Chameleon™ Ultra, Vision, and Vision-S Laser Systems

Operator's Manual

COHERENT®

Superior Reliability & Performance

Operator's Manual
Chameleon™ Ultra, Vision, and Vision-S
Laser Systems

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 www.coherent.com/company/patents.

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Should you experience any difficulties with your laser or need any technical information, please go to our web site www.Coherent.com. Should you need further assistance, please contact Coherent Technical Support by e-mail customer.support@coherent.com or telephone, 1-800-367-7890 (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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1 INTRODUCTION

1.1 Signal Words and Symbols in this Manual

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

1.1.1 Signal Words

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

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

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

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

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

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

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

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

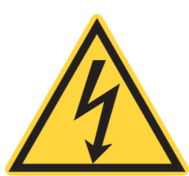
1.1.2 Symbols

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

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

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

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



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

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

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

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

1.2 Preface

This manual contains user information for the Chameleon™

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

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

1.3 Export Control Laws Compliance

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

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

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

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

1.4 The Operator's Manual

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

Installation, deinstallation, servicing, and detailed troubleshooting are only to be performed by formally trained and instructed personnel. Consequently, these procedures are not contained in the Operator's Manual but in the separate Service Manual.

This Manual:

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

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

1.4.1 Intended Audience

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

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

1.4.2 Availability and Use

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

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

1.4.3 Numbering of Sections, Pages and Instructions

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

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

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

1.4.4 Cited Standards

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

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

1.5 Laser Terminology

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

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

A Laser
Consists of an amplifying medium capable of emitting coherent radiation with wavelengths up to 1 mm by means of stimulated emission.

B Laser system
A laser (A), where the radiation is generated, together with essential additional facilities (E) that are necessary to operate the laser (e.g. cooling, power, and gas supply).

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

1.6 Units of Measurements

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

Temperatures are primarily indicated in degrees celsius (°C) and fahrenheit (°F).

1.7 Feedback Regarding Documentation

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

In any correspondence, please provide the following:

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

1.7.1 Feedback Address

E-mail documentation.support@coherent.com

Post Coherent Inc
Documentation and Training Development Department
5100 Patrick Henry Drive, MS-P2-49
Santa Clara, CA. 95054
USA

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2 Laser Safety

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

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

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

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

2.1 Hazards

Hazards associated with lasers generally fall into the following categories:

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

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

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

2.2 Optical Safety

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

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

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

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

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

2.2.1 Recommended Precautions and Guidelines

1. Observe all safety precautions in the preinstallation and operator’s manuals.
2. Always wear appropriate eyewear for protection against the specific wavelengths and laser energy being generated. See “Laser Safety Eyewear” (p. 12) for additional information.
3. Avoid wearing watches, jewelry, or other objects that may reflect or scatter the laser beam.
4. Stay aware of the laser beam path, particularly when external optics are used to steer the beam.
5. Provide enclosures for beam paths whenever possible.
6. Use appropriate energy-absorbing targets for beam blocking.
7. Block the beam before applying tools such as Allen wrenches or ball drivers to external optics.
8. Limit access to the laser to trained and qualified users who are familiar with laser safety practices. When not in use, lasers should be shut down completely and made off-limits to unauthorized personnel.
9. 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.
10. Post laser warning signs in the area of the laser beam to alert those present.
11. Exercise extreme caution when using solvents in the area of the laser.
12. Never look directly into the laser light source or at scattered laser light from any reflective surface, even when wearing laser safety eyewear. Never sight down the beam.
13. Set up the laser so that the beam height is either well below or well above eye level.
14. Avoid direct exposure to the laser light. Laser beams can easily cause flesh burns or ignite clothing.
15. Advise all those working with or near the laser of these precautions.

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

2.2.2 Laser Safety Eyewear

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

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

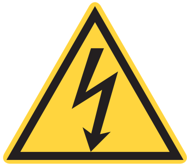
2.2.3 Viewing Distance

The Chameleon™ produces optical power levels that are dangerous to the eyes and skin if exposed directly or indirectly. This product must be operated only with proper eye and skin protection at all times. Never view directly emitted or scattered radiation with unprotected eyes. When viewing the laser during operation, the operator must maintain the Nominal Ocular Hazard Distance (NOHD) between the laser or scatter radiation and the operator's eyes. The NOHD for the power range of the Chameleon family's direct viewing of the collimated beam is 2.506 km. The NOHD is based on the Maximum Permissible Exposure (MPE = 0.1 W/cm2) level for each power condition as specified in ANSI Z136.1 and IEC 60825-1.

2.3 Electrical Safety

Chameleon™ use AC and DC voltages.

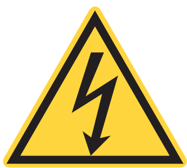
DO NOT disassemble the enclosure. There are no user serviceable components in the controller or laser head. All units are designed to be operated as assembled. The Warranty will be voided if the laser head, the controller, or the cable is disassembled.



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

2.3.1 Recommended Precautions and Guidelines

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



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

1. Disconnect main power lines before working on any electrical equipment when it is not necessary for the equipment to be operating.
2. Do not short or ground the power supply output. Protection against possible hazards requires proper connection of the ground terminal on the power cable, and an adequate external ground. Check these connections at the time of installation, and periodically thereafter.
3. Never work on electrical equipment unless there is another person nearby who is familiar with the operation and hazards of the equipment, and who is competent to administer first aid.
4. When possible, keep one hand away from the equipment to reduce the danger of current flowing through the body if a live circuit is touched accidentally.
5. Always use approved, insulated tools.
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.

2.4 Maximum Accessible Radiation Level

The Chameleon™ produces visible and invisible radiation over:

Wavelength range	600 nm to 1200 nm
Maximum average power	10 W
Pulse duration	10 fs - CW
Pulse energy	125 nJ
Full angle divergence	0.45 mrad to 1.5 mrad

2.5 Safety Features and Compliance to 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, and in Laser Notice 56, dated May 8, 2019, administered by the Center for Devices and Radiological Health (CDRH).

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

2.5.1 Laser Classification

Governmental standards and requirements specify that the laser must be classified according to the output power or energy and the laser wavelength. The Chameleon™ 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, Clause 4 respectively. In this manual, the classification will be referred to as Class 4.

2.5.2 Protective Housing

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

2.5.3 Remote Interlock Connector

The Chameleon™ 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].

2.5.4 Key Control

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

2.5.5 Laser Radiation Emission Indicators

The appropriately labeled lights on both the power supply and the laser head illuminate approximately 30 seconds before laser emission can occur. Amber lights are used so that they are visible when the proper type of safety glasses are used [CFR 1040.10(f)(5)/EN 60825-1, clause 4.6].

2.5.6 Beam Attenuator

A beam attenuator, or shutter, prevents contact with laser radiation without the need to switch off the laser [CFR 1040.10 (f)(6)/EN 60825-1, clause 4.7].

2.5.7 Operating Controls

The laser controls are positioned so that the operator is not exposed to laser emission while manipulating the controls [CFR 1040.10(f)(7)/EN 60825-1, clause 4.8].

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

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

2.6 Electromagnetic Compatibility

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

Conformance to the EMC requirements is achieved though compliance with EN 61326-1/IEC 61326-1 (Electrical Requirements for measurement, control and laboratory use).

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

2.7 Environmental Compliance

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

2.7.1 RoHS Compliance

The European Union RoHS Directive 2011/65/EU restricts the use of certain hazardous substances in electrical and electronic equipment. Coherent is in compliance with this Directive and can provide RoHS certification upon request. Compliance of this Laser with the European requirements is certified by the CE mark.

2.7.2 China-RoHS Compliance

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

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

Any hazardous substances found in the Chameleon laser system are listed in the table. The environmental-friendly use period is 20 years, indicated by the number 20 inside the circle.

The China RoHS Regulation also requires that the date of manufacture be identified (in Chinese characters) on the product label. See Table 2-1.

Table 2-1. China-RoHS Compliant Components

	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	X	O	O	O
电缆装配 Cable Assembly	O	O	O	O	O	O
光学部件装配 Optic Assembly	X	O	O	O	O	O
板金组装 Sheet Metal Assembly	X	O	O	O	O	O
电源 Power Supply	X	O	O	O	O	O
组装二极管激光器 Laser Diode Assembly	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。

2.7.3 EU REACH

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

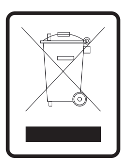
Coherent products are "articles" as defined in REACH Article 3(3) and do not release substances under their normal use. Suppliers of articles must provide recipients with information on Substances of Very High Concern (SVHC) if those are present above a concentration limit of 0.1% on an article level.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

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

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

2.7.4 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. Contract the local distributor for procedures for recycling this equipment.

2.7.5 Battery Directive

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

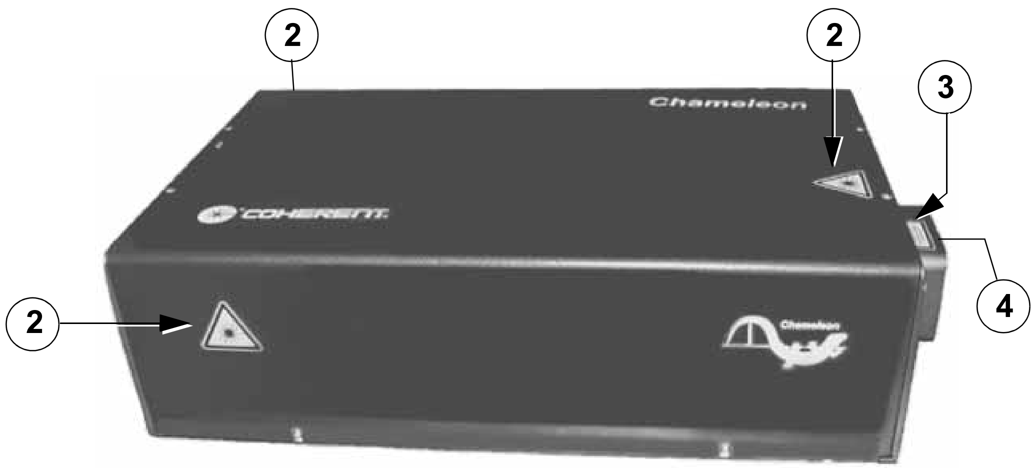
Table 2-2. Batteries Contained in this Product

Description	Type
12 volt sealed rechargeable UL (Verdi V18)	Pb-acid
Note: The Vision-S PSU does not contain a battery.	

Dispose of batteries according to local regulations. Do not dispose as normal waste. Consult your local waste authorities for guidance. The batteries are not accessible to the operators of the Chameleon Ultra, Vision, and Vision-S. Battery replacement is to be performed by Coherent trained engineers only. Contact Coherent Service or an authorized service representative to replace the battery.

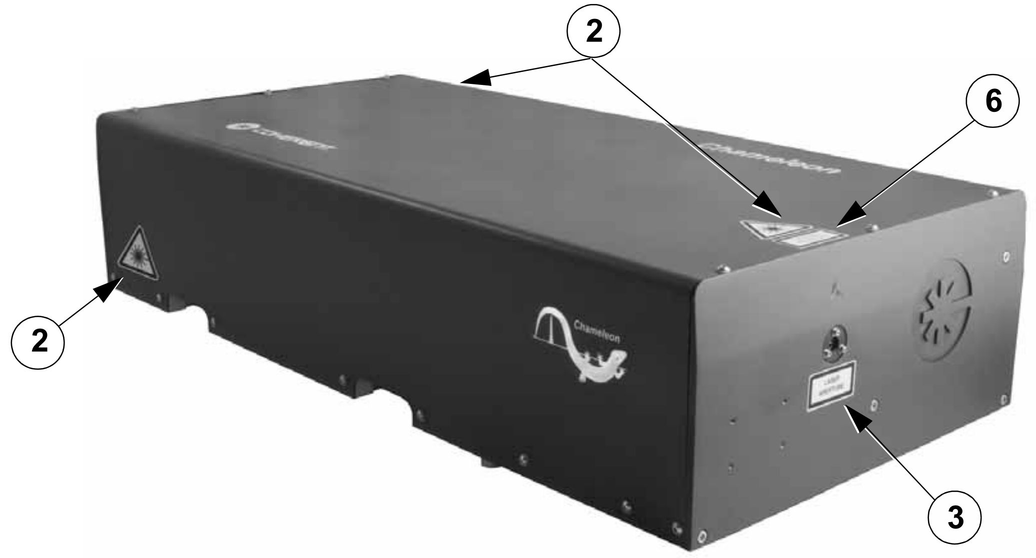
2.7.6 Location of Safety Labels

Refer to Figure 2-1 for the location of all safety labels. These include warning labels indicating removable or displaceable protective housings, apertures through which laser radiation is emitted, and labels of certification and identification [21 CFR § 1040.10(g), 21 CFR § 1010.2, and 21 CFR § 1010.3/IEC 60825-1, Clause 7].

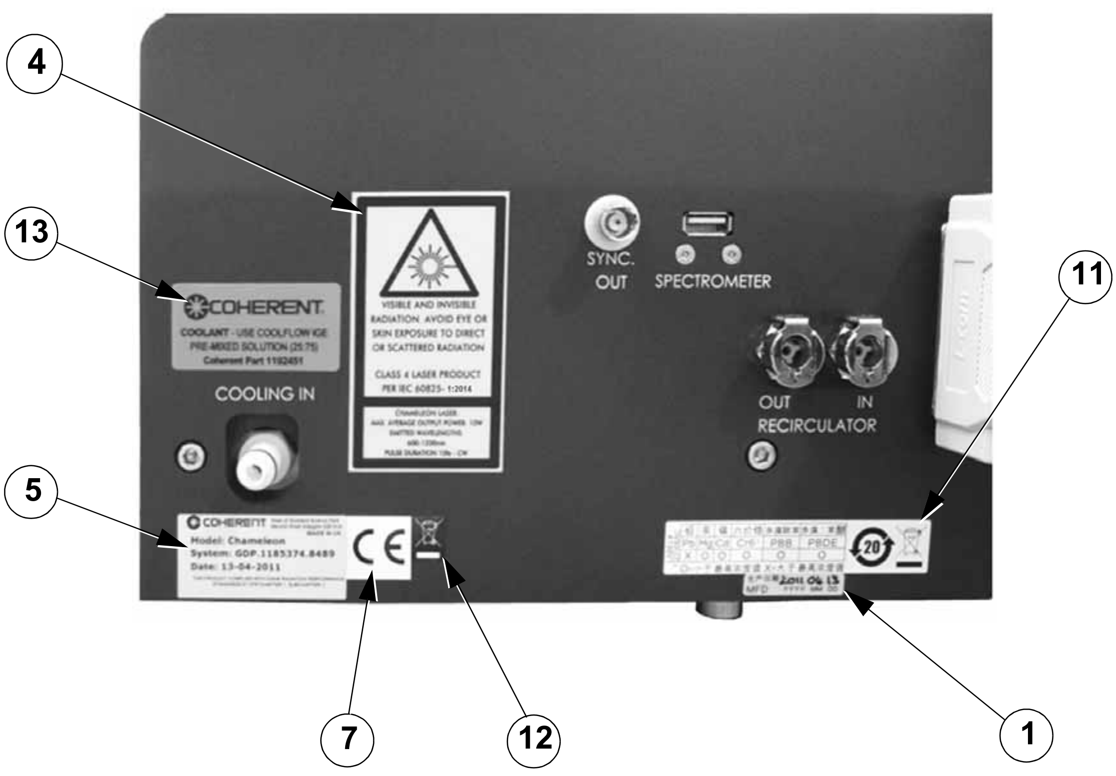


Chameleon Ultra Laser Head - Side View

Figure 2-1. Safety Features and Labels (Sheet 1 of 7)

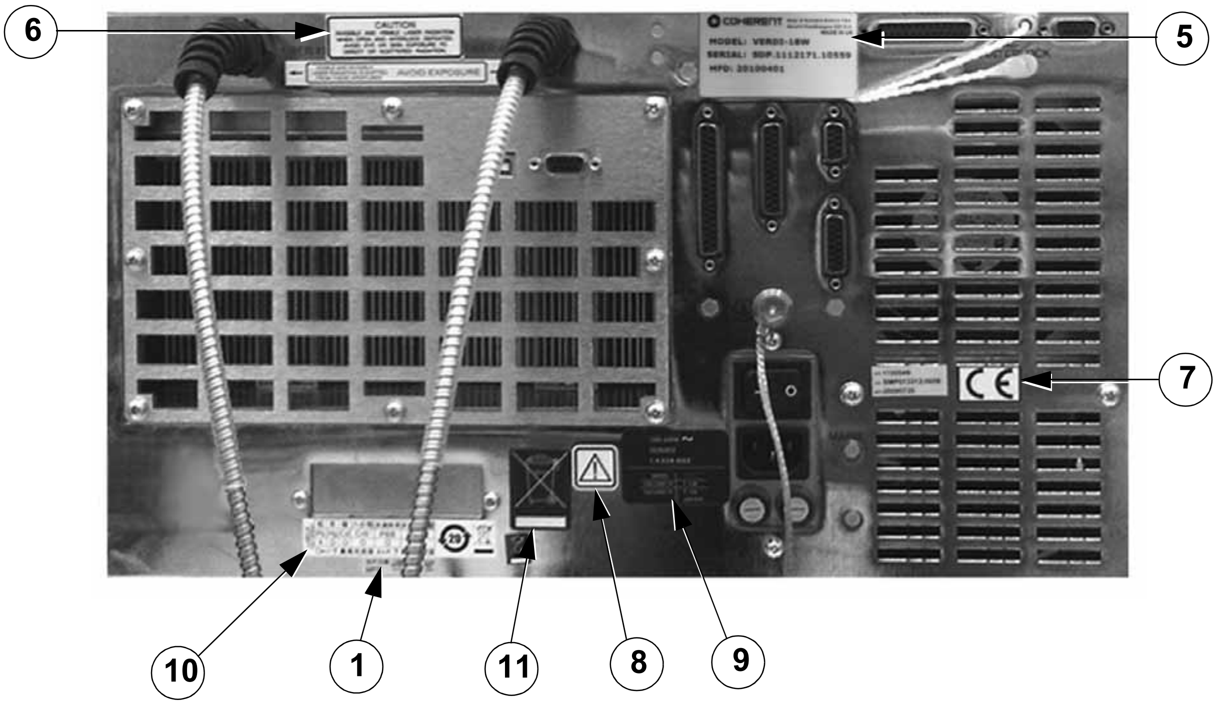


Chameleon Vision Laser Head - Isometric View

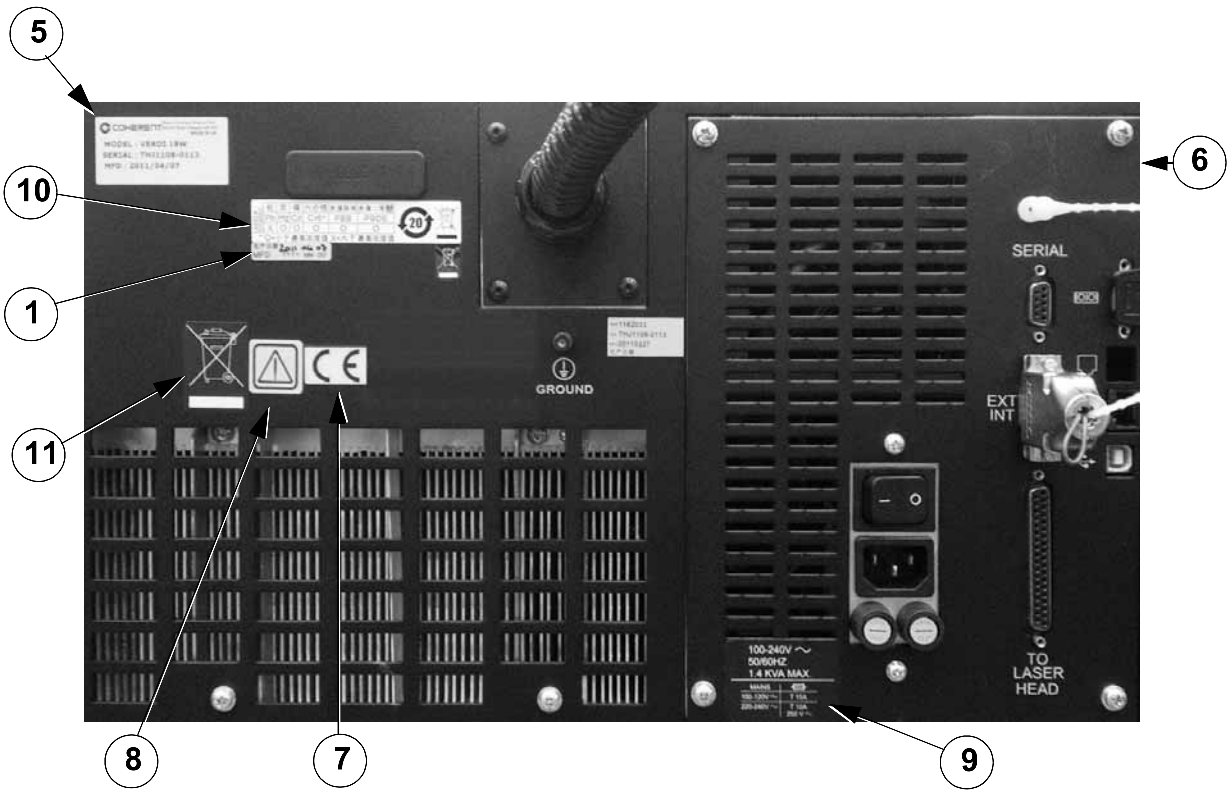


Chameleon Vision Laser Head - Back View

Figure 2-1. Safety Features and Labels (Sheet 2 of 7)



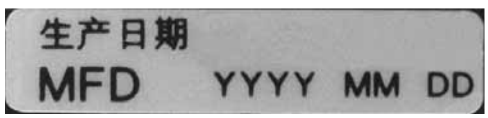
Power Supply (Ultra)



Power Supply (Vision-S)

Figure 2-1. Safety Features and Labels (Sheet 3 of 7)

Chiller

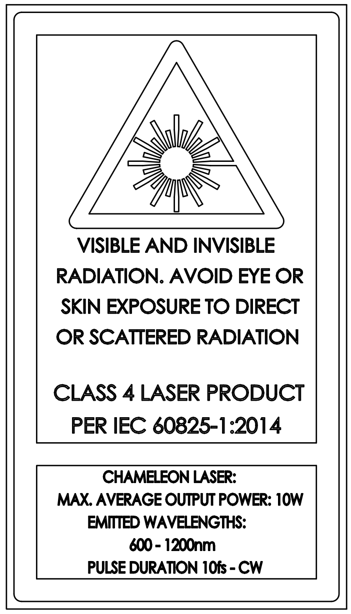


1. Date of Manufacture Label

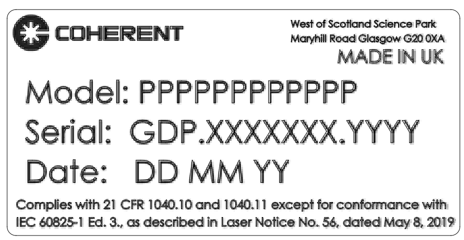
2. Laser Warning

3. Laser Aperture Indicator

Figure 2-1. Safety Features and Labels (Sheet 4 of 7)

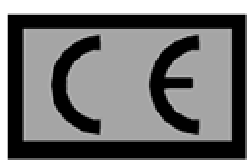


4. CDRH-Required Safety Information



5. Serial Number and Information

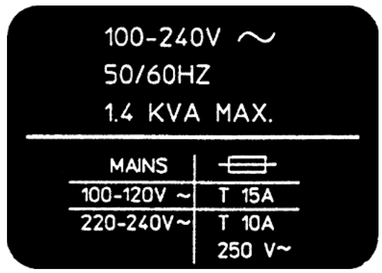
6. Caution Label



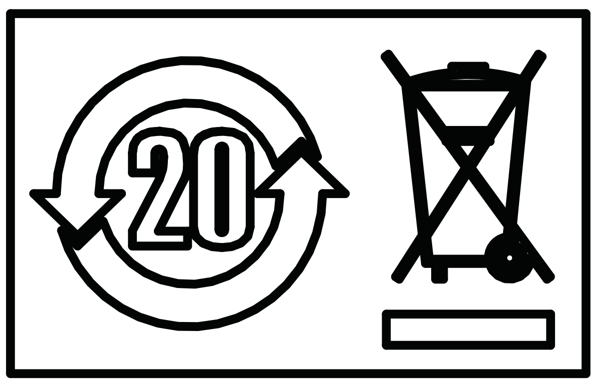
7. CE Certification

Figure 2-1. Safety Features and Labels (Sheet 5 of 7)

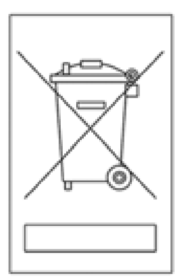
8. Caution Mark



9. Voltage Label



10. China RoHS Labeling



11. Wheelie Bin Disposal Label

Figure 2-1. Safety Features and Labels (Sheet 6 of 7)

12. Coolant Label

Figure 2-1. Safety Features and Labels (Sheet 7 of 7)

2.8 Sources of Additional Information

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

2.8.1 Laser Safety Standard

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

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

2.8.2 Publications and Guidelines

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

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

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

International Electrotechnical Commission (IEC)
www.iec.ch

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

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

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

2.8.3 Equipment and Training

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

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

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

3 DESCRIPTION AND SPECIFICATIONS

3.1 System Description

The Chameleon™ Ultra, Vision, and Vision-S lasers are compact, tunable, Verdi-pumped ultrafast lasers that produce modelocked, femtosecond pulses at an 80 MHz repetition rate.

The Chameleon Ultra, Chameleon Vision, and Chameleon Vision-S consist of a laser head, power supply (connected by an umbilical to the laser head), a miniature recirculating unit (MRU) and a closed loop chiller.

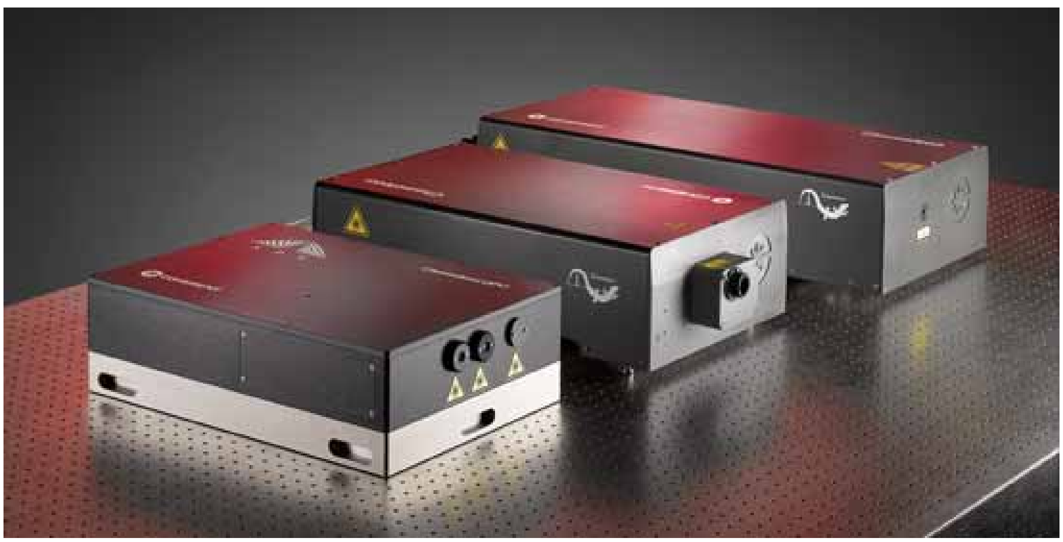


Figure 3-1. Chameleon™ Family
(Chiller, Power Supply, and Recirculator Unit Not Shown)

3.1.1 Chameleon Laser Heads

The Chameleon Ultra, Vision, and Vision-S laser heads (refer to Figure 3-2) include a Verdi solid state pump laser, two PowerTrack™ mirrors and the Ultra-Fast (VPUF) laser head. The laser head also contains beam steering mirrors that allow the beam to be positioned precisely.

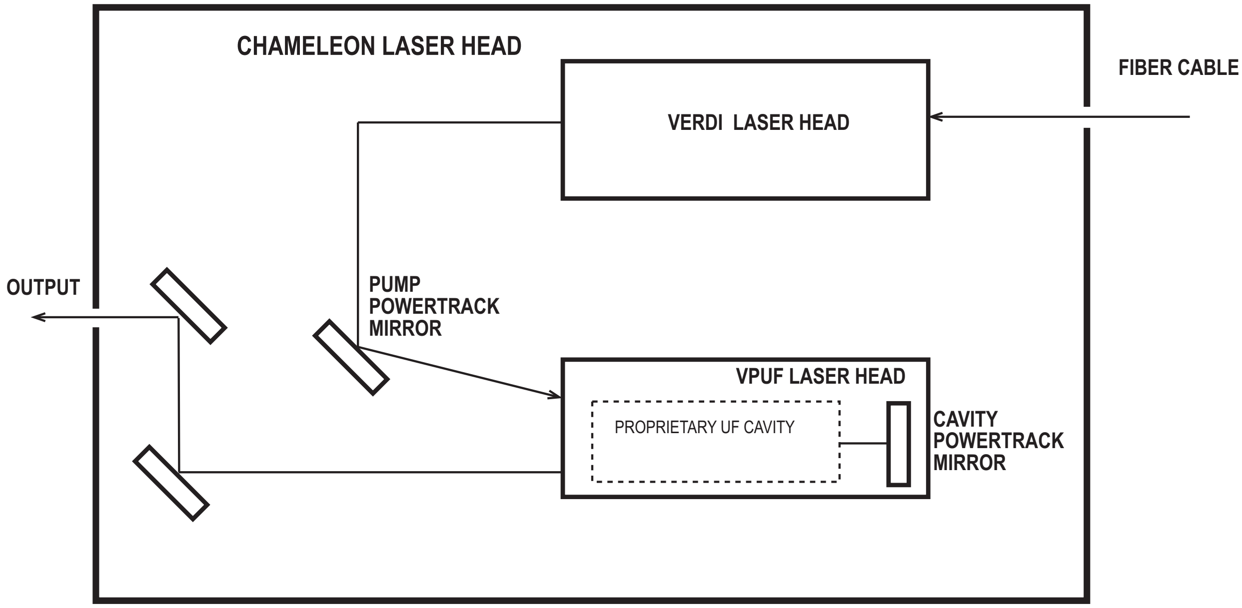


Figure 3-2. Chameleon (Ultra, Vision, and Vision-S) Laser Head

3.1.1.1 Verdi Laser Head

The major Verdi optical elements include Neodymium Vanadate ($Nd:YVO_4$) as the gain medium in a dual-end pumped geometry with the pump power provided by fiber optic delivery.

LBO (Lithium Triborate, LiB_3O_5) is used as the nonlinear wavelength-doubling medium. This is a Type I, non-critically phase matched LBO crystal held at approximately 150°C.

An etalon is used as the single-frequency optic. Since the laser is a unidirectional, homogeneously broadened system, it tends to run naturally single frequency, but the etalon reinforces this behavior.

Unidirectional operation is achieved using an optical diode.

An astigmatic compensator, two pump mirrors and two end mirrors are also included in the optical design. All optical components are mounted on Invar for strength and stability.

For more information about these components, refer to Theory of Operation.

3.1.1.2 PowerTrack

The PowerTrack function uses two Piezo-driven mirrors to actively maintain optimum pump beam alignment into the VPUF cavity, as well as optimum alignment of the VPUF cavity itself. This minimizes Chameleon Ultra, Vision, and Vision-S output power fluctuations and drift.

Optimum pump beam (532 nm) alignment is provided by a pump power track (PPT) mirror contained in the VPUF head. The alignment of the PPT mirror is optimized by two PZTs. The PZTs operate in a feedback loop to optimize the alignment of the Verdi pump beam and hence power emitted by the VPUF head.

Optimum cavity alignment is provided by the cavity power track (CPT) mirror, also contained in the VPUF head. The alignment of the CPT mirror is optimized in the same way as for the PPT.

In normal operation, the Chameleon Ultra, Vision, and Vision-S lasers always operate with either pump or cavity power track active. Both mirrors cannot be active at the same time and while one power track mirror is active, the other is held at a fixed alignment. The Chameleon Ultra, Vision, and Vision-S have a control protocol that performs appropriate switching between the PPT and CPT.

There is a direct relationship between the laser head baseplate temperature and the PZT positions. The optics in the VPUF head are aligned in the factory with the chiller set at 20°C. If the baseplate temperature varies significantly, the temperature-dependent VPUF head becomes distorted, which causes misalignment of the optics.

The PZTs compensate for small changes in alignment. If the baseplate temperature deviates too much from the original however, the PZTs reach one extreme of their range of motion and are unable to compensate for the misalignment. This results in low Chameleon Ultra, Vision, and Vision-S power, modelocking difficulty, and PZT faults. Refer to External Control for further information.

3.1.1.3 VPUF Laser Head

The VPUF head is an ultrafast laser cavity that uses a Ti:Sapphire crystal as the gain medium. Modelocking is obtained using the Kerr-Lens modelocking (KLM) technique with an automatic starter triggering the initiation of modelocking. The laser cavity is built on an aluminum plate for both mechanical strength and stability and is sealed to minimize environmental contamination. The desired output wavelength is tuned automatically on command.

Accumulated heat in the laser head is dissipated by the water-cooled baseplate. Baseplate temperature is monitored by a CPU in the power supply, which shuts the system down if the laser head temperature becomes too high.

3.1.1.4 Spectrometer

The laser head has a built-in spectrometer to allow direct readout of laser wavelength. The spectrometer has a resolution of 2 to 3 nm and covers the Chameleon Ultra, Vision, and Vision-S's full tuning range. This may be easily interfaced to a customer-supplied computer via a commonly used Universal Serial Bus (USB) electrical connection. The spectrometer manufacturer provides simple software to download data.

3.1.2 Miniature Recirculating Unit (MRU)

The MRU is a separate unit that is connected directly to the laser head using two PTFE hoses. It performs the task of cleaning, conditioning and dehumidifying the air inside the laser head to maintain stability and long-term operation.

It is important that the MRU is always switched on, even when the laser is not being used. Failure to operate the MRU could result in failure to lase within the water absorption spectrum between 910 nm and 980 nm.

It is important to ensure that the interlock connection between the Chameleon Ultra, Vision, or Vision-S power supply and the MRU X1 rear panel remains connected to ensure that the laser cannot be run if the MRU X1 is switched off.

See MRU X1 for specific information about the MRU.

The airflow of the unit is factory set to approximately 1.0 L/min. (3 PSI line pressure). The very low flows are designed to minimize noise induction by the recirculator pump. The Teflon tubing that connects the recirculator to the laser head is limited to 6 feet in length. The laser is interlocked to the MRU and cannot run if the unit is off.

NOTICE

The MRU must always be shut off before disconnecting the hoses. The MRU contains a pump that could be damaged due to any increase in pressure caused by a closed valve or blockage.

3.1.3 Power Supply

The main functions of the power supply are to supply DC power for the laser diode system that pumps the gain medium in the Verdi laser head, control the servo loops, provide cooling for the laser diode assemblies, control and monitoring, data storage and a user interface.

3.1.3.1 Servo Loops

The CPU-controlled servo loops are briefly described below. Additional information is located in Theory of Operation.

- **Verdi light loop.** A photodiode in the Verdi head monitors the Verdi laser power via the CPU. The CPU controls the output power from the Verdi based on this photodiode and in conjunction with the requested power from the power supply front panel.
- **LBO temperature.** The LBO doubling crystal is held at approximately 150°C by a resistive heater. To prevent rapid change of temperature that may cause LBO crystal damage during warm-up, the CPU regulates a slow ramp-up to operating temperature. This typically lasts between 30 to 45 minutes.

  In case of loss of AC power due to a power failure or inadvertently turning off the rear panel power switch, the laser is equipped with a battery-powered, microprocessor-controlled cool-down feature. This feature lowers the LBO temperature gradually to room temperature.
- **Pump diode heat sink temperature.** Diode heat sink temperature is held constant by thermo-electric coolers (TECs). Excess heat is dissipated by forced air-cooling through heat sinks. The diode heat sinks are located within the power supply.
- **Etalon temperatures.** These optical components are maintained at a preset level by TECs, which are capable of heating or cooling the optical element.
- **PowerTrack.** Refer to the section titled “PowerTrack” (p. 29).

3.1.3.2 Laser Diode Assembly

Two identical laser diode assemblies (Fiber Array Package, Integrated, or FAP-I™) are located in the power supply. The temperature of and current to each assembly is controlled individually and monitored by the CPU. Each FAP-I houses a diode bar and a TEC.

3.1.4 Umbilical Cable

The umbilical contains fiber optic cables to transmit light from the diode bars in the power supply to the laser head and also houses electrical cables that provide control and monitoring signals between the laser head and power supply.

3.1.5 Installation

For instructions on connecting and installing the Chameleon Ultra, Vision, or Vision-S laser head and power supply refer to Installation.

3.2 Specifications, Requirements, and Dimensions

Specifications for the Chameleon Ultra, Vision, and Vision-S lasers are available on the Coherent website:

https://www.coherent.com/lasers/main/chameleon-family

For detailed specifications related your system, refer to the datasheet shipped with the laser system.

3.2.1 Utility Requirements

Table 3-1. Utility Requirements

Parameter	Requirement
Power Requirements	90 to 250 VAC[1][2]
Maximum Current	Max. 15.5 Amp @ 85 VAC
Line Frequency	47 to 63 Hz
Cooling	Power supply: Air cooled with ambient air Laser head: Water-cooled.
Note: All specifications and requirements are subject to change without notice. [1] The power supply is autoranging and accommodates the full range of input voltages without hardware changes. [2] The electrical service should have a main power disconnect switch located in close proximity to the laser. The main power disconnect switch must be marked clearly as the disconnecting device for the laser and must be within easy reach of the operator.	

3.2.2 Environmental Requirements

Table 3-2. Environmental Requirements

Parameter	Requirement
Operating Temperature	15 to 28 ºC
Relative Humidity	Non-condensing
Altitude	Sea level to 10,000 feet

3.2.3 Dimensions and Weights

Table 3-3. Dimensions and Weights

	Power Supply	Ultra Laser Head	Vision Laser Head	Vision S Laser Head	Umbilical
Length	618.0 mm (24.33 in.)	610.4 mm (24.03 in.)	779.5 mm (30.69 in.)	799.8 mm (31.49 in.)	3 m (9.84 ft.)
Width	436.0 mm (17.17 in.)	369.0 mm (14.53 in.)	369.0 mm (14.53 in.)	369 mm (14.53 in.)	—
Height	269.0 mm (10.59 in.)	189.2 mm (7.45 in.)	189.2 mm (7.45 in.)	189.2 mm (7.45 in.)	—
Weight	41 kg (90 lbs.)	42 kg (93 lbs.)	52 kg (115 lbs.)	52kg (115 lbs.)	1.8 kg (4 lbs.)
Diameter	—	—	—		38 mm (1.5 in.)

3.2.3.1 Chameleon Ultra Laser Head Dimensional Drawings

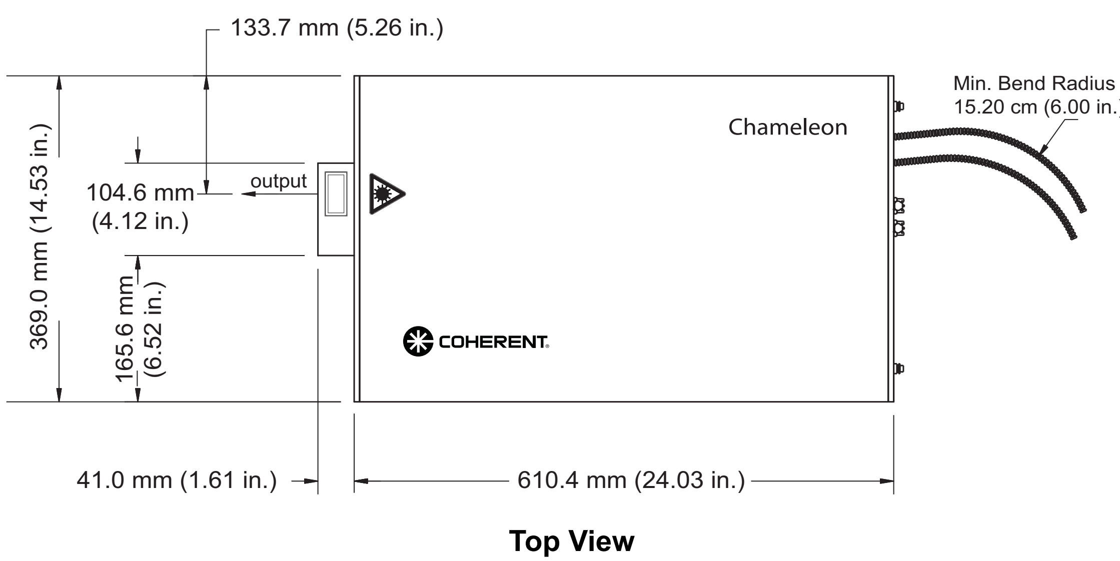
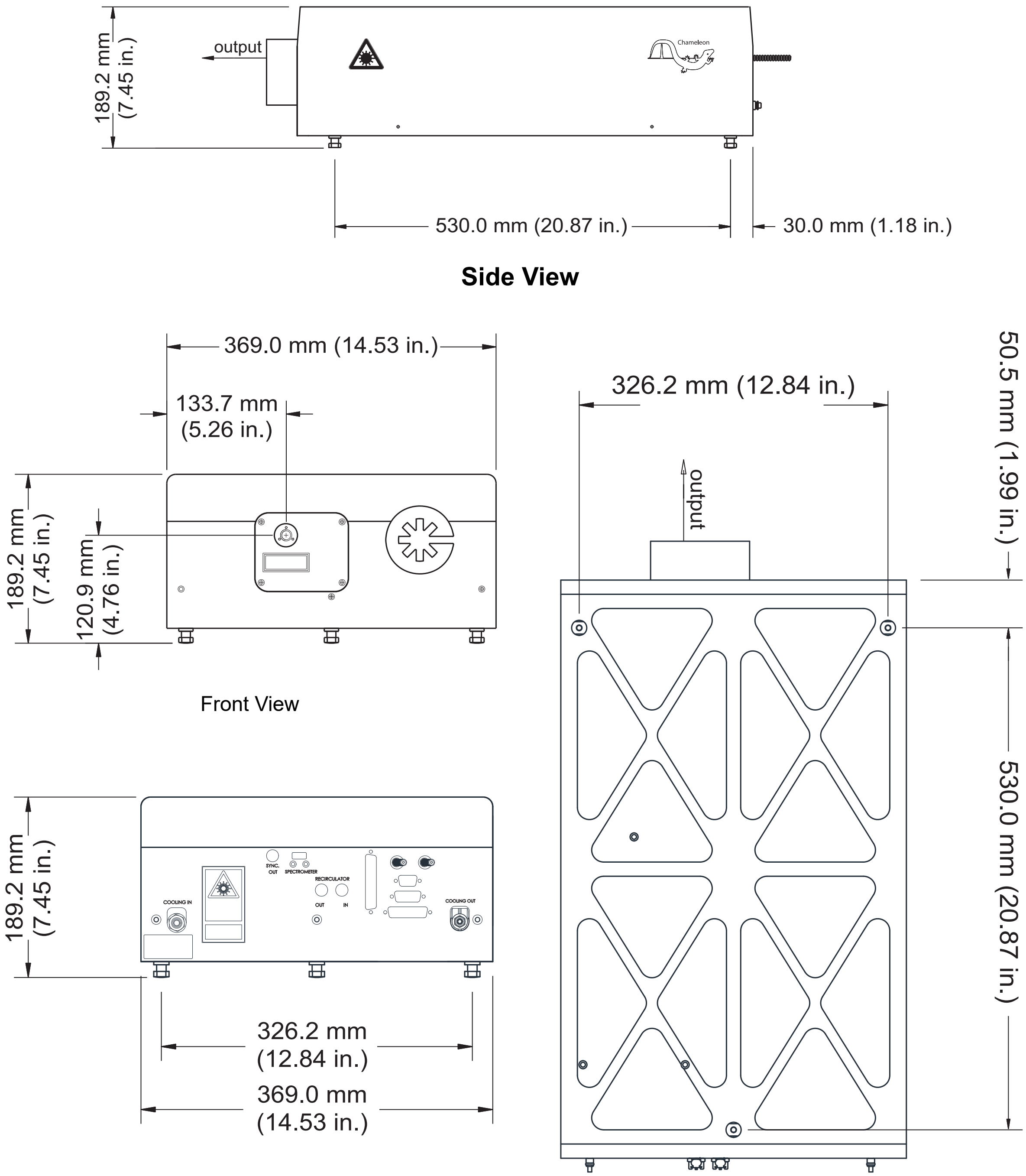


Figure 3-3. Chameleon Ultra Laser Component Dimensions



Rear View **Bottom View**

Figure 3-3. Chameleon Ultra Laser Component Dimensions (Continued)

3.2.3.2 Chameleon Vision Laser Head Dimensional Drawings

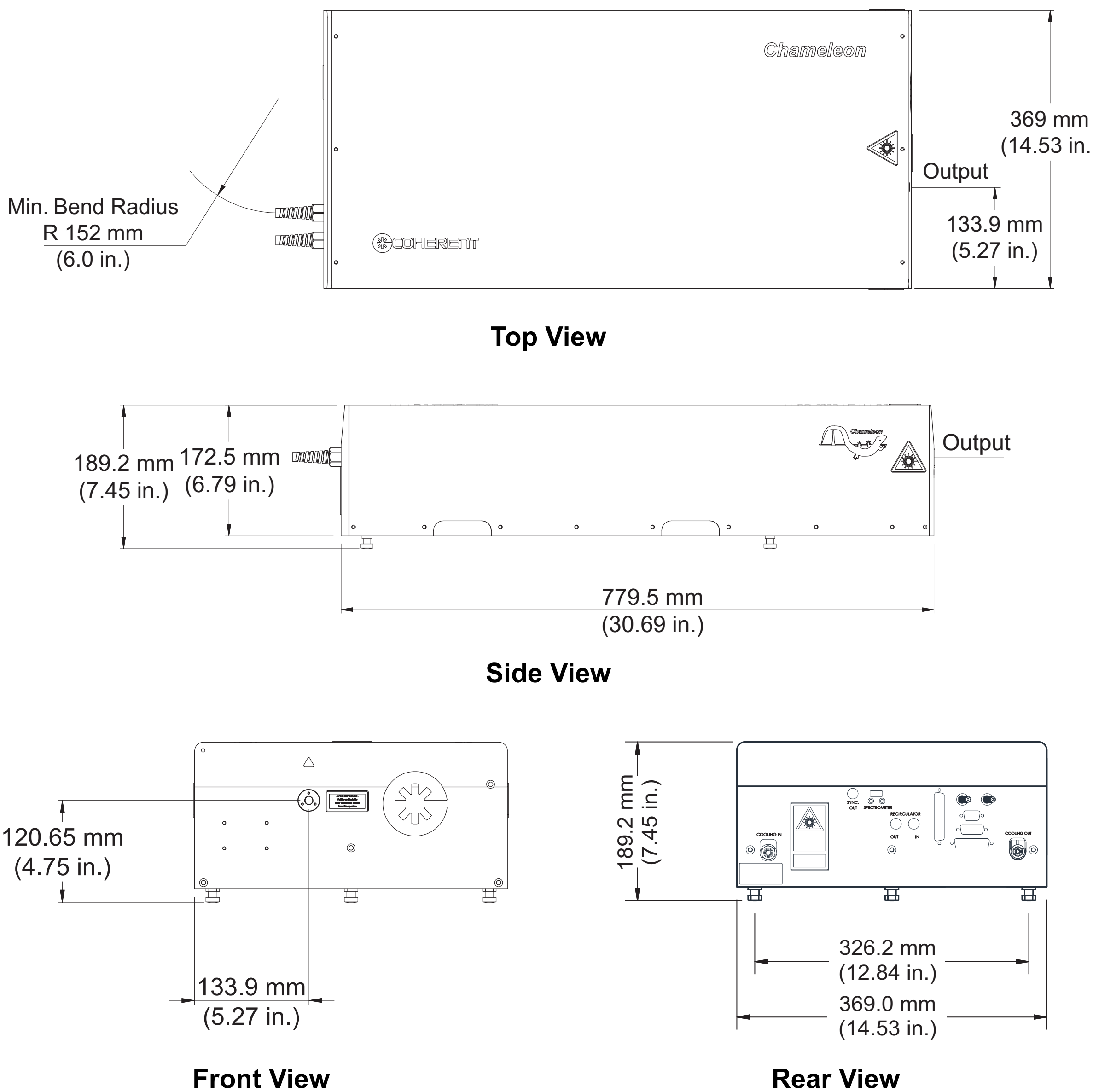
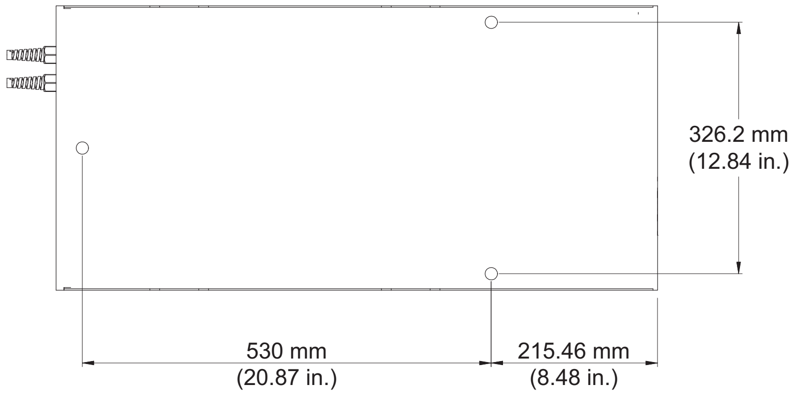


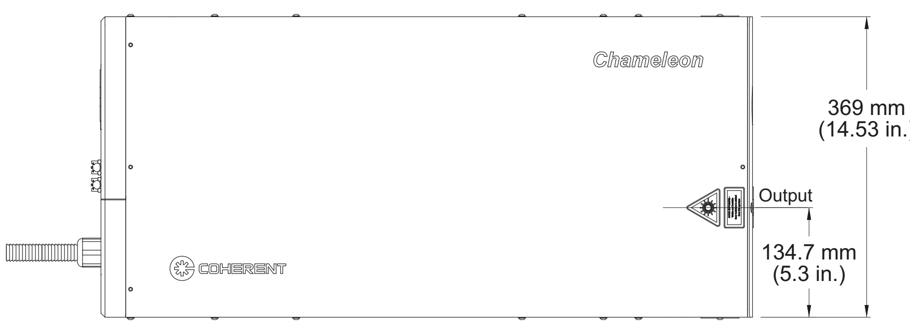
Figure 3-4. Chameleon Vision Laser Component Dimensions



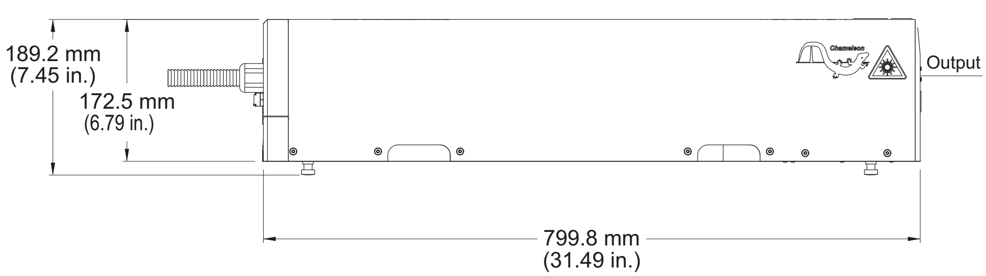
Bottom View

Figure 3-4. Chameleon Vision Laser Component Dimensions (Continued)

3.2.3.3 Chameleon Vision-S Laser Head Dimensional Drawings

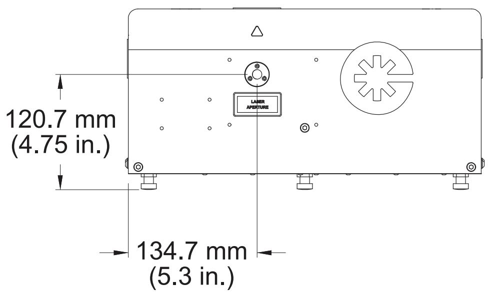


Top View

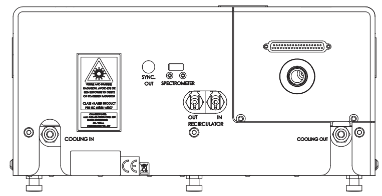


Side View

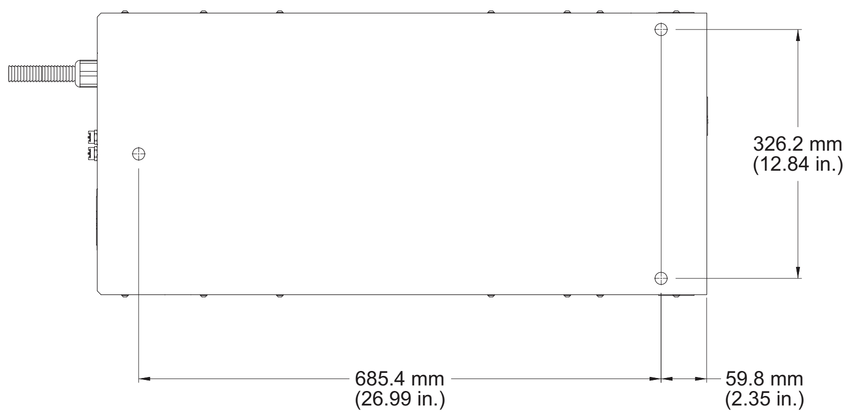
Figure 3-5. Chameleon Vision-S Laser Component Dimensions



Front View



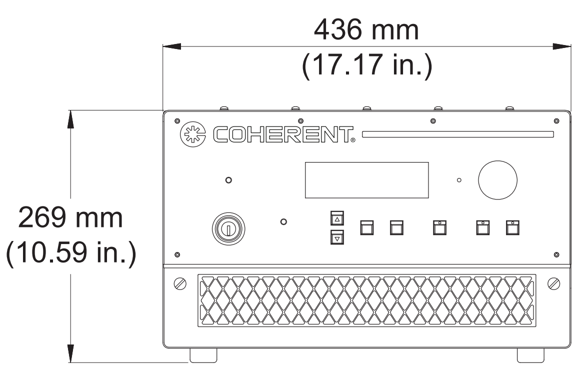
Rear View



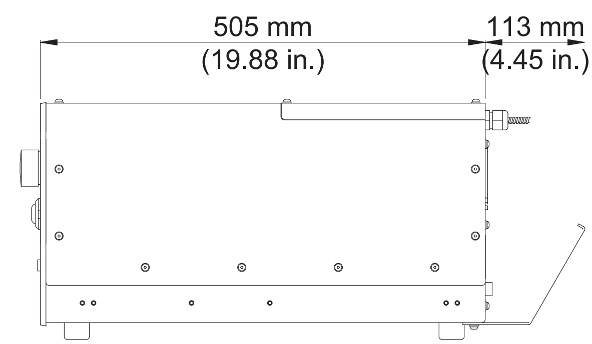
Bottom View

Figure 3-5. Chameleon Vision-S Laser Component Dimensions (Continued)

3.2.3.4 Chameleon Ultra and Vision Power Supply Dimensional Drawings



Front View



Side View

Figure 3-6. Power Supply for Ultra and Vision

3.2.3.5 Chameleon Vision-S Power Supply Dimensional Drawings

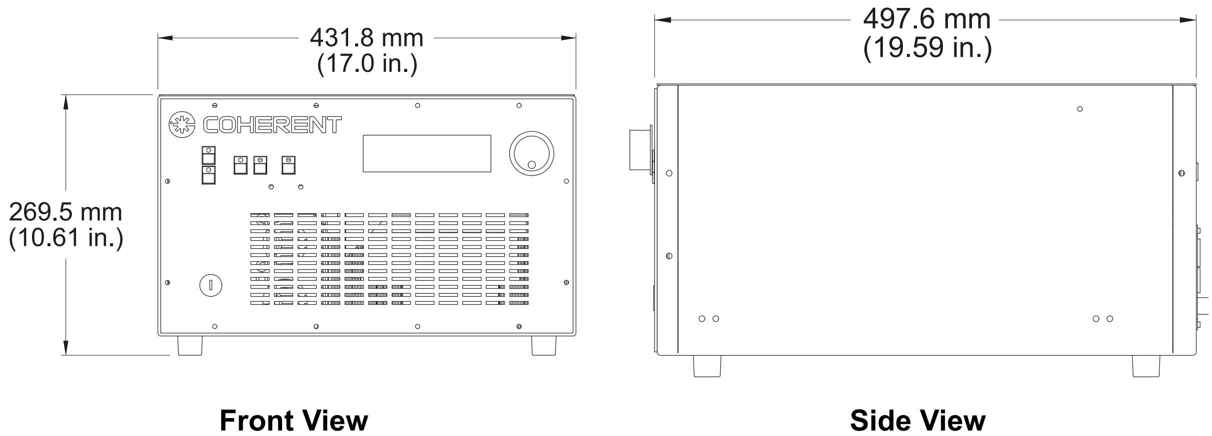


Figure 3-7. Power Supply for Vision-S

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4 INSTALLATION

4.1 Receiving and Inspection

Inspect shipping containers for signs of rough handling or damage. Indicate any such signs on the bill of lading. Report any damage immediately to the shipping carrier and to Coherent Service Department (800-367-7890) or to an authorized representative.

NOTICE

Retain shipping containers. The containers are required if the system is returned to the factory for service. The containers may also be needed to support a shipping damage claim.

Chameleon Ultra, Vision, and Vision-S lasers consist of four major components: the laser head, the power supply, the chiller and MRU air recirculator. The laser head and power supply are connected by the umbilical. Coherent recommends that two people unpack and transport the Chameleon Ultra, Vision, and Vision-S lasers. Each of these components should be lifted by at least two people.

4.2 External Interlock

An interlock connector is located on the power supply rear panel. During operation, the interlock status is continually monitored by the CPU. If the interlock is open, an interlock fault message is displayed on the power supply front panel and laser emission is terminated. Laser emission does not resume until the interlock circuit is closed and the interlock fault is manually cleared.

Since the laser system should never be operated without purified air from the MRU, the MRU X1 is positioned in the middle of the interlock loop effectively moving the interlock connector to the MRU X1 rear panel. This external interlock must be closed (by jumper or switch contacts) and the MRU pump must operate before the interlock loop circuit is satisfied.

The laser system includes the interlock cable that connects the power supply to the MRU X1, an interlock over-ride (defeat) jumper (a shorted HR10 plug, or shorted 15-way D-Type plug for the Vision-S), and an un-wired HR10 plug to be used in a customer-designed interlock circuit.

Local safety regulations and customer application will dictate which interlock method to employ. A basic interlock circuit using a control or door switch is provided in Appendix A. A more advanced interlock circuit, complete with a "Laser In Use" warning light is shown below in Figure 4-1. Note that the interlock circuit provides insufficient power to drive a load, therefore do not place any load on the external interlock circuit.

The interlock connection on the power supply rear panel must be connected to the MRU X1 using the cable provided. The user-furnished external interlock is then connected to the HR10 connector on the MRU X1 (see MRU X1). This interlock method prevents the laser from operating if the MRU is not running or the external interlock circuit is opened.

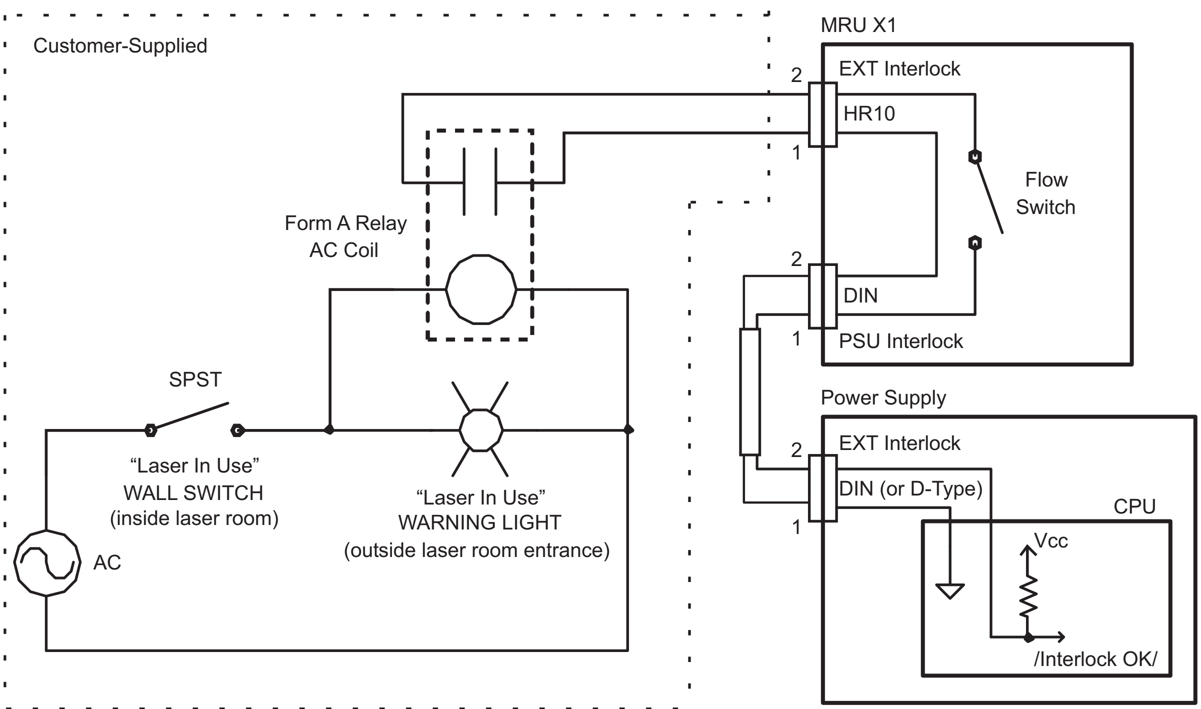


Figure 4-1. Example External Interlock Circuit

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

4.3 Coolant – Laser Head

The Chameleon Ultra, Vision, and Vision-S Ti:Sapphire crystal requires a flow of coolant for proper operation. A chiller must be used at all times. See “Install the Chiller” (p. 49) for further instruction.

4.4 MRU Operating Parameters

The airflow from the MRU air recirculator is factory set to approximately 1.0 L/minute (3 psi line pressure). The very low flows are designed to minimize noise induction by the recirculator pump.

4.5 Installation Considerations

Installation is generally carried out by a Coherent Field Service representative, however, it is extremely useful to pre-visualize the installation in relation to the following points:

- Storage of the Chameleon crates, both in the interim period between delivery and installation, and post-installation
- Access routes to the final location and moving equipment required on the day (i.e. a wheeled trolley, capable of taking the weight of the laser head and PSU, may be required)
- Laser safety protocols
- Environmental conditions
- Utility requirements
- Safe and careful handling

- Routing of the umbilical cables (>15.0 cm bend radius for the fibers)
- Correct filling of the water chiller
- Location, especially regards the cooling intakes/exhausts which should not be blocked

The Chameleon Ultra, Vision, and Vision-S laser systems are shipped with the optical fibers connected to both power supply and laser head ends. Position the power supply with the fiber umbilical as straight as possible. Ensure the umbilical is not twisted or kinked. Great care should be taken not to subject the fibers to mechanical stress, e.g. bend radius of less than 150 mm (6 inches), pulling at either end connector.

The recommended distance between the Chameleon Ultra, Vision, or Vision-S laser head output and any optical system following is 160 - 610 mm (6 - 24 inches).

Locate the laser head, power supply, chiller and MRU recirculator (see Figure 4-2 or Figure 4-3) in a convenient location, preferably away from heat- producing sources. If the power supply overheats, the system shuts down automatically without damage to system components. Ensure the power supply-cooling intake and exhaust (rear, top and left side) are not blocked or obstructed.

Make sure to provide user access to all system controls, and service access to all lasers system components, covers and connections.

Refer to "Controls, Indicators, and Features" (p. 51) for the location of all connectors referenced in the following procedure.

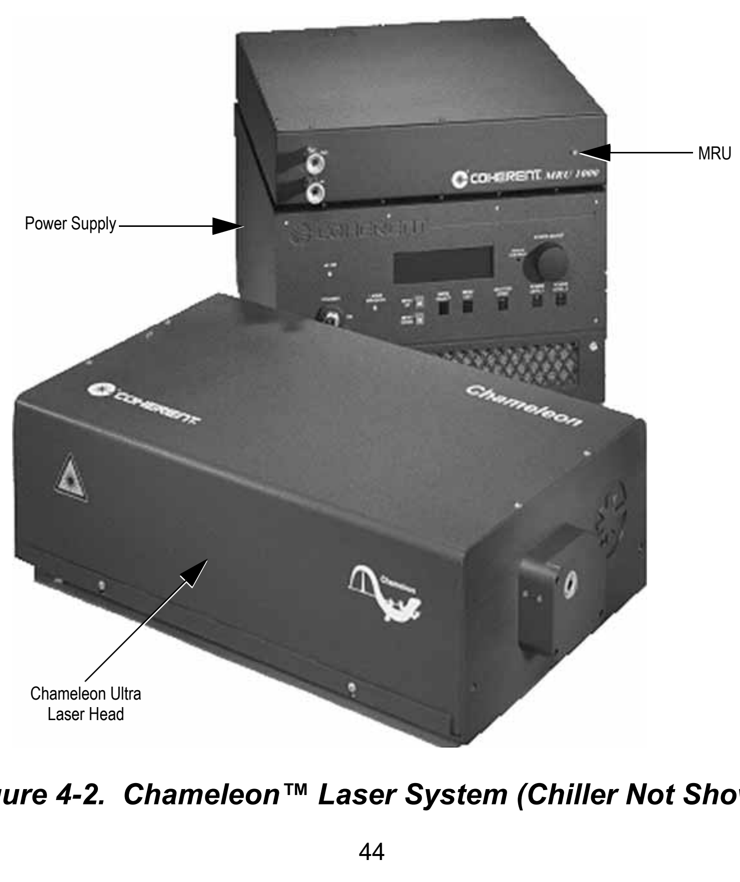


Figure 4-2. Chameleon™ Laser System (Chiller Not Shown)

Figure 4-3. Chameleon^{TM} Vision Laser System (Chiller Not Shown)

4.6 Install the Power Supply

1. Move the power supply to an accessible-friendly location, preferably away from heat producing sources. Ensure the cooling intake and exhaust (front and back) are not blocked or obstructed. If storing the power supply in a 19 in. (48 cm) equipment rack, allow a minimum clearance of 18 in. (46 cm) for the front panel of the power supply.
2. On the power input module, verify that the two AC fuses are appropriate for the local AC supply voltage (use 15A fuses for 100 VAC mains or 10A fuses for 220 VAC mains). On new or repaired systems, there is a fuse selection warning label that need to be removed before the AC power cord can be connected.
3. Inspect the plug end of the power cord and install the proper mating connector, if necessary. Each locality should inspect the power cord and install the proper connector if necessary. The connector should be installed in a properly grounded outlet with a maximum of 16 Amp service for proper overcurrent and earth fault protection.

4.7 Install the Laser Head

1. Place the laser head on an optical table or other stable platform. Position the laser head such hat the output aperture is 150 - 610 mm (6 to 24 inches) away from the next optical system.
2. Secure the laser head to the table with the supplied mounting feet.

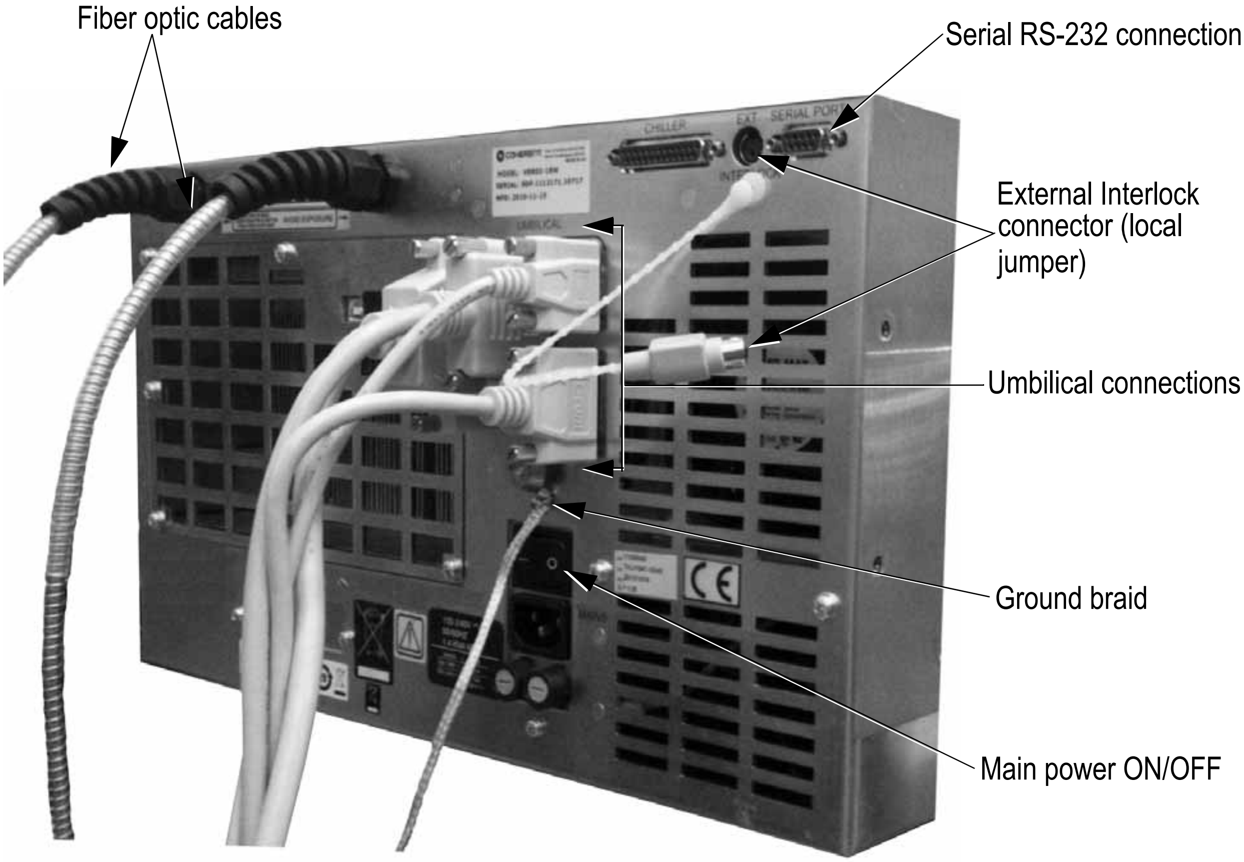
4.8 Umbilical Connection

1. Attach the four umbilical cables to the rear panel of the power supply. Each cable has a different size connector, so it is straightforward to make the correct connections. Refer to Figure 4-4.
2. Attach the umbilical ground braid to the rear panel of the power supply.
3. Unscrew and remove the U-shaped clamp from the umbilical strain relief bracket. Secure the umbilical cable between the bracket and clamp and tighten the clamp screws.
4. Feed the AC power cord through the feed-through in the umbilical strain relief bracket and plug into the rear panel of the power supply. Do not connect to AC power at this time.

4.9 Install the MRU X1

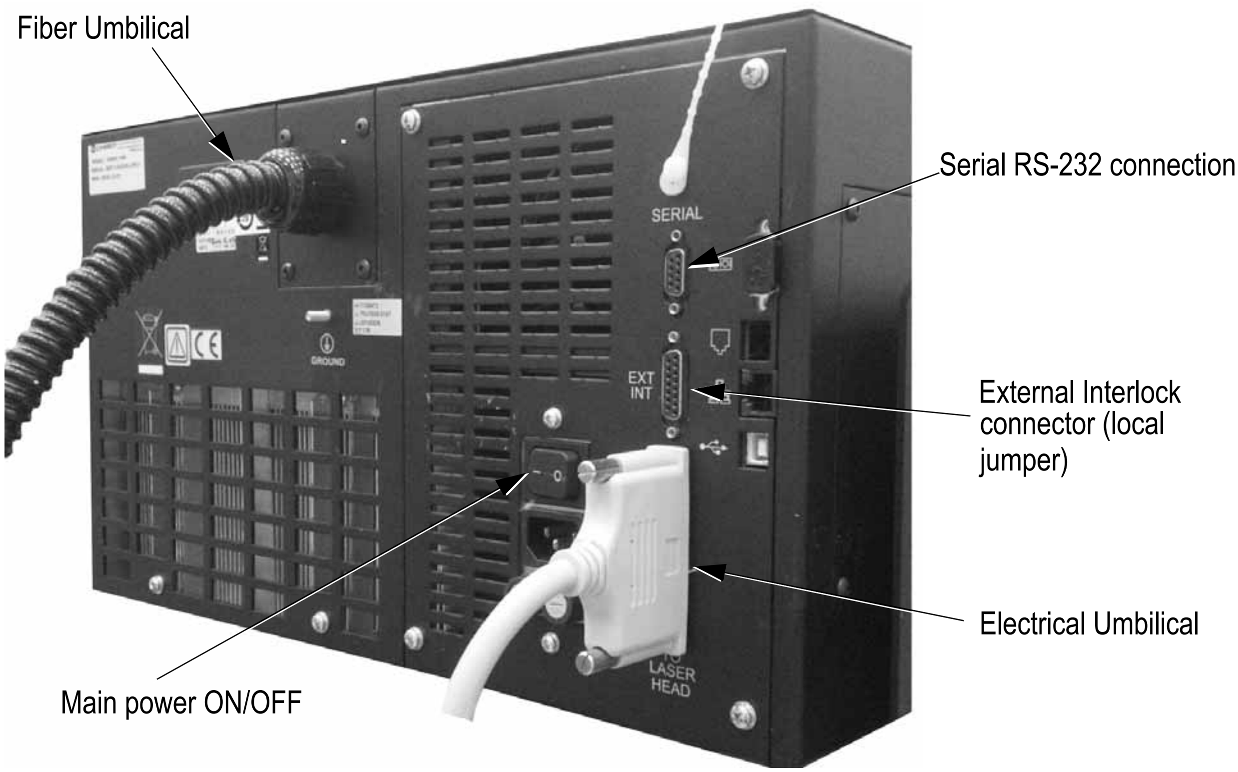
Position the MRU X1 in an accessible location within 4 m (13 feet) of the power supply (length of the interlock cable) and 1.8 m (4 feet) of the laser head (air hose length). It is normal to set the MRU X1 on top of the power supply. If installing the power supply in a 19 inch equipment rack, allow a minimum vertical clearance of 456 mm (18 inches) above the top panel of the MRU X1.

1. Locate the interlock cable (mini-DIN connectors on both ends), the HR10 interlock over-ride (defeat) plug and the un-wired HR10 plug.
2. Connect one end of the mini-DIN interlock cable to the EXT Interlock jack on the power supply. Connect the other end of the cable to the PSU Interlock jack on the MRU X1.
3. Connect the interlock over-ride plug (or HR10 plug wired to the customer-supplied interlock circuit) to the EXT Interlock jack on the MRU X1.



Power Supply (Verdi)

Figure 4-4. Umbilical Connections



Power Supply (Verdi Otto)

Figure 4-4. Umbilical Connections

NOTICE

The connectors for the MRU air lines must not be contaminated during handling or set up. These ports provide a direct line to the laser head. If clean handling is not observed, contamination may work itself inside the laser head and reduce the lifetime of the laser.

4. Remove the protective caps from the inlet and outlet ports at the back of the laser head and from the front of the MRU.
5. Remove the clean air hose from the clean packaging. Protect from contact contamination (including protection from dirt and grease on hands) during fitting.
6. Fit the outlet port from the recirculator to the inlet port of the laser head, then fit the outlet port from the laser head to the inlet port of the recirculator.
7. Connect the MRU to facility power and turn the recirculator on. The green LED should illuminate on the front panel of the MRU and a quiet humming sound should be audible, indicating that the pump is operating normally.

8. Allow the MRU to run for a minimum of two hours before proceeding.

NOTICE
The recirculator must be run for a minimum of two hours before operating the system. Failure to run the air recirculator will result in loss of modelock within the water absorption region (910 nm - 980 nm).

4.10 Install the Chiller

The chiller is shipped completely drained of coolant and must be filled before use. Fill the reservoir with coolant. Connect the chiller to the laser head with the supplied hoses. Be sure the set temperature is set to 20°C.

1. Connect the coolant hoses that run between the chiller and the laser head. Take care to note the flow direction. Ensure that the output of the chiller is connected to the input of the laser head, and vice versa.
2. Fill the chiller reservoir (fill tank) with the coolant.
3. Locate the power cord and connect it to the chiller. If necessary, install a proper mating plug on the mains end. The plug must be installed in a properly grounded outlet with a maximum of 15 Amp service for proper overcurrent and earth fault protection.
4. Turn the chiller on and allow the coolant to fill the hoses and laser head. Refill the chiller reservoir as required.

NOTICE
Do not overfill the chiller reservoir. Ensure sure that hoses is not spilled externally around the filler cap. Immediately wipe up any spilled water with absorbent tissues. Any coolant that may leak inside the chiller could possibly cause electrical failure of the chiller PCB.

5. Verify the chiller temperature is set to 20°C.
6. Check the system for leaks.

4.11 Turn-On Procedure

Perform the cold start procedure located in Operation.

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5 CONTROLS, INDICATORS, AND FEATURES

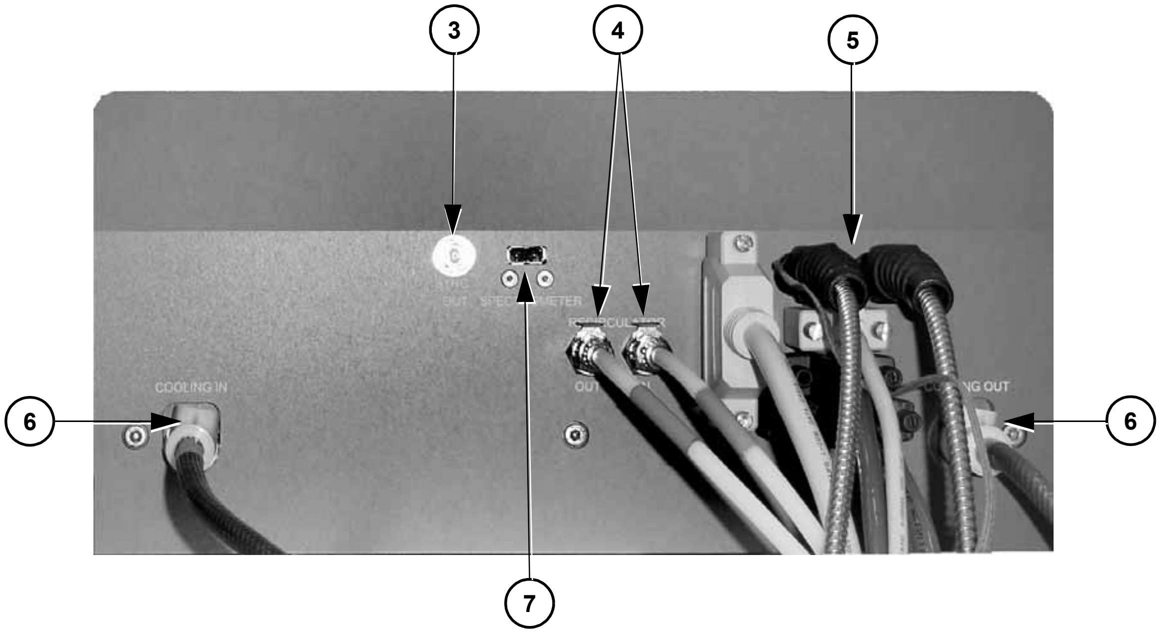
Figure 5-1 (p. 51) and Table 5-1 (p. 52) describe the controls, indicators, and features of the Chameleon™ laser head models.

Figure 5-2 (p. 53), Figure 5-3 (p. 54), and Table 5-2 (p. 55) describe the controls, indicators, and features of the Chameleon™ power supply models.

5.1 Laser Head

Front View

Figure 5-1. Chameleon Laser Head Features



Rear View

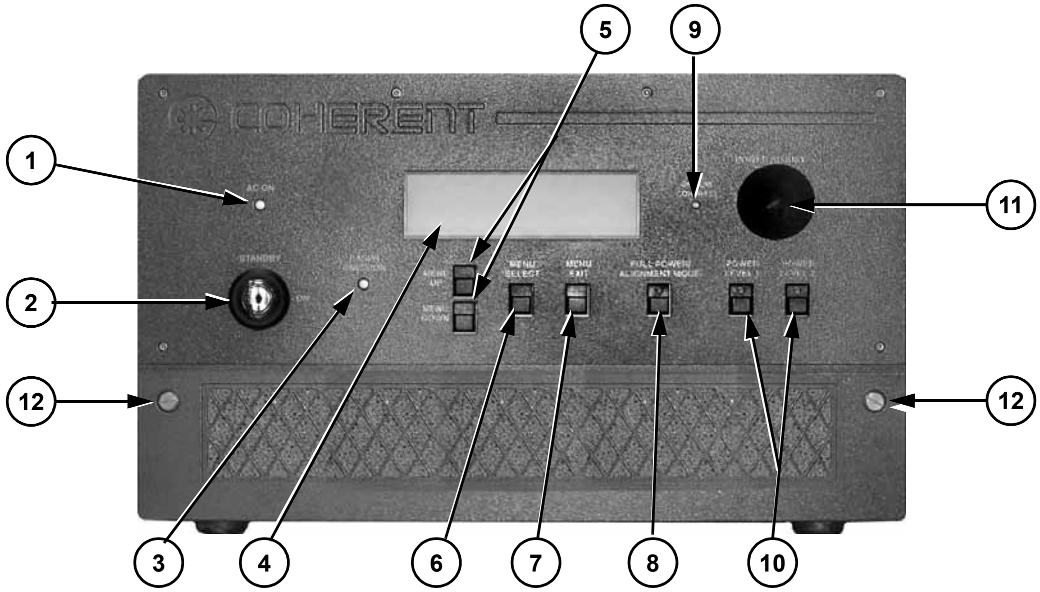
1.Emission indicator
2.Exit window
3.Fast photo diode (sync out) BNC connector
4.MRU connectors
5.Umbilical (optical fibers)
6.Cooling water inlet and outlet fittings
7.Internal spectrometer USB connector

Figure 5-1. Chameleon Laser Head Features (Continued)

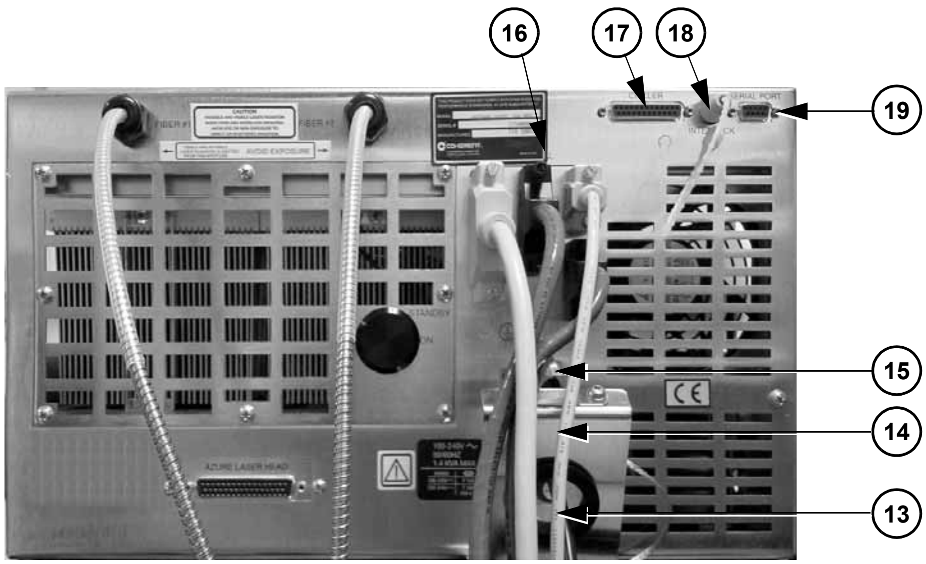
Table 5-1. Chameleon Laser Head Features Description

Item	Control	Function
1	Emission indicator	Lights when laser emission is possible.
2	Exit window	Emits ultrafast laser light from this window when the laser is on and the shutter is open.
3	Fast photo diode (sync out) BNC connector	Synchronizes external equipment with the Chameleon (Ultra, Vision, or Vision-S) output pulse. This output can also be used to monitor the output pulse with an oscilloscope.
4	MRU connectors	Connects the MRU to the Chameleon (Ultra, Vision, or Vision-S) laser head. The recirculator should be left on at all times.
5	Umbilical	Houses the fiber optic and electrical cables that provide an interface between the laser head and power supply.
6	Cooling inlet and outlet fittings	Connects to a closed-loop chiller.
7	Internal spectrometer USB connector	Allows the user to connect an external computer (supplied by user) to the Chameleon (Ultra, Vision, or Vision-S) internal spectrometer and monitor the system wavelength.

5.2 Power Supply



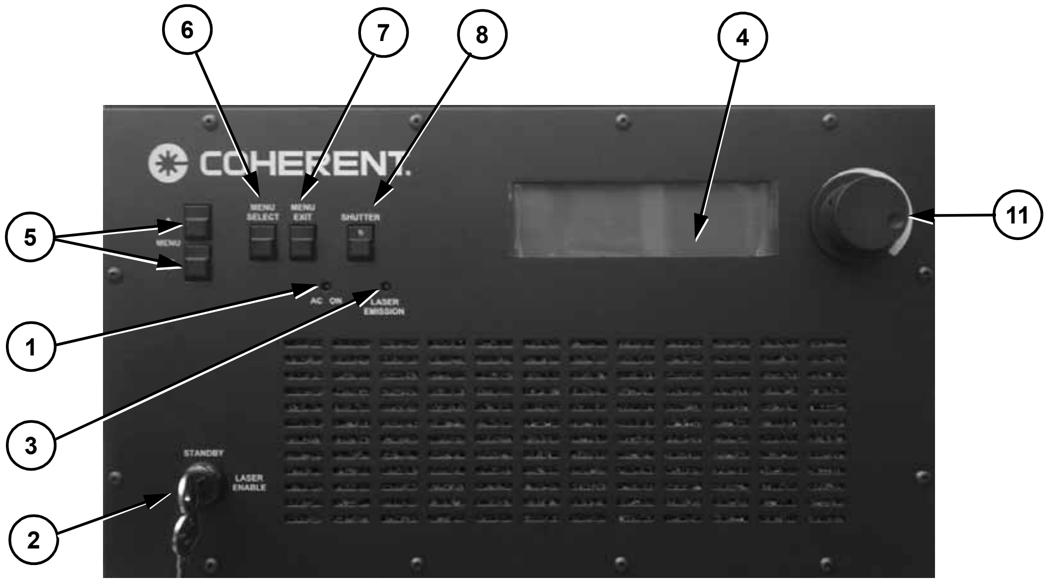
Front View



Rear View

1.AC ON indicator
2.Keyswitch
3.LASER EMISSION indicator
4.Display
5.MENU UP/DOWN pushbuttons
6.MENU SELECT pushbutton
7.MENU EXIT pushbutton
8.SHUTTER OPEN pushbutton indicator
9.DISPLAY CONTRAST adjust
10.POWER LEVEL 1/2 pushbutton indicators
11.POWER ADJUST or rotary knob
12.Air filter retaining screws (2x)
13.Fuses
14.Power cord receptacle
15.Power ON/OFF switch
16.Umbilical
17.MODEM connector, not used
18.EXTERNAL INTERLOCK connector
19.SERIAL PORT connector

Figure 5-2. Power Supply (Verdi) Ultra and Vision Controls and Indicators



Front View

Rear View

1.AC ON indicator
2.Keyswitch
3.LASER EMISSION indicator
4.Display
5.MENU UP/DOWN pushbuttons
6.MENU SELECT pushbutton
7.MENU EXIT pushbutton
8.SHUTTER OPEN pushbutton indicator
9.NA
10.NA
11.POWER ADJUST or rotary knob
12.NA
13.Fuses
14.Power cord receptacle
15.Power ON/OFF switch
16.Umbilical
17.NA
18.EXTERNAL INTERLOCK connector
19.SERIAL PORT connector

Figure 5-3. Power Supply (Verdi Otto) Vision-S Controls and Indicators

Table 5-2. Power Supply Features Description

Item	Control	Function
1	AC ON indicator	Lights when power is applied to the power supply via the power switch on the power supply rear panel.
2	Keyswitch	Toggles the Chameleon (Ultra, Vision, or Vision-S) laser either in the STANDBY or ON state. The key can be removed when in STANDBY position to prevent unauthorized operation. The key cannot be removed when in ON position.
3	LASER EMISSION indicator	Lights when laser emission is possible.
4	Display	Displays pump laser status, operating parameters and diagnostic data. Refer to Table 6-2 for a complete description of the Chameleon (Ultra, Vision, or Vision-S) displays.
5	MENU UP/DOWN pushbuttons	Allows scrolling through the menus. Refer to Table 6-2 for a complete description of the Chameleon (Ultra, Vision, or Vision-S) displays and menus.
6	MENU SELECT pushbutton	Allows selection of the indicated menu.
7	MENU EXIT pushbutton	Exits current menu. Can also be used to clear inactive faults as described in the troubleshooting charts in "Maintenance". Pressing MENU EXIT while in the main menu causes the single-frequency mode to recenter as described in Table 7-3, “FLASH” command.
8	SHUTTER OPEN pushbutton indicator	Opens and closes the shutter on the laser head remotely. The pushbutton indicator LED lights when the shutter is disabled.
9	DISPLAY CONTRAST adjust	Allows adjustment of the display by user for best viewing.
10	POWER LEVEL 1/2 pushbutton indicators	Not functional on the Chameleon (Ultra, Vision, or Vision-S).
11	POWER ADJUST or rotary knob	Allows continuous adjustment of various settings including the wavelength.
12	Air filter retaining nuts	Secures air filter cover to power supply.
13	Fuse	250 V, 10 A, time-delay fuse provides electrical protection.
14	Power cord receptacle	Connects the power supply to 110 VAC facility power, using supplied cord.
15	Power ON/OFF switch	Applies/removes all power from the pump laser. Refer to the shut-down procedures to avoid unnecessary use of the internal battery.
16	Umbilical	Houses electrical cables and the fiber optic cables.
17	MODEM connector	Not used.
18	EXTERNAL INTERLOCK connector	Allows connection of an external interlock. The pump laser does not operate when this connector is open. Refer to the "Installation", for additional information on the interlock.
19	SERIAL PORT connector	Allows external computer control of the Chameleon (Ultra, Vision, or Vision-S). Refer to "External Control" for additional information on external computer control, including commands, queries, and system requirements.

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6 OPERATION

WARNING!
Wear laser safety glasses to protect against the radiation generated from the laser. It is assumed that the operator has read Laser Safety and is familiar with laser safety practices and the dangers involved. Ensure all personnel in the area wear laser safety glasses.

The Chameleon Ultra, Vision, and Vision-S lasers are designed to be operated with the head cover in place. Do not open the laser head. There are no user-serviceable components or adjustments inside. The warranty is voided if the enclosure is disassembled.

6.1 Turning the System On

6.1.1 Cold Start

The cold-start procedure must be used when the Chameleon Ultra, Vision, or Vision-S power supply rear panel power switch has been off for more than 60 minutes. In this condition, all servos are off and the pump laser has to stabilize the servos that can take up to 60 minutes. During this time, the laser diodes cannot be turned on.

The cold-start procedure can be performed when the laser is externally controlled using a computer. For a list of RS-232 commands and queries, refer to Table 7-3 (p. 75) and Table 7-4 (p. 77).

Ensure the keyswitch is in the STANDBY position prior to performing the following step. Turning the keyswitch on results in a fault display until the pump laser LBO reaches the proper temperature.

1. Ensure that the chiller is switched on and the temperature is set to 20°C.
2. Ensure the MRU is switched ON. Allow the MRU to run for a minimum of two hours before proceeding.

3. Set the power switch on the power supply rear panel to the ON position. The AC power and laser emission indicators on the front panel of the power supply light. (If either of these indicators does not light, refer to Maintenance.)
4. The main menu appears on the power supply front panel. Initially, the status indicator displays "Laser warming up". This indicates that the LBO crystal in the pump laser is being heated to the required operating temperature, which takes approximately 45 minutes to complete; the percentage value in the status display provides a progress indicator.
5. When the LBO temperature is locked at its operating temperature the status display on the front panel changes to "stand by".
6. Turn the keyswitch on the power supply front panel to ON.
7. The display status will then read, "power ramping (xx%)" as the laser diodes ramp to their operating power. This takes a few minutes to complete; progress update is displayed as a percentage value in the status display.
8. Once the diodes have reached their operating power the status display changes to "starting" for a few seconds and then to "OK", indicating that modelocked laser output is available from the laser head at the wavelength and power indicated on the front panel.
9. To tune the laser set the desired wavelength using the POWER ADJUST or rotary knob and press Select.
10. Monitor the baseplate temperature periodically; typically this is less than 35°C.

6.1.2 Warm Start

A warm start can be performed when the Chameleon Ultra, Vision, or Vision-S power supply rear panel power switch has been on for more than 60 minutes. The recommended daily operation of the Chameleon Ultra, Vision, or Vision-S lasers is to use this warm-start turn-on procedure in conjunction with the turn-off procedure that leaves the rear panel power switch in the ON state.

If the pump laser power supply has been off for longer than 60 minutes (AC ON indicator not lit), refer to the procedure titled "Cold Start".

The warm-start procedure can be performed when the laser is externally controlled using a computer. For a list of RS-232 commands and queries, refer to Table 7-3 (p. 75) and Table 7-4 (p. 77).

1. Ensure that the baseplate chiller is turned on. The chiller temperature should be set to 20°C.
2. Ensure the MRU is switched ON.

3. The LASER EMISSION and AC Power indicators should be on. (If either of these indicators does not light, refer to Maintenance.)
4. The main menu appears on the power supply front panel display. Refer to Figure 6-1 and Table 6-2 (p. 64) for a complete description of the display menus.

CAUTION!
Ensure the laser output is blocked or is directed at an intended target. Ensure all personnel in the area are wearing laser safety glasses before proceeding to the next step. Not taking the necessary precautions could cause burns or serious eye damage.

5. Turn the keyswitch on the power supply front panel to the ON position.
6. The display status will then read, “power ramping (xx%)” as the laser diodes ramp to their operating power. This takes a few minutes to complete; progress update is displayed as a percentage value in the status display.)
7. Once the diodes have reached their operating power, the status display changes to “starting” for a few seconds and then to “OK”, indicating that modelocked laser output is available from the laser head at the wavelength and power indicated on the front panel.
8. To tune the laser, set the desired wavelength using the POWER ADJUST or rotary knob and press select.
9. Monitor the baseplate temperature periodically; typically this is less than 35°C.

6.2 Turning the System Off

6.2.1 Daily Use

When Chameleon lasers are used on a daily basis, turn-off normally consists of turning the keyswitch to the STANDBY position. This shuts the current to the laser diodes off and places the pump laser in standby. When the Chameleon Ultra, Vision, or Vision-S is in standby mode, the baseplate chiller should be left on, as should the MRU recirculator.

The “Daily Use” turn-off method avoids the heater ramp-up cycle described in the paragraph titled “Cold Start” (p. 57).

Table 6-1. Recommended Shutdown Procedures

Expected Downtime	PSU	MRU	Chiller	Laser Head
Daily Use	STANDBY	ON	ON	ON
Complete Shutdown	OFF	OFF	OFF + DRAINED	OFF + DRAINED

WARNING!
Do not turn the power switch on the power supply rear panel off. Shutting down the system power could cause the LBO to cool down incorrectly and causing it to crack. This will only occur if the battery back up is not charged or is defective. Also, there is a slight possibility of corrupting the EEprom data.

Refer to the paragraph titled "Long Term Laser Shut-Off" (p. 60) if all power is to be removed from the system.

The laser can be turned off when the laser is externally controlled using a computer. For a list of RS-232 commands and queries, refer to Table 7-3 (p. 75) and Table 7-4 (p. 77).

6.2.2 Long Term Laser Shut-Off

This procedure removes all power from the system and is recommended for performing system maintenance or if no operation is anticipated for a long period of time. Use the cold-start procedure to turn the Chameleon Ultra, Vision, or Vision-S on after a complete shut-down.

The Chameleon Ultra, Vision, and Vision-S can be shut down completely when the laser is controlled externally using a computer. For a list of RS-232 commands and queries, refer to Table 7-3 (p. 75) and Table 7-4 (p. 77).

It is generally recommended that where possible, the chiller and MRU are left running, even when the laser is keyed off and switched off at the power supply. In cases where the laser will be switched off for greater than 1 week and it's not practical to leave the chiller and MRU running, the chiller must also then be drained. Refer to the datasheets under the link, https://www.coherent.com/lasers/main/chameleon-family, for non-operating storage requirements.

NOTICE
To prevent system degradation due to water contamination, the MRU recirculator should be left on and connected to the Chameleon Ultra, Vision, or Vision-S laser head. Refer to Table 6-1 for guidance.

CAUTION!
Permanent damage can be done to the laser head if this procedure is not carried out!

6.2.2.1 Laser Switch-Off

1. Key the laser off on the Power Supply
2. Use the menu select button to enter and navigate to “system shut-down” option and press select.
3. PSU screen will display “system cooling down (xxx%)” wait until value reaches 100%. This will take around 45 minutes.
4. When cool down reaches 100% laser can be switched off using button switch on the rear of the PSU and power cable can be disconnected from the mains.

To avoid unnecessary use of the backup battery, do not turn the power switch on the power supply rear panel off while the pump laser is in the cool-down cycle. The cool-down cycle takes approximately 45 minutes.

Do not turn the power switch on the rear of the power supply off or disconnect AC power from the power supply if a “LBO Battery” fault is active. Refer to Maintenance for additional information.

Turning the power switch off or removing AC power from the power supply causes the internal battery to be used rather than AC power to complete the LBO cool-down cycle. This causes unnecessary drain on the battery. To extend battery life, use the LBO cool-down cycle from the menu.

If the laser is to be moved to a new location, the laser head baseplate should be drained. Use the open-ended hose supplied in the accessory kit and compressed air to expel the water from the laser head cooling channels.

6.2.2.2 Chiller Switch-off

1. Switch chiller off using on/off button switch.
2. Disconnect the "head out/chiller in coolant" hose from the laser head connector labeled "Cooling Out".
3. Connect the open ended drainage hose.
4. Place open end of hose in a large suitable beaker or flask with volume greater than 1 L.
5. Defeat the valve at the loose end of the "head out/chiller in coolant" hose.
6. Switch chiller on and let it run until all coolant liquid has emptied into the beaker or flask.
7. Chiller will return a fault saying the coolant level is low.
8. Switch off chiller using on/off button switch.
9. Disconnect the drainage hose from the laser head and connect it to the chiller drain port.
10. Ensure the beaker or flask is below the height of the chiller and remove the chiller fill cap.
11. Allow the chiller to fully drain. Remove the drainage hose and replace the fill cap.
12. Disconnect from mains.
13. Dispose of the coolant in a safe and environmentally compliant manner.

6.2.2.3 MRU Switch-off

1. Switch off power using on/off button on rear of MRU box.
2. Disconnect from mains supply.

6.3 Menu Displays

Figure 6-1 shows the Chameleon Ultra, Vision, and Vision-S Main Display and the Base Menu screens. The wavelength-tuning menu can be reached from the Main Menu by pressing EXIT on the power supply front panel. Once in the wavelength-tuning menu, the user can return to the main menu by pressing the power supply SELECT button.

Navigation through a list of submenus, such as those in the Base Menu screen, is achieved by pressing the UP and DOWN arrow keys on the power supply front cover. When the selection arrow (see Figure 6-1) points to the desired submenu, that item can be activated by pressing the SELECT pushbutton. Pressing the EXIT pushbutton deactivates the submenu and re-displays the wavelength tuning menu screen. Examples and explanations for all Chameleon Ultra, Vision, and Vision-S submenus can be found in Table 6-2.

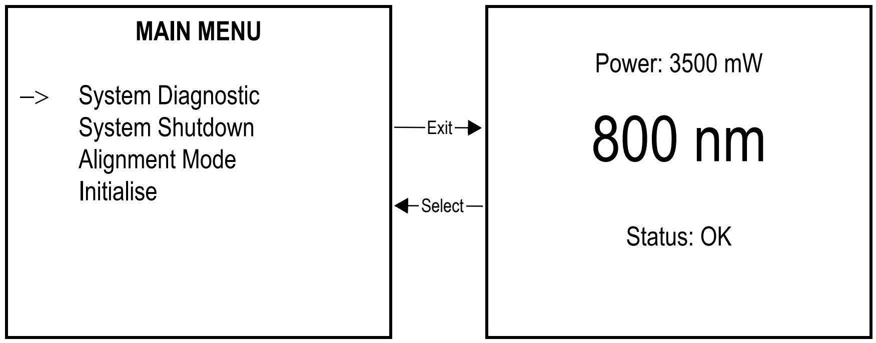


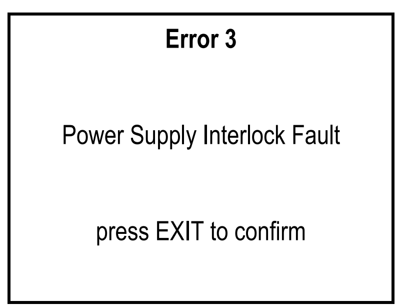
Figure 6-1. Main Menus

6.3.1 System Status Messages

The current status of the laser system is displayed in the wavelength tuning menu. Possible status messages are listed in Table 6-2, “Chameleon Ultra, Vision, or Vision-S Submenus,” on page 64.

6.3.2 Fault Handling

In case of a fault, the CPU closes the shutter, sets the laser diode current to zero and displays the Fault Status Screen. For example:



To clear a fault, the appropriate troubleshooting steps should be taken. The power supply keyswitch should be turned to the STANDBY position and the EXIT pushbutton pressed. See Table 8-1, "Troubleshooting/Fault Messages," on page 85 for a complete listing of system faults and troubleshooting procedures.

When the condition that caused the fault no longer exists, exit the Fault Status screen to clear the fault. Once the keyswitch is turned to the ON position, laser operation returns to its pre-fault state, except the shutter remains closed.

If the fault condition still exists, the system message "FAULT ACTIVE" is displayed in the Main Display screen.

Table 6-2. Chameleon Ultra, Vision, or Vision-S Submenus (Sheet 1 of 3)

Power: 3500 mW 800nm Status: OK	The user must access this menu to adjust the Chameleon Ultra, Vision, or Vision-S output wavelength. Select the desired wavelength using the front panel power knob and press Menu select. The screen displays the actual modelocked power available from the Chameleon Ultra laser head and the current operating status of the laser as follows: **OK**:Normal operation, modelocked laser output available at displayed power and wavelength **Standby**:Keyswitch OFF **Power ramping (0.9%)**: Diodes ramping to operating power, progress displayed as a percentage **Starting**:System at operating power and staring modelock **Tuning**: Tuning operation in progress **Cooling down (xx%)**: System cooling down during total shutdown, progress displayed as a percentage **Warming up (xx%)**: System warming up during cold start, progress displayed as a percentage
SYSTEM DIAGNOSTICS RS-232 Baud Rate System Information Fault Screen	The system diagnostics menu permits access to the following system diagnostic sub menus.

Table 6-2. Chameleon Ultra, Vision, or Vision-S Submenus (Sheet 2 of 3)

RS-232 SETTING

New settings: 19200, 8, N, 1

Turn knob for new baud rate

Press SELECT to confirm
Press EXIT to cancel

Allows adjustment of the baudrate for the RS-232 communications. Press SELECT to accept the new baudrate value before exiting this screen.

SYSTEM INFORMATION

Cx:	-20%	Px*:	25%
Cy:	-32%	Py*:	-45%
Wavelength:	831nm	Step:	1564
ChamPwr:	1900mW	Pump:	8.9W
Run Hours:	1500	S/N:	1234
PSU Software:			7.72
Head Software:			7.72
Verdi Software:			8.88

* Indicates the mirror currently under powertrack servo control.

Displays key laser operating parameters:

Mirror positions as percentage values in the range −100% to +100%.

- **Cx**:Cavity *x* mirror position
- **Cy**:Cavity *y* mirror position
- **Px**:Pump *x* mirror position
- **Py**:Pump *y* mirror position
- **Wavelength**:Current laser output wavelength in nm
- **Step**:Current stepper position
- **ChamPwr**:Current available laser output power in milli-watts
- **Pump**:Current pump laser power
- **Run Hours**: System cooling down during total shutdown, progress displayed as a percentage
- **S/N**:Chameleon Ultra, Vision, or Vision-S laser head serial number

Error 3

Power Supply Interlock Fault

press EXIT to confirm

The Fault Screen displays faults related to both the Chameleon Ultra, Vision, Vision-S and Verdi pump lasers. If faults are active, fault codes and descriptions are also displayed. Refer to Table 8-1, “Trouble-shooting/Fault Messages,” on page 85 for a complete list of faults and associated corrective actions.

System Shutdown

Press SELECT to continue

Press EXIT to abort

Initiates system cool-down prior to total system shut-down.

Table 6-2. Chameleon Ultra, Vision, or Vision-S Submenus (Sheet 3 of 3)

Alignment Mode EXIT when finished	Reduces laser output to a nominal low power to facilitate alignment in applications where the normal operating power is likely to cause damage to sensitive components. It is not recommended that the laser be left in ALIGNMENT mode for more than 30minutes at a time.  **CAUTION!** **The laser still poses a significant laser hazard when operating in this mode and can cause serious eye damage or burns. The user should follow the laser safety precautions outlined in Laser Safety.**
INITIALISE Please wait	The INITIALISE routine should be used if the laser does not operate correctly at any particular wavelength; e.g. it gives low power or will not modelock reliably. The routine automatically tunes the laser to a preset wavelength at the peak of the gain and then scans the cavity and pump mirrors to determine the optimum alignment. Once the routine is completed, the laser automatically tunes itself to the original wavelength.

Table 6-3. Chameleon Vision Dispersion Submenus (Sheet 1 of 3)

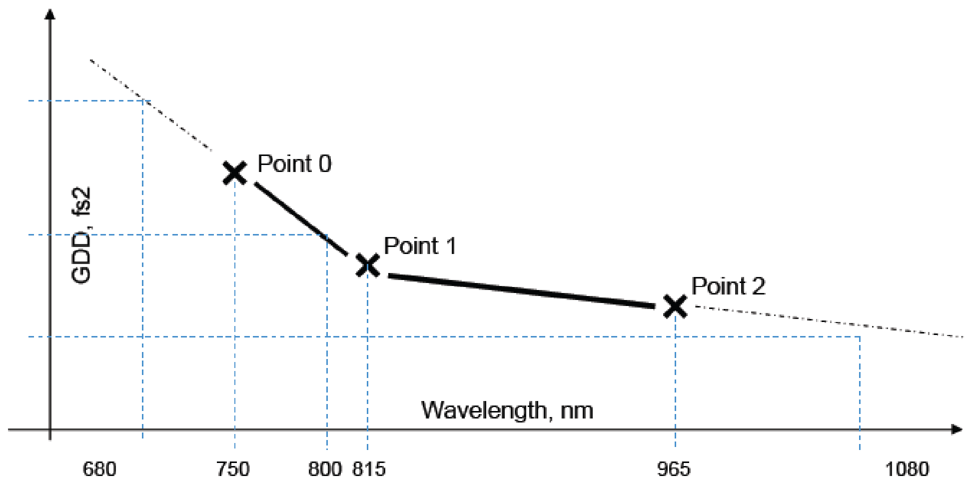
Power: 3400mW Curve ABC1: GDD: 13400 800nm Status: OK	If the laser is a Chameleon Vision with integrated pre-compensation, the front screen shows the current selected curve and GDD value.
MAIN MENU –> Dispersion Settings System Diagnostic System Shutdown Alignment Mode Initialise	There are also several more menu screens accessible from the MAIN MENU under Dispersion Settings.
DISPERSION SETTINGS –> Select Curve New Curve Delete Curve Calibrate Curve	Pre-defined curves can be selected under SELECT CURVE.
SELECT DISPERSION CURVE **Selected curve: 1 abc1** MANUAL ZERO –> ABC1 ABC2 BLANK	If MANUAL is selected, the GDD value can be set using the POWER ADJUST or rotary knob Curve 0 is always reserved for the ZERO curve. All curves beyond this can be user-defined.
NEW DISPERSION CURVE Select curve: 3 BLANK –>Enter curve name:	If New Curve is selected then any of the available curves can be renamed.

Table 6-3. Chameleon Vision Dispersion Submenus (Sheet 2 of 3)

CURVE NAME Turn knob for A-Z Press knob to Set Char Up-Down to move Cursor VISION_1 Select-Save Exit-Cancel	Initiates system. If "Enter curve name" is selected the following screen is displayed.
DELETE DISPERSION CURVE Selected curve: 1 ABC1 Press Select to Delete Press Exit to Cancel	To delete a curve, enter "Delete Dispersion Curve."
CALIBRATE DISPERSION CURVE Select curve: 1 ABC1 Calibration point: 3 Wavelength: 800 GDD Value: 17800 Max GDD: 25000	The curve can be calibrated using a minimum of 3 points. The curve is selected using the POWER SELECT or rotary knob. Use the Menu Up-Down to go to the next parameter. Using the POWER SELECT or rotary knob, select the wavelength and GDD for each point. The maximum available GDD at that wavelength is shown.
Power: 425mW Curve ABC1: GDD: 7600* 1061nm Status: OK	Note that the "curve" is actually a linear interpolation between the defined points. If a wavelength is selected which is outside the defined curve then a GDD value is extrapolated from the last known data. This condition is indicated by an asterisk beside the GDD value on the front screen.

To Clarify:

Table 6-3. Chameleon Vision Dispersion Submenus (Sheet 3 of 3)



In this example, if a wavelength of 800nm is selected, a GDD value is interpolated from the solid line shown between points 0 and 1. However, if a wavelength outside the defined range is selected, then a GDD value is extrapolated from the last known data for that curve.

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7 EXTERNAL CONTROL

7.1 How to Interface the Chameleon Laser

This section provides details on how to interface a Chameleon Ultra, Vision, or Vision-S laser to a remote computer via the RS-232 connector on the rear of the power supply.

The RS-232 interface is based on a set of laser control instructions, consisting of commands that affect laser operation and queries that request the laser to return status information to the host. The instruction set is sufficient to support user-written programs that emulate the functions of the Chameleon Ultra, Vision, or Vision-S front panel.

7.2 RS-232 Command Language

7.2.1 Instruction Syntax for RS-232 Communication

Communication with the Chameleon Ultra, Vision, or Vision-S is with two types of instructions:

- Commands that 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 linefeed (<CR><LF>) or a semicolon (;).

For example:

LASER = 1<CR><LF>

Switches the Chameleon Ultra or Chameleon from STANDBY to ON.

?LIGHT<CR><LF>

Requests the laser to return the measured laser output power.

The laser always responds to an instruction by returning a message terminated by a carriage return and linefeed. Table 7-1 lists the possible responses from the laser.

Table 7-1. Response from Laser after Receiving Instruction

Instruction Sent To Laser	Response From Laser			
	Echo Off Prompt Off	**Echo Off Prompt On**	**Echo On Prompt Off**	**Echo On Prompt On**
Command + <CR><LF>	<CR><LF>	Chame- leon><CR> <LF>	Command + <CR><LF>	Chameleon> Command + <CR><LF>
Query + <CR><LF>	Data + <CR><LF>	Chameleon> Data + <CR><LF>	Query + Data + <CR><LF>	Chameleon> Query + Data + <CR><LF>
Command + <CR><LF> (Illegal operand)	RANGE ERROR: + Command + <CR><LF>	Chameleon> RANGE ERROR: + Command + <CR><LF>	Command + RANGE ERROR: + Command + <CR><LF>	Chameleon> Command + RANGE ERROR: + Command + <CR><LF>
Command <CR><LF> (Illegal instruction)	Command Error: + Command + <CR><LF>	Chameleon> Command Error: + Command + <CR><LF>	Command + Command Error: + Command + <CR><LF>	Chameleon> Command + Command Error: + Command + <CR><LF>
Query<CR><LF> (Illegal instruction)	Query Error: + Query + <CR><LF>	Chameleon> Query Error: + Query + <CR><LF>	Query + Query Error: + Query + <CR><LF>	Chameleon> Query + Query Error: + Query + <CR><LF>
1. Multiple items are separated by the "**&**" character. For example, a list of system faults is returned as "**3&5&6**."				

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

7.2.1.1 ECHO Mode

The Chameleon Ultra, Vision, or Vision-S 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.

7.2.1.2 PROMPT Mode

The Chameleon Ultra, Vision, or Vision-S provides a “prompt” mode for terminal operation in which the laser returns; for example, “Chameleon>” after each command. This feature can be turned on or off using the “PROMPT” command.

7.2.1.3 ?

The single character “**?”** may be substituted for “PRINT” in all queries. For example:

?LIGHT is equivalent to **PRINT LIGHT**

7.2.1.4 = or :

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

LASER = 0 is equivalent to **LASER: 0**

7.3 RS-232 Interface Connection

The Chameleon Ultra, Vision, or Vision-S Laser’s RS-232 port configuration is described in Table 7-2 and typical cable requirements are shown in Figure 7-1. The 9-pin RS-232 port is configured as 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 power supply.

7.3.1 RS-232 Port Configuration

Table 7-2. RS-232 Port Description

Configuration	DCE, No Handshaking	
Data bits	8	
Stop bits	1	
Parity	none	
Baud rate	User selectable:	1200 2400 4800 9600 19200 (default factory setting) 38400 57600

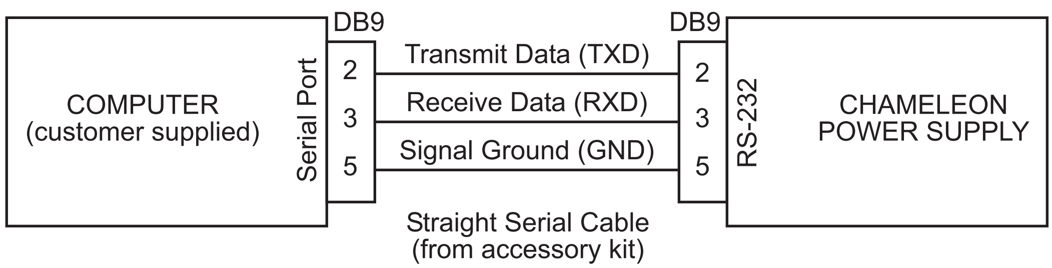

Figure 7-1. RS-232 Pin Configuration

7.3.2 Setting The Baud Rate

The baud rate of the 9-pin RS-232 port can be adjusted through the "RS-232 Baudrate Setup" menu on the front panel (Figure 6-1 on page 6-63) or via the SERIAL BAUDRATE = NNN command described in Table 7-1 and Table 7-2. After the baud rate is changed, the new setting is used until it is changed even if the system power is switched off.

To set the baud rate by the remote computer, send the **SERIAL BAUDRATE = NNN** command to the laser at the currently set baud rate. After sending this baud rate command, host computer communications port must be reinitialized to the new baud rate.

The factory set baud rate is 19200.

When an RS-232 command is issued to change a setting, the display may not update to reflect the changes taking place in the system. The user should press MENU EXIT and MENU SELECT to update the display.

7.4 Instruction Set

Table 7-3 (below) and Table 7-4 (p. 77) describe the instructions (long and short forms) for use in RS-232 with the Chameleon. Table 7-5 (p. 83) and Table 7-6 (p. 84) describe the additional instructions available with the Chameleon Vision and Vision-S.

Table 7-3. Chameleon RS-232 Commands

Commands	Action Performed
BAUDRATE=nnnnn B=n	Sets the RS-232 Serial port baud rate to the specified value. nnnnn = 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200.
ECHO=n E=n	A change in echo mode takes effect with the first command sent after the echo command. n = 0 Turns echo off. Characters transmitted to the laser are not echoed to the host. n = 1 Turns echo on. Characters transmitted to the laser are echoed to the host.
FLASH=1 FL=1	Flash Verdi laser output below lasing threshold to allow single-frequency mode to recenter.
HOME STEPPER=1 HM=1	Homes the tuning motor. This action can take 3-30 seconds.

Table 7-3. Chameleon RS-232 Commands (Continued)

Commands	Action Performed
LASER=n L=n	Changes mode. n = 0 Puts laser in STANDBY **Turning the keyswitch to STANDBY and then to the ON position overrides this command.** n = 1 Resets faults and turns laser on. Clears fault screen on power supply and fault history (`?FAULT HISTORY`), so lasing resumes if there are no active faults. **Keyswitch must be in the ON position.**
LBO HEATER=n LBOH=n	Turns LBO heater on/off. n = 0 Off (cool down) n = 1 On (heating)
LBO OPTIMIZE=n LBOOPT=n	Begins optimization routine. n = 0 Indicates that no optimization is currently in process n = 1 Begins optimization routine
LOCK FRONT PANEL=n LFP=n	Enables/disables user input from the front panel. n = 1 Disabled n = 0 Enabled
PROMPT=n >=n	Turns “CHAMELEON>” prompt on/off. n = 0 Off n = 1 On
SEARCH MODELOCK=n SM=n	Enables/disables search for modelocking n = 0 Enabled n = 1 Disabled
SHUTTER=n S=n	Changes state of the external shutter. n = 0 Closed n = 1 Open
WAVELENGTH=nnn VW=nnn	Sets the Chameleon wavelength to the specified value in nanometers. If the specified wavelength is beyond the lower or upper wavelength limit, the wavelength is set to the lower or upper limit.
WAVELENGTH STEP=nnn VWS=n	Changes the Chameleon wavelength by the specified amount in nanometers.
HOME STEPPER = n HM=n	Homes the tuning motor (this action can take between 3 to 30 seconds)

Table 7-3. Chameleon RS-232 Commands (Continued)

Commands	Action Performed
HEARTBEAT=n HB=n	When enabled, shuts the laser down if no RS-232 activity occurs within a time specified by the heartbeat rate (HBR). n = 1 Enables heartbeat n = 0 Disables heartbeat
HEARTBEATRATE=nnn HBR= nnn	Specifies to time-out period (between 1 to 100 seconds) for laser shut down in the absence of RS-232 activity.
RECOVERY=1 REQ=1	Initiates recovery sequence. This action can take up to 2 minutes to complete.
ALIGN=n	Accesses alignment mode n = 1 Enters alignment mode n = 0 Exits alignment mode

Table 7-4. Chameleon RS-232 Query Set

Queries	Returned Information
PRINT LASER ?L	Returns status of the laser: 0 = Off (standby) 1 = On 2 = Off due to a fault (check faults or fault history)
PRINT KEYSWITCH ?K	Returns status of the keyswitch: 0 = Off 1 = On
PRINT FAULTS ?F	Returns a list of number codes of all active faults, separated by an “**&**” or Returns “System OK” if there are no active faults

Table 7-4. Chameleon RS-232 Query Set (Continued)

Queries	Returned Information	
	0 = no faults 1 = Laser Head Interlock Fault 2 = External Interlock Fault 3 = PS Cover Interlock Fault 4 = LBO Temperature Fault 5 = LBO Not Locked at Set Temp 6 = Vanadate Temp. Fault 7 = Etalon Temp. Fault 8 = Diode 1 Temp. Fault 9 = Diode 2 Temp. Fault 10 = Baseplate Temp. Fault 11 = Heatsink 1 Temp. Fault 12 = Heatsink 2 Temp. Fault 16 = Diode 1 Over Current Fault 17 = Diode 2 Over Current Fault 18 = Over Current Fault 19 = Diode 1 Under Volt Fault 20 = Diode 2 Under Volt Fault 21 = Diode 1 Over Volt Fault 22 = Diode 2 Over Volt Fault 25 = Diode 1 EEPROM Fault 26 = Diode 2 EEPROM Fault 27 = Laser Head EEPROM Fault 28 = PS EEPROM Fault 29 = PS-Head Mismatch Fault 30 = LBO Battery Fault	31 = Shutter State Mismatch 32 = CPU PROM Checksum Fault 33 = Head PROM Checksum Fault 34 = Diode 1 PROM Checksum Fault 35 = Diode 2 PROM Checksum Fault 36 = CPU PROM Range Fault 37 = Head PROM Range Fault 38 = Diode 1 PROM Range Fault 39 = Diode 2 PROM Range Fault 40 = Head - Diode Mismatch 43 = Lost Modelock Fault 47 = Ti-Sapph Temp. Fault 49 = PZT X Fault 50 = Cavity Humidity Fault 51 = Tuning Stepper Motor Homing 52 = Lasing Fault 53 = Laser Failed to Begin Modelocking 54 = Headboard Communication Fault 55 = System Lasing Fault 56 = PS-Head EEPROM Mismatch Fault 57 = Modelock Slit Stepper Motor Homing Fault 58 = CHAMELEON_VERDIEPROM_FAULT 59 = CHAMELEON PRECOMPENSATOR HOMING FAULT 60 = CHAMELEON_CURVEEPROM_FAULT
PRINT FAULT HISTORY ?FH	Returns a list of number codes (see ?F) of all faults that have occurred since the last laser on command, separated by an “**&**”, or returns “System OK” if there are no latched faults. The “laser on” command or the EXIT button on the power supply when the fault screen is active clears the fault history and fault screen.	
PRINT SHUTTER ?S	Returns the status of the external shutter: 0 = Closed 1 = Open	
PRINT UF POWER ?UF	Returns actual UF (Chameleon) power, *nnn.nn*, in milliwatts.	
PRINT CAVITY PEAK HOLD ?PHLDC	Returns the status of the cavity peak hold: 0 = Off 1 = On	
PRINT CAVITY PZT MODE ?PZTMC	Returns the mode of the cavity PZT: 0 = Auto 1 = Manual	

Table 7-4. Chameleon RS-232 Query Set (Continued)

Queries	Returned Information
PRINT CAVITY PZT X ?PZTXC	Returns the cavity PZT X (Rd) voltage, *n.nn*, in volts.
PRINT CAVITY PZT Y ?PZTYC	Returns the cavity PZT Y (Rd) voltage, *n.nn*, in volts.
PRINT PUMP PEAK HOLD ?PHLDP	Returns the status of the pump peak hold: 0 = Off 1 = On
PRINT PUMP PZT MODE ?PZTMP	Returns the mode of the pump PZT: 0 = Auto 1 = Manual
PRINT PUMP PZT X ?PZTXP	Returns pump PZT X (Rd) voltage, *n.nn*, in volts.
PRINT PUMP PZT Y ?PZTYP	Returns pump PZT Y (Rd) voltage, *n.nn*, in volts.
PRINT POWER TRACK ?PTRK	Returns state of the PowerTrack: 0 = Off 1 = On
PRINT MODELOCKED ?MDLK	Returns state of the Chameleon: 0 = Off (Standby) 1 = Modelocked 2 = CW
PRINT PUMP SETTING ?PP	Returns pump power setpoint as fraction of QS to CW pump band.
PRINT TUNING STATUS ?TS	Returns the tuning status: 0 = Ready (i.e. no tuning operation being performed) 1 = Tuning in progress 2 = Search for Modelock in progress 3 = Recovery operation in progress
PRINT SEARCH MODELOCK ?SM	Returns the status of search for modelocking: 0 = Disabled 1 = Enabled
PRINT HOMED ?HM	Returns the homing status of the tuning motor: 0 = Has not been homed 1 = Has been homed
PRINT WAVELENGTH ?VW	Returns the last commanded UF (Chameleon) wavelength, *nnn*, in nanometers.
PRINT STEPPER POSITION ?STPRPOS	Returns the position (counts) that the motor was last moved to for a desired tuning.

Table 7-4. Chameleon RS-232 Query Set (Continued)

Queries	Returned Information
PRINT CURRENT ?C	Returns the measured average diode current, *nn.n*, in amps.
PRINT DIODE1 CURRENT ?D1C	Returns laser diode #1 measured current, *nn.n*, in amps.
PRINT DIODE2 CURRENT ?D2C	Returns laser diode #2 measured current, *nn.n*, in amps.
PRINT BASEPLATE TEMP ?BT	Returns laser head baseplate measured temperature, *nn.nn*, in °C.
PRINT DIODE1 TEMP ?D1T	Returns laser diode #1 measured temperature, *nn.nn*, in °C.
PRINT DIODE2 TEMP ?D2T	Returns laser diode #2 measured temperature, *nn.nn*, in °C.
PRINT VANADATE TEMP ?VT	Returns vanadate measured temperature, *nn.nn*, in °C.
PRINT LBO TEMP ?LBOT	Returns LBO measured temperature, *nnn.nn*, in °C.
PRINT ETALON TEMP ?ET	Returns etalon measured temperature, *nn.nn*, in °C.
PRINT DIODE1 SET TEMP ?D1ST	Returns laser diode #1 set temperature, *nn.nn*, in °C.
PRINT DIODE2 SET TEMP ?D2ST	Returns laser diode #2 set temperature, *nn.nn*, in °C.
PRINT VANADATE SET TEMP ?VST	Returns vanadate set temperature, *nn.nn*, in °C.
PRINT LBO SET TEMP ?LBOST	Returns LBO set temperature, *nnn.nn*, in °C.
PRINT ETALON SET TEMP ?EST	Returns etalon set temperature, *nn.nn*, in °C.
PRINT DIODE1 TEMP DRIVE ?D1TD	Returns laser diode #1 temperature servo drive setting.
PRINT DIODE2 TEMP DRIVE ?D2TD	Returns laser diode #2 temperature servo drive setting.
PRINT VANADATE DRIVE ?VD	Returns vanadate temperature servo drive setting.
PRINT LBO DRIVE ?LBOD	Returns LBO temperature servo drive setting.

Table 7-4. Chameleon RS-232 Query Set (Continued)

Queries	Returned Information
PRINT ETALON DRIVE ?ED	Returns etalon temperature servo drive setting.
PRINT DIODE1 HEATSINK TEMP ?D1HST	Returns laser diode #1 heat sink measured temperature, *nn.nn*, in °C.
PRINT DIODE2 HEATSINK TEMP ?D2HST	Returns laser diode #2 heat sink measured temperature, *nn.nn*, in °C.
PRINT LBO HEATER ?LBOH	Returns the status of the LBO heater: 0 = Off (cooldown) 1 = On (heating)
PRINT LIGHT REG STATUS ?LRS	Returns the status of the light loop servo: 0 = Open (current regulation) 1 = Locked 2 = Seeking 3 = Fault
PRINT DIODE1 SERVO STATUS ?D1SS	Returns the status of diode #1 temperature servo: 0 = Open 1 = Locked 2 = Seeking 3 = Fault
PRINT DIODE2 SERVO STATUS ?D2SS	Returns the status of diode #2 temperature servo: 0 = Open 1 = Locked 2 = Seeking 3 = Fault
PRINT VANADATE SERVO STATUS ?VSS	Returns the status of the vanadate temperature servo: 0 = Open 1 = Locked 2 = Seeking 3 = Fault
PRINT LBO SERVO STATUS ?LBOSS	Returns the status of the LBO temperature servo: 0 = Open 1 = Locked 2 = Seeking 3 = Fault
PRINT ETALON SERVO STATUS ?ESS	Returns the status of the etalon temperature servo: 0 = Open 1 = Locked 2 = Seeking 3 = Fault

Table 7-4. Chameleon RS-232 Query Set (Continued)

Queries	Returned Information
PRINT DIODE1 HOURS ?D1H	Returns the number of operating hours on laser diode #1.
PRINT DIODE2 HOURS ?D2H	Returns the number of operating hours on laser diode #2.
PRINT HEAD HOURS ?HH	Returns the number of operating hours on the system head.
PRINT DIODE1 VOLTAGE ?D1V	Returns the measured voltage across diode #1, *n.n*, in volts.
PRINT DIODE2 VOLTAGE ?D2V	Returns the measured voltage across diode #2, *n.n*, in volts.
PRINT SOFTWARE ?SV	Returns the version number of the power supply software.
PRINT MODEM BAUDRATE ?MB	Returns the present modem port baudrate.
PRINT POWER SUPPLY ID ?PI	Returns "2BC" or "2BS" for 2-bar power supply, "1BC" or "1BS" for 1-bar power supply.
PRINT BAT VOLTS ?BV	Returns the measured voltage across the battery, *nn.nn,* in volts.
PRINT AUTOMODELOCK ?AMDLK	Returns the status if the automodelock routing: n = 1 Enabled n = 0 Disabled
PRINT PZT CONTROL STATE ?PZTS	Returns an integer, followed by a space, followed by a short text of the PZT control state as displayed on the PZT Control Screen.
PRINT TUNING LIMIT MAX ?TMAX	Returns value of maximum available wavelength in nm.
PRINT TUNING LIMIT MIN ?TMIN	Returns value of minimum available wavelength in nm.
?ALIGN	Returns the status of the alignment mode: n = 1 Enabled n = 0 Disabled
?ALIGNP	Returns the laser power available in mW with alignment mode enabled.
?ALIGNW	Returns the alignment mode laser wavelength in nm.
?LFP	Returns the lock front panel status. n = 1 Locked n = 0 Unlocked

Table 7-4. Chameleon RS-232 Query Set (Continued)

Queries	Returned Information
?PZTXCM	Returns the last power map result for the cavity X PZT position as a percentage of the available range.
?PZTXCP	Returns the current cavity X PZT position as a percentage of the available range.
?PZTXPM	Returns the last power map result for the pump X PZT position as a percentage of the available range.
?PZTXPP	Returns the current pump X PZT position as a percentage of the available range.
?PZTYCM	Returns the last power map result for the cavity Y PZT position as a percentage of the available range.
?PZTYCP	Returns the current cavity Y PZT position as a percentage of the available range.
PZTYPM	Returns the last power map result for the pump Y PZT position as a percentage of the available range.
?PZTYPP	Returns the current pump Y PZT position as a percentage of the available range.
?RH	Returns the relative humidity as a percentage value.
?SN	Returns the Chameleon serial number.
?ST	Returns the current operating status as a text string, such as “Starting” or “OK”.

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Table 7-5. Chameleon Vision and Vision-S RS-232 Commands

Commands	Action Performed
GDDCURVE=xx	Sets the GDD calibration curve. xx = curve number This switches the system into auto GDD. Reserve curve 0 for zero dispersion curve.
GDD=xxxxx	Manually sets the GDD value. xxxxx = GDD in fs^2 This switches the system into manual GDD.
GDDCURVEN=xxxxxx	Selects the GDD curve by name xxxxxx
SETCURVEN:x=yyyyyy	Changes the name of calibration curve x to yyyyyy. Note: All curve names are automatically converted to upper case.

Table 7-5. Chameleon Vision and Vision-S RS-232 Commands (Continued)

Commands	Action Performed
SETCURVEPT:ww=x: yyyy:zzzzz	Changes curve ww point x to zzzzz fs^2 at yyyy nm.
SAVECURVE:x	Saves the values input via the SETCURVEPT command, where x is the relevant curve number.
DELCURVE=xx	Deletes curve number xx.

Table 7-6. Chameleon Vision and Vision-S RS-232 Query Set

Queries	Returned Information
?GDDCURVE	Returns the current calibration curve by curve number
?GDD	Query current GDD setting Returns yyyyy where yyyyy is the GDD in fs^2 or yyyyy X, where the character X denotes that the value has been extrapolated from limited calibration data
?GDDCURVEN	Returns the current curve by name
?CURVEN:x	Returns the name of current curve number x
?CURVEPT:ww=x	Query values of curve ww point x Returns: zzzzz yyyy where zzzzz is GDD, yyyy is wavelength
?CURVE:ww	Query calibration values for curve ww Returns array of calibration points: x1 yyyy1 zzzzz1 x2 yyyy2 zzzzz2 x3 yyyy3 zzzzz3 etc.
?COMP	Returns 0 if pre-compensator disabled, 1 if enabled
?HMCOMP	Query precompensator stepper, Returns 0 if not homed, 1 if homed.
?GDDMAX	Returns the maximum GDD value available at the current wavelength.
?GDDMIN	Returns the minimum GDD value available at the current wavelength.
?GDDMAX:xxxx	Returns the maximum GDD value available at wavelength xxxxnm.
?GDDMIN:xxxx	Returns the minimum GDD value available at wavelength xxxxnm.

8 TROUBLESHOOTING

WARNING!
To avoid the risk of potentially fatal electric shock, do not open the Chameleon Ultra, Vision, or Vision-S laser head. There are no user serviceable components or adjustments inside. There are dangerous high voltage currents and hazardous levels of laser energy inside the laser head. There is no cover interlock to eliminate these dangers upon removal of the laser head cover.

8.1 Troubleshooting

Table 8-1 lists possible problems/error messages with a reference to the associated troubleshooting checklist located in this section.

Table 8-1. Troubleshooting/Fault Messages

Problem	Troubleshooting Reference
Pump laser does not start (no laser output)	Checklist 1
Pump laser shuts down	Checklist 1
Chameleon™ laser output unstable	Checklist 2
AC ON indicator on power supply front panel does not light when power switch on rear panel is ON.	Checklist 3
LASER EMISSION indicator on power supply front panel or on the laser head does not light when keyswitch is in the ON position.	[1]
Fault Messages:	
Fault Code 1: Head interlock fault	[1]
Fault Code 2: External interlock fault	Checklist 4
Fault Code 3: Power supply cover interlock fault	Checklist 5
[1] Contact Coherent or an authorized representative. If the laser system or components must be returned directly to Coherent, an RMA (Return Material Authorization) number is required.	
Fault Code 4: LBO temperature fault	Checklist 6

Table 8-1. Troubleshooting/Fault Messages (Continued)

Problem	Troubleshooting Reference
Fault Code 5: LBO Not Locked at Set Temperature	Checklist 6
Fault Code 6: Vanadate temperature fault	Checklist 6
Fault Code 7: Etalon temperature fault	Checklist 6
Fault Code 8: Diode 1 temperature fault	Checklist 6
Fault Code 9: Diode 2 temperature fault	Checklist 6
Fault Code 10: Baseplate temperature fault	Checklist 7
Fault Code 11: Diode heat sink 1 temperature fault	Checklist 8
Fault Code 12: Diode heat sink 2 temperature fault	Checklist 8
Fault Code 16: Diode 1 over current fault	Checklist 9
Fault Code 17: Diode 2 over current fault	Checklist 9
Fault Code 18: Over current fault	Checklist 9
Fault Code 19: Diode 1 under voltage fault	Checklist 10
Fault Code 20: Diode 2 under voltage fault	Checklist 10
Fault Code 21: Diode 1 over voltage fault	Checklist 10
Fault Code 22: Diode 2 over voltage fault	Checklist 10
Fault Code 25: Diode 1 EEPROM fault	Checklist 11
Fault Code 26: Diode 2 EEPROM fault	Checklist 11
Fault Code 27: Laser Head EEPROM fault	Checklist 11
Fault Code 28: Power Supply EEPROM fault	Checklist 11
Fault Code 29: Power supply-head mismatch fault	Checklist 11
Fault Code 30: LBO battery fault	Checklist 12
Fault Code 31: Shutter state mismatch	Checklist 13
Fault Code 32: CPU PROM Checksum Fault	Checklist 11
Fault Code 33: Head PROM Checksum Fault	Checklist 11
Fault Code 34: Diode1 PROM Checksum Fault	Checklist 11
Fault Code 35: Diode2 PROM Checksum Fault	Checklist 11
Fault Code 36: CPU PROM Range Fault	Checklist 11

Table 8-1. Troubleshooting/Fault Messages (Continued)

Problem	Troubleshooting Reference
Fault Code 37: Head PROM Range Fault	Checklist 11
Fault Code 38: Diode1 PROM Range Fault	Checklist 11
Fault Code 39: Diode2 PROM Range Fault	Checklist 11
Fault Code 40: Head - Diode Mismatch	Checklist 11
Fault Code 41: Not Used	N/A
Fault Code 42: Not Used	N/A
Fault Code 43: Not Used	N/A
Fault Code 45: Not Used	N/A
Fault Code 46: Not Used	N/A
Fault Code 47: Not Used	N/A
Fault Code 48: Not Used	N/A
Fault Code 49: Not Used	N/A
Fault Code 50: Cavity humidity fault	Checklist 17
Fault Code 51: Tuning stepper motor homing fault	Checklist 18
Fault Code 52: Lasing Fault	Checklist 14, 16
Fault Code 53: Laser failed to begin modelocking	Checklist 14, 16
Fault Code 54: Headboard communication fault	Checklist 12
Fault Code 55: System lasing fault	Checklist 14, 16
Fault Code 56 Power supply---head EEPROM mismatch fault	Checklist 12
Fault Code 57: Modelock slit stepper motor homing fault	Checklist 18
Fault 58 - CHAMELEON_VERDIEPROM_FAULT	Checklist 11
Fault 59 - CHAMELEON PRECOMPENSATOR HOMING FAULT	Checklist 18
Fault 60 - CHAMELEON_CURVEEPROM_FAULT	Checklist 11

8.2 Checklist 1: Pump Laser Does Not Start, Pump Laser Shuts Down

If the Verdi pump laser cannot be started, or if the laser shuts down while operating, check the following items. DO NOT look into the laser head emission port, under any circumstances.

- [ ] Examine the pump and cavity PZT values in the SYSTEM INFORMATION menu PZT values that are outside the range -80% to 80% indicate that the initialize routine should be run (see Table 6-2, “Chameleon Ultra, Vision, or Vision-S Submenus,” on page 64 for Chameleon sub-menus).
- [ ] Verify the AC Power indicator on the front panel of the power supply is lit. If not, refer to Checklist 3.
- [ ] Access both “FAULT STATUS” menus. Correct any existing faults. Refer to fault-specific troubleshooting checklists.
- [ ] Verify no external beam blocks or shutters are blocking the laser beam.
- [ ] Verify power setpoint of the system.
- [ ] Verify that the laser has not been put into Standby using the RS-232 command `L=0`. If the system is in RS-232 activated Standby, the Main menu reports “RS232 Key Standby”.
- [ ] Verify the chiller is turned on and the cooling water is circulating through the baseplate.
- [ ] Verify the power supply fans are operating, the rear panel air filter is clean and the power supply cooling air intakes and exhausts are not blocked.
- [ ] Disconnect any user-supplied electrical interfaces to the system. Replace any user-supplied interlocks with the interlock supplied with the system. Attempt to operate the laser.

If none of these checkpoints indicate the source of the problem or if further troubleshooting advice is required, contact Coherent Service or an authorized service representative.

8.3 Checklist 2: Laser Power Unstable

If the laser power is noisy, fluctuating, or otherwise unstable, check the following items. DO NOT look into the laser head emission port, under any circumstances.

[ ] Verify the ambient room temperature and the laser head heat sink temperature are not excessively unstable or abnormally high or low. Verify the flow and temperature of the cooling water are stable and at their setpoints. Verify the laser baseplate temperature is stable.

[ ] Access “FAULT STATUS” menus. Correct any existing faults. Refer to relevant fault-specific troubleshooting checklists.

[ ] Check the laser power stability with an external power meter.

[ ] Verify the laser is operating within its specified wavelength range. Change the wavelength slightly, so that the laser reverts to the automatic default power setting. Re-evaluate power stability.

[ ] View the Verdi pump power stability and the Chameleon Ultra, Vision, or Vision-S power stability in the top-level menu, to determine whether the instability originates with the Verdi pump laser, or the VPUF head.

[ ] The laser output may require a short period of warm up time to stabilize the temperature servos. Allow the laser to run at desired power for 60 minutes, to allow head temperatures to stabilize. Reassess laser power stability after this warm up period.

[ ] If possible, measure the characteristic frequency of the noise or power fluctuations.

[ ] Verify the noise does not originate with the AC power supplied to the laser.

[ ] Consult the laser maintenance logbook to identify any recent maintenance procedures or system changes that may have provoked the power instability.

If none of these checkpoints indicate the source of the problem or if further troubleshooting advice is required, contact Coherent Service or an authorized service representative.

8.4 Checklist 3: "AC ON" Indicator Off

If the "AC ON" Indicator on the front panel of the power supply is not lit, check the following items:

[ ] Verify the power cord is connected to an active facility power source. Verify the power cord is not damaged and is securely connected to the laser power supply and to facility power. Verify the power switch on the rear panel of the power supply is on.

[ ] After performing "Long Term Laser Shut-Off" (p. 60), disconnect the laser system from facility power and remove the fuse. Check the power supply fuse. Replace if necessary. Refer to the fuse replacement procedure later in this section for details. Verify continuity (closed circuit) between the two fuse terminals in the power supply.

If none of these checkpoints indicate the source of the problem or if further troubleshooting advice is required, contact Coherent Service or an authorized service representative.

8.5 Checklist 4: External Interlock Fault

The laser does not operate with the external interlock circuit open. The external interlock circuit can be closed with a Coherent- supplied interlock that plugs into the rear panel of the power supply, or with a user-supplied circuit. If an external interlock fault is displayed, check the following items:

[ ] Press MENU EXIT to clear the fault display. If the fault does not clear, a fault message appears on the main menu and on the Fault Status menu.

[ ] Check that MRU is switched on and operating correctly.

[ ] Ensure the Coherent-supplied or user-supplied external interlock is securely connected to the EXTERNAL INTERLOCK connector on the MRU rear panel.

[ ] If a user-supplied interlock is installed, turn the keyswitch to STANDBY and replace the user interlock circuit with the external interlock supplied by Coherent. If the fault clears, the user-supplied interlock is defective.

[ ] Verify continuity of the interlock.

[ ] Turn the power switch on the rear panel of the power OFF for approximately 10 seconds. Turn the switch ON.

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

8.6 Checklist 5: PS Cover Interlock Fault

The power supply interlock is triggered if the power supply cover is not securely fastened to the power supply chassis. If the power supply interlock fault is triggered, check the following items:

- [ ] Turn the keyswitch to STANDBY. Ensure the power supply cover is secure and all screws are fully tightened.
- [ ] Press EXIT to clear the fault. If the fault does not clear, a fault message appears on the main menu and the Fault Status menu.
- [ ] Turn the power switch on the rear panel of the power OFF for approximately 10 seconds. Turn the switch ON.

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

8.7 Checklist 6: LBO, Vanadate, Vanadate 2, Etalon, Diode 1 and Diode 2 Temperature Faults, LBO Not Locked at Set Temperature Fault

A temperature fault indicates the actual temperature is outside the acceptable range. The “LBO Not Locked at Set Temperature” fault is triggered when the LBO temperature deviates more than 1°C from the setpoint. If any of the LBO, vanadate, etalon, diode 1, or diode 2 temperature faults are triggered, check the following items:

- [ ] Press EXIT to clear the fault. If the fault does not clear, a fault message appears on the main menu, as well as the Fault Status menu.
- [ ] If the AC power to the laser has just been turned on, allow 60 minutes for the temperatures to stabilize.
- [ ] For diode 1 or diode 2 temperature faults, verify the power supply cooling air intakes and exhausts are not obstructed.

If the fault persists, record the following system settings and contact Coherent Service or an authorized service representative.

8.8 Checklist 7: Baseplate Temperature Fault

A baseplate temperature fault indicates the laser head baseplate temperature has exceeded 40°C and the laser has shut down to prevent thermal damage to any head components. If the baseplate temperature fault is triggered, check the following items:

[ ] Press EXIT to clear the fault display. If the fault does not clear, a fault message is displayed on the main menu as well as the Fault Status menu.

[ ] Verify the ambient temperature is not abnormally high. Verify the chiller water temperature is at its setpoint. Verify the cooling water flow is normal and unobstructed through the laser head by disconnecting the chiller water return hose.

The laser system must cool down and the facility power disabled before verifying the cooling water flow through the laser head.

[ ] Ensure the head is not located near a heat-generating source.

[ ] Turn the power switch on the rear panel of the power supply off for approximately 10 seconds. Turn the power supply on.

If the fault persists and the ambient temperature and laser head location and heatsinking meet the above requirements, contact Coherent Service or an authorized service representative.

8.9 Checklist 8: Diode Heat Sink Temperature Fault

A diode heatsink temperature fault is generated when the diode heatsink temperature exceeds 65°C. If either diode 1 or diode 2 heatsink temperature fault is triggered, check the following:

[ ] Press EXIT to clear the fault display. If the fault does not clear, a fault message is displayed on the main menu as well as the Fault Status menu.

[ ] Verify the cooling fans in the power supply are not obstructed and are running. The fans may be viewed after removing the air filter in the rear panel of the power supply.

[ ] Verify the power supply cooling air intakes and exhausts are not obstructed. If other equipment is located directly on top of the power supply, relocate it elsewhere, so that the cooling vents on top of the power supply are free of obstruction.

[ ] Clean the air filter on the rear panel of the power supply. Refer to the procedure in this chapter for details.

[ ] Verify the power supply is not located near a heat source.

[ ] Verify the ambient temperature is not excessively high.

If the fault persists and the ambient temperature and power supply location meet the above requirements, contact Coherent Service or an authorized service representative.

8.10 Checklist 9: Diode Over Current Faults

When the diode current reaches the maximum current, an over current fault is triggered. An over current fault may be indicative of a non-optimized laser system. Check the following:

[ ] Press EXIT to clear the fault display. If the fault does not clear, a fault message is displayed on the main menu as well as the Fault Status menu.

Contact Coherent technical support or a local service representative to assist in determining the need for FAP-I replacement.

8.11 Checklist 10: Diode Under Voltage, Diode Over Voltage Faults

The diode under voltage and over voltage faults indicates that the voltage between the diode anode and cathode is beyond the acceptable range. Should either of these faults occur, check the following:

[ ] Press EXIT to clear the fault display. If the fault does not clear, a fault message is displayed on the main menu as well as the Fault Status menu.

[ ] Turn the power switch on the rear panel of the power supply off for approximately 10 seconds. Turn the power supply on.

Contact Coherent technical support or a local service representative to assist in determining the need for FAP-I replacement.

8.12 Checklist 11: Diode EEPROM, Laser Head EEPROM, Power Supply EEPROM, Head-Diode Mismatch, PROM Checksum, EEPROM Range Faults

EEPROM faults typically indicate memory corruption. Should any of these faults occur, check the following:

[ ] Press EXIT to clear the fault display. If the fault does not clear, a fault message is displayed on the main menu as well as the Fault Status menu.

[ ] Turn the power switch on the rear panel of the power supply off for approximately 10 seconds. Turn the power supply on.

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

8.13 Checklist 12: LBO Battery Fault

The LBO battery fault indicates that the backup battery, which protects the LBO crystal from AC power interruptions, is not charged to a minimum of 13 V. If this fault occurs, DO NOT remove AC Power from the laser without first running the LBO cool-down from the "LBO Settings" menu.

Should this fault occur, check the following:

[ ] Press EXIT to clear the fault display. If the fault does not clear, a fault message is displayed on the main menu and the Fault Status menu.

[ ] Turn the power switch on the rear panel of the power supply OFF for approximately 10 seconds. Turn the power supply ON. It is not necessary to cool the LBO crystal down if the power is turned off for only 10 seconds.

The CPU monitors the battery charge only when the system is initially powered up. Therefore, this fault appears only during the first few minutes after the AC power to the laser system is turned on. Disappearance of the fault message DOES NOT indicate that the battery has been restored to its full charge. Disappearance of the Low Battery Charge fault message only indicates that the CPU is no longer monitoring the battery charge. Contact Coherent Service or an authorized service representative to replace the battery.

8.14 Checklist 13: Shutter State Mismatch Fault

The shutter state mismatch fault indicates a conflict between the shutter state as detected by the shutter monitor and the CPU. Should this fault occur, do the following:

[ ] Press EXIT to clear the fault display. If the fault does not clear, a fault message is displayed on the main menu and the Fault Status menu.

[ ] Turn the power switch on the rear panel of the power supply off for approximately 10 seconds. Turn the power supply on.

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

8.15 Checklist 14: Lost Modelock Fault

This fault indicates that the laser can no longer detect a modelocked pulse. If the system loses modelocking, check the following:

[ ] Press EXIT to clear the fault display. If the fault does not clear, a fault message is displayed on the main menu and the Fault Status menu.

[ ] Examine the pump and cavity PZT values in the SYSTEM INFORMATION menu. PZT values that are outside the range –80% to 80% indicate that the INTIALISE routine should be run (see Table 6-2 (p. 64) for Chameleon sub-menus).

[ ] Turn the keyswitch to Standby and attempt to restart the laser.

[ ] Verify the Verdi pump laser is operating at the expected power.

[ ] Verify the VPUF head is lasing at the expected power.

[ ] Verify chiller temperature is 20°C.

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

8.16 Checklist 16: Pump and/or Cavity PZT X, PZT Y Faults

PZT X and PZT Y faults occur when the PZT reaches either end of its range of motion, to maintain alignment of the Verdi pump beam into the VPUF head. If this fault occurs, check the following:

[ ] Press EXIT to clear the fault display. If the fault does not clear, a fault message is displayed on the main menu and the Fault Status menu.

[ ] Examine the pump and cavity PZT values in the SYSTEM INFORMATION menu. PZT values that are outside the range –80% to 80% indicate that the INTIALISE routine should be run (see Table 6-2 (p. 64) for Chameleon sub-menus).

[ ] Turn the keyswitch to Standby and attempt to restart the laser.

[ ] Verify the Verdi pump laser is operating at the expected power.

[ ] Verify the VPUF head is lasing at the expected power.

[ ] Verify chiller temperature is 20°C.

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

8.17 Checklist 17: Cavity Humidity Fault

Cavity humidity fault occurs when the relative humidity is too high to ensure modelocking performance across the entire tuning range. If this fault occurs, check the following:

[ ] Press exit to clear the fault display. If the fault does not clear, a fault message is displayed on the main menu and the fault status menu.

[ ] Ensure that the MRU-X1 is switched on (see MRU X1).

[ ] Ensure that the air hose connections to the MRU-X1 are correctly fitted.

[ ] Ensure that the MRU-X1 drying filter does not require replacement.

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

8.18 Checklist 18: Stepper Motor Homing Error

The stepper motor homing error occurs when either the tuning modelock slit stepper motor fails to home. Should this fault occur check the following:

[ ] Press exit to clear the fault display. If the fault does not clear, a fault message is displayed on the main menu and the fault status menu.

[ ] Turn the system to standby for a few seconds using the keyswitch and then restart the system using the warm start procedure. See "Warm Start" (p. 58)

[ ] Home the stepper motor using the appropriate RS-232 command.
Fault code 51: send RS-232 command HM=1
Fault code 57: send RS-232 command HMSLIT=1
Fault code 59: send RS-232 command HMCOMP=1

[ ] Turn the power supply in the rear of the power supply off for approximately 10 seconds. Turn the power supply on.

[ ] Confirm that the laser is operating with specified output and wavelength and that the system is tuning correctly.

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

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9 MAINTENANCE

WARNING!
To avoid the risk of potentially fatal electric shock, do not open the Chameleon Ultra, Vision, or Vision-S laser head. There are no user serviceable components or adjustments inside. There are dangerous high voltage currents and hazardous levels of laser energy inside the laser head. There is no cover interlock to eliminate these dangers upon removal of the laser head cover.

9.1 Fuse Replacement

9.1.1 Criteria for Replacement - Defective fuse per Checklist 1.

Do not turn the power switch off or disconnect the AC power input until the cool-down cycle is complete.

1. Perform the procedure “Long Term Laser Shut-Off” (p. 60). The associated cool-down cycle takes approximately 45 minutes. The front panel display then indicates when the cool-down cycle is complete.
2. Turn the power switch on the power supply rear panel off and disconnect the power cord from facility power.

NOTICE
A fuse that fails repeatedly is an indication of a more serious problem. In this case, the system should be returned to the factory. If the laser system or components must be returned directly to Coherent, a return material authorization (RMA) number is required. Contact Coherent or an authorized representative.

3. The location of the fuse is shown on Figure 5-2 and Figure 5-3. Insert a small screwdriver and twist to remove the fuse holder.

4. Replace the fuse with properly rated time-delay fuse and reinstall the fuse holder. Connect the power supply power cord to facility power.
5. Perform the procedure “Long Term Laser Shut-Off” (p. 60).

9.1.2 Verification of Successful Installation

6. The AC ON indicator on the power supply front panel then lights.

9.2 Battery Replacement

The power supply contains a sealed lead acid battery that must be processed according to applicable local regulations concerning batteries. The battery is marked with the crossed wheeled bin logo with the metal identification. The battery in the power supply is not user-replaceable and therefore if a ‘Fault#30’ is indicated, follow checklist 12: LBO Battery Fault. If the fault is not resolved by following this procedure, contact Coherent or an authorized representative for further instruction.

9.3 Cleaning the Air Filter

9.3.1 Air Filter Locations

- **Verdi Power Supply** - The air filter is located on the power supply front panel as shown in Figure 5-2 on page 53.
- **Verdi Otto Power Supply** - The air filters are located on the side and front panels inside the power supply as shown in Figure 5-3 on page 54.

9.3.2 Criteria for Cleaning

Visual inspection on a periodic basis; inspect more frequently if the operating environment is less than ideal.

Clean the air filter when the laser is turned off.

9.3.3 Removal

Do not turn off the power switch or disconnect the AC power input until the cool down cycle is complete.

Do not remove the air filter while the fan is running. The fan is operational when the keyswitch is in the STANDBY position.

1. Perform the procedure “Long Term Laser Shut-Off” (p. 60). The associated cool-down cycle takes approximately 45 minutes. The front panel display then indicates when the cool-down cycle is complete.
2. Turn the power switch on the power supply rear panel off and disconnect the power cord from facility power.

9.3.4 Air Filter Removal and Cleaning Procedure for the Verdi Power Supply

1. Loosen the two retaining nuts (Figure 5-2 on page 53 or Figure 5-3 on page 54) and remove the air filter.
2. Clean the air filter by rinsing with water and dry with a blower.
3. Reinstall the air filter and perform the procedure “Cold Start” (p. 57).

9.3.5 Air Filter Removal and Cleaning Procedure for the Verdi Otto Power Supply

1. Remove the four screws from the top cover of the power supply.
2. Remove the top cover from the power supply.
3. Loosen the two retaining nuts located on the side panel, which hold the side air filter.
4. Remove the air filter.
5. To access the air filter located on the front panel, remove the screws holding the front panel to the chassis.
6. Disconnect the ribbon cable P210 from connector J210 on the display PCB.
7. Loosen the two retaining nuts located on the front panel, which hold the front air filter.

8. Remove the air filter.
9. Clean the air filters by rinsing with water and dry with a blower.
10. Reinstall the air filters and retaining nuts, reconnect the ribbon cable to the display PCB, reinstall the front panel, and the top cover.

9.3.6 Verification of Cleaning

11. Visual inspection.

9.4 Replacing the Coolant in the Chiller

The recommended coolant replacement cycle is every 6 months in which the coolant must be drained and renewed.

If the existing coolant in the chiller is Optishield Plus, please contact Coherent or an authorized representative.

1. Disconnect the mains power from the Chiller and drain the coolant from the system (including the laser head) into a secure container.

For proper coolant waste disposal, please follow the disposal instructions listed on the SDS (Safety Data Sheet) and/or coolant container. Treat as controlled waste (refer to SDS for further information), dispose of in accordance with local waste disposal authority.

2. If the drained coolant shows signs of contamination, flush the system with distilled water only and repeat this cycle as necessary.
3. Follow instructions for "Install the Chiller" (p. 49) to re-install the Chiller with the correct mixture of coolant.

10 MRU X1

10.1 Description and Specifications

The Coherent miniature recirculator unit, the MRU X1, shown in Figure 10-1, is a stand-alone, 19" compatible rack mount unit designed to dry and filter air, then circulate it at atmospheric pressure and low flow rate. Clean dry air is sent to a sealed laser head to enable and maintain long-term reliable operation. A return line completes the air re-circulation back to the MRU X1.

Front View

Rear View

Figure 10-1. Coherent MRU X1

This unit was designed for use specifically in conjunction with Chameleon Ultra, Vision, and Vision-S lasers. It controls the humidity and cleanliness of the environment within the laser chamber to ensure long reliable operation of the optics and control mechanisms.

10.1.1 System Features

There are two filter stages within the MRU X1:

- The first stage removes moisture and molecular contaminants via a replaceable filter.
- The second stage is a 0.3 μm high-efficiency particulate air (HEPA) filter, removing any dust and debris emanating from the preceding filter stage.

The second filtration stage is designed for minimal user intervention and, depending on the ambient conditions, should last the lifetime of the Chameleon Ultra, Vision, and Vision-S laser.

The air is circulated by means of a clean, oil-free diaphragm pump.

There are two interlock functions on the MRU X1. If for any reason these are open circuit, laser action is prevented:

1. **EXT. INTERLOCK -** This connects to a 4-pin HR-10 plug provided in the accessory kit. This can be used to connect the laser to another external interlock, such as a door for example, and replicates the original function of the EXT. INTERLOCK on the back panel of the laser power supply.
2. **PSU INTERLOCK -** This connects the original EXT. INTERLOCK socket on the back of the laser power supply to the MRU X1 by a cable with 3-pin mini-DIN plugs, provided in the accessory kit.

10.1.2 System Specifications

Table 10-1. MRU X1 System Specifications

System Parameter	Specification
Dimensions	450 mm x 432 mm x 95 mm (17.8" x 17.0" x 3.7")
Weight	12 kg (26.5 lbs.)
Airflow Rate	1 to 2.5 L/min.
Maximum Continuous Pressure	1.4 bar (absolute)
Maximum End Vacuum	0.24 bar (absolute)
Voltage Input	100 to 240 VAC, 50/60 Hz
Fuse Rating	5 Amp (T5A L 250 V)
BNC Output	0 to 5 V, 1 MΩ
Interlock Circuit Rating	Normally open 12 VDC (dependent on laser circuit)
Interlock Impedance	< 0.2 Ω
Relative Humidity	5 to 95%
Operating Temperature	15° to 35°C (59° to 95°F)

10.2 Safety

The MRU X1 is a low-flow, low pressure device operating at around 3 to 5 psi and is an inherently safe device.

However, since it operates in conjunction with Class 4 laser systems, the appropriate laser manual safety procedures and government regulations pertaining to Class 4 laser emissions in laboratories must be enforced in the MRU X1 environment.

10.2.1 Chemical Safety

In normal operation, the user will not come into contact with the chemicals contained within the enclosed drying filter.

The chemical presents no risk to health, providing that the sealed container is not opened. There is no need to open the filter housing to replenish the contents since the filter must be exchanged as a complete module. Please refer to the Manufacture Safety Data Sheets (MSDS) for the filter material for further information. Please dispose of the drying filter in accordance with local government health and safety regulations.

10.2.2 Operating Controls

The MRU X1 has only one user-operated control. The ON/OFF switch on the back panel, which is part of the mains input power module. The switch turns the MRU X1 power on to activate the power supply, interlock PCB and the air pump.

10.2.3 Location of Safety Labels

There are seven labels, five of which are safety labels positioned on the rear panel of the MRU X1, and the remaining two being located inside the enclosure. The product nameplate label, the specified fuse rating label, the CE Mark label the EU/China RoHS symbols, and the Wheeled Bin label are located on the back panel to the left of the power entry module.

Inside the MRU X1 enclosure, the electrical hazard label is placed above the power supply on the protective shield and the earth label is beside an internal earth post.

Product Nameplate Label
located on rear panel

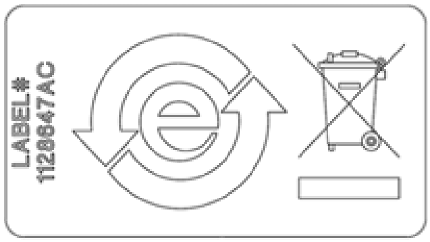
Fuse Rating Label
located on rear panel

H.V. Warning Label
situated on protective
cover above power supply

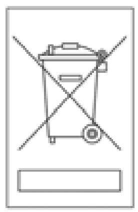
Earth Ground Label
situated beside the
earth terminal post

Figure 10-2. MRU X1 Labels

Certificate of Conformity Label
situated on rear panel



EU RoHS Wheel Bin and
China RoHS “e”
located on rear panel



Wheeled Bin
located on rear panel

Figure 10-2. MRU X1 Labels (Continued)

10.2.4 Compliance with Government Requirements

Conforms to the relevant European Union harmonization legislation:

Directives:

2014/35/EU	Low Voltage Directive (LVD)
2014/30/EU	Electromagnetic Compatibility (EMC)
2011/65/EU	Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment (RoHS-2)

Standards:

Safety:	EN 61010-1/IEC 61010-1: Safety requirements for measurement, control and laboratory use EN 60825-1/IEC 60825-1: Safety of Laser Products
EMC:	EN 61326-1/IEC 60825-1: Electrical Requirements for measurement, control and laboratory use
RoHS:	EN 63000/IEC 63000: Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances

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

10.3 Installation

10.3.1 Receiving and Inspection

On receipt of the MRU X1, remove it from its box and check that all parts are present and undamaged.

10.3.2 External Connections

Before making or breaking any electrical or air connections to the MRU X1, ensure that the system is switched off and that the laser has been switched to the STANDBY position. Refer to "Turning the System Off" (p. 59) for laser operating instructions if necessary.

10.3.3 Air Connections

The MRU X1 comes ready-made with all necessary connectors and hoses. The hoses and fittings are color-coded to ensure the flow direction is correct.

NOTICE

The connectors for the MRU must not be contaminated during handling or set up. These ports provide a direct line to the laser head. If clean handling is not observed, contamination may work itself inside the laser head reducing the lifetime of the laser.

1. Connect the blue band hose quick-release connector to the MRU X1 OUT port (blue label) on the back of the MRU X1 system. This should be pushed home firmly until it clicks and locks in position.
2. Connect the other end of this blue band hose to the laser head IN port. Push the quick-release connector in firmly until it clicks and locks in position.
3. Connect the red band hose quick-release connector to the laser head OUT port (red label). This should be pushed home firmly until it clicks and locks in position.
4. In similar manner, connect the return red band hose from the laser head to the MRU X1 IN (red label) port on the MRU X1 system. This should be pushed in firmly until it clicks and locks in position.
5. Finally, confirm that the air flow direction is correct: MRU X1 OUT to laser head IN; laser head OUT to MRU X1 IN.

NOTICE

Different fitting types for air and water-cooling connection lines prevent accidentally or inadvertently connecting air lines to the water-cooling circuit or water-cooling lines to the air circuit. If using fittings different than original, make certain the air and water lines are not mixed up! Pumping water into the laser head air lines voids the warranty. Pumping water into the MRU X1 air lines voids the warranty.

10.3.4 Interlock Connections

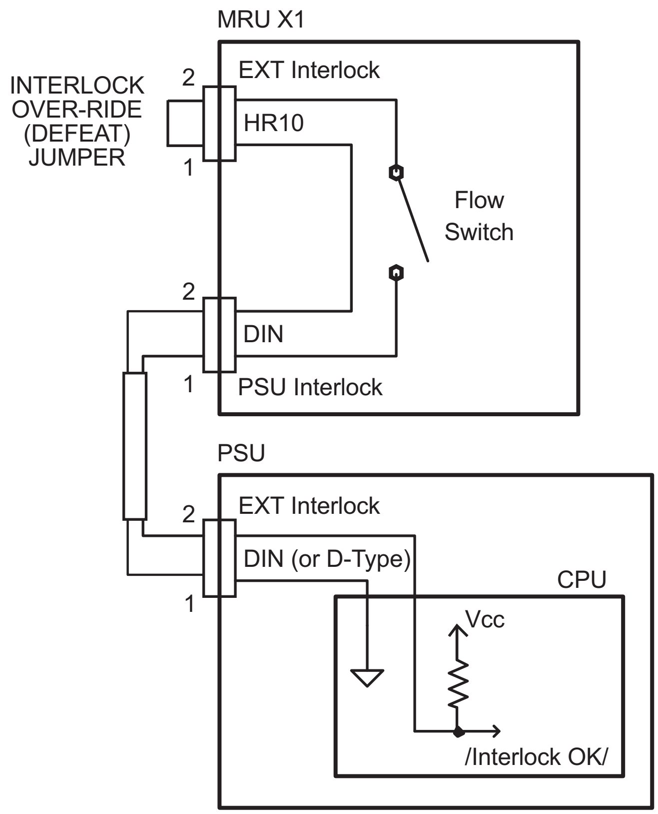
It is essential to the safe and reliable operation of the MRU X1 that the interlock connection between the MRU X1 and the laser power supply is made correctly. Failure to do so could result in serious injury to personnel and could cause severe damage to the laser and invalidate the warranty.

The interlock system has been designed using different style connectors so that MRU X1 is the master interlock. The laser power supply interlock will not be satisfied unless the MRU X1 is powered on and the MRU X1 EXT interlock is closed (interlock override plug installed or customer provide switch or contact is closed). A customer constructed door interlock cable, using the provided HR10 connector, cannot be plugged into the power supply bypassing the MRU X1. The purpose of this design is to reduce the chance of the laser operating without a functional MRU X1.

1. Connect the PSU interlock cable supplied in the accessory kit to the PSU INTERLOCK socket on the back of the MRU X1 unit.
2. Connect the other end of this cable to the EXTERNAL INTERLOCK on the back of the Chameleon Ultra, Vision, or Vision-S laser power supply.
3. Connect the external interlock over-ride plug supplied in the accessory kit to the EXT INTERLOCK on the back of the MRU X1 unit.

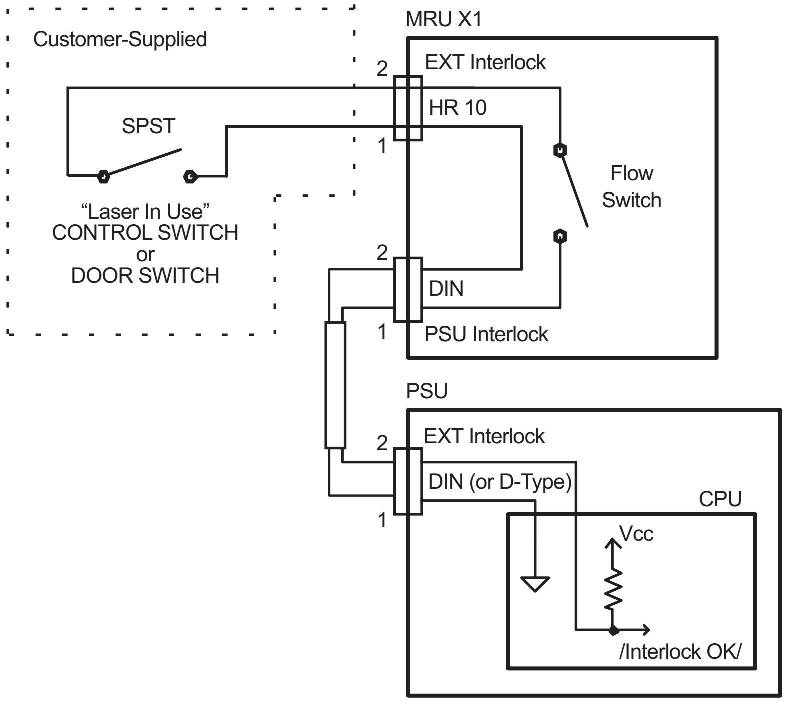
This external interlock must be satisfied by either the interlock over-ride (interlock defeat) plug or via connection to a control switch, relay contacts or some other external safety device, such as a trip switch. If the interlock circuit is opened or broken in any way, the laser switches off immediately. When the break is rectified, the laser must be reset to clear the Interlock Fault (see "Checklist 4: External Interlock Fault" (p. 90)).

Examples interlock circuits are shown in Figure 10-3.

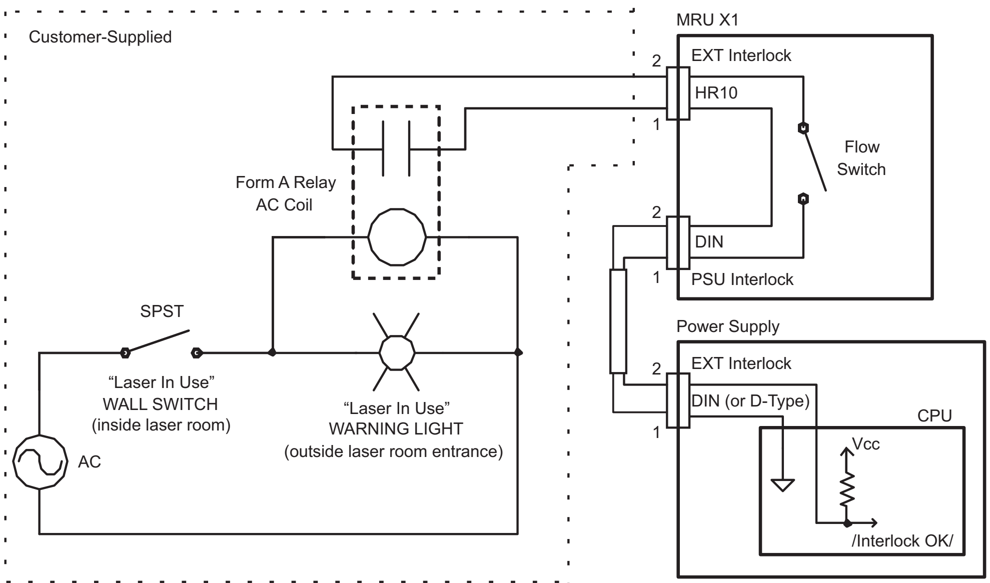


A. Interlock Circuit Over-ridden (defeated) by Jumper

Figure 10-3. Example Interlock Circuits



B. Interlock Circuit Satisfied by Closure of SPST Switch

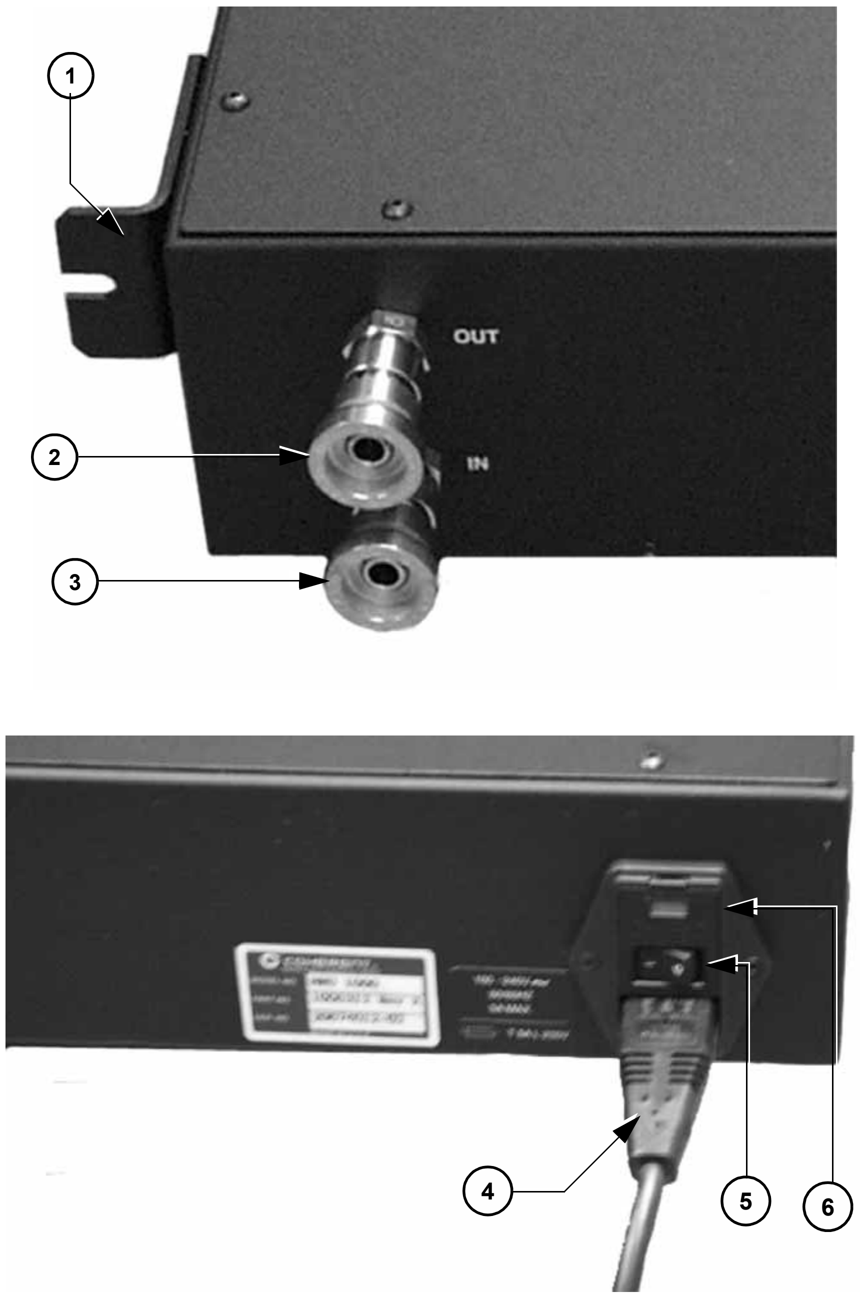


C. Interlock Circuit Satisfied by Closure of Relay Contacts; Relay Energized by "Laser In Use" SPST Switch

Figure 10-3. Example Interlock Circuits (Continued)

If the user has already constructed a door interlock cable that uses a connector style other than the HR10, the cable must be modified to use the HR10 style connector used on EXT connection on the MRU X1.

10.4 Controls and Indicators



1.	Rack mount	4.	Facility power connector
2.	Air Flow "Out" connector	5.	Power switch and LED
3.	Air Flow "In" connector	6.	(Input) Fuse block

Figure 10-4. MRU X1 Controls and Indicators

Table 10-2. MRU X1 Controls and Indicators

Item	Control	Function
1	Rack mount	Allows the MRU X1 to be installed in a standard laboratory mount.
2	Flow “Out” connector	Connects the output line flow to Chameleon Ultra, Vision, or Vision-S laser head.
3	Flow “In” connector	Connects the return line flow from Chameleon Ultra, Vision, or Vision-S laser head.
4	Power Cord Connector	The power input module provides cord connection of the MRU X1 to facility power. The internal power supply is auto-switching, 100 - 240 VAC 50/60 Hz.
5	Power Switch and LED	Turns the MRU X1 on. The LED in the power switch illuminates when the power is enabled. To assure the longest lifetime from the Chameleon Ultra, Vision, or Vision-S laser system the MRU X1 should be left on at all times. For additional information see “Daily Use” (p. 59).
6	Fuse Block	Retains the mains input fuses, T 5A (x2)

10.4.1 Front Panel Indicator

The following sections highlight the controls, indicators and features located on the front panel of the MRU X1.

10.4.1.1 Power LED

An LED is provided to indicate whether the MRU X1 is powered. When powered on, the LED will glow bright green.

10.4.2 Rear Panel Controls and Indicators

The following sections highlight the controls, indicators and features located on the rear panel of the MRU X1.

10.4.2.1 Air In & Air Out Ports

The AIR OUT and AIR IN ports are Swagelock automatic shut-off type, such that when the connector is removed, the port seals itself. The fittings must be pushed quite firmly together until they “click” and lock home.

The air directionality must be followed on the MRU X1. The fittings are therefore color-coded blue for AIR OUT and red for AIR IN. See Figure 10-5.

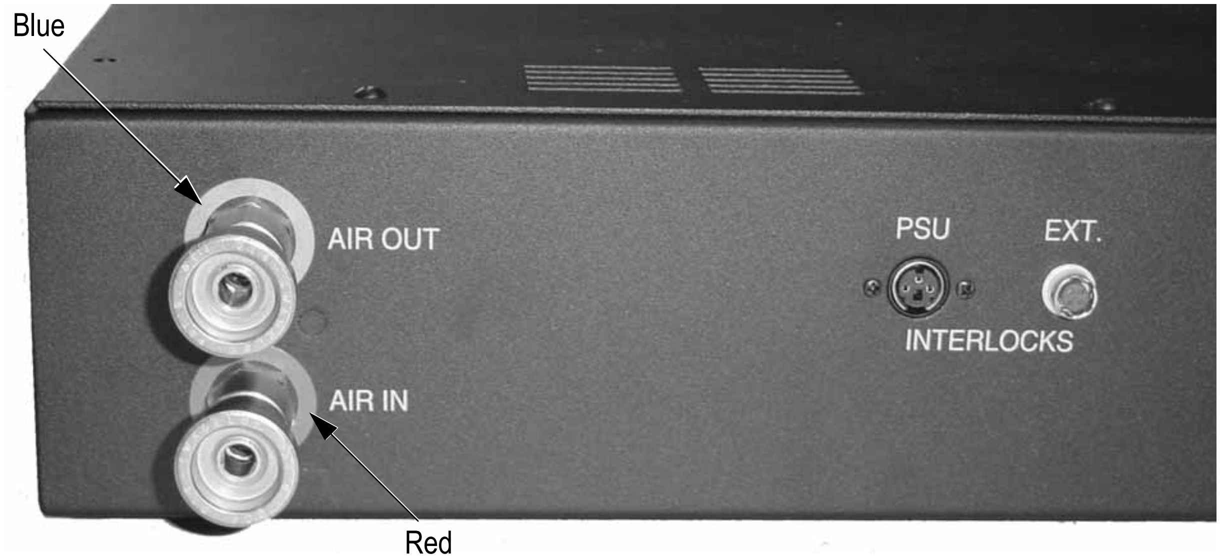


Figure 10-5. Air Ports and Laser Interlocks (Back of Unit)

10.4.2.2 Interlocks

Two interlock connections are provided on the rear panel - the PSU (power supply unit) interlock and the EXT (external) interlock. See Figure 10-5.

The PSU interlock connects the MRU X1 to the laser power supply interlock port using 3-pin mini-DIN type connectors on a 4 m length of cable. The EXT interlock connection must be closed, either by a shorted mating plug (interlock over-ride plug) or via an optional customer supplied door switch using a 4-pin HR10 type connector.

The PSU cable, an EXT interlock over-ride plug and a spare HR10 connector are provided in the MRU X1 accessory kit.

10.4.2.3 Mains Power Input

The MRU X1 has a universal mains power input beside the power switch on the rear panel. The fuse holder can be pulled out enabling the fuses to be checked. See Figure 10-6.

Figure 10-6. Mains Input Showing Fuse Access

10.5 Maintenance and Troubleshooting

10.5.1 Contacting Coherent Service

The following section describes basic troubleshooting procedures which can help the user diagnose and correct many operational troubles with the MRU X1. If a particular problem cannot be resolved, or if a procedure calls for it, Coherent Service should be contacted. Please have the following information ready for the Coherent Service representative:

- The model name and serial number of the Chameleon Ultra, Vision, or Vision-S laser with which the MRU X1 is currently being used.

10.5.2 Maintenance

The MRU X1 requires only minimal maintenance intervention to verify the operation of the interlock circuit, to replace expired drying filters.

10.5.2.1 Interlock Circuit Checkout

On an annual basis (or more frequently if local regulations require), verify the interlock circuit is functional.

1. Place the Chameleon Ultra, Vision, or Vision-S in a normal operating mode.
2. Open (or remove) the EXT Interlock connection from the rear of the MRU X1 and verify the laser faults with an External Interlock error.
3. Close (or insert) the EXT Interlock connection to the rear of the MRU X1 and reset the Interlock fault.
4. With the laser again in a normal operating mode, turn off the MRU X1 power switch and verify the laser faults with an External Interlock error.
5. Turn MRU X1 power back on, reset the Interlock fault and verify the laser returns to normal operating mode.

10.5.2.2 Drying Filter

When the indicating band on the drying filter changes color to "depleted" as per the label on the drying filter, the filter must be replaced immediately. It is advisable to change the drying filter just prior to its depletion. It is not recommended to operate the MRU X1 or laser when the drying filter indicator band shows depleted.

10.5.2.3 Inspect/Change Drying Filter

The drying filter within the MRU X1 should be inspected for a color change, described above, on a 6 month schedule. However, if the MRU X1 is operated in very humid environments the frequency should be increased based on experience.

The laser must be in STANDBY when this activity is carried out. Otherwise, the MRU X1 interlock will cause the laser to shutdown when power to the MRU X1 is turned off or the filter housing is disconnected.

1. Key the laser to the STANDBY position.
2. Switch OFF the MRU X1 and disconnect the power cable.
3. Disconnect the external cooling tubes from the rear of the MRU X1.
4. Put protective dust caps on the tube ends to prevent contamination.
5. Remove the screws from the MRU X1 cover.
6. Lift the MRU X1 cover from the housing and store safely (a earth strap is attached between MRU X1 cover and inner housing).
7. Disconnect the tubes leading into the expired filter by the press-release method at the connections.
8. Remove the tie-wraps holding the filter in position.

9. Remove the expired filter from the clips.
10. Discard the expired filter as recommended in the SDS.

Figure 10-7. MRU X1 Internal Components

11. Unpack new the filter and position in the clips.
12. Attach the tube connections at both ends of the filter.
13. Ensure the color band on the filter is visible.
14. Use the tie-wraps supplied with the new filter to hold the clips together at each end of the filter cylinder.
15. Ensure the tubes are not caught on any metal fittings.
16. Tighten the tie-wraps to secure the filter cylinder.
17. Check all the fitting connections to ensure they are correctly sealed.
18. Replace the MRU X1 cover to its original position and secure with the screws.
19. Remove dust covers from the external tube ends and reconnect the tubes to the correct location at the rear of the MRU X1.
20. Reconnect the power cable and switch ON the MRU X1.
21. Check that the MRU X1 is operational when the indicator light changes from red to green.

10.5.2.4 HEPA Filter Replacement

It is recommended to replace the HEPA filter every three years or 25,000 hours of operation, though effectively it lasts the life of the system.

10.5.2.5 Fuse Replacement

The following procedure outlines the replacement of the MRU X1 mains fuse(s).

1. Using a small, flat screwdriver lever, open the top catch and flip down the door above the mains input socket. Refer to Figure 10-6.
2. Then lever out and pull the red draw holding the two fuses.
3. Remove the two fuses and check to see which is blown using a DVM.
4. Replace the blown fuse(s) with a 5 A (T5 A L 250 V) and slide the draw back into place.
5. Replace the catch.

11 PACKING PROCEDURE

The following is the factory-recommended packing procedure for the Chameleon Ultra, Vision, and Vision-S laser systems. This procedure must be followed if the Chameleon Ultra, Vision, or Vision-S system is to be shipped to another location after initial installation.

Table 11-1 lists the contents when the system is shipped from Coherent.

The Chameleon Ultra, Vision, or Vision-S system crate consists of a single molded foam compartment. To prevent ESD damage, the compartment must be lined with anti-static material before placing the laser head and power supply into the crate. The excess anti-static material should be folded over to cover and protect the top of the power supply.

Table 11-1. Chameleon Ultra, Vision, and Vision-S Shipping List

1. Laser head	4. Accessories kit
2. Power supply	5. MRU X1
3. Chiller	6. 5 L coolant container

Coherent recommends that three people work together to pack the Chameleon Ultra, Vision, or Vision-S. The laser head and power supply are connected by the umbilical. To prevent damage to the fiber optic delivery cables running between the head and the power supply, the umbilical should be wound loosely in the foam cutout as illustrated in Figure 11-4 on page 122.

NOTICE
The Chameleon system is shipped with the fibers connected at both ends. Excessively tight fiber bends (less than a 5-inch radius) can cause permanent damage to the fiber optic cables.

Prepare the Chameleon system for shipping by following these steps:

1. Disconnect the cooling hoses from the laser head and the chiller.
2. Loosely coil the water hoses (excess water may have to be removed), keeping the coils as flat as possible, fit end caps, and place in bags (Figure 11-1).

Figure 11-1. Water Hose in Bag

3. Disconnect the air hoses from the laser head and the MRU.
4. Fit end caps to the air hoses and to the MRU input and output.
5. Remove coolant from the laser head by connecting open ended hose connector to the laser head connector labeled “Cooling Out”. Place open end of hose in a large suitable beaker or flask with volume greater then 1 L. Switch chiller on and let it run until all coolant liquid has emptied into the beaker or flask. Chiller will return a fault saying the coolant level is low. Switch off Chiller using on/off button switch.
6. Once water has been removed from the laser head, fit end caps to the laser head, including the BNC connector as shown in Figure 11-2.
7. Drain the chiller and fit the end caps to the Cooling In and the Cooling Out connectors as shown in Figure 11-3.Dispose of the coolant in a safe and environmentally compliant manner occurring to your local regulations.

NOTICE

To avoid being damage during the packing procedure, keep the fibers away from the heavy parts of the system - head and power supply, and from being tangled up in the electrical cables. Take care to ensure fibers are always strain-free.

Place the Chameleon Ultra, Vision, or Vision-S in the shipping crate as follows:

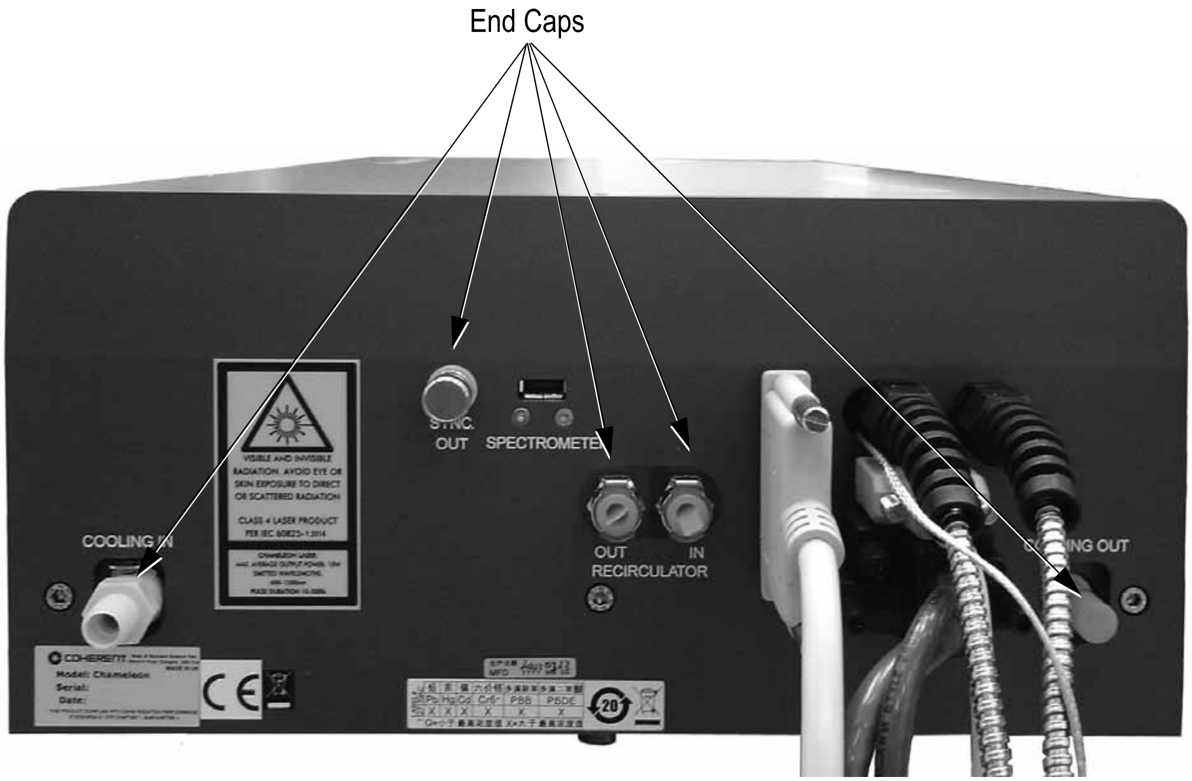


Figure 11-2. End Caps for Laser Head

Figure 11-3. End Caps for Chiller

1. Place the laser head in the cutout as shown in Figure 11-4. The laser head is heavy and should always be handled by two people.

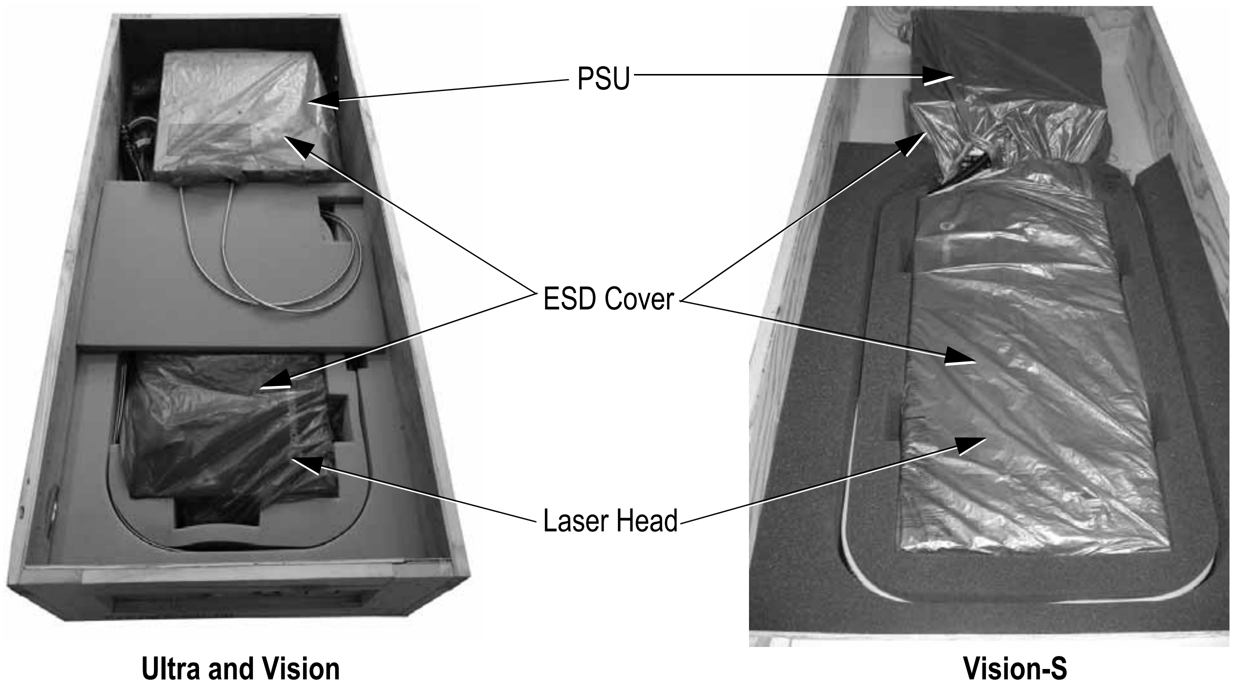


Figure 11-4. ESD Cover on Power Supply and Laser Head

2. The power supply should also be handled by two people. To get the umbilical to lie properly in the foam cutout, carry the power supply clockwise around the crate. Then place the power supply in the foam cutout as shown in Figure 11-4. At this point a third person can help by guiding the umbilical into the cutout.
3. Wrap the ESD cover over the laser head and power supply (Figure 11-4).
4. Fit thin piece of foam as per Figure 11-5. For the Ultra and Vision units, place short bend of the fiber cable over the thin piece of foam.

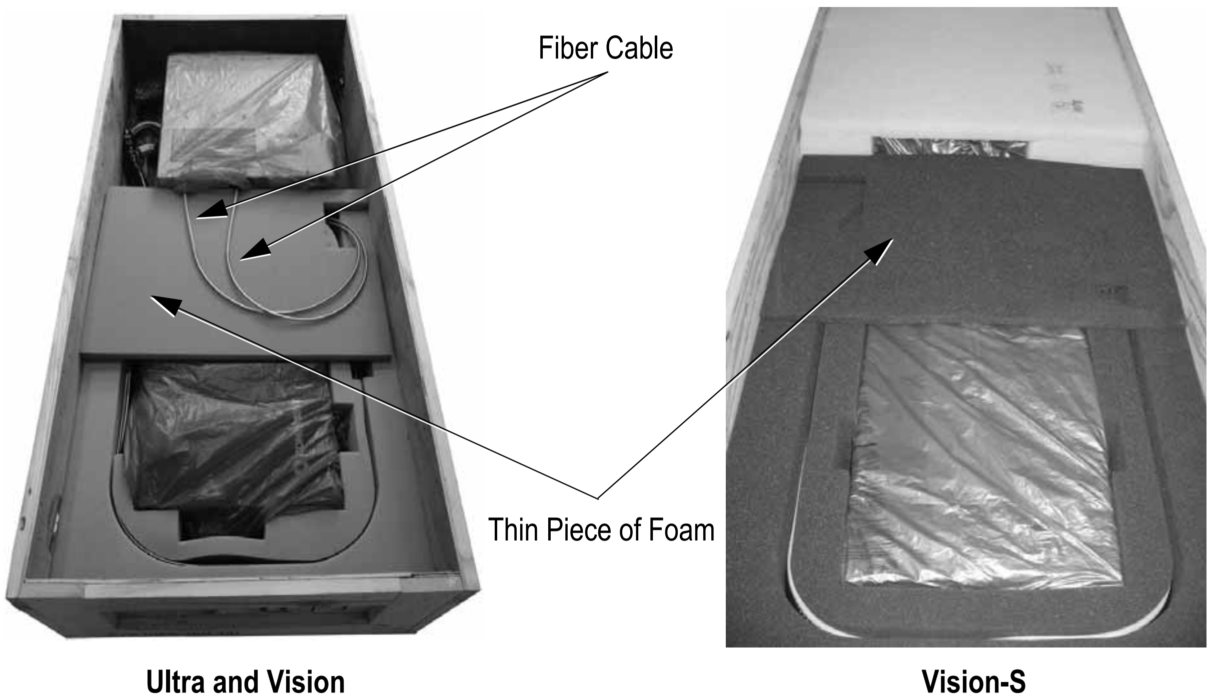


Figure 11-5. Placement of Thin Foam Cover

5. Fit the small top foam insert over the power supply and the larger foam insert over the laser head (Figure 11-6).
6. Fit the crate lid and clamp it down using a minimum of 8 metal straps (Figure 10).

When shipping the entire system, always be sure to place the MRU and the chiller in their appropriate shipping containers as delivered.

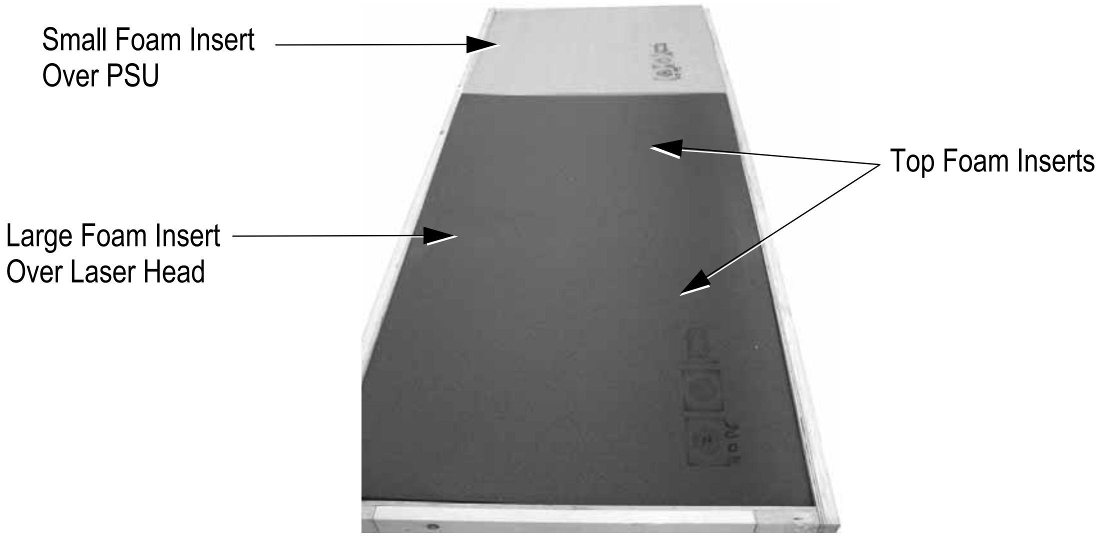


Figure 11-6. Fitting Top Foam Inserts

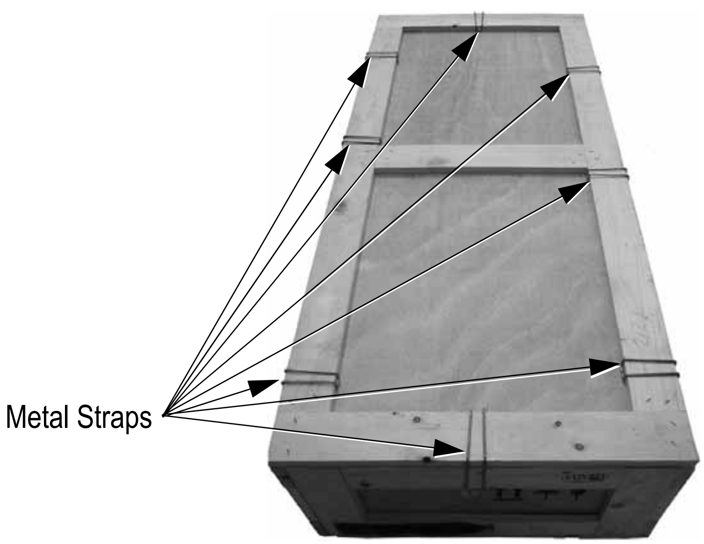


Figure 11-7. Fitting Top Foam Insert and Clamping the Lid

12 THEORY OF OPERATION

12.1 Chameleon™ Laser Head

The Chameleon Ultra, Vision, and Vision-S laser head (Figure 3-2) consists of a Verdi laser head and a sealed Verdi-Pumped Ultra-Fast (VPUF) laser head. The 532 nm output from the Verdi pumps the VPUF head.

Optimum pump beam (532 nm) alignment is provided by an active PowerTrack mirror. The position of the PowerTrack mirror is optimized by two PZTs. The PZTs operate in a feedback loop to optimize the alignment of the Verdi pump beam and therefore, the power emitted by the VPUF head.

12.2 VPUF Laser Head

The following is a very brief explanation of the operation of a laser.

A laser is an optical oscillator that creates a very highly directed beam of light at a precise wavelength or frequency. There are three important components of all lasers:

- High reflector
- Gain medium
- Output coupler/partial reflector

The region of space between the high reflector and the output coupler is referred to as the laser cavity.

If the atoms in the gain medium are properly “prepared”, light passing through the medium will be intensified, or amplified. The high reflector at one end of the laser and the output coupler, which as a partial reflector, causes the amplified light to be returned to the gain medium for further amplification. Only light traveling strictly perpendicular to the high reflector and output coupler will make many passes through the gain medium without zigzagging off the mirrors and will therefore be amplified significantly. This strong “preferential treatment” of light moving in a precise direction is what gives the laser its highly directed beam.

The output of the laser is simply a sampling of the light circulating in the cavity provided by the output coupler. The output coupler reflects most of the light incident on it, but allows a fraction to be transmitted forming the output of the laser.

12.3 The Gain Medium

Light is absorbed rather than amplified in most materials. The atomic explanation of absorption and amplification are similar; the difference being in the initial state of the atom.

Atoms are normally in their low-energy state and pick up energy from incident light, thus absorbing the light. Upon absorbing this light, the atom is in an energetic state and can, when stimulated properly, fall to its original state – and upon doing so, emit light.

Atoms in their energetic or excited state can be stimulated to emit light by light itself. If, moreover, the stimulating light and the stimulated light are identical in wavelength, more light of that wavelength leaves the region of the atom than arrived there. Therefore the light is “amplified”.

12.3.1 Preparing the Atoms for Amplification — Pumping

Some means are required to raise the atoms to their high energy or excited state, because at normal temperatures most are in a lower energy state and will absorb rather than emit light. The process is referred to as pumping. There are many methods of pumping and different methods are appropriate for different atoms.

In the case of the Ti:Sapphire laser, another laser is required as the pump laser to excite the titanium. Each atom requires intense light and only a laser can provide this highly focused and directed light.

12.4 Longitudinal Modes

Only certain wavelengths will be amplified depending on the details of the amplifying medium and the mirrors. In general, wavelengths may be restricted further by optical filters or other devices. In principle, the Ti:Sapphire gain medium in the Chameleon Ultra, Vision, and Vision-S lasers will amplify from 680 nm to 1100 nm. The laser mirrors restrict the possible wavelengths to ~ 400 nm. The specific wavelengths that can oscillate are further restricted due to a resonance condition similar to the vibrating frequencies of a string.

The requirement is that each lasing wavelength must satisfy the condition that an integral number of half wavelengths must "fit" precisely between the mirrors. Because the integer is not specified, there can be many wavelengths that satisfy this criterion. An adjustable tuning element in the Chameleon Ultra, Vision, and Vision-S lasers is then used to select the central wavelength that is amplified.

Each of the possible wavelengths is known as a "longitudinal mode".

12.5 Transverse Mode

The light is contained between the mirrors within a very well- defined volume, which is much narrower than the physical diameter of the mirrors. This distribution is known as the "transverse mode" of the laser.

The diameter of the beam anywhere within the laser cavity depends critically on the distance between the mirrors and in the case of Chameleon Ultra, Vision, and Vision-S lasers, the intensity of the light. This is important in understanding the principle upon which these lasers operate.

12.6 Theory of Modelocking

Again, the following explanation of modelocking is presented in its simplest form, but sufficient for the understanding of the operation of the Chameleon Ultra, Vision, and Vision-S lasers.

Within the cavity of a modelocked laser, a single short pulse of light bounces back and forth between the mirrors.

At each bounce from the output coupler, a small portion of the pulse escapes to form the output of the laser. The time between pulses is equal to the time it takes for light to make one round trip from the output coupler to high reflector at the other end of the cavity back to the output coupler. In the case of Chameleon Ultra, Vision, and Vision-S lasers, this time is approximately 12.5 ns.

The inverse of this time gives the number of pulses per second, commonly referred to as the repetition rate, rep. rate, or sometimes as the "frequency". For the Chameleon Ultra, Vision, and Vision-S, the rep. rate (or frequency) is 80 MHz.

Once a pulse is formed within the cavity, most atoms that were in their excited state (prepared to emit light), have been stimulated to do so by the passage of the pulse through the gain medium. For a period of time then after passage, there are insufficient atoms in the excited state, to form and amplify another pulse. This means that only a single pulse is formed at a time and the output consists of a sample of this one pulse, as it periodically arrives at the output coupler.

12.7 Formation of the Pulse

12.7.1 Active Modelocking

Many active techniques for creating a short optical pulse have been developed. All act upon the laser in basically the same way, however. In order to initiate the pulse, some sort of optical shutter, or "modulator", is opened, closed and opened again at precisely the correct rate to allow a pulse of light to pass through the shutter as it travels back and forth between the high reflector and output coupler. Only light that arrives at the shutter at precisely the correct time to pass through without being blocked will be amplified. Because the shutter is closed at all other times, a second pulse cannot be formed.

It is not difficult to see that the timing of the shutter is extremely important and must be precisely equal to the time interval between successive bounces of the pulse to be amplified. In other words, the modulator frequency must be precisely equal to the repetition rate (pulse frequency). If this technique must be used to form the modelocked pulse, great care and ingenuity must be employed to keep these two frequencies identical. Since the time between pulses depends on the length of the cavity, any change in the length of the cavity must be accompanied by an accurate readjustment of the modulator frequency. Alternatively, the cavity length can be regulated so the repetition rate always matches the modulator frequency. There are many very practical commercial systems (e.g., YAG and YLF lasers) that utilize this type of modelocking successfully through ingenuity, precision components and competent engineering, despite the complexity of design.

12.7.2 Passive Modelocking

A shutter or modulator in which timing is accurately controlled externally is not necessary in some modelocked systems. If some material or mechanism could be used that automatically opens to allow the pulses through but is closed otherwise, a self-adjusting modulator could be constructed. In other words, the light pulse would open its own shutter when it arrives, rather than depending on it being open upon arrival. Therefore, if the pulse arrived early or late, the shutter would still open, allow the pulse to pass through and then close. This method is known as "passive modelocking".

There are indeed materials that behave in this manner. This is possible because the instantaneous intensity of the pulses are extremely high, compared to the intensity when the laser is operating unpulsed or continuously (CW operation). Organic dyes fit this description, which are normally opaque but become transparent to light of very high intensity. This intensity dependent transmission is referred to as saturable absorption.

Unfortunately, saturable absorbers are commonly exotic dyes with properties that are very wavelength-dependent. They are often in liquid form and must either be refreshed frequently or flowing. In addition, the dye concentration must be adjusted as the laser power changes.

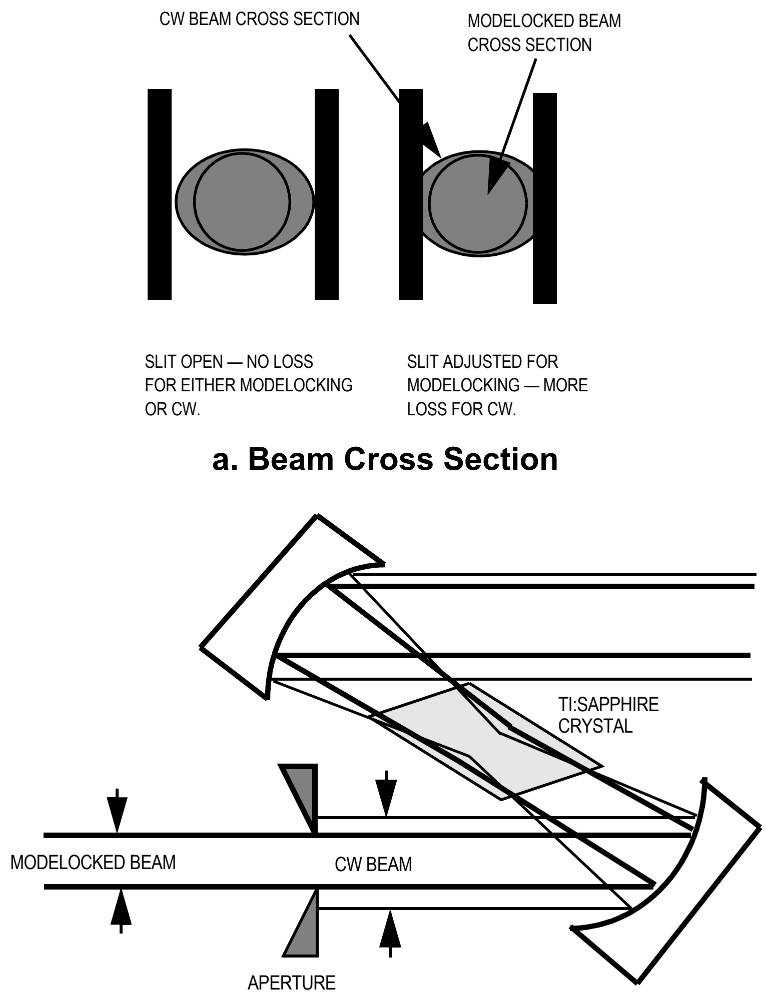
12.7.3 Chameleon Ultra, Vision, and Vision-S Saturable Absorber System

Coherent's saturable absorber system does not suffer from the limitations mentioned above. It uses no dyes or liquids, does not have to be renewed, operates independently of wavelength and is adjusted for various powers using a simple mechanical control.

The Chameleon Ultra, Vision, and Vision-S laser cavity has been designed such that the beam diameter within the cavity changes by a small amount as the intensity of the light changes. More specifically, the beam diameter at certain locations within the cavity is large when the laser is operating in CW mode, but becomes smaller when the laser is producing high-intensity modelocked pulses.

A simple slot or "slit" is now placed at the appropriate location and its width is adjusted so the large-diameter laser beam associated with continuous operation will be interrupted at its edges. A high-intensity pulse, however, passes uninterrupted through the slit, because the beam is smaller. Refer to Figure 12-1.

The modelocking device in Chameleon Ultra, Vision, and Vision-S lasers is a saturable absorber system, because it consists of two parts:



a. Beam Cross Section

b. Beam Geometry

Figure 12-1. Chameleon™ and Chameleon Vision Saturable Absorber System

- A material that decreases the laser beam size in the presence of high-intensity pulses
- The slit that introduces losses for large beams

The properties of light passing through any material depend on a property referred to as the “index of refraction”, or *n*; the higher *n*, the lower the velocity of light. If the velocity of light is different for different parts of the light beam, the beam will bend or otherwise be re-shaped, since different parts of the beam are traveling at different speeds. This is known as “refraction”.

A common refractive element is the lens (e.g., a biconvex lens), which is thicker in the middle than at the edges, so the center of the beam is slowed down more than the edges. This causes the light to bend toward the center. In the case of the lens, the index is the same everywhere, but still, since there is more glass in the middle than the edges, the edges are slowed down less. A lens can also be formed by making the index of refraction at the center of the material larger than the index at the edges. This will also bend light and is known as a “gradient index lens”.

The most common way to change the index of a material is to change its chemical composition. However, in Chameleon Ultra, Vision, and Vision-S lasers, the index is changed by the light itself. At sufficiently high intensity, the electric fields associated with the light can actually distort the atoms of the material and alter its index. This effect is known as the “optical Kerr effect”. The beam is less intense at its edges as compared to the center; the index at the center will be different – and a gradient index lens is formed. Because it is the optical Kerr effect that alters the index, the lens thus formed is referred to as a “Kerr lens”.

The Kerr lens is formed only when the intensity of the light is extremely high. The instantaneous intensity of modelocked light pulses are sufficient to form this lens, but the weak intensity of the laser, which is operating CW, is not; therefore, the lens is formed only upon the arrival of a modelocked pulse. It is this lens that narrows the laser beam. A mechanism has now been created that narrows the beam only for modelocked pulses. The addition of a slit to allow only narrow beams to pass unattenuated now forms the complete saturable absorber system, which provides a real driving force for modelocking.

12.7.4 Origin of the Term “Modelocked”

It may not be obvious why this pulsed output operation is referred to as “modelocked”. The explanation is in the output of the laser.

As mentioned in the description of the laser itself, the laser can operate at a number of wavelengths, which satisfy the condition that an integral number of half wavelengths will “fit” between the high reflector and output coupler. Any one of the wavelengths that satisfy this condition is called a “longitudinal mode”.

When several modes are lasing simultaneously, they add to each other, so, on a random basis, there will be instants at which the light from all the modes will add to create an intense sum. Other times this sum will be less intense, depending on the relative timing or phase of each mode. It can be shown that the larger the number of modes, the higher the instantaneous intensity will be. Figure 12-2 shows the intensity of light with varying number of modes, randomly-phased or timed.

If the phase between each mode is adjusted non-randomly and held constant, the peak powers become much larger and the random spiking between these pulses diminishes. This is known as locking the modes together– modelocking.

Once the modes are locked together, the larger the number of modes locked together, the higher the pulse intensity and the narrower the pulse. Interestingly, the frequency of the pulses is precisely equal to the frequency separation of adjacent longitudinal modes.

12.8 The Starting Mechanism

Normally, the laser will operate in the CW mode with minor power fluctuations, none of which cause powers that are sufficiently high to cause a Kerr lens to form, not even for an instant. Therefore, some mechanism must be introduced to create a sufficiently high peak power to "open" the saturable absorber system. By changing the cavity length at the proper speed, very high-power fluctuations can be induced. Once the instantaneous power in one of these fluctuations becomes high enough, a slight Kerr lens is formed; the beam is narrowed and can pass unattenuated through the slit. This pulse is amplified and becomes the dominant pulse that will form the mode-locked output.

Normally, in a laser such as Ti:Sapphire, only one or two longitudinal modes operate simultaneously. This is due to the fact that all atoms within the lasing medium are considered to be equivalent and are capable of emitting light over a range of frequencies and will emit at the same frequency as the stimulating light. Therefore, the earliest light to reach high intensity through the amplification process will establish the frequency for subsequent light. No atoms will remain in their upper state to amplify light at another frequency. In reality, two modes can operate simultaneously due to a phenomenon known as "spatial hole burning" that will not be covered here.

The random fluctuations caused by only two modes do not cause very high instantaneous powers. A prerequisite for high intensity fluctuations is that the laser be encouraged to simultaneously operate with as many longitudinal modes as possible.

Of all the longitudinal modes that can lase, a few are more likely than others. This is due to the fact that any wavelength-selecting element will cause more losses on either side of the selected wavelength. As the wavelength selector is changed, some modes are discouraged and others are encouraged. Alternately, the modes themselves can be shifted in wavelength by changing the cavity length, so a different set of wavelengths satisfy the "integral half waves between reflectors" criterion. If the cavity length is changed rapidly enough, the freshly discouraged modes (previously oscillating modes) will die out, leaving atoms available for the new modes. There will be a period during which both can lase simultaneously. We have therefore created a transient condition under which the output of the laser contains more longitudinal modes than normally possible.

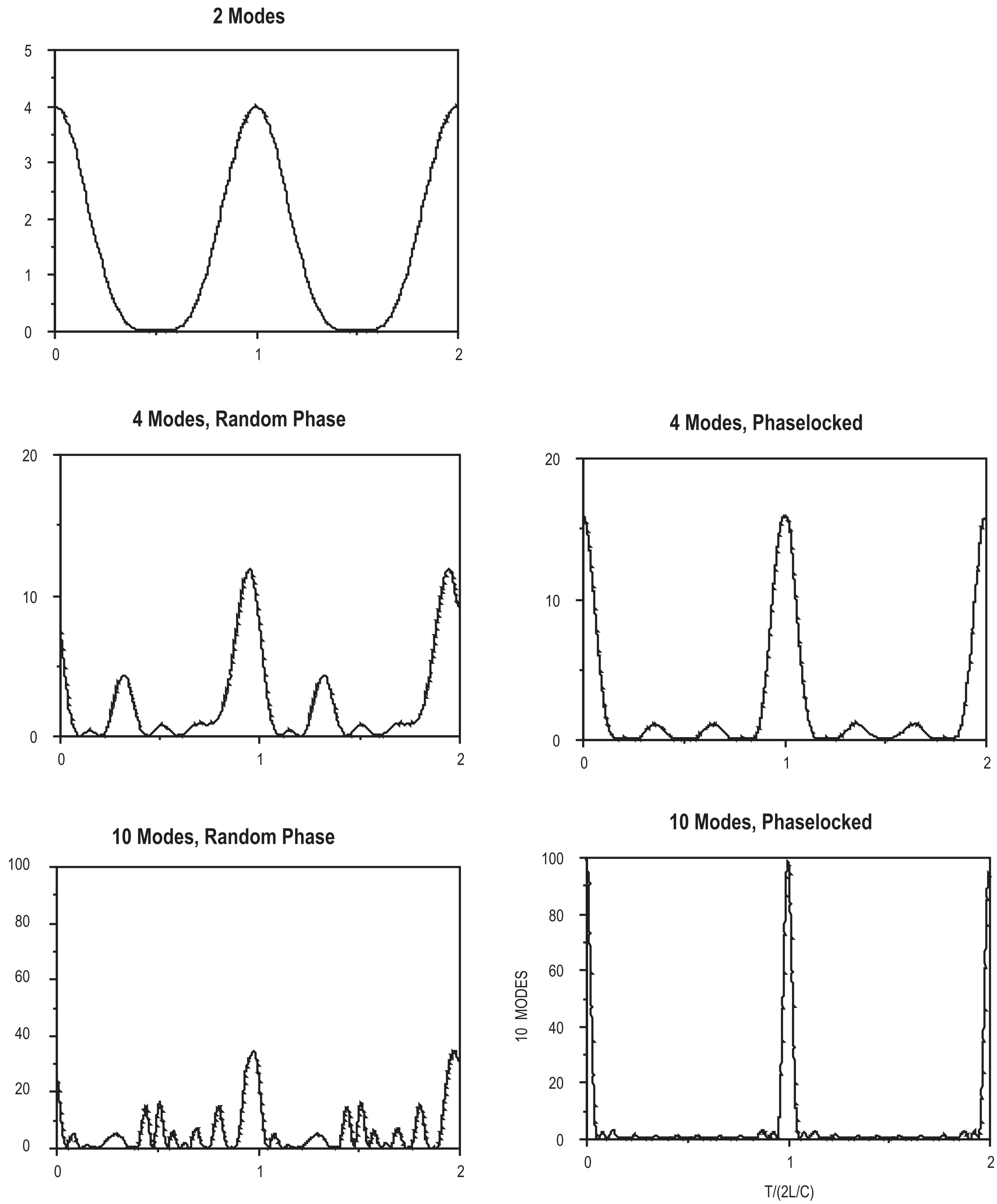


Figure 12-2. Intensity of Light with Varying Number of Modes

Once a larger number of modes are lasing, peak intensities are produced to initiate Kerr lens formation and the modelocking process begins.

It is important to mention that once modelocking starts, it will continue without the need of the starting mechanism. The rapid length variation can be halted.

In Chameleon Ultra, Vision, and Vision-S lasers, the length of the cavity is changed slightly by vibrating an intracavity mirror.

12.9 Transmission of Ultrashort Pulses of Light Through Glass

12.9.1 Group Velocity Dispersion

The wavelength of an ultrashort pulse of light cannot be determined precisely because it is formed by the sum of a distribution of wavelengths on either side of the center wavelength. The width of the distribution is inversely proportional to the length of the pulse. Moreover, in order to produce a short pulse of light from the distribution, the timing or phase between each component wavelength must be precisely correct, or the pulse will not be as short as it could be.

An ultrashort pulse will be become longer after it has passed through glass. This is because in all normal materials, the index of refraction and therefore the speed of light depends nonlinearly on the wavelength.

Figure 12-3 shows a hypothetical dispersion curve, i.e., a graph of refractive index (n) versus wavelength (λ) with a shape typical of many common materials that are transparent in the optical spectrum. The shape is typical in the sense that the index decreases monotonically with increasing wavelength, while maintaining a gradual upward curvature. This is often referred to as "normal dispersion", whereas a material with a downward curvature is referred to as having "anomalous dispersion".

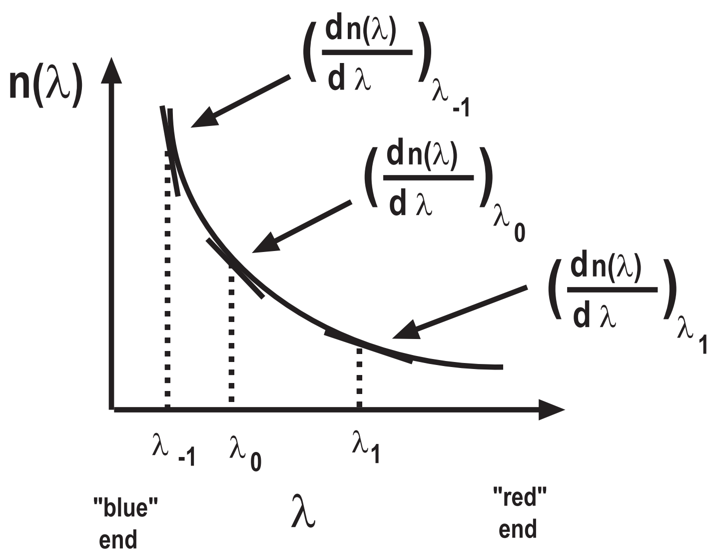
$\frac{dn(\lambda)}{d\lambda}$ At a given wavelength, the refractive index $n(\lambda)$ determines the phase velocity or the velocity of a monochromatic wave. The slope of the refractive index curve (see left) determines the group velocity and thus defines the velocity of a wave packet (short light pulse) with a central wavelength λ.

$\frac{d^2n(\lambda)}{d\lambda^2}$ The second derivative of the curve (see left), determines the GVD, which governs the rate at which the frequency components of a wave packet change their relative phases.

GVD causes temporal reshaping of wave packets. This can be the shape broadening or a compressing, depending upon the initial conditions (chirp) of the wave packet spectrum. The term “chirp” means that the frequency of the packet is changing with time (as in the chirping of a bird).

A pulse is said to be “positively chirped” if its instantaneous frequency increases from leading edge to trailing edge, as in Figure 12-4. This is the type of chirp that normally will be imparted to a pulse after traversing “normal” materials with an upward curvature as shown in Figure 12-3. Its blue spectral components will be retarded with respect to the red, creating a systematic variation of phase with respect to wavelength.

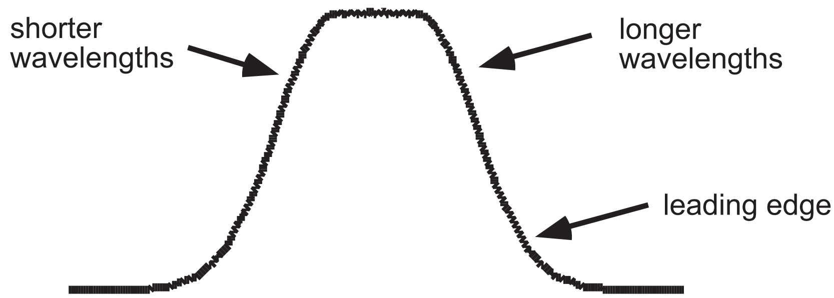
Similarly, a pulse is said to be negatively chirped if its red spectral components have been retarded with respect to the blue as seen in Figure 12-4.



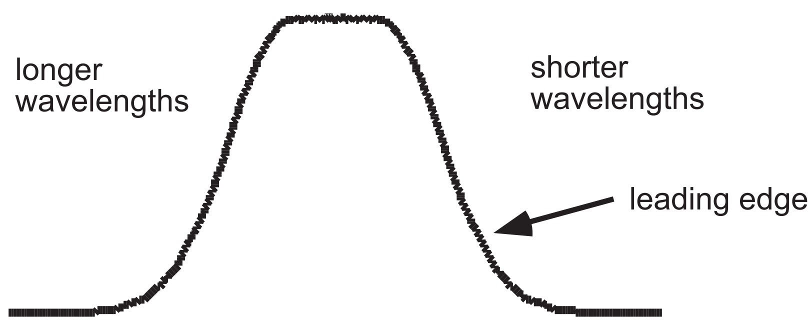
The curvature and hence GVD is determined by the 2nd derivative of the dispersion relation.

$$\frac{d^2 n(\lambda)}{d\lambda^2} \propto \text{"Group Velocity Dispersion"}$$

Figure 12-3. Group Velocity Dispersion Derivative



b. Positive Chirp — Red Frequency Components Lead The Blues (Results From +GVD)



a. Negative Chirp — Blue Frequency Components Lead The Reds (Results From –GVD)

Figure 12-4. Group Velocity Dispersion

12.10 Self Phase Modulation

In addition to the phenomena already described, pulses in ultrafast lasers are also affected by self-phase modulation (SPM). Due to the optical Kerr effect, intense light pulses propagating through dense media create a local index of refraction that is dependent on the light field intensity. Therefore, the leading and trailing edges of the pulse will cause less change in the index than the center where the intensity is highest. This will subsequently cause parts of the pulse to move faster, thus altering the pulse shape.

Frequency components propagating through the material are thus phase-shifted differently, depending upon where they occur in the pulse. This phenomenon actually generates new frequencies (or eliminates old ones depending upon the initial conditions). These frequency components are inherently chirped and can broaden the pulse unless the chirp is compensated. It can be shown that chirp which results from SPM has the same sign (positive) of the chirp introduced through normal material GVD.

12.11 Dispersion Compensation

Because of self-phase modulation and the GVD from the many dispersive elements within the laser cavity, some method must be employed to allow the slow frequencies or wavelengths to catch up with the faster ones. Each time it traverses the cavity, the circulating pulse receives a slight chirp from the dispersive elements it encounters. Without compensation, the cumulative effect of even a very small chirp per round-trip would create broadening and pulse substructure. We thus require an element or system of elements that has negative GVD; that is, the relationship between wavelength and speed or index must be the reverse of what it is in a normal material. In principle, negative chirps could be introduced by propagating the pulse through a material at a wavelength in which the curvature of the index curve goes downward—but in practice, this is not very practical. To accomplish this with some variability in the magnitude of the desired compensation, some type of special optical system must be constructed.

In the previous section on group velocity dispersion, the concept of GVD was introduced in the context of index of refraction. The existence of a finite second derivative of the index with respect to the wavelength was required in order to create GVD. In fact, this description does not apply only to simple material dispersion curves, but also can be generalized to any optical system by realizing that a more general description of GVD requires the existence of a finite second derivative of the optical path length with respect to wavelength.

For a given wavelength and a given optical system, one can express the phase evolution of the light wave traveling through the system by taking into account all of the effects that occur along the optical path, including refraction at surfaces.

A path length curve, analogous to that shown in Figure 12-3, can be constructed for any complex optical structure having wavelength dependent beam paths. GVD can therefore be regarded as a property of an optical construction.

An example of a simple scheme for compensating GVD consists of a pair of prisms separated by a distance oriented in a specific way with respect to each other. It can easily be shown that the net GVD of this prism pair can be made negative by proper choice of prism material (and its index properties) and the distance between the prisms.

This GVD compensation scheme operates as shown in Figure 12-5.

1. A pulse is formed and chirped by self-phase modulation in the Ti:Sapphire crystal and by GVD in the various intracavity optical components in the laser.
2. The chirped pulse enters prism 1.
3. Since prisms bend or refract different wavelengths into different angles, the beam spreads as it heads for the second prism.
4. The blue components are bent more severely than the red ones, thus creating the possibility of wavelength dependent path lengths for the various rays.

As mentioned above, this system behaves exactly opposite of most materials. The GVD of this system is said to be negative, since the blue part of the pulse travels through the system faster than the red.

The magnitude of the GVD compensation can be easily controlled over a range by prism glass path adjustment (see "Changing GVD"). The range is sufficient to allow the "net cavity GVD" to be tuned through zero.

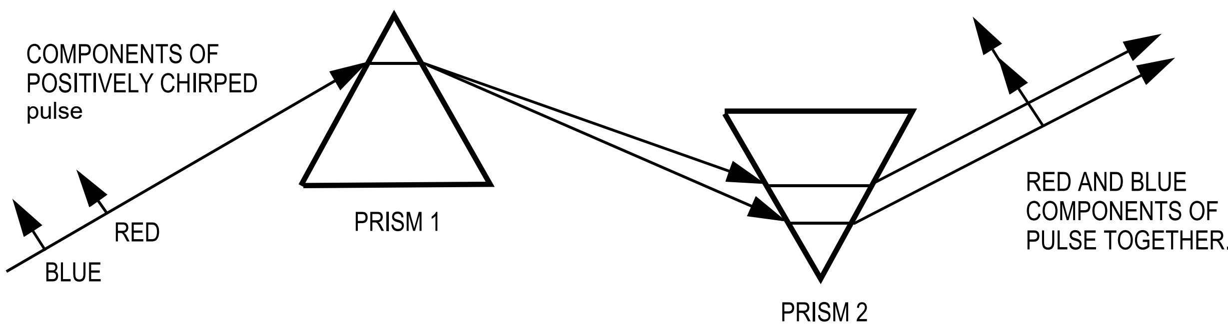


Figure 12-5. One Method of GVD Compensation

12.12 Changing GVD

The total round trip chirp of the system is the sum of the chirps arising from SPM, positive material GVD and negative GVD of the compensator. A simple way to adjust the GVD component of the chirp is to change the amount of glass within the cavity.

Translating one of the prisms in the compensator is a very convenient way of inserting more or less glass. Thus the proper GVD can be adjusted very simply. The Chameleon Vision provides a wide range of negative chirp to compensate for downstream optic elements, e.g. microscope objectives.

12.13 The Formation of Final Pulse Width

In practice, the pulse-forming mechanism is dynamic in nature. Although the optical materials within the cavity define the total dispersion within the cavity, self phase modulation depends on the intensity of the pulse. As the pulse gets shorter, its intensity becomes higher, since all of the energy in the long pulse is now emitted over a shorter interval. There is therefore more self phase modulation, and therefore more broadening.

Finally, the pulse reaches a stable width and pulse amplitude. This process of establishing an equilibrium pulse, which upon one trip through the cavity remains unchanged, is related to a nonlinear pulse formation process called “Soliton-formation”. The periodically reforming wave is referred to as a Soliton.

Soliton-like pulse formation has many attractive features. First, if the pulse for some reason becomes more intense, the increased self-phase modulation will cause the pulse to broaden, distributing the pulse energy over a longer period of time and thus reducing the pulse intensity. The laser is therefore self-regulating. The output is extremely stable.

12.13.1 Propagation of Ultrashort Pulses Through Optical Materials

Because ultrashort pulses broaden considerably when passing through any glass, it is important that this be taken into account in any experimental arrangement. Figure 12-6 shows the effect of several common glasses for various initial pulsewidths. Fused silica and BK7 are relatively benign, whereas a dense glass such as SF10 should certainly be avoided. It is also noted that longer initial pulses, e.g. 140 fs, suffer less from pulse broadening than shorter pulses, e.g 75 fs.

12.14 PowerTrack

The PowerTrack function actively maintains optimum Verdi pump beam alignment into the VPUF cavity and optimum resonator alignment. This serves to minimize fluctuations in the ultrafast output power.

Piezo-Electric Transducer-driven levers alter the tilt and therefore the direction of the output of the PowerTrack mirror, as shown in Figure 3-2. In STANDBY mode, there is no voltage provided to the levers. Once the system is keyed to the “Laser On” position, the PZT controller provides voltage to these levers and carries out a rapid scan of the mirror in the *X* and *Y* directions (large changes in PZT voltage and hence pump beam position). This occurs first with the pump and then the intracavity PowerTrack mirror.

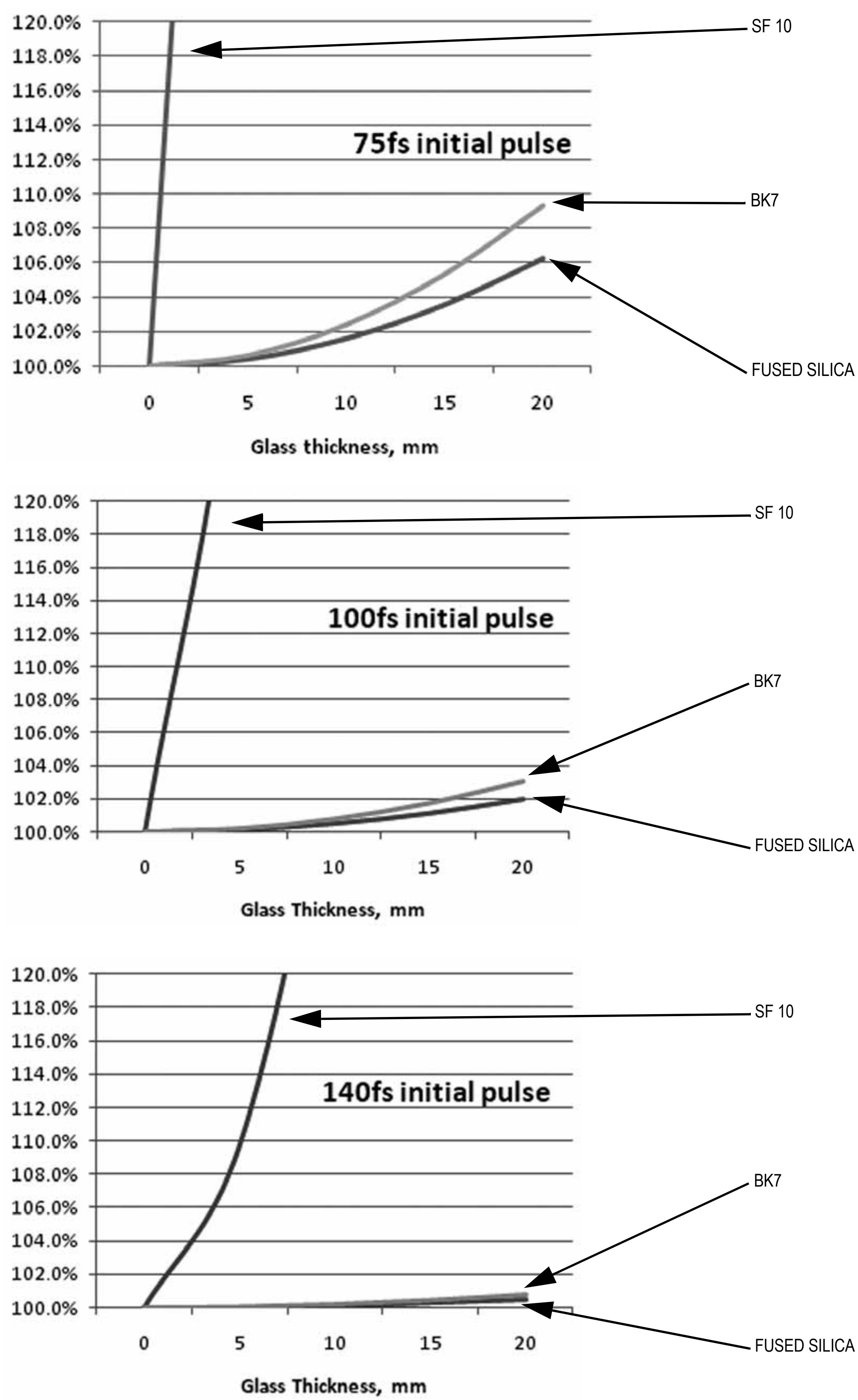


Figure 12-6. Comparison of Pulse Broadening in Fused Silica, BK7,and SF10

Scanning can be observed as large changes in the PZT*x* and PZT*y* voltages in the PZT Control submenu. Once a preset threshold level of continuous wave (CW) lasing is achieved, the raster scan is switched to a smaller amplitude Dither Scan (smaller changes in PZT voltage and hence pump beam position). The Dither scan is centered about the Raster Scan voltages found to achieve the threshold level of CW lasing. System electronics then correlate increases in power with changes in PZT voltage. This, in turn, allows the Dither Scan to fine tune the PZT voltage in the direction needed for optimum alignment.

Once the pump mirror alignment has been optimized in this way, the pump PowerTrack position is held and the intracavity mirror position is then optimized using the procedure just described.

12.15 Autocorrelation

Autocorrelation is a commonly used technique for measuring the duration of ultrafast pulses. A real-time autocorrelator is a useful pulse-width measurement tool for an ultrafast laser like the Chameleon Ultra, Vision, or Vision-S.

12.15.1 Optical Schematic Overview

The optical schematic of a typical scanning autocorrelator is shown in Figure 12-7. The laser beam enters the input port and strikes the beam splitter, forming two beams designated “fixed” and “variable”. The fixed beam path is defined by mirrors M1 through M3 and has a total distance D_F. The variable beam path includes mirror M4 and a moving mirror assembly that creates a time dependent beam distance $D_V(t)$.

The two beams are parallel but slightly separated when they reach the lens, which refracts them along mutually converging paths that cross in the second harmonic crystal. An output second harmonic beam (at twice the laser frequency) appears after the crystal, travelling in a direction that bisects the angle between the two input beams. This beam contains the autocorrelation signal and is detected by the photomultiplier.

12.15.2 The Concept of Autocorrelation

When a single pulse with envelope function $E(t)$ enters the autocorrelator, it is split by the beamsplitter into two identical copies. The one which follows the fixed path requires a time interval of $\frac{D_F}{c}$ to reach the lens, whereas the one that follows the variable path requires $\frac{D_V(t)}{c}$.

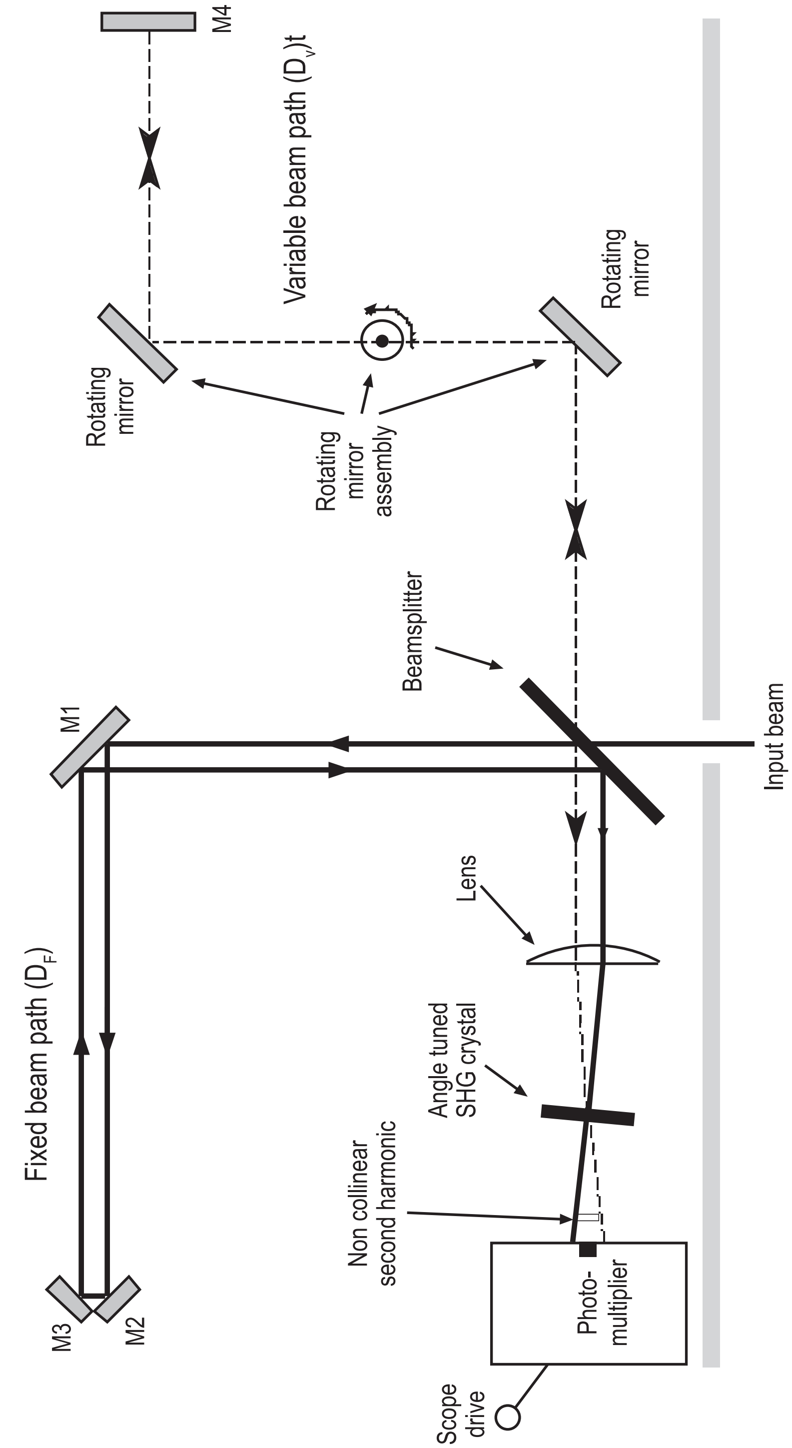


Figure 12-7. Typical Autocorrelator Optical Schematic Diagram

E(*t*) has been converted to a signal of the form:

$$E\left(t-\frac{D_F}{c}\right)+E\left(t-\frac{D_V}{c}\right)= E(t)$$

at the lens. The two copies of the pulse travel to the SHG. In general, second harmonic generation produces an output proportional to the square of the input, or in this case.

Equation [12-1]. Square of the Envelope Function of the Signal in the Autocorrelator

$$E^2\left(t-\frac{D_F}{c}\right)+\left(E^2\left(t-\frac{D_V(t)}{c}\right)+E\left(t-\frac{D_F}{c}\right)E\left(t-\frac{D_V}{c}\right)\right)$$

The first term of Equation [12-1] represents a second harmonic pulse formed only from light that propagated along the fixed beam path and the second term is the same quantity for the variable beam path. The third term, however, represents a pulse formed from a mixing of the light that traveled along the two different paths. Its magnitude depends on the path difference between the fixed and variable arms of the autocorrelator, as can be seen by substituting $t' = t-\frac{D_F}{c}$ into Equation [12-1] and rearranging the terms to produce:

Equation [12-2]. The Envelope Function Expressed as a Function of the Temporal Path Difference of the Two Arms

$$E^2(t')+E^2(t'-A(t))+E(t')E(t'-A(t))$$

where $A(t) = \frac{(D-D_V(t))}{c}$ is the time difference introduced by the autocorrelator between the fixed and variable copies of the pulse, changing over time according to the action of the spinning mirrors.

The photomultiplier tube (PMT) is much slower than the pulse envelope function *E*(*t*). The photomultiplier therefore integrates the light incident upon it and produces a signal *S*(*t*) that is mathematically the integral of Equation [12-2].

Equation [12-3]. Response of the PMT to the Incident Light

$$S(t) = \int((E^2((t')+E^2t'-A(t))+E(t')E(t'-A(t)))dt$$

The first two integrals are identical and are independent of the path difference *A*(*t*). The third integral contains the pulse autocorrelation information that we wish to measure.

12.15.3 Background-Free Autocorrelation by Non-Collinear Phase Matching

While it is possible to obtain useful information from the signal represented by Equation [12-3], the first two integrals constitute a fixed background level that complicates the interpretation of observed data. These two integrals are effectively eliminated by the method of non-collinear phase matching in the SHG crystal. A simple theoretical understanding of this method can be gained from the momentum representation of the second harmonic process, in which there is a three-wave interaction satisfying the following conservation requirement.

Equation [12-4]. The conservation of momentum for a Second Harmonic process

$$k_F + k_V = k_{SHG}$$

The *k*'s are vector quantities associated with the fixed, variable and second harmonic light fields, respectively. The direction of each *k* is the direction of beam propagation and the magnitude of each *k* is inversely proportional to the wavelength of the light. The vector equation (Equation [12-4]) can be represented geometrically for the case of non-collinear phase matching by Figure 12-8, where it is assumed that k_F and k_V are identical in magnitude but slightly different in direction. The figure shows that the direction of k_{SHG} must fall halfway between the fixed and variable beam directions. Thus the non-collinearly phase-matched pulse, the third term in Equation [12-4], can be identified and selected by its propagation direction. The photomultiplier is positioned behind a small entrance slit that passes predominantly the non-collinear beam, thus measuring a signal produced by only the third term in Equation [12-3]. This is often called background-free autocorrelation.

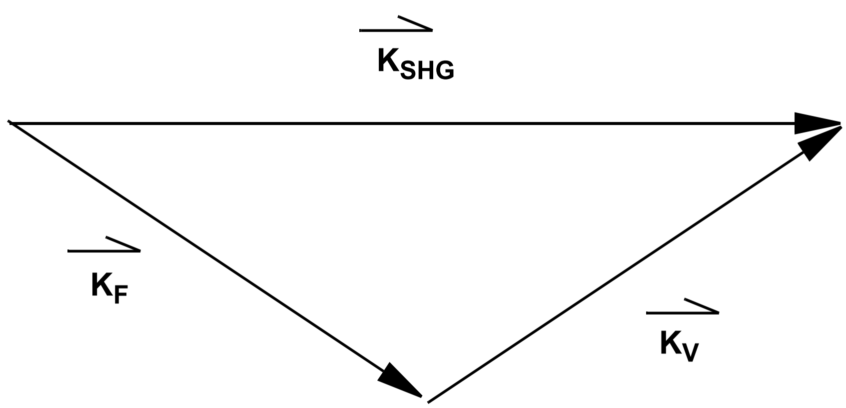


Figure 12-8. Non-collinear Phase Matching

12.15.4 Calibration and Real-time Display

The below expression for *A*(*t*) is a reasonable approximation for the changes that occur in the variable delay path as a function of time.

$$A(t) = t_0 + mt$$

Deviations from the straight line approximation behavior can be evaluated by calibrating the autocorrelator at several different positions within its total scan range. For measurement of Chameleon pulses, such deviations are generally not significant.

Equation [12-5]. Response of the PMT Expressed as a Function of the Pulse Time Delay

$$S(t'') = \int E(t')E(t' - t_o + t'')dt'$$

The substitution $t'' = mt$, relating pulse delay time t'' to real time t, has been made. This is the exact expression for the pulse autocorrelation function (except for the constant offset t_O). The variable t'' is the pulse time delay introduced by the spinning mirrors. It is related to real time by the constant factor m that is the calibration factor for the autocorrelator.

When making an autocorrelation measurement on a high repetition rate laser such as the Chameleon Ultra, Vision, or Vision-S, pulses are continually incident on the autocorrelator. The photomultiplier signal represents the instantaneous value of $S(t'')$, that varies over time as the mirrors spin. On most autocorrelators, the photomultiplier output is then sent to an oscilloscope (some autocorrelators have a built-in display) to provide a real-time display of the autocorrelation function. The calibration factor m must be applied to the real-time display to convert real time t to pulse delay time t''.

A typical calibration factor might be 30 ps/ms, indicating that a 30 ps pulse autocorrelation width would produce an oscilloscope trace with a FWHM of 1 ms. A Chameleon pulse with an autocorrelation width of 300 fs would therefore produce an oscilloscope trace with a FWHM of 10 µs.

The autocorrelator provides a trigger signal to initiate the oscilloscope sweep. This signal is synchronized to the spinning mirrors, such that successive sweeps of the mirrors will superimpose on the oscilloscope display. Adjustment of the trigger signal in time is accomplished with an external control on the autocorrelator; this adjustment effectively changes the value of t_O in Equation [12-5].

12.15.5 Time Resolution

The time resolution of the autocorrelator is related to the time constant of the photomultiplier. An estimated time resolution can be obtained by multiplying this time constant by the calibration factor. The autocorrelator has a time constant of approximately 1 µs, corresponding to a 30 fs time resolution. This is adequate to display the Chameleon pulse with high accuracy.

12.15.6 Interpretation of Autocorrelation Traces

An autocorrelation trace is an indirect measure of a pulse shape and in principle cannot reveal the exact shape of $E(t)$. For example, $S(t'')$ in Equation [12-5] is always symmetrical about the position t''-t_O;

autocorrelation functions are always symmetrical around their peak. Information about asymmetries in $E(t)$ is therefore unavailable from a measurement of $S(t'')$.

As a tool for measuring pulse widths, autocorrelation techniques are limited by the fact that there is no general relationship between the width of $S(t'')$ and the width of $E(t)$. The ratio of FWHMs between $S(t'')$ and $E(t)$ can be calculated for model pulse shapes, but it is difficult to estimate the validity of the model for a given practical situation. Table 12-1 lists some common model pulse shapes and the corresponding FWHM ratio.

Autocorrelation traces for Chameleon Ultra, Vision, or Vision-S pulses suggest by their functional form that they are best described by a sech^2 pulse shape. Table 12-1 indicates that a factor of 0.648 should be applied to convert observed autocorrelation widths to actual pulse widths. While such a conversion may provide a useful insight into the detailed properties of the pulse, it should be done with an awareness of the assumptions and possible errors involved.

Table 12-1. Time-Bandwidth Products For Typical Model Pulse Shapes

Function	I (t)	τ_p/τ_{ac}	$\Delta\nu\,\tau_{ac}$	$\Delta\nu\,\tau_p$
Square	$I(t) = \left\{\frac{1; \lvert t \rvert \le \tau_p/2}{0; \lvert t \rvert > \tau_p/2}\right\}$	1	1	1
Gaussian	$I(t) = \exp - \left[\frac{4(\ln 2)t^2}{\tau_p/2}\right]$	0.707	0.624	0.441
Hyperbolic secant	$I(t) = \text{sech}^2\left(\frac{1.76t}{\tau_p}\right)$	0.648	0.486	0.315
Lorenzian	$I(t) = \frac{1}{1 + \left(\frac{4t^2}{\tau_p^2}\right)}$	0.500	0.441	0.2206
Symmetric 2-sided exponential	$I(t) = \exp - 2\left\lvert\frac{t(\ln 2)}{\tau_p}\right\rvert$	0.413	0.344	0.142

$\tau_p \equiv$ FWHM of intensity envelope function in seconds.
$\tau_{ac} \equiv$ FWHM of autocorrelation function of corresponding intensity envelope.
$\Delta\nu \equiv$ FWHM of power spectrum in units of Hertz.

12.16 Time-Bandwidth Product

Multiplying together the spectral bandwidth and the real temporal width produces the time-bandwidth product that has a theoretical minimum value known as the transform limit. This chapter defines this terminology.

The time-dependent electric field $E(t)$ associated with any laser pulse at a fixed point in space can be written in general form as in Equation [12-6].

Equation [12-6]. Time-Dependent Electric Field

$$E(t) = A(t)\exp(-i\omega_0 t)$$

In this expression, $A(t)$ is the envelope function and ω_0 is the carrier frequency. Both $A(t)$ and $E(t)$ are complex functions. The frequency spectrum associated with the pulse $E(t)$ is given by the Fourier transform of $E(t)$, that is designated $E'(\omega)$.

Equation [12-7]. Fourier Transform of *E*(*t*)

$$E(\omega) = \left(\frac{1}{2\pi}\right)\int E(t)e^{-i\omega t}dt$$

Equation [12-8]. Fourier Transform of *E'*(*t*)

$$E'(\omega) = A'(\omega - \omega_0)$$

While the functions $A(t)$ and $A'(\omega)$ are complex, only the square of the field; i.e., $|E(t)|^2$ or $|E(\omega)|^2$, is generally observable due to the fact that photodetectors respond to intensity (power) and not to E-field. Thus information about the imaginary parts of $E(t)$ and $E'(\omega)$ that relate to phase variation within the pulse is not directly observable. However, this information can be inferred by comparing the pulse envelope intensity $|A(t)|^2$ with the power spectrum $|A(\omega)|^2$. A simple approach to this can be taken in cases where the envelope functions $A(t)$ and $A'(\omega)$ are smoothly varying. One can then define the intensity temporal width and the pulse bandwidth of the power spectrum as:

Equation [12-9]. Pulse Width (Seconds)

$$\tau_p = \mathrm{FWHM}(|A(t)|)^2$$

Equation [12-10]. Bandwidth (Hz)

$$\Delta\nu = 2\pi\mathrm{FWHM}(|A'(\omega)|)^2$$

FWHM denotes the full width at half maximum.

The observable quantities τ_p and $\Delta\nu$ determine the time-bandwidth product (*T*).

Equation [12-11]. Time-Bandwidth Product

$$\tau_p \times \Delta\nu = T$$

The time-bandwidth product is an easily measured characteristic of ultrafast pulses. It provides a useful estimate of pulse quality, since it achieves its minimum value when $A(t)$ is purely real and the pulse is fully phase coherent. For ultrafast pulses, however, interpretation of time-bandwidth product data suffers from the limitation that the pulse envelope function $|A(t)|^2$ can only be measured indirectly by means of autocorrelation techniques. It is possible to examine several model functions for $A(t)$ and to calculate the minimum time-bandwidth product for each model using Equation [12-6] through Equation [12-10]. This information is presented in Table 12-1.

12.17 Power Supply

The power supply houses several circuit boards, an internal commercial power supply, two laser diode assemblies and cooling fans. The power supply provides the following functions for the pump laser:

- Provides a light source (pump) for the gain medium in the Verdi head cavity via a fiber optic in the umbilical; light is generated by the laser diode assembly
- Provides a user interface; the user interface consists of the front and rear panel controls and indicators
- Controls and monitors the servo loops in the laser; the controls and servo loops are:
    - TEC loops for Vanadate, Etalon, Ti:Sapphire and diodes
    - LBO heater (monitor and control)
    - Light loop
    - Diode heat sinks (monitor and control)
    - Baseplate temperature (monitor only)
- Provides a source of DC voltage for all system functions; the internal power supply provides +48 VDC, which is distributed to the laser

12.17.1 Laser Diode Assembly

The hermetically sealed laser diode assembly contains a fiber array package-integrated (FAP-I), a circuit board with an EEPROM and a heat sink sensor.

WARNING!
Direct or reflected radiation from a laser diode assembly (FAP-I) is capable of causing severe eye damage. Do not look into the output port of the FAP-I, or the end of the fiber optical cable when connected to the diode assembly, when the FAP-I is installed in the system.

The FAP-I consists of a laser diode bar with collection and symmetrizing optics mounted within an environmentally sealed package. The FAP-I efficiently converts a low-voltage, high-current electrical power into a circularly-symmetric, multi-mode laser beam. The FAP-I is designed to operate under CW operating conditions at high, multi-watt output powers for thousands of hours. Waste heat from the laser diode bar is transferred through the FAP-I base to a heat sink.

The FAP-I contains a laser diode bar that efficiently converts electrical energy into optical laser energy. The laser diode bar consists of a multiplicity of independent emitters spaced linearly along a single semiconductor substrate. The output of each of these emitters is captured by a collecting optical fiber. This linear array of fibers is then bundled into a circularly symmetric output.

At low drive currents, the laser diode bar will have insufficient gain to lase. In this operating regime, some light, originating from spontaneous emission, will be visible. As the drive current is increased, the laser diode bar will reach threshold, where it will have sufficient gain to lase. This drive current is the threshold current. Further increases in current will cause a linear increase in output optical power up to the specified operating power.

In general, semiconductor devices perform better at lower operating temperatures. The optical-to-electrical conversion efficiency is higher and the device lifetime is longer. It is desirable to operate the FAP-I at low temperatures consistent with observing the specified operating temperature limits to improve device performance and lifetime.

However, the precise semiconductor operating wavelength is a function of operating temperature. Control of the temperature is extremely important to bring the wavelengths of the diodes within the absorption window of Vanadate.

12.17.2 Diode/Heat Sink Temperature

The laser diode assembly that houses the FAP-I is mounted on a finned heat sink located in the power supply. The temperature of the diode bars located within the FAP-I is controlled by a TEC. Waste heat from the diode bars is transferred to the passive heat sink.

The heat sink is cooled by fans that exhaust waste heat from the laser diode assembly to the outside of the power supply. Incoming ambient air is filtered by an air filter, which can be cleaned periodically, depending on the operating environment.

The laser diodes have an operating temperature range of 5.0°C to 35.0°C.

I ACCESSORIES

I.1 Power Meters and Sensors

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

For the most common diagnostics – measuring the output power of the Chameleon Familiy– Coherent recommends the a PM10-19C USB sensor (Figure I-1).

I.1.1 Coherent's Recommendation

The PM10-19C USB sensor is ideal for tight spaces and provides plug and play laser power measurement directly on a PC without the need for additional electronic instrumentation.

Features Include:

- Direct USB 2.0 connection to PC
- Water-cooled
- Spectrally flat from 0.19 μm to 11 μm
- Noise equivalent 0.2 mW to 1 mW
- 19 mm aperture

The PowerMax PC applications software is supplied free with the sensor.

Features Include:

- Trending, tuning, and histogram
- Statistics (mean, minimum, maximum, and standard deviation) and log batch to file
- Operate multiple devices simultaneously and perform synchronized ratiometery (A/B analysis) with trend and log results to file

Figure I-1. PM10-19C USB PN 1168344

II WARRANTY

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

Laser systems are warranted to conform to Coherent's published specifications and to be free from defects in materials and workmanship for a period of 13 months from ship date or 5000 hours of operation, whichever occurs first.

II.1 Responsibilities of the Buyer

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

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

II.2 Limitations of Warranty

The foregoing warranty shall not apply to defects resulting from:

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

- Opening the pump laser head housing, or
- Opening the sealed UF cavity housing.

Coherent assumes no liability for customer-supplied material. The obligations of Coherent are limited to repairing or replacing, without charge, equipment that proves to be defective during the warranty period. Replacement sub-assemblies may contain reconditioned parts. Repaired or replaced parts are warranted for the duration of the original warranty period only. The warranty on parts purchased after expiration of system warranty is ninety (90) days. Our warranty does not cover damage due to misuse, negligence or accidents, or damage due to installations, repairs or adjustments not specifically authorized by Coherent.

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

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

GLOSSARY

°C	Degrees Celsius
°F	Degrees Fahrenheit
µ	Microns
µs	Microsecond(s)
$1/e^2$	Beam diameter parameter
AC	Alternating current
Amp	Amperes
CDRH	Center for Devices and Radiological Health (U.S. Government)
CE	Conformité Européenne, English translation: European Conformity
CFR	Code of Federal Regulation
cm	Centimeter(s)
DC	Direct current
EC	European community
EEPROM	Electrically erasable programmable read only memory
EMC	Electromagnetic compliance
FAP-I™	Fiber array package-integrated
FD	Fine dust
Fu	Fume
FuD	Fume and dust
I	Inhalable
IARC	International Agency for Research on Cancer
IC	Insoluble compounds
I/O	Input/output
kg	Kilogram(s)
LBO	Lithium Triborate, LiB_3O_5
LD	Laser diode
LED	Light emitting diode
LVD	Low voltage directive
m	Meter(s)
MAC	Maximal Arbeidsplaats Concentratie
MAK	Maximal Arbeitsplatz-Konzentration
mAmp	Milliampere(s)
MHz	Megahertz
mm	Millimeter(s)
mrad	Milliradian(s)
MSDS	Material Safety Data Sheet
msec	Millisecond(s)
mV	Millivolt(s)
mW	Milliwatt(s)

N.A.	Not applicable
N.E.	None established
N.D.	None determined
NDM	Negative dispesive mirror
Nd:YVO	Neodymium:Gadolinium Orthovanadate
nm	Nanometer(s)
OEL/MEL	Occupational exposure standard/maximum exposure limit
OEM	Original equipment manufacturer
rms	Root mean square
TD	Total dust
TEC	Thermo-electric cooler
TEM	Transverse electromagnetic (cross-sectional laser beam mode)
TWA	Time-weighted average
R	Respirable
SC	Soluble compounds
STEL	Short-term exposure limit
VAC	Volts, alternating current
VDC	Volts, direct current
VME	des Valeurs limits de Moyenne d'Exposition
VPUF	Verdi-Pumped UltraFast
W	Watt(s)

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Chameleon™ Ultra, Vision, and Vision-S Laser Systems Operator’s Manual

Part No. 1313538 Rev. AB

COHERENT®

Superior Reliability & Performance

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Chameleon™ Ultra, Vision, and Vision-S Laser Systems Operator’s Manual

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