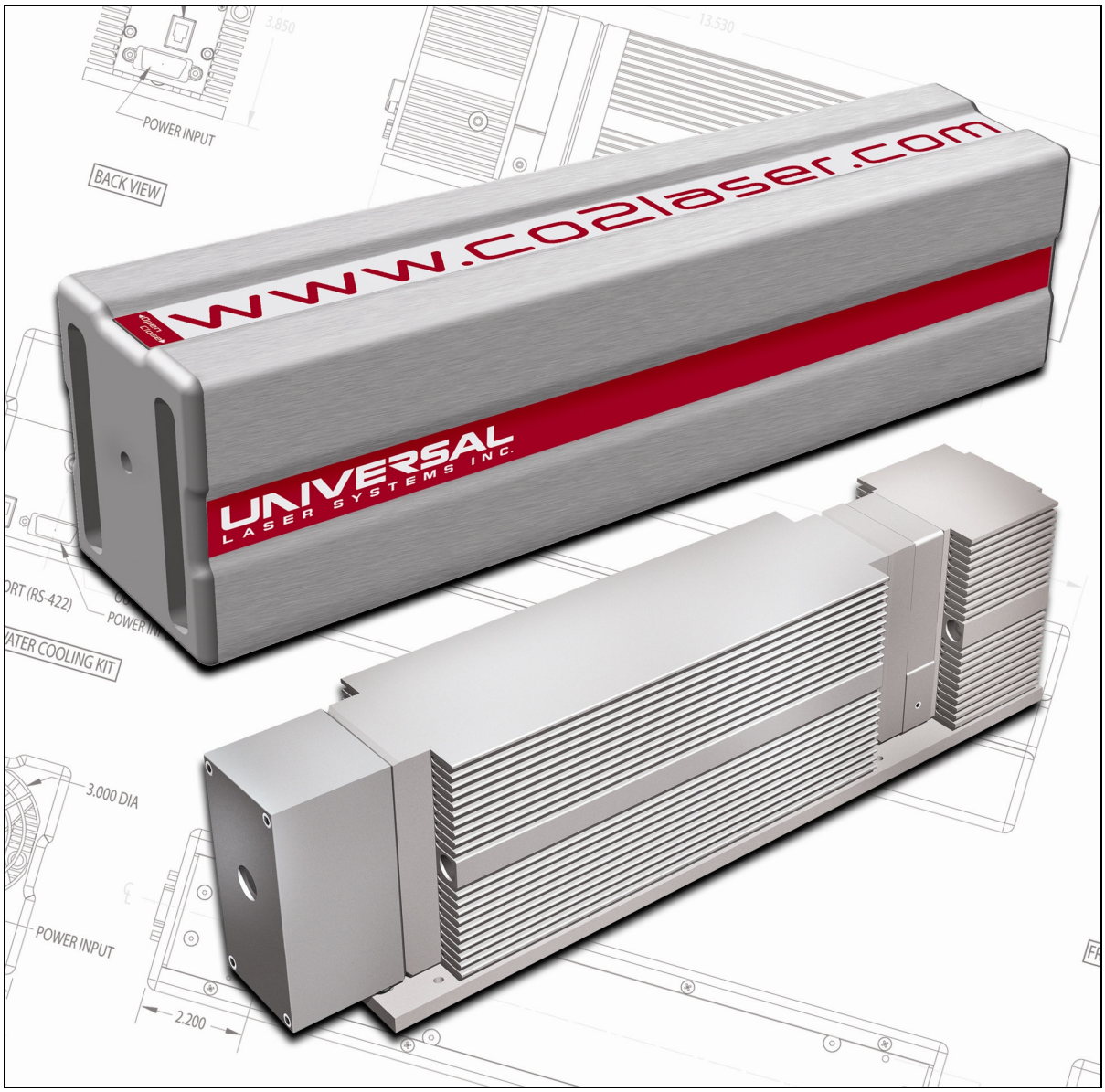

UL-10 OEM Integration Manual

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The product described herein is covered under one or more of U.S. Patents: 5,661,746; 5,754,575; 5,867,517; 5,881,087; 5,894,493; 5,901,167; 5,982,803; 6,181,719.

Contents

1.0 Introduction

Thank you for choosing a Universal Laser Systems CO_2 laser for your application. ULS is committed to providing the marketplace with low cost CO_2 lasers, which take advantage of our patented technology to provide compact size, ease of integration and high performance. This integration manual will guide you through the process of installing a ULS laser into your equipment and provide you with the information you need to operate the laser. Please read this entire manual and familiarize yourself with its contents. If you need help, please feel free to call Universal Laser Systems and we will be happy to provide you with assistance.

2.0 Specifications

Specifications for the UL-10 OEM lasers are summarized below.

Parameter*	Model		
	UL-10 (basic)	UL-10 (air-cooled)	UL-10 (water-cooled)
Rated Power**	10 W		
Wavelength	10.6 μ		
Power Stability	± 10% after 15 minutes of CW operation		
M^2	1.4 ± 0.2		
Beam Size (Near Field)	4 ±1 mm		
Beam Divergence (Full Angle)	5 ± 1 mR		
Beam Ellipticity (Near Field)	1.4:1		
Polarization	Linear (Perpendicular to the laser base plate)		
Pointing Stability	200 μR		
Optical Pulse Rise or Fall Time	120 ± 40 μS		
Optical Modulation	100% up to 5 KHz		
Modulation Signal Type	TTL Compatible		
Cooling	**Air (integrator must provide fans and shroud)**	**Air Cooling (built-in fan and shroud)**	**Water Cooling**
Weight	7.25 Lb. [3.3 kg]	8.6 Lb. [3.9 kg]	8.6 Lb. [3.9 kg]
Environmental			
Ambient Temperature***	50-95°F [10-35°C]		
Relative Humidity	< 90% (non-condensing)		
Power Requirements			
DC Input Voltage	48.0 VDC		
RMS Current (CW, including fan)	4 A		
Inrush Current	70 A, 150 μS		

* The above specifications are subject to change without notice.

** Output power is guaranteed to exceed this level for a period of 15 months from the date of purchase, regardless of use.

*** At temperatures below 50°F [10°C] operation may be intermittent and there is a potential for damage to the power supply and optics.

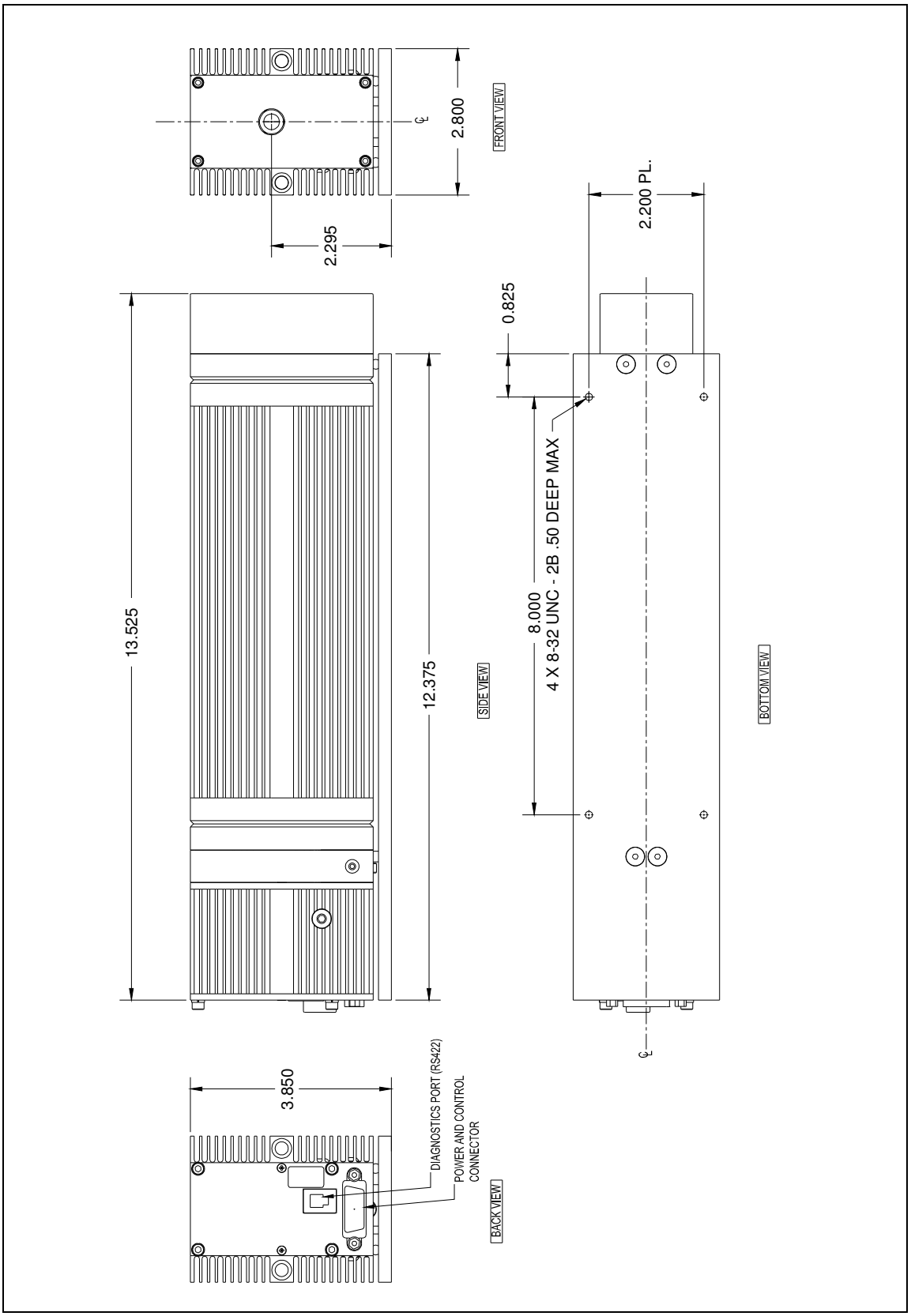


Figure 1 – Dimensional Specifications for Basic OEM Configuration

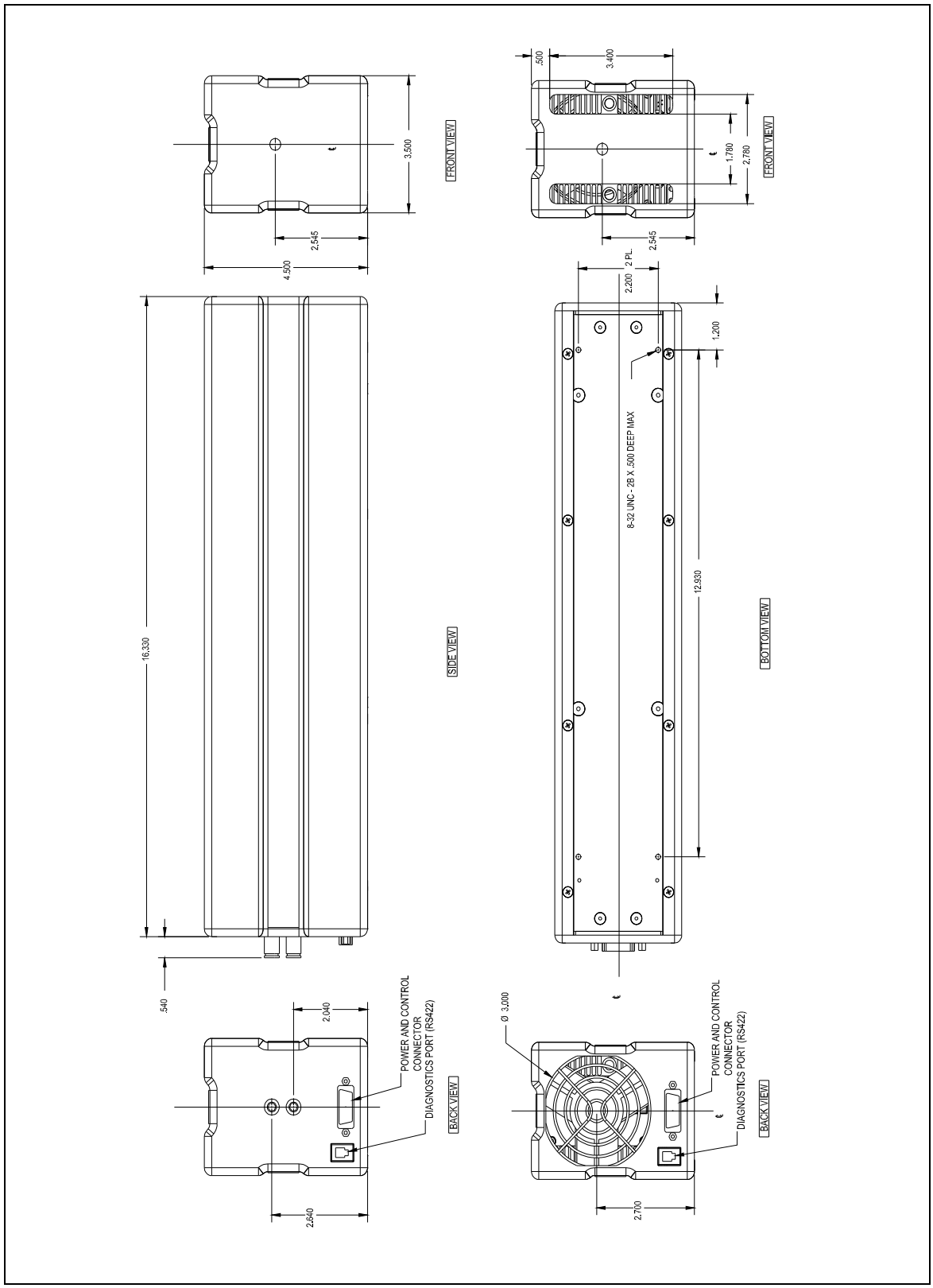


Figure 2 – Dimensional Specifications for Water and Air-Cooled OEM Configurations

3.0 Safety Issues

3.1 Laser Safety

ULS OEM lasers are sold as components and therefore are not required to conform to U.S. or European safety regulations. It is the responsibility of the buyer to design and certify any equipment incorporating a ULS OEM laser to meet all local safety regulations prior to sale to the public. The texts of these regulations are available from the respective governing bodies of the countries the equipment is to be sold into.

Any personnel working with or around open lasers must be aware of the following:

- **Exposure to the laser beam may cause physical burns and can cause severe eye damage.** Proper eye protection should be used at all times. All eye protection should be appropriate for the radiation wavelength generated by the laser in use.

- **Exposure to the laser beam may cause ignition of volatile or combustible materials.** Do not use lasers in the presence of these types of materials.

- **Never look directly into the laser output port.**

- **Interlock all rooms in which open beams may be present and post appropriate warnings on or near the doors.** Access to these rooms should be limited to properly trained technicians when lasers are in use.

- **Use appropriate protective coverings over all beam paths whenever possible.**

- **Lasers and optical elements should be positioned to keep the beam and reflections below eye level.**

Notice: For more information on EMI standards, refer to local EMI safety regulations.

3.2 Electrical Safety

ULS lasers operate at 48 VDC, which is below the voltage limit that is considered dangerous by most safety standards. However, the lasers draw large amounts of current and the power supplies needed to provide the 48 VDC usually require 90-240 VAC to operate. For these reasons, proper safety precautions should be taken with every portion of the electrical system.

Notice: For more information on EMI standards, refer to local EMI safety regulations.

3.3 Electromagnetic Interference

ULS OEM lasers are sold as components and therefore are not required to conform to all U.S. or European safety regulations regarding EMI. It is the responsibility of the customer to design and certify any equipment incorporating a ULS OEM laser to meet all local safety

regulations prior to sale to the public. However, testing by ULS has demonstrated that with a properly selected power supply and line filtering, all ULS OEM lasers will pass the relevant U.S. and European EMI standards for Class A equipment. See Section 5.3 for more information.

Notice: For more information on EMI standards, refer to local EMI safety regulations.

3.4 Contacts for Safety Information

Below is a list of useful contacts for information on safety regulations in the U.S. Canada, and Europe:

United States

Food and Drug Administration - Center for Devices and Radiological Health (CDRH), 1-800-638-2041.

Federal Communications Commission (FCC), (301)362-3000.

Underwriters Laboratories Inc. (UL), Illinois (708)272-8800, New York (516)271-6200, California (408)985-2400.

Laser Safety Institute of America, (407)380-1553.

Occupational Safety and Health Administration (OSHA), (202)693-2300.

Canada

Canadian Standards Association (CSA), (416) 747-4000.

Europe

European Committee for Electrotechnical Standardization (Cenelec), rue de Stassart 35, B-1050 Brussels

International Organization for Standardization (ISO), 1 rue de Varembé, Case postale 56, CH-1211 Genève 20 Switzerland

4.0 A Brief Description of the Laser

This ULS OEM CO_2 gas laser uses a sealed-off, RF-excited, slab design and a multi-pass, free space resonator[1]. Each laser consists of a plasma tube, with mirrors at each end forming an optical resonator, and an RF power supply assembled together in a chassis with convenient mounting provisions. Various cooling arrangements using water or air are available.

The plasma tube consists of two opposing electrodes in a slab configuration, meaning the cross-section of the gap between the electrodes is rectangular instead of square. This allows for a multi-pass resonator in which the laser beam makes several passes within the plasma using the full width of the rectangular electrode gap. The advantage of this is a powerful laser beam from a relatively short tube.

The length of the gap between the electrodes is designed to allow free space operation of the laser. This means that the gap is wide enough to allow the laser beam to form without any substantial waveguide effects caused by reflection of light from the surfaces of the electrodes. This provides for a very good quality beam in the near field as well as far field.

The optical resonator is formed by a system of three mirrors, one in the back and two in the front, with one front mirror being partially reflective to allow the beam to exit the tube. These mirrors are tuned to specific angles to generate multiple passes of the laser beam within the plasma formed between the electrodes.

One of the electrodes is attached to the RF power supply through a matching network that allows the impedance of the tube to be tuned to match the impedance of the supply. The RF power supply operates at approximately 40 MHz. Power control of the laser beam is provided through pulse width modulation of the RF by an external TTL signal provided by the user.

1 As described in U.S. Patent 5,661,746

5.0 UL OEM Laser Installation and Operation

5.1 Mounting Method

Each version of the UL-10 OEM laser contains 4 threaded holes in its base plate for mounting the laser. The dimensions for these hole patterns is given below. It is recommended that the screws not extend more than 0.50" [12.7 mm] into the laser. The laser can be mounted in any orientation including vertical. Dimensions for the mounting-hole pattern are given below. The laser should be mounted using a three-point arrangement to avoid warping or bowing the assembly. If the laser is mounted on a flat surface it should be flat to within 0.025 inches [0.65 mm].

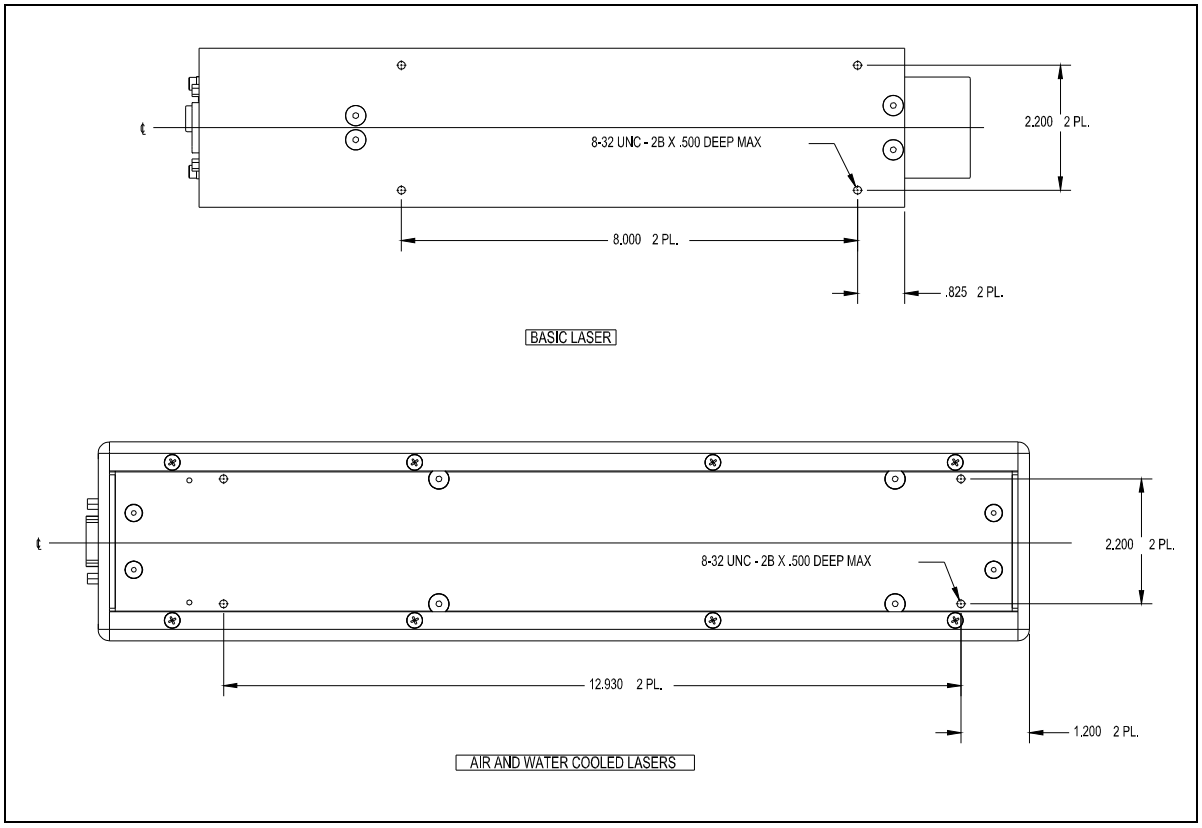
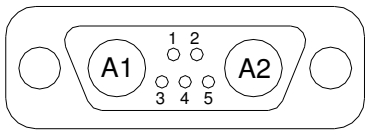


Figure 3 - Detail of Mounting Hole Dimensions

5.2 Electrical Connections

All electrical connections for the laser are made through one twelve-pin connector located on the back of the laser. The mating connector will accommodate a combination of 18 AWG [1.1 mm^2] wire for power and 22 AWG [0.30 mm^2] wire for signals. Figure 4 below details the electrical characteristics of each of the pins in the connector. Figure 5 details the circuits inside the laser attached to the pins.



WIRE HARNESS MATING HARDWARE
MATING CONNECTOR: POSITRONICS "CBD7W2F20000"
POWER PINS: "FS4016D"
SHELL: ANY 9 PIN D-SUB SHELL

VIEW OF CONNECTOR ON LASER

Figure 4 – Laser Connector Pin Diagram

Pin Number	Input Name	Laser Input/Output	Wire Size	Description
A1	+48V	Power input	18 AWG [2.0 mm^2]	+48 volt power; do not swap polarity.
A2	Power Ground	Power input	18 AWG [2.0 mm^2]	Power ground.
1	Interlock -	Interlock return	22 AWG [0.30 mm^2]	See description for Pin 2.
2	Interlock +	12 volt source (only use for interlock)	22 AWG [0.30 mm^2]	Connect safety switches between pins 1 and 2 to enable laser. Do not use this pin as a power source for other purposes.
3	Modulation +	Optically isolated input	22 AWG [0.30 mm^2]	Laser modulation signal is connected between pins 3 and 4.
4	Modulation -	Optoisolator return signal	22 AWG [0.30 mm^2]	Optically isolated return signal for “modulation +” (pin 3).
5	Laser Diode	Optically isolated input	22 AWG [0.30 mm^2]	+5 V signal on pin 5 will turn on the red laser pointer (when available).

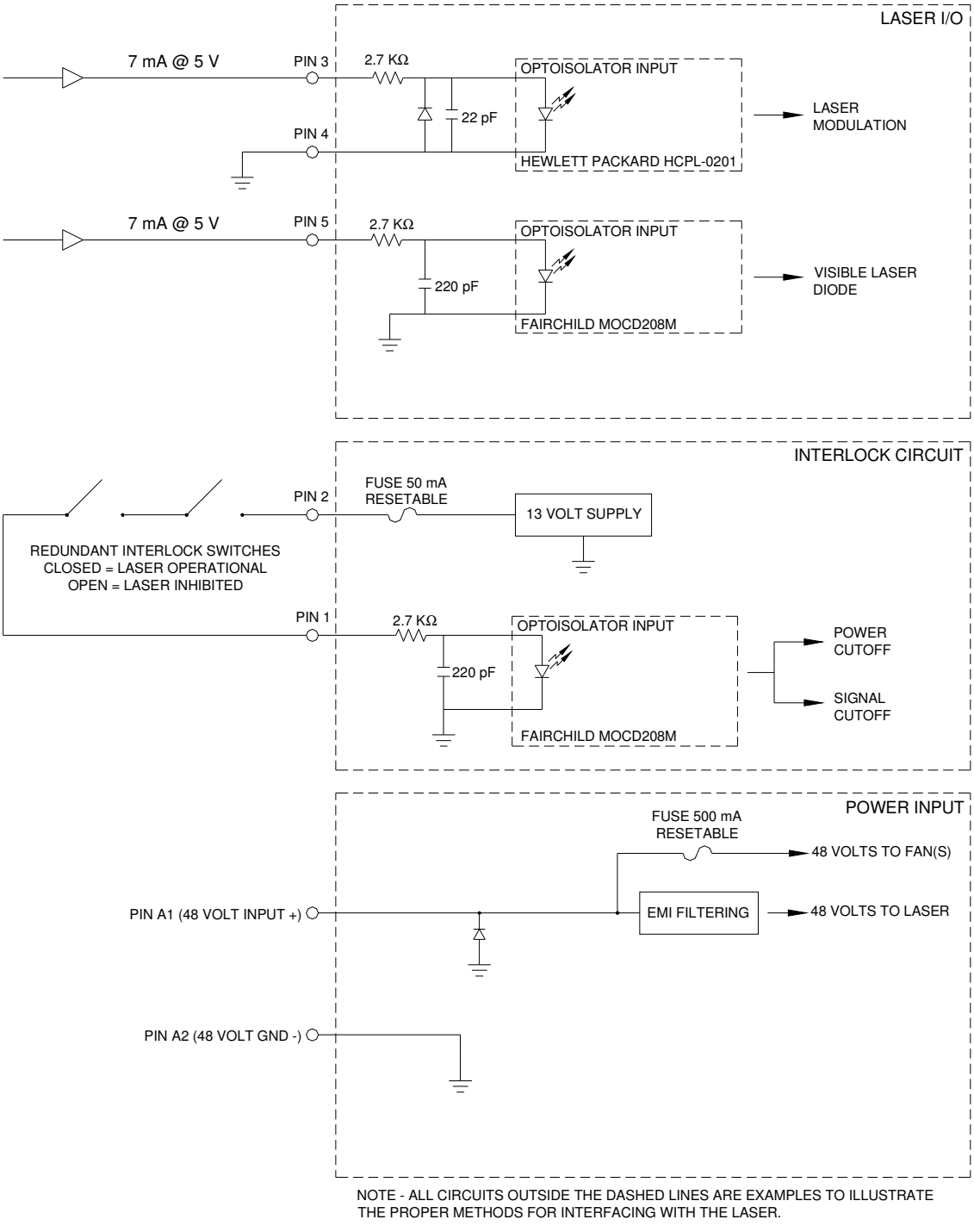


Figure 5 – Laser Interconnect Schematic

5.3 Power Requirements

A good quality 48 volt DC power supply should be used to power the laser. Nominal output should not exceed 48 volts and regulation should be within 0.5% under 100% load. The power supply should have good transient response characteristics to handle the fluctuating current requirements caused by modulation of the laser. The power and signal connector provides 48 volts and ground connections to the power supply. A single 18 AWG [1.1 mm^2] wire each is sufficient for 48 volts and ground. Careful attention should be paid to power entry filtering when designing to meet Class A conducted EMI regulations. In order to meet Class A emitted EMI regulations, it is important that the 48 volt power wires be no more than 3 feet (1 meter) in length and that the 48 volt power supply and laser chassis be attached to a common earth ground through very low induction connections. Finally, it is advisable to use shielded wiring for all I/O connections to the laser.

5.4 Interlock Circuit

An interlock circuit is incorporated into the laser, which can be combined with external switches to satisfy safety requirements when designing Class 1 laser equipment. At least two redundant switches must be used for each panel providing access to a Class 1 enclosure. Please refer to the appropriate safety regulations for more information on Class 1 laser equipment design.

The interlock circuit is self-sourced using a 12 volt output supplied by the laser on pin 2. The interlock is shunted by connecting pin 1 to pin 2 allowing the laser to operate. Any break in this connection will cause the laser to stop operating. Switches can be placed in series with these pins to create a safety interlock circuit.

5.5 Laser Modulation

A TTL compatible signal must be provided to pin 3 of the power and signal connector to drive the laser. Output power can be controlled from 0 to 100% (CW Mode) by pulse width modulation of the input signal. The electrical requirements for the modulation signal are as follows:

Nominal Voltage	5 Volt (7 volts max)
Current	7 mA Min
Logic high	2.70 Volts Min
Logic Low	1.725 volts Max

As with all CO_2 lasers, delays are inherent in the response of the laser beam output to the input signal. A typical laser will have response characteristics similar to those detailed in the oscilloscope traces in figures 6 and 7 below. These figures show a TTL signal and corresponding laser power output.

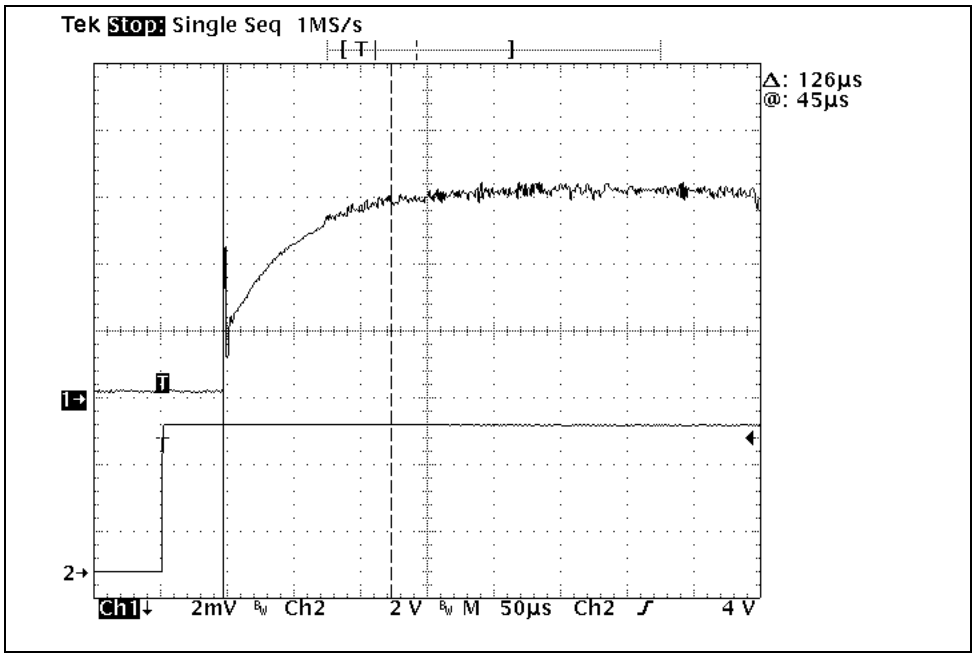


Figure 6 – Oscilloscope trace of typical rise time for a laser

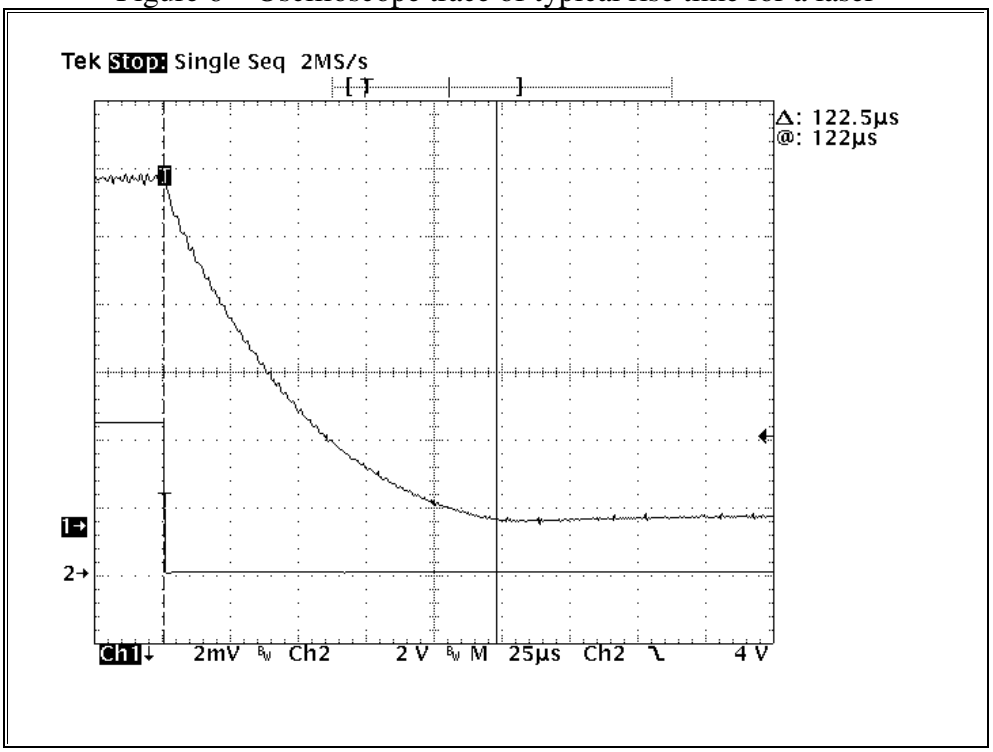


Figure 7 – Oscilloscope trace of typical fall time for a laser

5.6 Laser Tickle

It is a common practice with CO_2 lasers to provide some means of stimulating the mixture when the laser is off in order to improve its response. ULS lasers have a built-in, low duty cycle, secondary modulation signal called a tickle signal to accomplish this effect. This

signal is pre-tuned at the factory for optimal performance of the laser and normally does not require adjustment.

5.7 Air Cooling

Careful attention should be paid to proper airflow through the laser (see figures 8 and 9) when integrating it into equipment. The UL-10 OEM laser is available in two air-cooled versions: The basic version in which the fans and air flow shroud are not supplied and the air-cooled version in which the fan and shroud are included. With either version, any restriction of airflow will result in reduced power output and can cause permanent power loss or failure over extended periods of time. Ambient air should be directed to the laser's air flow intake, and exhaust air from the laser should be directed out of equipment with as little restriction as possible. If the laser is placed in an enclosure, it may be necessary to provide additional fans to draw exhaust air out of the enclosure to reduce a rise in temperature inside the enclosure, which can affect laser output power. The exhaust air should be no more than about 10°C above ambient.

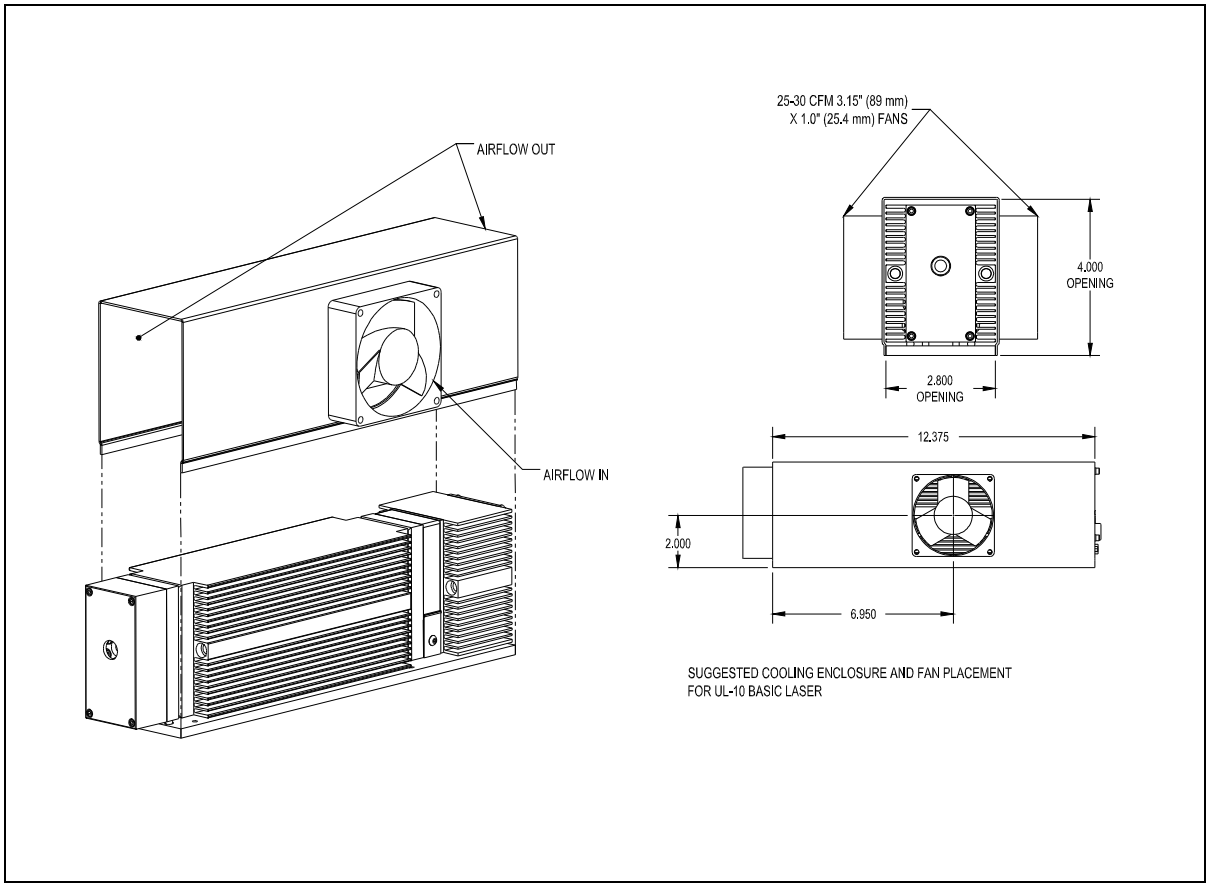


Figure 8 – Detail of Air Flow Through the Basic Laser

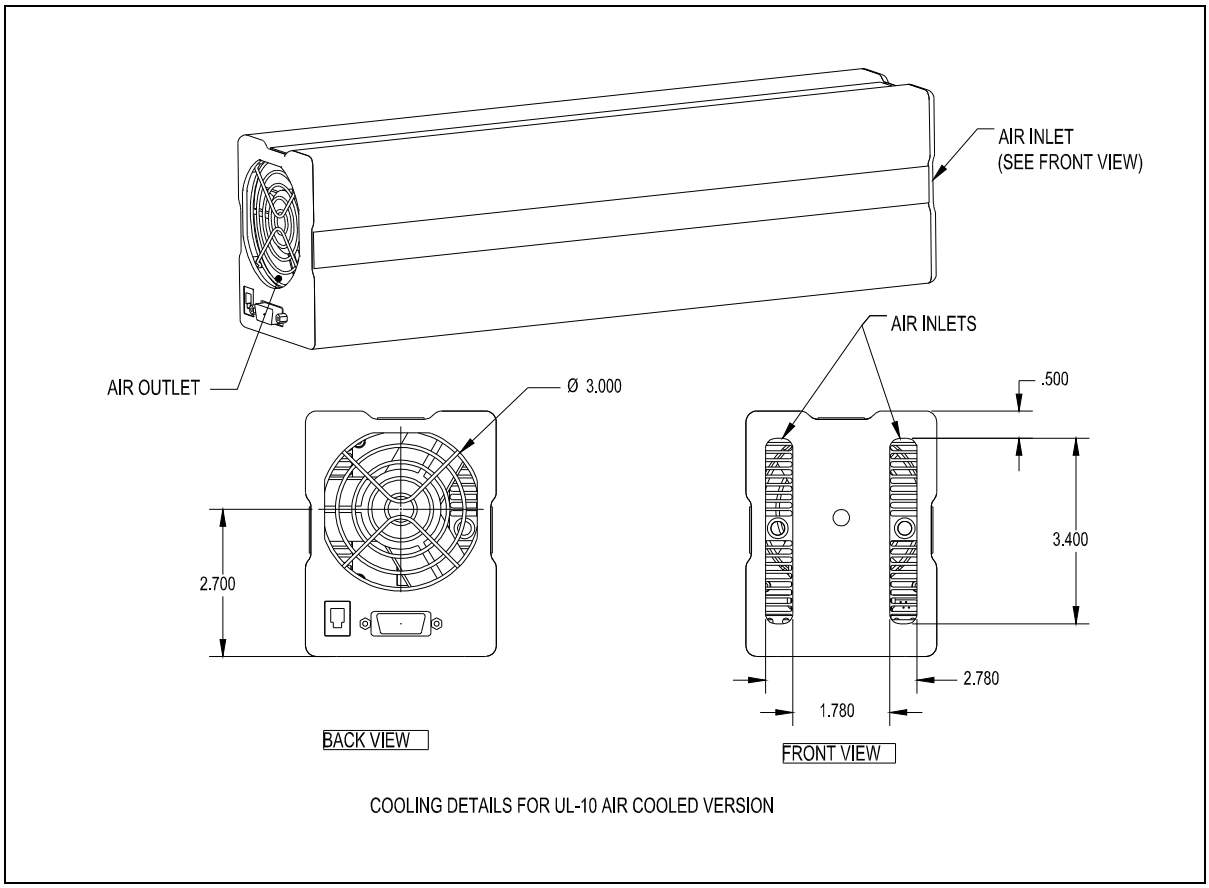


Figure 9 – Detail of Air Flow Through the Air Cooled Laser

Finally, ambient air should be filtered before entering the laser to prevent a buildup of dust and debris on the cooling fins which can reduce cooling efficiency, however, care should be taken when selecting a filter media to ensure that the filter does not restrict air flow. For relatively clean environments, a low restriction filter media (45 pores per inch, for example) might be adequate, but for dirtier environments a heavier filter media might be required and also a booster fan can be employed on the exhaust end to help pull air through the laser.

5.8 Ambient Temperature

Air-cooled lasers by nature are sensitive to ambient temperatures. Hotter ambient temperatures will reduce power output and cooler ambient temperatures will increase power output. An ambient temperature range of 50-95°F [10-35°C] should be observed to guarantee proper laser operation. At temperatures below 50°F [10°C] operation may be intermittent and there is a potential for damage to the power supply and optics. At temperatures above 95°F [35°C] ULS lasers are not guaranteed to provide the rated power output. Lasers can safely be operated at ambient temperatures above 95 °F [35°C], however, power output will diminish as ambient temperature rises and longevity can be significantly reduced.

5.9 Water Cooling

The UL-10 OEM laser is available in a water-cooled version. This version has ¼” quick fit fittings for ¼” OD tubing detailed in Figure 10. Press the tubing in to secure it and press the

release ring on the quick fitting while gently pulling the tubing to remove it. The laser should be supplied with chilled water set just below room temperature 65-68ºF (18 or 20ºC) to avoid condensation. The chiller should be able to remove about 200 watts of heat from the water and have a flow rate of about 1 to 2 GPM (3.8 to 7.6 LPM) at 0 PSI and pressure capability to 60 PSI (415 KPa).

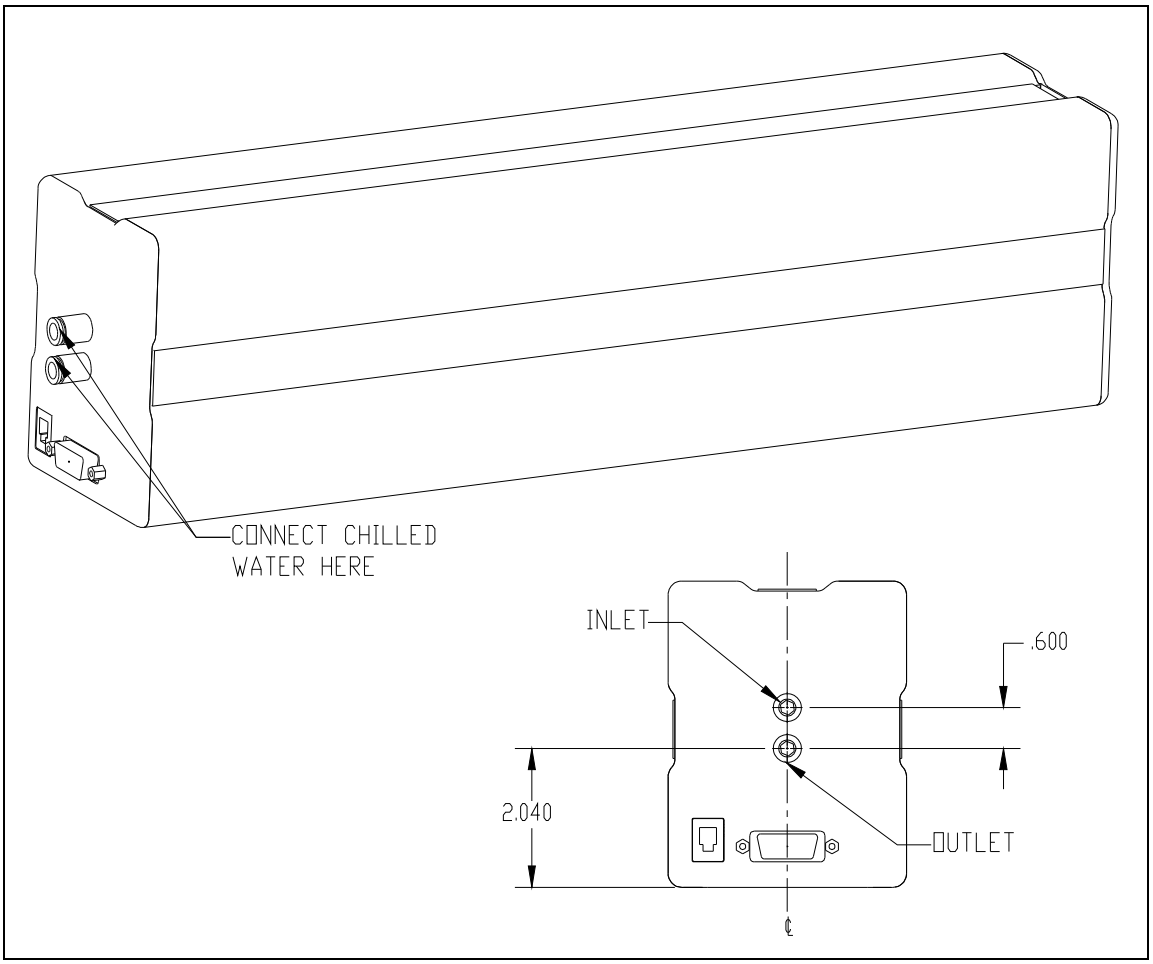


Figure 10 – Detail of Water Cooled Laser

5.10 Laser Beam Output

The beam exits the laser as detailed in Figure 11. When integrating a laser with external optics or a beam delivery system, care should be taken to seal the beam path in order to prevent contamination of the laser's optics. Laser optics are exposed to the environment through the beam exit aperture on the laser. Failure to protect laser optics from dust, fumes and debris will cause premature failure of the laser and can void the warranty.

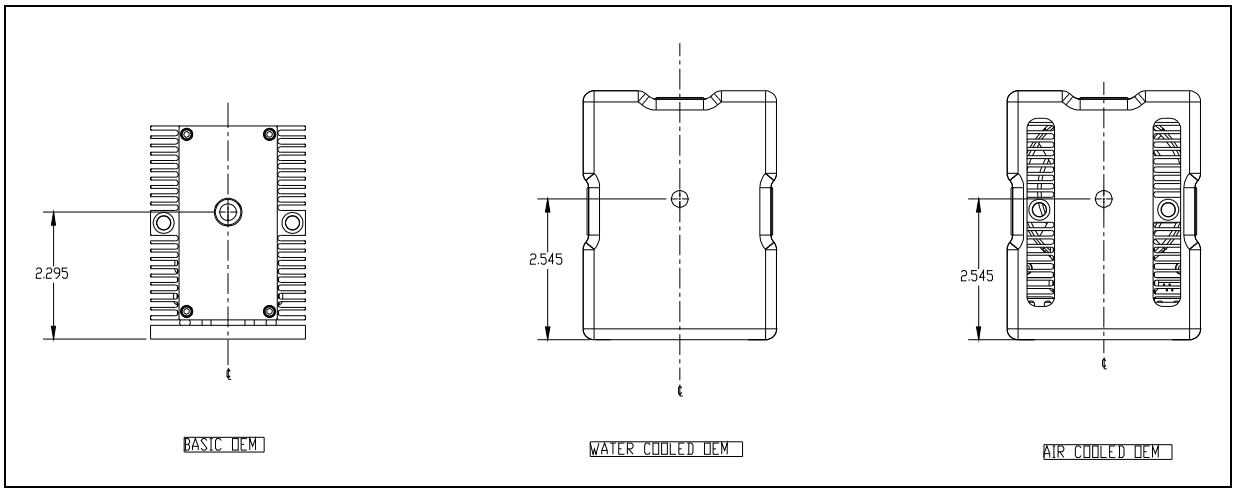


Figure 11 – Detail of Beam Output

6.0 10W Laser Communications Protocol Revision 1.0

The 10 Watt Laser contains an RS422 serial interface that can be used to read the status of the laser. The protocol is implemented on top of an RS422 physical link and is point-to-point addressable. The master control will initiate queries and the laser (slave device) will respond to each query. The laser contains a modular 4-pin jack for the serial cable. The other end of the cable is connected to an RS422 to RS232 converter which is then connected to the serial port of a PC. Revision 1.0 protocol is implemented in 10W Laser Firmware Revision 2.

Universal Laser Systems provides a Windows based, easy to use user interface to connect and communicate with the laser. The following status information can be read from the laser: interlock status, key switch status, laser emission status, laser diode status, tickle frequency and tickle duty cycle. In addition, the tickle duty cycle can be adjusted by the user in the field within factory set limits.

6.1 Protocol Format & Attributes

All messages are sent and received in ASCII code

REQUEST FORMAT: Each request message frame consists of the following elements: Start character, Function, Register, Data, End of Message character.

START	FUNCTION	REGISTER	DATA	END OF MSG

START:

Messages begin with a colon ":" character.

FUNCTION:

Function to be performed on the device. Current firmware supports write or read from registers defined in the device. See Table 6.2.a for function codes.

REGISTER:

Register is the variable address to be operated on. Register consists of the following attributes: Range: 1…8 in ASCII. See Table 6.2.b for register map.

DATA:

Data is the data to be written to the Register. Range: See Table 6.2.b. During read operations there is no data field.

END OF MESSAGE:

All messages end with a carriage return ASCII code 13 (or hex 0x0D)

REPLY FORMAT: Each reply message frame consists of the following elements: Start character, Request Status, Data, End of Message character.

START |	COMMS STATUS |	DATA |	END OF MSG

COMMS STATUS:

Status of the current request is sent back to the master. Range: K, E, & B. See Table 6.2.c for definitions.

6.2 Detail Definition of Function Codes, Registers and Status Messages

6.2.a Function Codes

Function Code	*Description*
4	Read single register
5	Write single register

6.2.b Register Mappings

Register Name	**Register #**	**Data (Character)**
Key Switch State	*1*	OPEN = 0; CLOSE = 1
Interlock State	*2*	OPEN = 0; CLOSE = 1
Emission State	*3*	EMIT = 1; NONE = 0;
Diode State	*4*	ON = 1; OFF = 0;
Tickle Frequency	*5*	FREQ VALUE = 5…20
Tickle Duty Cycle	6	DUTY CYCLE = 3…7 in micro seconds
Power State	*7*	RF ON = 1; RF OFF = 0;
Firmware Version	*8*	Firmware revision number

6.2.c Reply Message Codes

Code	**Description**
K	Request successful
E	Communications Error
B	Device Busy

Notes:

a. Register numbers in italics are for read only operations.
b. Register numbers in bold are for read and write operations.

6.3 Communication Example

The host/master controller sends and receives messages from the slave. **<CR>** represents a carriage-return.

Example 1: Read interlock status

Request message string

:42<CR>

Reply from slave if successful and interlock is closed

:K1<CR>

Reply from slave if communications are unsuccessful and interlock is closed

:E0<CR>

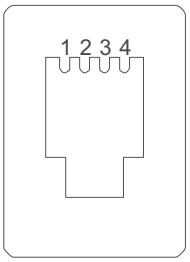
Reply from slave if communications are successful and interlock is open

:K0<CR>

6.4 Serial Port Wiring

Communications parameters: 9600 baud, No Parity, 8 Data bits, 1 Stop bit.

Pin Layout for RS422 Port



PIN1	RX+
PIN2	RX-
PIN3	TX-
PIN4	TX+