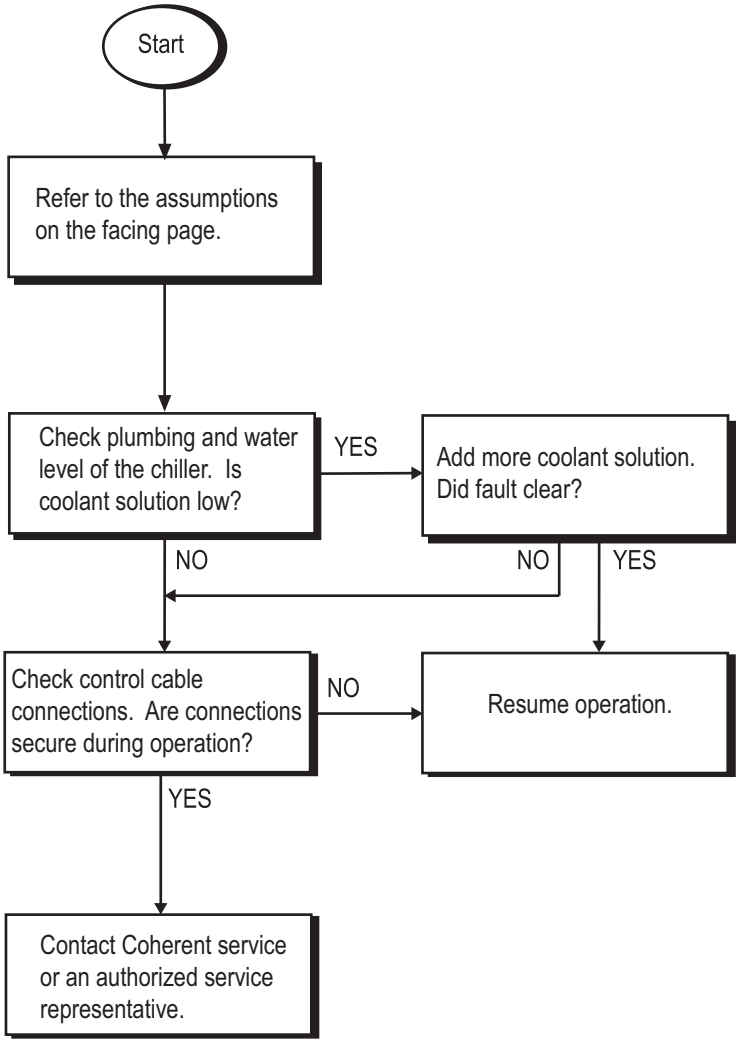
[3] The computer's power saving, sleep, and hibernation settings do not allow the computer to turn off during laser operation.

[4] The Heartbeat Function is enabled and timeout setting is appropriate (see "Heartbeat Function" on page 4-24).

If the fault persists, contact Coherent or an authorized representative.

If the laser system must be returned directly to Coherent, an RMA (Return Material Authorization) number is required. Contact Coherent or an authorized representative.

Chart 13. Chiller Water Level/Chiller Temperature Fault[1]



1. If the laser system must be returned directly to Coherent, a Return Material Authorization (RMA) number is required. Contact Coherent or an authorized representative.

Chart 13. Chiller Water Level/Chiller Temperature Fault

Assumptions:

[1] To clear the fault, press the CLEAR button in the System Faults panel of the GUI Main menu tab or send a FACK=1 command.
If the fault does not clear, a message will appear in the System Faults panel on the Main menu tab.
If the fault clears resume operation.

[2] The chiller hoses are connected to the laser head rear panel and the connector is firmly seated.

[3] The chiller is filled with Coherent recommended Coolflow DTX (available from Hydratech[a]) at 28% volume mixed with distilled water.

If the fault persists, contact Coherent or an authorized representative.

If the laser system must be returned directly to Coherent, an RMA (Return Material Authorization) number is required. Contact Coherent or an authorized representative.

a. http://www.hydratech.co.uk/coolflowige.html

Changing the Laser Head Desiccant

The humidity sensor is located within the access cover and can be read in the **Humidity** panel of the **Temperature Menu Tab**. When the relative humidity inside the laser head reads > 8% as measured by the sensor, a warning message will be displayed in System Faults panel on the Main menu tab of the GUI.

The desiccant housing is located inside the access cover. The desiccant cover location is shown in Figure 7-1.

If the desiccant needs to be replaced more than once in 12 months, contact a Coherent representative for further evaluation.

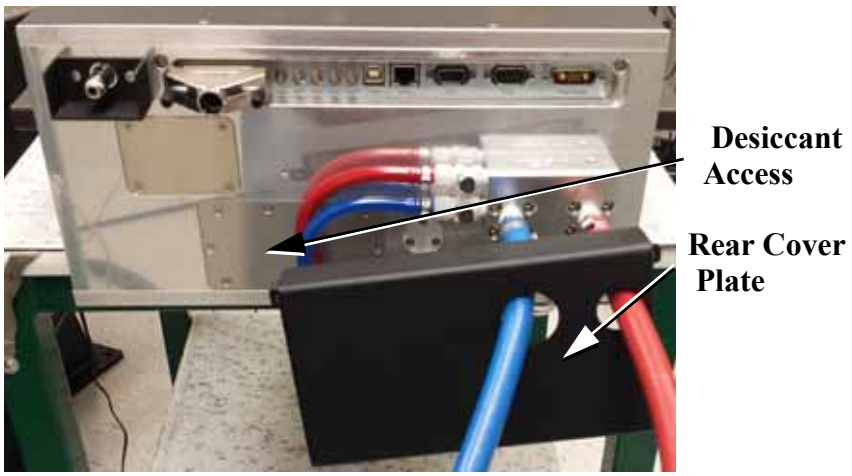


Figure 7-1. Head Desiccant Location

Criteria for Replacement

Check the relative humidity reading on the Temperature Menu Tab screen (or using the ?RELH serial command) and replace the desiccant if >8%.

Do not remove the access cover while the laser is on. Turn the keyswitch to the STANDBY position, and turn OFF the main AC power (the switch is located on the rear panel of the power supply).

Desiccant Replacement Procedure

If the desiccant needs to be replaced.

1. Put laser in Standby Mode. Turn off the power switch from the back panel of the laser power supply.

2. Remove the three screws (with 2mm hex key) holding the black, rear cover to expose the desiccant access plate.
3. Note which hose plugs into which connnector, then unplug the hoses in front of the desiccant access plate and carefully move them aside (see Figure 7-2).

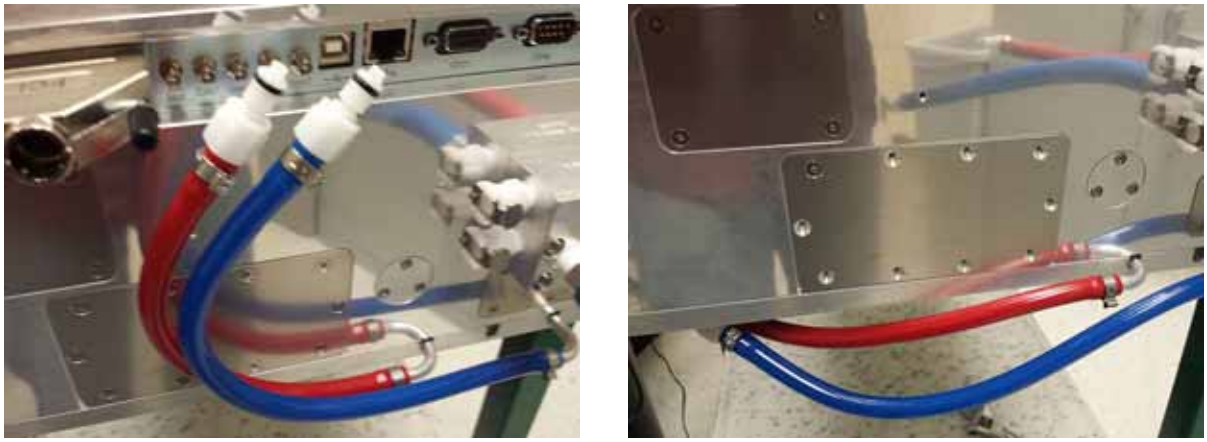


Figure 7-2. Clearing the Desiccant Access Plate

4. Remove screws (with 2mm hex key) around the desiccant access plate.
5. Remove the old desiccant pouch and replace it with a new pouch (part number 1285564, orderable from Coherent).
6. Secure the desiccant access plate.
7. Plug the hoses back into the housing.
8. Re-install the rear cover plate.
9. Turn main AC power switch on the rear panel of the power supply to the <ON> position and perform the procedure titled "Initial Start-up Procedure" on page 4-2.

APPENDIX A: THERMAL MANAGEMENT

Introduction

When installing the Monaco laser head, the heat load must be properly dissipated. Insufficient cooling can trigger an over temperature condition, especially with the higher power models.

See Table A-1 for the recommended water flow rate. The chiller temperature is controlled through the laser firmware and should not be adjusted.

Table A-1. Heat Load and Flow Rate

MODEL	HEAT LOAD	FLOW RATE
MONACO	500 W	5.5 L/min (1.5 gal/min)

Routinely check the chiller flow rate remains constant and the chiller filter does not become clogged over time (for the Coherent-supplied TermoTek P307A chiller an extra chiller filter is included in the Accessory Kit and can also be ordered, part number 1261959). Restricted water flow will impact the thermal management of the laser head and may impact laser performance. If the system exhibits low flow or suspected possible biological growth, and should maintenance be required:

- Flush chiller with clean distilled water
- Run chiller with a 3-5% solution peroxide for 30 minutes
- Re-fill reservoir with coolant (see “Water Cooling below).

The temperature of the laser head baseplate is monitored and displayed on the **Temperature Menu Tab** of the GUI. The baseplate temperature is used to monitor the effectiveness of heat dissipation.

In all cases Monaco lasers will operate properly over a wide range of operating temperatures, but for maximum power and pointing stability and minimum pointing angle drift, the temperature of the base plate should vary no more than ±1°C. The Monaco laser will shut down if the baseplate temperature exceeds 33°C.

The conditions which generate the most heat in the Monaco laser head are:

- Diodes ON
- Pulsing OFF

When heat is efficiently dissipated, it serves several purposes:

- **Avoid over-temperature faults.** The laser will automatically shut down if the baseplate temperature exceeds 33°C.
- **Consistent pointing angle.** The pointing angle of the laser changes up to 25 microradians per °C change in the baseplate temperature. Maximizing the baseplate temperature stability will minimize temperature-induced pointing angle drift.
- **Enhanced power stability.** Excessive changes in the laser baseplate temperature will affect the power stability of the laser.

The Monaco laser operates optimally when the baseplate temperature is less than 25°C.

Water Cooling

The Monaco laser has a closed-loop chiller as a standard part of the system.

1. Fill the chiller with Coherent recommended Coolflow DTX (available from Hydratech[1]) at 28% volume mixed with distilled water for corrosion and algae control. Otherwise, the PH level becomes too aggressive for the cooling circuit materials. Coolant supplied by Coherent is always pre-mixed.
2. Check that the correct voltage plug is attached to the internal connector (see "Chiller Setup" on page 3-4).
3. Coherent recommends changing the chiller coolant every six months.

NOTICE!
To avoid damage to the Monaco system, use ONLY distilled water in the chiller's closed loop system. DO NOT use facility tap or deionized water.

1. https://www.hydratech.co.uk/uk/products/coolflow-dtx-high-efficiency-non-toxic-glycol-antifreeze/4

NOTICE!
To avoid damage to the Monaco system, do not use the chiller for any equipment other than the Monaco laser. Galvanic corrosion will occur if materials are incompatible.

NOTICE!
To avoid damage to the Monaco system, ensure the chiller flow rate remains constant while power is being supplied to the laser head (even when the system is in the Standby state).

Chiller

Coherent provides a chiller to be used with the Monaco as described in Table A-2.

Table A-2. Recommended Chillers

MODEL	PRODUCT	PART NUMBER
Monaco	P307 Termotek Air to Water Chiller, 570W 100-240V AC 50/60Hz RoHS Compliant	1254673
Monaco	P307 Termotek Water to Water Chiller, 570W 100-240V AC 50/60Hz RoHS Compliant	1327329

APPENDIX B: ENVIRONMENTAL GUIDELINES

Introduction

A very important contributing factor to the long-term operational reliability of lasers such as the Monaco 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 and 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.

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 from a laser such as the Monaco 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 largest 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 micromachining systems. Its importance should not be overlooked.

In general, 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).

In addition, 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 tubes 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.
- The cleanliness of the CDA purge gas is critical to the life of the laser and optics in the system, so the system developer should explicitly define this and advise the end user to supply high purity air that is dry and free of contaminants.

Temperature and Humidity

High performance lasers such as the Monaco 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, since the laser head contains the cooling pipes, headboard, diodes, and control electronics and is not hermetically sealed, and thus is less protected from humidity. 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 the enclosure. 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 Monaco 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. For more information, see Table 7-1, "Trouble-shooting/Fault Messages," on page 7-2.

Excessive Vibration

The Monaco contains motorized micro-positioning stages that are used to optimize the cavity. 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.

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.

Coherent also recommends using the enhanced serial protocol (See "Enhanced Serial Protocol" on page 6-3) for protecting against potential electrical noise issues.

APPENDIX C: PACKING PROCEDURE

Introduction

The following packing method for the Monaco laser system is the factory recommended procedure. This procedure must be followed if the laser system is shipped to another location after initial installation or returned to the factory for service. For a complete list of all items shipped with the laser system, see Table C-1.

NOTE: RMAs (returning to the factory for service) do not require anything but the laser head to be shipped back.

Table C-1. Monaco Crate Contents[a]

1.	Laser Head
2.	Power Supply Power Supply Keys, Qty 2 Power Supply Cable, US Power Supply Cable, European
3.	Accessory Kit Screwdriver, 6mm Hex USB Flash Drive (Operator's Manual & Coherent GUI software) HD BNC to BNC Plug Adapter, Qty 2 Extended Interface Defeat Plug External Interlock Defeat Plug Quick Disconnect Fittings, Body/Insert Hose Clamp, Qty 2 CoolFlow DTX Coolant Chiller Filter Final Test Data Sheets
4.	Integration Kit Power Supply Cable USB Cable DB9 Cable, Chiller to Laser Head HD BNC to BNC Plug Adapter, Qty 3 Rubber Hose, Blue, 10 Feet Rubber Hose, Red, 10 Feet Quick Disconnect Fittings, Body/Insert Hose Clamp, Qty 2
5.	Mounting Plate Screws, Hex Socket, M4 x 8mm, Qty 8

a. May vary by customer requirements

Packing the System

Use the following procedure to pack the laser system:

WARNING!
Drain all residual water from the laser head prior to packing for shipment.

1. Using the factory-provided quick couplings, drain all coolant from the laser head.

Figure C-1. Quick Couplings

2. Package the laser head with the factory-provided resealable transport bag (Coherent part number 1315234) and zip the bag closed as shown in Figure C-2.

NOTICE!
Be careful not to tear the bag during insertion.

3. Use the crate in which the Monaco arrived, or obtain the Monaco Head Crate (part number 1302765, see Figure C-3) The crate dimensions are 29 x 52 x 37 inches, and the approximate crated weight will be 300 lbs

Figure C-2. Placing Laser Head Into Bag

Figure C-3. Monaco Crate

4. Remove clips and set aside. Remove crate top and all foam except the bottom foam seat assembly (see Figure C-4).

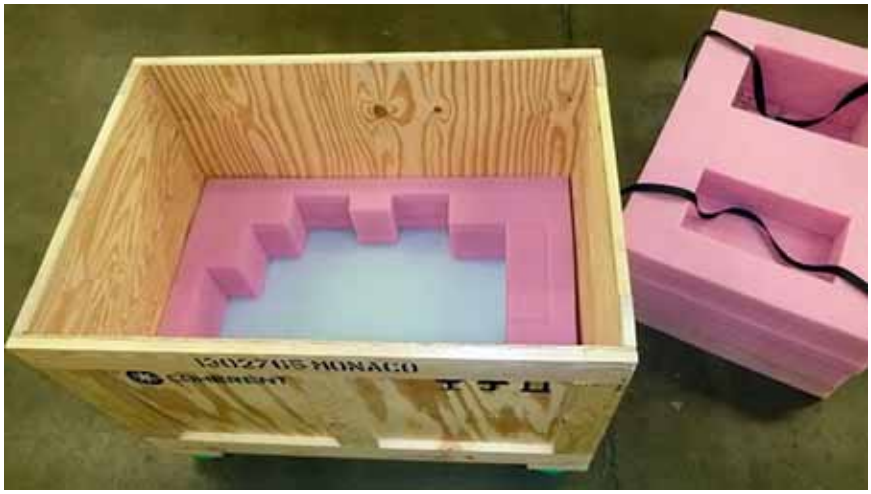


Figure C-4. Crate/Bottom Foam Seat

5. Reference Figure C-5 for foam and laser head stacking order.
6. Carefully place the bagged laser head into the shipping crate in the proper orientation and into the bottom foam seat (see Figure C-6). The foam block (shown in light pink in Figure C-6) must be in place unless the laser head has an optional attachment installed.
7. Unzip bag slightly and push out as much air as you reasonably can.

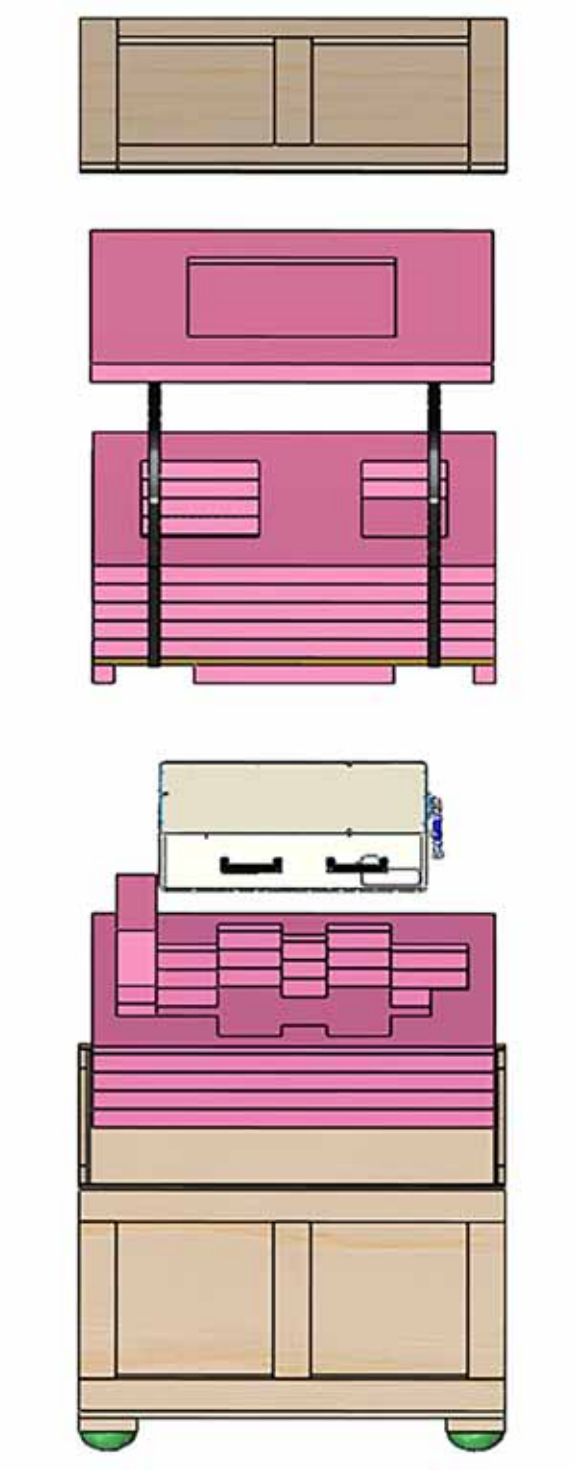


Figure C-5. Foam/Laser Head Installation Order

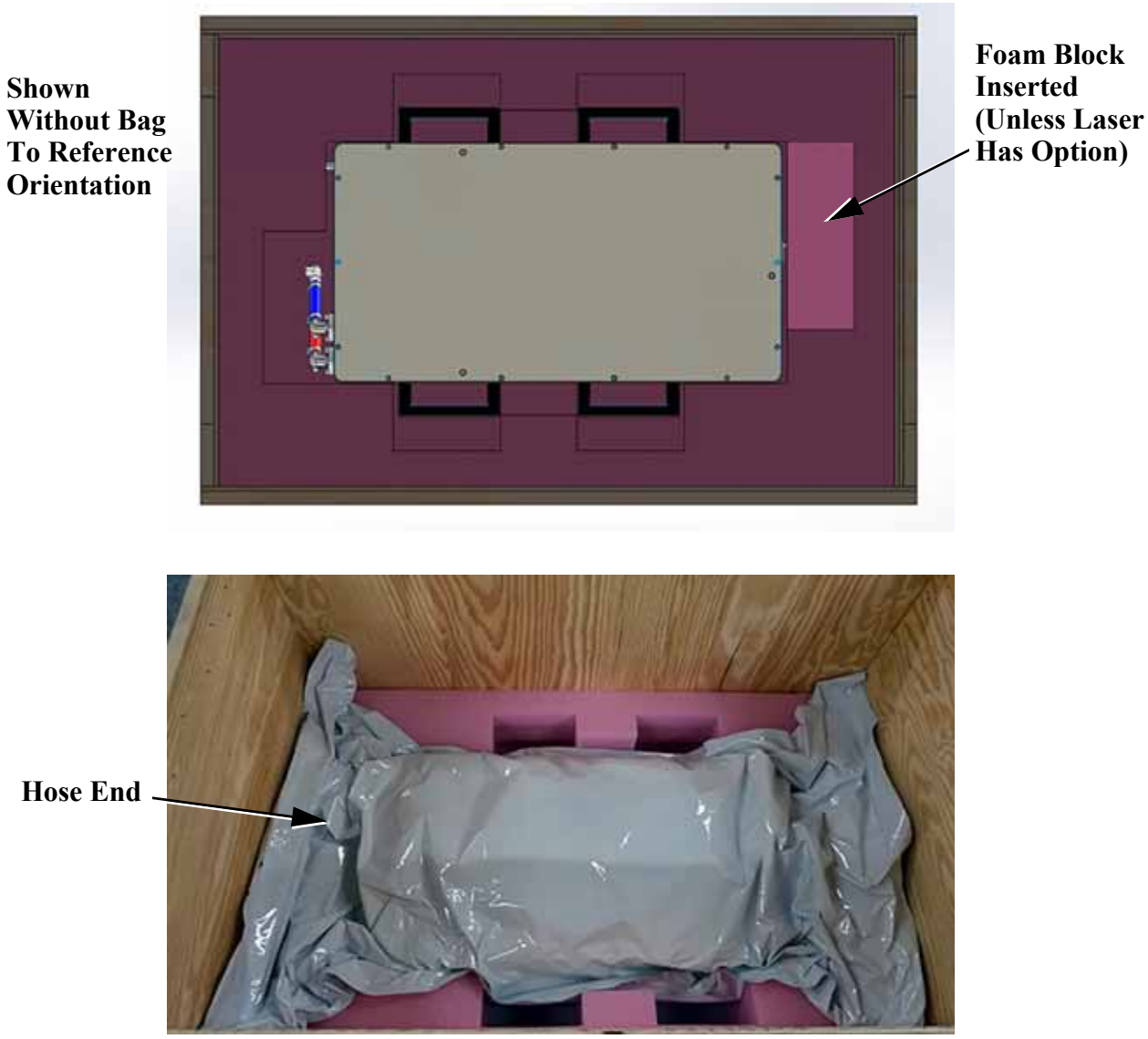


Figure C-6. Placing the Laser in the Bottom Foam Seat

8. FULLY re-zip the bag closed (Figure C-7).

Figure C-7. Resealing the Bag.

9. Place accessory foam section over the laser head. The cutout orientation must match the bottom foam seat. Push down so that the accessory foam section is fully seated on top of the laser head (see Figure C-8).

Figure C-8. Accessories Foam Insert

10. Install the top foam section as shown in Figure C-9.

Figure C-9. Top Foam

11. Install the crate cover and secure it to the crate using two wire clips on each side of the crate and one each on the ends as shown in Figure C-10.

Figure C-10. Crate Cover

NOTICE!
To prevent damage, the shipping container must post the warnings shown in Figure C-11 below.

Figure C-11. Shipping Container Warning

12. See Figure C-11 for the crate orientation and shipping container warnings.

13. Coherent recommends installing a purple 37G shock watch on each long side of the crate and a tip-tilt (Tip-N-Tell or equivalent) sensor on one side of the crate before shipping. See Figure C-12.

Figure C-12. Recommended Label Positions and 37G Shockwatch Label (2 EA)

14. Notify the shipper that the crate contents are fragile, sensitive to shock and moisture, and must be shipped upright.

APPENDIX D: PARTS LIST

Table D-1. Parts List

DESCRIPTION	COHERENT PART NUMBER
Monaco Operator's Manual	1297688
Mounting Plate	1303793
Screwdriver, 6mm Hex (for use with Mounting Plate)	1319164
Extended Interface Defeat Plug	1284954
External Interlock Defeat Plug	1295564
Cables: Power Supply Cable Chiller Cable AC Power Cable HD BNC to BNC Plug Adapter	 1259980 1081568 1110736 1270800
Desiccant, 3.5"L x 1.75" W x 1.0" T Pack	1285564
Power Supply Key, Set of Two	1116159
Integration Kit, Monaco (includes hoses, fittings, and cables)	1303784

Table D-2. Recommended Chiller/Coolant/Filter

PRODUCT	PART NUMBER
P307-19717 TermoTek Air to Water Chiller, 570W 100-240V AC 50/60Hz P307-21097 TermoTek, Water to Water Chiller, 570W 100-240V AC 50/60Hz	1254673 1327329
Coolant, Premix CoolFlow DTX 28%/Distilled Water 72%	1298481
Filter Media, TermoTek Chiller	1261959

APPENDIX E: ACCESSORIES

Power Meters and Sensors

Coherent offers a variety of instruments for laser test and measurement. For additional detailed information, including product selection guides, please visit our web site at **www.Coherent.com**.

For the most common diagnostics, Coherent recommends the LabMax-TO™ power meter with a PM150X or LM-200 HTD power sensor to measure the output of the Monaco.

Coherent Recommendation

Below is a product combination covering the 0.19 µm to 11 µm wavelength range for all Monaco power levels. The power meter is a versatile, easy to use digital meter designed for field service and production applications. The power sensors are air-cooled, surface absorbing and intended for low to medium Pulsed and CW powers.

LabMax-TO Power Meter Part Number 1104619	PM150X Power Sensor (up to 150 Watts) Part Number 0012-1330

WARRANTY

Coherent, Inc. warrants Diode-Pumped Solid State 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 of 12 months.

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.

Limitations of Warranty

The foregoing warranty shall not apply to defects resulting from any of the following:

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

tioned parts. Repaired or replaced parts are warranted for the duration of the original warranty period only. The warranty on parts purchased after expiration of the system warranty is ninety (90) days. Coherent's warranty does not cover damage due to misuse, negligence or accidents, or damage due to installations, repairs or adjustments not specifically authorized by Coherent.

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

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

GLOSSARY

°C	Degrees centigrade or Celsius
°F	Degrees Fahrenheit
Ω.	Ohms
µm	Micron(s) = (10^{-6})
µJ	MicroJoule(s) = (10^{-6} Joules)
µrad	Microradian(s) = (10^{-6} radians)
µs	Microsecond(s) = (10^{-6} seconds)
µsec	Microsecond(s) = (10^{-6} seconds)
$1/e^2$	Beam diameter parameter
A	Amperes
AC	Alternating current
Amp	Amperes
CDRH	Center for Devices and Radiological Health
cm	Centimeter(s)
CPU	Central processing unit
CW	Continuous wave (operating mode)
DAC	Digital-to-analog converter
DC	Direct current
DCE	Data communications equipment
ESD	Electro-static discharge
fs	Femtoseconds = (10^{-15} seconds)
fsec	Femtoseconds = (10^{-15} seconds)
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) (1000 Hertz)
kV	Kilovolt(s) = 10^3 volts
kohm	Kilohm(s)
LCD	Liquid crystal display
LD	Laser diode
LED	Light emitting diode
m	Meter(s)
mA	Milliamperes = 10^{-3} Amperes
mAmp	Milliampere(s)
mm	Millimeter(s)
mrad	Milliradian(s)

ms	Millisecond(s)
msec	Millisecond(s)
mV	Millivolt(s)
mW	Milliwatt(s)
nm	Nanometers = (10^{-9} m) (wavelength)
OEM	Original equipment manufacturer
PRF	Pulse repetition frequency
ps	Picoseconds = (10^{-12} seconds)
psec	Picoseconds = (10^{-12} seconds)
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
TEM	Transverse electromagnetic mode
TTL	Transistor-to-Transistor Logic
TXD	Transmit Data
UV	Ultraviolet (wavelength at 355 nm)
V	Volt(s)
VAC	Volts, alternating current
VDC	Volts, direct current
W	Watt(s)

INDEX

Monaco Laser IR Operator's Manual

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Monaco IR Lasers Operator's Manual

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