Service Manual
Monaco Lasers

COHERENT.
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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**.

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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.

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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.

Monaco SVC Manual

LIST OF TABLES

NOTICE

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

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.

1.1.1 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.

1.1.1.1 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)

1.1.1.1.1 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.

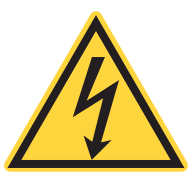
Consult the ANSI, ACGIH, IEC and LIA standards listed at the end of this section for guidance.

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.
17. The short pulse width and high pulse energy can increase the chance of photo-deposits on optics. It is recommended that users clean and check any optics used in conjunction with the system every week.

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.

1.1.1.2 Electrical Safety

1.1.1.2.1 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.

1.1.2 Safety Features and Compliance with Government Requirements

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

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

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 IEC 60825-1 “Safety of Laser Products”. Compliance of this laser with the European requirements is certified by the CE mark.

1.1.2.1 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.

1.1.2.2 Laser Classification

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

1.1.2.3 Protective Housing

The laser head is enclosed in a protective housing that prevents human access to radiation in excess of the limits of Class 1 radiation as specified in the 21CFR, Part 1040 Section 1040.10 (f)(1) and 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.

1.1.2.4 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)/ IEC 60825-1, Clause 6.4].

1.1.2.5 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)/IEC 60825-1, Clause 6.6].

1.1.2.6 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)/ 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.

1.1.2.7 Beam Attenuator

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

1.1.2.8 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)/IEC 60825-1, Clause 6.9].

1.1.2.9 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)/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.

1.1.3 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.

1.1.4 Environmental Compliance

1.1.4.1 RoHS Compliance

The RoHS directive restricts the use of certain hazardous substances in electrical and electronic equipment. Coherent can provide RoHS certification upon request for products requiring adherence to the RoHS Directive. Coherent is compliant with EN50581:2012 for the RoHS Directive.

1.1.4.2 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 1.1-1 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 1.1-1. China-RoHS Compliant Components

1.1.5 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 1.1-2 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.

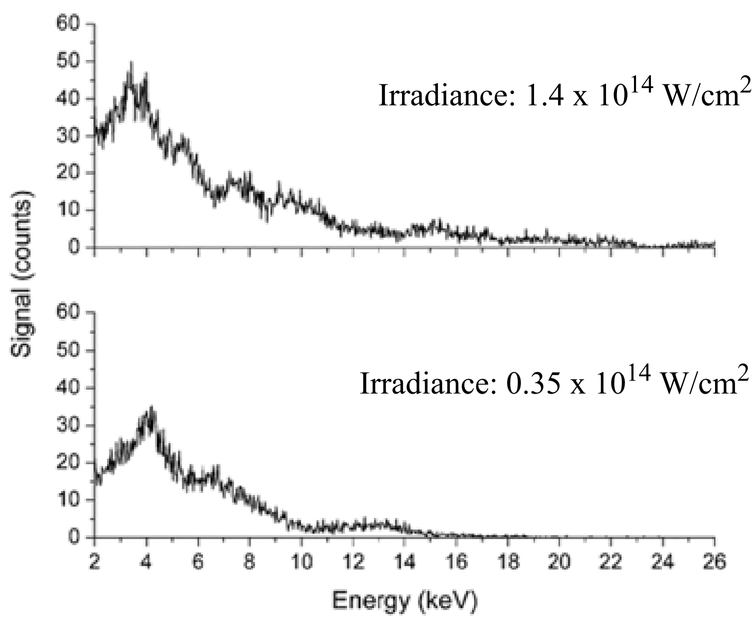


Figure 1.1-2. Measured X-ray Spectrum of Molybdenum for Different Peak Intensities of the Focused Beam[1] (800 nm, 35 fs, 1 kHz)

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.

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

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

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

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 1.1-3 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 1.1-3. 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]:

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

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

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 1.1-4 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 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 1.1-4. 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 1.1-5 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 1.1-6 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.

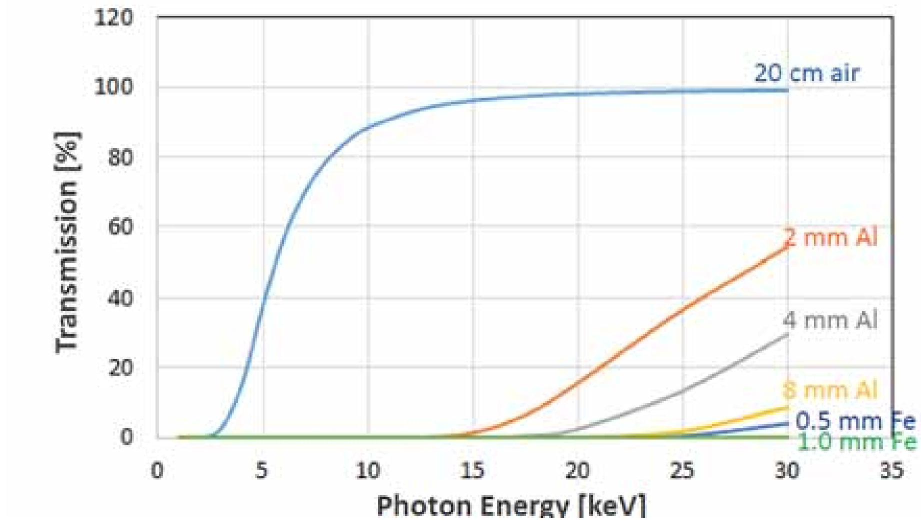


Figure 1.1-5. Calculated X-Ray Transmission for Various Materials[1]

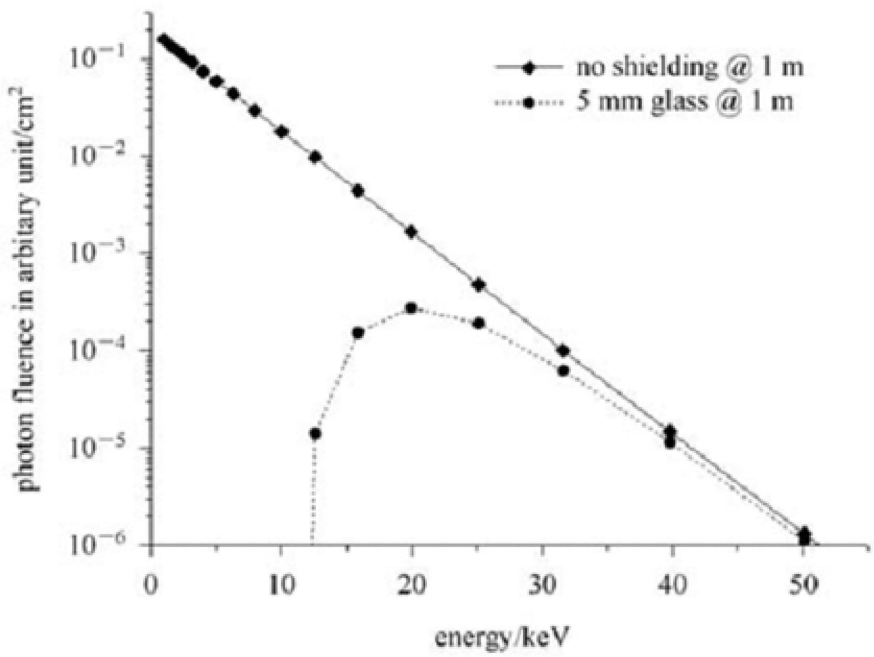


Figure 1.1-6. X-ray Spectrum With and Without 5 mm Glass Shield[2]

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

Back Reflection

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

NOTICE!
***Back reflection* (also referred to as *retroreflection*) occurs when a part of the laser beam is sent back into the laser's exit aperture. Back reflection can be caused by any object in front of the laser and may result in instability, noise, and even damage 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 can be mounted at the output of the Monaco laser. It is recommend users make use of the waveplate for polarization insensitive applications. These can also be purchased from Coherent - contact Product Support.
- 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.

1.1.6 EU REACH

REACH (Registration, Evaluation, Authorization and Restriction of Chemicals) is a European Union Commission (EUC) Regulation on chemicals and their safe use (EC 1907/2006) entered into force on 01 June, 2007 and will be phased in until 2018.

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

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

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

1.1.7 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.

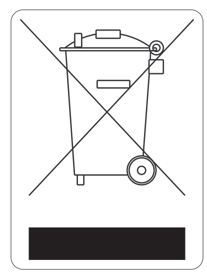


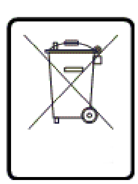
Figure 1.1-7. Waste Electrical and Electronic Equipment Label

1.1.7.1 Battery Directive

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

Table 1.1-1. Batteries Contained in this Product

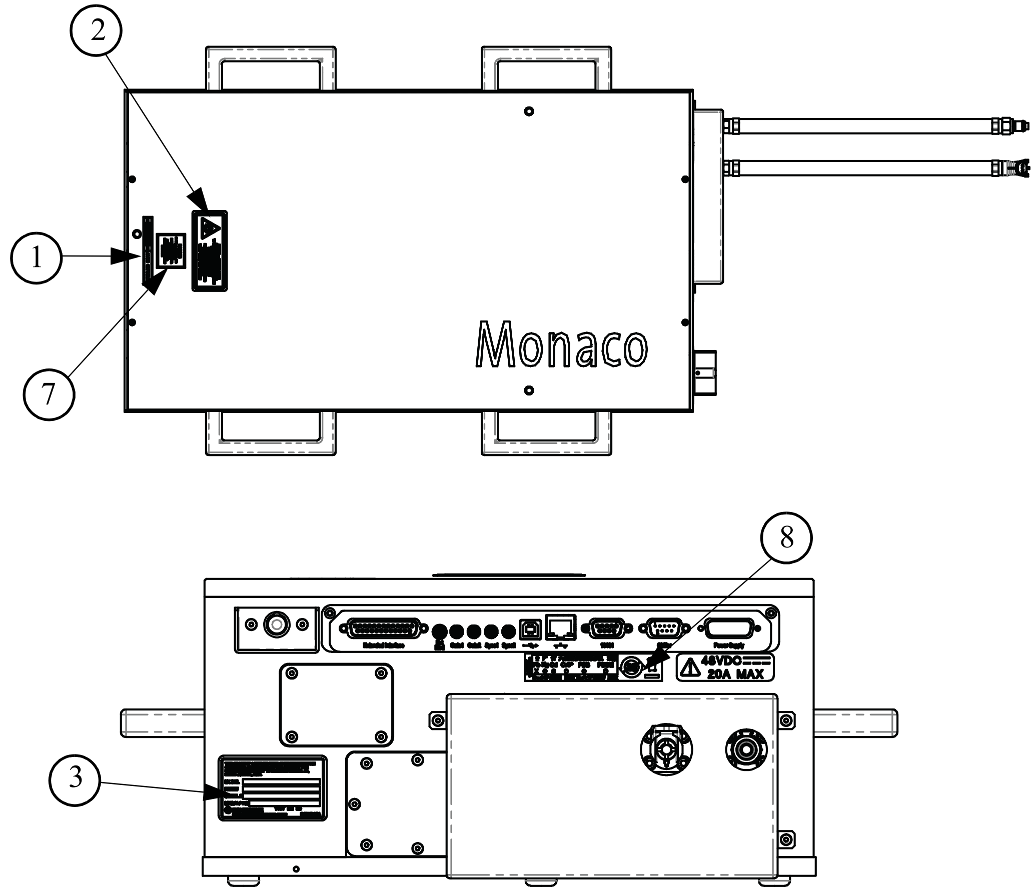
DESCRIPTION	TYPE
3V Memory Backup Coin Cell	Lithium



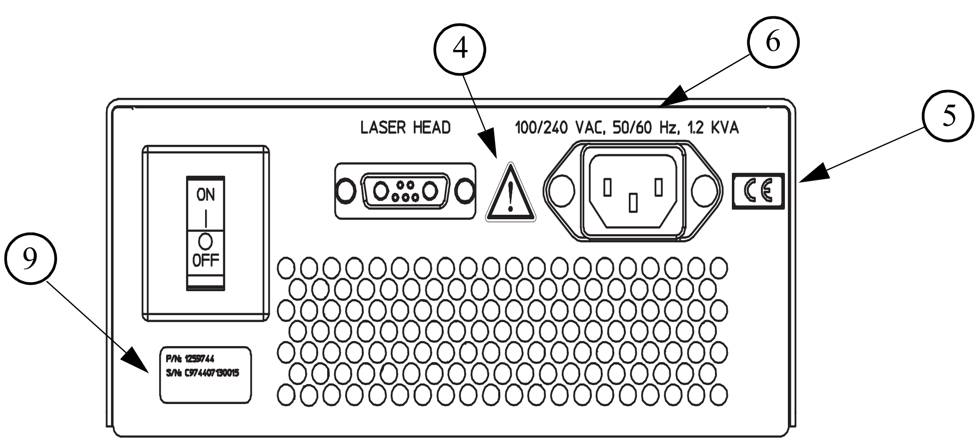
Dispose of batteries according to local regulations. Do not dispose as normal waste. Consult your local waste authorities for guidance.

Location of Safety Labels

Refer to Figure 1.1-8 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/ IEC 60825-1, Clause 7].



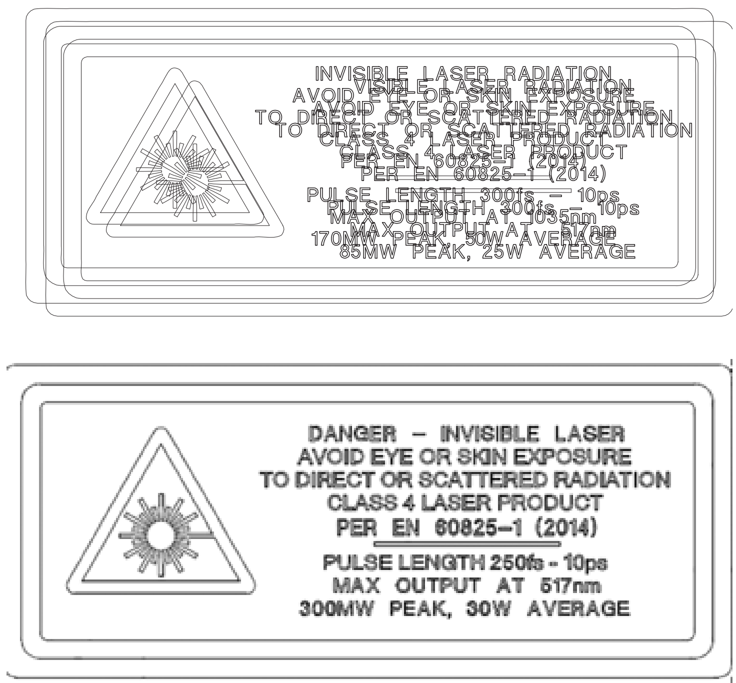
LASER HEAD



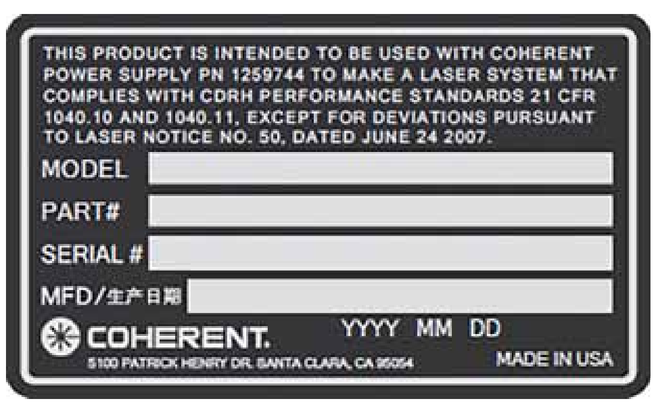
POWER SUPPLY

Figure 1.1-8. Safety Features and Labels (Sheet 1 of 3)

1. APERTURE WARNING



2. RADIATION WARNING



3. LASER HEAD SERIAL NUMBER IDENTIFICATION

Figure 1.1-8. Safety Features and Labels (Sheet 2 of 3)

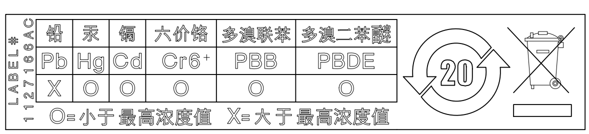
4. CAUTION MARK

5. CE CERTIFICATION

100/240 VAC, 50/60 Hz, 1.2 KVA

6. VOLTAGE RATING

7. RADIATION WARNING



8. CHINA ROHS

P/N: 1259744
S/N: C974407130015

9. POWER SUPPLY SERIAL NUMBER IDENTIFICATION

Figure 1.1-8. 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.gov

Publications and Guidelines

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

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

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

International Electrotechnical Commission (IEC)
www.iec.ch

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

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

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

Equipment and Training

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

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

Service Equipment

In addition to the standard maintenance hand tools and cleaning equipment, the following items may be needed:

1. Computer (laptop or full size)
2. Periscope kit or risers to raise the beam up on the optical table (e.g. periscope kit part numbers NB1-K14 (x2), and RS99 from Thorlabs). The Monaco beam height out of the laser is very low, so cannot easily be directed into a power meter or other detector.
3. Power Meter (appropriate for the power and wavelength of the laser)
4. IR Viewer/Card sensitive to 1035nm for alignment
5. Half waveplate (autocorrelator or other detection equipment may require horizontal polarization at the input)
6. 300Mhz Oscilloscope with 2GS/s and standard deviation ability
7. Photodetector for pulse detection, 1ns rise time or slower (e.g. Thorlabs DET10A Si Biased Detector, 200-1100nm)
8. Autocorrelator as needed for pulse width verification (e.g. APE PulseCheck), which customer may have.

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.

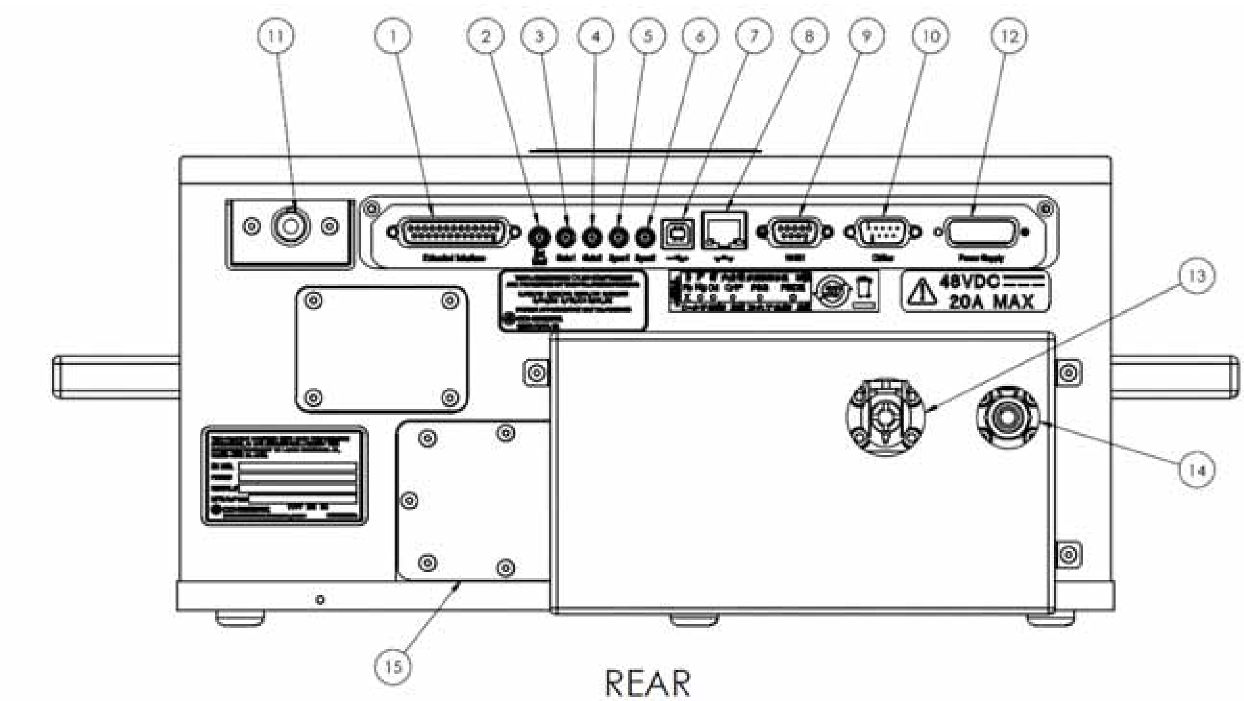
NOTICE!
It is the customer's responsibility to comply with IEC60825 safety standards during any use of the signals described in this document.

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. 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 1.2-1 while performing the following instructions.

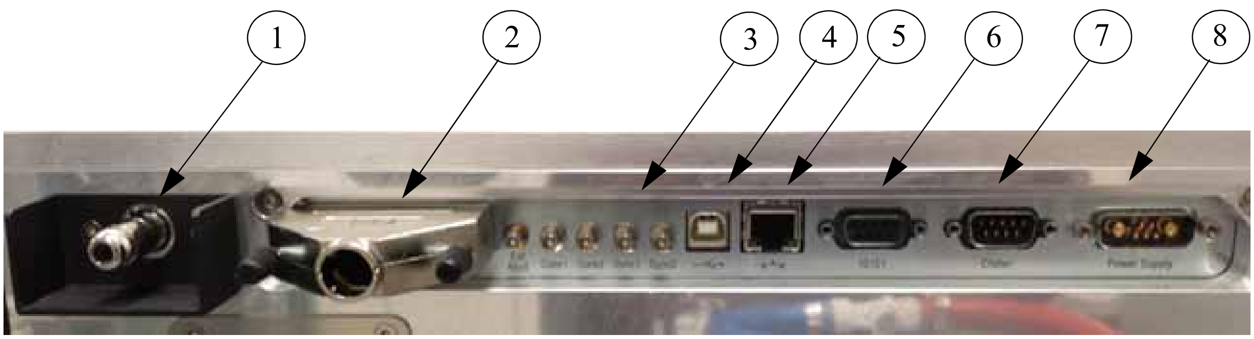


1. Extended Interface
2. EXT MOD Input
3. Gate 1
4. Gate 2
5. Sync 1
6. Sync 2
7. USB Connector
8. Ethernet Connector
9. RS-232 Connector
10. Chiller RS232
11. External Interlock
12. Power Supply Cable
13. Coolant In
14. Coolant Out
15. Desiccant Access

Figure 1.2-1. 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. Sync BNC connector
4. USB connector
5. Ethernet connector
6. RS-232 connector
7. Chiller RS-232 connector
8. Power cable

Figure 1.2-2. Laser Head Connections Photograph

Chiller Installation

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 "Thermal Management" on page I-169. **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.**

The Monaco is typically operated in conjunction with either a Termotek P307 Chiller or an SMC HRR012 Chiller. The Monaco laser software controls the actual chiller temperature, so there is no need to set or change the chiller temperature.

Termotek Chiller Setup

The following procedure applies if the Monaco is operating with a Termotek P307 Chiller.

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 "Thermal Management" in the Operator's Manual.

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3. Fill the chiller reservoir with the coolant specified in the appendix section "Thermal Management" of the Operator's Manual.

NOTICE!
To maintain performance of the Monaco laser system, the chiller coolant must be changed every six months. Failure to do so may void the warranty of the laser.

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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 1.2-3 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.

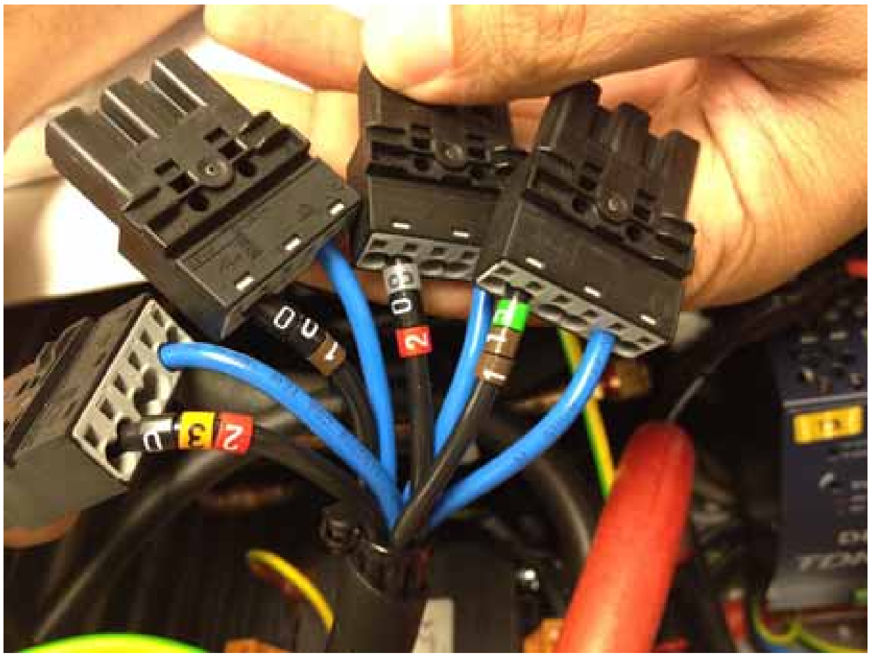

Figure 1.2-3. P307 Chiller Voltage Inputs (230VAC plug shown connected)

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. Remove the red bleeding cap by depressing the black lock ring at its base while pulling. Note, do not start the chiller with bleeding cap removed.
10. 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

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

PH level becomes too aggressive for the cooling circuit materials. Coolant supplied by Coherent is always pre-mixed.

11. Replace the red bleeding cap.

12. 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 query?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 1.2-4 below). Once the chiller is operating, loosen the bypass valve locking nut and twist the knob to adjust the flow rate.

Figure 1.2-4. P307 Chiller Bypass Valve

SMC Chiller Setup

The following procedure applies if the Monaco is operating with an SMC HRR012 Chiller.

13. The SMC chiller requires a power cable with 3 cores x 14 AWG (3 cores x 2.0 mm^2) connected to a 1-phase 200-230V AC (50/60 Hz) source. Strip the sheath from both ends of the cable.

NOTICE
The SMC Chiller only includes the power cable connector. Some newer versions of the SMC Accessory Kit include a power cable for the SMC chiller, but the user previously needed to supply their own cable.

14. Disassemble the power supply connector (supplied with the chiller as an accessory), and mount one end of the cable to the

L, N, and E terminals on the connector and reassemble the power supply connector. See Figure 1.2-5.

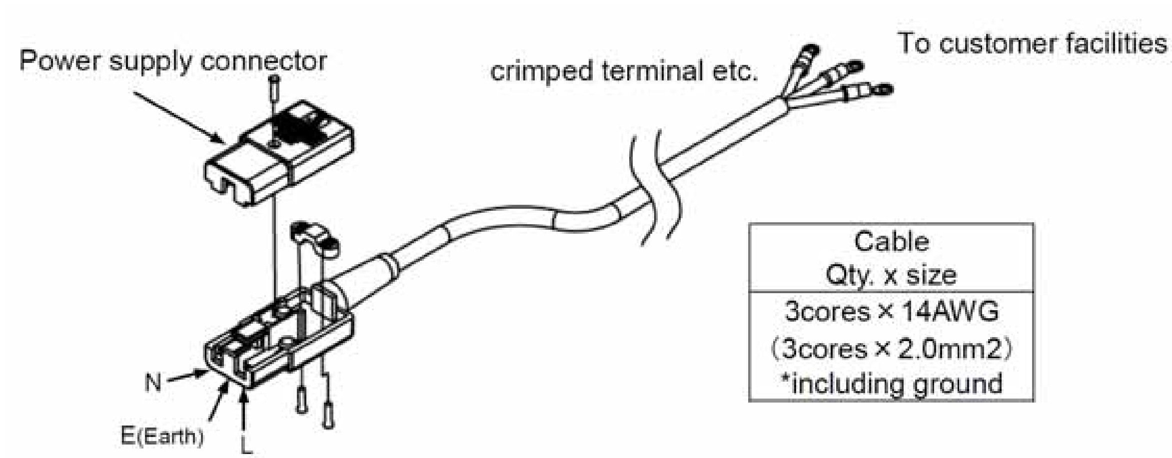


Figure 1.2-5. Preparing SMC Chiller Power Cable

15. Connect the other end of the cable to crimped terminals that are compatible to the facility power supply.
16. Insert the power supply connector to the power supply connector socket of the chiller.
17. Connect the crimped terminals to the secondary side of the earth leakage breaker and grounding on the facility power supply. See Figure 1.2-6.
18. Install fitting adapters into rear of chiller. The chiller uses PT threads and the fittings are NPT threads. See Figure 1.2-7.
19. Wrap all threads with Teflon tape to prevent leaks. Always wrap in a clockwise direction. See Figure 1.2-7.
20. Install female fitting to inlet (top). Do not overtighten.
21. Install male fitting to filter outlet. Do not overtighten.;
22. Open the front screen panel of the chiller using a phillips head screwdriver. Install the particle filter. A special wrench tool is included with the chiller to assist - do not overtighten. Replace the front screen panel. See Figure 1.2-8.
23. Verify that the blue bypass valve (see Figure 1.2-8) is closed (turn clockwise to tighten).

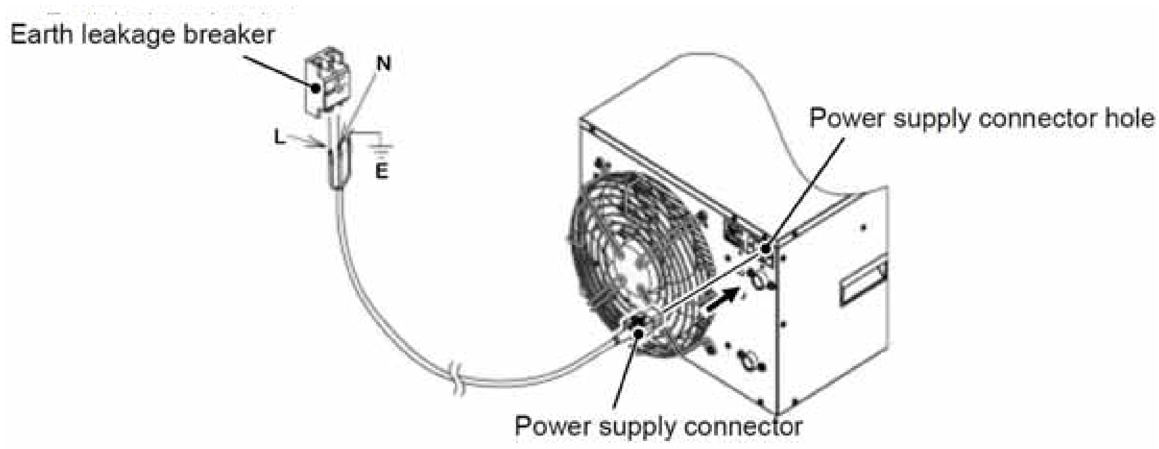


Figure 1.2-6. SMC Chiller Power Connections

24. 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.

NOTICE
To maintain performance of the Monaco laser system, the chiller coolant must be changed every six months. Failure to do so may void the warranty of the laser.

25. Turn on the AC power to the chiller.

NOTICE
Do NOT connect the Monaco laser to the SMC chiller before completing the SMC Chiller Software Procedure below for older versions of the Monaco firmware. Later versions of the Monaco firmware connect the chiller and configure it for RS-232 communication automatically.

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

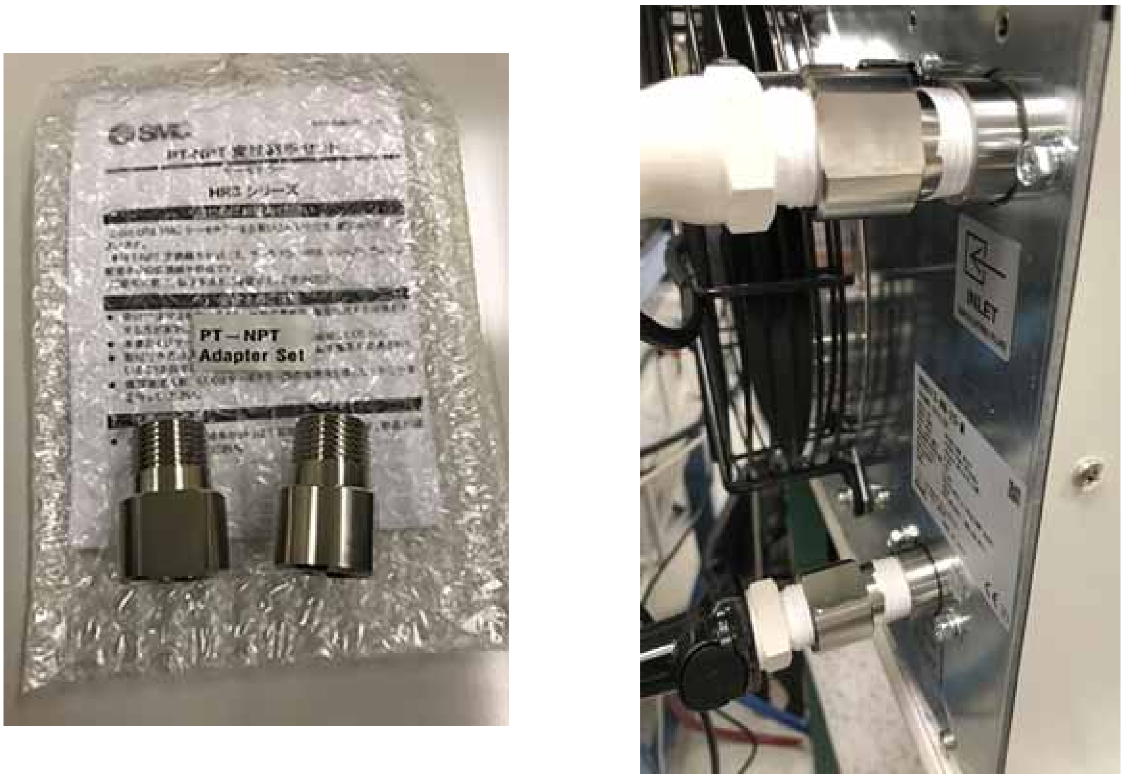


Figure 1.2-7. Installing Fitting Adapters

SMC Chiller Software Procedure

Control must be changed from Local and RS-485 communication to Remote, Serial RS-232 communication.

1. From the Temperature Monitor screen long press the [MENU] button (5 seconds) to reach the advanced setting mode, see Figure 1.2-9.
2. Press the [MENU] button until it switches to the Communication menu. See Figure 1.2-10.
3. Press the down arrow [▼] key twice to reach the communication specification setting screen, press [ENT]. See Figure 1.2-11.
4. The “485” setting should be blinking. Press the down arrow [▼] key to switch from “485” to “232”, and press [ENT] to select. The “232” setting should stop blinking.
5. Press the [MENU] button five times to exit back to the Temperature Monitor screen.

Figure 1.2-8. SMC Chiller Particle Filter and Wrench Accessory

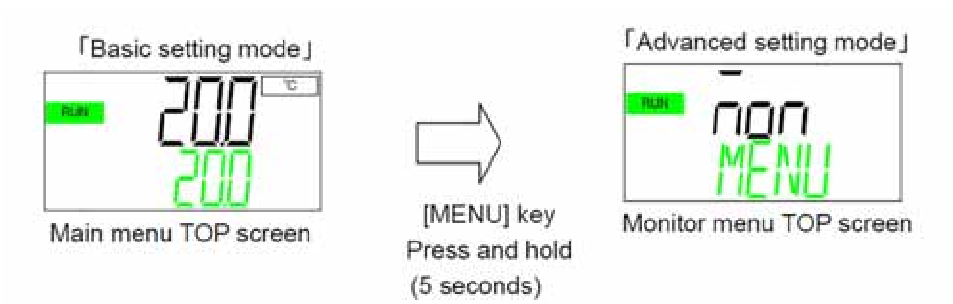


Figure 1.2-9. Advanced Setting Mode

6. Connect the SMC chiller to the Monaco laser using the Chiller/Null Modem cable provided in the chiller accessory kit.

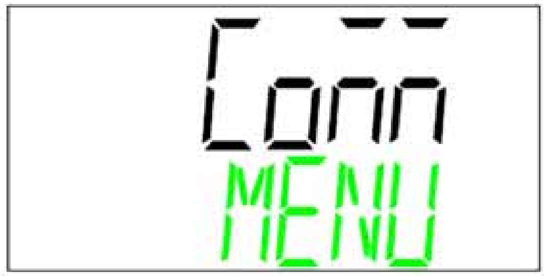


Figure 1.2-10. Communication Menu

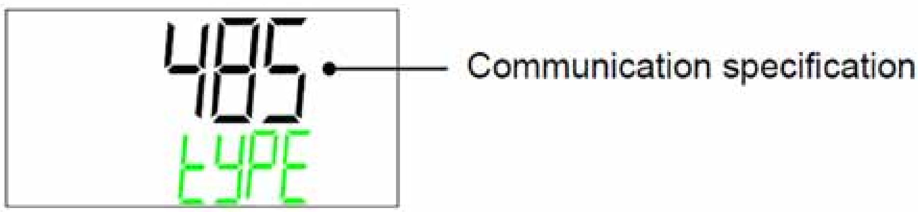


Figure 1.2-11. Communication Specification

NOTICE!
Do NOT connect the Monaco laser to the SMC chiller using a standard RS-232 (9-pin) cable as this could damage the chiller.

The cable supplied with the laser is a 3-conductor cable with a null modem configuration. Early Monaco head boards have a jumper installed on JP54 (rev. AD and rev. AF) or JP4 (rev. AH and above) that supplies 24V for a now obsolete application. Using a standard 9-pin D-sub cable with null modem adapter supplies 24VDC that will damage the SMC chiller interface. Monaco systems built after May 2019 have this jumper removed. See Monaco Chiller Update FSU on Spectrum.

Monaco Laser Connectors

There are twelve connectors on the back of Monaco Laser laser head to connect equipment. Figure 1.2-1 shows the location of the connectors.

Computer Interface

A Windows computer is the user interface necessary to operate the Monaco laser system. The Monaco Laser 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 1.2-1 must be connected. The only data rate supported is 19200 Baud.

Table 1.2-1. 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 Laser 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 Laser 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 LOCKOUT=0 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 1.2-2 on page 1.2-4). The Extended Interface defeat plug provided with the Monaco laser is intended to provide appropriate signals for use when not integrated into a control system.

1.2.0.1 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 1.2-2. 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.

1.2.0.2 Extended Interface

The extended interface connector provides an additional customer interface. Table 1.2-4 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 1.2-4 below).

The Extended Interface defeat plug provided with the Monaco laser is intended to provide appropriate signals for use when not integrated into a control system. The defeat plug provides 5V signals for pins 11, 12, 17, and 19, a 0.2V signal for pin 15 using pin 21, and closes interlock current loop pins 3 and 4. The EXT MOD input can be used with the defeat plug (see “EXT MOD Input” on page 1.2-19). It is recommended to either use the special defeat plug labeled “For External Modulation” (part number 1412089) included with your laser that has the resistor to pin 15 removed, or remove the resistor to pin 15. With the resistor removed, serial command and Coherent GUI pulse energy modulation will not be available.

Table 1.2-3. Extended Interface Connector

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

Table 1.2-4. 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 maximum current.
3	EXT_INTERLOCK+	Current loop	Out	Pins 3 and 4 must be connected for the laser to operate (Interlock fault when circuit is open). These signals should be connected to customer equipment for safety, such as switches on access doors.
4	EXT_INTERLOCK-	Current loop	In	Pins 3 and 4 must be connected for the laser to operate (Interlock fault when circuit is open).
5	LASER_READY	TTL	Out	High when laser is ready for output.
6	SYSTEM_STATUS	TTL	Out	High when status is OK. Low when Fault occurs.
7,8,9, 10	Reserved			
11	Laser Shutdown	TTL	In	High to operate the laser. Hold low for a minimum of 3 seconds to shut down the laser. If this pin is unused and the interface defeat plug is not used, connect to pin 21.
12	FF-Interlock	TTL	In	High to operate the laser. Transition Low/connecting to ground disables laser. The FF-Interlock is a fast shutdown and hard wired to immediately turn off the laser without ramping down. If this pin is unused and the interface defeat plug is not used, connect to pin 21.
13	Shutter Status: OPEN	TTL	Out	Direct connection to shutter (High or 5 V when shutter is open)
14	Shutter Status: CLOSED	TTL	Out	Direct connection to shutter (High or 5 V when shutter is closed)

Table 1.2-4. Extended Interface/RS-232 Connector Pinouts (Continued)

PIN	SIGNAL NAME	SIGNAL	DIR	DESCRIPTION
15	Pulse Energy Control	0-5 V / 10 kΩ Impedance	In	Analog Input pulse energy control - modulates pulse energy. Note that output power is not linear with voltage (0-0.1V is no output, 0.1-5V scales laser output). 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	High to open shutter, ground closes shutter. If this pin is unused and the interface defeat plug is not used, connect to pin 21.
18	GND Shutter Control	Ground	–	
19	Pulse Picker Enable	TTL	In	High to enable laser output. Low to disable the laser output. If this pin is unused and the interface defeat plug is not used, connect to pin 21.
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. Use only for inputs on this interface. Not intended to power external devices.
22	Reserved			Not to be used for any other purpose.
23, 24, 25	Reserved	No connection.		

1.2.1 Beam Modulation Modes

The Monaco allows for several different ways to modulate the pulse energy as shown in Table 1.2-5 below. The laser parameters can be adjusted manually or through Coherent’s GUI.

Table 1.2-5. 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**			

Table 1.2-5. Beam Modulation Modes and Inputs (Continued)

		Beam Modulation Operating Mode		
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	Install Coherent supplied External interface plug or pull up to 5V	Must be 0 V or no connection	0.00 - 5.00 V
EXT MOD connector	0.00 - 5.00	Doesn't matter	Ground - 5.00 V	Must be 0 V or no connection

Pulse energy modulation can be performed by one of the three following methods:

1) Internal – Using the serial command RL or Coherent GUI RF%, 0-100.

- External pulse energy modulation serial command EM=0
- Extended Interface pin 15 OR EXT_MOD mini BNC >0.1V

2) EXT MOD mini BNC connector – 0-5V analog signal

- External pulse energy modulation serial command EM=1
- Extended Interface pin 15=0V OR disconnected

3) Extended Interface pin 15 – 0-5V analog signal

- External pulse energy modulation serial command EM=1
- EXT_MOD mini BNC=0V OR disconnected
- Serial Command ALTMODE = 0 (after firmware release 39)

Notes:

- EXT MOD can be used to vary pulse to pulse energy.
- Enter the ?PENRGV query/serial command for the percentage of 5V applied on external interface pin 15. EXT MOD is not monitored.
- EXT MOD and External Interface pin 15 signals are independent controls. Prior to firmware release 39, these signals would

be added together if used simultaneously. After firmware release 39, the default setting was set for the EXT MOD mini BNC connector to be used (ALTMODE = 1). Use the serial command ALTMODE = 0 to switch to the Extended Interface pin 15 for pulse energy modulation. DO NOT APPLY VOLTAGE ON BOTH SIMULTANEOUSLY.

- DO NOT EXCEED 5V ON EXTERNAL PULSE ENERGY MODULATION INPUTS.

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, 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. Please note:

- The output power is not linearly proportional to the input applied, and may require some testing to get the desired response.
- If there is a signal to pin 15 of the External Interface (see Table 1.2-4 above) it will override the input to the EXT MOD BNC connector.
- At 0V input, there is approximately 200mW of laser output leakage. This can be removed by using the GATE input (see “Gate 1 and Gate 2” on page 1.2-21), applying a negative bias of -200 mV (with reference to ground on the laser), or by reconfiguring the extended interface defeat connector (see Table 1.2-4 on page 1.2-16) as follows:
    - Connect pin 21 to pins 11,12,15,17,19 (to set high on all controls). All these connections are required to operate the laser.
    - Connect pin 3 to pin 4 (this is the interlock)
    - Pin 15 is open. Note that this will also disable pulse energy control from the GUI interface.

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 1.2-6. 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

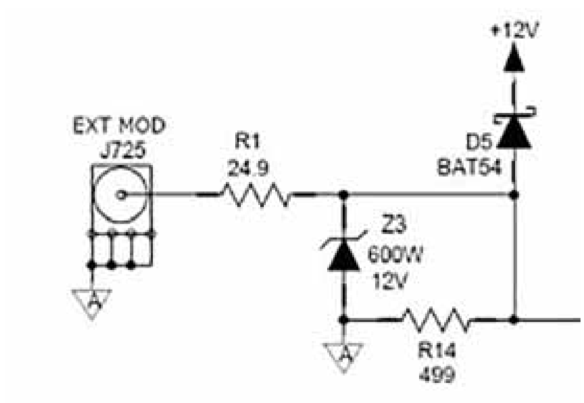


Figure 1.2-12. External Modulation Diagram

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 output is user selectable and has two modes. The default mode (SYNC2=0) 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. The second mode for Sync 2 (SYNC2=1) is a representation of the pulses from the seeder (approximately 50 MHz). Adapters for connecting the HD-BNC connectors with standard BNC connectors are included in the Accessory Kit for the laser.

Table 1.2-7. 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 or input for PulseEQ Mode. Gate 1 is used to control the duration of a string of pulses, or provide the input signal for PulseEQ. 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. If PulseEQ is enabled (by clicking the PulseEQ button on the Triggering tab), the output repetition rate of the laser will be determined by the input signal to Gate 1. 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 1.2-8. 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.	

RS-232 Interface Connection

The Monaco Laser’s RS-232 port configuration is in Table 1.2-9, and typical cable requirements are shown in Figure 1.2-14. The

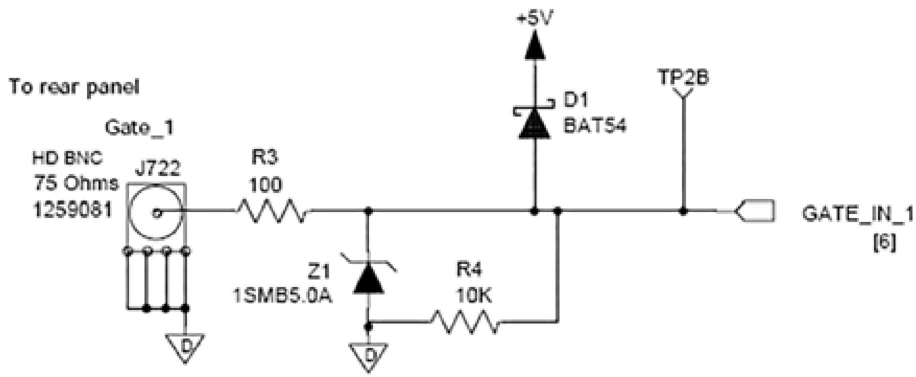


Figure 1.2-13. Gate Diagram

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.

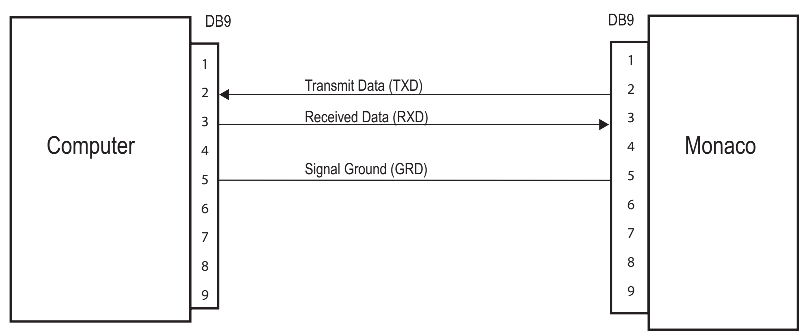


Figure 1.2-14. RS-232 Pin Configuration

RS-232 Port Configuration

The factory set baud rate is 19200.

Table 1.2-9. RS-232 Port Description

CONFIGURATION	DCE, NO HANDSHAKING
Data bits	8

Table 1.2-9. RS-232 Port Description

Stop bits	1
Parity	none
Baud rate	19200 (factory setting)

Power Supply Connector

The cable connection between the power supply and head uses a 7W2 D-sub connector with the pinout shown in Table 1.2-11 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 1.2-10. Power Supply Connector

Connector	Norcomp 680S7W2203L401
Mating Connector	Norcomp 680S7W2103L401

Table 1.2-11. 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.

Table 1.2-11. Power Supply Connector Pinouts (Continued)

PIN	SIGNAL NAME	DESCRIPTION
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.

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/support/software/

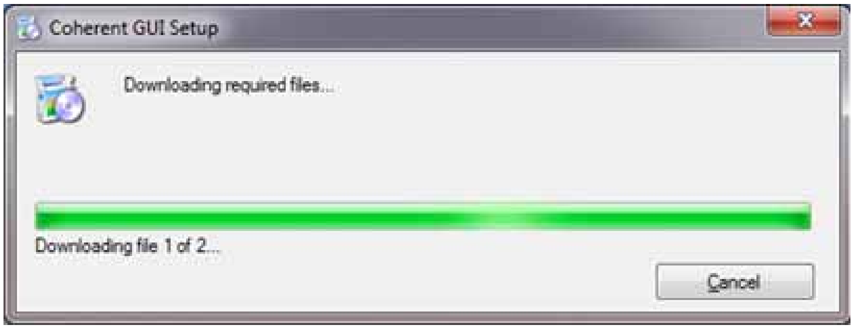
NOTICE!
The Coherent GUI requires 4GB RAM, 2.5GHz CPU, i5 Intel processor, Windows XP (Windows 7 or higher is recommended).

Microsoft Components

Select the "Accept" button as indicated in the menu form, and shown in Figure 1.2-15.

Figure 1.2-15. Microsoft Software License

The setup program will install the required files, as shown in Figure 1.2-16.



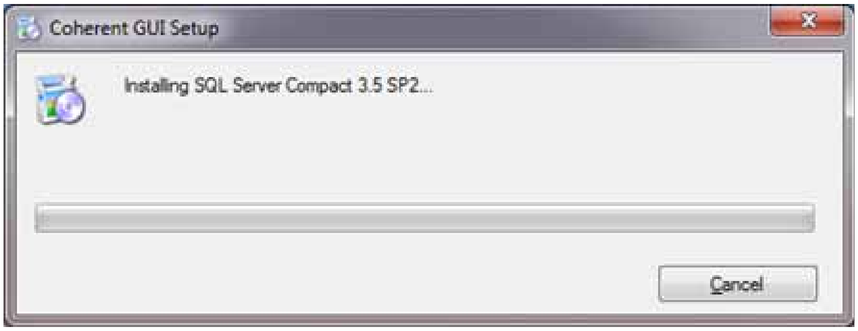


Figure 1.2-16. Installing SQL

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 1.2-17.

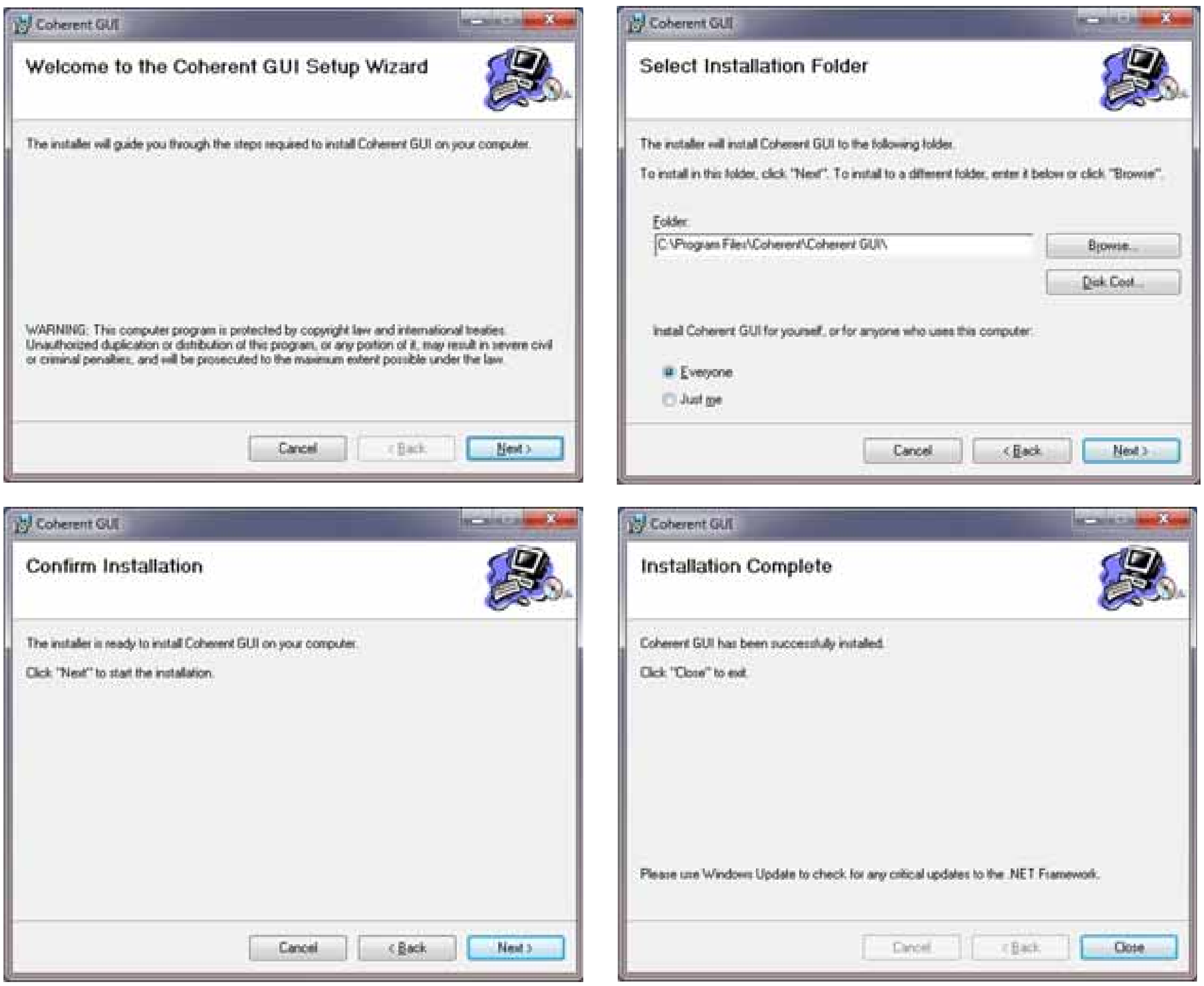
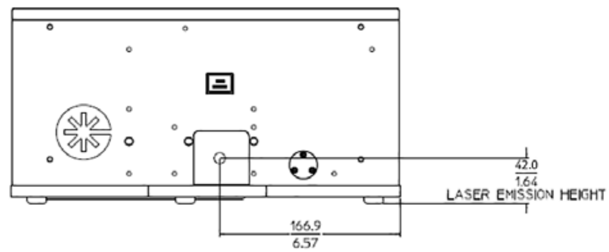
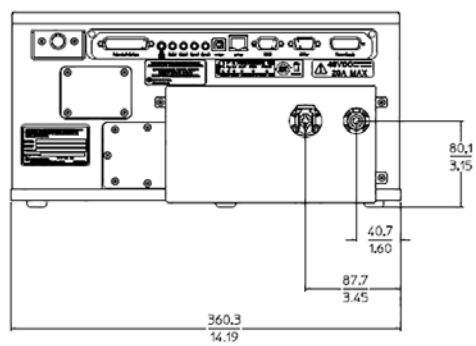
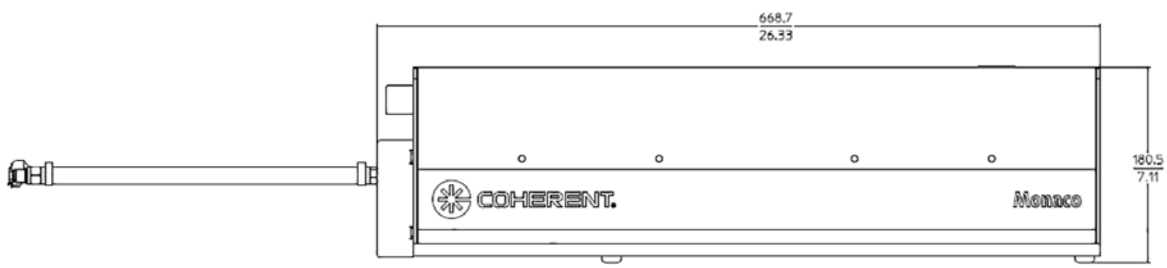
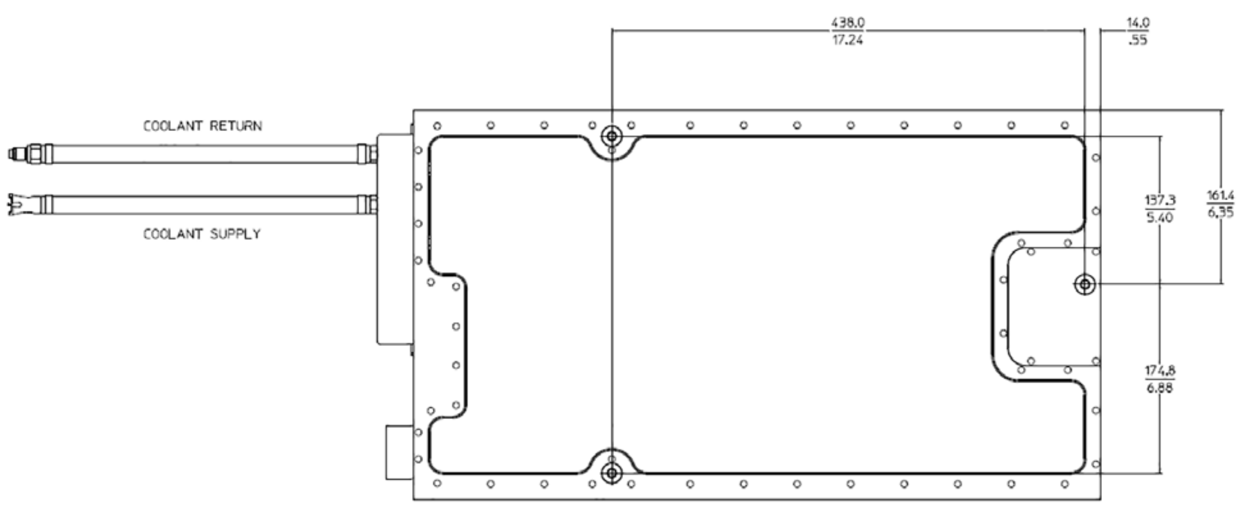


Figure 1.2-17. GUI Setup Installation


42.0
1.64
LASER EMISSION HEIGHT
166.9
6.57


80.1
3.15
40.7
1.60
87.7
3.45
360.3
14.19


668.7
26.33
180.5
7.11
COHERENT
Monaco


438.0
17.24
14.0
.55
COOLANT RETURN
COOLANT SUPPLY
137.3
5.40
161.4
6.35
174.8
6.88

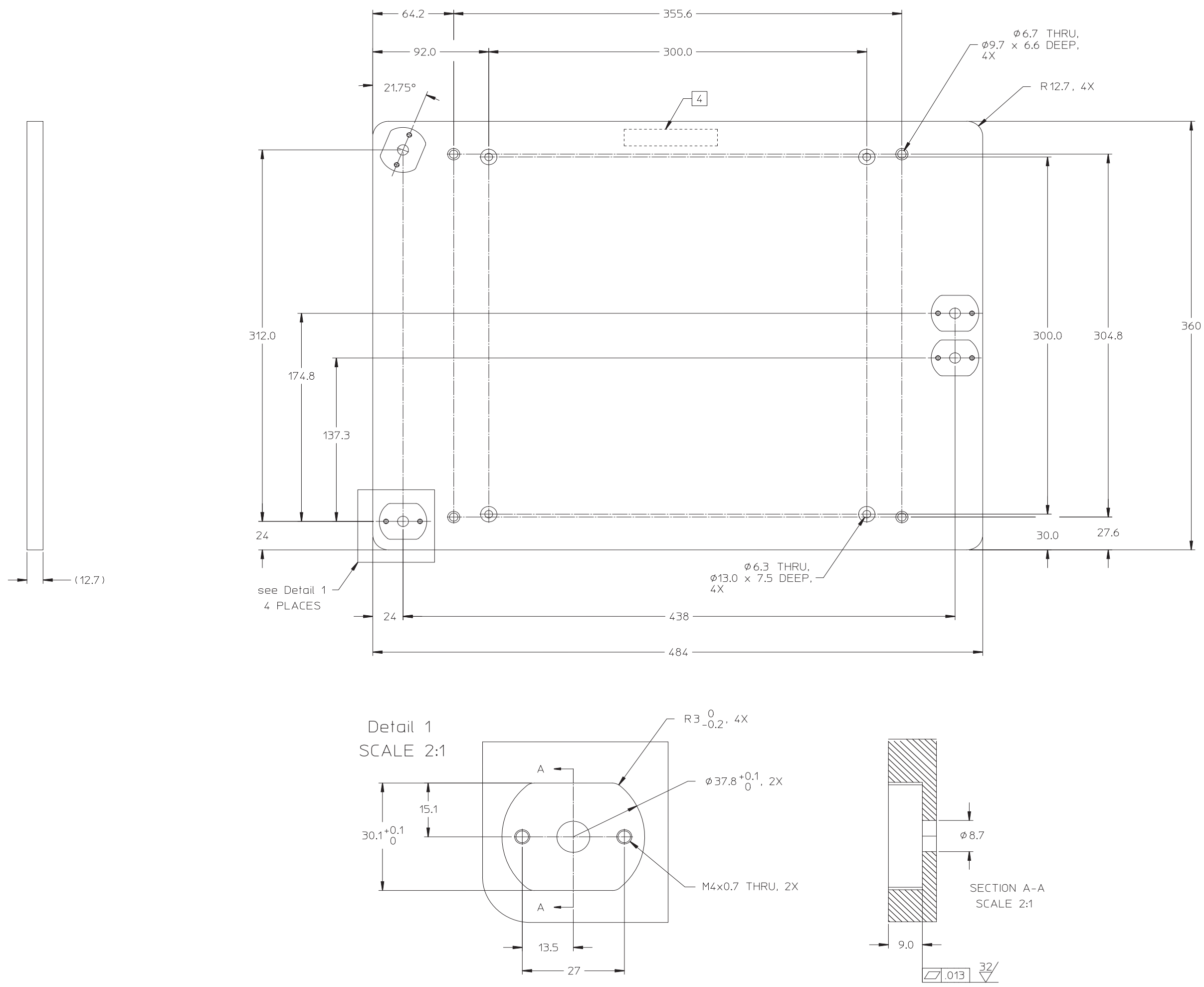


Figure 1.2-19. Kinematic Alignment Plate (Part Number 1303793)

Customer Training

The following Customer training should be provided at the time of installation.

1. All Turn-On and Turn-Off procedures:
    a. Turn-On (Cold Start)
    b. Turn-On (Warm Start)
    c. Turn-Off (Daily Use)
    d. Turn-Off (Complete Shutdown)
2. Instruct the customer on the functions of the Monaco software (GUI and RS-232 communication) and the rear panel connections of the Monaco power supply.
3. Instruct the customer on the importance of thermal management. Reference the operator manual for additional information on thermal management.
4. Instruct the customer on the Pulse Modes outlined in the operators manual, including Continuous, Process Burst, Divided, and Seeder Burst Modes.
5. Instruct the customer on the following maintenance procedures, which are outlined in Section Five of the Operators Manual:
    a. Review troubleshooting charts.
    b. Changing the desiccant
    c. Changing the SESAM spot.

Closing the Installation

A copy of the Monaco Data Sheet located in Section 4.1 “Data Sheet” should be filled out and attached to the Service Report for all installations and maintenance visits. All of the required information is available on the Details Menu tab display of the Monaco GUI.

The installation procedure is now complete.

System Description

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

The Monaco consists of a fiber oscillator (master oscillator), pulse picker and fiber preamplifier, and PCF based CPA power amplifier. The Monaco Green system also contains an internal SHG crystal, and the Monaco UV both SHG and THG harmonic generation.

Monaco Laser Head

The optical elements of the laser head include a seed laser, seed acousto-optic modulator (AOM), amplifier, and amplifier acousto-optic modulator (AOM). See Figure 1.3-1 below for the laser head block diagram.

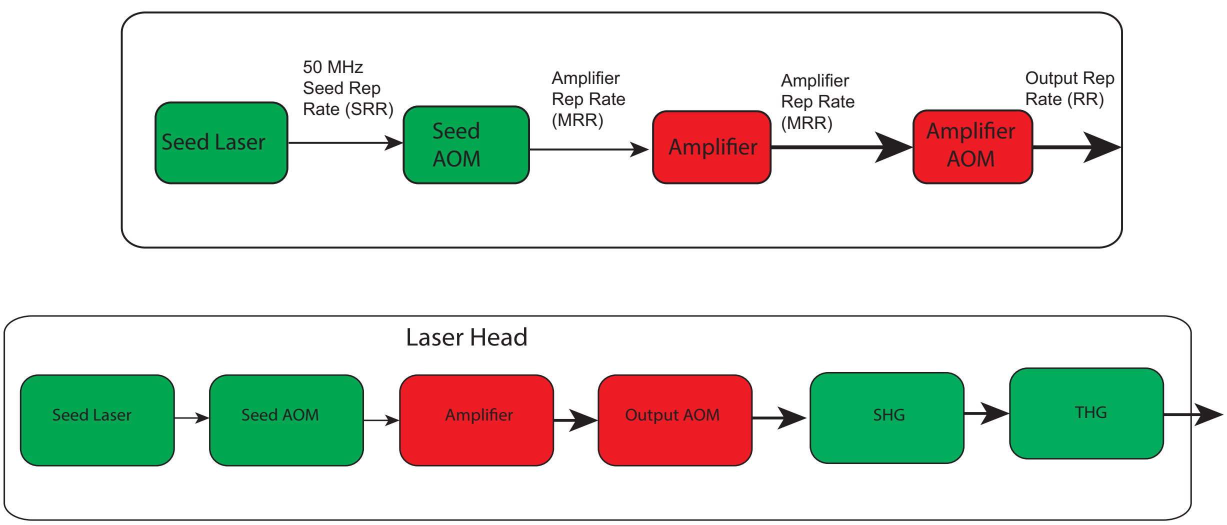


Figure 1.3-1. Laser Head Block Diagrams

The key Monaco specifications are listed in Table 1.3-1 below. Shortest pulse length is specified at <350 femtoseconds, and mode quality M^2 <1.2.

Table 1.3-1. Monaco Key Specifications

MODEL	WAVELENGTH	FUNDAMENTAL REPETITION RATE	PULSE ENERGY
1035-40-40	**1035 nm**	**1 MHz**	**40 uJ**
1035-80-40	**1035 nm**	**500 kHz**	**80 uJ**
1035-80-60	**1035 nm**	**750 kHz**	**80 uJ**
517-20-20	**517 nm**	**1 MHz**	**20 uJ**
517-40-20	**517 nm**	**500 kHz**	**40 uJ**
517-40-30	**517 nm**	**750 kHz**	**40 uJ**
345-20-25	**345 nm**	**1.25 MHz**	**20 uJ**

Note that the Monaco is distinguished by all of the optical elements up to and including the main amplifier being fiber-based. See Figure 1.3-1 for a schematic of the Monaco architecture, and Table 1.3-2 for a description of the major components and parameters.

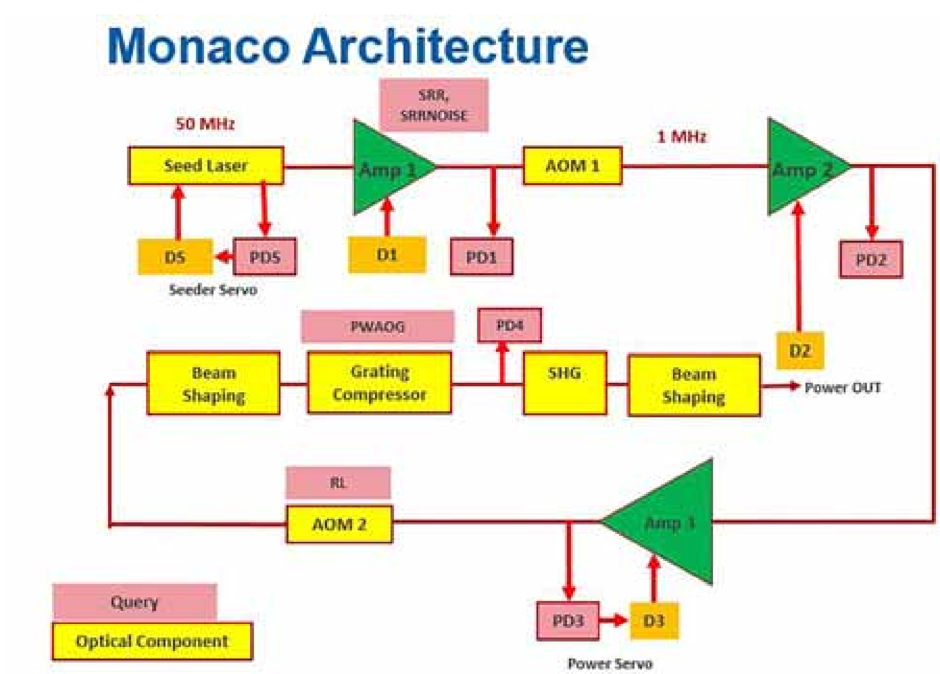


Figure 1.3-2. Monaco Architecture

Table 1.3-2. Monaco Major Components and Parameters

ACTIVE SUBSYSTEM	FUNCTION	PUMP SOURCE	DETECTOR	OTHER COMPONENT	KEY PARAMETER
SEED LASER	Generate 50 MHz pulse train	**DS**	**PDS**	**SESAM**	**DSC, PDSV, SRR, SRRNOISE**
AMP 1	Amplify	**D1**	**PD1**		**D1C, PD1V**
AOM 1	Pick one out of every 50 pulses	**D2**		**AOM 1 DRIVER**	**A1DT, A1DW**
AMP 2	Stretch & amplify	**D3**	**PD2**		**D2C, PD2V**
AMP 3	Final amplification		**PD3**		**D3C, PD3V**
AOM 2	Control output			**AOM 2 DRIVER**	**A2DT, A1DW, RL, PM**
COMPRESSOR	Compress pulses & adjust pulse width				**MPWA, MPWSA, MPWADELTA**
FINAL DETECTORS	Monitoring right before exiting		**PD4, PD5**		**PD4V, PD5V**

Seed AOM & Seeder Burst

A modelocked seed laser provides a 50 MHz pulse train for subsequent pulse picking and amplification. A fast AOM on the seed laser output (AOM 1) allows the 50 MHz pulse train to be divided-down to achieve lower repetition rates, and suitable gating of the seed AOM offers single or seeder bursts of pulses in the reduced repetition rate pulse-train. The seeder is set on a light loop, and once set there is not much to change.

The pulse train is then delivered to the amplifier. Fiber lasers can handle very high CW powers, but the high peak power of the pulses from the Monaco require that the pulse be stretched in a fiber, amplified, and then compressed using gratings. The seed laser provides ~300fs pulses at 50 MHz that are pulse picked in the seed AOM (AOM 1) to lower repetition rates. Note that amplifier repetition rates typically cannot be lowered below 200kHz. The parameters for AOM 1 are critical to ensure that there are no pre- or post-pulses.

User settings allow control of the reduced repetition rate from the seed AOM and the number of pulses in each seeder burst. Amplifier repetition rates can be adjusted from 200kHz (in seeder bursts) up to the seeder repetition rate of 50 MHz. 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 1.3-3.

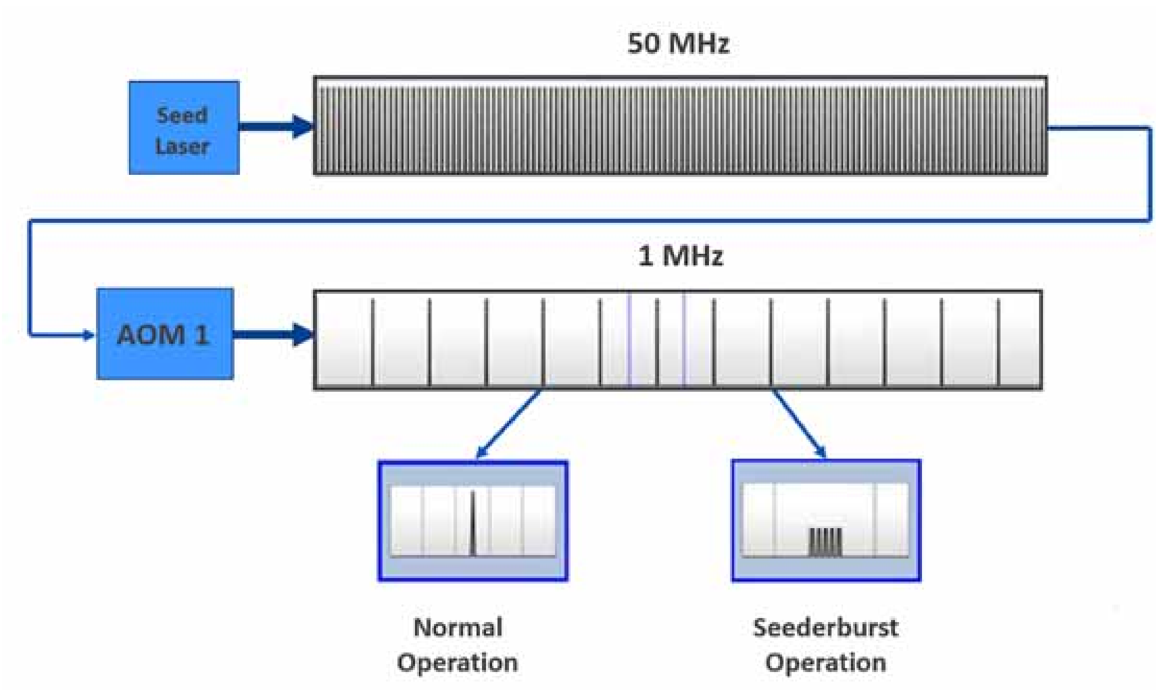
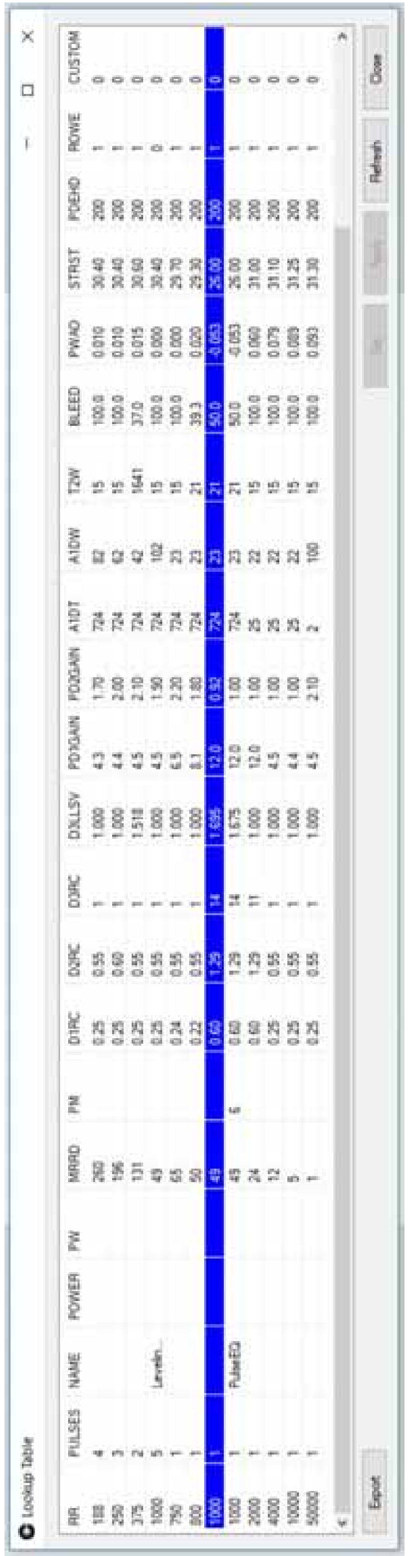


Figure 1.3-3. Seed Laser AOM & Seeder Burst Example

Available Modes/Lookup Table (LUT)

When the Monaco laser is configured at the factory, the modes of operation are set and can vary with the laser model. These modes are defined by the Lookup Table (LUT) and indicate all the available amplifier repetition rates and seeder burst mode options and their settings. The available modes have changed with the models and history of the Monaco laser. For example, some Monaco lasers may have 4 MHz operation or Seeder Burst modes available and some may not. On the next page is an example of the Lookup Table rows for a model 1035-80-60 Monaco system. The available rows will be different for every model. Also, the column layout has changed significantly as the product has been developed. For this reason, downgrading firmware on a Monaco laser is particularly challenging and often requires Engineering support.

Note that Service engineers cannot adjust the LUT directly, but by switching the laser to that mode/row and using Service-level commands values can be adjusted. Adjusting values in the LUT is usually not needed except in rare cases, such as when a PD threshold or current (e.g. DSLLSV) needs to slightly changed. Also important to note is that at the Service level, FSEs can turn off rows (making that mode of operation unavailable by the user) but cannot turn them on.



RR	PULSES	NAME	POWER	PW	MRRD	PM	D1RC	D2RC	D3RC	D3LLSV	PD1GAIN	PD2GAIN	A1DT	A1DW	T2W	BLEED	PWAO	STRST	PDEHD	ROWE	CUSTOM
188	4				260		0.25	0.55	1	1.000	4.3	1.70	724	82	15	100.0	0.010	30.40	200	1	0
250	3				196		0.25	0.60	1	1.000	4.4	2.00	724	62	15	100.0	0.010	30.40	200	1	0
375	2				131		0.25	0.55	1	1.518	4.5	2.10	724	42	1641	37.0	0.015	30.60	200	1	0
1000	5	Levelin...			49		0.25	0.55	1	1.000	4.5	1.90	724	102	15	100.0	0.000	30.40	200	0	0
750	1				65		0.24	0.55	1	1.000	6.5	2.20	724	23	15	100.0	0.000	29.70	200	1	0
800	1				50		0.22	0.55	1	1.000	8.1	1.80	724	23	21	39.3	0.020	29.30	200	1	0
1000	1				49		0.60	1.29	14	1.695	12.0	0.92	724	23	21	50.0	-0.053	26.00	200	1	0
1000	1	PulseEQ			49	6	0.60	1.29	14	1.675	12.0	1.00	724	23	21	50.0	-0.053	26.00	200	1	0
2000	1				24		0.60	1.29	11	1.000	12.0	1.00	25	22	15	100.0	0.060	31.00	200	1	0
4000	1				12		0.25	0.55	1	1.000	4.5	1.00	25	22	15	100.0	0.079	31.10	200	1	0
10000	1				5		0.25	0.55	1	1.000	4.4	1.00	25	22	15	100.0	0.089	31.25	200	1	0
50000	1				1		0.25	0.55	1	1.000	4.5	2.10	2	100	15	100.0	0.093	31.30	200	1	0

Figure 1.3-4. Monaco Lookup Table (LUT)

Amplifier AOM & Laser Output

The pulse train from the seed AOM is further amplified in a high-gain amplifier, which exits the laser through an amplifier AOM. The amplifier AOM (AOM 2) allows a wide range of gating, power tuning and pulse selection options. For an overview of the amplifier AOM (AOM 2) Pulse Modes, see Table 1.3-3 below, but for a full description of these options see the Operation section of the Monaco Operator's Manual. The user has multiple options with the seed AOM in conjunction with amplifier AOM.

.

Table 1.3-3. Monaco AOM2 Pulse Modes and Operating Parameters

PM#	PM Description	External Gating	Burst Mode	Divided Mode	Output Rep Rate
0	Continuous	off	off	off	MRR
1	Gated	on	off	off	User Defined, 0 to MRR or random
2	Divided	off	off	on	MRR/MRRD
3	Gated - Divided	on	off	on	User Defined, 0 to MRR/MRRD, or random
4	Process Burst	on	on	off	Lets out BP# of pulses at MRR rep rate at each triggering
5	Process Burst-Divided	on	on	on	Lets out BP# of pulses at MRR/MRRD rep rate
6	PulseEQ	off	off	off	User Defined, lets out pulses at each triggering (up to 1 MHz)

Conceptually for the AOM2 pulse modes there are three parameters that you can adjust. Each row in the AOM2 Pulse Mode table provides the configuration of the laser for each pulse mode. From the GUI menus you do not enter the Pulse Mode, you are checking these three parameters on/off - External Gate, Process Burst, and/or Divided - to reach each of six possible configurations. PulseEQ mode is set from the Triggering tab of the GUI. Alternatively the pulse mode can be chosen directly through the serial command PM. For example, from the Prompt screen entering PM=2 would choose Divided Mode.

Note that Gated and Gated/Divided are essentially the same modes (Gated is just Gated/Divided with the divider MRRD=1), and Process Burst and Process Burst/Divided are essentially the same modes (Process Burst is just Process Burst/Divided with the divider MRRD=1).

Note that unlike lasers like the AVIA, there are NO external triggering signals. When the Gate is high, you are just allowing pulses to come out. This is important to explain to customers who may be accustomed to external triggering (see “Monaco Modes vs Hyper-Rapid Modes” on page 7.1-1 for detailed information).

PulseEQ Mode

In the externally triggered PulseEQ mode, the laser pulse energy is held constant at a value determined by the amplifier repetition rate (MRR) setting, and is independent of the external trigger repetition rate ($PRF_{external}$) or timing between external trigger pulses. Most modes of operation are described fully in the Operator’s Manual, but below are several notes on PulseEQ operation for Service:

- PulseEQ was first released with firmware Release 38.1
- PulseEQ was originally only allowed for 1 MHz (continuous mode) pulse energy and worked best from 100-800kHz repetition rates ($PRF_{external}$), but now additional modes have been tested and released in newer models.
- Prior to firmware Release 39, switching into PulseEQ mode requires the laser diodes to be ramped down first to prevent the possibility of damaging the laser. This was done by
    - choosing the 1 MHz mode/row of operation
    - pressing the STOP button on the Main Tab of the GUI or by using the serial command L=0, and waiting a few seconds for the system to ramp down
    - switching to PulseEQ mode by pressing the PulseEQ button on the Triggering Tab of the GUI or by using the serial command PM=6.
    - pressing the START button on the Tab of the GUI, or using L=1.
- Prior to firmware Release 39, switching to PulseEQ could occasionally cause a fault shutdown (e.g. PD2V<PD2VLVL Fault). If a user experiences this issue, the recommendation is to upgrade to firmware Release 39.

- After firmware Release 39, PulseEQ does not require powering down the laser. The process was simplified to choosing the PulseEQ mode desired from either the drop down menu on the main table of the GUI (see Figure 1.3-5 below), or by using the serial command SET to choose the row of the LUT (e.g. "SET=PulseEQ/800kHz/300fs").

Figure 1.3-5. Choosing PulseEQ Mode

- PulseEQ performance is improved with the introduction of the Rev. AK headboard (to be released Fall 2020) into Monaco lasers. Prior to the Rev. AK board, pulsewidth and pulse energy varies slightly more with large changes to the repetition rate. The effect is more pronounced in Green or UV models of the Monaco.

Service Strategy

The Monaco laser is designed to be an OEM serviced laser with installations performed by certified Coherent staff or certified OEM personnel. The Monaco has limited field service capability and requires depot repair for optical failures, although a customer clean room could be utilized. The standard service sequence is typically:

1st Attempt: Remote diagnostics/remote recovery
2nd Attempt: Field Service at customer site
3rd Attempt: Depot repair at authorized repair facility
(currently only Santa Clara, CA)

The Monaco offers service agreement programs to cover unplanned events, as well as unit exchange programs for maximum uptime. The standard warranty is 12 months from date of installation, 13 months from date of shipment from the manufacturing site. Requests for failure analysis on defective material must be made when the replacement is requested. Remote diagnostics and troubleshooting (as allowed by the customer) are key components of the Service Strategy.

The diodes cannot be replaced in the field without a splicing tool and clean room, and there are no current plans to offer diodes as FRUs. The expected diode reliability is less than a 10% failure rate in 22,500 hours.

The SESAM is a consumable component. Degradation occurs due to two main factors - the number of starts and the number of hours. Indications are that the act of startup tends to wear the SESAM spot more than individual hours. This suggests that it may be a better option for the laser to run and remain modelocked rather than shutting it down if the idle period is not too long. The system switches the SESAM spot automatically after 600 starts, and there are enough spots to last the lifetime of the laser. If a particular spot is within one week of maximum recommended usage (5,000 hours) the Monaco system will provide a warning that changing the spot is recommended. The SESAM spot can be manually changed using the SSP serial command. Seed parameters are maintained by the seed servo, therefore need not be adjust with spot changes. If reliable modelocking is not restored by a spot shift, service tools are available to evaluate the cause and optimize it if needed. See “No Modelocking/ High Seed Rep Rate Noise” on page 2.1-7.

The desiccant should be changed whenever humidity rises above 8%. Apart from the laser head, power supply, chiller, desiccant, and connecting cables/hoses the only FRU is the headboard. For some rare cases replacement of the external shutter, PD3, or recirculator may be required.

Specifications

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

Table 1.3-4. Environmental Specifications

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

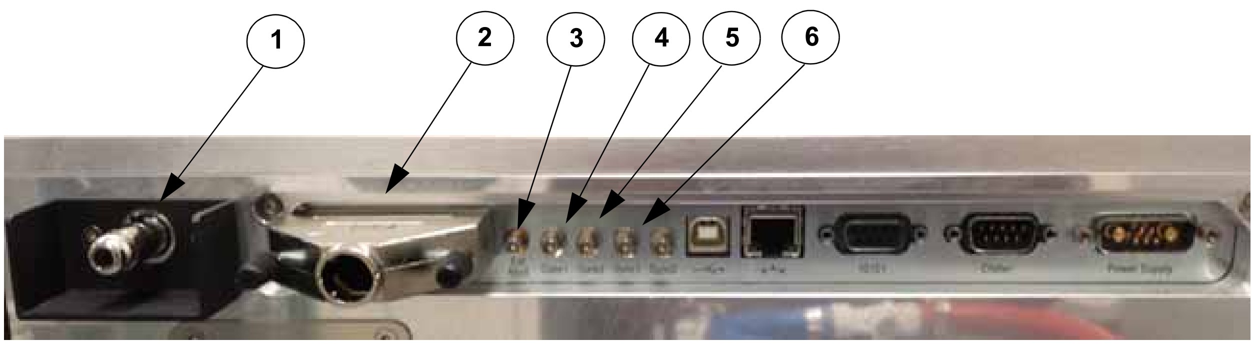
Table 1.3-5. Laser System Dimensions

	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).		

Introduction

This section provides guidelines for integrating the Monaco laser into a user's larger tool or system as well as some good practices to ensure the best performance and lifetime from the laser. The Installation section provides information on the connections and control interfaces for the Monaco laser. The relevant external connections are:

- External Interlock
- Extended Interface
- EXT MOD Input
- Gate 1
- Gate 2
- Sync 1



1. External Interlock
2. Extended Interface
3. EXT MOD BNC connector
4. Gate 1 connector
5. Gate 2 connector
6. Sync BNC connector

Figure 1.4-1. Laser External Connections

Using Factory Provided Defeat Plug

When the Extended Interface and Gate/Sync connections are not being utilized, software control is being used, and the user is using the factory provided defeat plug (as shown in Figure 1.4-1 above), the following apply:

- The External Interlock connector is only for emergency shutdown (e-stop),
- There is control of the shutter and pulsing from the GUI/Serial Commands only.
- There is selection for the external gate from the GUI/Serial Commands only.
- There is internal pulse energy control from the GUI/Serial Commands only.
- The GUI/Serial Commands provide laser status details.

Control Using the Extended Interface

When the Extended Interface connection is being used to control the laser (see Table 4-4 of the Installation section for details), the following apply:

- The External Interlock circuit and FF-Interlock input (pin 12) triggers immediate shutdown the laser. This is intended for emergency shutdown only (e-stop).
- Laser Shutdown input (pin 11) is used for controlled shutdown events triggered by the user's system for safety. This is the preferred method of shutting down the laser as it will shut down appropriately to preserve laser lifetime.
- Shutter Control (pin 17) and Pulse Picker Enable (pin 19) inputs are used for maintenance and connection to access panels/door interlocks to prevent unwanted laser emission. Software control (GUI/Serial Commands) for shutter and pulsing control are still required for laser emission.
- The GUI/Serial Commands are used for enabling external gating.
- All three methods of pulse energy control are selectable – software, external BNC, and Extended Interface
- Outputs from the Extended Interface are available to provide status on the shutter, laser fault and laser ready for emission (pins 5,6,13, and 14).
- GUI/Serial Commands provide detailed laser status.

Control Using Sync and Gate Connections

When the Sync 1, Gate, and/or EXT MOD BNC external connections are used to control the laser, the following apply:

- SYNC 1 and SYNC 2 outputs are available to time gate laser pulses with the selected pulse frequency of the laser (see Sync in Installation section).
- GATE 1 is an input intended for the selection of laser pulses to output. This can be used to select individual pulses OR a string of pulses (see Gated Mode in Operation section).
- EXT MOD is a selectable analog input to modulate the laser pulse energy. This input can be used to gate pulses as well. The pulse energy can be varied pulse-to-pulse.

Good Practices

The following practices allow for the best performance and lifetime from the Monaco laser:

- Do not turn off the laser power supply unless the laser is shut down (laser is in the READY or FAULT state).
- Do not leave the laser power supply on while the pump of the laser chiller is off (no chiller fluid flow).
- Use the External Interlock circuit and FF-Interlock (on Extended Interface) only for emergency situations.
- Use the shutter and pulse picker enable controls for access interlocks (e.g. system doors and panels) while the user's system is in operation (placing and removing part/workpiece from fixtures, interlocks for beam access during alignment).
- Provide adequate laser control to maximize laser usage while laser is in the ON state. Put the laser in the READY state when not in use.

Operating Conditions to consider:

- If there is intermittent daily use during a single eight hour shift in a laboratory, start up the laser when first needed and only shut down at the end of the shift.
- If there is continuous single shift usage during a typical five day week, start up the laser at the beginning of the shift and shut down at the end of the shift
- If there is continuous daily usage during the week, start up the laser at the beginning of the work week and shut down at the end of the last work day of the week.

- If there is continuous 24/7 usage, leave the laser on full time except for maintenance.

Interlocks

All Monaco interlocks operate on the same principle. A current is generated and passed through a series of devices to ground. Some of those devices are switches or connectors that must be closed. Some of them are LEDs that must have their current sensed. If the current is broken, then actions are taken to turn off the laser diodes that reduce the Monaco laser output to zero.

External Interlock

The first interlock described is the External Interlock. The accompanying Monaco Interlock Drawing schematic may be referred to for clarity. Like most of the interlocks the current source is on page 11 of the schematic. U8 is a current generator that supplies a steady current through the interlock chain. The signal exits the device and is called EXT_INTLK_TOP. In the lower right of page 11 the current passes out to J710 pin 1. This pin is presented to the customer in a steel shelled audio connector on the back panel of the laser. Normally there is a jumper wire inside the connector on the back panel and the current is returned to J710 pin 2. If the customer desires to use this interlock they may insert a door switch or unpowered relay contacts in series with the wire loop. If their device opens the laser will stop. The same thing will happen if the steel connector is removed. This particular interlock also runs to another connector on the back panel. J710pin 2 comes back as a signal called EXT_INTERLOCK_AR+. It goes to a connector on page 2 of the schematic. It leaves on J1 pin3 and returns on J1 pin 4. It is now called EXT_INTERLOCK_AR-. These two external connections must both be closed for the laser to operate. The signal returns to page 11 where it changes names to EXT_INTLK_RTN. From there it passes through two opto-isolators U14 and U13. U13 and U14 act to detect current flow in the External interlock. The sensed current passes to U84 and U79 where two new signal names are generated.

EXT_ILOCK_CLOSED and EXT_ILOCK_CLOSED_DUP

The first signal goes to pages 4, 9, and 12. On page 4 it is gated with the Head interlock signal and becomes Interlocks_Good. There it is fed to another gate and eventually to a signal called Regulator_Off. When Regulator_Off goes high it turns off the 3.3V supply. This supply is the power source for DS, D1 and D2 current. Therefore when either or both of the External Interlocks are opened, the Diode currents go off. In addition, the External interlock signal goes to the FPGA on page 9 where it is latched and stored in a register. The register can be read by the processor. The register is also part of an output from the FPGA called FPGA_FAULT. FPGA_Fault goes from the FPGA to page 1. It is forced through a diode, D45, into the signal Diode_I_Reset. This signal goes to pages 5, 7 and 8 where it shuts off the set current for diodes DS, D1 and D2. This signal is latched by the FPGA and is not cleared by the processor until the processor notices the fault and sets all the current drive DACs to zero then the fault latch is cleared after the interlock is closed. The External_Interlock_Closed signal is also sent to the processor where it can be read directly. The second signal connected to the external interlock is EXT_ILOCK_CLOSED_DUP. This signal is redundant in that it depends on no IC that is common to the previous path. This signal goes to pages 12 and 13. On page 12 it may be read directly by the processor. On page 13 it is inverted and sent into a diode and on to a FET where it forces the set current of D3 to zero. So one branch shuts off diodes DS, D1 and D2 and the other independent branch shuts off D3.

Keyswitch

The keyswitch current source is U9 on page 11. The signal is called ELAMP_TOP. It is sent to page 1 of the schematic. On page one in the lower right corner it is sent to connector J711 pin 1. This connector runs to the Monaco power supply. In the supply is a physical keyswitch. The key has two independent contact pairs wired in series. The key cannot be removed in the “On” position. The signal returns from the power supply on J711 pin 5 and is called KEY_RETURN. Key_Return passes through U15 and becomes the sensed signal KEY_ON. This signal goes to pages 4, 9, and 12. On page 4 it is gated with a supply off signal from the CPU and makes it way through a series of gates to Regulator_Off. This shuts off DS, D1, and D2. On 9 page it goes into the PFPGA and enters the same register that can be read by the processor. The Key being off is not considered a fault however. It is a normal state that the customer can put the laser in. The key turns off the emission light on the power supply when it is off and can be monitored on the GUI or queried with the ?K command. On page 12 the key can be monitored by the CPU directly.

Laser Emission

Laser Emission current begins on page 11 in U139. The signal is called LASER_EMISSION_TOP. It passes down to the bottom of page 11 and enters U138. There it leaves called LASER_EMISSION_RTN after having sensed the current in the laser emission diodes plugged into J726. The LEDs are independent and supported by redundant wiring. The signal /LE_ON turns the Laser Emission LEDs on when the processor directs them to be on. Laser Emission_Return comes back to U75 an goes to ground. The signal Head_Ilock. Closed is generated by U75 and goes to pages 4, 9, and 12. On page four it shuts the regulator off through the same path as the two interlocks above. On page 9 it enters the FPGA and becomes part of the fault register. On page 12 it may be monitored directly by the processor.

Extended Interface

The extended interface is intended for faster hardware control of the laser. Since it does not depend on a command and response interface like the Ethernet USB or RS-232 channels for that laser it can be somewhat faster. It contains a few safety signals that will be described here.

FF_Interlock

FF_Interlock is intended to be a very fast way the customer can shut down the laser. It is shown on page 2 of the schematic. It enters the laser on J1 pin 12 and is buffered by U24. From there it goes to pages 2, 6, and 10. On page 2 it is converted to 3.3v to go to pages 9 and 12. On page 6 it can shut down the pulsing of AOM2. If AOM2 is off no laser pulses can exit the laser because the laser energy is steered away from the output and sent into a water cooled beam dump. On page 10 it is gated in with the Fast Shutoff signals and sets D3 current to zero amps. On pages 9 and 12 it enters the FPGA and Processor, respectively. FF_Interlock becomes part of the fault register in the FPGA.

Pulse Picker Enable

Pulse Picker Enable is a customer controlled signal that allows the customer to inhibit the production of lase r pulses. On Page six it inhibits or passes pulses to AOM2. It enters the FPGA and the processor on pages 9 and 12 respectively. Pulse picker enable does not generate a fault. It is simply a way of turning the laser pulses on and off.

Pulse_Energy_Control

Pulse Energy control is an analog signal that modulates the laser pulse energy by controlling the analog input and the amplitude output level of AOM2.

Shutter_Control

Shutter Control is a hardware signal that allows the customer to open and close the shutter. The shutter open and closed signals are fed back to the customer can monitor the state of the shutter.

Laser_Shutdown

Laser Shutdown is a digital signal that allows the customer to do an orderly (non-emergency) shut down of the laser. All the diodes are shut down in order from D3 to DS in a much slower manner than with FF_Interlock.

Other Safety Features

1) The processor has the ability to control the power to AOM2. See page 6 upper left corner.
2) If the customer analog modulation is below a certain level hardware detects this and shuts off the pulsing to AOM2 . See the ?LOW_OFF signal on page 6.
3) The D3 current drive has a hard limit of a current drive that it will not go beyond. See U20 on page 13.
4) D3 has an over current detector. See the lower right corner of page 13 U37. In the event of an over current the D3 current is shut down.

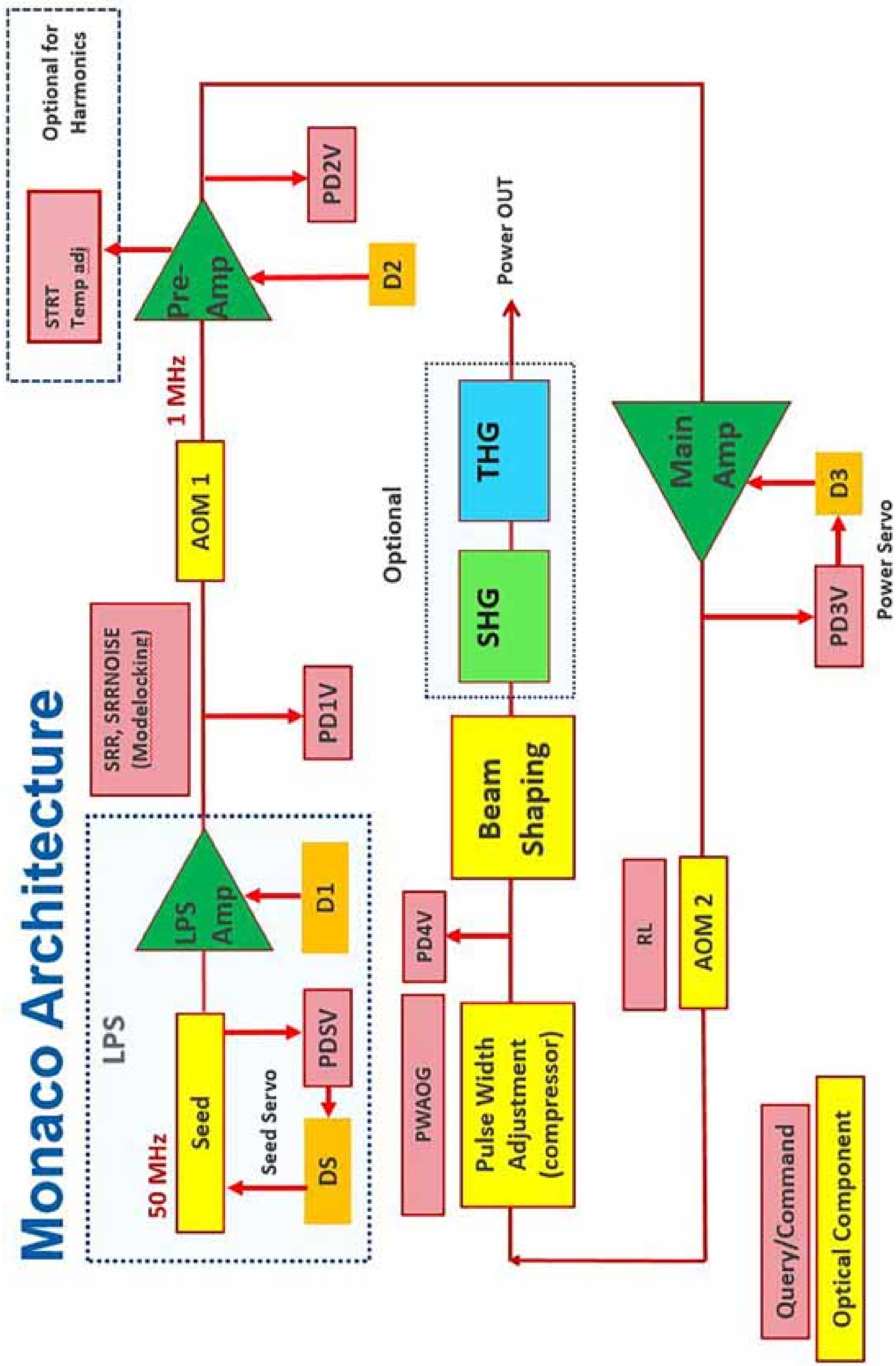
Introduction

Troubleshooting the system is greatly aided if the FSE understands the theory of operation of the various sub-systems that make up the Monaco. There is an extensive fault list that will help narrow the possibilities of which sub-system(s) has failed. Serial commands are available to employ the same diagnostic skills a FSE would use on other Coherent DPSS systems. In addition to this Service Manual, troubleshooting the Monaco system may require any or all software tools available to the FSE. Current versions of the Event Log reader and the Coherent GUI are available on Spectrum under the TBU-DPSS-SC tab. See Figure 2.1-1 for a system control and optical diagram to better understand the Monaco architecture. Additionally, see Figure 1.3-2 on page 1.3-2 for a simplified optical diagram. The important sensors for evaluating optical performance of each section are the photodiodes: PDS, PD1, PD2, PD3, and PD4. It's important to understand that each section of the system builds upon the last. A very small deficiency at PD1 can result in a large deficiency at PD3. Each photodiode does not only represent the output of each diode but is also affected by the other components in that section. Diode output can remain the same yet a degradation of another optical component can result in a lower reading at that photodiode.

While PDS through PD3 have a somewhat linear response, PD4 is a 2-photon detector which has a more exponential response. It is quite sensitive to pulse width as narrower pulse width generally results in higher intensity read at PD4.

While many commands may be executed through the GUI by pushing a button, a more extensive tool set is available using the terminal/command prompt. Entering help followed by a few key letters or words will return relevant commands and queries.

The Monaco Operator's manual contains troubleshooting outlines and suggestions for all possible software error messages. Reference the operator manual before performing the action steps presented in this section.


Monaco Architecture
LPS
50 MHz
Seed
Seed Servo
DS
PDSV
LPS Amp
D1
SRR, SRRNOISE (Modelocking)
PD1V
AOM 1
1 MHz
Pre-Amp
D2
PD2V
STRT Temp adj
Optional for Harmonics
PWAOG
Pulse Width Adjustment (compressor)
PD4V
Beam Shaping
SHG
THG
Optional
Power OUT
RL
AOM 2
Main Amp
D3
PD3V
Power Servo
Query/Command
Optical Component

First Steps

Before beginning any troubleshooting, extract the log file at a minimum. Additionally, a fresh Settings Snapshot has proven to be helpful to reference and/or restore the system to what it was before service.

As a general rule, the next step in troubleshooting the Monaco system is to reboot the system and verify that the fault is real and repeatable. Many problems resolve themselves by simply reinitializing the startup settings.

Consistent cooling is extremely important for Monaco performance. It is a requirement that the Monaco be able to communicate with the chiller as the baseplate temperature servo regulates it. Proper flow rate is critical to maintaining temperature. Check the filter and coolant are cleaned and changed regularly. The recommended flow rate is 5.0 lpm. The system should be given sufficient time to come to thermal equilibrium before checking system performance.

The next step is to connect the service engineer's computer to the laser via USB. It is better to first verify system performance using the service engineer's computer (with the current GUI) rather than the customer's to focus troubleshooting on the system and minimizing the variables from operating systems and software compatibility.

Every attempt has been made to ensure this service manual is as complete and accurate as possible, but the Monaco system has undergone much development since its inception. It's not practical to revise the manual every time a change happens. In lieu of constant revisions, many issues are discussed in detail and published in the firmware update FSBs. These are available in Spectrum. It is impossible to provide a solution to every possible scenario and for every model Monaco regardless of when it was built. If unable to identify the problem and restore system operation, then as a last step before depot repair extract the complete log file and upload it to https://dpssdata.com using either the log extraction or Blog post tools in the GUI. Contact Product Support with a full description of the problem and actions taken so far to resolve it.

State Machine

During normal startup the Monaco laser state machine will transition through all the states listed below in Table 2.1-1. It can be helpful during troubleshooting to observe the start up sequence if the laser stalls or delays during startup. The states shown are a streamlined version of the sequence. For a complete understanding, query ?Lname:1, ?Lname:2, etc.

As of this writing there are 24 different states of being.

Table 2.1-1. State Machine Transitions

STATE NAME	DESCRIPTION
BOOT	System enters this state on start-up
STANDBY	Key is off, diodes are off, no faults
FAULT	Turn off all diodes
READY	Key is on, diodes are off, no faults
CONFIGURATION	Configure laser from lookup table
DIODE SEED RAMPUP	Enable seed temp servo and enable seed current and ramp to 110%. Waiting for seed diode current to ramp.
DIODE SEED TEMP	Waiting for seed diode temp servo to lock
DIODE SEED ON	Change seed current setpoint at 100%. The seed oscillator is running.
DIODE 1 RAMPUP	Latch PDS in the FPGA safety circuit and enable D1 temp servo & enable D1 current, then waiting for diode 1 current to ramp
DIODE 1 TEMP	Waiting for diode 1 temp servo to lock
MODELOCK	PD1 above threshold, modelocked
DIODE 1 ON	The first pre-amp is running
REPRATE NOISE	Place holder future SESAM check.

Table 2.1-1. State Machine Transitions (Continued)

STATE NAME	DESCRIPTION
DIODE 2 RAMPUP	Latch PD1 in the safety circuit & enable D2 & enable D2 temp servo then & enable CFBG temp servo wait for diode 2 current to ramp
DIODE 2 TEMP	Waiting for diode 2 temp servo to lock
DIODE 2 IS ON	The second pre-amp is running
WAIT FOR TEMPERATURE	Wait for the baseplate to get close to chiller, wait for CFBG servo to tight lock
DIODE 3 RAMPUP	Latch PD2 in safety circuit, then enable D3 current
DIODE 3 TEMPERATURE	Wait for chiller set point and base plate temperature to be within CHBPDELTA
ON	Run the D3 light loop if it is enabled (note light loop is disabled in other states)
DIODE 3 RAMP DOWN	Ramp down the current for diode 3
DIODE 2 RAMP DOWN	Unlatch PD2 safety circuit in FPGA, then ramp down the current for diode 2.
DIODE 1 RAMP DOWN	Unlatch PD1 safety circuit in FPGA, then ramp down the current for diode 1
DIODE SEED RAMP DOWN	Unlatch PDS safety circuit in FPGA, then ramp down the current for seed diode
SEED OPTIMIZATION	Seed optimization for SESAM

GUI Does Not Connect

Should the GUI not connect, first verify the GUI is using the correct connection method. Service engineers typically use a USB connection so as to not disturb a customer's existing connection (usually Ethernet), but this section applies to any connection method. If the laser is not connected through any method, the best practice is to reboot the laser first and then restart the GUI.

If experiencing difficulty connecting, try using an alternate connection method such as Ethernet or RS-232. TIP: If the IP address is unknown, you may use the Hostname. All Monacos have a host name of monaco_(head serialnumber). Other alternative methods include a plain terminal program such as Hyper Terminal, Tera Term, or the Windows Telnet client, among programs available. A lower level Windows driver called VCOM is also supported for problematic USB connections, but another connection must exist to use it. Enter USB=VCOM to use the VCOM driver.

Note that earlier firmware versions (prior to v1.232a.97) have been known to get stuck in a reset loop which prevents connection. There is an alternative solution by shorting pins 2-3 on JP27 (rev. AF head board) or JP29 (rev. AJ head board). This will enable the watchdog timer to be satisfied, enabling connection to upgrade firmware. Some boards do not have the usual jumper header, instead only solder pads. If that is the case, simply make a temporary connection using a conductor. Do NOT forget to remove the jumper when finished. Failure to do so could leave the system in a condition vulnerable to corruption.

Lost Password

There are two types of password protection for the GUI that can be enabled: the GUI Password and the PASSWORD command. The GUI Password prevents the GUI from being opened without entering the designated password. The PASSWORD command will restrict the GUI to READONLY access and will not allow laser parameters to be changed.

If the customer forgets the password from the PASSWORD command, then enter Service mode and use PASSWORD=new, or PASSWORD=0 to remove the password.

If the customer sets the GUI Password and then forgets what they set it to then currently the only way to recover is to delete the hash of the password from the registry (ASCII password string in flash storage).

Troubleshooting the Log File

Commonly the next step after checking the chiller, external connections, and communication is to look at the performance and history of the laser in the log file. Before any remote service session with the Monaco laser, the laser's log file should be downloaded by the user and sent for review. The review of the fault history in the log file is greatly aided by using the EventLog Reader. See "Software Troubleshooting Tools" on page 3.2-1 for more information.

No Modelocking/ High Seed Rep Rate Noise

Failure to modelock is indicated by the SRRNOISE fault. Other faults including (but not limited to) fast shut downs, PD1V<PD1VL (#90), FPGA Seed Frequency OOB (#5), etc. could indicate poor modelocking performance. Before changing any settings, confirm the issue is really poor modelocking. Bring up a graph of SRRNOISE and look for correlation with any other displayed faults. Typically, simply shifting the SESAM spot is sufficient to restore modelocking. If the system will not modelock, or modelock reliably, it may be necessary to manually scan the seed diode current to first find modelocking. The method for that is presented later in this section.

1. Change the SESAM spot to determine if there is a bad spot, particularly if ?SSPC (number of starts) and ?SPH (number of hours) show substantial use on that spot.
2. If changing the SESAM spot doesn't restore performance, there could be something else causing poor modelocking.
   When evaluating the suspected cause of poor modelocking (high SRRNOISE), a more thorough analysis requires examining the seed diode current over time as well as looking for any other unusual behavior. Large differences in required diode current from spot to spot could point toward misalignment or a problem with the shifter or SESAM. Depot repair would be required in those instances.
   After evaluating other possible causes, it may prove worthwhile to return to the original spot (if hours and starts are fairly low) and run the Modelock Window Tool (PD4 Optimizer, PD4O) located on the Tools tab of the GUI (must be in Service

mode). See Figure 2.1-2 below. The tool will automatically

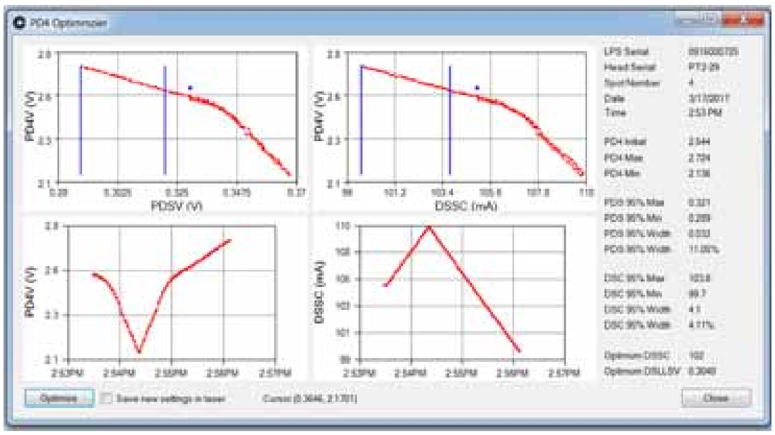


Figure 2.1-2. Modelock Window Tool

scan for the highest pulse peak energy using the PD4 input and recommend an optimum setting for the diode seed light loop set voltage (DSLLSV) and diode seed set current (DSSC). Note that running the PD4 Optimizer using the PD4O serial command, instead of the GUI, will automatically update the settings for DSLLSV and DSSC but without the benefit of the graphs in the GUI tool for a visual representation of the modelock window width and set point. You can query the result by using ?PD4ORESULT DSSC.

Using the Modelock Window tool in the GUI will give the option of running the optimizer without saving the settings if the box is not checked.

NOTE: The Modelock Window tool (also known as the PD4 optimizer) is a manual procedure to change the seeder light loop settings set by the factory. All spots are tested to ensure similar settings and performance during manufacture.

Since changing SESAM spots is a customer maintenance feature, it is only under extraordinary circumstances that the optimizer needs to be used.

The modelock window should be ~10mA. Anything less suggests a damaged/degraded/substandard spot. Note that the system needs to modelock before being able to use the tool.

3. If the system refuses to modelock at all, the following procedure may be helpful. Read this entire procedure before beginning.

As with all service procedures, this method requires that the system be set to 1 MHz, continuous pulsing operation with RF set to 100% and pulse width set to the minimum calibrated position.

In Service mode, set the GUI startup to only start to D1. This will protect the system for unexpected spikes and potential diode damage. Press Start.

As the laser tries to start, it will attempt to modelock 3 times, ramping the diodes down between attempts, before trying again. After the 3rd unsuccessful attempts a fault will be generated. This fault will need to be cleared before resuming.

During these attempts, switch to the Servo tab of the GUI. If the system does not acquire modelock, increase DSLLSV a small amount. A few percent should be sufficient for each attempt. Let it try again. If there is no success, increase DSLLSV a little more. Continue this process until the system modelocks and runs with just D1.

IMPORTANT: The typical seed diode current required is somewhere between ~90 to 140mA. Each system is different but usually toward the lower end of the range. A general guide is that the total increase should not exceed roughly 10-15%.

Once the system modelocks reliably, increase DSLLSV so that the current is increased by a few percent. This will provide a safe setting so the rest of the system can be energized. Change the startup to D2 and press Start. D2 should ramp up and stabilize.

After stabilization, change the startup to D3 and press Start. Turn on pulsing (RRD=1) and open the shutter to allow it to fully warm up. Once the system is warmed up, run the Modelock Window tool to set the optimum DSLLSV and DSSC values. Query them to make sure the new settings are saved.

Low Power

If the laser has lost power, place the laser into Continuous pulse mode (PM=0) at the specified rep rate and check that all operating parameters match the original factory settings by referencing the Setting Snapshots page. If the settings are not the cause, then follow the following steps for **IR Monaco systems**:

1. Restart the laser verifying the transition through all states and the laser has come to thermal equilibrium.

2. If power has not been restored, then verify PD3V matches the original value from the factory by referencing the Setting Snapshots page.

3. If PD3V is low, verify that the cause is not due to losses at PDSV, PD1V, or PD2V. If the reason for low PD3V is a loss earlier in the system, remedy that before increasing amplification. If the voltage at PD2V is the same as when shipped, inspect the trend of D3C over time, looking for a gradual increase. If low power is caused by gradual degradation of D3 or an optical component in the main amplifier, then the rated diode current for the final amplifier light control loop can be adjusted by increasing the parameter D3LLSV up to a maximum total of 110%. Note that it may be necessary to also increase D3LLMAXC and/or D3RC to accommodate this. Verify that output power has been restored.

4. If PD3V is close to the original value, then the problem is past the main amplifier and may lie in the compressor angle. Verify PD4V matches the original value from the factory by referencing the Setting Snapshots page. If it differs significantly then there may be a misalignment in the compressor.

5. At the shortest pulsewidth, adjust the grating using the PWAO command while observing PD4V to determine if the peak power/pulsewidth is optimized. If it is not, then the PWAO command can be used to adjust the angle. This adjustment must be made for each mode of operation that the customer utilizes (e.g. at 1 MHz and 4 MHz).

6. The operating temperature for best performance of the laser has been set during manufacture, but for some operating environments the baseplate temperature of the laser may need to be adjusted for the laser to run at the specified output power. The baseplate temperature control loop can be adjusted by using the BST command, but this is time consuming given the long time for the laser to reach equilibrium after adjustments.

Follow the following steps for **Green or UV Monaco systems** (note that Monaco UV system often require power optimization at installation):

1. Give the laser and power meter sufficient time to warmup. The shutter should be open with full power laser output while waiting for the laser warm-up, because the power meter may also need a warm-up. Wait 40 minutes for full thermal equilibrium to be achieved. Thermal equilibrium can also be

confirmed by checking when STRTD has stabilized. This method is more deterministic of when the air temperature inside the laser has actually stabilized.

2. Confirm the laser is operating at the shortest pulse width. Unlike the Monaco IR, the Monaco Green/UV laser power is very sensitive to pulse width and output power is specified at the factory for only the shortest pulse width. *The shortest pulse width for the system will vary from laser to laser, so the shortest pulse width must be confirmed from the laser data-sheet shipped with the system.*

3. **For UV Monaco lasers only, sacrificial window check:** Over time the window may build up deposition on the outer surface and scatter a fair amount of power. In the case of slow output power degradation, and before attempting to optimize settings to recover power, verify that the power drop is not due to sacrificial window depositions. It is helpful to review the evolution of PD3V and PD4V. If there is not much change, then check for depositions on the window. Rotate window (after removing the three screws as shown below) if needed and verify if recovering power is possible.

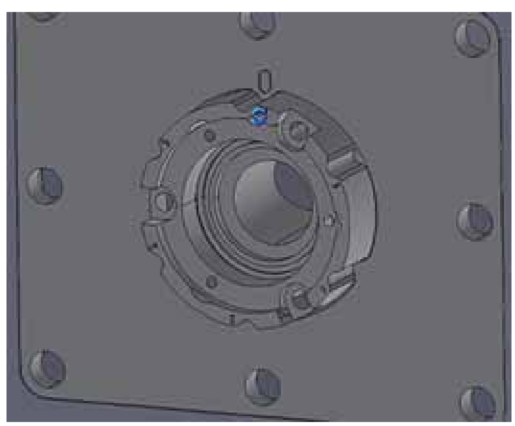


Figure 2.1-3. Sacrificial Window

4. At the shortest specified pulse width for the laser, adjust the grating angle in small increments using the PWAO command, while observing the output power on an external power meter for green or observing the parameter UVP for UV output. Adjust in 0.001 increments in a +/- 0.01 range until the proper angle for best power is found. Note that the optimum angle for output power is often offset from the angle that provides the highest peak power (PV4V). Also note that newer Monaco

systems will be more sensitive to grating changes. The range scanned should be large enough to see power drop by more than 5% on both sides.

5. Confirm that the laser power has been optimized by changing the pulse width to a different value (e.g. 500 fs), and then back to the shortest pulse width. If the power has dropped, then check that the pulse width adjustment was entered with the correct sign (positive or negative).
6. If power has not been restored by adjusting the grating angle, then there can be power gains from adjusting stretcher temperature STRT (again while observing output power using UVP or an external power meter). Adjust in 0.1 degree increments in a +/- 0.5 degree range until the proper temperature for best power is found.
7. Repeat steps 4 and 5 as needed for best optimization of power.
8. In more extreme cases, if power can not be restored by adjusting the grating angle and STRT, then there can be small power gains from adjusting stretcher temperature STRT2 (again while observing output power using UVP or an external power meter). Adjust in 0.1 degree increments in a +/- 0.5 degree range until the proper temperature for best power is found.
9. If output power has not been restored and the power is within 5% of specification, a slight adjustment to D3 light loop (D3LLSV) would be acceptable. If power is not within 5% then there is likely a more serious problem and adjusting the light loop is not advisable. Note that after adjusting the D3 light loop the above power optimization procedure will need to be repeated.

NOTE: If the customer operates in more than one mode of operation (utilizes different rows of the LUT), **then each mode must be adjusted individually for optimum power**. For example, operation at 800 kHz and 4 MHz will require different settings for PWAO and STRT. Global offsets to all the modes (such as by using the command PWAOG) should not be used.

NOTE: Adjusting the seed current settings (see “No Modelocking/ High Seed Rep Rate Noise” on page 2.1-7) should never be used as a method to restore power to the Monaco.

Not Meeting Pulse Width

If the laser is not meeting the pulse width specification, the operating parameters and the current and factory settings (from Settings Snapshot) match then the following steps can be taken:

(Note that this procedure is not normally necessary as the Peak Power Optimizer tool is an automatic method for finding the PWAOG value, see Figure 2.1-8 on page 2.1-19.)

1. Send the grating motor home using MPWH=1, then enter the minimum pulse width specified for the laser (or ?PWMIN to find the minimum pulse width followed by PWS=xxx to set it).
2. At the shortest specified pulse width for the laser (e.g. 350fs), note the setting for the grating angle MPWA from either the Grating Rotation tool, or the query ?MPWA. The grating angle can be adjusted in small increments (0.005 degree steps) using the MPWA command, or more easily using the Grating Rotation tool (see Figure 2.1-4), while observing the autocorrelator and/or PD4V. Once the proper angle for shortest pulse width (highest PD4V) is found, note the difference in angle from the original angle noted (e.g. change of -0.020). Note that the change can be positive or negative to the original value of MPWA. Next, use the query ?PWAOG to find the current angle offset (e.g. 0.05). Finally, enter the new angle offset in milliradians by adding the two values together (-0.020 + 0.05 = 0.03) and using this sum with the PWAOG command (e.g. PWAOG=0.03). Note that this is a global change and will change the preset grating angles for ALL the Monaco pulsewidths. Also note that changing the grating angle using the MPWA command is only a temporary change, and angles will default back to their original preset values unless the angle offset is entered using the PWAOG command.
3. If pulsewidth is still not meeting specification, the stretcher temperature can be adjusted in small increments (~0.5deg) using the STRT command while observing the autocorrelator and/or PD4V. The pulsewidth should be very sensitive to changes in STRT. Continue changing the temperature in the direction that shows improvement until pulsewidth meets specification. Note that changes to the stretcher temperature using STRT will remain until reset.

High Pre-/Post-Pulse

NOTE: This is not a typical field service procedure as these parameters are set during manufacture and are not likely to change. The method is given for reference only.

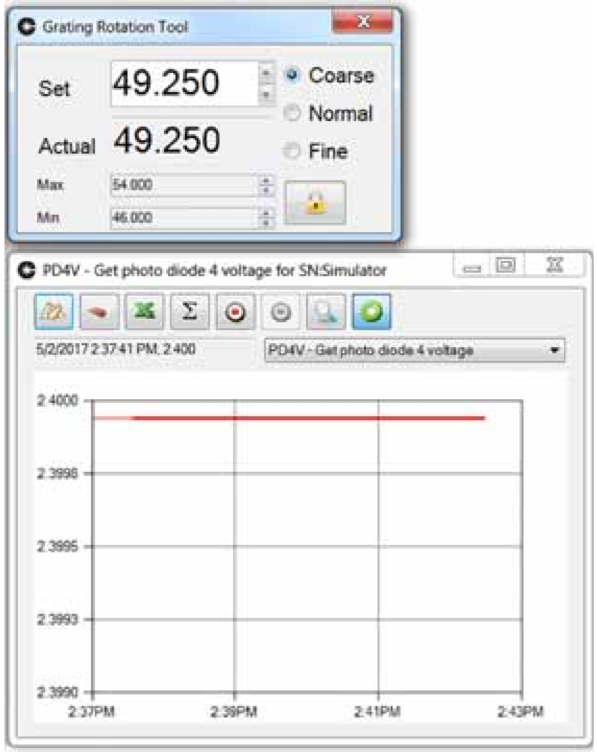


Figure 2.1-4. Grating Rotation Tool

The seeder AOM (AOM1) picks pulses from the 50MHz pulse train from the seeder (60MHz for some older systems) for the fundamental frequency specified (typically 1MHz). The AOM timing must be centered on the pulse. Observing the pulse train on the oscilloscope you can examine the amplitude of the pre- and post- pulses for an indication of how well the timing is aligned. If the pulse train exhibits strong pre- and/or post-pulses at the 50 MHz repetition rate of the seeder (see below) the seeder AOM (AOM1) can be adjusted to minimize them. See Figure 2.1-5 below for an example of a strong post pulse.

Before adjusting the AOM1 parameters, reduce the D3 current to approximately 3A. This will minimize the chance for any damage to occur.

The two parameters that can be adjusted are the AOM1 delay time (A1DT) and window (A1DW). These parameters can be adjusted to minimize the pre- and post-pulse levels, but be aware there will always be some leakage (<1.5% of peak pulse) and adjusting these

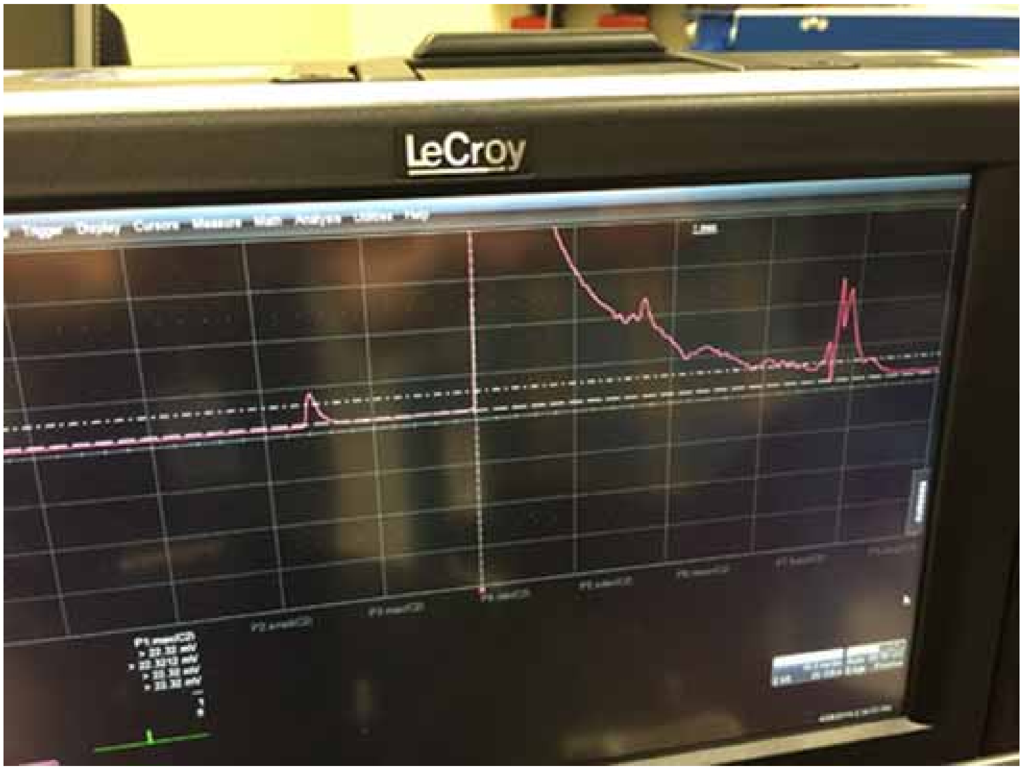


Figure 2.1-5. Pre- and Post-Pulses

parameters can affect the output power of the laser. When adjusting these parameters the chart for the peak energy, PD4V, as well as the output power should be observed to best optimize performance.

Water Cooling

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.

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.

The recommended chiller water flow rate is 5.5 L/min and best matches performance tested in the factory. The chiller temperature is controlled through the laser firmware and should not be adjusted.

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

The chiller coolant and filter must be changed every six months. A warning message will be given when the service period is reached. After the coolant and filter have been changed, the serial command CHSERVICED=1 must be entered to remove the warning.

Routinely check the chiller flow rate remains constant and the chiller filter does not become clogged over time. 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 1 full day
- Flush chiller with clean distilled water
- Re-fill reservoir with coolant

Chillers require regular circulation, and coolant should not be left sitting in the reservoir for more than a few days. Drain and flush out the coolant before leaving a chiller to sit for any extended period.

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

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 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 tempera-

ture 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.

Service Mode GUI Tools

From the GUI Tools Tab in Service Mode are several programs for optimizing the output and changing settings of the Monaco (see Figure 2.1-6 next page).

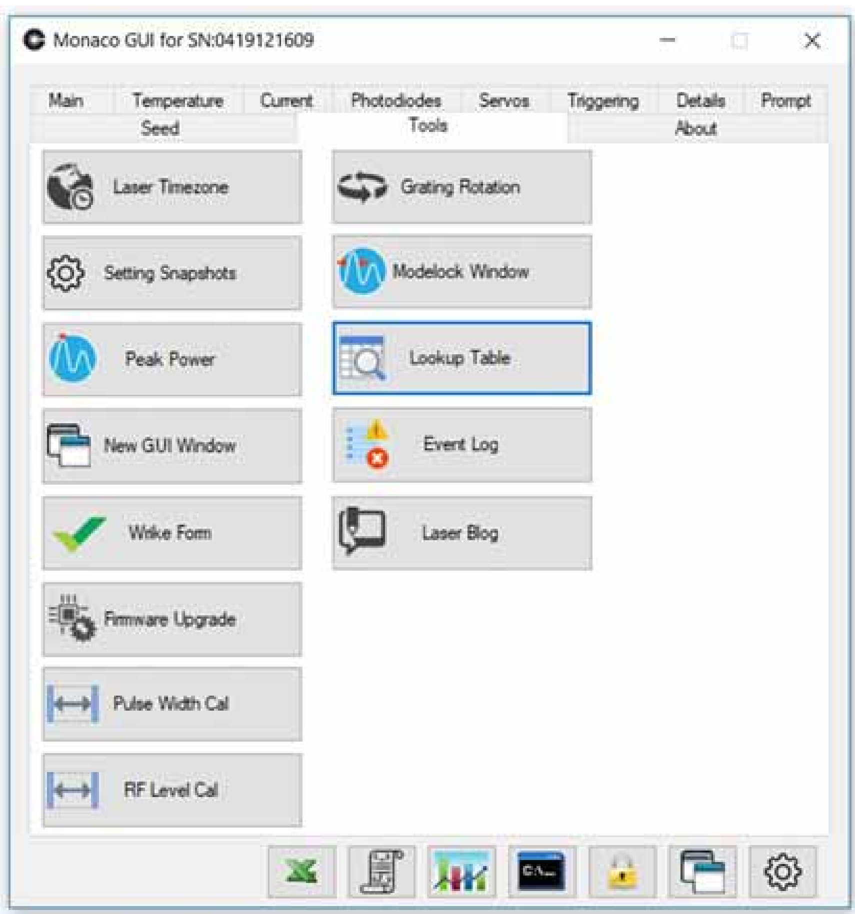


Figure 2.1-6. GUI Tools Tab

The Settings Snapshots allows the FSE to Export, Import, or Restore settings for the laser. Saving this file is recommended at the start of any session where the laser settings may be adjusted, such as before upgrading the firmware of the laser (see Figure 2.1-7 on page 2.1-18). Note that ALL the settings are only visible in Service

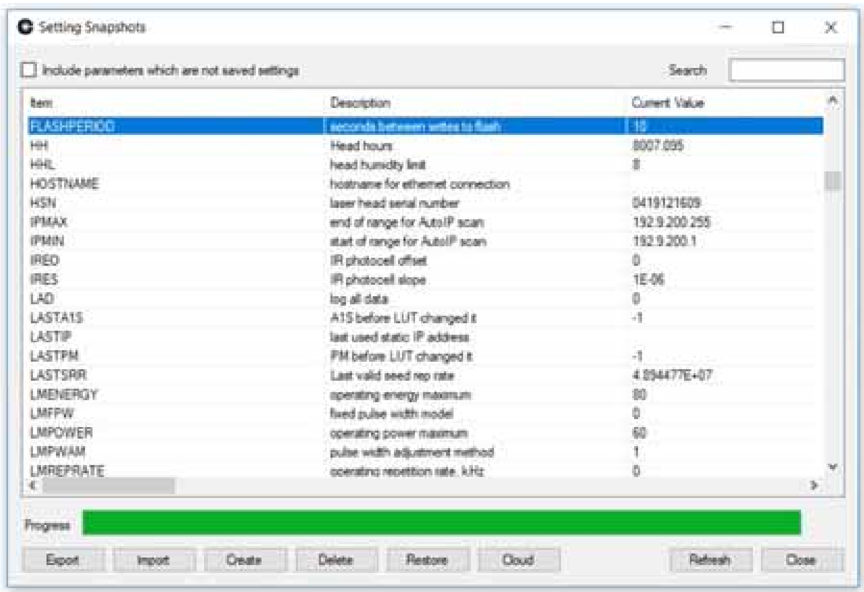


Figure 2.1-7. Settings Snapshots Window

Mode. While it is recommended to save the Settings Snapshot as a binary file, to see the settings you would need to save it as an Excel file.

The Peak Power optimizer will scan either the Grating Offset (PWAOG) or the Stretcher Temperature (STRT) for a maximum for PD4V - the photodetector measuring peak power (see Figure 2.1-8 on page 2.1-19).

The GUI calibrates the Pulse Width and the RF Level outputs displayed according to measurements at the factory, but the customer may wish to have these outputs calibrated to their own autocorrelator or power meter. The Pulse Width Calibration and RF Level Calibration tools allow these to be calibrated or to import a saved calibration table (see Figure 2.1-9 on page 2.1-20). Pulse Width Calibration is described in detail in “Pulse Width Calibration” on page 4.2-1. Note that the RF Calibration Tool was included in

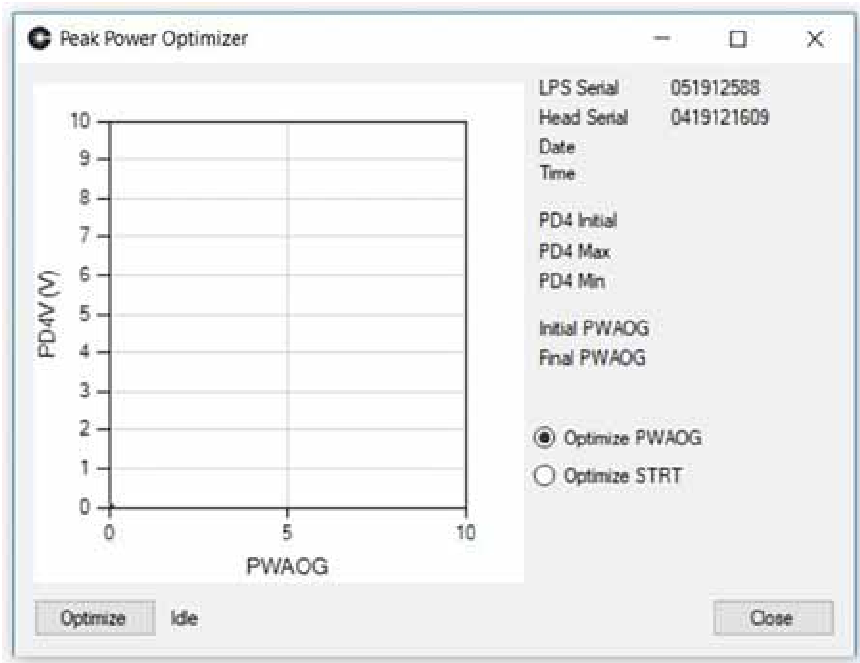


Figure 2.1-8. Peak Power Optimizer

Firmware Release 38 (August 2019), so customers upgrading from earlier firmware would need to have the table populated by the FSE to have a linear RF Level displayed on the GUI.

The Grating Rotation Tool was previously discussed in “Not Meeting Pulse Width” on page 2.1-13.

The Eventlog tool is a legacy tool originally included with the GUI and has been superseded by the Event Log Reader (see “Eventlog Reader” on page 3.2-1 in the Software section).

The Modelock Window tool was previously discussed in “No Modelocking/ High Seed Rep Rate Noise” on page 2.1-7.

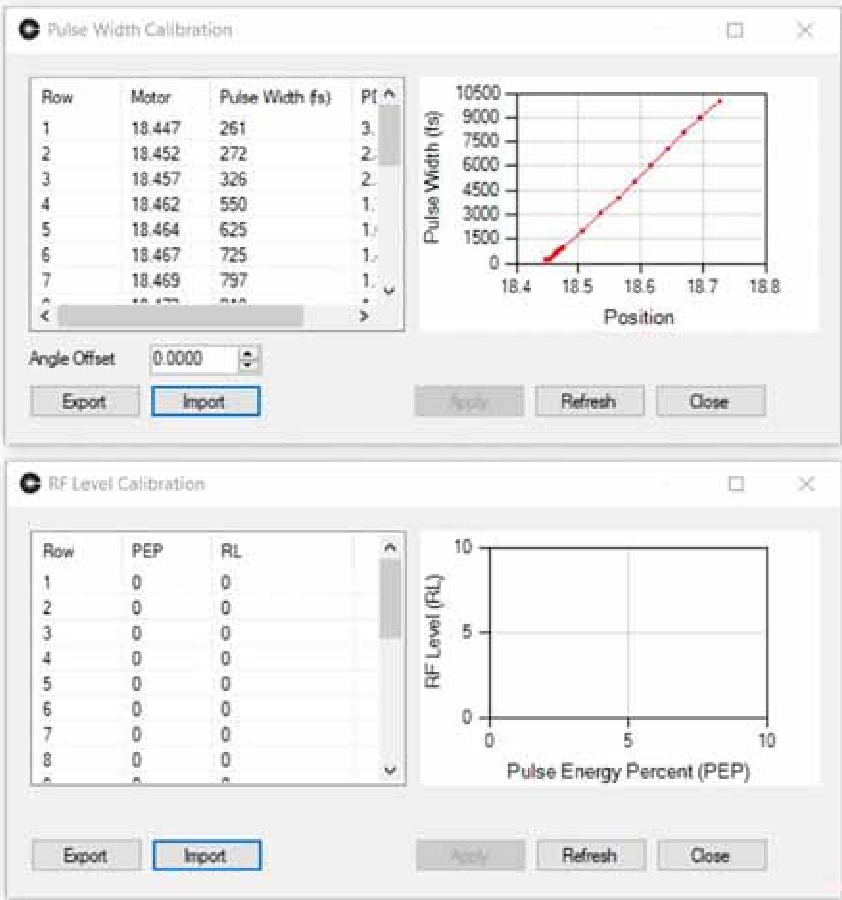


Figure 2.1-9. Calibration Tools

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 2.2-1 for a list of system faults. When a Monaco fault condition occurs, the emission indicators will turn off and the shutter, if equipped, will close. Note that for a **Critical Fault** condition diodes will immediately shut down, while during a normal fault condition diodes will ramp down with control to prevent damage. In both fault conditions the temperature servos stay on.

Some faults are dynamic faults. Descriptive text is added to show what led to the fault. In these cases it's important to understand the entire fault message. For example, Fault #7 Timeout may have various reasons:
"Waiting for Seed Diode Temperature state (Seed temperature)"
"Seed Diode On state (PD1V > PD1LVL)"
"Waiting for Baseplate Temperature state (CHST_Baseplate temperature delta)"

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 serial 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.

Whenever possible, ask the user for a copy of the log file to assist in troubleshooting.
A simple way to list the Fault history of the laser from the GUI menu is to use the Data query. e.g. ?DATA F DAYS=10
?FNAME:xx is useful to decode the fault number.
Deeper analysis is facilitated by using the Event Log viewer.

Table 2.2-1. Monaco System Faults/Warnings

FAULT#	DESCRIPTION
1	"#1 – Emission Lamp Interlock Fault"
2	"#2 - External Interlock Fault"
3	"#3 - Light Loop Fault"
5	"#5 - FPGA Fault"
6	"#6 - Diode Interlock Fault"
7	"#7 - Timeout Fault"
8	"#8 - Rep Rate Noise Fault"
9	"#9 - The HSN on EEPROM is not recognized by this laser"
10	"# 10- SHG Temperature Fault"
12	"#12 - DS Temperature Fault"
13	"#13 - D1 Temperature Fault"
14	"#14 - D2 Temperature Fault"
15	"#15 - Stretcher Temperature Fault"
16	"#16 - Baseplate Temperature Fault"
17	"#17 - Baseplate 2 Temperature Fault"
18	"#18 - Seed Servo Stuck Fault"
19	"#19 - Seed Servo Drive Too Low Fault"
20	"#20 - Seed Maximum Temp Differential Fault"
21	"#21 - Diode 1 Stuck Fault"
22	"#22 - Diode 1 Servo Drive Too Low Fault"
23	"#23 - Diode 1 Maximum Temp Differential Fault"
24	"#24 - Diode 2 Stuck Fault"
25	"#25 - Diode 2 Servo Drive Too Low Fault"
26	"#26 - Diode 2 Maximum Temp Differential Fault"

Table 2.2-1. Monaco System Faults/Warnings (Continued)

FAULT#	DESCRIPTION
27	"#27 - Stretcher Servo Stuck Fault"
28	"#28 - Stretcher Servo Drive Too Low Fault"
29	"#29 - Stretcher Maximum Temp Differential Fault"
30	"#30 - Diode Seed Over Current Fault"
31	"#31 - Shutter State Mismatch Fault"
32	"#32 - Diode 1 Over Current Fault"
33	"#33 - Diode 2 Over Current Fault"
34	"#34 - Diode 3 Over Current Fault"
35	"#35 - Diode Seed Under Current Fault"
36	"#36 - Diode 1 Under Current Fault"
37	"#37 - Diode 2 Under Current Fault"
38	"#38 - Diode 3 Under Current Fault"
40	"#40 - Diode 3 Under Voltage Fault"
41	"#41 - Diode 3 Over Voltage Fault"
50	"#50 - Chiller Water Level Fault"
51	"#51 - Chiller Temperature Fault"
52	"#52 - Chiller Comm Fault"
53	"#53 - Chiller Flow Fault"
54	"#54 - Chiller Delta Fault"
55	"#55 - Stretcher 2 Temperature Fault"
56	"#56 - Stretcher 2 Servo Stuck Fault"
57	"#57 - Stretcher 2 Servo Drive Too Low Fault"
58	"#58 - Stretcher 2 Maximum Temp Differential Fault"
62	"#62 - Spot Hour Elapsed Fault"

Table 2.2-1. Monaco System Faults/Warnings (Continued)

FAULT#	DESCRIPTION
64	"#64 - Motor Controller A1 Fault"
68	"#68 - SESAM Motor Stuck At Home Fault"
69	"#69 - SESAM Motor Not Find Home Fault"
70	"#70 - Rotational Motor Communication Fault"
71	"#71 - Rotational Motor Angle Fault"
72	"#72 - Pulse Width Motor Fault"
80	"#80 - Thread Exception Fault"
90	"#90 - Fast Shutdown - Photodiode 1 Voltage Fault"
91	"#91 - Fast Shutdown - Photodiode 2 Voltage Fault"
94	"#94 - Photodiode 1 Voltage Out of Range Fault"
95	"#95 - Photodiode 2 Voltage Out of Range Fault"
96	"#96 - Photodiode 3 Voltage Low Fault"
97	"#97 - Photodiode 5 Back Reflect High Fault"
98	"# 98 - Configuration Fault"
99	"#99 - Seed Optimization Fault"
100	"#100 - SHG Servo Stuck Fault"
101	"#101 SHG Servo Drive Too Low Fault"
102	"#102 - SHG Maximum Temp Differential Fault"
106	"#106 - Hardware Watchdog Reset Occurred Fault"
300	"#300 - Software Thread Stalled Fault"
301	"#301 - Communication To Control Computer Lost Fault"
302	"#302 - Unable To Read From FPGA Fault"
303	"#303 - Wrong FPGA Firmware Installed Fault"
304	"#304 - Power On Self-Test (POST) Failed Fault"

Table 2.2-1. Monaco System Faults/Warnings (Continued)

FAULT#	DESCRIPTION
305	"#305 - Unable To Write To FPGA Fault"
306	"#306 - DC GOOD Signal Is Bad Fault"
307	"#307 - GUI Is Out of Date Fault"
308	"#308 - Unapproved Chiller Fault"
309	"#309 - I2C Failure Fault"
310	"#310 - Illegal Storage Value Fault"
500	"#500 - Relative Humidity Warning"
502	"#502 - Spot Hour Elapsed Warning"
504	"#504 - State Machine Had A Timeout Warning"
505	"#505 - Chiller Water Level Warning"
506	"#506 - Chiller Flow Warning"
507	"#507 - Diode 3 Light Loop Limit Warning"
508	"#508 - Rotational Motor Angle Warning"
509	"#509 - Rotation Motor Angle Tolerance Warning"
510	"#510 - Seed Drive Is Low Warning"
511	"#511 - Diode 1 Drive Is Low Warning"
512	"#512 - Diode 2 Drive is Low Warning"
513	"#513 - Stretcher Drive Is Low Warning"
514	"#514 - SHG Drive Is Low Warning"
515	"#515 - Chiller-Baseplate Delta Warning"
516	"#516 - Chiller Delta Warning"
517	"#517 - Seed Diode Light Loop Limit Warning"
518	"#518 - Rep Rate Noise Warning"
519	"#519 - Rotational Motor Version Warning"

Table 2.2-1. Monaco System Faults/Warnings (Continued)

FAULT#	DESCRIPTION
520	"#520 - Photodiode 1 Saturated Warning"
521	"#521 - Photodiode 2 Saturated Warning"
522	"#522- Stretcher 2 Drive Is Low Warning"
523	"#523 - Diode 4 light loop limit"
524	"#524 - Diode 3 Calibration Values Exceed Normal Variations Warning"
800	"#800 - Bootloader Is Below Revision v1.3 Warning"
801	"#801 - Operating System Image Is Below Revision v1.3 Warning"
802	"#802 - Operating System Is Not 7.0 Warning"
803	"#803 - Software Thread Is Too Slow Warning"
804	"#804 - CPU Temperature Is Too High Warning"
805	"#805 - Battery Is Low Warning"
806	"#806 - Module Temperature Is Too High Warning"
807	"#807 - Baseplate Temperature Is Too Low Warning"
808	"#808 - Configurable Test Warning"
809	"#809 - Spot Movement Failed Warning"
810	"#810 - Laser On Last Good Spot Warning"
811	"#811 - Non Standard Shutdown Warning"
812	"#812 - Diode Calibration Failed Warning"

Table 2.2-2. Monaco Headboard Fuse List

	DESCRIPTION
F1	**Extended Interface, protects pin 2, 24V, 4A 125V**
F2	**EXT INTLK_RTN, 60V 300mA J1-4**

Table 2.2-2. Monaco Headboard Fuse List

	DESCRIPTION
F3	EXT_INTLK_TOP, 60V 300mA J710-1
F4	Chiller Connector J713-9, CHILL_REM_ST+, +24V 300mA

Faults

NOTICE

For every fault that is based on a circuit that is not functioning, the general rule is to reboot the system and then re-seat the connnectors to the device. After that, see the specific suggestions for each fault.

#1 – Emission Lamp Interlock Fault

Definition: Interlock appears to be open starting at the Emission Lamp.

Action: Check points J726-1 and J726-3 for 5VDC: if no 5VDC at J726-1 and J726-3, change the board.
If 5VDC is present, check the LED drive (TP182) is low active: when LEON = 0, TP182 =5V when off, and when LEON=1, TP182 = 0V when on.
If no LED drive, change the board.

#2 - External Interlock Fault

Definition: Interlock appears to be open starting at the external interlock.

Action: Check that the External Interlock Defeat Plug is installed. Check customer’s interlock wiring, if used. Unplug customer interface and insert Interface Defeat Plug. If neither resolves the issue, the headboard may be at fault.

#3 - Light Loop Fault

Definition: Power servo (D3) regulator has lost lock.

Action: The required diode voltage (D3LLSV) exceeds the available diode voltage (PD3V). Look for a drop in gain somewhere: PDS, PD1V, PD2V, PD3V.

#5 - FPGA Fault

Definition: Dynamic fault. There are 11 different reasons for this fault to appear. The most common is “Seed Frequency OOB” (out of bounds). This indicates a lack of modelocking. Other messages describe other components not conforming to expected parameters or out of bounds. The steps below are for Seed Frequency OOB. Upload the log file and contact Product Support for other messages.

Action:
1. Change the SESAM spot.
2. If changing the SESAM spot doesn’t restore performance, use the Modelock Window tool located on the Tools tab of the GUI (see “No Modelocking/ High Seed Rep Rate Noise” on page 2.1-7 for a full description of these actions).
3. The modelock window should be ~10mA wide. A narrower window or a large deviation from factory setting in required seed current may indicate a damaged spot or misalignment. Typical seed current should range from ~90-140 mA.

If these steps do not resolve the problem, the system likely must be returned for depot repair.
NOTE: With firmware release 36 and 37 (v1.254.107 and v1.278.112), SRRNOISE detection was improved to make it more tolerant of false faults. See FSB 920 and 931.

#6 - Diode Interlock Fault

Definition: D3 enable signal is not active.

Action: If customer is using the External Interface, install the defeat plug. Check interlocks and Fast Shutdown (see schematic) - pins J1-11 and J1-12 need to be high active (connected to J1-21 5VDC in the external interface plug).
J730-1 should be low (0VDC)
J730-8 should be high (5VDC)
If one of these signals is missing, change the headboard.
If both signals are present, return for depot repair.

#7 - Timeout Fault

Definition: State machine to turn on the laser has not progressed in allotted time, most often because temperature is too slow to adjust or photocell level is not reached.

Action: Query system for state at timeout event (?L and ?Lname:xx). Although not the only reason, Diode 3 waiting for temperature is most common. Most commonly this is caused by some temperature not reaching its set point, and the cause must be determined. Some temperatures must be within 0.1 in order to be tightlocked (?TSTLS). Others must be within 0.5 ºC (Diodes, CFBG, STRT). Firmware versions before Monaco v1.192.86 have a more stringent requirement to move on to the next state (ON). This requirement was eased in this release.

#8 - Rep Rate Noise Fault

Definition: Seed rep rate noise (?SRRNOISE) has exceeded 100.

Action: Change the SESAM spot to determine if there is a bad spot, particularly if the ?SSPC query shows the spot has close to 600 (or more) restarts. If changing the SESAM spot doesn't restore performance, then go back to the original spot and run the Modelock Window tool from the Tools Menu of the GUI. The modelock window should be ~10mA wide. A narrower window or a large deviation from factory setting for required seed current may indicate a damaged spot or misalignment. Typical seed current should range from ~90-140mA (see "No Modelocking/ High Seed Rep Rate Noise" on page 2.1-7 and for a full description of these actions).

10- SHG Temperature Fault

Definition: Second harmonic temperature is outside specified range (SHGT < SHGTMIN, or SHGT > SHGTMAX).

Action: Check that J750-1 has 48VDC. If no voltage, check J732 (+) and J733 (-) for 48VDC input to headboard. If no voltage, change power supply.
Check if thermistor is open or shorted: unplug J729-9 and J729-10, should measure 10 Kohms at 25 º C.
Check TEC output on the headboard: check TP152 and TP151. If no voltage, change headboard.
If there is voltage check J729-8 and J729. If there is voltage, TEC or cable is bad.
There could be an optical reason for this. If the SHG maintains

temperature with diodes off and then overheats when diodes are turned on, cause is likely absorption, misalignment, or errant reflection. This would require depot repair.

#12 - DS Temperature Fault

Definition: Seed diode temperature is outside specified range (DST < DSTMIN, or DST > DSTMAX).

Action: Determine if the problem is optical or electrical. If the servo regulates temperature with diodes off but not when diodes are on, the diode is likely producing excessive heat. There may also be decreased optical output (power) combined with excessive heat production.
1. If POST shows 202 failure, check thermistor: unplug JS04-5 and JS04-12, should measure 10 KOhms at 25 º C. If fails, return for depot repair.
2. If thermistor checks OK and POST shows 202 failure, replace the headboard.
3. If above passes, exercise servo via commands and check TEC: TP185 and TP186. If no change to voltage, replace the headboard.
4. If voltage checks OK, check JS04-3 and JS04-4. If there is no voltage, change the headboard.
5. If TEC voltage (TP185 and TP186) checks OK, check JX04-3 and JX04-4 on the seed diode board. If no voltage, then change the cable.
6. If there is voltage at JX04-3 and JX04-4 and thermistor checks OK, the TEC is bad and return for depot repair.

#13 - D1 Temperature Fault

Definition: Diode 1 temperature is outside specified limits (D1T < D1TMIN or D1T > D1TMAX).

Action: Determine if the problem is optical or electrical. If the servo regulates temperature with diodes off but not when diodes are on, the diode is likely producing excessive heat. There may also be decreased optical output (power) combined with excessive heat production.
1. If POST shows 203 failure, check thermistor: unplug J104-5 and J104-12, it should measure 10 KOhms. If it fails, return for depot repair.
2. If thermistor checks OK and POST shows 203 failure, replace the headboard.
3. If above passes, exercise servo and check TEC: TP189 and TP190. If no voltage, change the headboard.

4. If voltage checks OK, check J104-3 and J104-4. If there is no voltage, change the headboard.
5. If voltage checks OK, check JX04-3 and JX04-4 on diode 1 board. If no voltage, then change the cable.
6. If there is voltage at JX04-3 and JX04-4 and thermistor checks OK, the TEC is bad and return for depot repair.

#14 - D2 Temperature Fault

Definition: Diode 2 temperature is outside specified range (D2T < D2TMIN, or D2T > D2TMAX).

Action: Determine if the problem is optical or electrical. If the servo regulates temperature with diodes off but not when diodes are on, the diode is likely producing excessive heat. There may also be decreased optical output (power) combined with excessive heat production.
1. If POST shows 204 failure, check thermistor: unplug J204-5 and J204-12. It should measure 10Kohms at 25 º C. If fails, return for depot repair.
2. If thermistor checks OK and POST shows 204 failure, replace the headboard.
3. If above passes, exercise servo and check TEC: TP46 and TP48. If no voltage, change the headboard.
4. If voltage checks OK, check J204-3 and J204-4. If there is no voltage, change the headboard.
5. If voltage checks OK, check JX04-3 and JX04-4 on diode 2 board. If no voltage, then change the cable.
6. If there is voltage at JX04-3 and JX04-4 on the diode 2 board and thermistor checks OK, the TEC is bad and return for depot repair.

#15 - Stretcher Temperature Fault

Definition: Stretcher temperature is outside specified range (STRT < STRTMIN, or STRT > STRTMAX).

Action: Determine if the problem is optical or electrical. If the servo regulates temperature with diodes off but not when diodes are on, an optical issue is likely producing excessive heat. There may also be decreased optical output (power) combined with excessive heat production.
1. If POST shows 205 failure, check thermistor: unplug J704-3 and J704-4, should read 10 Kohms at 25 º C. If it fails, then return for depot repair.
2. If POST shows 205 failure, but thermistor checks OK, then replace the headboard.

3. If POST 205 passes, exercise servo and check TEC: TP104 and TP114. If no voltage, then change headboard.
4. If above voltage checks OK, then check J704-1 and J704-2. If no voltage, then change headboard.
5. If both the voltage at J704-1 and J704-2 and the thermistor check OK, then TEC or cable is bad - return for depot repair.

#16 - Baseplate Temperature Fault

Definition: Baseplate temperature is outside specified range (BT < BTMIN, or BT > BTMAX, typically 10 - 33 º C).

Action: Is Baseplate 2 also faulted (Fault 17)? If so, that indicates a chiller problem. If not, that indicates to a thermistor issue.
1. Check chiller for proper cooling, including flow rate and coolant fill. Ensure filter is clean and coolant is changed regularly. If any indication of biological growth is present, system must be flushed using a 3-5% solution of hydrogen peroxide at least overnight, preferably for 12 hours.
2. If POST shows 200 failure, check baseplate thermistor: unplug J734-5 and J734-6, should read 10 Kohms at 25 º C. If it fails, then return for depot repair.
A shorted or open thermistor will result in extremely high or extremely low reported temperatures.
3. If thermistor checks OK, check for missing bias voltage, TP56. If it is missing, change the headboard.

#17 - Baseplate 2 Temperature Fault

Definition: If BT deviates from BST by 2 degrees a fault is generated..

Action: Is Baseplate 1 also faulted (Fault 16)? If so, that may indicate a chiller or coolant problem. If not, it may indicate a thermistor issue. Typically a thermistor fails either fully open or fully shorted. Extremely high or low indicated temperatures tend to indicate a thermistor failure. More likely, a small cooling tube that cools the main pump to the PCF has become clogged or restricted. This passageway can become restricted and the main flow or baseplate temperature is not changed. See step 1 to resolve.
1. Check chiller for proper cooling, including flow rate and coolant fill. Ensure filter is clean and coolant is changed regularly. If any indication of biological growth is present, system must be flushed using a 3-5% solution of hydrogen peroxide at least overnight, preferably for 12 hours.

2. If POST shows 201 failure, check baseplate 2 thermistor: unplug J735-1 and J734-2, should read 10 Kohms at 25 º C. If it fails, then return for depot repair.
A shorted or open thermistor will result in extremely high or extremely low reported temperatures.
3. If thermistor checks OK, check for missing bias voltage, TP42. If missing, change the headboard.

#18 - Seed Servo Stuck Fault

Definition: The drive is at either minimum (-65,535) or maximum (+65,535) for greater than 5 seconds and the temperature has moved less than 0.02 º C.

Action: 1. If POST shows 202 failure, check thermistor: unplug JS04-5 and JS04-12, should measure 10 KOhms at 25 º C. If fails, return for depot repair.
2. If thermistor checks OK and POST shows 202 failure, replace the headboard.
3. If above passes, exercise servo via serial commands and check TEC: TP185 and TP186. If no change to voltage, replace the headboard.
4. If voltage checks OK, check JS04-3 and JS04-4. If there is no voltage, change the headboard.
5. If TEC voltage checks OK, check JX04-3 and JX04-4 on the seed diode board. If no voltage, then change the cable.
6. If there is voltage at JX04-3 and JX04-4 and thermistor checks OK, the TEC is bad and return for depot repair.

#19 - Seed Servo Drive Too Low Fault

Definition: Seed drive is below the DSTDF setpoint.

Action: 1. If POST shows 202 failure, check thermistor: unplug JS04-5 and JS04-12, should measure 10 KOhms at 25 º C. If fails, return for depot repair.
2. If thermistor checks OK and POST shows 202 failure, replace the headboard.
3. If above passes, exercise servo via commands and check TEC: TP185 and TP186. If no change to voltage, replace the headboard.
4. If voltage checks OK, check JS04-3 and JS04-4. If there is no voltage, change the headboard.
5. If TEC voltage checks OK, check JX04-3 and JX04-4 on the seed diode board. If no voltage, then change the cable.
6. If there is voltage at JX04-3 and JX04-4 and thermistor checks OK, the TEC is bad and return for depot repair.

7. If servo operates normally with diodes off, the TEC may be inefficient or the diode is giving too much heat. In this case, the system will likely need to be returned for depot repair.

#20 - Seed Maximum Temp Differential Fault

Definition: The difference between the actual temperature and the set temperature exceeded the amount set by DSTMTD.

Action: 1. If POST shows 202 failure, check thermistor: unplug JS04-5 and JS04-12, should measure 10 KOhms at 25 º C. If fails, return for depot repair.
2. If thermistor checks OK and POST shows 202 failure, replace the headboard.
3. If above passes, confirm proper servo operation by exercising servo via commands and check TEC: TP185 and TP186. If no change to voltage, replace the headboard.
4. If voltage checks OK, check JS04-3 and JS04-4. If there is no voltage, change the headboard.
5. If TEC voltage checks OK, check JX04-3 and JX04-4 on the seed diode board. If no voltage, then change the cable.
6. If there is voltage at JX04-3 and JX04-4 and thermistor checks OK, the TEC is bad and return for depot repair.
7. If the servo operates normally with diodes off, the TEC may be inefficient or the diode is giving too much heat. In this case, the system will likely need to be returned for depot repair.

#21 - Diode 1 Stuck Fault

Definition: The drive is at either minimum (-65,535) or maximum (+65,535) for greater than 5 seconds and the temperature has moved less than 0.02 º C.

Action: 1. If POST shows 203 failure, check thermistor: unplug J104-5 and J104-12, it should measure 10 KOhms. If it fails, return for depot repair.
2. If thermistor checks OK and POST shows 203 failure, replace the headboard.
3. If above passes, exercise servo and check TEC: TP189 and TP190. If no voltage, change the headboard.
4. If voltage checks OK, check J104-3 and J104-4. If there is no voltage, change the headboard.
5. If voltage checks OK, check JX04-3 and JX04-4 on diode 1 board. If no voltage, then change the cable.
6. If there is voltage at JX04-3 and JX04-4 and thermistor checks OK, the TEC is bad and return for depot repair.

#22 - Diode 1 Servo Drive Too Low Fault

Definition: D1 drive below D1TDF setpoint.

Action: 1. If POST shows 203 failure, check thermistor: unplug J104-5 and J104-12, it should measure 10 KOhms. If it fails, return for depot repair.
2. If thermistor checks OK and POST shows 203 failure, replace the headboard.
3. If above passes, exercise servo and check TEC: TP189 and TP190. If no voltage, change the headboard.
4. If voltage checks OK, check J104-3 and J104-4. If there is no voltage, change the headboard.
5. If voltage checks OK, check JX04-3 and JX04-4 on diode 1 board. If no voltage, then change the cable.
6. If there is voltage at JX04-3 and JX04-4 and thermistor checks OK, the TEC is bad and return for depot repair.
7. If the servo operates normally with diodes off, the TEC may be inefficient or the diode is giving too much heat. In this case, the system will likely need to be returned for depot repair.

#23 - Diode 1 Maximum Temp Differential Fault

Definition: The difference between the actual temperature and the set temperature exceeded the amount set by D1TMTD.

Action: 1. If POST shows 203 failure, check thermistor: unplug J104-5 and J104-12, it should measure 10 KOhms. If it fails, return for depot repair.
2. If thermistor checks OK and POST shows 203 failure, replace the headboard.
3. If above passes, exercise servo and check TEC: TP189 and TP190. If no voltage, change the headboard.
4. If voltage checks OK, check J104-3 and J104-4. If there is no voltage, change the headboard.
5. If voltage checks OK, check JX04-3 and JX04-4 on diode 1 board. If no voltage, then change the cable.
6. If there is voltage at JX04-3 and JX04-4 and thermistor checks OK, the TEC is bad and return for depot repair.
7. If the servo operates normally with diodes off, the TEC may be inefficient or the diode is giving too much heat. In this case, the system will likely need to be returned for depot repair.

#24 - Diode 2 Stuck Fault

Definition: The drive is at either minimum (-65,535) or maximum (+65,535) for greater than 5 seconds and the temperature has moved less than 0.02 º C.

Action: 1. If POST shows 204 failure, check thermistor: unplug J204-5 and J204-12. It should measure 10Kohms at 25 º C. If fails, return for depot repair.
2. If thermistor checks OK and POST shows 204 failure, replace the headboard.
3. If above passes, exercise servo and check TEC: TP46 and TP48. If no voltage, change the headboard.
4. If voltage checks OK, check J204-3 and J204-4. If there is no voltage, change the headboard.
5. If there is voltage at JX04-3 and JX04-4 on the diode 2 board and thermistor checks OK, the TEC is bad and return for depot repair.
6. If no voltage at JX04-3 and JX04-4, then change the cable.

#25 - Diode 2 Servo Drive Too Low Fault

Definition: D2 drive below D1TDF setpoint
(D2TD < D2TDF).

Action: 1. If POST shows 204 failure, check thermistor: unplug J204-5 and J204-12. It should measure 10Kohms at 25 º C. If fails, return for depot repair.
2. If thermistor checks OK and POST shows 204 failure, replace the headboard.
3. If above passes, exercise servo and check TEC: TP46 and TP48. If no voltage, change the headboard.
4. If voltage checks OK, check J204-3 and J204-4. If there is no voltage, change the headboard.
5. If there is voltage at JX04-3 and JX04-4 on the diode 2 board and thermistor checks OK, the TEC is bad and return for depot repair.
6. If no voltage at JX04-3 and JX04-4, then change the cable.
7. If the servo operates normally with diodes off, the TEC may be inefficient or the diode is giving too much heat. In this case, the system will likely need to be returned for depot repair.

#26 - Diode 2 Maximum Temp Differential Fault

Definition: The difference between the actual temperature and the set temperature exceeded the amount set by D2TMTD.

Action: 1. If POST shows 204 failure, check thermistor: unplug J204-5 and J204-12. It should measure 10Kohms at 25 º C. If fails, return for depot repair.
2. If thermistor checks OK and POST shows 204 failure, replace the headboard.
3. If above passes, exercise servo and check TEC: TP46 and

TP48. If no voltage, change the headboard.
4. If voltage checks OK, check J204-3 and J204-4. If there is no voltage, change the headboard.
5. If there is voltage at JX04-3 and JX04-4 on the diode 2 board and thermistor checks OK, the TEC is bad and return for depot repair.
6. If no voltage at JX04-3 and JX04-4, then change the cable.
7. If the servo operates normally with diodes off, the TEC may be inefficient or the diode is giving too much heat. In this case, the system will likely need to be returned for depot repair.

#27 - Stretcher Servo Stuck Fault

Definition: The drive is at either minimum (-65,535) or maximum (+65,535) for greater than 5 seconds and the temperature has moved less than 0.02 º C.

Action:
1. If POST shows 205 failure, check thermistor: unplug J704-3 and J704-4, should read 10 Kohms at 25 º C. If it fails, then return for depot repair.
2. If POST shows 205 failure, but thermistor checks OK, then replace the headboard.
3. If POST 205 passes, exercise servo and check TEC TP104 and TP114. If no voltage, then change headboard.
4. If voltage checks OK, check J704-3 and J704-4. If there is no voltage, change the headboard.
5. If above voltage checks OK, then check J704-1 and J704-2. If no voltage, then change headboard.
6. If both the voltage at J704-1 and J704-2 and the thermistor check OK, then TEC or cable is bad - return for depot repair.

#28 - Stretcher Servo Drive Too Low Fault

Definition: Stretcher drive is below the STRTDF setpoint (STRTD < STRTDF).

Action:
1. If POST shows 205 failure, check thermistor: unplug J704-3 and J704-4, should read 10 Kohms at 25 º C. If it fails, then return for depot repair.
2. If POST shows 205 failure, but thermistor checks OK, then replace the headboard.
3. If POST 205 passes, exercise servo and check TEC TP104 and TP114. If no voltage, then change headboard.
4. If voltage checks OK, check J704-3 and J704-4. If there is no voltage, change the headboard.

5. If above voltage checks OK, then check J704-1 and J704-2. If no voltage, then change headboard.
6. If both the voltage at J704-1 and J704-2 and the thermistor check OK, then TEC or cable is bad - return for depot repair.
7. If the servo operates normally with diodes off, the TEC may be inefficient or the stretcher may have a problem. In this case, the system will likely need to be returned for depot repair.

#29 - Stretcher Maximum Temp Differential Fault

Definition: The difference between the actual temperature and the set temperature exceeded the amount set by STRTMTD.

Action: Confirm proper servo operation.
1. If POST shows 205 failure, check thermistor: unplug J704-3 and J704-4, should read 10 Kohms at 25 º C. If it fails, then return for depot repair.
2. If POST shows 205 failure, but thermistor checks OK, then replace the headboard.
3. If POST 205 passes, exercise servo and check TEC driver output (TP104 and TP114). If no voltage, then change headboard.
4. If voltage checks OK, check J704-3 and J704-4. If there is no voltage, change the headboard.
5. If above voltage checks OK, then check J704-1 and J704-2. If no voltage, then change headboard.
6. If both the voltage at J704-1 and J704-2 and the thermistor check OK, then TEC or cable is bad - return for depot repair.
7. If the servo operates normally with diodes off, the TEC may be inefficient or the stretcher may have a problem. In this case, the system will likely need to be returned for depot repair.

#30 - Diode Seed Over Current Fault

Definition: Seed diode actual current (read back TP177) exceeded SET current (TP153) window during ramp up.

Action: Scale is 2.5V/Amp +/- 5%, so if set =100mA, 237 to 263mV is measured. If read back is incorrect, replace the headboard.
If possible, try to increase the current slowly to avoid the fault. If steady state operation can be achieved, compare the GUI read current to the set current. A large offset under or over will trigger the fault.
Most likely the problem component is the headboard.
Also, the diode could be shorted or open. In that case, the system requires depot repair.

#31 - Shutter State Mismatch Fault

Definition: Shutter not connected and/or failed to open when commanded, or shutter stuck open or closed.

Action:
1. Check that the wiring is not interfering with shutter movement. Check that the shutter is actually moving.
2. Check J702-2 is ground when shutter is open, and J702-10 is ground when shutter is closed.
3. If this is not true, check that the interrupter flag is blocking the U1 (closed) and U2 (open) photocell on the shutter assembly and that J702-5 and J702-7 have 5VDC. Check with the IR viewer that U1 and U2 have IR light.
If any of the preceding in step 3 is not true, replace the shutter assembly.
If all in step 3 is true, replace the headboard.

#32 - Diode 1 Over Current Fault

Definition: Diode 1 actual current (read back TP178) exceeded D1_I_SET (TP167) current window during ramp up.

Action: Scale is 2.5V/Amp +/- 5%, so if set =100mA, 237 to 263mV is measured. If read back is incorrect, replace the headboard.
If possible, try to increase the current slowly to avoid the fault.
If steady state operation can be achieved, compare the GUI read current to the set current. A large offset under or over will trigger the fault.
Most likely the problem component is the headboard.
Also, the diode could be shorted or open. In that case, the system requires depot repair.

#33 - Diode 2 Over Current Fault

Definition: Diode 2 actual current (read back TP34) exceeded SET current (TP61) window during ramp up.

Action: Scale is 2.5V/Amp +/- 5%, so if set =100mA, 237 to 263mV is measured. If read back is incorrect, replace the headboard.
If possible, try to increase the current slowly to avoid the fault.
If steady state operation can be achieved, compare the GUI read current to the set current. A large offset under or over will trigger the fault.
Most likely the problem component is the headboard.
Also, the diode could be shorted or open. In that case, the system requires depot repair.

#34 - Diode 3 Over Current Fault

Definition: Diode 3 read current is 1.5 A higher than the set current.

Action: Check J730 pins 2,3 for short.
If no short, replace the headboard.
If shorted, return for depot repair.

#35 - Diode Seed Under Current Fault

Definition: Seed diode actual current (read back TP177) is less than SET current (TP153) window during ramp up.

Action: Scale is 2.5V/Amp +/- 5%, so if set =100mA, 237 to 263mV is measured. If read back is incorrect, replace the headboard.
If possible, try to increase the current slowly to avoid the fault.
If steady state operation can be achieved, compare the GUI read current to the set current. A large offset under or over will trigger the fault.
Most likely the problem component is the headboard.
Also, the diode could be shorted or open. In that case, the system requires depot repair.

#36 - Diode 1 Under Current Fault

Definition: Diode 1 actual current (read back TP178) is less than SET current (TP167) window during ramp up.

Action: Scale is 2.5V/Amp +/- 5%, so if set =100mA, 237 to 263mV is measured. If read back is incorrect, replace the headboard.
If possible, try to increase the current slowly to avoid the fault.
If steady state operation can be achieved, compare the GUI read current to the set current. A large offset under or over will trigger the fault.
Most likely the problem component is the headboard.
Also, the diode could be shorted or open. In that case, the system requires depot repair.

#37 - Diode 2 Under Current Fault

Definition: Diode 2 actual current (read back TP34) is less than SET current (TP61) window during ramp up.

Action: Scale is 2.5V/Amp +/- 5%, so if set =100mA, 237 to 263mV is measured. If read back is incorrect, replace the headboard.
If possible, try to increase the current slowly to avoid the fault.

If steady state operation can be achieved, compare the GUI read current to the set current. A large offset under or over will trigger the fault.
Most likely the problem component is the headboard.
Also, the diode could be shorted or open. In that case, the system requires depot repair.

#38 - Diode 3 Under Current Fault

Definition: Diode 3 current is less than SET current (D3IFMIN).

Action:
1. Check interlocks.
2. Check event log for fast shutdown (FSD) event. Resolve the FSD event cause.
Check J730 pin 1 (fast shutdown): Low (0 VDC) is good, high (5 VDC) means fast shutdown is triggered.
Check J730 pin 8 (Cosel enable): If high (5 VDC), it is enabled. If Low (0 VDC), it is disabled.
If pin 1 is high and/or pin 8 is low (which is not normal as these should be short signals only), replace the headboard.
5. Check D3RC with D3C.
6. Check TP20 (D3I_Set): If no response to changing D3C, replace the headboard.
If TP20 responds, there is a possible Cosel board or D3 failure. Return for factory repair.

#40 - Diode 3 Under Voltage Fault

Definition: Diode 3 voltage (D3V) is less than D3VMIN.

Action:
1. Check event log for fast shutdown (FSD) event. Resolve the FSD event cause.
2. Check J730 connections:
Pin 1 (fast shutoff): should read low (0 VDC), high (5 VDC) means fast shutdown is triggered.
Check J730 pin 10: should read +12 VDC
Check J730 pin 11: should be DGND
Check J730 pins 2,3 (D3V +/-): at an indicated 0.5-13A, it should read from 16-20.2 VDC (if there is a problem, the diode may be reading shorted or open).
Check J730 pin 8 (Cosel enable): should read high (5 VDC) as enabled. If Low (0 VDC), it is disabled.
3. If pins above measure incorrectly, replace the headboard.
If pins measure correctly (except pins 2,3), return for depot

repair.
If pins 2,3 measure correctly, replace the headboard.

#41 - Diode 3 Over Voltage Fault

Definition: D3V is greater than D3VFMAX.

Action: Check J730 connections:
Check J730 connections:
Pin 1 (fast shutoff): should read low (0 VDC), high (5 VDC) means fast shutdown is triggered.
Check J730 pin 10: should read +12 VDC
Check J730 pin 11: should be DGND
Check J730 pins 2,3 (D3V +/-): at an indicated 0.5-13A, it should read from 16-20.2 VDC (typically the diode may be reading shorted or open).
Check J730 pin 8 (Cosel enable): should read high (5 VDC) as enabled. If Low (0 VDC), it is disabled.
3. If pins above measure incorrectly, replace the headboard.
If pins measure correctly (except pins 2,3), return for depot repair.
If pins 2,3 measure correctly, replace the headboard.

#50 - Chiller Water Level Fault

Definition: Chiller coolant level is low.

Action: Check chiller coolant level and plumbing.
Pin J713-6 indicates a fault; low active. If coolant level is OK, replace chiller.

#51 - Chiller Temperature Fault

Definition: Chiller temperature has moved out of specified range (CHT > CHTH, or CHT < CHTL).

Action: Check chiller coolant. Bleed air if needed. Check flow rate is set to 5.5 LPM. Check plumbing for obstruction. Ensure filter is clean and coolant is changed regularly. If any indication of biological growth is present, system must be flushed using a 3-5% solution of hydrogen peroxide at least overnight, preferably for 12 hours. If above is unsuccessful, replace the chiller.

#52 - Chiller Comm Fault

Definition: Chiller communication timed out.

Action: The most common problems with the chiller are bad connection, bad cable, unapproved chiller, or the software configuration does not match chiller type. Query ?CHTYPE - valid responses are AUTO, P307, or SMC.
1. Check cable: resistance of pins 2 and 3. If cable checks OK, replace the chiller. Note: SMC chiller requires a 3-conductor null modem type of cable; use Coherent Part number 1376872.
2. Check the headboard: LED D17 blinks red when the chiller transmits. It blinks green when the Toradex transmits.

#53 - Chiller Flow Fault

Definition: Chiller flow rate is below minimum.

Action: Ensure that the chiller is properly connected, turned on, and set to the correct flow rate. Review the chiller set up instructions in “Chiller Installation” on page 1.2-4.
Pin J713-4 indicates a fault, low active.
Ensure filter is clean and coolant is changed regularly. If any indication of biological growth is present, system must be flushed using a 3-5% solution of hydrogen peroxide at least overnight, preferably for 12 hours.

#54 - Chiller Delta Fault

Definition: The chiller/chiller set point temperature delta exceeds CHDELTAWARN (0.5 C).

Action: Check for air in the system. Check for proper coolant level. Check that the environment is not too warm (outside operating specification). There must be a temperature delta for the air cooled chiller to shed its heat. Ensure filter is clean and coolant is changed regularly. If any indication of biological growth is present, system must be flushed using a 3-5% solution of hydrogen peroxide at least overnight, preferably for 12 hours.

#55 - Stretcher 2 Temperature Fault

Definition: Stretcher temperature is outside 0 - 100 º C.

Action: Determine if the problem is optical or electrical. If the servo regulates temperature with the diodes off but not when diodes are on, an optical issue likely is producing excessive heat (absorption). There may also be decreased optical output (power) combined with excessive heat production.
1. If POST shows 207 failure, check Thermistor: unplug J704-8 and J704-9, should read 10 Kohms at 25 º C. If it fails,

then return for depot repair.
2. If POST shows 207 failure, but thermistor checks OK, then replace the headboard.
3. If POST 207 passes, exercise servo and check TEC driver output (TP200 and TP201). If no voltage, then change headboard.
4. If above voltage checks OK, then check J704-6 and J704-7. If no voltage, then change headboard.
5. If both the voltage at J704-6 and J704-7 and the thermistor check OK, then TEC or cable is bad - return for depot repair.

#56 - Stretcher 2 Servo Stuck Fault

Definition: The drive is at either minimum (-65,535) or maximum (+65,535) for greater than 5 seconds and the temperature has moved less than 0.02 º C.

Action:
1. If POST shows 207 failure, check Thermistor: unplug J704-8 and J704-9, should read 10 Kohms at 25 º C. If it fails, then return for depot repair.
2. If POST shows 207 failure, but thermistor checks OK, then replace the headboard.
3. If POST 207 passes, exercise servo and check TEC driver output (TP200 and TP201). If no voltage, then change headboard.
4. If above voltage checks OK, then check J704-6 and J704-7. If no voltage, then change headboard.
5. If both the voltage at J704-6 and J704-7 and the thermistor check OK, then TEC or cable is bad - return for depot repair.

#57 - Stretcher 2 Servo Drive Too Low Fault

Definition: Stretcher drive is below the STR2TDF setpoint (STR2TD < STR2TDF).

Action: 1. If POST shows 207 failure, check Thermistor: unplug J704-8 and J704-9, should read 10 Kohms at 25 º C. If it fails, then return for depot repair.
2. If POST shows 207 failure, but thermistor checks OK, then replace the headboard.
3. If POST 207 passes, exercise servo and check TEC driver output (TP200 and TP201). If no voltage, then change headboard.
4. If above voltage checks OK, then check J704-6 and J704-7. If no voltage, then change headboard.
5. If both the voltage at J704-6 and J704-7 and the thermistor

check OK, then TEC or cable is bad - return for depot repair.
6. If the servo operates normally with diodes off, the TEC may be inefficient or the stretcher may have a problem. In this case, the system will likely need to be returned for depot repair.

#58 - Stretcher 2 Maximum Temp Differential Fault

Definition: The difference between the actual temperature and the set temperature exceeded the amount set by STR2TMTD.

Action: 1. If POST shows 207 failure, check Thermistor: unplug J704-8 and J704-9, should read 10 Kohms at 25 º C. If it fails, then return for depot repair.
2. If POST shows 207 failure, but thermistor checks OK, then replace the headboard.
3. If POST 207 passes, exercise servo and check TEC driver output (TP200 and TP201). If no voltage, then change headboard.
4. If above voltage checks OK, then check J704-6 and J704-7. If no voltage, then change headboard.
5. If both the voltage at J704-6 and J704-7 and the thermistor check OK, then TEC or cable is bad - return for depot repair.
6. If the servo operates normally with diodes off, the TEC may be inefficient or the stretcher may have a problem. In this case, the system will likely need to be returned for depot repair.

#62 - Spot Hour Elapsed Fault

Definition: Maximum allowable SESAM spot hours have elapsed (SSPHMAX = 5000).

Action: Change SESAM spot.

#64 - Motor Controller A1 Fault

Definition: Rotational motor controller is not responding.

Action:
1. Reboot the system.
2. If fault still present, reseat controller A1K2 on the headboard.
3. If fault still present, replace the headboard. The A1K2 controller is not available as a stand alone part because it is calibrated during the head manufacturing process, replacement is not possible in the field.
4. If fault still present, return for depot repair.

#68 - SESAM Motor Stuck At Home Fault

Definition: SESAM motor controller is not responding.

Action:
1. Reboot the system.
2. If fault still present, try changing the SESAM spot.
3. If fault still present, check J728-7: when SESAM is at Home position, it should read GND.
If it reads 5V but the fault persists, replace the headboard.
If it reads DGND and fault won't clear, return for depot repair.

#69 - SESAM Motor Not Find Home Fault

Definition: SESAM motor controller is not responding.

Action:
1. Reboot the system.
2. If fault still present, check J728-7:
If the voltage goes to DGND when motor tries to home during reboot, yet the fault persists, replace the headboard.
If it remains 5V, return for depot repair.

#70 - Rotational Motor Communication Fault

Definition: Rotational motor controller is not responding.

Action:
1. Reboot the system.
2. If fault is still present, reseat the controller at A1K2.
3. If fault is still present, the problem could be the motor, controller, or headboard. There is no easy way to determine which part is causing the problem, so depot repair is recommended.

#71 - Rotational Motor Angle Fault

Definition: Grating position error.

Action:
1. Reboot the system, send motor home (MPWH=1), and reset the pulse width (PW).
2. If fault still present, it is possible periodic noise can couple into motor position detection. Later versions of firmware (after 1.060a.36) will confirm the motor position before faulting the laser, so a firmware upgrade could solve the issue.
3. If the problem persists, return laser for depot repair.

#72 - Pulse Width Motor Fault

Definition: Motor is not responding, or the position is not where it should be (the error MPWAERROR is too large).

Action:
1. Reboot the system.
2. If fault is still present, resolution may require serial commands at a higher level of access than Service. Upload log file and contact Product Support for further analysis.

#80 - Thread Exception Fault

Definition: A firmware's thread has stopped unexpectedly.

Action:
1. Reboot the system - cycle power supply.
2. A persistent fault may indicate a hardware problem. Further analysis is required. Upload the logfile and contact Product Support.

#90 - Fast Shutdown - Photodiode 1 Voltage Fault

Definition: A fast shutdown has occurred, and PD1V may only be a symptom.

Action:
1. Check Event Log for root cause of the fast shutdown.
2. Fast shutdowns can also occur due to high (>100) SRRNOISE, see "#8 - Rep Rate Noise Fault" on page 2.2-9.

#91 - Fast Shutdown - Photodiode 2 Voltage Fault

Definition:A fast shutdown has occurred, and PD2V may only be a symptom.

Action:
1. Check Event Log for root cause of the fast shutdown.
2. Fast shutdowns can also occur due to high (>100) SRRNOISE, see "#8 - Rep Rate Noise Fault" on page 2.2-9.

#94 - Photodiode 1 Voltage Out of Range Fault

Definition: PD1V is either below threshold or greater than twice the threshold.

Action:
1. Check the datalog. Verify the PD1 gain and D1C are the same as the gain and current you are currently running.
If those are true, then PD1V should be very close to what you have now.
If the difference is ~10% lower than before, you likely have an

optical problem requiring depot repair (this assumes you have the same rep rate and AOM1 timing as before.
If the difference is greater (2X), then the problem is likely the headboard.

#95 - Photodiode 2 Voltage Out of Range Fault

Definition: PD2V is either below threshold or greater than twice the threshold.

Action:
1. Check the datalog. Confirm PDS, PD1, and PD2 gain as well as DSC, D1C, and D2C have not changed.
2. Check PDSV and PD1V have not changed.
3. A small drop (<10%) in PD2V may indicate an optical problem requiring depot repair. A large change (2X) may indicate a problem with the head board.

#96 - Photodiode 3 Voltage Low Fault

Definition: PD3V failed to exceed threshold voltage. This could be either optical or electrical, or even a symptom of a fast shutdown. Determine root cause before making any changes.

Action:
Optical:
Check all photodiode levels and diode currents. A loss of gain in the low power stage and preamplifier will result in a low PD3V reading. Look for a long term downward trend as well as a sudden loss of voltage. Changes in the pre-amplifier sections may be very small. Zoom in on the graphs to see changes more accurately. A sudden loss of voltage will usually require depot repair. Long term gradual loss may be the result of degradation in any of the pre-amplifier stages, either a fiber component or diode output. The goal should be to return each stage back to the same voltage as when it shipped. Do NOT turn up D3 to compensate for a loss in preamplifier gain.

Electrical:
1. Check interlocks.
2. Reseat the J730 connector.
3. If fault still present, check J730-1 (fast shutdown): It should measure low (0 VDC). If it reads high (5 VDC), fast shutdown has tripped.
Check J730-8: It should read high (5VDC) when enabled. It will read low (0 VDC) when disabled.

#97 - Photodiode 5 Back Reflect High Fault

Definition: This is a Monaco HX only problem. Normally PD5V is zero volts. When the back reflection off some optical surface gets too high, a threshold is tripped. When the threshold is tripped, a fast shutdown should occur.

Action: Check for external back reflections entering output.

98 - Configuration Fault

Definition: The lookup table (LUT) is not fully configured. This should be rare and may indicate a settings corruption.

Action: The lookup table (LUT) is configured during production, and can be restored from a backup Settings Snapshot.

#100 - SHG Servo Stuck Fault

Definition: When the drive is at either minimum (-65,535) or maximum (+65,535) for greater than 5 seconds and the temperature has moved less than 0.02 º C.

Action:
1. Check POST (see “POST Results” on page 2.2-42): J729 pin 10 should read 5 V REF. If no VREF, replace the headboard.
2. Check TP 151 and TP 152 while exercising the servo via commands: a change in voltage indicates driver is working. If no change, replace the headboard.
3. Check J729-8 and J729-1 while exercising the servo via serial commands: a change in voltage indicates power is being fed to the SHG oven. If no voltage, replace the headboard.
4. Unplug J729 and check the resistance of the thermistor: across pins 9 and 10 it should read 10 kOhm at 25 º C. If it reads open or short, return system for depot repair.

#101 SHG Servo Drive Too Low Fault

Definition:

Action: **Action**:
1. Check POST (see “POST Results” on page 2.2-42): J729 pin 10 should read 5 V REF. If no VREF, replace the headboard.
2. Check TP 151 and TP 152 while exercising the servo via commands: a change in voltage indicates driver is working. If no change, replace the headboard.
3. Check J729-8 and J729-1 while exercising the servo via commands: a change in voltage indicates power is being fed to

the SHG oven. If no voltage, replace the headboard.
4. Unplug J729 and check the resistance of the thermistor: across pins 9 and 10 it should read 10 kOhm at 25 º C. If it reads open or short, return system for depot repair.
If the servo operates normally with the diodes off, the SHG crystal may be absorbing. Return the system for depot repair.

#102 - SHG Maximum Temp Differential Fault

Definition: The SHG temperature has exceeded the maximum specified temperature (SHGT > SHGMTD).

Action: Does the fault only appear when the diodes are on? If so, SHG may be absorbing and system must be returned for depot repair.
If the fault appears when the diodes are off, see "#100 - SHG Servo Stuck Fault" on page 2.2-29.

#106 - Hardware Watchdog Reset Occurred Fault

Definition: This announcement will occur whenever the system is restarted by serial command such as BOOT=1 or RESET=1. Otherwise, it indicates that the system has reset due to a watchdog timeout.

Action: Refer to the Event Log for the root cause. The watchdog timer must be satisfied periodically. Disconnecting the control PC without shutting down the laser can result in the loss of the Heartbeat. Loss of the Heartbeat is a watchdog timeout (WDT) event.

#300 - Software Thread Stalled Fault

Definition: Firmware's thread has taken too long to execute.

Action:
1. Reboot the system.
2. If fault still present, further analysis may be required. Upload the log file and contact product support.

Note: Some early firmware versions were susceptible to Fault #301 and Warning #803.

#301 - Communication To Control Computer Lost Fault

Definition: Commands have not been received by the laser in sufficient time.

Action: Send commands faster by ensuring other applications are not slowing communication, or set a longer timeout with HB=n where n is the number of seconds allowed between commands. If that doesn't fix the issue, setting HB=0 disables monitoring of the time between commands (the power-on default). If diodes are on while extracting large datalogs the laser can shut down, but it can also result in a dropped connection. A slow thread can result in dropped connections and continual resets. See also "#803 - Software Thread Is Too Slow Warning" on page 2.2-39.

#302 - Unable To Read From FPGA Fault

Definition: The communication between the CPU and FPGA are not reliable.

Action: Reboot the system. If problem persists, the problem is likely a mismatch between firmware and FPGA programming versions. The firmware package is a suite consisting of CPU firmware, FPGA programming, and other files required for a complete installation. Always check what is in the upgrade package and compare with the currently installed firmware suite to ensure compatible components e.g. 50 vs. 60 MHz seed FPGA. Usually this is only seen on early (prior to May 2017) units. Current GUI versions (after v3.88) prohibit installation of incorrect package components. Reinstall firmware package. Issue may require escalation to Product Support.

#303 - Wrong FPGA Firmware Installed Fault

Definition: Firmware suite package does not have matching components.

Action: The firmware package is a suite consisting of CPU firmware, FPGA programming, and other files required for a complete installation. Always check what is in the upgrade package and compare with the currently installed firmware suite to ensure compatible components e.g. 50 vs. 60 MHz seed FPGA. Usually this is only seen on early (prior to May 2017) units. Current GUI versions (after v3.88) prohibit installation of incorrect package components. Reinstall firmware package. Issue may require escalation to Product Support.

#304 - Power On Self-Test (POST) Failed Fault

Definition: (Dynamic) One or more of the Power ON Self Tests failed. The failed test will be displayed along with the fault message. See POST Results Table 2.2-3 on page 2.2-42.

Action: Query ?POST to see which test(s) failed. The POST checks voltages and continuity during the boot up sequence. The most common failure is that an interlock is not satisfied.

#305 - Unable To Write To FPGA Fault

Definition: The communication between the CPU and FPGA failed.

Action: Reboot the system. Reboot the system. If problem persists, the problem is likely a mismatch between firmware and FPGA programming versions. The firmware package is a suite consisting of CPU firmware, FPGA programming, and other files required for a complete installation. Always check what is in the upgrade package and compare with the currently installed firmware suite to ensure compatible components e.g. 50 vs. 60 MHz seed FPGA. Usually this is only seen on early (prior to May 2017) units. Current GUI versions (after v3.88) prohibit installation of incorrect package components. Reinstall firmware package. Issue may require escalation to Product Support.

#306 - DC GOOD Signal Is Bad Fault

Definition: DC_Good signal is missing

Action: Power off and power on again. The most likely cause is the power supply voltage is low or failed. If the system boots up, and appears to run normally, query POST test 100 for pass/fail.
DC_Good signal is derived off of the head board, TP99. It is low active. If the signal is missing and the power supply is OK, the head board is at fault.

#307 - GUI Is Out of Date Fault

Definition: The GUI is a down revision.

Action: Upgrade GUI to the latest revision. Performing an upgrade while connected to the Coherent network will result in a more recent, internal version of the GUI. If not connected to the Coherent network, the upgrade file will be the customer released version available on the www.coherent.com website.

#308 - Unapproved Chiller Fault

Definition: The chiller is not a qualified/approved model.

Action: Set chiller type by using the command “CHTYPE=”. The Monaco must be able to communicate with the chiller. Currently only the Termotek P307 and SMC chillers are supported.

#309 - I2C Failure Fault

Definition:

Action: Reboot the system. If the fault persists, the headboard or Datalogger Module may have failed. Extract and upload the log file, then contact Product Support to discuss recovery options.

#310 - Illegal Storage Value Fault

Definition: A dynamic memory location has an invalid value stored.

Action: The usual scenario where this fault appears is during a firmware upgrade when a setting’s default minimum and or maximum has changed. This causes the existing setting to become incorrect. It is a dynamic fault that will display a string of text listing the setting that is now incorrect. Query ?help (setting) to see the default min/max values. Change the original setting to be within limits. The event log may also offer further information. Contact Product Support if unsure.

Warnings

#500 - Relative Humidity Warning

Definition: Humidity reading greater than HHL of 8%.

Action: Confirm humidity levels with the ?RELH query. Change the desiccant pack.

#502 - Spot Hour Elapsed Warning

Definition: Warning is indicated when spot hours reaches 4832 (SSPHMAX - SSPHWARN). The default values are SSPHMAX = 5000, and SSPHWARN=168 (giving a 1 week warning notice).

Action: Change the SESAM spot.

#504 - State Machine Had A Timeout Warning

Definition: The state machine failed to move to the next status within the allotted time.

Action: This can happen for different reasons. A common example is when a temperature servo fails to reach a tight-locked condition within the allotted time. Since this is a warning, it should be able to be cleared and operation won't be interrupted. There is also a timeout fault that will display the cause if the problem is serious enough to stop the laser.

#505 - Chiller Water Level Warning

Definition: As determined by the chiller coolant level sensor.

Action: Check water level is correct, and refill coolant as needed.

#506 - Chiller Flow Warning

Definition: The chiller believes there is incorrect flow. The flow may be too high or too low.

Action: Check the plumbing between the chiller and laser for restrictions, extended hose lengths, excessive height difference between chiller and laser head.

Chiller flow rate limits are:
Low flow warning: CHF < 4.7 lpm
High flow warning: CHF > 5.3 lpm

Ensure filter is clean and coolant is changed regularly. If any indication of biological growth is present, system must be flushed using a 3-5% solution of hydrogen peroxide at least overnight, preferably for 12 hours.

#507 - Diode 3 Light Loop Limit Warning

Definition: The light loop is running out of head room; D3C is approaching D3RC.

Action:
1. Ensure laser has sufficient warmup time.
2. Measure laser output to ensure specified power.
3. If power is low, investigate why. Look closely at DS, PD1V, PD2V, and D3C for degradation. Very small amounts of degradation can result in large power changes at the amplifier exit. D3LLMAX allows the light loop voltage to increase up to 120% of the D3LLSV. If the light loop set voltage is not enough to maintain the specified output power, do NOT increase D3LLSV, especially if D3C shows no degradation.Check that D3LLMAXC = 18A. Do not increase more than that. Usually this indicates that D3C is approaching D3RC. If normal degradation of D3C causes this gap to close, increase D3RC by ~10-15%. Do not increase more than that.

D3RC may be different for modes of operation other than the 1 MHz mode and may need updating. Upload the log file and contact product support if needed.

#508 - Rotational Motor Angle Warning

Definition: Rotational (PW) motor position is not where it is supposed to be.

Action: Reboot the system. If fault persists, contact Product Support.

#509 - Rotation Motor Angle Tolerance Warning

Definition:

Action:
1. Reboot the system.
2. If fault persists, check for sources of vibration or shock to the system and remove them if possible.
3. Contact Product Support.

#510 - Seed Drive Is Low Warning

Definition: DSTDW is at or below 1000.

Action: See “#19 - Seed Servo Drive Too Low Fault” on page 2.2-13 for troubleshooting.

#511 - Diode 1 Drive Is Low Warning

Definition: D1TDW is at or below 1000.

Action: See “#22 - Diode 1 Servo Drive Too Low Fault” on page 2.2-15 for troubleshooting.

#512 - Diode 2 Drive is Low Warning

Definition: D2TDW is at or below 1000.

Action: See “#25 - Diode 2 Servo Drive Too Low Fault” on page 2.2-16 for troubleshooting.

#513 - Stretcher Drive Is Low Warning

Definition: Stretcher drive is at or below 1000.

Action: See “#28 - Stretcher Servo Drive Too Low Fault” on page 2.2-17 for troubleshooting.

#514 - SHG Drive Is Low Warning

Definition: SHG drive is below ?SHGDW.

Action: A low SHG drive usually means that the crystal is absorbing if the drive is low when diodes are on but normal when diodes are off. If low when diodes are off, indications tend to point toward hardware and a fault should be displayed. Check connections at the head board.

#515 - Chiller-Baseplate Delta Warning

Definition: Warning will occur if the chiller/baseplate temperature delta is above CHBPDELTAMAX. This can happen at start up if the ambient temperature is far enough above chiller temperature.

Action: Check for proper coolant level. Make sure that air is purged from the system. Check that the environment is not too warm (outside specifications). There must be a temperature delta for the air cooled chiller to shed its heat. Ensure filter is clean and coolant is changed regularly. If any indication of biological growth is present, system must be flushed using a

3-5% solution of hydrogen peroxide at least overnight, preferably for 12 hours.

#516 - Chiller Delta Warning

Definition: Warning will occur if the chiller/chiller set point temperature delta exceeds CHDELTAWARN (0.5 º C).

Action:
1. Check the chiller coolant level, and refill as needed.
2. Check chiller plumbing for restrictions, extended hose lengths, excessive height difference between chiller and laser head.
3. Bleed air from the system.
4. Check the air space around the chiller and ensure there is proper air flow.
5. Check that the environment is not too warm (outside specifications). There must be a temperature delta for the air cooled chiller to shed its heat. Ensure filter is clean and coolant is changed regularly. If any indication of biological growth is present, system must be flushed using a 3-5% solution of hydrogen peroxide at least overnight, preferably for 12 hours.

#517 - Seed Diode Light Loop Limit Warning

Definition: DSC is approaching DSRC.

Action: This may indicate degradation of the seed diode. Inspect for a DSC increase over the laser lifetime. Use the modelock window tool to determine if DSSC can be reset. Typically DSC does not exceed ~130-140mA. Excessive degradation requires depot repair.

#518 - Rep Rate Noise Warning

Definition: Seed Rep Rate Noise (SRRNOISE) is >50 and <100.

Action: It is very rare to see this warning. Typically SRRNOISE increases so rapidly that a fault will occur before a warning can be displayed. Should this warning actually be displayed, it would be the result of noisy modelocking rather than failed modelocking. If the SESAM spot has relatively few starts or hours, stable modelocking may be recovered by optimizing the modelocking window. If problems persist, change the spot.
Also see “No Modelocking/ High Seed Rep Rate Noise” on page 2.1-7 for a full description of these actions.

#519 - Rotational Motor Version Warning

Definition: Vendor made a change to their firmware. If it's less than version 88, then this warning is triggered.

Action: The normal action is to replace the motor driver board and recalibrate. This is not possible in the field.

#520 - Photodiode 1 Saturated Warning

Definition: PD1V is twice the threshold.

Action: Unplug D1-J704, close SW8-C, and see if the warning goes away.
If warning goes away, the D1 board has a problem - return for depot repair.
If the warning does not go away, replace the headboard.

#521 - Photodiode 2 Saturated Warning

Definition: PD2V is twice the threshold.

Action: Unplug D2-J704, close SW7-C, and see if the warning goes away.
If the warning goes away, D2 board has a problem - return for depot repair.
If the warning does not go away, replace the headboard.

#522- Stretcher 2 Drive Is Low Warning

Definition: STR2TDW is at or below 1000.

Action: See "#57 - Stretcher 2 Servo Drive Too Low Fault" on page 2.2-24 for troubleshooting.

#524 - Diode 3 Calibration Values Exceed Normal Variations Warning

Definition:

Action: Recalibrate D3.

#800 - Bootloader Is Below Revision v1.3 Warning

Definition: Toradex module programming is down revision.

Action: Check bootloader version using ?SV query. There is currently no mechanism to update the bootloader programming in the field. The software team assistance would be required. The bootloader will be upgraded during depot repair if needed. Contact Product Support if an identifiable problem exists.

#801 - Operating System Image Is Below Revision v1.3 Warning

Definition: Toradex module programming is down revision.

Action: Check image version using ?SV query. Current T-20 image is IM:1.3.
There is currently no mechanism to update the T-20 image in the field. The software team assistance would be required. The image will be upgraded during depot repair if needed. Contact Product Support if an identifiable problem exists.

#802 - Operating System Is Not 7.0 Warning

Definition: Toradex module programming is down revision.

Action: Check operating system (OS) version using ?SV query. Current T-20 module OS and image are IM:1.3, OS:7.0. It should be extremely rare to see this warning unless working on a prototype Monaco. There is currently no mechanism to update the T-20 image in the field. The software team assistance would be required. The OS will be upgraded during depot repair if needed. Contact Product Support if an identifiable problem exists.

#803 - Software Thread Is Too Slow Warning

Definition: The system has become too busy and fails to "pat the watchdog" in the allotted time.

Action: Reboot system, reboot host PC. Confirm the problem by inspecting the event log for other occurrences. Firmware versions prior to release 34 (v1.192.86) occasionally displayed this warning. If the warning is persistent, a firmware upgrade may resolve the problem.

#804 - CPU Temperature Is Too High Warning

Definition: Internal CPU temperature reading is greater than the maximum allowed.

Action:
1. Check ?CPUT and ?CPUTMAX.
2. Check chiller operation.
3. Check baseplate temperature ?BT.

#805 - Battery Is Low Warning

Definition: CR2032 battery is less than 2V.

Action: Replace the battery on the headboard. If replacing with power off, the clock will need to be reset.

#806 - Module Temperature Is Too High Warning

Definition: CPU Module temperature reading is greater than the maximum allowed.

Action:
1. Check ?CPUMT and ?CPUMTMAX.
2. Check chiller operation.
3. Check baseplate temperature ?BT.

#807 - Baseplate Temperature Is Too Low Warning

Definition: Baseplate temperature is at or below BTWLOW.

Action: Let system come to room temperature. If fault persists:
1. Check baseplate set temperature.
2. Check that BTEN=1 (control loop is enabled).
3. Check chiller set versus actual temperature.

#808 - Configurable Test Warning

Definition: The UNDOC command TEST was used to set up a warning (e.g. TEST=Software test in progress).

Action: To remove this warning:
1. Type the command “TEST=” in the command prompt. Ensure that there is nothing entered after the command.
2. Press the “Clear” button in the GUI, or type FACK=1 in the command prompt.

#809 - Spot Movement Failed Warning

Definition: No more SESAM spots in the forward direction.

Action: Use the command SSP- to shift backward. There may be viable spots remaining.
The system may only have “consumed” spots. If so, return for depot repair.

#810 - Laser On Last Good Spot Warning

Definition: No more good spots remaining.

Action: Check if any spots remain. There may be spots that were previously skipped over. Before returning system, check that no viable spots remain. If none remain, return for depot repair.

#811 - Non Standard Shutdown Warning

Definition: Something went wrong in the software communication of the system (e.g. watchdog timeout) and the laser was shut down.

Action: Troubleshoot to determine the cause for the shut down. Often the laser will return to normal operation after restart.

#812 - Diode Calibration Failed Warning

Definition: Diode calibration values are outside expected results.

Action: Perform calibration again.

POST Results

The POST checks circuit continuity and voltages during start up of the laser. Failure will result in one of the codes listed in the table below

Table 2.2-3. POST Results

POST #	DESCRIPTION
100	DC GOOD
101	VOLTAGES
102	BATTERY
103	REALTIME CLOCK
104	STORAGE
200	BT1
201	BT2
202	DST
203	D1T
204	D2T
205	CFBGT
206	PC3T
207	RH
208	INTERLOCKS
209	KEY
210	PDS AVG V
211	PD1 V
212	PD2 V
213	PD3 V
214	PD4 PWF
215	DS I

Table 2.2-3. POST Results

POST #	DESCRIPTION
216	D1 I
217	D2 I
218	D3 I
219	D3 V SENSE
220	D3I SET

Software Troubleshooting Tools

Commonly the next step after checking the chiller, external connections, and communication is to look at the performance and history of the laser in the log file. Before any remote service session with the Monaco laser, the laser's log file should be downloaded by the user and sent for review. The review of the fault history in the log file is greatly aided by using the Eventlog Reader. Download the latest version of the Eventlog Reader from the Coherent Spectrum TBU site.

The general strategy is to look for either:

- events leading up to specific fault displayed on the GUI. The Eventlog Reader is particularly useful for this. OR

- general degradation or performance where one would observe trends over time making use of the history from the log file.

Eventlog Reader

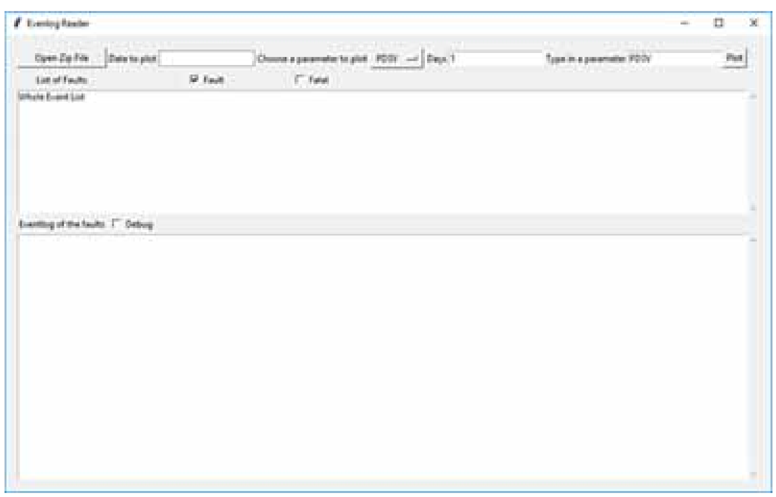


Figure 3.2-1. Eventlog Reader

The Eventlog Reader is a tool for scanning all of the event logs and generating graphs for the various parameters concerned. The Event Log Reader loads very quickly, and provides a first cursory look at log files. Using the Eventlog Reader allows you to see most of the firmware events leading up to a fault or warning displayed. This can provide insight into what caused the fault. For a more in-depth analysis of the system data, the GUI in offline mode must be utilized.

Log files are “double zipped” with a top layer of encryption. To open a log file with the Eventlog Reader, the file first must have the first layer unzipped using the Offline Service password. Then the remaining zip file can be opened using the Eventlog Reader.

When the Event Log window is displayed, the top pane shows all of the faults and warnings. Highlighting one of these faults in the upper pane will display the firmware events that happened around that time stamp in the lower pane. Looking at these firmware events will enable you to see what might have led up to the fault. For example, Warnings that were ignored or the frequency of the Fault. One can see how frequently a fault or warning message has appeared giving an indication of the length or severity of the problem. Another example might be a system with poor modelocking where different fault messages appear, the symptom (e.g. PD2V < PD2LVL) is shown, but the root cause (SRRNOISE>100) is only displayed in the Event Log. Using the Eventlog Reader in combination with the graphs from the GUI can offer a more complete understanding.

Obtaining the Log File

1. Open the log file. This requires logging in with the Offline Service password (for older lasers, the Customer Service password may be required).
2. Open the GUI in Offline Mode, and choose the log file (see Figure 3.2-2).

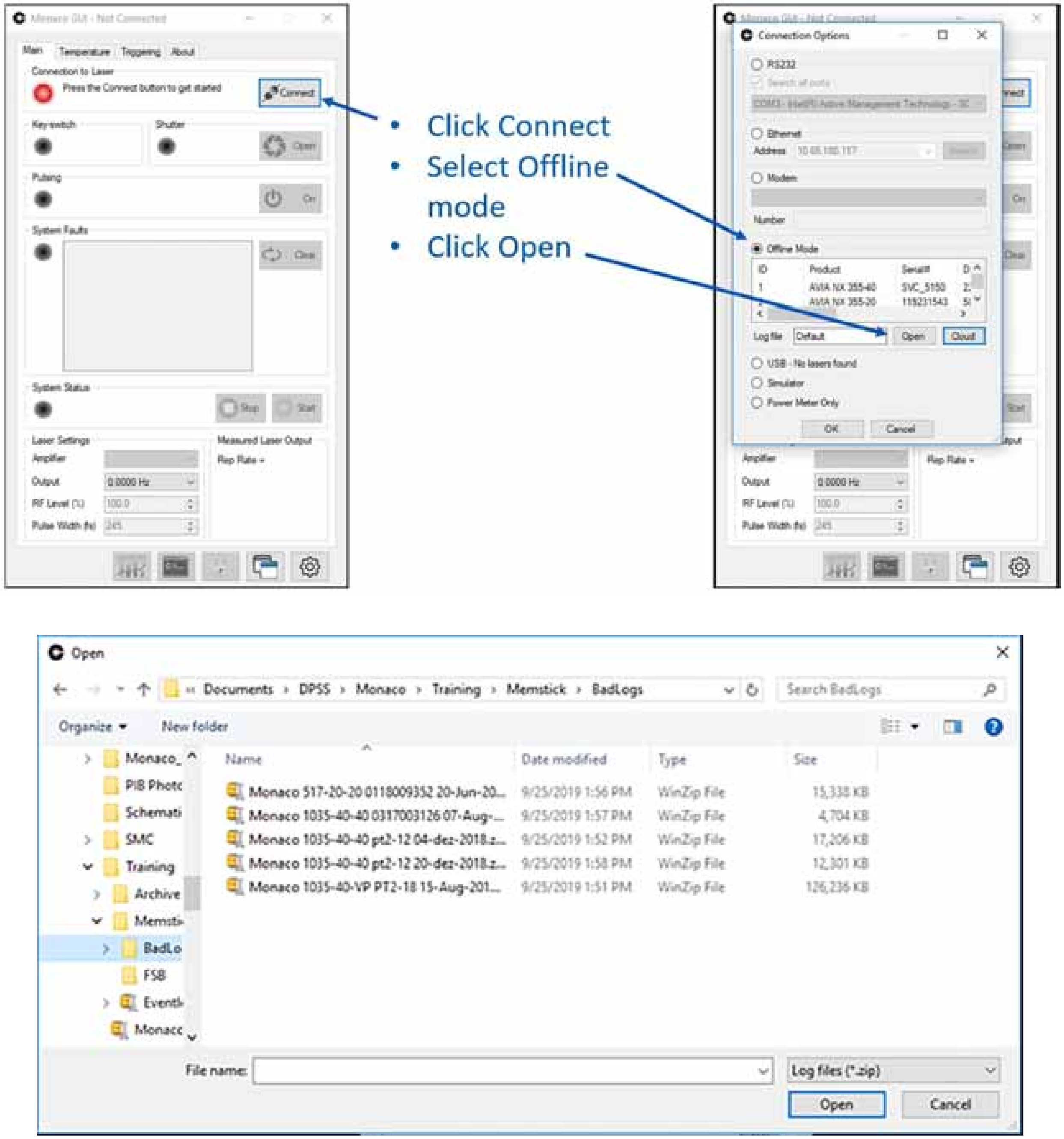


Figure 3.2-2. Opening Zipped Log File

3. The Data Import window opens. It is automatically populated with all laser parameters, but it is not necessary to import all of the data from the log file. Log in with the offline password (see Figure 3.2-3).

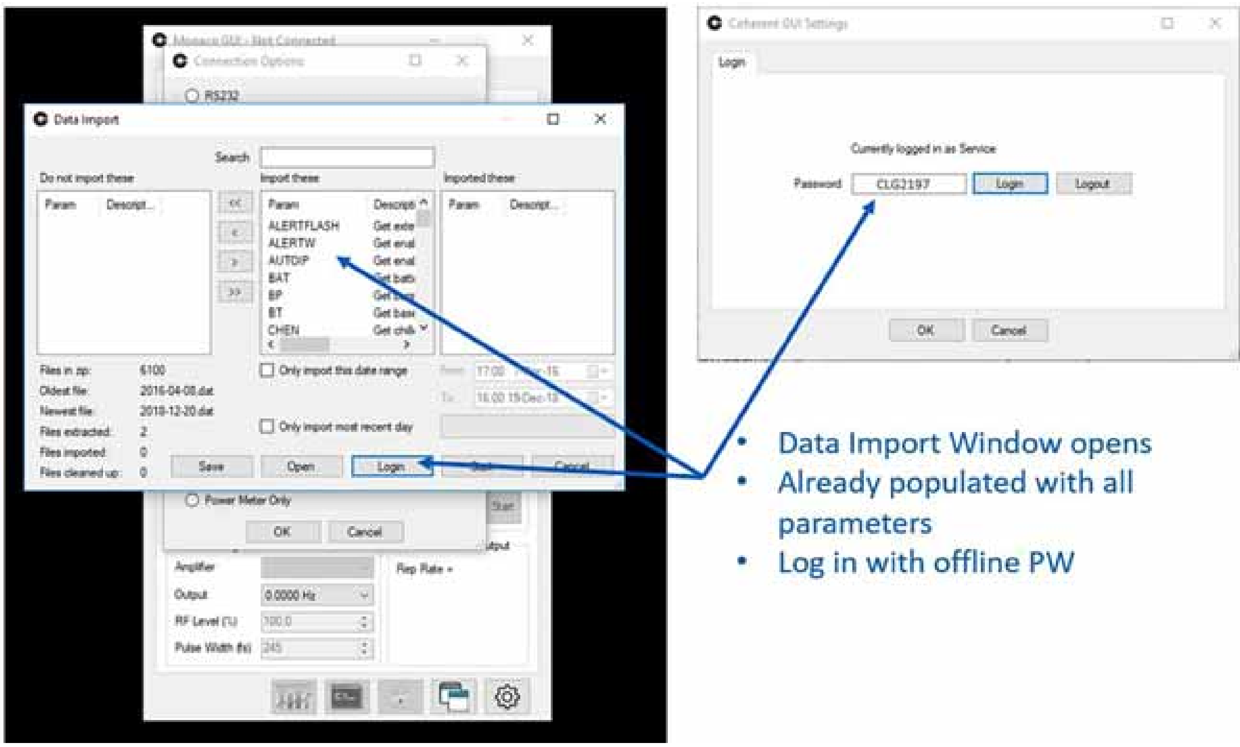


Figure 3.2-3. Data Import Window

4. Select all the desired laser parameters. If a saved parameter list is desired instead, clear all the parameters and open the parameter list text file. A saved parameter list may be created by first selecting all the desired parameters and then "saving" the file (see Figure 3.2-4).

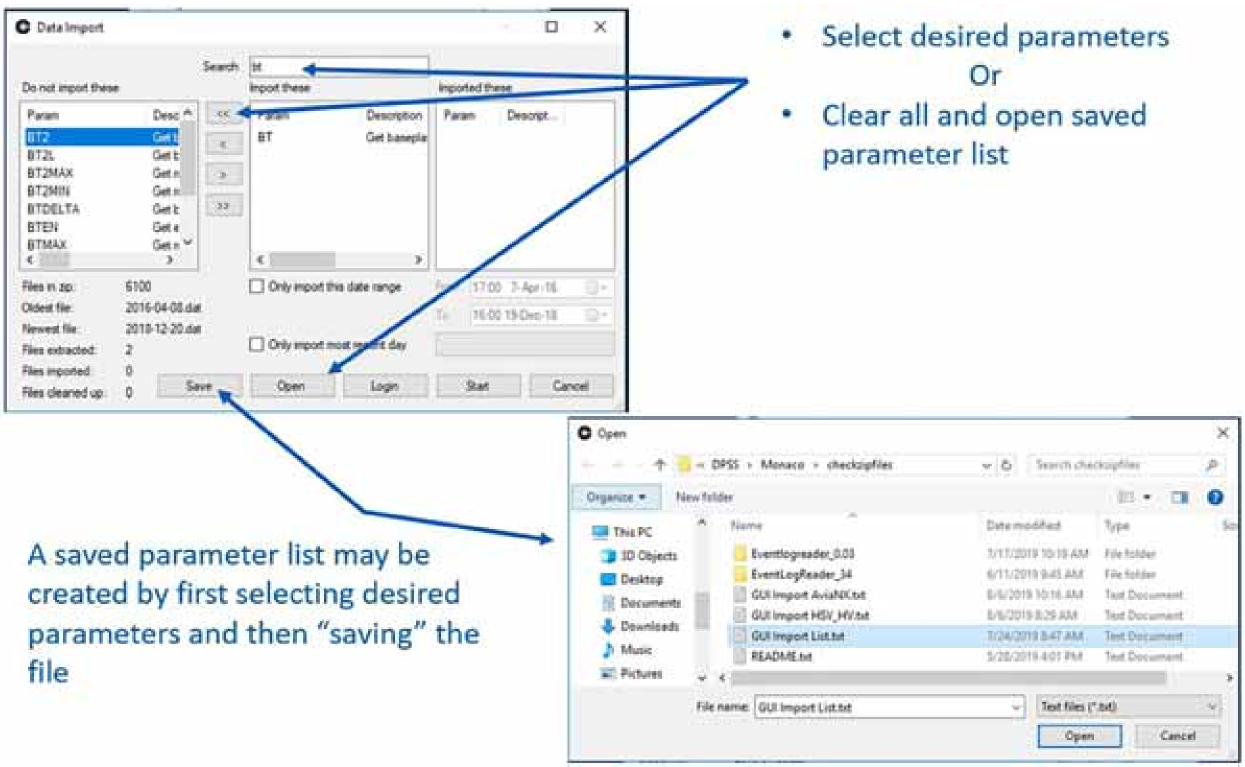


Figure 3.2-4. Selecting Parameters from Log File

5. The data import list may be opened with the Notepad application on your computer. Shown in Figure 3.2-5 are example parameters often used for troubleshooting.

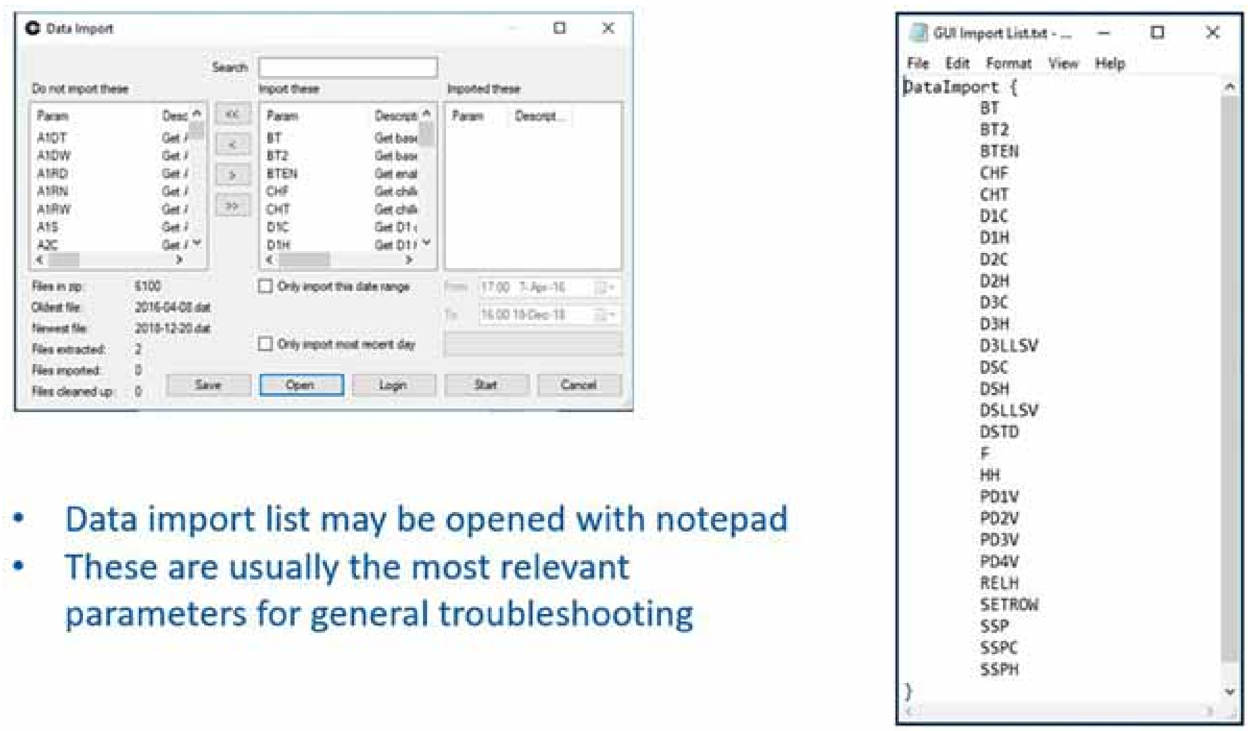


Figure 3.2-5. Data Import List (edit label in ppt)

6. Click the Start button. The green bar will indicate progress. Importing the log file can take some time, so be patient.

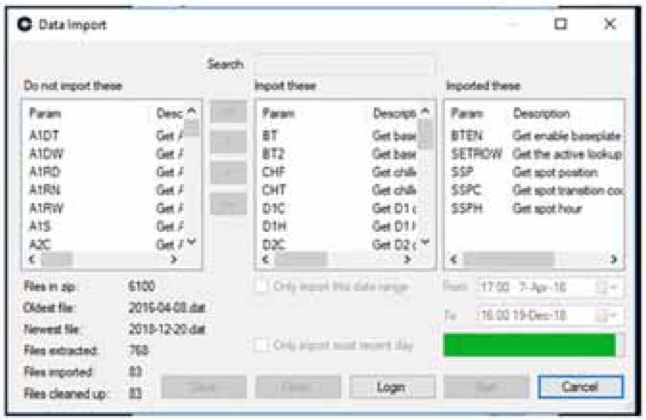


Figure 3.2-6. Importing the Log File

7. Log files are “double zipped” with a top layer of encryption. To open a log file with the Eventlog Reader, the file first must have the first layer unzipped using the Offline Service password. Then the remaining zip file can be opened using the Eventlog Reader.

Figure 3.2-7. Opening Log Files

8. Load the secondary zip file. The Reader will open all the event logs simultaneously and report the total errors.

When the Event Log window is displayed, the top pane shows a list of all of the faults and warnings. Highlighting one of these faults in the upper pane will display the firmware events that happened around that time stamp in the lower pane highlighted in blue (with the fault displayed in pink). Pay attention to the selection types highlighted e.g. fault, fatal, info, or debug messages. Looking at these firmware events will enable you to see what might have led up to the fault.

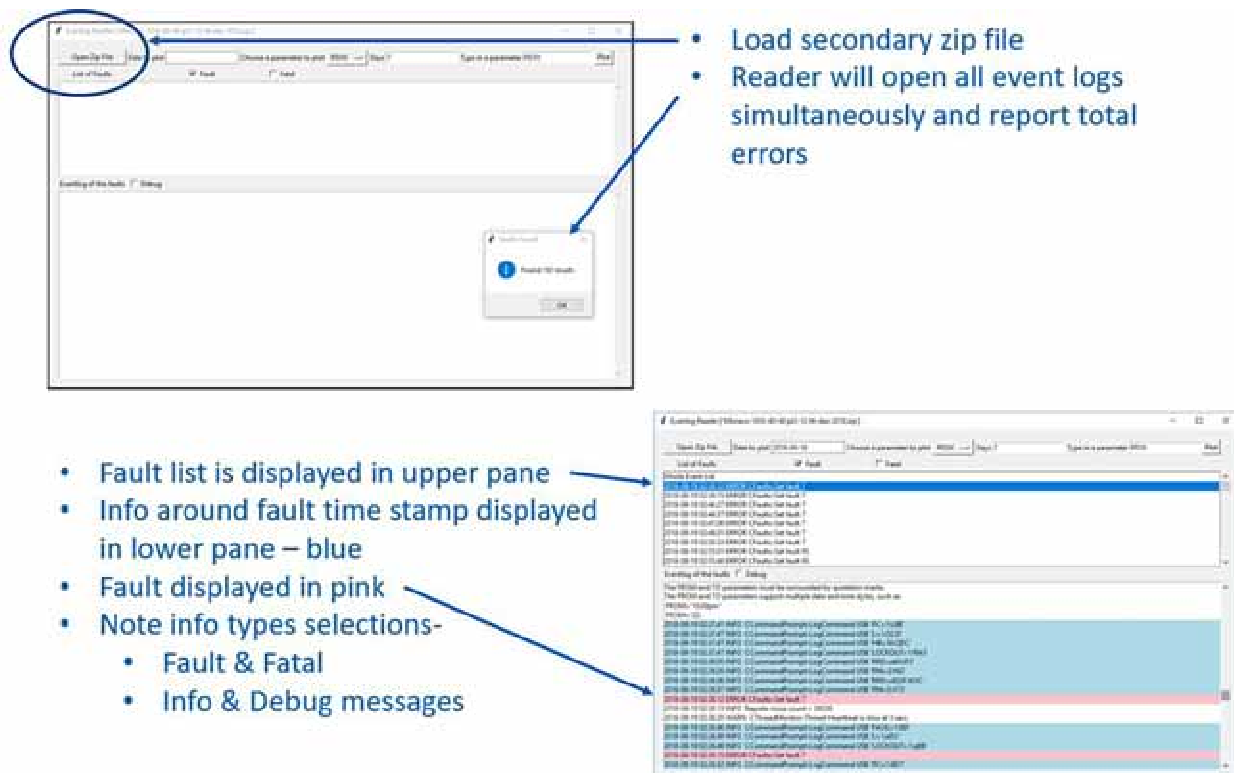


Figure 3.2-8. Load Secondary Zip File/Event Log Display

Event Log Troubleshooting

After the log file data has been imported, the system history and trends can be graphed. For example:

- The Photodiodes tab is a good place to start. Clicking on bottom graphing icon will open graphs of all five photodiode voltages over time.
- From the Details tab, single parameters to graph can be selected by double-clicking the label from the parameters list.

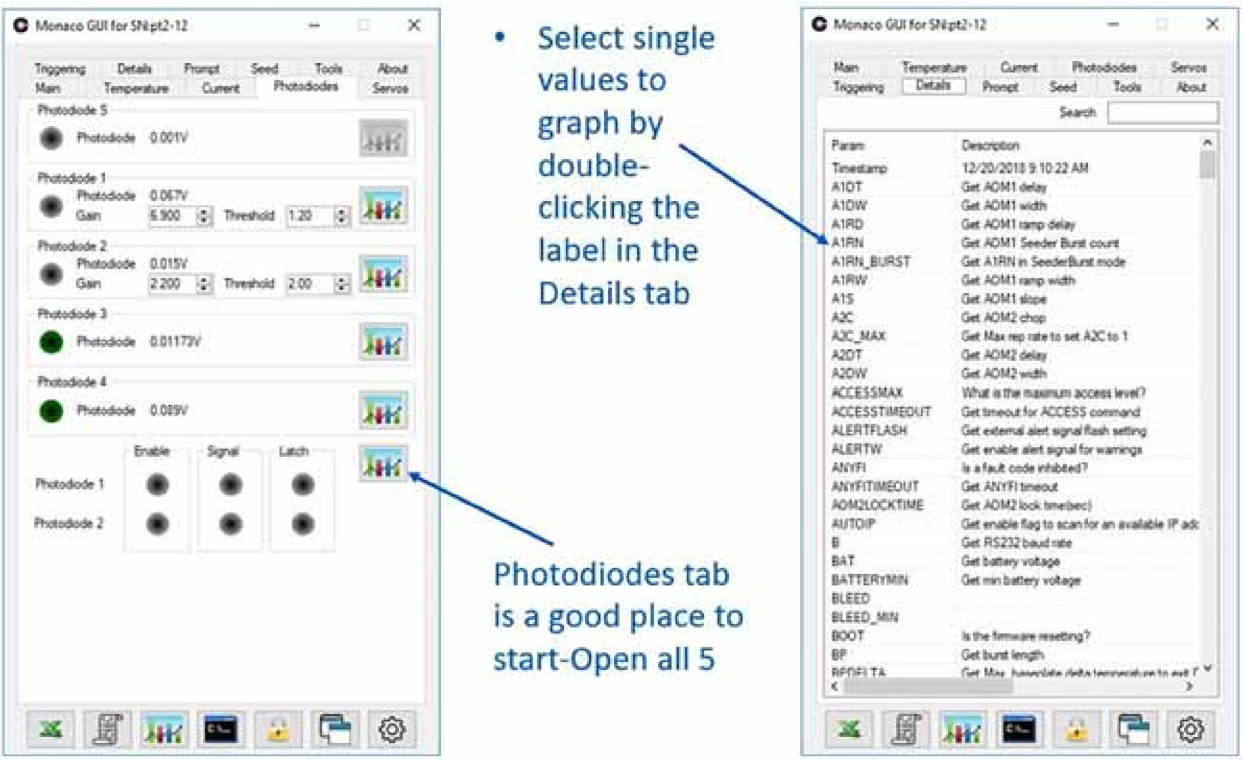


Figure 3.2-9. Graphing System History

The default time scale displayed on the graphs may either be too short or too long to be useful. There are four ways to adjust the scale:

1. Click the "Set Graph Scale" icon in the upper left corner of the graph pane, then select "All Data", OR
2. From the Set Graph Scale window, choose the start and end dates, OR
3. From the graph window, click on the "Show older data" or "Show more recent data" red buttons in the upper center of the pane, OR
4. Using the cursor, highlight the area of the graph you wish to zoom in on.

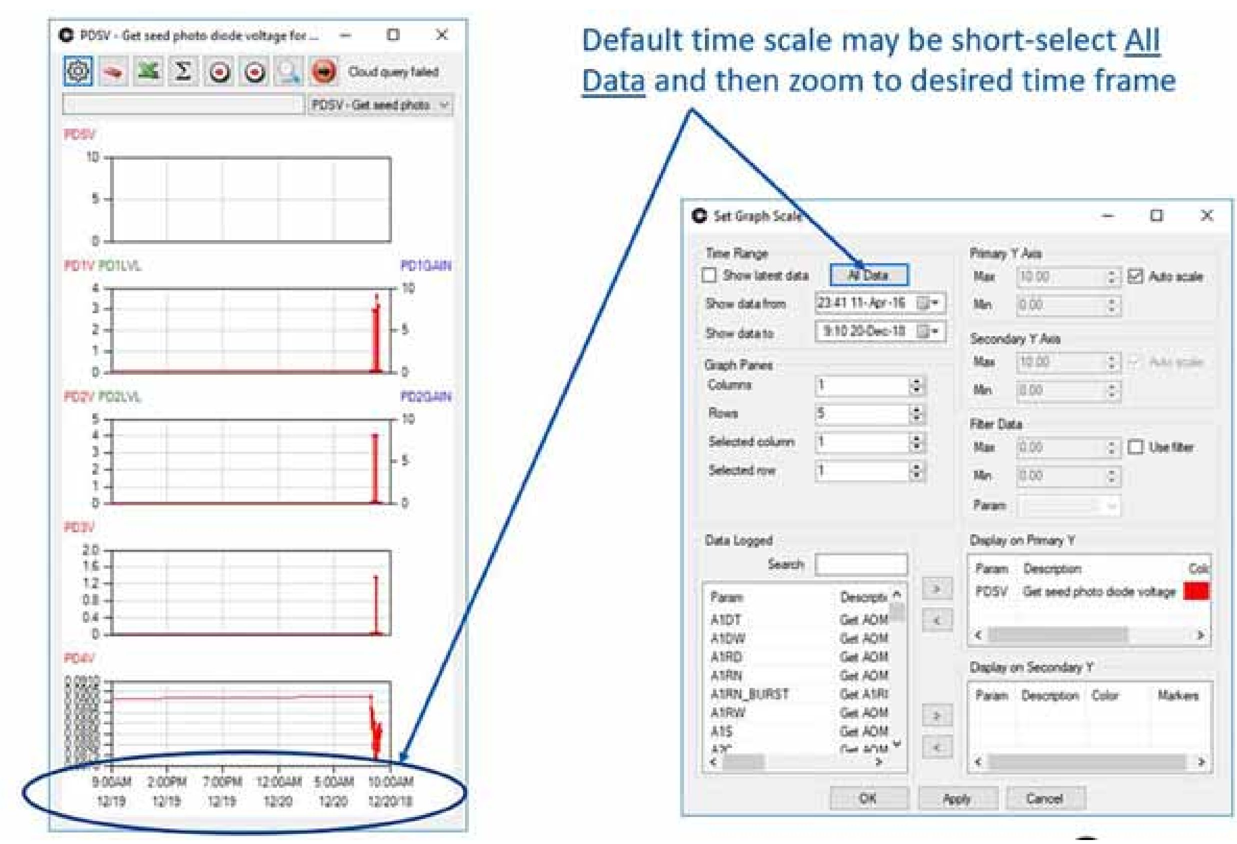


Figure 3.2-10. Adjusting Time Scale

The plotting can be done using the Eventlog Reader, but can also be done using the GUI. The GUI has more flexible options for manipulating graphs, but may take longer to initially load.

In order to create plots from the Eventlog Reader:

- Choose a parameter to plot (e.g. SRRNOISE) from the drop-down menu or type it into the field as shown in the circled area.
- Set the date to start and date range in days
- Click Plot.

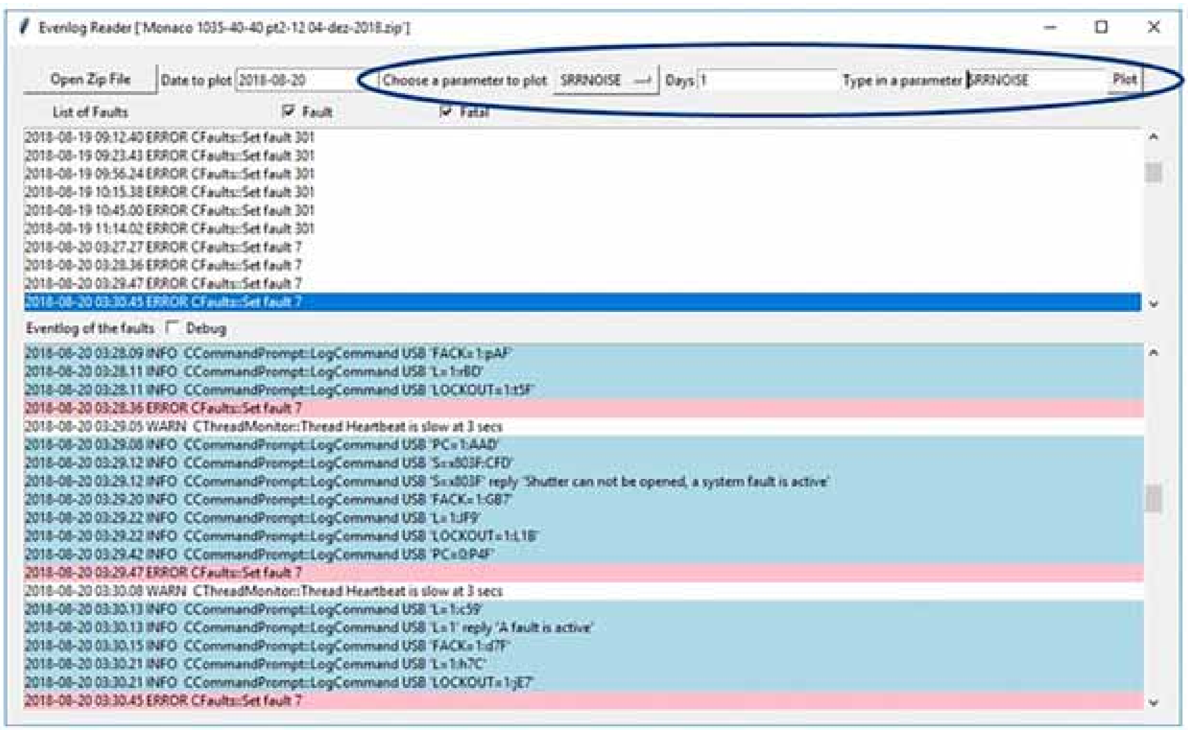


Figure 3.2-11. Creating Plots with Event Log Reader

Graphing the Fault history adds the Fault numbers together, which makes it difficult to discern the actual fault number and when they occurred

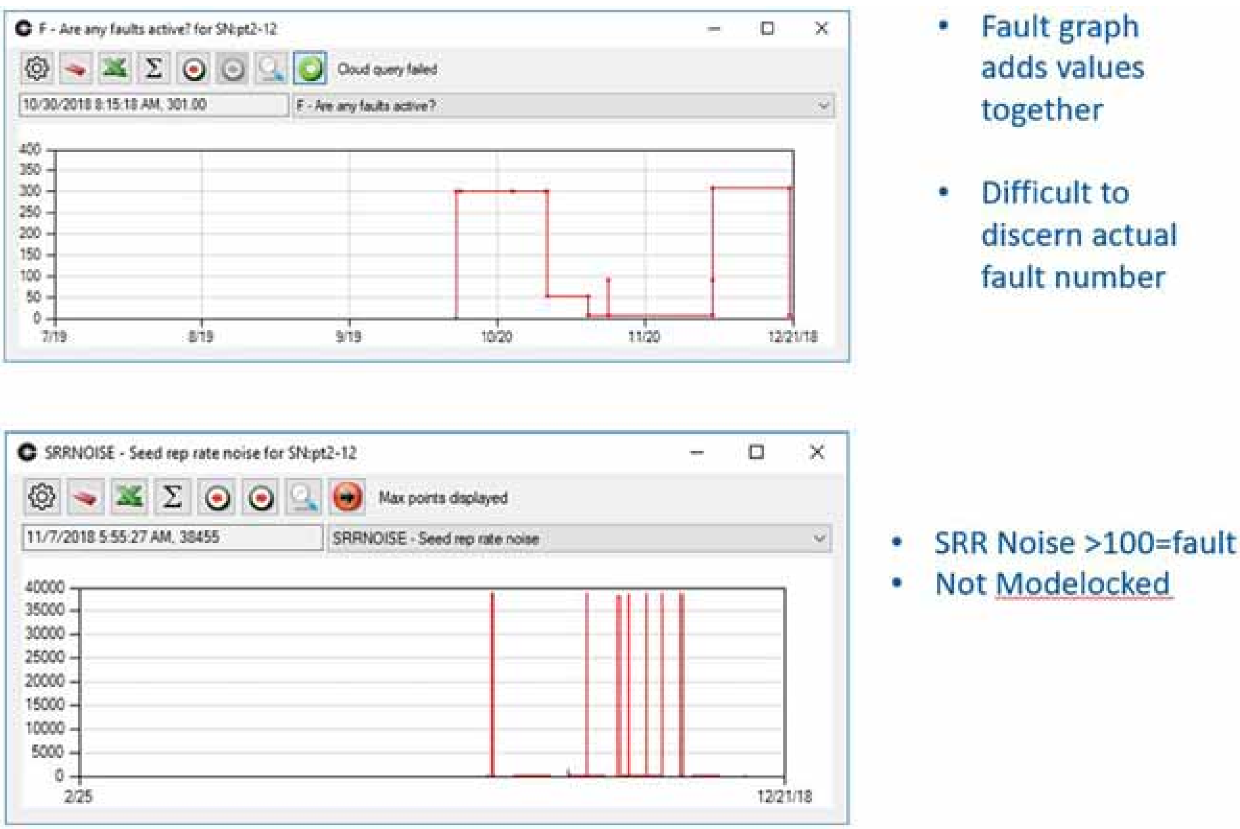


Figure 3.2-12. Graphing Fault History

5. The faults are displayed on the chart generated, although the Fault numbers may be difficult to read from the chart. In the example shown, the fault was cleared numerous times but not corrected so many instances were captured.

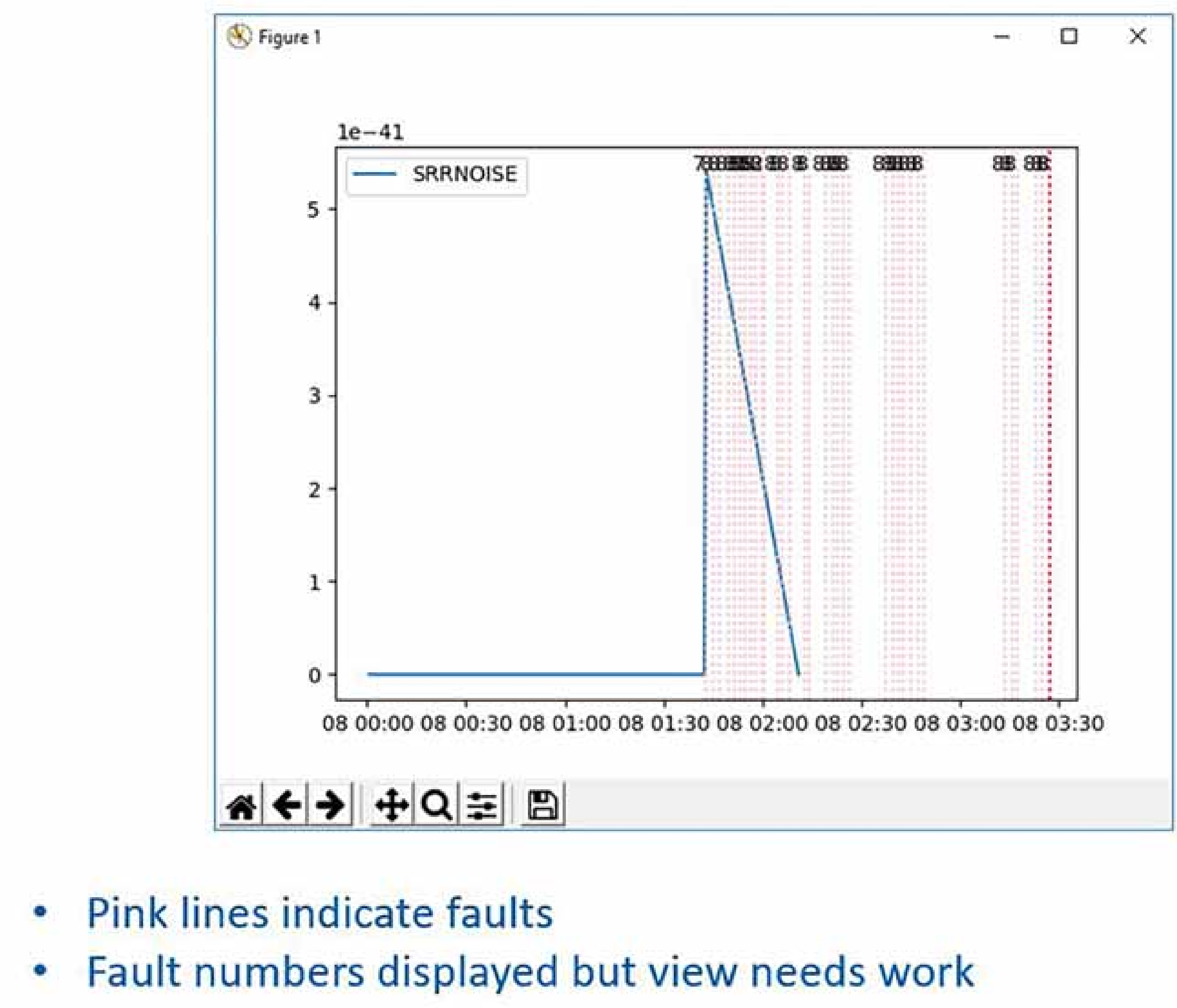


Figure 3.2-13. Faults Displayed

The chart below is a better example of the faults displayed on the chart. In this case, the reason for the CPU temperature rise is unclear because the baseplate appears stable.

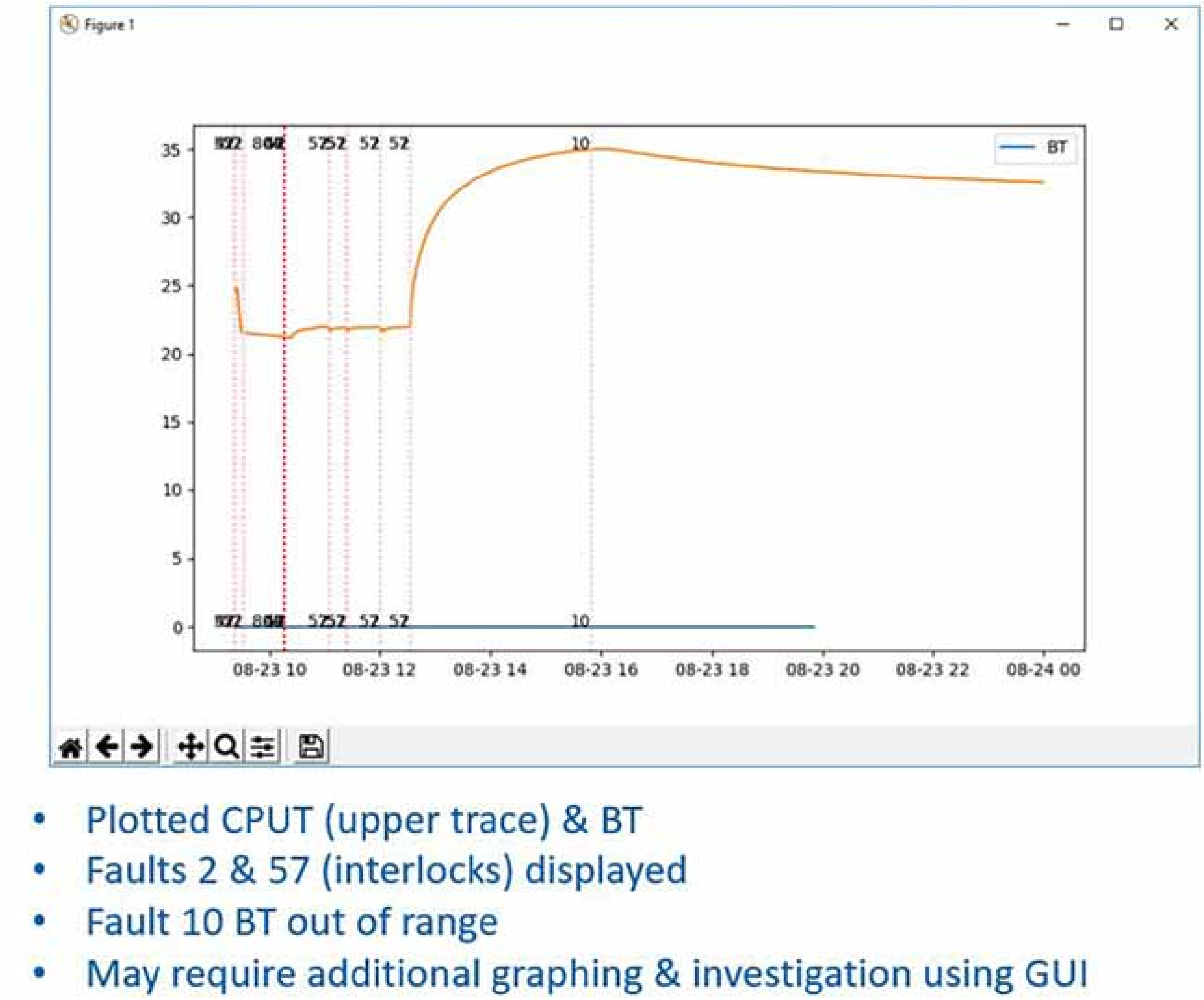


Figure 3.2-14. Plotting Faults

Below is an example of looking at the history of the laser to see inflection points indicating potential issues.

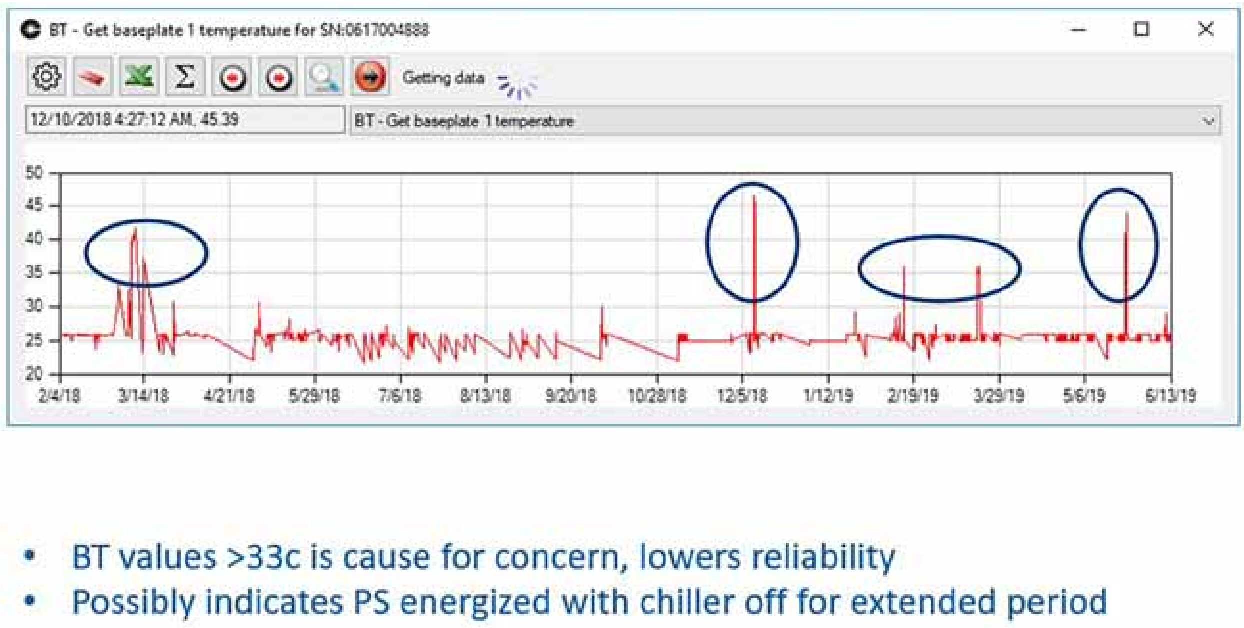


Figure 3.2-15. Troubleshooting Example

Firmware Updates

While firmware should not be updated as a standard maintenance procedure, updating the firmware may address specific reliability issues, system bugs, and feature enhancements. Below is a description of the recommended procedure for updating the firmware of the Monaco system.

1. Ensure the Shutter is closed and Pulsing/Diodes are off.
2. Open the Command Window and query the head serial number and software version using the commands ?HSN and ?SV.
3. Copy the responses to a notepad file as this information can be useful for troubleshooting at the factory (see Figure 3.2-16). Just highlight the text, right click, and choose Copy. Then right click on the Desktop and choose New Text Document, and give the new file a name such as the serial number of the laser. Open the notepad file, right click in the window, paste the text into the file, and Save.

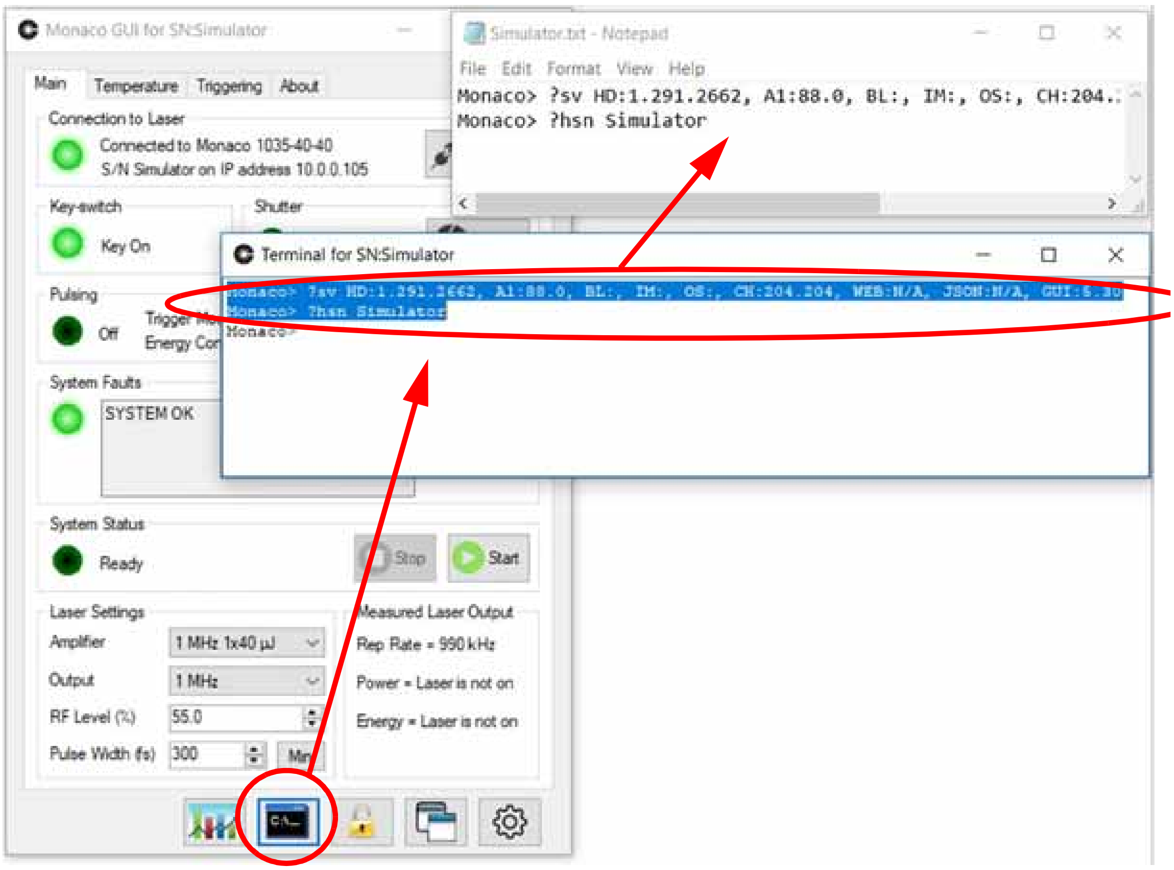
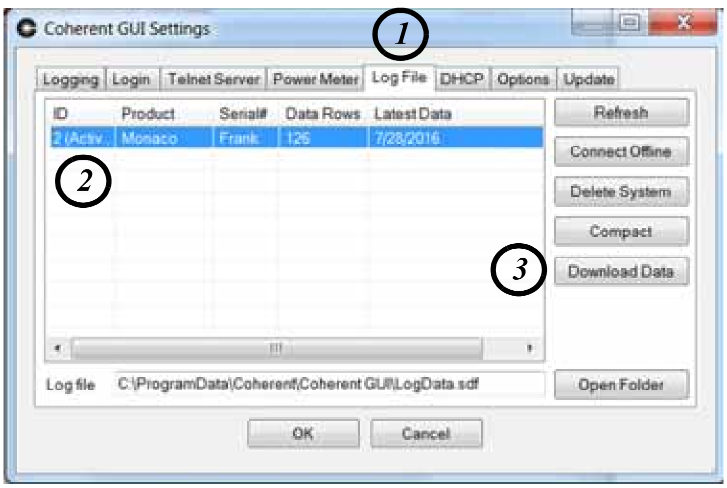


Figure 3.2-16. Query the Head Serial Number and Software Version

4. Next download the Log File. Click on the Adjust settings icon at the bottom of the GUI screen, click on the Log File tab as shown in Figure 3.2-17, select the active system from the list, click the Download Data button.

5. The Data Download window will open (see Figure 3.2-17 on page 18). 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. A message announcing “Done!” will display when the file is finished downloading.

6. Once the file is finished downloading, 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



1. Log File
2. Choose Active System
3. Download Data

4. Start Download
5. Save DataLog to Folder, Email, or Coherent Cloud

Figure 3.2-17. Downloading Datalog File

"Save" button. The folder window will open, and can be closed.

7. From the Tools tab (while in Service mode for the GUI), click on the Firmware Upgrade tool to open it.

8. Browse for the firmware update file on your PC, select it, click Open, and then click Upgrade (see Figure 3.2-18). Copies of the latest firmware (and GUI) files can be found and downloaded from the Service Sharepoint site: https://cohrinc.sharepoint.com/teams/Service/dpssSC/SitePages/Home.aspx

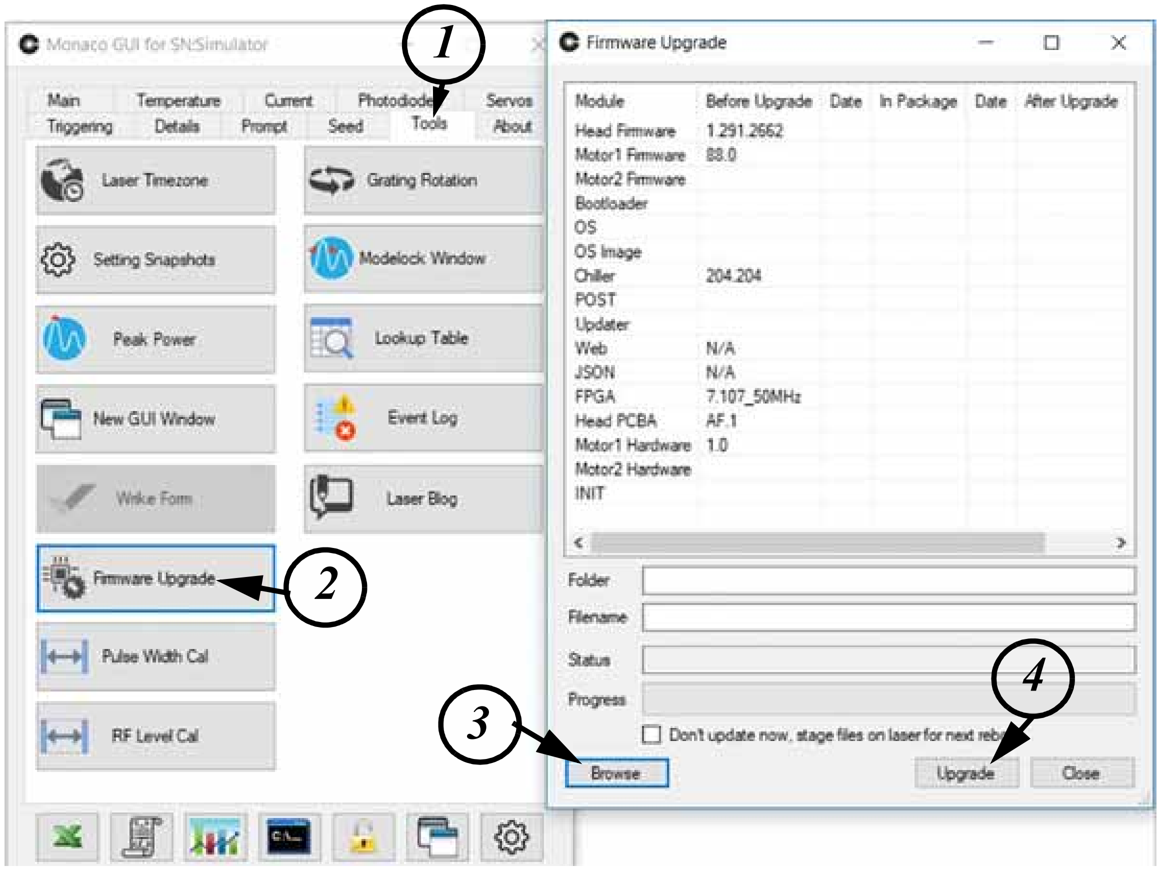


Figure 3.2-18. Firmware Update

9. Confirmation dialog boxes will appear. Click OK.
10. A series of status updates will appear and the progress bar will advance. After a period of time the system will automatically reboot. After the GUI reconnects, a final status update will appear stating "Upgrade Successful". Click OK, and close the Firmware Update window.

Using Telnet to Fix Firmware Issues

Some situations require making alterations to the Monaco file system to restore proper function. The symptoms include continual resetting and failure to connect. Also see FSB 975, Monaco Connection Issues. That FSB describes using the hardware watchdog jumper to stop the continual resets and enable a connection.

An alternative to using the hardware WDT jumper is to use an RS232 connection and the Updater program contained in the firmware. You will need to access 2 different types of connection. An RS232 connection and an ethernet connection.

Use a plain terminal program using RS232 to initially connect to the Monaco. When the system is in the process of booting up, press the ESC key rapidly until the updater screen appears (see Figure 3.2-19).

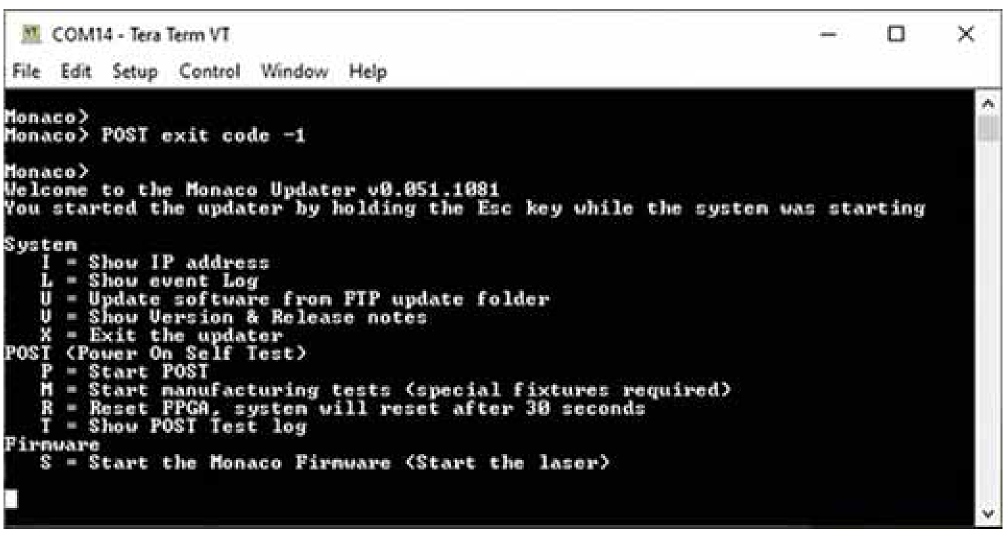


Figure 3.2-19. Terminal Updater Screen

Once this screen is displayed, Telnet may be used repair issues in the file system. Use the “I” key to display the IP address so you can use Telnet on an Ethernet connection.

All that is required is a stable connection to be able to connect via Telnet and fix any file issues.

Some possible errors are corruption of the datalog, firmware or cleaning out the update folder. A failed installation can leave files in the update folder resulting in messages indicating the update folder is not empty so firmware won't install. The technique is basically the same for each of these scenarios, only the target is changed.

Telnet is required. It is included in Windows but not enabled by default. To enable it, click the search windows icon  in Windows 10, go to Start, Run in Windows 7. Type in Windows Features and select Turn Windows Features on or off.

Or go to Control Panel and select Programs and Features. Select Turn Windows features on or off.

The window below will appear. Select Telnet Client as shown. Click OK.

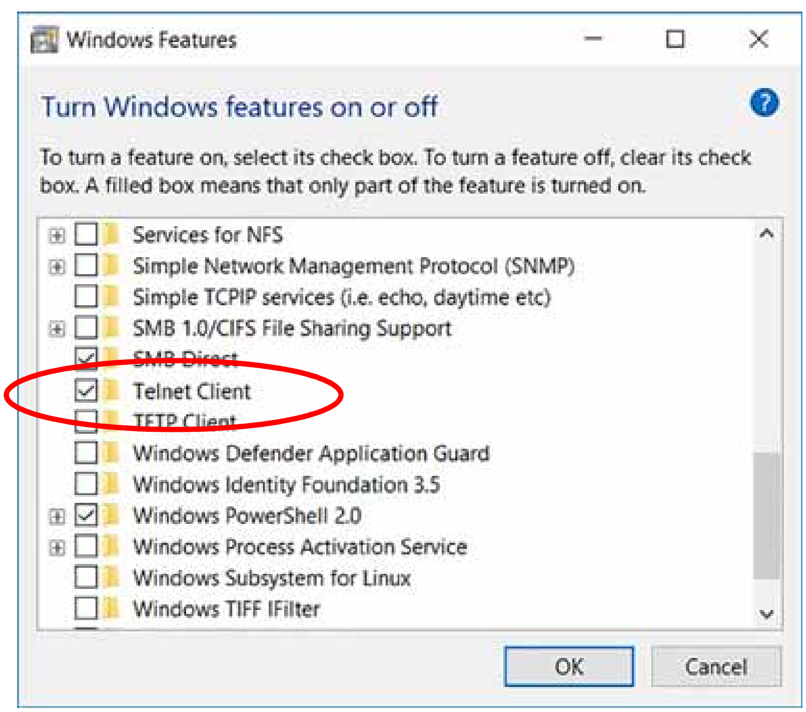


Figure 3.2-20. Select Telnet Client

In Windows 7, once the Telnet client is enabled, use it by going to the Start, Run, and typing in Telnet, and enter.

In Windows 10, again go to the Search Windows  icon and type in Telnet, and enter.

The window shown in Figure 3.2-21will appear.

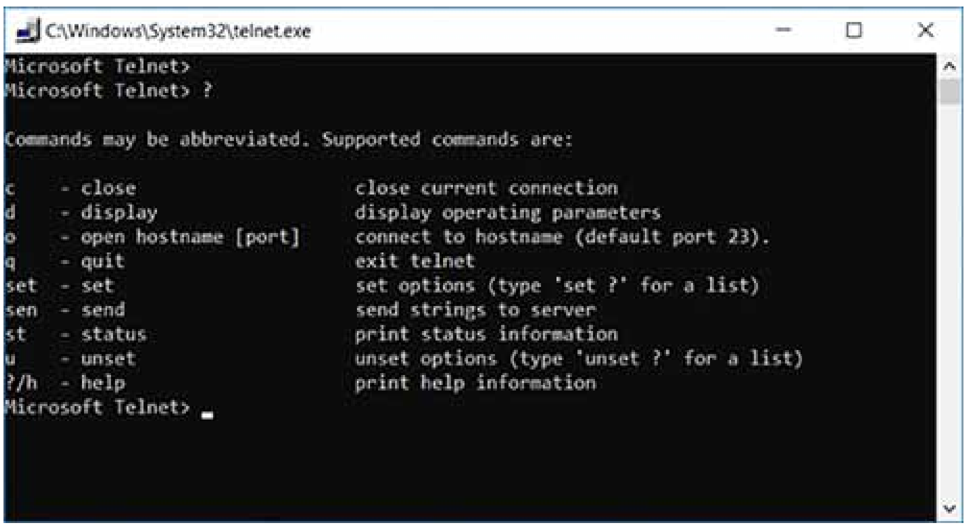


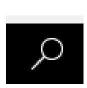
Figure 3.2-21. Telnet Window

A question (?) mark will display all possible commands.

Clean Out Update Folder

If a firmware upgrade is failing due to the Update folder not being empty, (a message will alert the user of this), use the flowing method to clean it out. You must have a stable connection. Use RS232 method above or the hardware WDT jumper.

1. Log in using Telnet
2. Open a Telnet window: Start→Run→ Telnet

Or  Telnet <enter>

3. Open IP address (port 24): Using port 24 enables access to the operating system (using the default port 23 connects to the Monaco firmware).

   Example: Using the Hostname:
   Open(*Monaco_headserialnumber*) 24
   Or
   Using IP address:
   open 10.66.38.74 24

4. Enter Username ("admin")
5. Enter Password (*production password required*)
6. List directories: type "Dir"
7. Navigate to update folder: "Cd flashdisk\update"
8. List files: type "Dir"
9. Delete any files in the update folder: type "Del *.*"
10. Use GUI to update firmware as normal.

Replace Corrupt Firmware

The process to replace corrupt firmware if a normal firmware upgrade through the GUI does not work as expected is listed below. There must be a stable connection - use RS232 method above or hardware WDT jumper. The major steps are:

- Extract the head firmware file from the update package zip file to the desktop.
- Log on via Ethernet using Telnet and rename the firmware file.
- Use FTP to send the new firmware to the Monaco
- Use Telnet to transfer new firmware file to the proper folder
- Reboot so new firmware begins to run.

Extract Firmware From Zip File

1. Select the head firmware and extract it to your desktop.
2. Rename it to Monaco.exe. (eliminate the version number). See Figure 3.2-22.

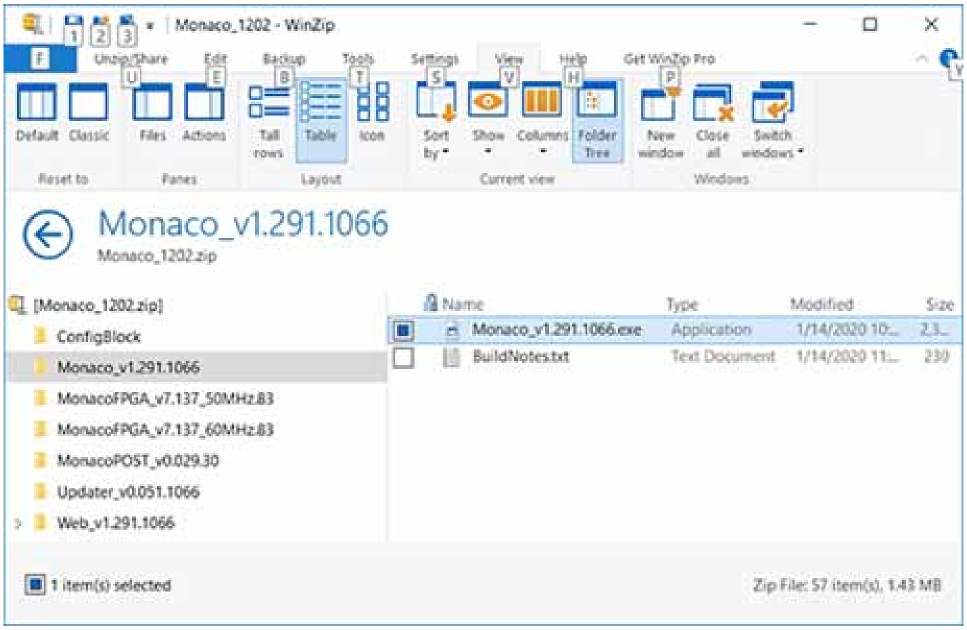
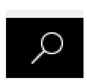


Figure 3.2-22. extract Firmware from Zip File

Your file is now ready to upload to the Monaco system.

Use Telnet to Rename the Existing Head Firmware

1. Open a Telnet window: Start→Run→ Telnet

Or  Telnet <enter> . See Figure 3.2-23.

2. Log in using Telnet:

   "Open (Monaco_*headserialnumber*) 24"

   OR by using the laser IP address:

   Example: "Open 10.66.38.74 24"

3. Enter Username: "admin"
4. Enter PW: (*production password required*)
5. Navigate to Monaco folder: "CD Flashdisk\Monaco"
6. List files: type "dir".
   The output should be as shown in Figure 3.2-24.

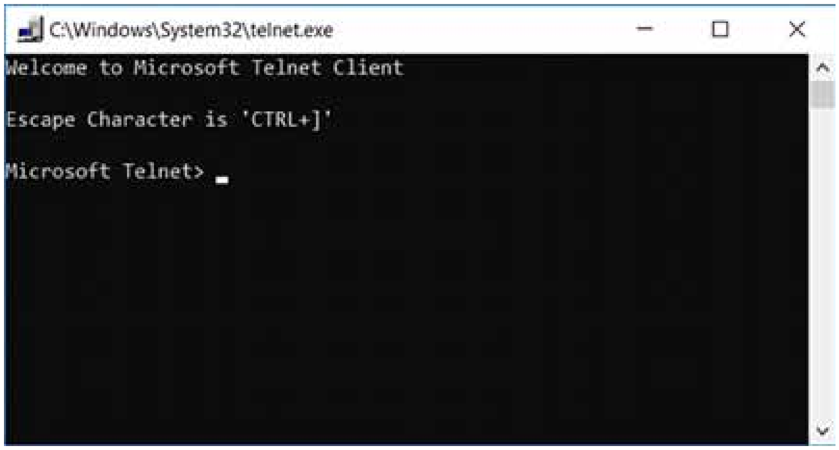


Figure 3.2-23. Telnet CMD Window

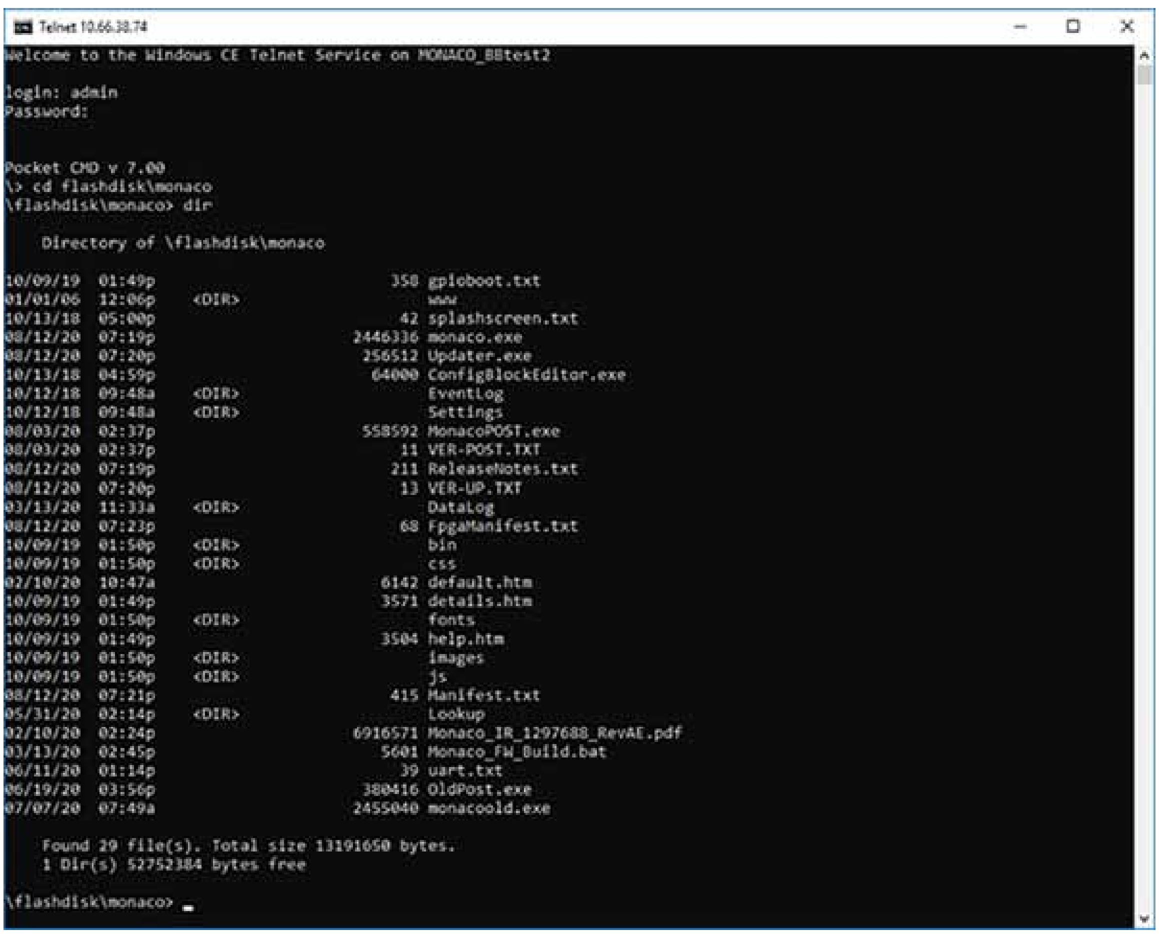


Figure 3.2-24. List Monaco Directory

7. Rename Monaco.exe:
   type "Ren Monaco.exe MonacoOld.exe"

Use FTP to Send New Firmware to Monaco

1. Open Another Command Window: Run --> CMD
2. Navigate to the Desktop where the new firmware file is found by typing "cd desktop". It should respond as:

   C:\Users*username*\Desktop>

3. Connect FTP server to Monaco system:

   Type "FTP *IPaddress"*

Or

   "FTP *hostname"*

For example with a laser with an IP address of 10.66.38.74:
   C:\Users*Username*\Desktop>ftp 10.66.38.74

4. When prompted, enter user credentials: type "admin"

Example:

   User (10.66.38.97:(none)): admin

5. When prompted (i.e. 331 User name okay, need password.), enter the password. Type the Production level password, which should remain hidden. The response should be:

   230 User logged in, proceed.

   ftp>

6. (STEP UNDER REVIEW) Navigate to the update folder. Type " cd flashdisk\update". This is where you will send your new firmware file to.
7. Perform the File Transfer (FTP): type "put monaco.exe". This should send the new firmware file to the Update folder of the Monaco. (In the example screenshot Figure 3.2-25 below, the file is called tempfile.txt.)

The response should be:

200 Command okay.
150 File status okay; about to open data connection.
226 Closing data connection.
ftp: xxx bytes sent in 0.22Seconds 0.16Kbytes/sec

See Figure 3.2-25 below as an example of a file transfer following these steps.

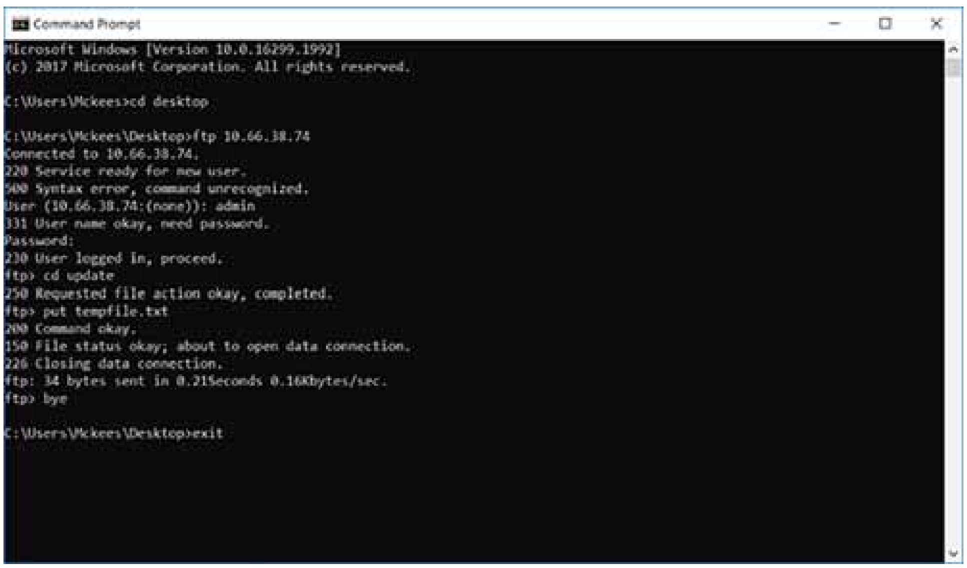


Figure 3.2-25. File Transfer

8. Quit the FTP program: type “bye”. The response should be:

   C:\Users\username\Desktop>

9. Close the CMD (FTP) window: type “exit”.
10. Switch to other CMD (Telnet) window connected to the laser.

At this time, the new firmware file should have been deposited (Put) into the Update folder.

11. Look in the laser’s Update directory and check the new firmware file is there. Type “cd flashdisk\update” to access the

folder, then type “dir”. See Figure 3.2-26 below. The firmware file should appear in the directory (in the example here the file name is “tempfile.txt”).

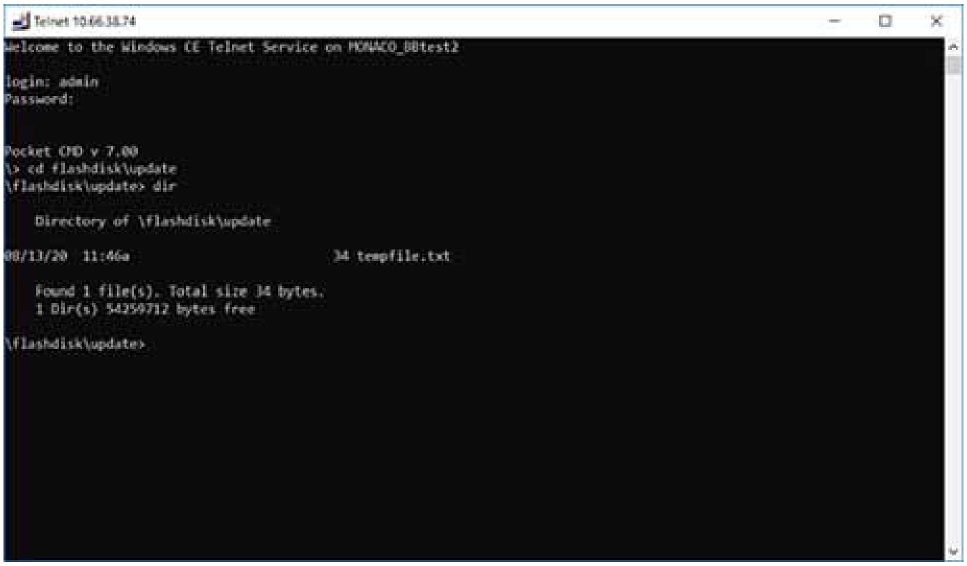


Figure 3.2-26. Verify File Transfer

12. Now change to the Monaco folder:
    type “cd \flashdisk\monaco”.
    The response should be:
    “\flashdisk\monaco>”
13. Move the uploaded file into the Monaco directory:
    type “Move .. update\monaco.exe”
14. Type “dir”, and check your file is now listed in the directory for the Monaco folder.
15. Close the connection. Type “exit” to leave telnet. The response should be:

    Microsoft Telnet>

16. Type “Quit” to close the CMD window.
17. Reboot the Monaco.

Telnet and FTP Information For Reference

Telnet Commands

Escape Character is 'CTRL+]'
Microsoft Telnet> ?
Commands may be abbreviated. Supported commands are:

Table 3.2-1. Telnet Commands

c - close	close current connection
d - display	display operating parameters
o - open hostname [port]	connect to hostname (default port 23)
q - quit	exit telnet
set - set	set options (type 'set ?' for a list)
sen - send	send strings to server
st - status	print status information
u - unset	unset options (type 'unset ?' for a list)
?/h - help	print help information

FTP Commands

Transfers files to and from a computer running an FTP server service (sometimes called a daemon). FTP can be used interactively.

Table 3.2-2. FTP Commands

-v	Suppresses display of remote server responses
-i	Suppresses auto-login upon initial connection
-n	Turns off interactive prompting during multiple file transfers

Table 3.2-2. FTP Commands (Continued)

-d	Enables debugging
-g	Disables filename globbing (see GLOB command)
-s:filename	Specifies a text file containing FTP commands; the commands will automatically run after FTP starts
-a	Use any local interface when binding data connection
-A	Login as anonymous
-x:send sockbuf	Overrides the default SO_SNDBUF size of 8192
-r:recv sockbuf:	Overrides the default SO_RCVBUF size of 8192
-b:async count	Overrides the default async count of 3
-w:windowsize:	Overrides the default transfer buffer size of 65535
host	Specifies the host name or IP address of the remote host to connect to

Notes:

- mget and mput commands take y/n/q for yes/no/quit.
- Use Control-C to abort commands.

Serial Commands

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 3.2-3 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).

Query

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

Table 3.2-3. 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.”		

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.

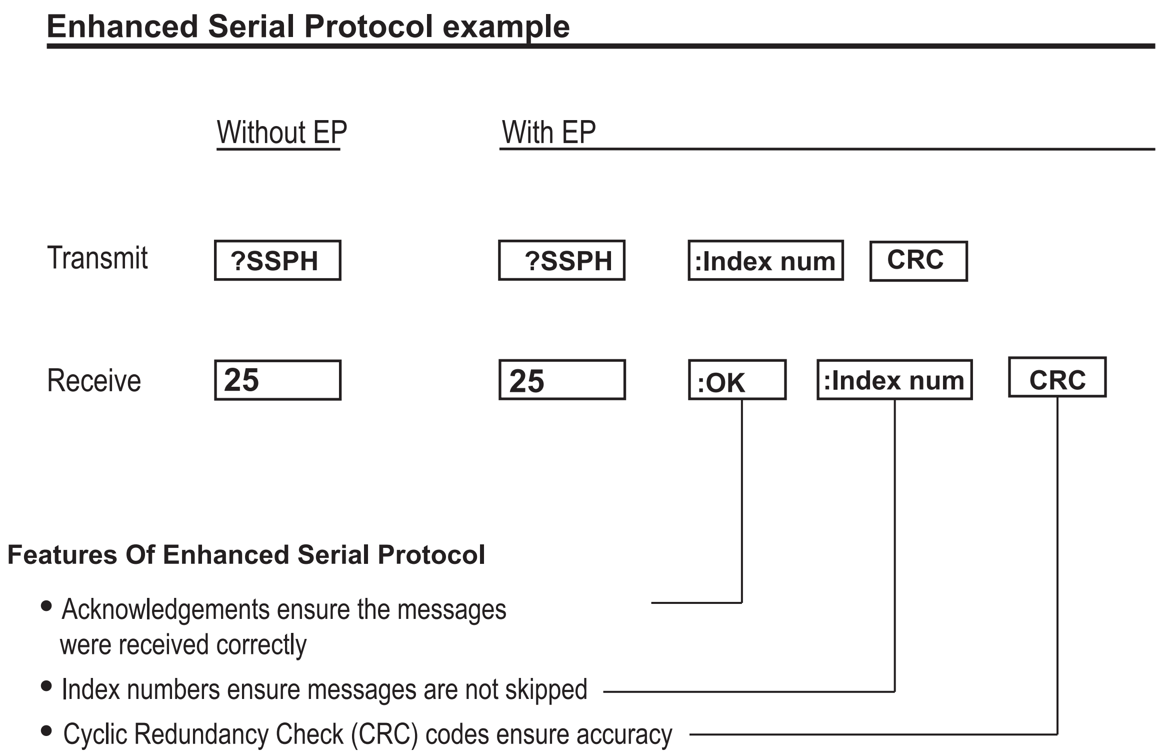


Figure 3.2-27. Enhanced Serial Protocol

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.

Instruction Set

Table 3.2-4 describes the instructions for use in RS-232 serial command communication with the Monaco system..

Table 3.2-4. RS-232 Commands and Queries (Sheet 1 of 12)

COMMANDS & QUERIES	RETURNED INFORMATION
PROMPT=n >=n	n = 0 turns off "Monaco Laser >" prompt n = 1 turns on "Monaco Laser >" prompt
?	Indicates a query
?A1DT	Get AOM1 delay
A1DT	Set AOM1 delay
?A1DW	Get AOM1 width
A1DW	Set AOM1 width
?A1RD	Get AOM1 ramp delay
A1RD	Set AOM1 ramp delay
?A1RN	Get AOM1 Seeder Burst count
A1RN	Set AOM1 Seeder Burst count
?A1RW	Get AOM1 ramp width
A1RW	Set AOM1 ramp width
?ACCESS	What is the current access level?
ACCESS	Change the access level
?ACCESSMAX	What is the maximum access level?
?ACCESSTIMEOUT	Get timeout for ACCESS command
ACCESSTIMEOUT	Set timeout for ACCESS command (value from 0 to 3000).
?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 with time internal defined by ALERTPERIOD).

Table 3.2-4. RS-232 Commands and Queries (Sheet 2 of 12)

COMMANDS & QUERIES	RETURNED INFORMATION
?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 with time internal defined by ALERTPERIOD).
?ALERTW	Get enable alert signal for warnings
ALERTW	Set enable alert signal for warnings
?ALTMOD	Gets the external modulation input mode
ALTMOD=n	Sets the external modulation input mode: n = 0 for extended interface pin 15 n = 1 for EXT MOD mini BNC connector
?ANYFI	Is a fault code inhibited?
ANYFI	Inhibit a fault code
?ANYFITIMEOUT	Get ANYFI timeout
ANYFITIMEOUT	Set ANYFI timeout
?AOM2LOCK	Is AOM2 lock enabled?
AOM2LOCK	Enable AOM2 lock
?AOM2LOCKTIME	Get AOM2 lock time (seconds)
AOM2LOCKTIME	Set AOM2 lock time (1 to 3600 seconds)
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
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.
?CHAPPROVED	Get chiller approval

Table 3.2-4. RS-232 Commands and Queries (Sheet 3 of 12)

COMMANDS & QUERIES	RETURNED INFORMATION
CHAPPROVED	Set chiller model approval
?CHBPDELTA	Get max chiller/baseplate delta temperature to exit D3 TEMP STATE
?CHBPDELTAMAX	Get chiller/baseplate warning will occur if the chiller/baseplate temperature delta is above this value
?CHBPDELTAMIN	Get chiller/baseplate warning will occur if the chiller/baseplate temperature delta is below this value
?CHDELTAFAULT	Get chiller delta fault will occur if the chiller/chiller set point temperature delta exceeds this value
?CHDELTAWARN	Get chiller delta warning will occur if the chiller/chiller set point temperature delta exceeds this value
CHEN = n	Set chiller enable: n = 0 turns off the chiller n = 1 turns on the chiller
?CHEN	Returns status of chiller enable
CHENAUTO	Enables the automatic chiller setting (0 = disable, 1 = enable)
?CHENAUTO	Returns the chiller enable automatic setting.
?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
?CHPL	Returns chiller minimum pressure
CHSERVEN	Enables the timer to generate a warning to customer to change the chiller water and filter. SERVICE access.
CHSERVSTART	Resets the start time for chiller service. SERVICE access.
CHSERVICED=n	Setting n=1 will clear the chiller service warning, and resets the service start time. CUSTOMER access.
?CHSERVICEHRSREM	Displays the remaining hours before chiller service is required.

Table 3.2-4. RS-232 Commands and Queries (Sheet 4 of 12)

COMMANDS & QUERIES	RETURNED INFORMATION
?CHSERVOPERIOD	Returns D3 light loop period
CHSERVOPERIOD	Set D3 light loop period
?CHSERVSTART	Gets the start time for chiller service. CUSTOMER access.
CHSERVSTART	Resets the start time for chiller service. SERVICE access.
?CHSN	Returns chiller serial number.
?CHST	Returns chiller set point
?CHSTARTTIME	Gets the start time for chiller service.
?CHSTOFF	Gets the chiller set point when diodes are OFF
CHSTOFF	Sets the chiller set point when diodes are OFF
?CHSTON	Gets the chiller set point when diodes are ON
CHSTON	Sets the chiller set point when diodes are On
?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

Table 3.2-4. RS-232 Commands and Queries (Sheet 5 of 12)

COMMANDS & QUERIES	RETURNED INFORMATION
?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
?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 protocol code numbers
?ENHANCED PROTOCOL ?EP	Returns enhanced protocol code numbers
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 ready state if the fault condition is lifted.

Table 3.2-4. RS-232 Commands and Queries (Sheet 6 of 12)

COMMANDS & QUERIES	RETURNED INFORMATION
?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” in Chapter 4 of the Operator’s Manual.
?HB	Returns the heartbeat timeout in seconds (0=disabled)
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 compo-nents
IP = nnn.nnn.n.n	Sets the static IP address
?IP	Returns the IP address for Ethernet

Table 3.2-4. RS-232 Commands and Queries (Sheet 7 of 12)

COMMANDS & QUERIES	RETURNED INFORMATION
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
?IREC	Returns IR count
?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.

Table 3.2-4. RS-232 Commands and Queries (Sheet 8 of 12)

COMMANDS & QUERIES	RETURNED INFORMATION
?LOOKUP REPRATES NAMES	Returns a list of the laser repetition rates/seeder burst lengths that are available in the format, (reprate in kHz):(seeder burst length). For example: ?LOOKUP REPRATES NAMES 200:5, 250:4, 1000:5, 1000:1, 2000:1, 4000:1 NOTE: This will inform the user what modes of operation are available using the GUI Amplifier menu or using the SET command (See “SET Command” on page 3.2-51.)
?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
?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

Table 3.2-4. RS-232 Commands and Queries (Sheet 9 of 12)

COMMANDS & QUERIES	RETURNED INFORMATION
?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.
PWFINE=n	Sets the pulse width fine tuning in %, range of -100 to 100. This works in conjunction with the Peak Power Optimizer.
?PWFINE	Returns the pulse width fine tuning in %
?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
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

Table 3.2-4. RS-232 Commands and Queries (Sheet 10 of 12)

COMMANDS & QUERIES	RETURNED INFORMATION
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
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 3.2-51.

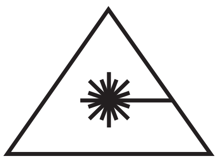
Table 3.2-4. RS-232 Commands and Queries (Sheet 11 of 12)

COMMANDS & QUERIES	RETURNED INFORMATION
?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: 0 = Good 1 = Bad 2 = Used 3 = Consumed
?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
?SUBNET	Returns the Ethernet subnet
?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

Table 3.2-4. RS-232 Commands and Queries (Sheet 12 of 12)

COMMANDS & QUERIES	RETURNED INFORMATION
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 the Operator's Manual 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.
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.

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.

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 (PULSES). Entering the query "?SET" will provide the current values for the laser parameters *MRR, PW, RRD, and PULSES* (e.g. "1000,400,2,1").

Amplifier Repetition Rate (*MRR*): 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. Values for *MRR* (in kHz) must be chosen from those in the GUI Amplifier Rep Rate drop down menu (see Figure 3.2-28). For example, for the laser shown a value of 1000 kHz could be entered in the SET command to configure the laser for 1MHz operation. However 600 kHz could not be entered because it 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 1-4 MHz can be entered manually.

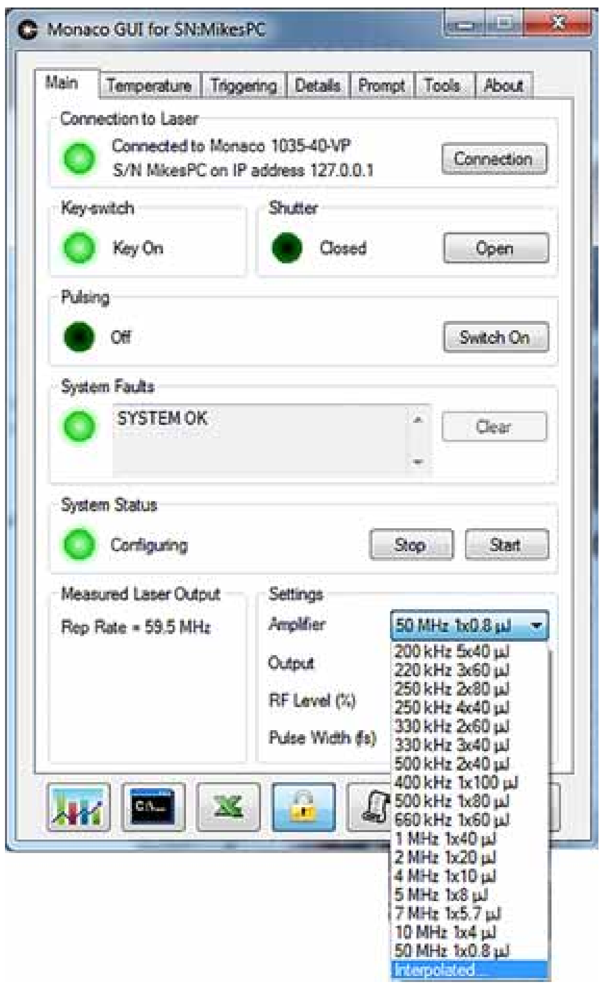


Figure 3.2-28. Amplifier Rep Rate Drop Down Menu

Pulse Width (*PW*): The SET command also allows the user to configure the laser's output pulse width. Values for *PW* (in femto-seconds) 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 10.1 psec pulse width, as shown on the datasheet, then the configuring the laser for 10.1 psec operation could not be entered as a valid SET command.

Repetition Rate Divisor (*RRD*): 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 Operator's Manual for Operating Modes). The laser's output pulse (or seeder burst) repetition rate would be the amplifier repetition rate divided by RRD. Values for *RRD* can be from 1 to 65535. For example, setting the amplifier repetition rate (MRR) to 1 MHz and the repetition rate divider (RRD) to 4 then the output repetition rate would be 250 kHz.

Number of Pulses per Seeder Burst (*PULSES*): The SET command also allows the user to configure the number of pulses in each seeder burst from the laser (see Operator's Manual for Seeder Burst Mode). Note that *PULSES* = 1 (one pulse in each seeder burst) is simply a continuous stream of single pulses. Values for the amplifier repetition rate (*MRR*) and for *PULSES* must be chosen from those in the GUI Amplifier Rep Rate drop down menu (see Figure 3.2-28). For example in the laser shown, the laser could be configured for 500 kHz repetition rate with 2 pulses per seeder burst, but 400 kHz repetition rate with 2 pulses per seeder burst is not an available option.

The SET command can be used to configure the laser in four ways:

1. SET=*MRR,PW,RRD,PULSES* where *RR* is the requested amplifier rep rate in kHz, *PW* is the pulse width in femtoseconds, *RRD* is the repetition rate divisor, and *PULSES* 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 500 kHz 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. Several examples of using the SET command this way are shown in Table 3.2-5 below:

Table 3.2-5. 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 output rep rate 450 fsec pulse width 2 pulses per seeder burst
SET=500	Set amplifier rep rate to 500 kHz, pulse width and rep rate divisor are unchanged, seeder burst set to 1 pulse
SET=400,,4,1	100 kHz output rep rate, pulse width unchanged

2. SET=*i* where if *i* is less than 10 (*i* < 10) then it will configure the laser for *i* pulses per seeder burst, and if i is greater than 10 (i>10) then it will configure the laser for an amplifier repetition rate of *i* kHz. All other parameters will remain unchanged (if possible). For example, "SET=2" will configure the laser for 2 pulses per seeder burst, set the amplifier repetition rate to 500 kHz, and leave all other parameters unchanged. Note that if multiple choices are available with 2 pulses per seeder burst, then an error will be returned and no change is made. As an example when *i* > 10, "SET=1000" sets the amplifier rep rate to 1 MHz, leaves pulse width and repetition rate divisor unchanged, and sets the seeder burst to 1 pulse. Note that if multiple choices are available at this amplifier rep rate, then the choice with 1 pulse per seeder burst is chosen.

3. SET *parameter1=x parameter2=y*, where *parameter1* or *parameter2* can MRR, PW, RRD, or PULSES and *x* or *y* can be any allowed values for those parameters. For example, SET MRR=200 PULSES=5 configures the laser for amplifier repetition rate (MRR) of 200 kHz and the number of pulses per seeder burst (PULSES) to 5.

4. SET=NAME where a group of settings can be given a unique name. Therefore another valid form of the SET command would be SET=NAME, where NAME is the designation given to the settings for that configuration. For example, if the

Monaco laser were configured with a group of settings titled "SMARTCLEAVE" then to configure the laser for "SMART-CLEAVE" operation, SET=SMARTCLEAVE would be entered. To list any available named modes, enter the query ?LOOKUP REPRATES NAMES. For example:
?LOOKUP REPRATES NAMES 200:5, 250:4, 1000:5, 1000:1, 2000:1, 4000:1, SMARTCLEAVE

In summary, shown below are all valid forms of the SET command:

SET=MRR,PW,RRD,PULSES

SET=PULSES

SET=MRR

SET MRR=x PULSES=y RRD=z PW=w

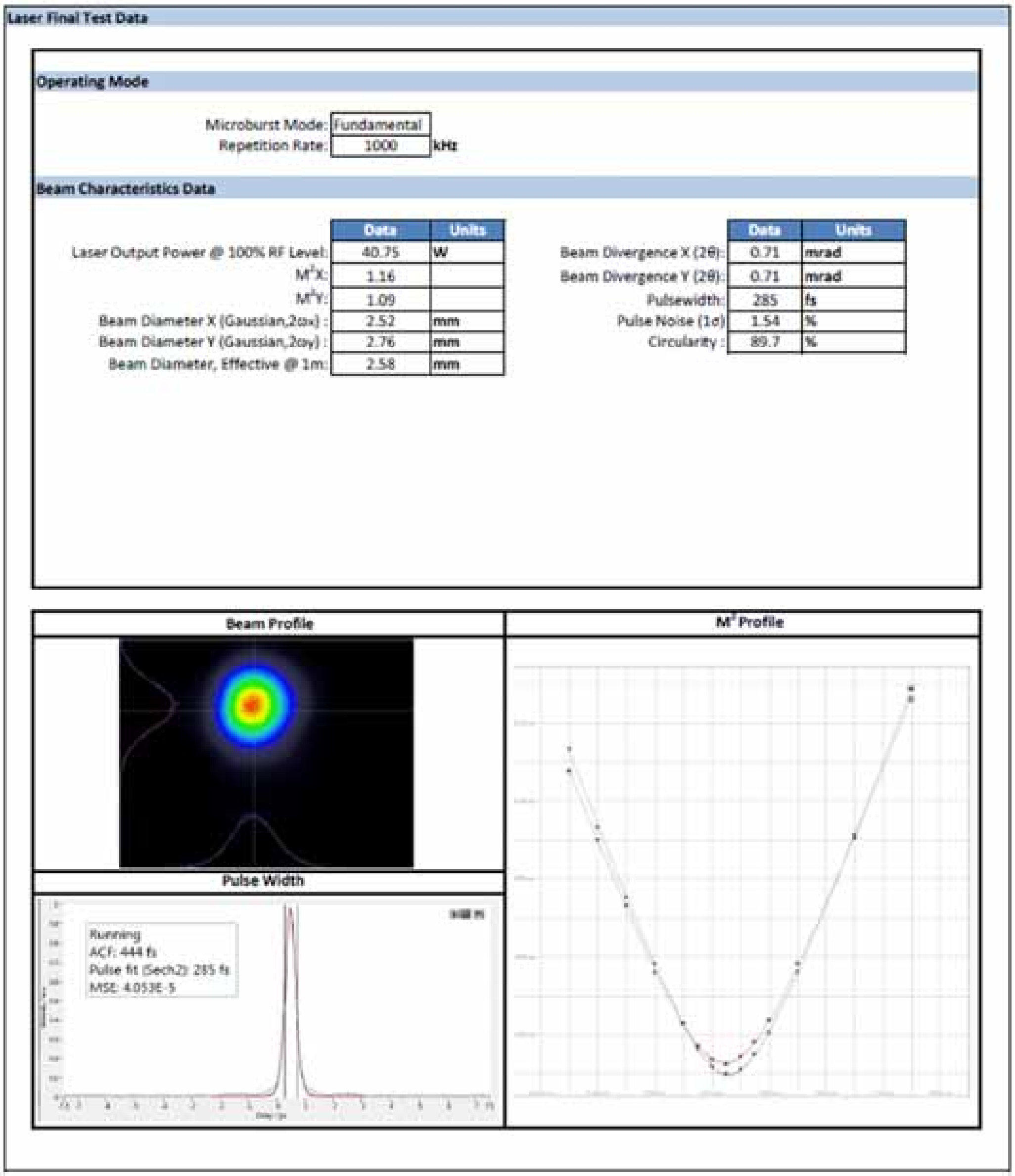
SET MRR=x PULSES=y RRD=z

SET MRR=x PULSES=y

SET=NAME

Introduction

The figures below provide an example of the data sheet shipped with the laser, and detail the parameters that should be operated at when verifying operation.



Laser Final Test Data

Operating Mode

Microburst Mode:	Fundamental	
Repetition Rate:	1000	kHz

Beam Characteristics Data

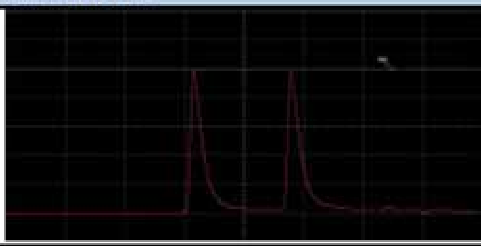
	Data	Units
Laser Output Power @ 100% RF Level:	40.75	W
M^2X:	1.16	
M^2Y:	1.09	
Beam Diameter X (Gaussian,2σx) :	2.52	mm
Beam Diameter Y (Gaussian,2σy) :	2.76	mm
Beam Diameter, Effective @ 1m:	2.58	mm

	Data	Units
Beam Divergence X (2θ):	0.71	mrad
Beam Divergence Y (2θ):	0.71	mrad
Pulsewidth:	285	fs
Pulse Noise (1σ):	1.54	%
Circularity :	89.7	%

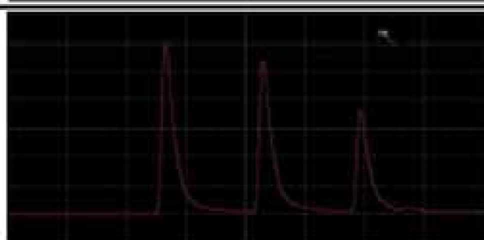
Figure 4.1-1. Customer Datasheet Example (Page 1)

Laser Final Test Data

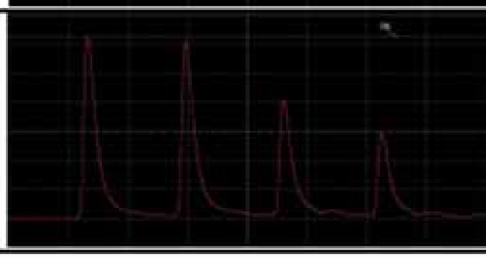
Microburst Mode Data



	Data	Units
Microburst Mode:	2	pulse
Repetition Rate:	500	kHz
Output Power @ 100% RF Level:	40.57	W
Pulsewidth:	302	fs*



	Data	Units
Microburst Mode:	3	pulse
Repetition Rate:	333	kHz
Output Power @ 100% RF Level:	40.5	W
Pulsewidth:	314	fs*



	Data	Units
Microburst Mode:	4	pulse
Repetition Rate:	250	kHz
Output Power @ 100% RF Level:	40.62	W
Pulsewidth:	360	fs*

*Pulse width numbers are obtained by overlaying pulses in the burst mode by Autocorrelation

Figure 4.1-2. Customer Datasheet Example (Page 2)

Pulse Width Calibration

The pulse width calibration procedure can be performed when the customer's pulse measurement device has a small variation from the laser's stated pulse width setting. When performing the pulse width calibration procedure, the laser must be tested at the specified output power and repetition rate. The laser should run for at least 30 minutes after all temperatures have been optimized.

Procedure

1. The customer should have their pulse measurement equipment set up (typically an autocorrelator). Check that the input polarization is correct (the Monaco has vertical polarization) and that the customer is assuming a SECH squared deconvolution factor for pulse width calculation. The pulse width must be measured at 40W so beam attenuation will probably be required.
2. Open the Pulsewidth Calbration Tool from the Tools tab.
3. Record the current settings by clicking on the Export button, and saving the Excel or text file to your computer (see Fig below).
4. From the GUI Main tab, choose the shortest pulse width setting for the laser (e.g. 300fs from Fig below).
5. Open up the command Prompt from the GUI, and enter serial command PWACAL=1 to begin the calibration procedure. NOTE: Once the calibration procedure is begun, all the pulsewidths must be entered.
6. Note the current grating angle by entering the query ?MPWA or by opening the Grating Rotation tool from the Tools tab.
7. Enter the pulsewidth in femtoseconds measured externally by the customer's equipment by entering the PW=xxx (e.g. PW=365
8. Adjust the compressor grating angle to the next angle in the table (for example 33.496 from Fig below). The compressor angle can be adjusted either by entering the command MPWA=XX.XXX (e.g. MPWA=33.496) or by entering directly into the Grating Rotation Tool.l

9. Repeat step 7, and continue repeating steps 8 and 7 until all the pulse widths from the original table has been entered. Additional points can be entered for improved correlation to the customer's instrument.

10. Enter the command PWACAL=0 to complete the pulse width calibration procedure. The pulse width calibration table will be automatically updated.

11. Check the calibration by entering pulse widths from the Main tab and comparing to the customer's measurement.

	A	B	C	D
1	Product	Monaco 1035-40-VP		
2	System	PT2-24		
3				
4	Row	Motor	Pulse Width (fs)	PD4V (V)
5	1	33.505	300	2.928
6	2	33.496	315	2.753
7	3	33.486	415	2.268
8	4	33.466	725	1.406
9	5	33.446	1100	1.025
10	6	33.417	1685	0.775
11	7	33.396	2050	0.656
12	8	33.347	3000	0.5
13	9	33.297	3915	0.411
14	10	33.286	4070	0.399
15	11	33.236	5030	0.346
16	12	33.187	5940	0.313
17	13	33.137	6890	0.293
18	14	33.067	8060	0.28
19	15	33.016	9000	0.27
20	16	32.961	10000	0.26

Figure 4.2-1. Pulse Width Calibration Example

IR Detector/ PD3 Change

The IR power detector (PD3 assembly) can be replaced in the field, often as a corrective action for a failure in the light control loop

Required Tools

- 2mm hex key
- 2.5mm hex key
- 4mm hex key
- Power meter to confirm performance

Required Parts

- Assembly, PCF IR Detector, Monaco (p/n 1304179)

Procedure

1. Check that the laser power supply is turned off before installation or rework of the IR detector.
2. Remove the handle (if installed) over the access panel which requires a 4mm screwdriver. See Figure 4.3-1 below.

Figure 4.3-1. Removing the Handle

3. Remove the cover-plate which requires a 2mm screwdriver to remove the five screws. See Figure 4.3-2.

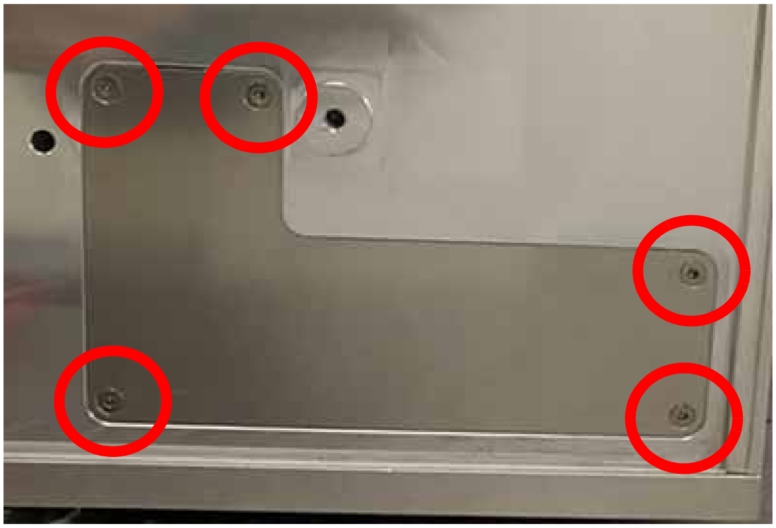


Figure 4.3-2. Removing the Cover-Plate

4. Disconnect the cable to the PCB and remove the three screws with a 2 mm screwdriver. Remove the PCB and place in an anti-static bag. See Figure 4.3-3 below.

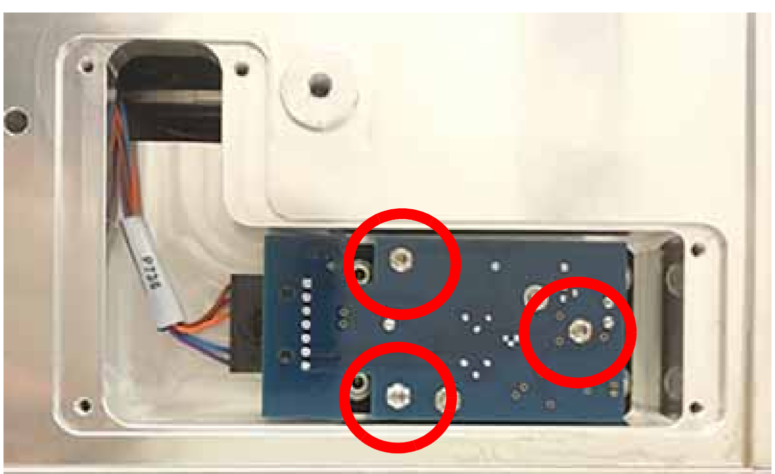


Figure 4.3-3. IR Detector PCB

5. Remove the mounting plate by removing the four screws with the 2.5 mm screwdriver. See Figure 4.3-4 below.

Figure 4.3-4. IR Detector Mounting Plate

6. Remove the O-Ring. See Figure 4.3-5 below.

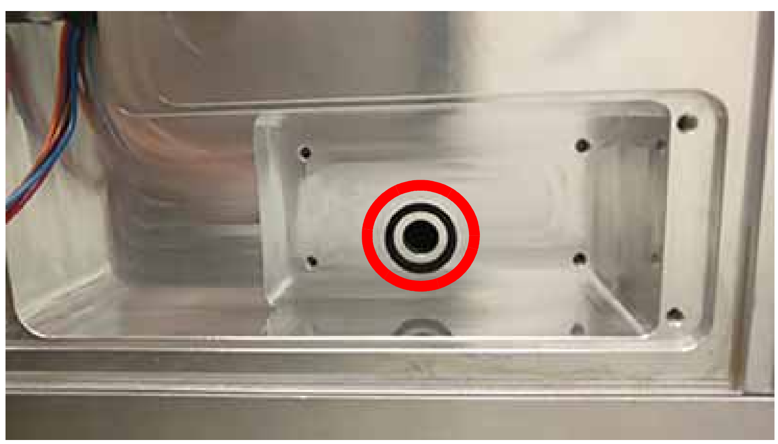


Figure 4.3-5. IR Detector O-Ring

7. Perform steps #6 - #2 in reverse order installing the new IR Detector assembly components (O-ring, mounting plate, and PCB).

8. Start the laser, and after warmup confirm the output power matches the setting and is stable using the power meter.

Headboard Change

The headboard is the main electronic FRU component for the Monaco laser and can be swapped in the field when required.

Required Tools

- Keysight 34134A DC Current Probe
- 2mm hex key
- 2.5mm hex key
- 4mm hex key
- 3/32” hex key
- Phillips head screwdriver
- 1/4” wrench
- Laser Emission extension cable, part number 1288096
- Standard ESD protection (e.g. wrist strap, ESD mat, etc.)

Required Parts

- FRU Assembly, Headboard, part number 1341017
  (Includes Standoffs, qty 6, part number 1277356)
- Warranty stickers for top cover, part number 1152062

Procedure

NOTE!
Proper ESD protection protocols (e.g. using the wrist strap) must be followed when working with the headboard PCBA.

---

1. Power on the laser and the GUI on the computer (laser emission off).
2. From the GUI’s Tool menu (in Service mode), export the following as a backup:
   - Export the Pulse Width calibration
   - Export the Lookup Table settings
3. From the Settings Snapshots tool, create a new snapshot and export the current settings.

4. If possible, turn on laser emission and check the current power with a power meter.

5. Check the current sensor readings from PDS, PD1, PD2, PD3, PD4 and record them, OR get the sensor readings for PDS, PD1, PD2, PD3, PD4 from the GUI's datalog from when the laser was last used (or when it was in production).

6. If it's not possible to turn on laser emission, note the output power from the datasheet that came with the laser. Some laser models have 40W output and some have 42W output.

7. Turn off power to the laser at rear of power supply.

8. Turn the chiller off.

9. Remove all the connections from the back of the laser (USB, Ethernet, power cable, etc.)

10. Remove the handles from the laser, two screws each (8 total) using a 4mm hex key.

11. Remove the beauty cover from the laser, 4 screws using a 2mm hex key. With a Beta4 cover, a tool may be needed to pry it up since the cover edge is pressed tightly into a groove.

12. Remove the interior cover by loosening the 14 screws using a 2.5mm hex key. It is usually easier to leave the screws in place and carefully move the cover aside.

13. Remove the O-Ring from the groove in the top of the housing.

14. Remove all connectors to the headboard. There should be 23 connectors in all, including the two main power input wires that require a Phillips head screwdriver (note the polarity of the wires before removing them) and an RF connector that requires a 1/4" wrench. See Figures 4.4-1 and 4.4-2 below.

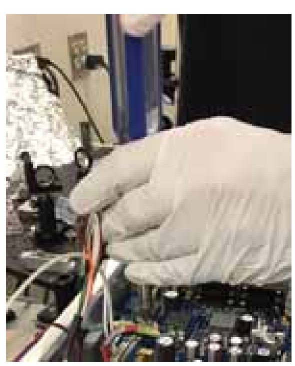
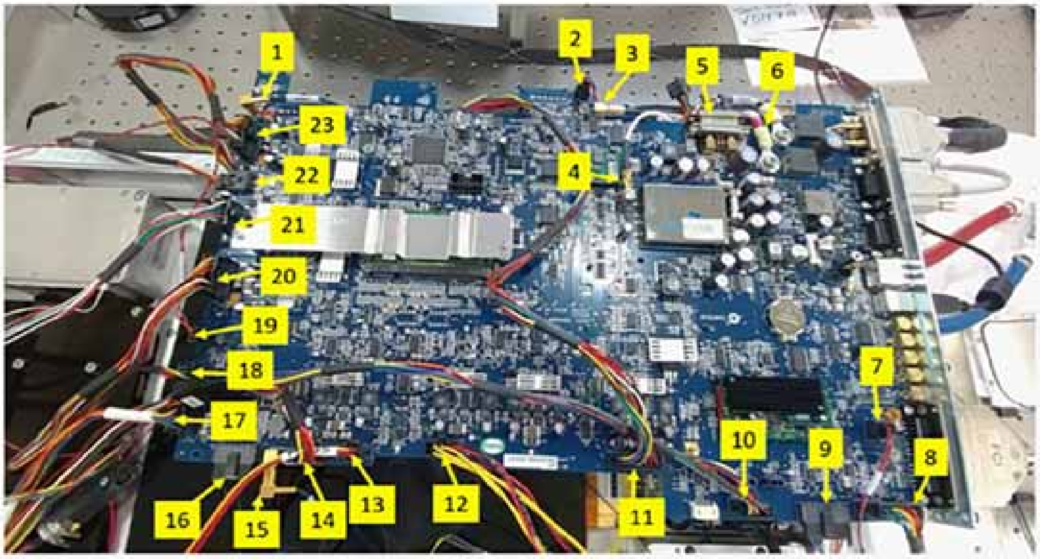


Figure 4.4-1. Removing Power Input and RF Connections



1. Photo Diode #1
2. AOM #2 Rf Driver power
3. AOM #2 Rf Driver Digital Input
4. AOM #2 Analog Input
5. AOM #1 Rf Driver
6. Power to nlight Board
7. Interlock
8. Nlight Driver Control
9. Photo Diode #3
10. Rotating Stage Driver
11. Diode #2 Control Board
12. CFBG Temp
13. Photo Diode #5 power
14. Feed Through
15. Photo Diode #5 signal
16. Base plate Thermistors 1,2
17. SESAM motor
18. Photo Diode #4
19. Recirculator Power
20. Seed Diode Driver Board
21. Shutter
22. Laser Emissions Light
23. Diode #1 Driver Board

Figure 4.4-2. Headboard Connections

1. J737
2. J721
3. J719
4. J724
5. J741
6. J732, J733
7. J710
8. J730
9. J736
10. J723
11. J204
12. J704
13. J705
14. J729
15. J715
16. J734
17. J728
18. J703
19. J760
20. JS04
21. J702
22. J726
23. J104

These are all the connectors as labelled on the Control Nexus board. The cables have the mating connectors labelled with Pxxx, in most cases. The exceptions are the 14pin diode DS, D1 and D2 connectors. These cables are interchangeable and are labelled with PX04. You must determine these three by their position on the board and the diode positions on the tray.

Figure 4.4-3. Headboard Connector Labels

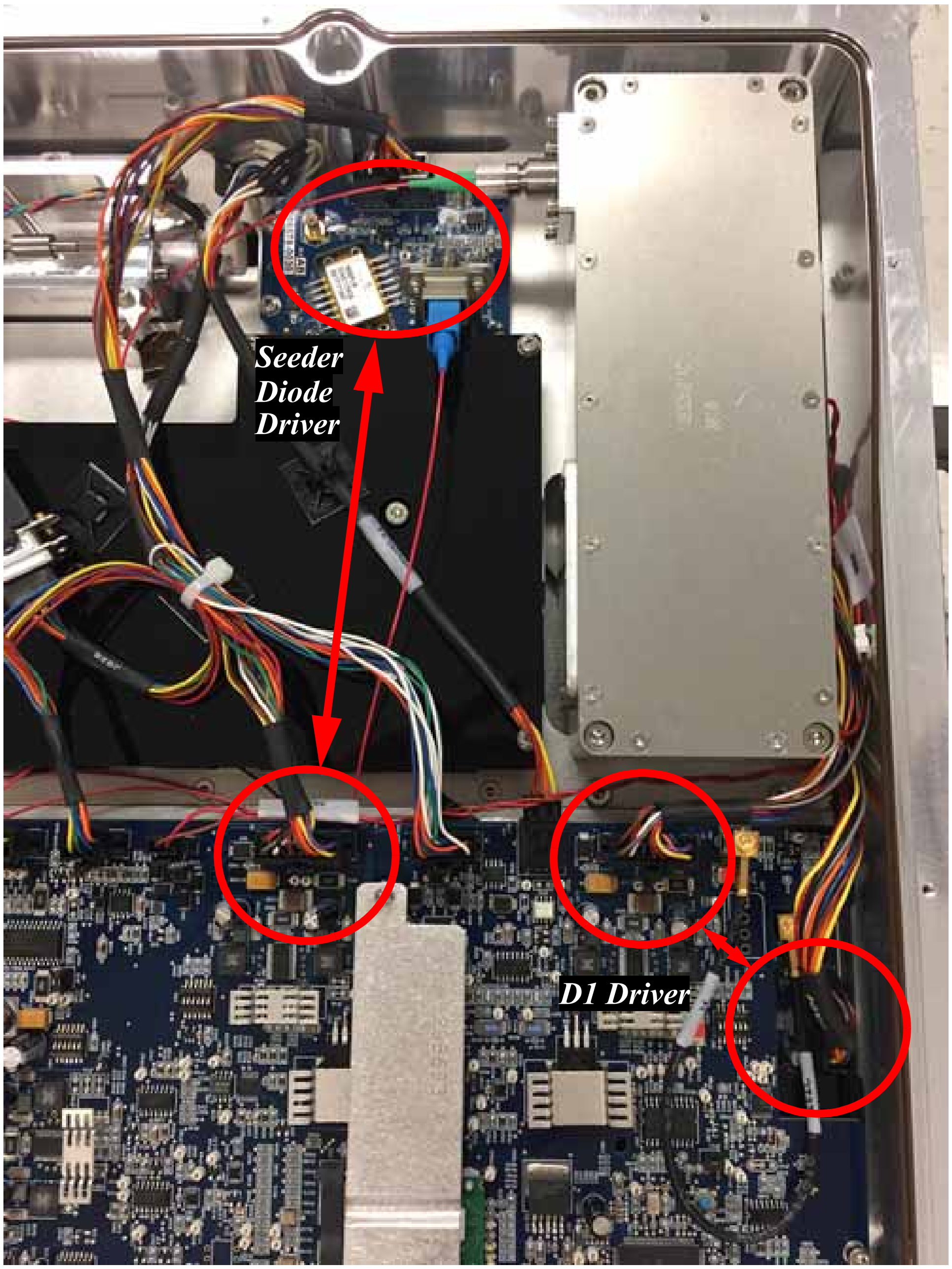


Figure 4.4-4. Seeder and D1 Connections

WARNING!
Take particular care when working around, or removing the connectors from, the front left corner of the headboard as the thin optic fibers (red and transparent) underneath are easily damaged. See Figure 4.4-5 below.

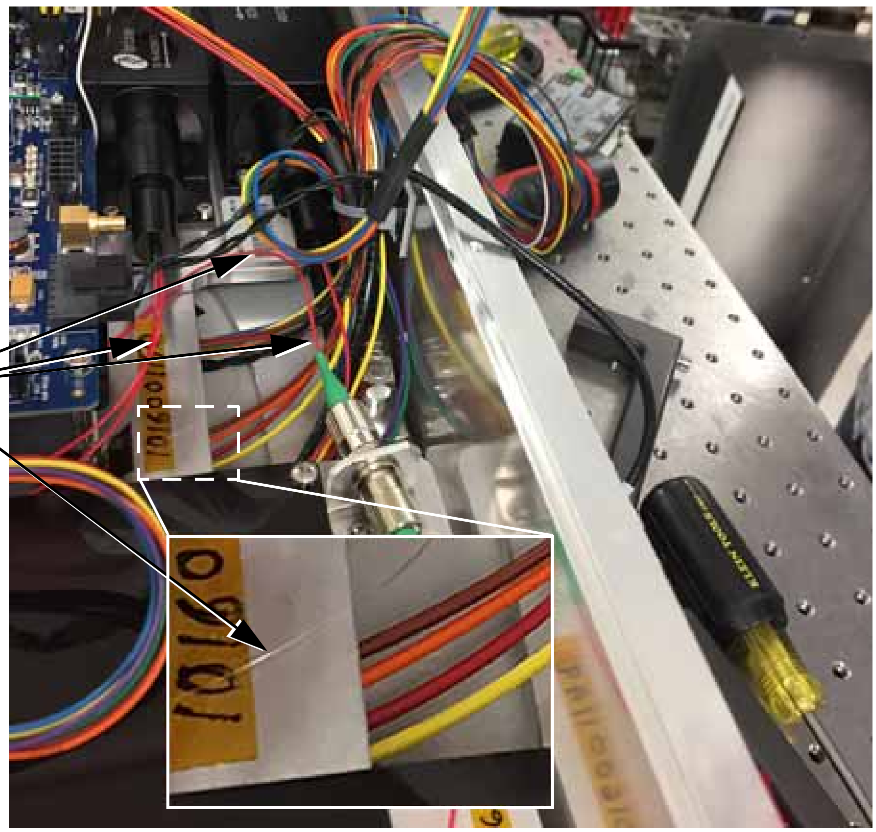


Figure 4.4-5. Delicate Optical Fibers (Transparent Fiber Shown Highlighted)

15. Carefully move the cables out and away from the headboard, particularly the power input wires.
16. Remove the Toradex Heat Sink and the Toradex module using a standard 3/32” hex key (note this is the only step that a non-metric, standard hex key is required). The heat sink stand-offs may need to be removed from the old headboard assembly and installed on the new board. See Figure 4.4-6 below. Put the module into an anti-static bag.

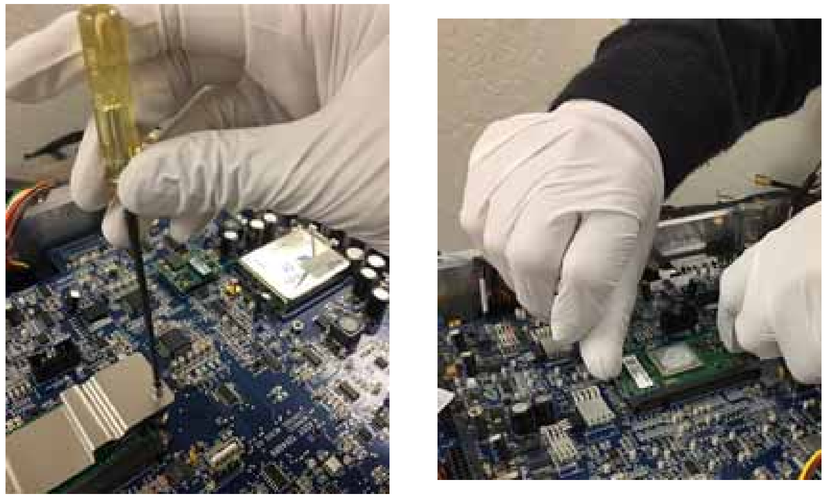


Figure 4.4-6. Removing the Toradex Module

17. Remove the motor driver board. Put it into an anti-static bag. See Figure 4.4-7 below.

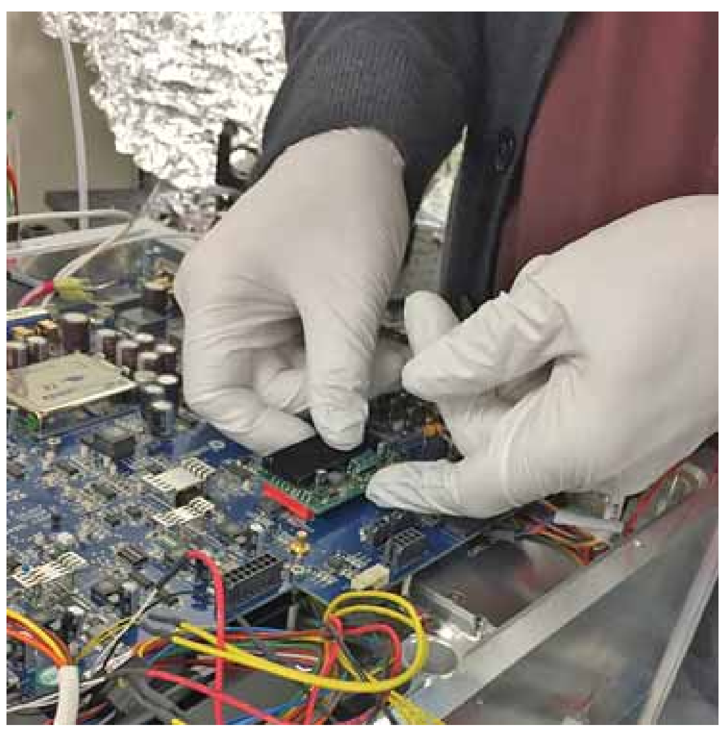


Figure 4.4-7. Removing the Motor Driver Board

18. Remove the Headboard PCBA after removing the screws. Note that it uses seven M3 screws requiring a 2.5mm hex key.

19. Mount a new headboard to the housing of the laser as shown in Figure 4.4-8 using the metal standoffs below and above the board. In general, any parts will be replaced with the latest revision. Consult FSB documentation for any compatibility issues.

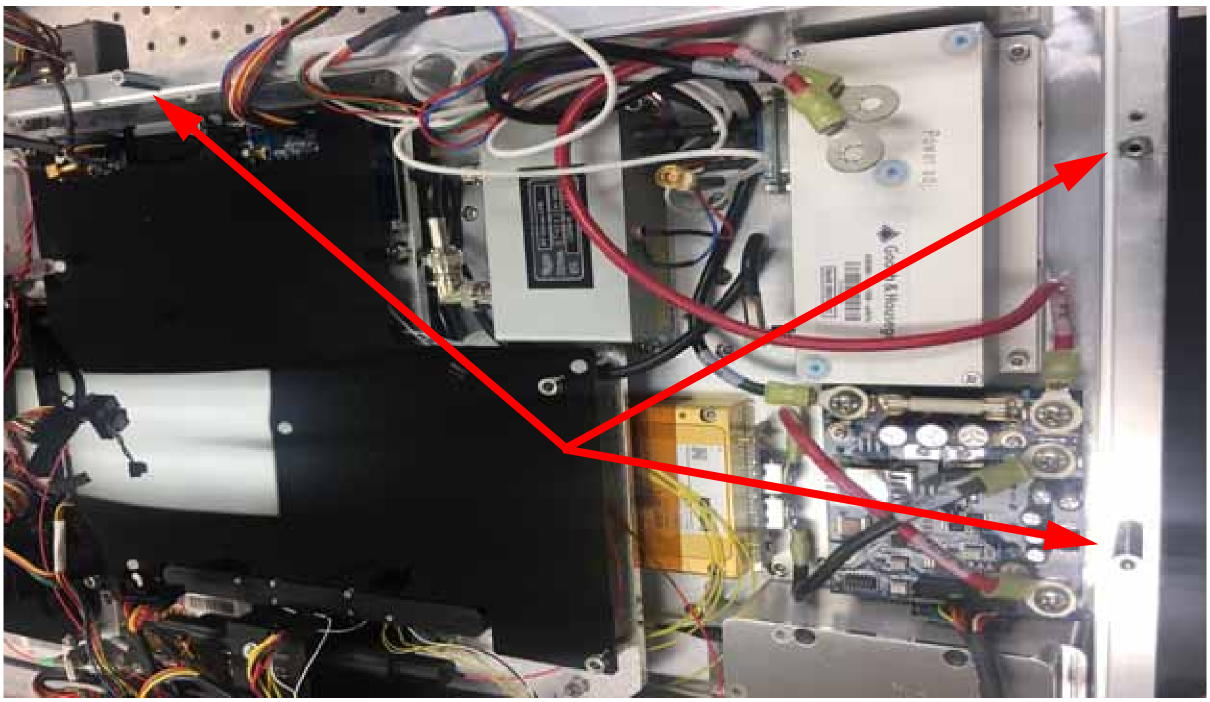


Figure 4.4-8. Mounting the Headboard to Housing

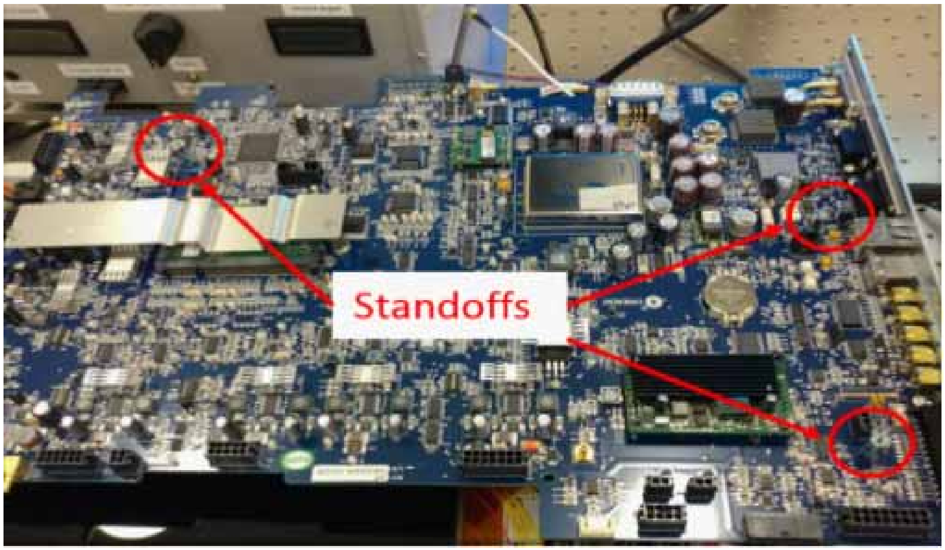


Figure 4.4-8. Mounting the Headboard to Housing (Continued)

20. Reverse steps 14 to 17 above (including installing the previous motor driver board and Toradex on the new headboard), and then replace all the connections at the back of the laser (USB, Ethernet, power cable, etc.). Refer to Figure 4.4-4 to ensure that the interchangeable Seeder Diode, Diode 1, and Diode 2 connections are placed correctly.(change order so that connector keeps board grounded)
    For some lasers it may be necessary to temporarily install the emission cable extension (part number 1288096) so that the emission light cable (#22 in Figure 4.4-2) remains connected while the headboard is mounted to the housing.
21. Plug in the Dongle into the extended interface (one should have been shipped with the laser).
22. Turn on power to the laser and enter Service mode.
23. Turn off the light loop via the serial command: D3LLEN=0.
24. From the Main tab of the GUI, Start the laser up to D2.
25. Ensure DS, D1, and D2 are at their previous current levels. Check that PDSV, PD1V, and PD2V are also at their previous values. Different revision headboards can have different amounts of circuit gain resulting in lower PD voltage values even though the current levels are the same.For example, changing from a Rev. AD headboard to a Rev. AF headboard requires changing the software gains in the Photodiode tab (see

Figure 4.4-9) to bring the voltage levels back to their previous values.
Increasing the gains to overcome the Threshold voltages, and allow the system to operate, should only be done after fully understanding why the voltage levels are low.
NOTE: Only change the software gains if the diode currents are at their previous levels. Reduced current and pumping in the preamplifier stages can result in damage to either the diodes or PCF or both. If the currents are not the same as previous levels, then contact Product Support.

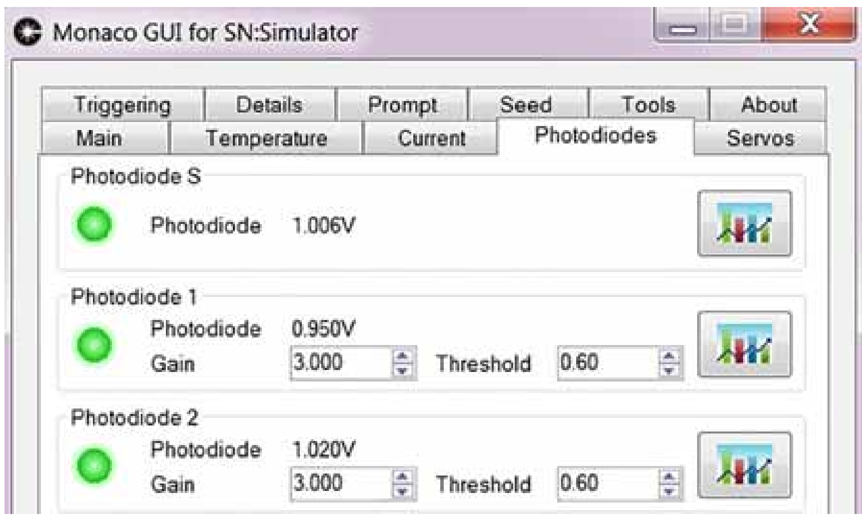


Figure 4.4-9. Software Gains in the Photodiode Tab

26. Use the current clamp on the black D3 diode current supply cable to monitor the actual current against the read current (positive indicator on the current clamp goes towards the diode). Use the zeroing dial if needed. See Figure 4.4-10 and Figure 4.4-11 below.

27. Open the command prompt window from the GUI to calibrate the diode. See Figure 4.4-12 below.

28. Enter the commands displayed below while monitoring current:
    - d3c=2, (set at 2A)
    - d3cp1=xxx.xx, (xxx.xx is the measured current when D3 is set at 2A)
    - d3c=10, (set at 10A)
    - d3cp2=xxx.xx, (xxx.xx is the measured current when D3 is set at 10A)
    - d3cal=1, (Calibration complete)
    - d3c=0

Figure 4.4-10. Diode Current Calibration

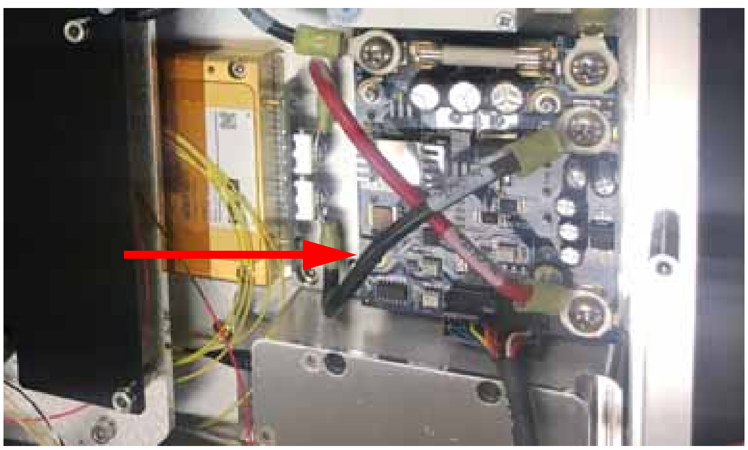


Figure 4.4-11. D3 Current Cable (black)

Figure 4.4-12. Command Prompt Window

29. Press Stop on the GUI Main tab to turn off DS, D1 and D2.
30. Turn off main power at the power supply.
31. Remove the headboard from the risers and install it into the laser head replacing the seven M3 screws requiring a 2.5mm hex key.
32. Turn main power back on at the power supply, reconnect GUI, and open the command window.
33. D3LLEN=1, turn the light loop back on.
34. Start the laser.
35. Check PD4V. It should be approximately the same as was previously recorded (and not zero). Note that PD4V values read differently with the cover off, so some difference is expected. If PD4V is low, run the PD4 Optimizer to find a more optimal seeder diode current.
36. Check PD3V. If not the same as the previously recorded PD3V and the output power is not 40-42W per the spec sheet for the laser, adjust PD3LLSV until it closely matches. If PD3LLSV is adjusted confirm that there is sufficient headroom for the D3 current (D3RC>D3C).
37. L=0, turn off the laser.
38. Turn off power to the laser at the power supply.
39. Install the covers reversing steps 10 to 13 above. Remove the user interface defeat plug and replace the customer connection if installed.
40. Turn on the laser and confirm performance, particularly PD4V.
41. Return laser to customer and ensure that they are delighted.

Servicing Different Head Board Revisions

The previous method for replacing headboards was written when the current revision headboard was AF. The latest board is now rev. AK. Newer revisions will be implemented, as development is ongoing. The pulse leveling scheme requires different optimization steps depending on which revision board is used.

Currently the Service Strategy for the Monaco is to replace boards only with the same revision (e.g. replace rev AF board with rev AF board). Repairing headboards with revisions no longer available as a FRU requires Depot Repair.

Shutter Replacement

The shutter is typically not a FRU for the Monaco laser, but can be swapped in the field when required. Note that the procedure below applies to both the IR and Green Monaco laser systems.

Required Tools

- 2.5mm hex key
- 3mm hex key
- 4mm hex key
- Cutters to remove cable tie

Required Parts

- Assembly, Shutter (contact Product Support)
- Plastic cable tie, 4” or greater
- Warranty stickers for top cover

Procedure

1. Power off the laser and remove all connections.
2. Remove the top cover frame: using the 2.5mm wrench, loosen the 14 screws. Carefully lift the cover frame keeping the screws in place. See Figure 4.5-1.

Figure 4.5-1. Removing the Cover Frame

3. Remove the sheet metal cover (see Figure 4.5-2).

Figure 4.5-2. Removing Sheet Metal Cover

4. Disconnect the shutter plug, being careful to avoid fibers including the seed fiber (see Figure 4.5-3).

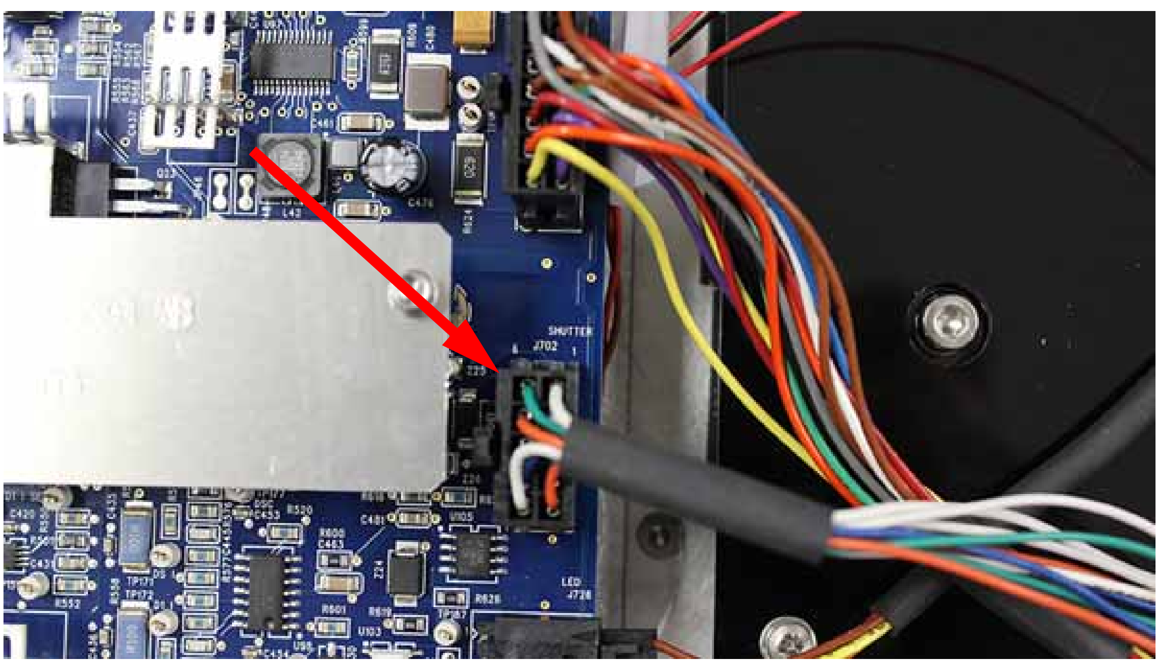


Figure 4.5-3. Shutter Plug

WARNING!
Take particular care when working around, or removing connectors from, the headboard as the thin optic fibers (red and transparent) are easily damaged. See Figure 4.5-4 below.

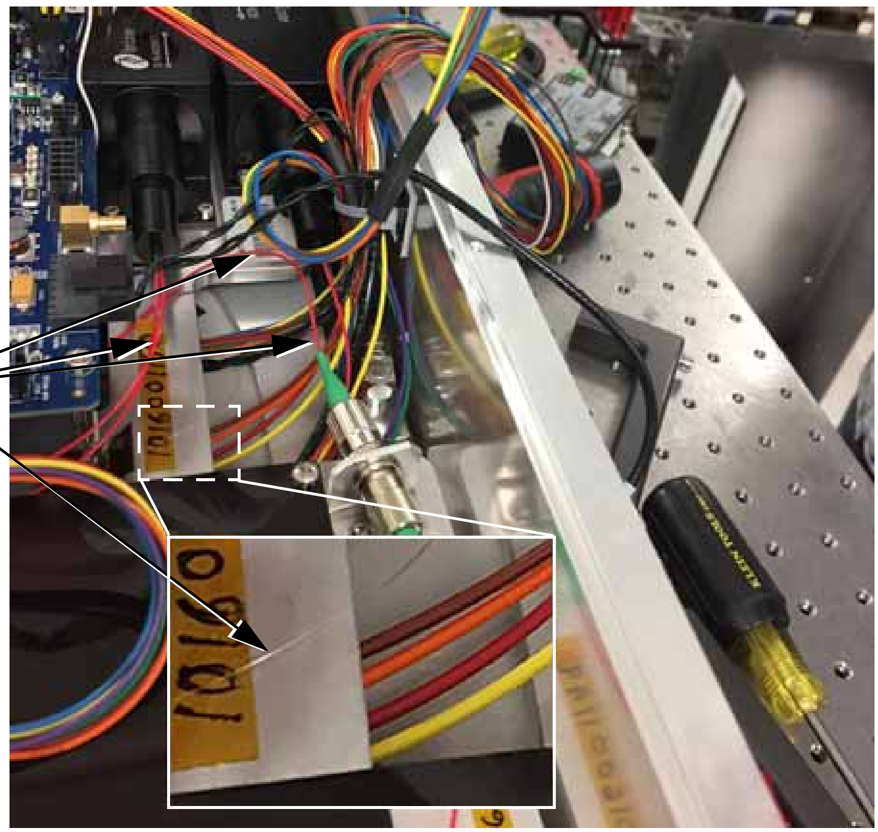


Figure 4.5-4. Delicate Optical Fibers (Transparent Fiber Shown Highlighted)

5. Remove the handles from the right side of the laser head (same side as the engraved Coherent logo) using the 4mm wrench.
6. With two people holding firmly, carefully lift the laser head and place it on its right side (engraved Coherent logo down) (see Figure 4.5-5).
7. Remove the shutter access cover using the 2.5mm wrench (see Figure 4.5-6).

Figure 4.5-5. Laser Head on Side

Figure 4.5-6. Shutter Access Cover

8. Remove the front cover plate/beam tube: remove the 2 screws and lock washers with the 3mm wrench (see Figure 4.5-7).

9. Remove the shutter assembly: remove the two screws with the 3mm wrench (see Figure 4.5-8). Carefully feed the unattached shutter assembly wire harness through the slot. Save the shutter assembly for return to the factory.

Figure 4.5-7. Shutter Front Plate/Beam Tube

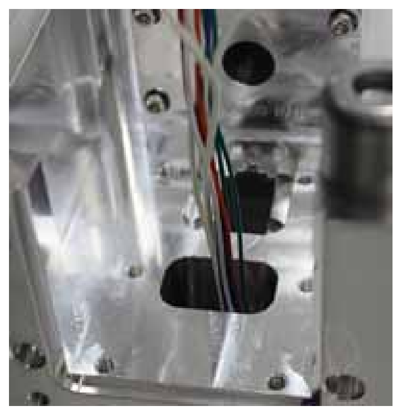


Figure 4.5-8. Removing the Shutter Assembly

10. Reversing steps 9 to 7, install the new shutter assembly (being careful to avoid the red seeder fiber when feeding the wire harness through the access slot), front cover/beam tube, and access panel. Also take care to arrange the wire harness in the same position as it was originally.
11. Again using two people carefully turn the laser so it rest on its base.
12. Reattach the shutter plug, again being careful to avoid any fibers.
13. Secure the wire harness with the cable tie.

14. Replace the O-ring if it has become dislodged. Check that the O-ring is firmly in its slot (see Figure 4.5-9).

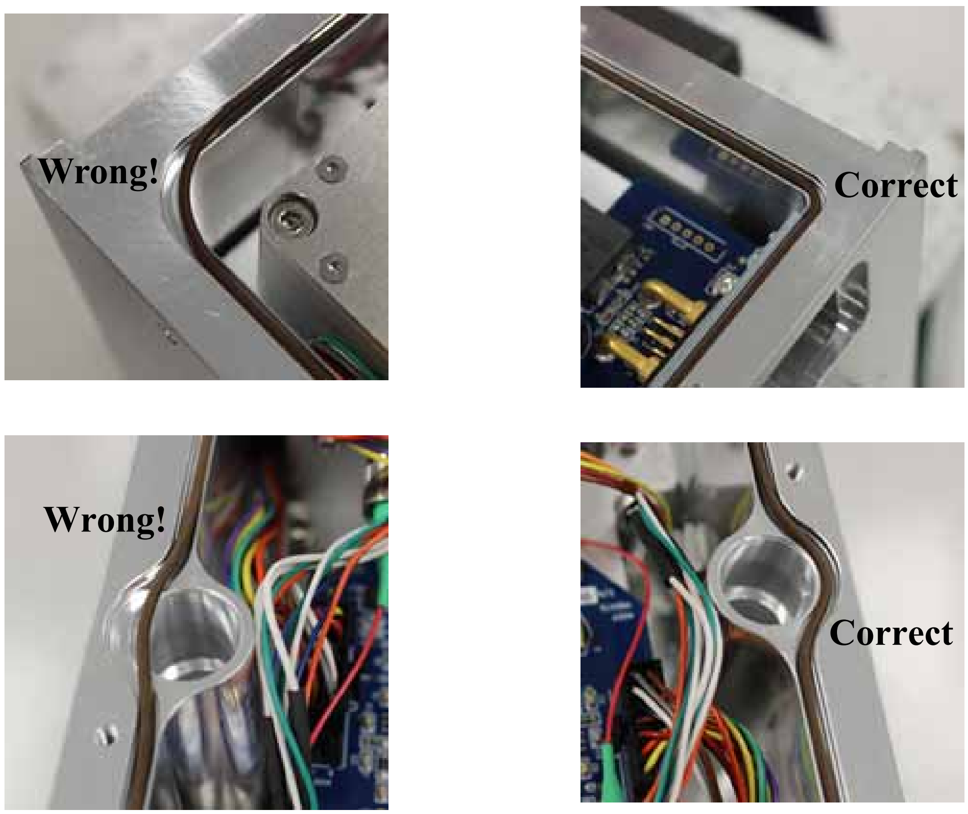


Figure 4.5-9. Incorrect/Correct O-Ring Placement

15. Reverse steps 3 and 2 to replace the cover to the laser head.

16. Restore the laser connections, power on the laser, and ensure that the customer is delighted.

Recirculator Replacement

The recirculator is typically not a FRU component for the Monaco laser, but can be swapped in the field when required

Required Tools

- 2.5mm Hex Key
- M5 Screw (can use one of the screws from the laser handle)

Required Parts

- FRU, Recirculator Assembly (part number 1328725)

Procedure

1. Power off the laser to prevent electrical shortage/damage.
2. Screw in the M5 screw into the recirculator housing to provide easy removal and handling of the recirculator (see Figure 4.6-1).

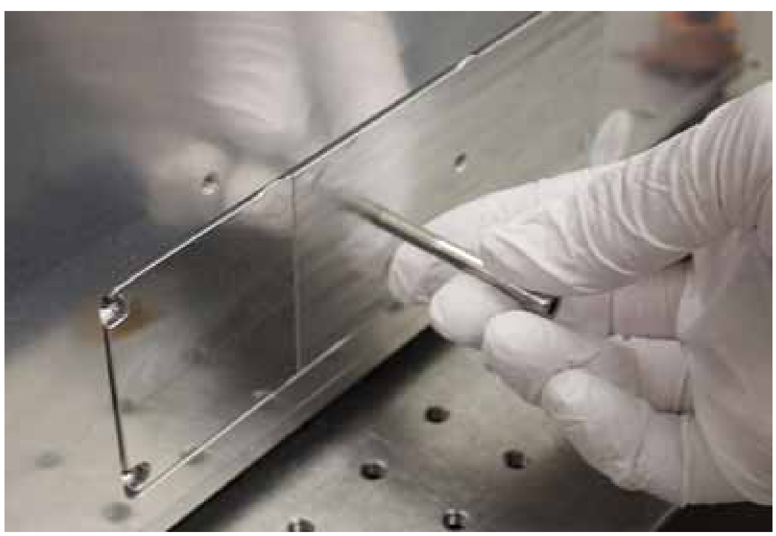


Figure 4.6-1. M5 Screw for Handling

3. Remove the old recirculator by removing the four M3 hex screws holding it in place with the 2.5mm hex key, gently

pulling it away from the laser housing, and disconnecting the wires. If the connector is not visible after gently pulling on the recirculator, then the cover to the laser must be removed to disconnect it.

Figure 4.6-2. Removing the Old Recirculator

4. Check the new pump's input and output tubing is clear and undamaged.
5. Verify that the two O-rings between laser housing and recirculator housing are sitting in the grooves on the laser side, not on the recirculator side (see Figure 4.6-3).

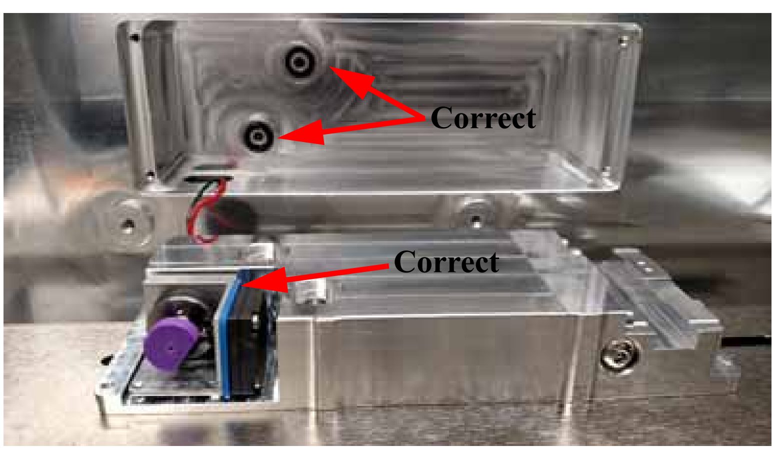


Figure 4.6-3. Positioning O-Rings

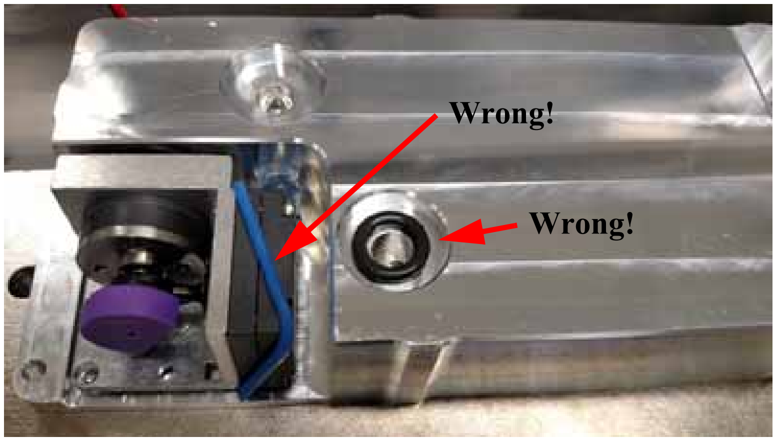


Figure 4.6-3. Positioning O-Rings

6. Connect/align the wires to the recirculator. Feed the wires through the access port ensuring they are straight and not crossed or kinked, which could prevent the proper mounting of the recirculator. (see Figure 4.6-4).

Figure 4.6-4. Recirculator Wire Placement

7. Align the blue O-ring as shown in Figure 4.6-3 and check that there is no twisting. If the O-ring is twisted or not positioned properly there could be excessive vibration and noise from the recirculator.

8. Replace the new recirculator into the laser housing and check that it is flush to the housing surface.Tighten the four screws evenly and slowly in an “X” pattern.
9. Power up the laser and check the recirculator’s working status by entering the serial command REN=1 to enable it. Recirculator operation should be audible but not loud.
10. Ensure that the customer is delighted.

NOTE!
Failing to follow steps 4-8 above may result in leaking air or insufficient vibration damping/noise reduction.

Description

The SMC floor mount chiller has been approved for use with Monaco. Below is an installation method that covers installing the filter, fittings and setting up the chiller to communicate. For the procedure for rack mounted SMC chillers see “SMC Chiller Setup” on page 1.2-7 of the Installation section. For older systems, the command CHAPPROVED:SMC=1 may need to be given and/or system firmware upgraded in order for the system to recognize the SMC chiller.

Chiller documentation comes with the chiller and is available on Spectrum.

Mechanical Procedure

1. Install fitting adapters into rear of chiller and filter housing. The chiller uses PT threads and the fittings are NPT threads. See Figure 4.7-1.
2. Wrap all threads with Teflon tape to prevent leaks. Always wrap in a clockwise direction. See Figure 4.7-2 left.
3. Install filter assembly to fitting adapter. See Figure 4.7-2 right.
4. Loosen the 10mm hex screws installed on either side of the outlet fitting on the rear of the chiller.
5. Install filter bracket to the rear of chiller and tighten screws. See Figure 4.7-3 left.
6. Secure filter housing to filter bracket using the four supplied screws. See Figure 4.7-3 right.
7. Install filter media and lower housing to upper housing.
8. Install female fitting to inlet (top). Do not overtighten.
9. Install male fitting to filter outlet. Do not overtighten.;

Figure 4.7-1. Installing Fitting Adapters

Figure 4.7-2. Teflon Tape and Filter Assembly

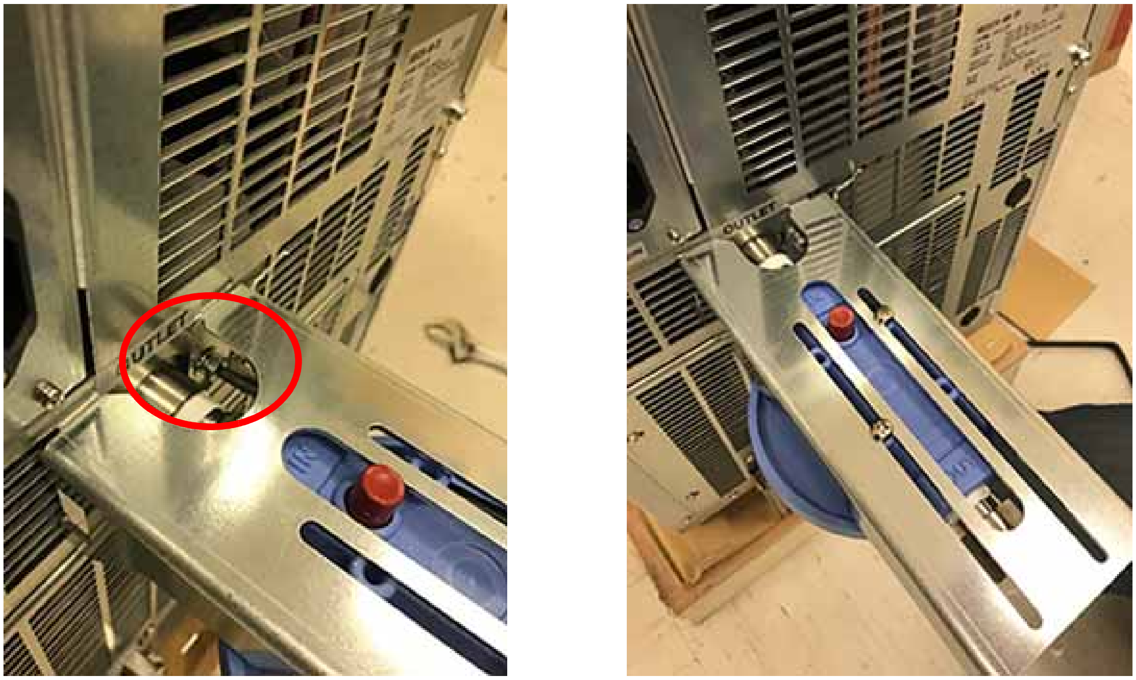


Figure 4.7-3. Filter Bracket

Software Procedure

You must change the control setup from Local and RS485 communication to Remote, Serial RS232 communication.

1. Long press the menu button (2 sec). Each time the menu changes, long press it again until it reads Co.01. See Figure 4.7-4 left.
2. Press up arrow button until the menu read SEr. Press Select. The menu will change to Co.03.
3. Press the up arrow until the lower part of the display reads 232c. Press Select.
4. Press Menu button. The display should change to the temperature reading.
5. Long press (2 sec.) the menu button until SE.01 shows in the display.
6. Press Select until display shows SE.13.

7. Press arrow button until display reads PSI. See Figure 4.7-4 right.
8. Press Menu. You should exit to the temperature reading.
9. If you have done everything correctly, the green LED next to REMOTE will be lit.
10. Confirm proper operation. The Monaco firmware should adjust the SMC chiller temperature in order to maintain the baseplate servo temperature. (BTEN=1)

NOTE: If the chiller does not respond to the Monaco firmware, the following Service commands may be required.

CHAPPROVED:SMC=1
CHTYPE=AUTO or CHTYPE=SMC

Figure 4.7-4. Chiller Control Setup

Description

Listed below is an alignment procedure for the External SHG Box for the Monaco laser. This procedure should only be performed if:

- The green beam output is not meeting power or beam quality specifications or the beam shows evidence of beam “clipping” after installation.
- The procedure is performed in a cleanroom environment.

If this is the initial install of a previous version of the SHG External Box, first go through the complete SHG Box Install procedure as outlined in Appendix A of the Monaco Green Operator’s Manual paying attention to potential interference.

Required Tools

- 1” tall, 1mm Aperture
- 1/4” Wrench
- 1.5mm Hex Key
- 2.0mm Hex Key (not pictured below)
- 2.5mm Hex Key
- 6.0mm Hex Key
- Long “T” handle 4mm Hex Key (included with Accessory Kit)
- IR Viewer (not pictured below)

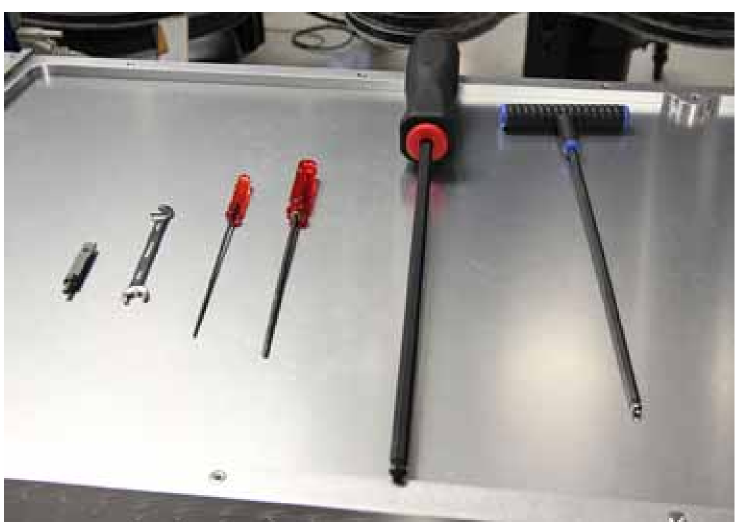


Figure 4.8-1. Required Tools

Required Parts External Boresighting Tool, Part Number 1319219AA

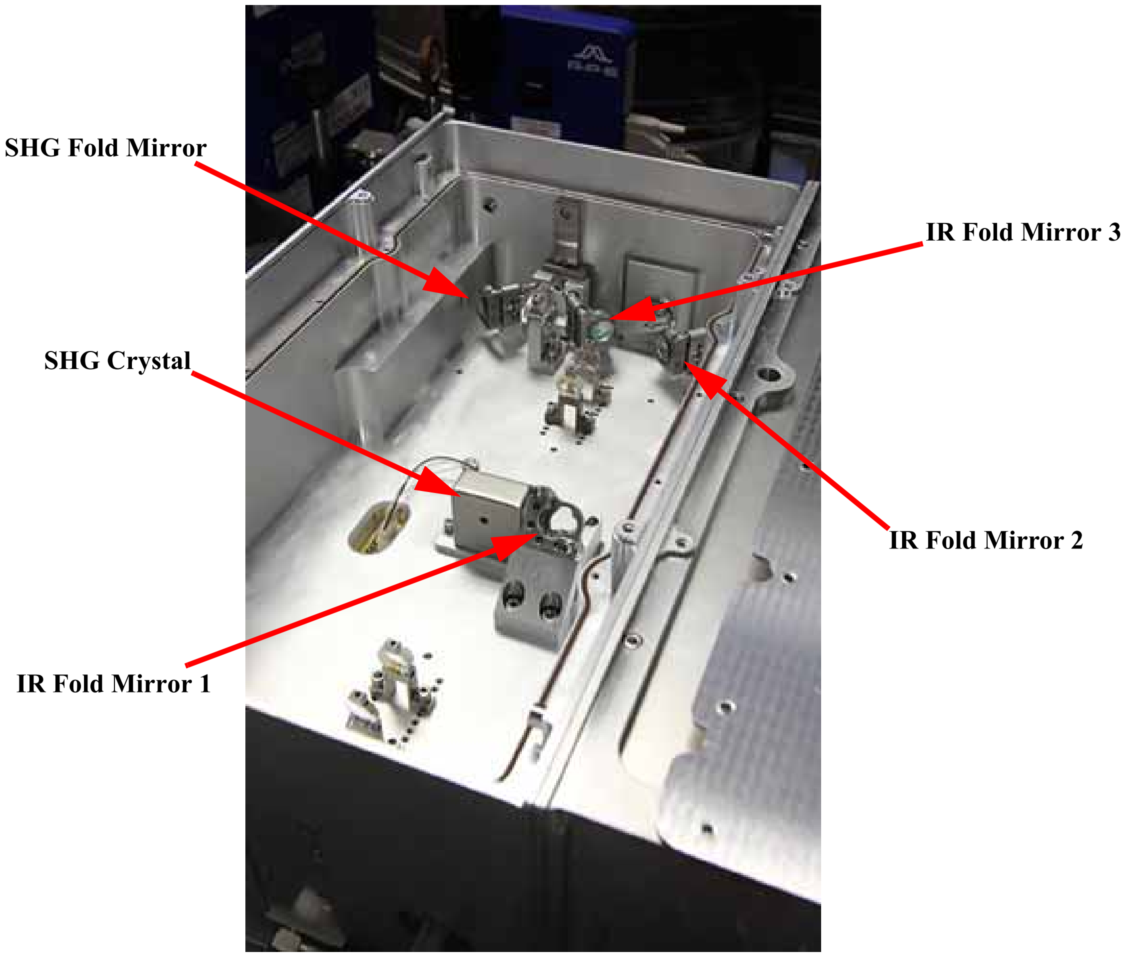


Figure 4.8-2. External SHG Box

Procedure

1. Attach the external boresighting tool, part number 131921988, using the 4 x M3 screws provided and a 2.5 mm hex key (see Figure 4.8-3).
2. Switch the laser to green output (laser is shipped with switch set to IR output) by unlocking the toggle and turning counter-clockwise with a 6.0mm hex key (Figure 4.8-4).
3. Set the RF Level to 5% from the GUI, turn on the laser, and using the one inch, 1mm aperture at the end of the external boresighting tool verify the SHG beam alignment (see Figure 4.8-5).

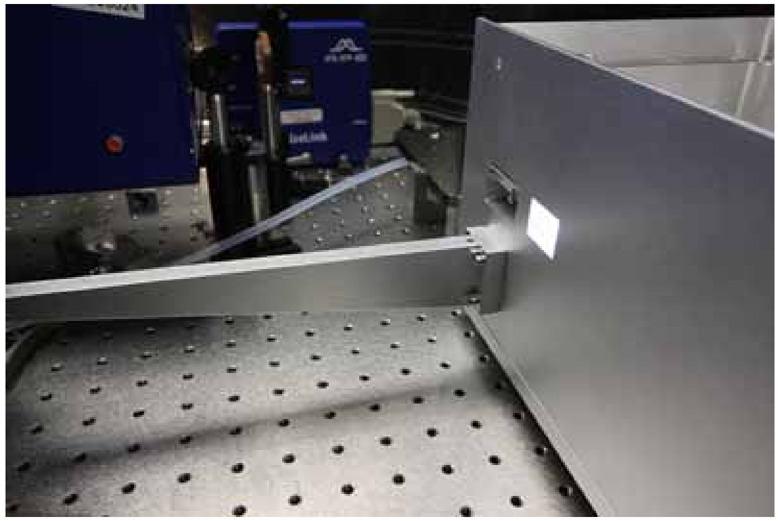


Figure 4.8-3. External Boresighting Tool

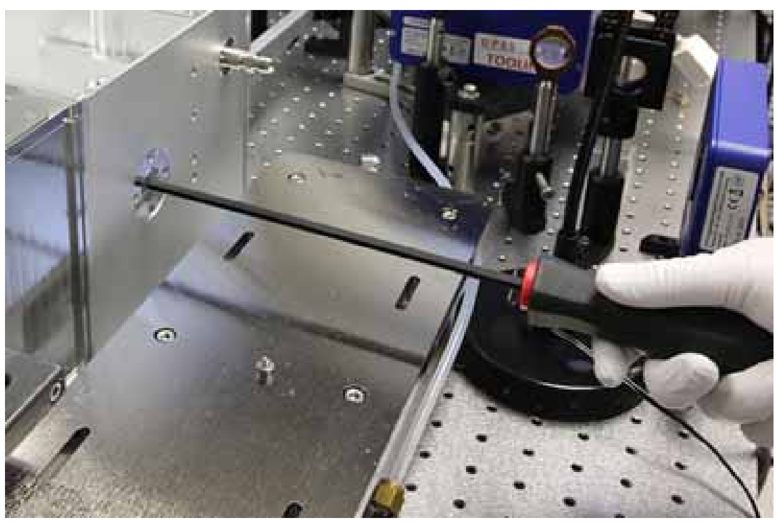


Figure 4.8-4. Changing Output Wavelength

4. Using the long "T" handle 4mm hex key verify the green beam alignment on the aperture when tightening the screws bolting the SHG box to the laser head (Figure 4.8-6). Note that you are just to ensure the screws are tight and the screws should not be loosened to recover alignment.

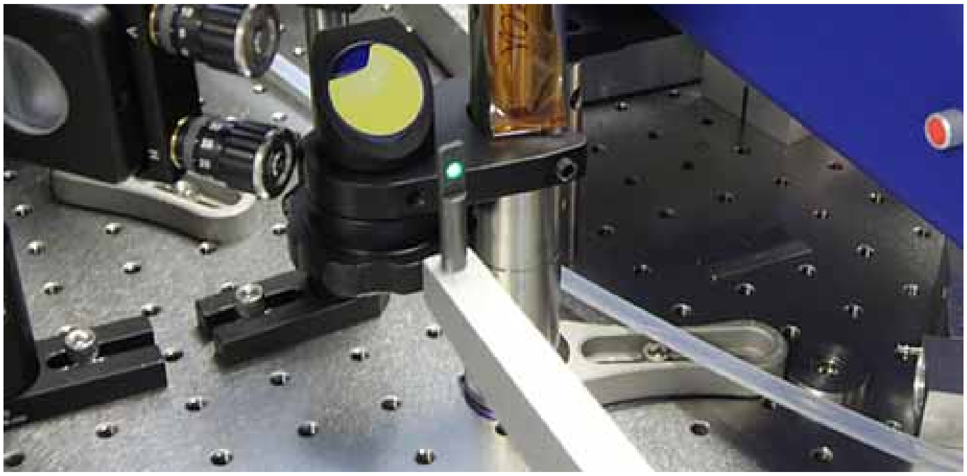


Figure 4.8-5. Green Beam Alignment

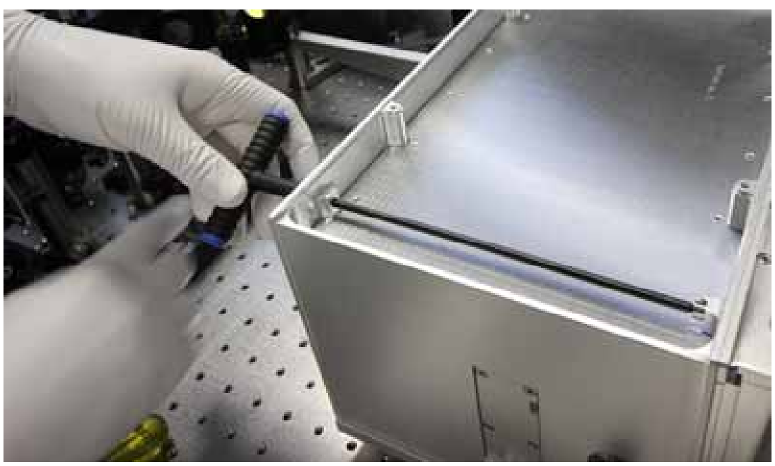


Figure 4.8-6. Tightening SHG Box to Laser Head

5. If the beam is well aligned to the aperture and looks round with no sign off clipping but the power at 100% RF was reported low, close the shutter and move the stage to the IR position. Open the shutter, check the IR beam location on the aperture at 5% with the IR Viewer, and then check power at 100%. If power is low, troubleshoot the IR laser for low power. If the power is good, close the shutter, switch the stage back to the SHG location, open the shutter, and monitor power at 100%.

Tune the SHG temperature to try and recover the power. If power cannot be recovered, check the PD4 signal is optimized against grating angle.

6. Enter the command REN=0 to turn off the recirculator.
7. Remove the beauty cover from the laser and external SHG box (4 x M3 screws for the SHG box) using the 2.0mm hex key.
8. Remove the top cover, 20 x M3 screws with the 2.5mm hex key. When removing the cover, tilt the front edge up first (Figure 4.8-7).

Figure 4.8-7. Removing SHG Box Top Cover

9. Check the O-ring seal is seated well (Figure 4.8-8).
10. Using the IR viewer, check for dirty optics/beam scatter for both the green and IR wavelengths, and clean optics if needed.
11. Check that the screws on the Fold Mirrors (Polaris mounts) are tight using the 1/4” wrench. Do not overly torque them, only tighten them if they have come loose (Figure 4.8-9).
12. Check that the screws on all the other optic mounts are tight using the 2.5mm hex key (Figure 4.8-10).
13. Switch the laser to IR output by unlocking the toggle and turning clockwise with the 6.0mm hex key (Figure 4.8-4)

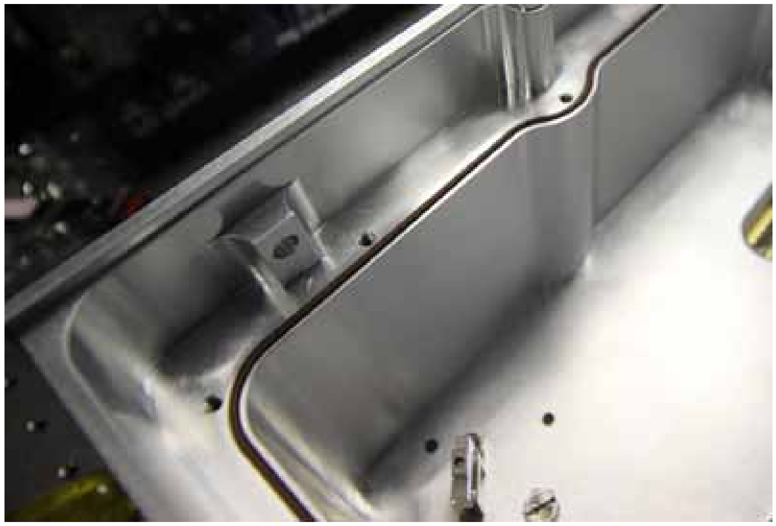


Figure 4.8-8. O-Ring Seal

Figure 4.8-9. Verify Tightness of Fold Mirror Screws

14. Still at 5% RF output, check the IR beam alignment with the IR viewer and with aperture placed as shown in Figure 4.8-11. The beam should be centered on the aperture, and if not adjust IR Fold Mirror 1.
15. Check the IR beam alignment with the IR viewer and with the aperture placed at the end of the external boresighting tool as

Figure 4.8-10. Verify Tightness of Optical Mounts

Figure 4.8-11. IR Beam Alignment Aperture Position 1 (Adjusting IR Fold Mirror 1)

shown in Figure 4.8-12. The beam should be centered on the aperture, and if not adjust IR Fold Mirror 2.

16. Lock down IR Fold Mirror 1 (leave IR Fold Mirror 2 unlocked for the next steps).

17. Switch the laser back to green output by unlocking the toggle and turning counterclockwise with a 6.0mm hex key

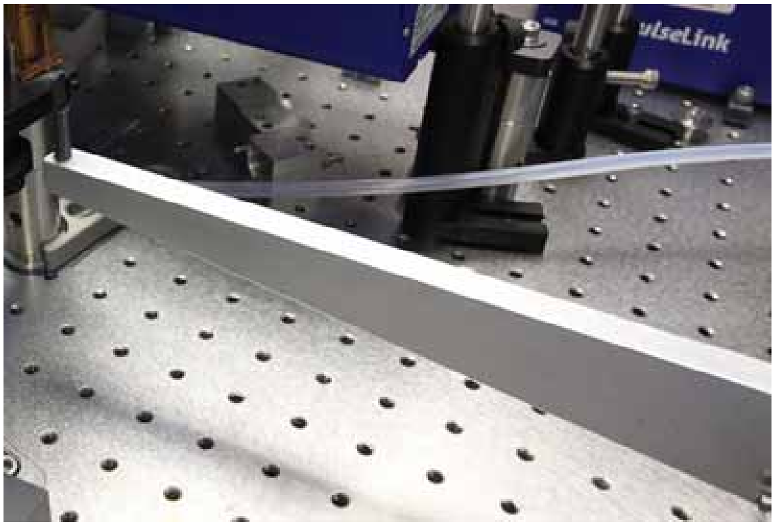


Figure 4.8-12. IR Beam Alignment Aperture Position 2 (Adjusting IR Fold Mirror 2)

(Figure 4.8-4). Ensure that the stage goes all the way down to contact with the plate underneath.

18. Check the green beam alignment by placing the aperture at the two locations shown in Figure 4.8-13. Adjust the IR Fold Mirror 3 if needed.

Figure 4.8-13. Green Beam Alignment Aperture Positions (Adjusting IR Fold Mirror 3)

19. Remove the aperture, raise the RF level to 20% from the GUI, and check the output power. Note that setting the RF level higher than 20% could damage the SHG crystal while adjusting mirrors to optimize for output power.

20. Adjust IR Fold Mirror 3 to optimize output power in the green. If adjusting IR Fold Mirror 3 doesn't recover power fully, walk the beam position with both the IR Fold 2 and 3 Mirrors if required. There are holes in the side walls of the actuators (TPI adjuster screws) that the 1.5mm hex key will fit through (see Figure 4.8-14). It is typically easier to use the 1.5mm hex key to adjust these mirrors given their location. Note that primarily the vertical adjustments for the mirrors are used to optimize phase matching in the SHG crystal for optimal output power, while the horizontal adjustments are used primarily for beam positioning.

Figure 4.8-14. Optimizing Output Power by Adjusting IR Fold Mirrors 2 and 3

21. Lock the IR Fold Mirrors down.

22. If the specified green output power has not been achieved, then check the SHG Temperature. If the SHG temperature matches what is shown on the customer datasheet, then adjust the temperature approximately 2-3 degrees to see if additional power can be restored.

23. Check the SHG Fold Mirror alignment with the aperture at the end of the external boresight tool (Figure 4.8-5), and adjust SHG Fold Mirror if needed.
24. Lock the SHG Fold Mirror.
25. Replace the covers and tighten screws.
26. Enter the command REN=1 to turn on the recirculator.
27. Ensure the customer is happy.

Spare Parts List

Parts listed below are common to the Monaco Laser platform models. 11

Table 5.1-1. Monaco Laser Spare Parts and FRUs (Sheet 1 of 2)

DESCRIPTION	PART NUMBER	COMMENT
TESTED PCB ASSEMBLIES		
Head Board Assembly	1341017	Assy PCBA Monaco Controller
LASER HEAD AND POWER SUPPLY		
Laser Head	1298853	Tested,1MHz,Variable Pulsewidth (contact factory for 60/80uJ)
Mounting Plate	1303793	
Power Supply,	1259744	Tested, New
CABLES		
AC Power cord	1106360	
Umbilical, 25-pin 15ft Umbilical, 37-pin 6ft Umbilical, 37-pin 5m	1117813 1097853 1099107	
MISCELLANEOUS		
Integration Kit	1303784	Includes hoses
Interlock Jumper	1102145	
Accessory Kit (IR Monaco) Accessory Kit (Green Monaco)	1303719 1365157	Does not include hoses
SMA Adapter (RoHS)	1098589	Requires 33-9432-000 Adapter Ring. Fits LM 45 & LM100

Table 5.1-1. Monaco Laser Spare Parts and FRUs (Sheet 2 of 2)

DESCRIPTION	PART NUMBER	COMMENT
Desiccant, Round Pouch	1287150	FRU part
Operator's Manual	1297688	
Fan Filter	1063222	
Emission Lamp Assembly	1149251	
Shutter Assembly (IR)	1394173	Series II Monaco
Shutter Assembly (Green)	1394174	Series II Monaco
BNC Shorting Plug	2105-0219	Pasternack Enterprises: PE6012
BNC Non-Shorting Cap	2105-0236	Pasternack Enterprises: PE6014
External Interlock Jumper	1102145	
Key, Set of Two	1116159	
Rack Mounting Kit (option)	1124329	
Packing Crates: Power Supply Laser Head	 1259744 1298853	
Recommended Chillers: P307-19717 Termotek, Air to Water Chiller, 570W 100-240V AC 50/60Hz, RoHS Compliant P307-21097 Termotek, Water to Water Chiller, 570W 100-240V AC HRR012-AN-20-M SMC Air to Water Chiller, 1200W 200-230V AC 50/60Hz HRR012-AN-10-M SMC Air to Water Chiller, 1200W 100-115V AC 50/60Hz	 1254673 1327329 1384296 1406808	
Filter Media, TermoTek Chiller Particle Filter, SMC Chiller Chiller Coolant, CoolFlow DTX premix	1261959 1281742 1306268	

FSB List

Copies of all Monaco Field Service Bulletins (FSB) are listed on the Service Spectrum site:

https://cohrinc.sharepoint.com/sites/PIC/Short-PulsedIndustrialLasers/Monaco/SitePages/CustomerInformation.aspx

Table 6.1-1. Field Service Bulletins (FSB)

NUMBER	DESCRIPTION	DATE
814	Monaco Cooling Manifold	2/1/17
819	Monaco Shutter	3/14/17
826	Monaco v1.031b.31 Firmware	5/26/17
834	Monaco Interface Plug	7/24/17
839	Monaco v1.060a.36 Firmware (Build 80)	8/10/17
847	Maonco Chiller Input Noise	9/8/17
850	Monaco Firmware Release v1.069a.40 (Build 88)	9/22/17
866	Monaco v1.105.51 Firmware (Build 105)	12/5/17
867	Monaco Firmware v1.113a.53 (Build 113)	1/17/18
881	Monaco v1.143.64 Firmware (Build 137)	4/26/18
887	Monaco SMC Chiller	6/27/18
889	Monaco v1.171.82 Firmware (Build 159)	8/28/18
905	Monaco Firmware v1.192.86 (Milestone 33 & 34)	11/12/18
910	Monaco Firmware v1.232a.97 (Build 196)	1/4/19
FSU	Monaco Green Optimization	1/9/19
FSU	Monaco Firmware Upgrade Guidance	1/29/19
920	Monaco v1.254.107 Firmware (Build 212)	3/1/19
926	AVIA NX and Monaco Chiller Maintenance	4/8/19

Table 6.1-1. Field Service Bulletins (FSB) (Continued)

NUMBER	DESCRIPTION	DATE
FSU	Monaco Chiller Communication	4/19/19
FSU	Monaco Chiller Update	5/3/19
931	Monaco Firmware v1.278.112 (Build 229)	5/16/19
970	Monaco Firmware Release 38.1	2/28/20
975	Monaco Connection Issues	3/20/20
980	Monaco System Storage Preparation	4/3/20
987	Monaco Firmware Release 39	6/17/20

This section is to provide some clarification to FSEs on the difference in operational modes and pulse control between the Monaco and the HyperRapid systems.

Internal Mode PM=0

The Monaco laser is operated at a steady pulse repetition rate set by the amplifier repetition rate (MRR). The amplifier repetition rate can be selected through the Coherent GUI Main menu (see Figure 7.1-1), or through the serial command SET. For systems with the Interpolated mode option, any repetition rate between 1 to 4 MHz can also be entered directly into the GUI or through the serial command SET. The Monaco is using the Sync 1 mini BNC connector to provide output to the user on the output repetition rate.

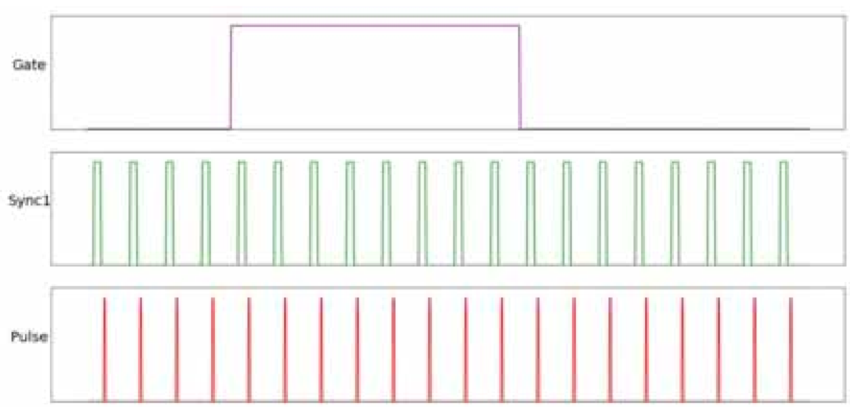


Figure 7.1-1. Monaco Continuous Mode (PM=0) - Does Not Use Gate Signal

The HyperRapid NXT/HyperRapid NX laser can be operating at a steady pulse repetition rate (PRF defined internally) up to the Output Pulse Repetition Rate (value can be found in the datasheet supplied with the laser). The internal repetition rate can be selected through the Coherent GUI Main menu or via command PM=0 and RRAMPSET=n (where n indicates the pulse repetition rate in kHz). The signal-inputs Trigger and Gate (interfaces at the laser head rear side) are ignored. Sync 2 is the output signal synchronized to the internal pulse repetition rate, laser output, and output signal Pulse Monitor. The time t_1 depicted below is approximately 1usec.

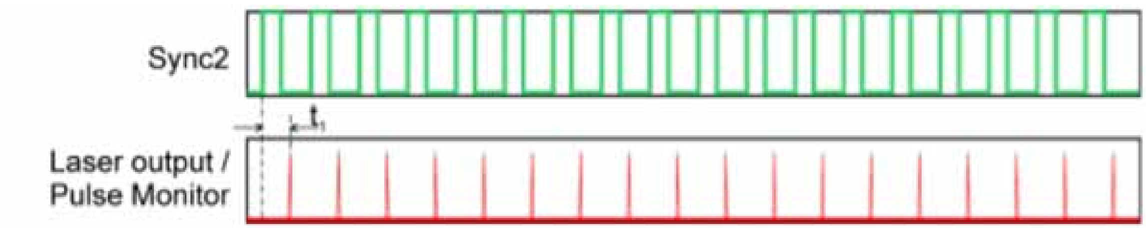


Figure 7.1-2. HyperRapid Continuous Mode (PM=0) - Does Not Use Trigger or Gate Signals

External Trigger (HyperRapid PM=1)

For the HyperRapid laser, External (PM=1) defines the pulse repetition rate by applying a TTL signal externally through the Trigger port on the rear side of the laser head. This feature is chosen from the Pulse mode menu or by sending the command PM=1. It is recommended to send this command directly after system start up (a warning might appear if the PRF or burst combination is changed and it is not valid for external triggering). The trigger frequency is limited for HRR systems to the value Single Pulse Picking (value can be found in the datasheet supplied with the laser). If the laser system is equipped with PulseEQ, the laser pulse energy does not depend on the pulse repetition rate for external triggering. The Gate input is ignored. The time t_1 indicated below is approximately 1 usec, and t_2 is approximately 2.5 usec.

There is no equivalent mode for the Monaco. PulseEQ mode (PM=6) is the closest the Monaco has to External Trigger.

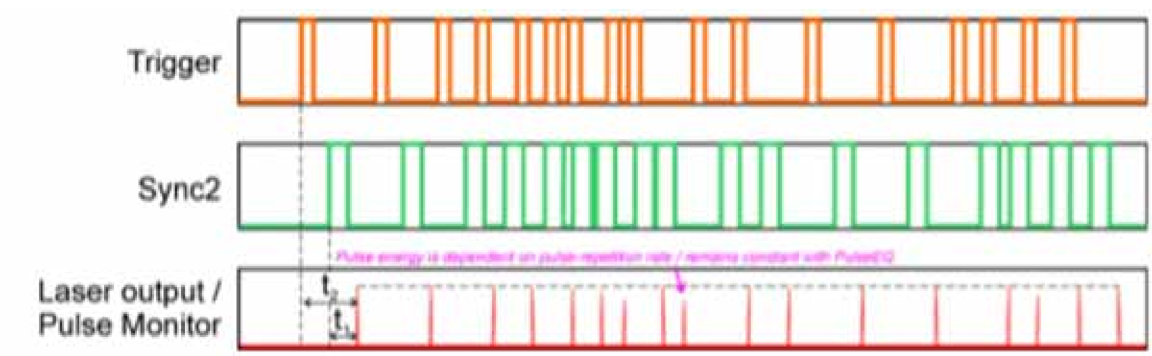


Figure 7.1-3. HyperRapid External Trigger (PM=1)

Gated Mode

The Monaco Gated Mode enables pulsing by applying a TTL signal externally through the Gate 1 port on the rear of the laser head. 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 7.1-4). To utilize Gated Mode the Enable External Gate button is selected from the GUI Triggering menu, or by entering the serial command PM=1.

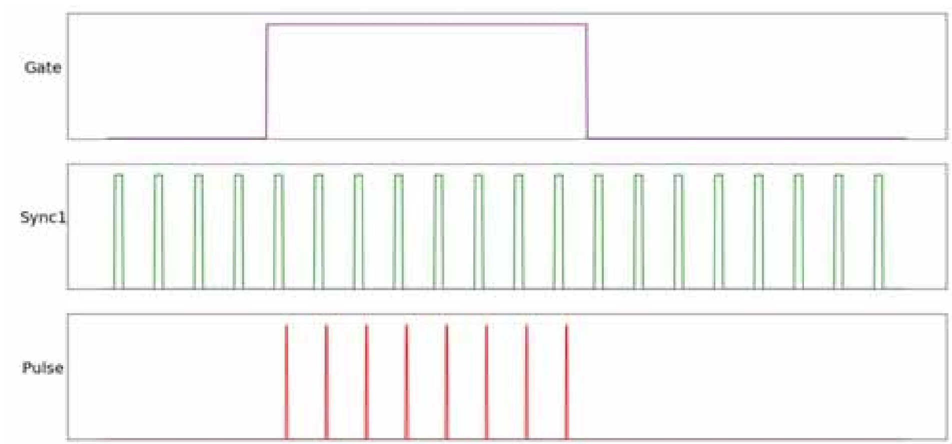


Figure 7.1-4. Monaco Gated Mode (PM=1)

The HyperRapid Internal and Gated Mode (PM=2) offers a static PRF (created internally) and driving the process shutter with the external Gate signal. The TTL Gate signal is connected to the Gate port on the rear side of the laser head. TTL high enables output pulses and TTL low inhibits output. The pulse repetition rate is defined internally and limited for HRR to the value Single Pulse Picking (the value can be found on the datasheet supplied with the laser). This feature is chosen out of the Pulse mode menu or by sending the command PM=2. The time t_1 depicted below is approximately 1 usec.

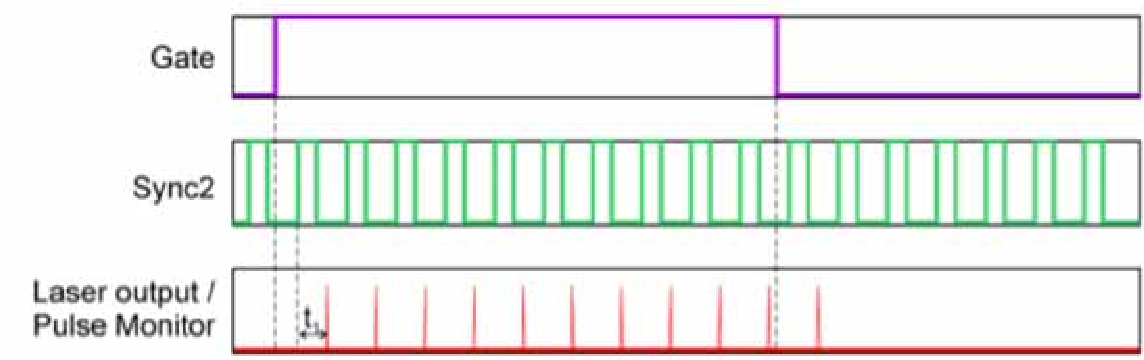


Figure 7.1-5. HyperRapid Internal Trigger and Gate Mode (PM=2)

External Gated (PM=3)

The HyperRapid External and Gated Mode (PM=3) is in case the application (e.g. scanner head) offers two signals (PRF and Gate) separately. A Trigger and Gate signal are applied to the corresponding connectors located on the rear side of the laser head. This feature is chosen out of the Pulse mode menu or by sending the command PM=3. The trigger frequency is limited for HRR to the value Single Pulse Picking (this value can be found on the datasheet supplied with the laser). The time t_3 is approximately 1 usec and t_2 is approximately 2.5 usec. If the laser system is equipped with PulseEQ, the laser pulse energy does not depend on the pulse repetition rate for external triggering.

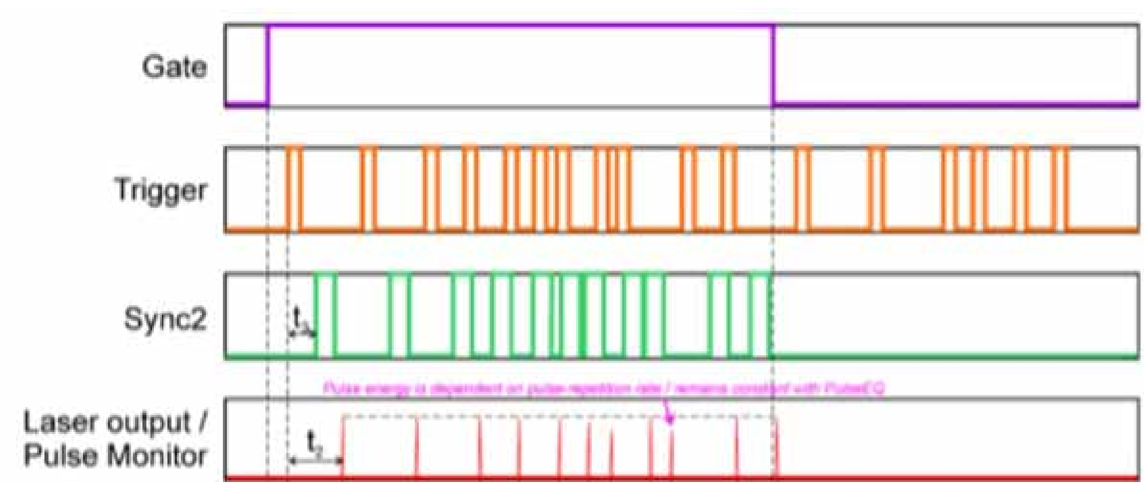


Figure 7.1-6. HyperRapid External and Gated Mode (PM=3)

There is no equivalent mode in the Monaco. For the Monaco, PM=3 is for Divided and Gated mode - gating with an assigned frequency.

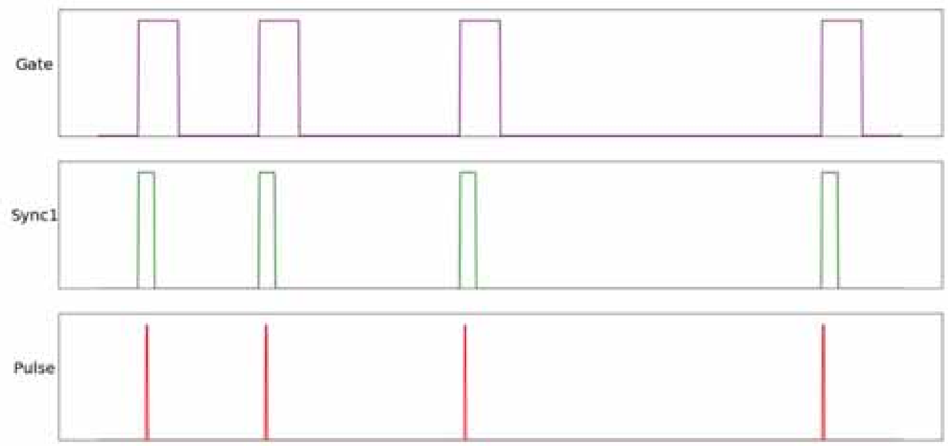


Figure 7.1-7. Monaco Divided and Gated Mode (PM=3)

External Modulation

In the Monaco 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, 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.

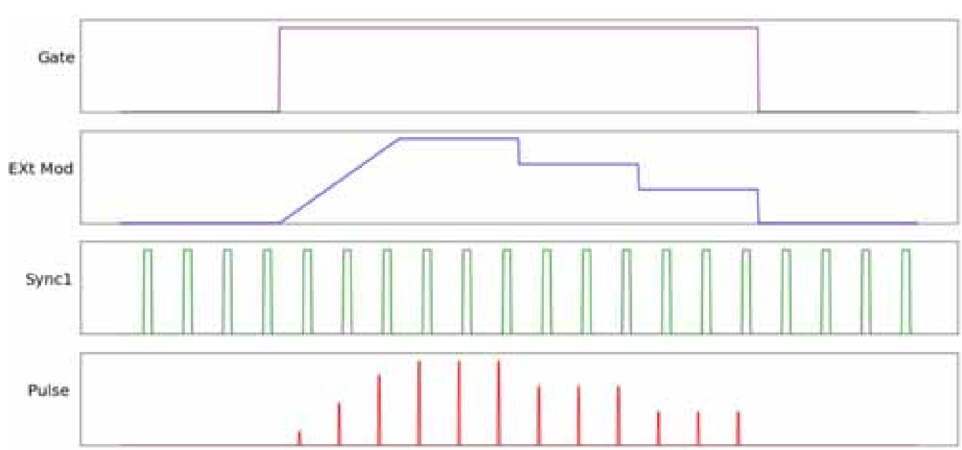


Figure 7.1-8. Monaco External Modulation

The HyperRapid Ext Mod connection works in a similar way. The process shutter offers the possibility to modulate the pulse energy (limited to the frequency indicated by Single Pulse Picking shown in the datasheet provided with the laser) in combination with all the other modes. The analog input connector Ext Mod is used in order to influence the output pulse energy. The time t_3 is approximately 1 usec, t_4 is approximately 1 usec.

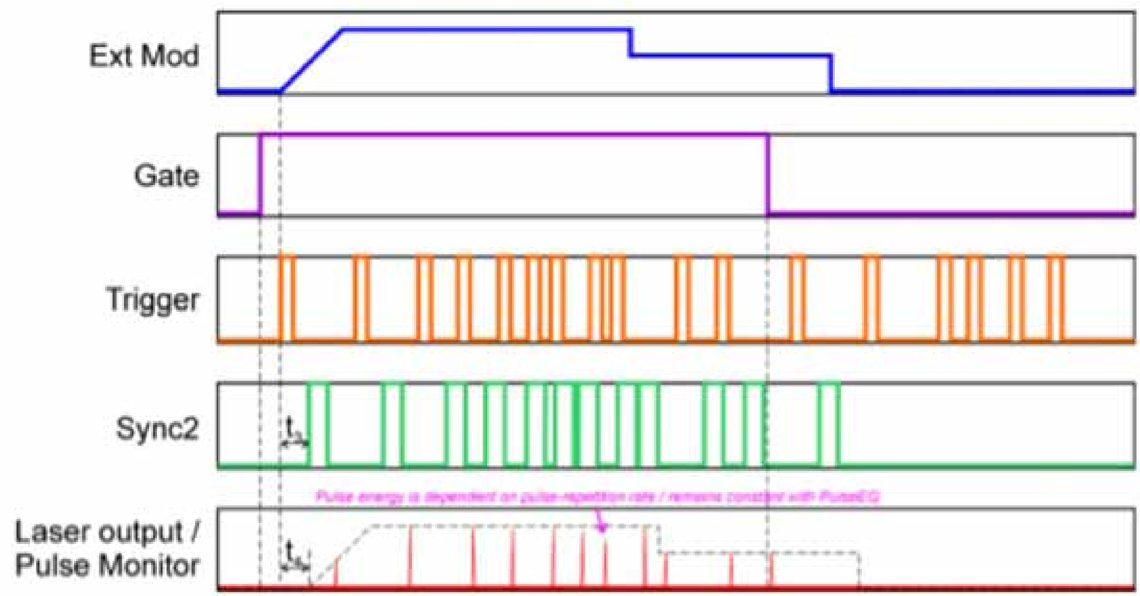


Figure 7.1-9. HyperRapid External Modulation

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