OEM Manual
Diamond™ G-100/150 Laser

COHERENT
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Technical Support

In the US:

Should you experience any difficulties with your laser or need any technical information, please visit our web site **www.coherentinc.com**. Additional support can be obtained by contacting our Technical Support Hotline at 800-367-7890 (408-764-4557 outside the U.S.) or E-mail (clg.tech.services@coherentinc.com). Telephone coverage is available Monday through Friday (except U.S. holidays and company shutdowns).

If you call outside our office hours, your call will be taken by our answering system and will be returned when the office reopens.

If there are technical difficulties with your laser that cannot be resolved by support mechanisms outlined above, please E-mail or telephone Coherent Technical Support with a description of the problem and the corrective steps attempted. When communicating with our Technical Support Department, via the web or telephone, the model and Laser Head serial number of your laser system will be required by the Support Engineer responding to your request.

Outside the U.S.:

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

Coherent provides telephone and web technical assistance as a service to its customers and assumes no liability thereby for any injury or damage that may occur contemporaneous with such services. These support services do not affect, under any circumstances, the terms of any warranty agreement between Coherent and the buyer. Operation of any Coherent laser with any of its interlocks defeated is always at the operator's own risk.

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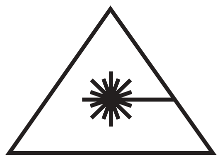
Preface

This manual provides operating and maintenance instructions for the Diamond G-100/150 OEM system. It is recommended that the user read Chapter Two, Laser Safety, before operating the laser.



Caution — use of controls or adjustments or performance of procedures other than those specified in this manual may result in hazardous radiation exposure.

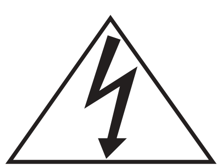
U.S. Export Control Laws Compliance

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

Export and re-export of lasers manufactured by Coherent are subject to the U.S. Export Administration Regulations administered by the Department of Commerce, Bureau of Export Administration.

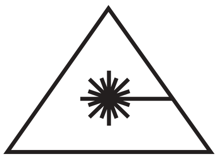
The applicable restrictions vary depending on the specific product involved, intended application, and the product destination. In some cases, an individual validated export license is required from the U.S. Department of Commerce prior to resale or re-export of certain products. If you are uncertain about the obligations imposed by U.S. law, obtain clarification from Coherent.

Symbols Used in This Manual and on the Laser System



This symbol is intended to alert the operator to the presence of dangerous voltages associated with the laser that may be of sufficient magnitude to constitute a risk of electric shock.

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.

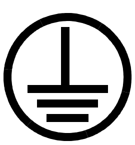
3~

3 PHASE ALTERNATING CURRENT.

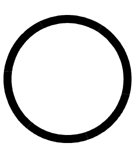
~

ALTERNATING CURRENT.

DIRECT CURRENT.



PROTECTIVE CONDUCTOR TERMINAL.



OFF OR STOP.

ON OR START.

CHAPTER ONE: DESCRIPTION AND SPECIFICATIONS

Introduction

The Diamond G-100/150 laser is an RF excited, sealed-off industrial CO_2 pulsed laser. The system (Figure 1-1) consists of a 100 or 150 Watt laser resonator and solid-state RF amplifier integrated within an all-metal enclosure. Operation requires cooling water, 48 VDC input power, driver signals, and proper optical delivery to the work piece.

The G-100/150 can operate in many pulse formats, and with a user-supplied control system, allows user control of the output power. The Diamond G-100 has an output power range of 10 to 100 Watts. The Diamond G-150 has an output power range of 10 to 150 Watts. Specifications are listed in Table 1-1. A simplified system block diagram is shown in Figure 1-2.

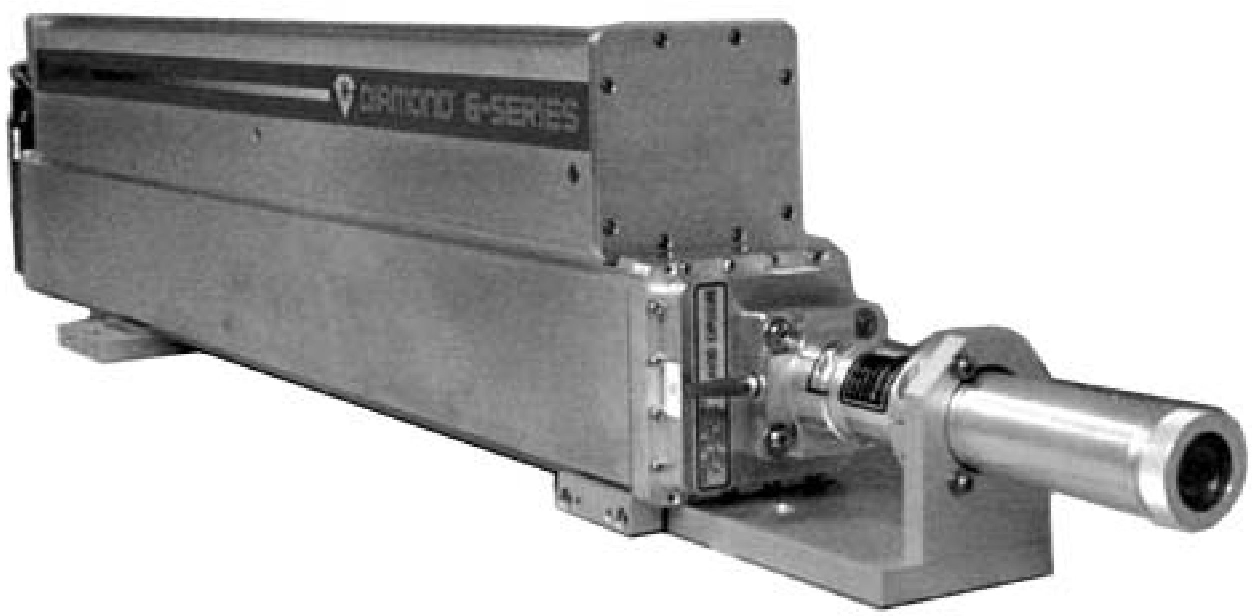


Figure 1-1. Diamond G-100/150 OEM Laser System with Beam Shaping Optics

Purpose of This Manual

This manual is designed to assist the original equipment manufacturer during the integration of the Diamond G-100/150 OEM laser. It contains information on the performance and operation of the laser as well as installation and control methods.

Table 1-1. Diamond G-100/150 Specifications and Utility Requirements

PARAMETER	SPECIFICATION	
GUARANTEED PERFORMANCE	**G-100**	**G-150**
Average output power	100 Watts(1)	150 Watts(1)
M^2 – Transverse mode quality	<1.5 (K >0.67)	<1.5 (K >0.67)
System warranty time	1 year	1 year
Tube shelf life	>1 year	>1 year
TYPICAL PERFORMANCE		
Peak effective power	250 Watts	375 Watts
Average power range	10 to 100 Watts	10 to 150 Watts
Pulse energy range	5 to 200 mJ	5 to 300 mJ
Pulse period (minimum)	10 µs (equivalent to a frequency of 100 kHz)	10 µs (equivalent to a frequency of 100 kHz)
Pulse width minimum	3 µs	3 µs
Output power stability(2)	< ±10%	< ±10%
Beam waist diameter ($1/e^2$) with beam shaper • with beam expander option • without beam shaping	TBD TBD 1.6 ± 0.3 Xmm : 2.3 ± 0.4 Ymm	2.2 ± 0.6 mm 5.4 ± 1 mm 1.4 ± 0.3 Xmm :2.2 ± 0.4 Ymm(3)
Beam divergence (full angle) with beam shaper • with beam expander option • without beam shaping	TBD TBD <11 mrad	<9.0 mrad <5 mrad <12.5 mrad
Beam waist asymmetry at laser output with beam shaper • with beam expander option • without beam shaping	TBD TBD <1.5:1	<1.2:1 <1.2:1 <2.0:1
Beam pointing stability	<200 µrad	<200 µrad
Beam polarization (parallel to narrow dimension of laser head)	Linear >100:1	Linear >100:1
Modulation pulse width range	3 to 1000 µs	3 to 1000 µs
Optical pulse rise and fall time	<90 µs	<60 µs
Wavelength	10.3 to 10.8 µm	10.3 to 10.8 µm

The above specifications subject to change without notice.

(1) Guaranteed at 600 µs pulse width at 60%duty cycle with the inlet cooling water at 25°C. Allow a 1%/°C power derating for inlet cooling water to a temperature of 35°C.

(2) At a constant coolant temperature. Stability defined as $\pm(P_{max}-P_{min})/2\ P_{max}$.

(3) Y = Laser Wide Dimension, X = Laser Narrow Dimension.

Table 1-1. Diamond G-100/150 Specifications and Utility Requirements (Continued)

PARAMETER	SPECIFICATION	
LASER HEAD ELECTRICAL REQUIREMENTS	**G-100**	**G-150**
DC input voltage(4)	48 VDC ±1%	
Maximum DC current	50 Amps	
Peak current	100 Amps	
WEIGHT		
Laser head assembly	35 pounds (16 kg)	37.5 lbs. (17 kg)
ENVIRONMENTAL		
Ambient temperature (operational)	5°C to 40°C (41°F to 104°F)	
Operating altitude	<6,500 feet (<2,000 meters)	
Relative humidity	<95% non-condensing at inlet coolant temperature	
Tube gas consumption	None	
Optional laser head purge	6 STD cubic feet/hour (2.8 liters per minute) Nitrogen 99.95% purity or 99.995% oil free air filtered with particle air filter to < 1 micron and dew point 10°C (18°F) lower than inlet cooling water temperature.	
WATER(5)		
Cooling water flow rate (minimum)	1.5 gpm (5.7 lpm)	
Cooling water temperature	10°C to 35°C (50°F to 95°F)	
Inlet pressure(6)	30 to 75 psi (205 to 520 kPa)	
Cooling water hardness (equivalent to $CaCO_3$)	<250 mg/liter	
Pressure differential(7)	30 psi (170 kPa) minimum	
Heat load(8)	2.5 kW	
Hardness (equivalent to $CaCO_3$)	<250 mg/liter	
pH	5 to 9	
Particulate size	<200 microns in diameter	

The above specifications subject to change without notice.

(4 DC input voltage to the laser head which consists of the RF amplifier and laser tube.

(5) These requirements are for facility tap water. If facility tap water is used, an in-line water filter is also recommended. If a closed loop system is used, it must meet the water requirements listed in this table. Also refer to the paragraph titled Cooling Water, located in this chapter for additional information including discharge of cooling water.

(6) Inlet pressure is based on 30 foot water lines. If different lengths are used, the difference must be taken into account when determining the inlet pressure.

(7) Between the inlet and return water lines. Pressure differential is based on 30 foot water lines. If different lengths are used, the difference must be taken into account when determining the pressure differential.

(8) If a closed-loop cooling system is used, it must have sufficient capacity to handle heat loads of 2.5 kW in addition to meeting the other water requirements listed in this table.

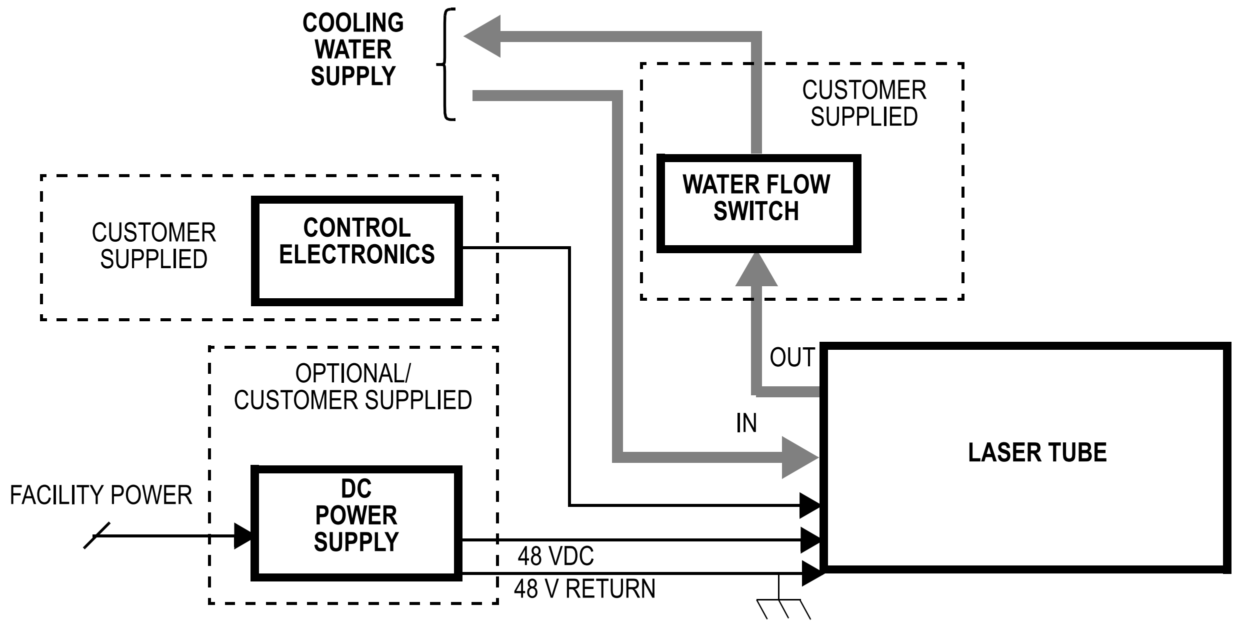


Figure 1-2. Simplified System Block Diagram

Laser Head

The laser head consists of an aluminum housing with two independent sections. The upper section contains the RF circuitry, and the lower section contains a sealed laser cavity. All necessary components reside within this housing to provide reliable, maintenance-free operation with full control and diagnostics.

Tube

The laser housing is sealed with all metal seal. The aluminum housing has high thermal conductivity, resulting in a thermally stable laser cavity.

Within the tube are 2 water cooled electrodes which provide excitation for the gas, cooling for the gas, and waveguide surfaces for the optical cavity. Coils are positioned along the length of these electrodes to ensure a uniform discharge.

Attached to the housing end pieces are 2 mirrors which are 100% reflective and designed for the necessary optical cavity. The inherent design of this laser cavity produces a high quality beam, with stable output power and the highest power per unit volume.

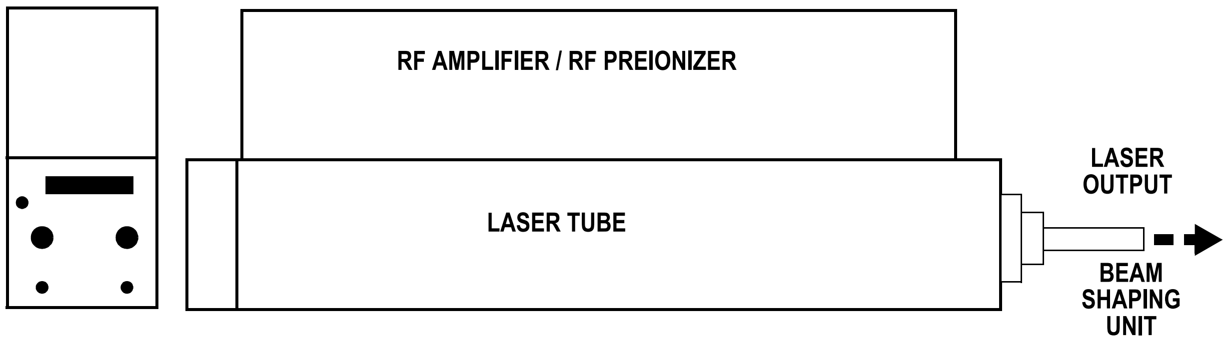


Figure 1-3. Laser Head Diagram

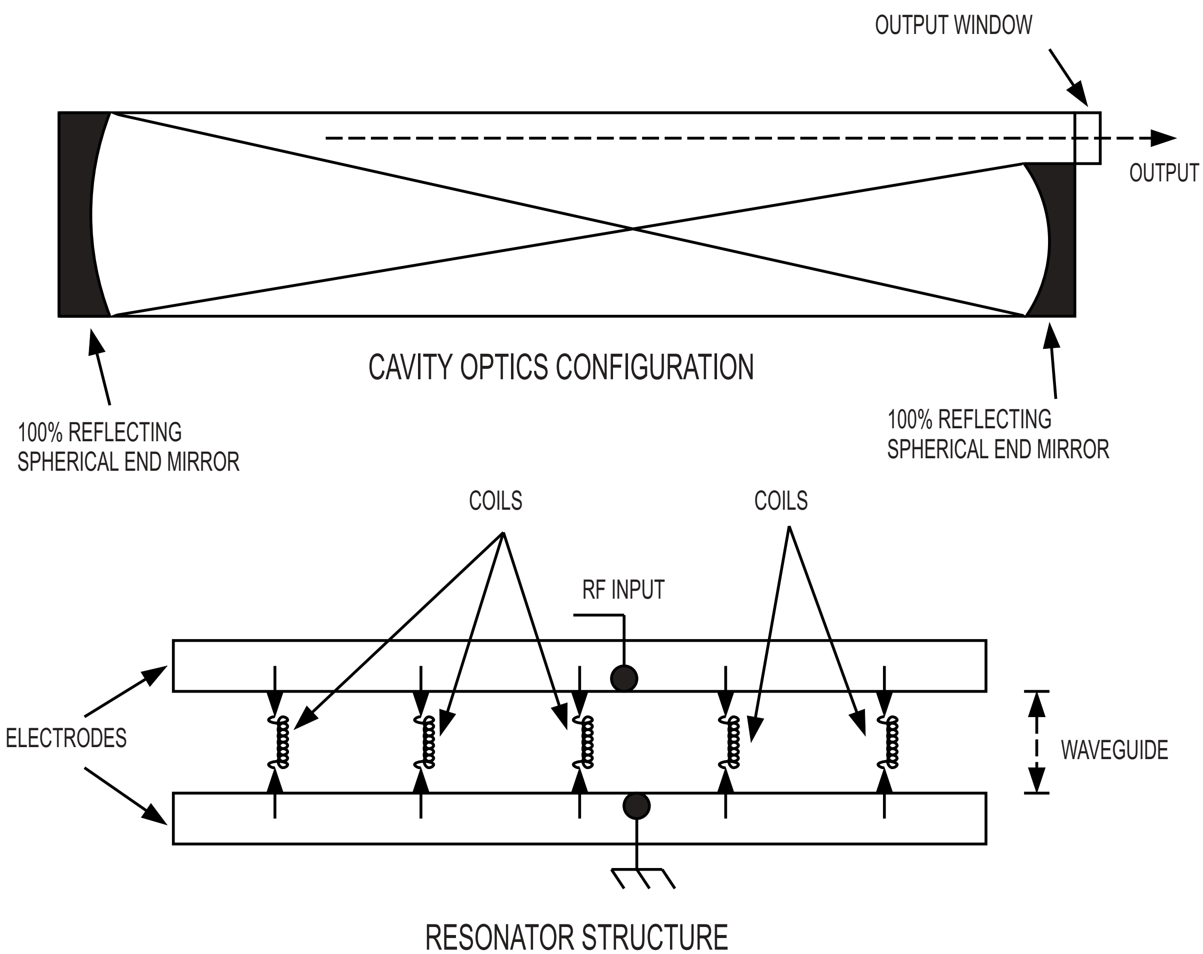


Figure 1-4. Laser Tube

Preionizer

The preionizer initiates a discharge in the tube gas for rapid starting if the laser is turned off. The preionizer is on continuously to ensure instant-on operation. The preionizer power source is an RF power supply integral with the main RF supply.

RF Amplifier

The integrated RF amplifier provides pulsed RF power to the laser tube to ionize the gas mixture in the tube. A modulation signal applied to the laser head controls the output pulse width and period. The RF amplifier produces up to 3000 Watts of RF output power.

The RF amplifier has the following features:

- Provides protection from duty cycles above 60%.
- Limits the pulse width to less than 1 msec.
- Monitors forward and reflected RF power to and from the laser tube.
- Provides a connection for an external safety interlock circuit which will shut down the laser when activated.
- Contains a factory set VSWR limit that limits duty cycle to less than 10% for faults typically related to the tube.
- Provides over temperature and system test functions.

Beam Shaping Unit

Two different versions of the beam shaping unit. (See Appendix C for Coherent part numbers) The first version is a cylinder lens unit designed to make a near round beam with equal divergence in the vertical to horizontal planes. The second version is a beam expander unit which produces a near round beam with reduced divergence.

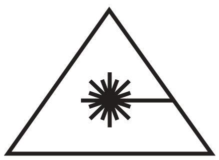
The beam shaper is a standard feature of the G-150 laser. The beam expander is an option for the G-150 lasers

CHAPTER TWO: LASER SAFETY

Optical Safety

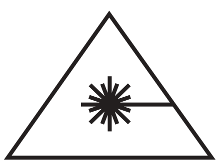
The Diamond laser has undergone extensive testing to ensure that, with proper usage, it is a safe and reliable device.

Laser light, because of its special properties, poses safety hazards not associated with light from other sources. The safe use of lasers requires that all laser users and everyone near a laser be aware of the dangers involved in laser operation.



Direct eye contact with the output beam from the laser will cause serious damage and may cause blindness.

All personnel in the same room as the laser or anyone who may be exposed to the laser beam should be informed that a laser is in operation. All personnel must wear laser safety glasses which protect against the wavelengths in use.



Exercise caution to protect against specular reflections since reflections at the Diamond wavelength are invisible.

Eye safety is a great concern when using a high-power laser such as the Diamond. There are often many secondary beams present at various angles near the laser. These beams are specular reflections of the main beam from polished surfaces. While weaker than the main beam, such beams may still be sufficiently intense to cause eye damage.

Laser beams are also powerful enough to burn skin, clothing or paint. They can ignite volatile substances such as alcohol, gasoline, ether, and other solvents and can damage the light-sensitive elements in video cameras, photomultipliers, and photodiodes.

Coherent provides the following recommendations to promote the safe use of the Diamond. Operators are advised to adhere to these recommendations and employ sound laser safety practices at all times.

- Use protective eyewear when operating the laser and guard against inadvertent exposure to skin or clothing. Select eyewear which is suitable for use with the wavelengths and radiation intensity that the laser emits. Refer to the *Guide for*

Selection of Laser Eye Protection, Laser Institute of America (5th Edition), 2000.

- Do not remove the protective covering over the beam path. During normal operation, internal reflections are confined within the laser head and pose no safety hazard.
- Never look directly into the laser output port when the power is on.
- Set up the laser and all optical components used with the laser away from eye level. Provide enclosures for the laser beam.
- Use the laser in a room with access controlled by door interlocks. Post warning signs. When operating the laser, limit access to the area to individuals who are trained in laser safety.
- Avoid operating the laser in a darkened environment.
- Do not use the laser in the presence of flammables, explosives, or volatile solvents such as alcohol, gasoline, or ether.

For additional information on laser safety, refer to the following publications:

- *American National Standard for the Safe Use of Lasers*, Z136.1-2000, American National Standards Institute, 2000.
- *Compliance Guide for Laser Products*. HITS Publications, (FDA 86-8260) Reprinted July 1989 U.S. Department of Health and Human Services, Public Health Service, Food & Drug Administration, Center for Devices and Radiological Health, Rockville, MD 20287
(available at www.fda.gov/cdrh.)
- *Laser Safety Guide,* Laser Institute of America. (10th Edition). Orlando, FL 2000.
- *Guide for Selection of Laser Eye Protection*, Laser Institute of America (5th Edition), 2000.
- D. Sliney and M. Wolbarsht. *Safety with Lasers and Other Optical Sources,*. Plenum Publishing Company, New York, N.Y., 1980.

Many of these documents on Laser Safety are available through Laser Institute of America, 13501 Ingenuity Drive, Suite 128, Orlando, CA 32826. Phone 800-345-2737 and on their web site www.laserinstitute.org. Regulatory information if available at their CDRH web site www.fda.gov/cdrh.

Electrical Safety

The G-Series laser head requires only +48 VDC. This voltage is supplied from commercially available power supplies from various manufacturers. The typical input voltage to these power supplies is 208 or 240 VAC, single phase with ground. These voltages can be lethal. Every portion of the electrical system should be treated as if it is at a dangerous voltage level. All the metal parts of the tube should be considered extremely dangerous.

The optional DC power supply and laser head covers should never be removed. There are no user serviceable components inside.

Laser Head

High voltages are present in the laser head when the power is on. Please read the appropriate manual chapters carefully before attempting any maintenance of components housed in the laser head.

Laser Safety Requirements

This laser does not conform to the United States Government requirements for laser safety. In the United States, it is the responsibility of the buyer that the product sold to the end user complies with all laser safety requirements prior to resell. These laser safety requirements are contained in 21 CFR, Sub Chapter J and are administered by the Center for Devices and Radiological Health.

The text of this federal law is available from the U.S. Government Printing Office Bookstore located in most major cities in the U.S. as well as Washington, D.C. A report detailing how the laser product complies with the Federal law is required before the product is shipped. The form of this report is covered in a pamphlet entitled: *Guide for Preparing Product Reports for Lasers and Products Containing Lasers*, Sept. 1995:

> U.S. Department of Health and Human Services
> Public Health Service
> Food and Drug Administration
> Center for Devices and Radiological Health
> Division of Small Manufactures Assistance
> Rockville, Md 20857
> Voice phone: 1-800-638-2041
> Web site: http://www.fda.gov/cdrh

Both the text of the applicable federal law and the guide are available at the CDRH web site.

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

Safety Interlocks

The DC power supply and laser head covers are not interlocked. These covers should never be removed. There are no user serviceable components inside.

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

Radiated Emission Compliance

The Diamond laser has been tested and verified that it is in compliance with the radiated emission limits of FCC Rules contained in 47 CFR Part 18 Subpart C for industrial, scientific, and medical equipment.

The following information to the user is provided to assist the OEM in complying with radiation safety standards. (47 CFR 18.213).

Interference Potential of the System

In our testing in a variety of laboratory and industrial settings, we have not found any significant electrical interference that can be traced to the Diamond laser. The Diamond laser is excited by an RF power supply operating at 81.36 MHz. The RF power is modulated at the same pulse width and pulse period selected in operating the laser.

Maintenance of the System

In order to have the Diamond laser operate properly, the RF connectors between the power module and the laser head must be always kept tight. No special tooling is required since a finger tight connections is satisfactory. We recommend checking these connections on a monthly interval to ensure that they are tight.

Simple Measures to Correct Interference

If the Diamond laser is determined to be the source of interference with other equipment the following steps can be taken to minimize this interference:

1. Check all the connections at the control cable connections to the laser head, power module, and remote control unit.
2. Use shielded cables including control cables to the unit experiencing the interference problem. The shield should be grounded.

Compliance to Standards Relevant to CE Mark

The Diamond G-100/150 OEM units are components and thus the system integrator is responsible for meeting the applicable standards for CE mark. As part of the testing program, the Diamond G-100/150 OEM laser with the DC power supply has been shown to be compliant with the relevant requirements of the electromagnetic compatibility directive and low voltage directive pertaining to electrical safety. The tests shows compliance with radiated emissions and conducted line emissions (EN 55011 (1991) Class A, Group 2), electrostatic discharge (EN 61000-4-2 (1995) Level 3 air, Level 2 contact), radiated immunity (EN 61000-4-3 (1997) Level 3/ENV 50204 (1995)/ENV 50140 (1993), Level 3, Criteria A), electrical fast transients (EN 61000-4-4 (1995) Level 3), and conducted RF immunity (EN 61000-4-6 (1996)/ENV 50141 (1993) Level 3).

Compliance to the applicable standards for a particular laser system incorporating the Diamond G-100/150 OEM unit must be demonstrated by the manufacturer of the laser tool. By testing the Diamond G-100/150 OEM system, it is shown that this step is possible. The primary issue for the system integrator is to show compliance with specific covers, routing of the electrical cables, laser safety standards, as well as other applicable standards.

CHAPTER THREE: UTILITY REQUIREMENTS AND SYSTEM INSTALLATION

Utility Requirements

The Diamond laser head requires 48 VDC, the DC power supply option requires AC power, and facility water is required for cooling the laser head. Electrical power, environment, and cooling water must meet the specifications provided in Table 1-1.

Electrical Service

Optional DC Power Supply with Single Phase AC Input

The optional 48 VDC power supply requires a user supplied 3-conductor line cord and a connector that plugs into 200 to 240 VAC, 50 to 60 Hz, single phase facility power with ground. See Table A-1 for recommended wiring size and electrical fusing.

Any DC power supply selected for use with the Diamond must be able to supply both the RMS and peak current specified in Table 1-1.

Main Power Disconnect

A main power disconnect must be located on the equipment housing the laser or near the equipment. The disconnecting device should be labeled as such and be located within easy reach of the operator. Consult applicable local electrical codes to select this hardware.

Cooling Water

The Diamond laser requires a flow of cooling water. Because the properties of the cooling water are important for laser performance, ensure that the conditions remain within the tolerance limits listed in Table 1-1 at all times. Check local and state regulations which may control use of city water for cooling. Some regulatory codes will not allow the discharge of cooling water into the sewer system.

Tap water temperature and pressure can vary with the time of day and season of the year. A closed-loop cooling system can be used to obtain consistent laser performance.

Selecting The Correct Cooling Water Temperature

The cooling water of the Diamond system can condense moisture from the air when the temperature of the cooling water is lower than the dew point of the air. The system must not operate under these conditions since it will lead to catastrophic failure in both the laser head and the RF power supply. When failures occur in either the optics or the RF power supply it must be returned to the factory for repair. Under most conditions, it is recommended to select the inlet cooling water temperature at room temperature or at least 25°C (77°F). This following information provides recommendations for operating conditions outside of the normal temperature and humidity range.

The conditions that lead to a situation where there can be condensation are warm and humid weather combined with water that is cooler than the surroundings. High risk conditions which will lead to condensation are:

- Operating the laser in a room that is not air conditioned in high humidity conditions
- Using cooling water that is not temperature controlled
- Leaving the cooling water on when the laser is not operating for extended time periods

The information required to determine if the cooling water temperature will lead to condensation is:

- Room temperature
- Relative humidity

Since the weather conditions change, these factors need to be periodically check especially in the spring and summer seasons. In environments that are air conditioned, we recommend setting the cooling water temperature to 25°C (77°F). As explained below for conditions that are not air conditioned, we recommend that the cooling water temperature be increased to the air temperature to avoid condensation in humid climates.

The recommended inlet cooling water temperature is provided in Table 3-1 and Table 3-2 for the complete operating temperature range of the Diamond laser system. Note that the first table is for temperature on the Celsius scale and the second is for temperatures on the Fahrenheit scale. To use this chart, find the row with the closest room temperature. Next read across until you find the column with the nearest relative humidity for the room with the laser. The number in the box is the recommended temperature for the inlet cooling water. If a closed loop cooling system is being used then select this temperature as the temperature set point. As an example, if the current room temperature is 28°C and the relative humidity is 68%, then the recommended inlet cooling water temperature is 35°C and the nearest relative humidity is 70%.

Table 3-1. Recommended Minimum Inlet Cooling Water Temperature for Celsius Temperature Scale

Room Temperature (°C)	**Maximum Relative Humidity**							
	30%	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**95%**
5	20	20	20	20	20	20	20	20
10	20	20	20	20	20	20	20	20
15	20	20	20	20	20	20	20	20
20	20	20	20	20	25	25	25	25
25	25	25	25	25	30	30	30	30
30	30	30	30	30	35	35	35	35
35	35	35	35	35	35	35	35	35
40	35	35	35	35	35	N/A	N/A	N/A

1. The minimum inlet cooling water temperature should account for variations in cooling water temperature with the thermal load, temperature stability of the cooling water system, and seasonal variations in cooling water temperature.
2. N/A indicates operation under these conditions is not acceptable since condensation will occur on the laser system. Either the ambient temperature must be reduced or the relative humidity must be reduced before operating the laser.

Selecting the cooling water temperature must also take into account changes in the cooling water temperature. For a closed loop cooling water system, there can be variations in the water temperature due to changes in the thermal load and the response time of temperature controller. The number given by the table will be the minimum water temperature that should be observed for the current room temperature and humidity conditions.

In many climates, the cooling water temperature should be changed due to seasonal variations in the ambient conditions. For example in times of high relative humidity and high room temperatures, the cooling water temperature will have to be increased to avoid problems with condensation. Under extreme conditions of temperature and humidity, the laser should not be operated as noted in Table 3-1 and Table 3-2. This can be solved by air conditioning the room with the laser to reduce both the room temperature and the humidity.

Table 3-2. Recommended Minimum Inlet Cooling Water Temperature for Fahrenheit Temperature Scale

ROOM TEMPERATURE (°F)	MAXIMUM RELATIVE HUMIDITY							
	30%	40%	50%	60%	70%	80%	90%	95%
41	68	68	68	68	68	68	68	68
50	68	68	68	68	68	68	68	68
60	68	68	68	68	68	68	68	68
70	70	70	70	70	77	77	77	77
80	77	77	77	77	86	86	86	86
90	86	86	86	86	95	95	95	95
95	95	95	95	95	95	95	95	95
104	95	95	95	95	95	N/A	N/A	N/A

1. The minimum inlet cooling water temperature should account for variations in cooling water temperature with the thermal load, temperature stability of the cooling water system, and seasonal variations in cooling water temperature.
2. N/A indicates operation under these conditions is not acceptable since condensation will occur on the laser system. Either the ambient temperature must be reduced or the relative humidity must be reduced before operating the laser.

When using tap water as cooling source, seasonal variations in the water temperature often can lead to conditions that will produce condensation. In this case, mixing some hot water with the inlet cooling water will be required to eliminate condensation or alternatively reducing the room temperature and humidity with an air conditioning system.

Installation

Installation consists of:

- Preparing the facility for installation
- Performing a receiving inspection
- Unpacking and inspecting system components
- Mounting the laser system components
- Connecting water lines
- Connecting the electrical cables
- Turning on the laser system

Preparing the Facility for Installation

Ensure facility electrical and water are adequate for laser operation as described below.

The facility outlet for the DC power supply option must have a fuse or circuit breaker at the appropriate rating. See Table A-1 for electrical requirements, including wire size and fusing.

Refer to the paragraph titled "Cooling Water" in this chapter, and to Table 1-1 for water requirements.

Receiving Inspection

Before unpacking the Diamond, inspect all shipping containers and note any damage. Any indication of damage should be noted on the bill of lading. The shipping carrier is responsible for damage in transit. Immediately report damage to the shipping carrier and to Coherent.

Unpacking

To avoid equipment damage, exercise care when removing wrapping materials.

To minimize the risk of functional or cosmetic damage, unpack the laser system at the installation site. While unpacking the Diamond laser, verify that all items on the packing list have been received. Save all containers and packing material including the water line end caps. They will be required if it becomes necessary to re-ship the equipment.

Table 3-3. Equipment Required for Installation

EQUIPMENT	QUANTITY	USE
+48 VDC power supply (if optional power supply is not a part of the system)	1	Provides +48 V power to the RF amplifier and to the laser head.
Mounting — laser head	2	See Figure 3-3 for details.
Water hose fittings (barb to pipe thread)	2	Adapts the 1/4 inch NPT pipe thread on the laser head to accept a 3/8 inch I.D. cooling water hose.
Cooling water hoses	2	Provides cooling water to the laser head. 3/8 inch I.D. nylon PVC cooling water hoses are recommended up to a total length of 50 feet.
Mounting bolts — DC power supply option	4	Secures DC power supply at base. See Figure A-1 for mounting locations.
Auxiliary cooling water inlet/outlet	2	0.125 inch NPT pipe thread.
Allen wrench set (english)	1	Attaching beam shaping hardware

Mounting Laser System Components

The laser head and optional DC power supply have provisions for permanent mounting. Refer to the figures listed below for overall dimensions, location of the mounting holes and mounting dovetails, and depth of mounting bolts.

- Laser head, Figure 3-3 and Figure 3-2
- DC power supply option, Figure A-1

The wire must be of the correct gauge to handle the current and insulation that meets the expected maximum temperature. See Table A-1 for recommendations. The wire should be twisted in order to minimize the inductance. A protective earth (P.E.) connection should be made to the laser head. Use the same 8-32 screw used to connect the 48 V return.

The laser head can be mounted in any orientation. If mounted vertically with the output window up, ensure no dust or other particulates fall on the collimating optic during installation. Leave the red beam seal on the output beam tube during installation.

A well filtered air environment will ensure long life of the DC supply and avoid contamination with dirty or oily particulates. The DC supply must be located in such a manner that there is no restriction of the air flow caused by the surrounding equipment. Fans are located inside the DC power supply to provide sufficient air flow for cooling. Recommended clearances of a minimum of 4 inches on both the front and back of the DC supply.

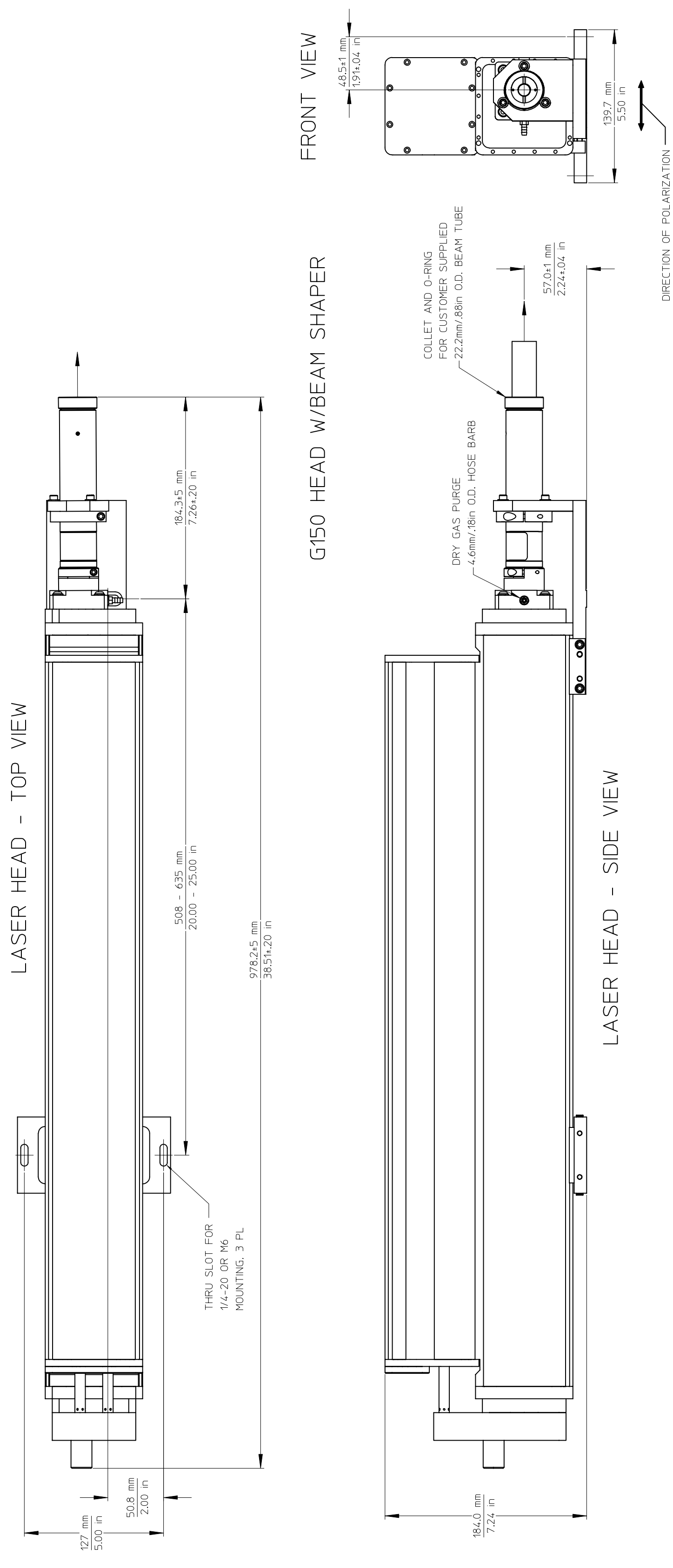


Figure 3-1. Laser Head Dimensions and Mounting Hardware Locations (w/Beam Shaper)

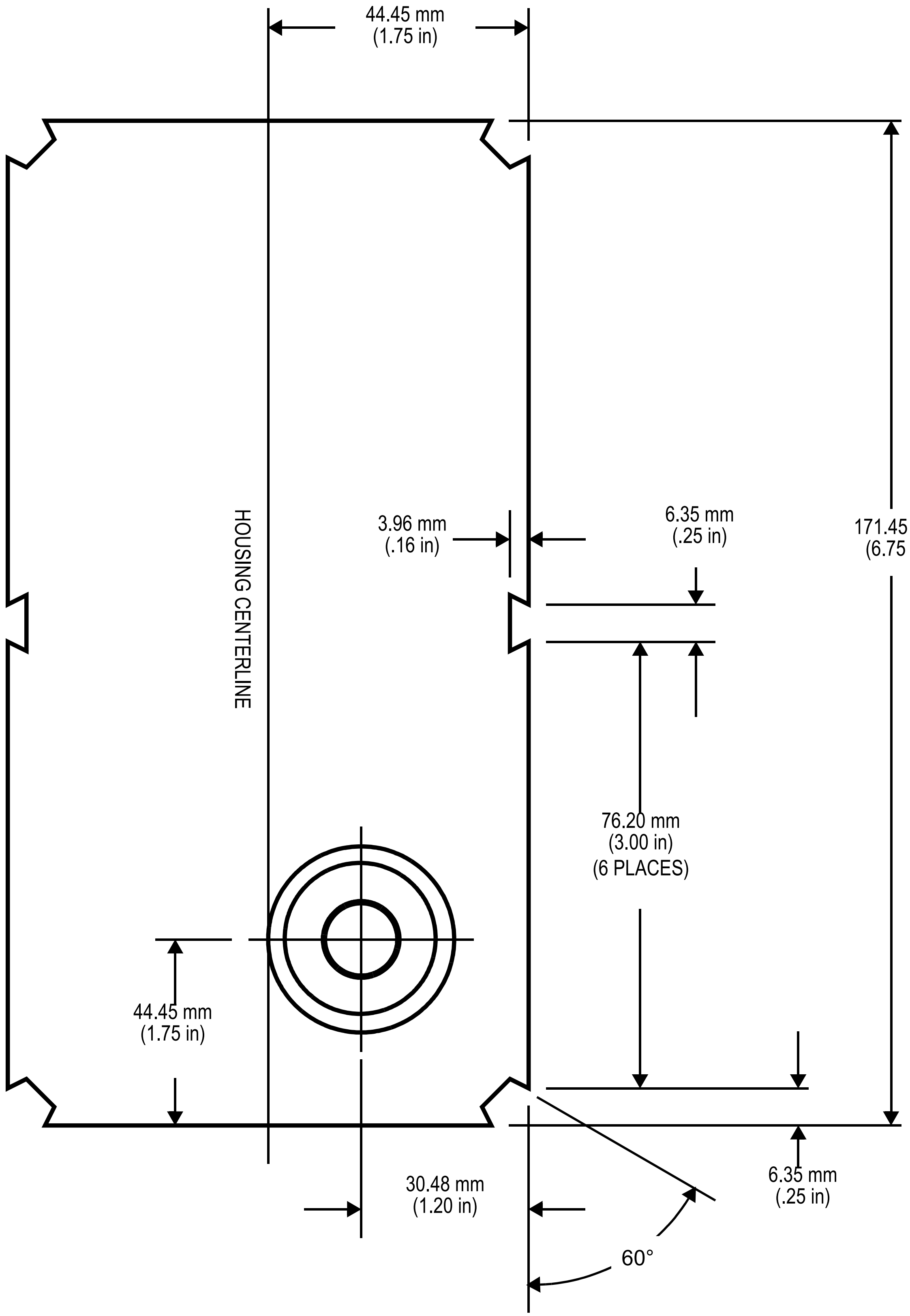


Figure 3-2. Alternative Laser Head Mounting Hardware Details

Attaching Beam Shaping Units

The G-150 lasers have either a beam shaping accessory to produce a round laser output or a beam expander accessory to produce a round laser output with reduced beam divergence. Both accessories comprise of (i) a mount/beam support assembly (ii) a rear foot assembly and (iii) the beam shaper or beam expander lens assemblies. See Figure 3-1 and Figure 3-4.

After unpacking the mount/beam support assembly should be mounted to the dovetail rail on the laser body at the output end of the laser as shown in Figure 3-1 (requires 9/64 inch Allen wrench). The rear foot assembly can be mounted the same way at a distance between 20 and 25 inches from the indexing block at the front of the laser.

Both the beam shaper and expander have cylinder optical elements and so need to be fitted with the correct orientation to ensure effective beam conditioning. The laser is delivered with a pre-aligned indexing block attached to which the beam shaper or expander assemblies must be fitted correctly. Once the mount/beam support assembly is fitted remove the seal plugs from the laser and lens assembly and slide the shaper or expander assembly through the mount clamp into the index block. Ensure that the reference pin engages in the index slot (see Figure 3-4) and tighten the index block clamp (7/64 inch Allen wrench). Finally tighten the mount/beam support assembly onto the shaper/expander assembly (1/8 inch Allen wrench) before tightening the three screws on the front of the beam support assembly (9/64 inch Allen wrench).

The beam shaper/expander assemblies are designed for integrator supplied 0.88 inch OD beam tubing. Also a gas purge port (0.18 inch OD hose barb) is supplied on the index block for clean dry gas purge. The integrators beam tubing should be designed to seal and allow this gas flow around optical components and exhaust from the system.

Optics Purge Gas

The Diamond laser is used in a wide range of material processing which often has by-products of dust, smoke, fumes, oil and various gases. These by-products can cause contamination output window as well as the beam delivery optics. This will severely degrade the system performance and can lead to damage of the optical components. Passing a purge gas through the beam shaping optics then into the customers beam delivery optics can prevent optics damage. Also under some conditions of high humidity, the laser beam can be distorted by optical absorption of the laser beam by water vapor. This effect can also be totally eliminated by a proper gas purge.

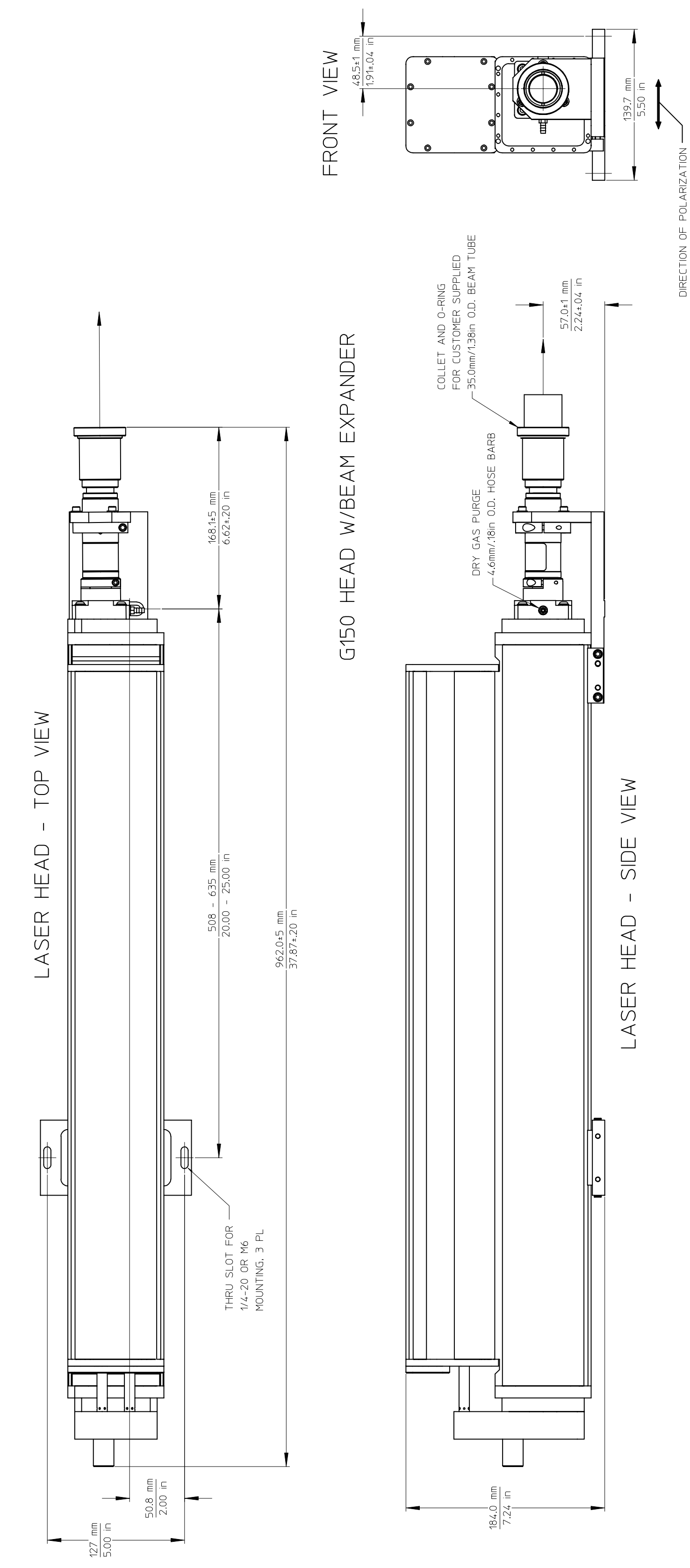


Figure 3-3. Laser Head Dimensions and Mounting Hardware Locations (w/Beam Expander)

The gas purge in the G-150 lasers enters in front of the output window and flows through the beam shaping optics out the exit aperture of the beam shaping optics. The beam tube provides a convenient connection to the beam delivery optics while maintaining a gas seal at this junction.

The quality of the purge gas is extremely important factor for trouble free operation of the Diamond laser system. The preferred purge gas is nitrogen with a purity of 99.95%. In many facilities, nitrogen of the purity level is provided from a nitrogen boil of a liquid nitrogen source.

If nitrogen is not available then the alternate source is oil-free and dry compressed air. Compressed air is also available in many facilities but typically is contaminated with water and oil vapors. The purity requirements for the compressed air are:

1. Filtered to remove particles larger than 1 micron.
2. Dried so that dew point is 10°C (18°F) lower than the inlet cooling water temperature to the Diamond laser system.
3. Oil free to better than 99.995%.

An optional filter kit with Teflon tubing can be installed to obtain this quality of air. The proper installation of the filter kit is shown in Figure 3-1 and is attached to the laser at the inlet fitting labeled PURGE. Note if the dew point cannot be achieved then a drier must be installed. Place the drier between the final filter stage and the laser head. A suitable drier is Balston 7601. The coalescing filter kit with Teflon tubing is available from Coherent or your local Coherent representative. See Parts List in the appendices for the part number of the filter kit and replacement filter cartridges.

It is the responsibility of the customer to provide nitrogen or compressed air that meets the specifications stated above. The warranty of the laser is voided and the customer is responsible for all cost of repair or damage to the laser.

See the Preventative Maintenance section in Chapter Six for the routine maintenance required for the purge gas filters.

Water Line Connections

Refer to Figure 3-4 for the location of laser head water hose connectors.

The cooling water source can be facility water or a closed-loop cooling system. If facility water is used, ensure that the water meets the requirements listed in Table 1-1. Refer to the paragraph titled “Cooling Water” in this chapter for additional information.

The recommended hose for cooling water consists of 3/8 inch (9.5 mm) ID nylon reinforced PVC water hose. Water cooling lines longer than 30 feet may require larger diameter lines to provide sufficient water flow. Use 1/4 inch NPT thread to connect main cooling lines to the laser head. The 1/8 inch NPT are for cooling lines to accessories such as water cooled shutters.

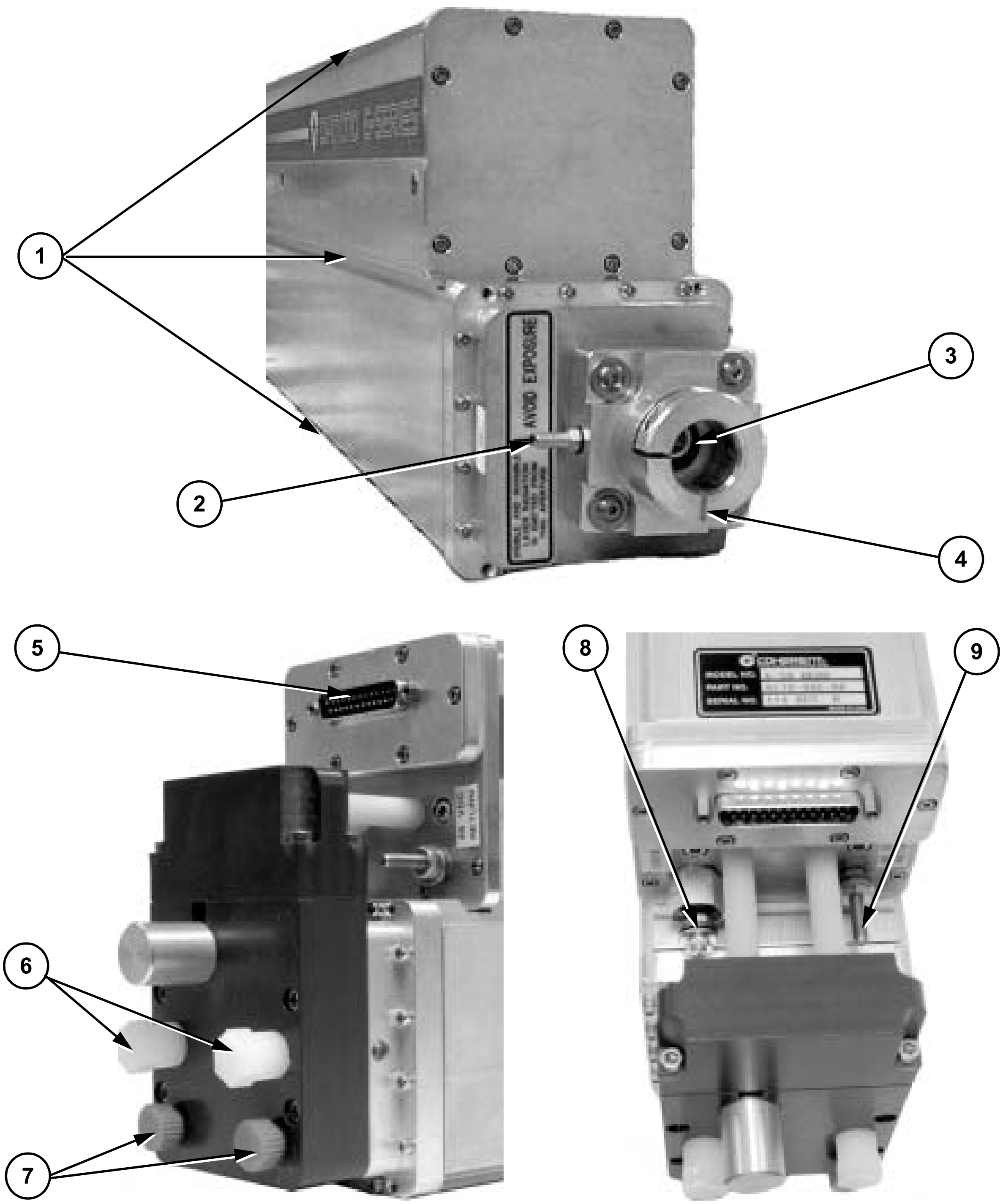
After connecting the water hoses, verify that there are no water leaks as follows:

- Open the valve in the water drain line.
- Slowly open the valve in the water supply line.
- With the water supply pressure and water line differential pressure in accordance with Table 1-1, check all connections for leaks.

DC Power Connections

The primary DC power connection that must be made is between the DC power supply and the laser head. A much lower power connection may go to the water flow switch.

Input power to the laser head is made at the terminals labeled +48 VDC and 48 VDC RETURN which are for the +48 VDC input and the return respectively. The lug labeled +48 VDC should be connected to the positive terminal of the DC power supply. The lug with the 48 V RETURN label connects to the negative terminal on the DC power supply. The maximum cable length recommended for the DC power supplies is 18 inches (45 cm). Twisting together the two wires between the DC supply and the laser head will minimize the inductance in these leads.



1. Mounting dovetails (both sides)
2. Purge gas port
3. Laser beam exit aperture
4. Index slot
5. DB25 control cable connector
6. Cooling water outlet/inlet
7. Auxiliary cooling water inlet/outlets
8. 48 VDC IN
9. 48 VDC return (–)

Figure 3-4. Laser Head Indicators and Connectors

Table 3-4. Laser Head Indicators and Connectors

ITEM	CONTROL	FUNCTION
1	Mounting dovetails	Can be used for mounting laser to system and also for mounting laser beam delivery hardware. See Figure 3-1 and Figure 3-3 for regular mounting details.
2	Purge gas port	6 STD cubic feet/hour (2.8 liters per minute) Nitrogen 99.95% purity or 99.995% oil free air filtered with particle air filter to < 1 micron and dew point 10°C (18°F) lower than inlet cooling water temperature.
3	Laser beam exit aperture	The output beam exits the laser head from this aperture.
4	Index slot	Ensure pin on beam shaping unit engages fully with this slot to ensure correct alignment.
5	DB25 control cable connector	Connector for a DB25 interconnection cable. This connector supplies control and input modulation signals to the RF amplifier within the laser head, and supplies status information from the RF amplifier. Refer to Chapter Four for a complete description of signals at this connector.
6	Cooling water outlet/inlet	Connection for water hose between the laser head and the cooling water supply. Cooling water travels through the RF amplifier and resonator in the laser head and out to the drain. Cooling water must meet specifications listed in Table 1-1. Refer to “Selecting The Correct Cooling Water Temperature” in this chapter for additional guidelines.
7	Auxiliary cooling water inlets/outlets	Provide cooling water access to such accessories as an acoustic optic modulator. Ensure that total water flow to laser is at least 1.5 gpm (5.7 lpm).
8	48 VDC IN	Connects +48 VDC from the DC power supply to the laser head. Refer to Figure A-2 for DC supply connections.
9	48 VDC return (–)	Connects to the DC supply negative terminal. For return current. Recommend connection to supply ground also.

CHAPTER FOUR: CONTROL INTERFACES

Introduction

This chapter describes the interface required to operate the Diamond G-100/150 OEM system. Critical signals which control laser power are the pulse width and pulse period to the RF amplifier in the laser head. Typical laser output power for various operating pulse widths and periods is shown in Chapter Five, Operation. If the optional DC power supply is used, it must also be properly enabled so that 48 VDC is available for the RF amplifier and supporting circuitry.

RF Amplifier Control Connector Interface

The RF amplifier control and indicator signals are summarized in Table 4-1 and are accessed through a DB25 connector on the rear of the laser head. To operate the laser, two input signals are required, as indicated in Table 4-1. In order to monitor the condition of the system, six output signals are provided and recommended for use in the control system. There are two test signals that are also available and which can be used to test the integrity of the input circuitry. The test function provides a pulse width of 100 µs at a pulse period of 1000 µs which also could be used to test the performance of the laser. Detailed descriptions and pinouts of the control connector interface are provided in Table 4-2.

Input Signal Requirements

The two inputs required to operate the laser are the ENABLE and MODULATION signals. Figure 4-1 shows the schematic of the input circuit of the RF amplifier interface circuit.

The ENABLE signal is typically used in safety circuits and also provides an very easy channel to enable and disable the laser. It could be connected with such faults as the water flow interlock or a safety interlock to disable laser operation when some other operation is taking place. Connecting this input to the RETURN will enable the RF amplifier thus allowing laser operation when the DC power supply is also enabled.

The second function required to operate the laser is the MODULATION signal. This signal will determine the laser "on" interval typically called the pulse width. The time interval between the start of an "on" period is called the pulse period. The pulse width must be in the range of 5 µs to 999 µs. MODULATION pulse widths longer than 1000 µs will automatically be limited to 1000 µs by the protection circuit in the RF amplifier. The duty cycle must be limited to

Table 4-1. Summary of RF Amplifier Control and Indicator Signals

IDENTIFICATION	BRIEF DESCRIPTION	CONNECTION
INPUT SIGNALS		
MODULATION	Controls laser average output power through input of pulse width and pulse period.	Required
ENABLE	Enables laser operations. Can be used in safety circuit.	Required
TEST ENABLE	Activates the test modulation output.	Test function
OUTPUT SIGNALS		
DUTY CYCLE	Warning indicating that the system has exceeded the maximum duty cycle.	Recommended
VSWR	Warning indicating error conditions related to tube or RF cable problem.	Recommended
DIGITAL FORWARD	Warning indicating low RF power from the RF amplifier.	Recommended
DIGITAL REFLECTED	Warning indicating high reflected power from tube or RF cable.	Recommended
ANALOG FORWARD	Signal proportional to the forward RF voltage.	Recommended
ANALOG REFLECTED	Signal proportional to the reflected RF voltage.	Recommended
TEST MODULATION	Provides modulation signal for testing laser and input circuitry at 10% duty cycle.	Test function
OVER TEMPERATURE	Signal that indicates excessive inlet water temperature	Recommended

less than 60%. The duty cycle is the ratio of the pulse width divided by the pulse period and then multiplied by 100. If either the duty cycle or the pulse width exceeds these limits a warning will occur on the DUTY CYCLE output. A more complete description of this signal and typical waveforms follow later in this chapter.

Drive Circuit for RF Amplifier

An example of a drive circuit to interface to the inputs described in the previous paragraph is shown in Figure 4-2. Suitable input devices are shown in Table 4-3.

The Diamond input interface shown in Figure 4-1 is designed to be driven by a differential line driver meeting the requirements of EIA Standard RS-422A. Common mode voltage on the driver signals should be kept as low as possible and cannot exceed ±15 V relative to the laser system ground. Examples of suitable line drivers are indicated in Table 4-3.

Table 4-2. RF Amplifier DB25 Connector Pinouts

Pin Numbers	Function	Description
1	ANALOG FORWARD voltage output signal	Analog output signal representing forward voltage from the RF amplifier to the laser head. +5 V full scale.
2	ANALOG REFLECTED voltage output signal	Analog output signal representing reflected voltage from the tube. +5 V full scale.
3	ENABLE input signal	Connecting this pin to return enables the RF amplifier. This pin can also be used for external safety interlock.
6	—	Not currently used on this product.
5(+) and 18(–)	TEST MODULATION —output signal	Differential output signal that produces a 100 µs pulse width at a pulse period of 1000 µs. Used as input for MODULATION signals in the test mode. See TEST ENABLE.
7 (+) and 20 (–)	MODULATION —input signal	Differential input signal that controls the laser output. Laser output power will be present for the duration of this pulse only. Pulse widths should be in the range of 10 to 998 µs at <60% duty cycle.
8 (+) and 21 (–)	DIGITAL REFLECTED power—output signal	Differential signal that does not change state when the RF amplifier is modulated on. If this signal does change state, this indicates a failed laser tube, RF cable, or RF connector.
9 (+) and 22 (–)	DIGITAL FORWARD power—output signal	Differential signal that changes state when the RF amplifier is modulated on. Under a failed condition of the RF amplifier, this signal will not change states.
10 (+) and 23 (–)	DUTY CYCLE LIMIT —output signal	Differential signal that does not change state unless the modulation pulse is on for more than a 60% duty cycle or a modulation pulse width longer than 1 ms.
11 (+) and 24 (–)	VSWR LIMIT —output signal	Differential signal that does not change under normal operating conditions. It will turn on if there is a tube fault that causes an excessive mismatch between the laser tube and the RF amplifier.
12	TEST ENABLE —input signal	Enables the TEST MODULATION output signal when connected to the RETURN.
13	—	Not currently used on Diamond.
14, 15, 16	RETURN	Reference for pin 1, 2, and 3
19, 25	—	Not currently used on this product.
4 (+) and 17 (–)	OVER TEMPERATURE —output signal	Differential signal changes state when cooling water exceeds 50°C limit. When this limit is exceeded, modulation of the laser is stopped until water temperature is reduced. The water temperature must be lowered to less than 40ºC to enable the modulation again.

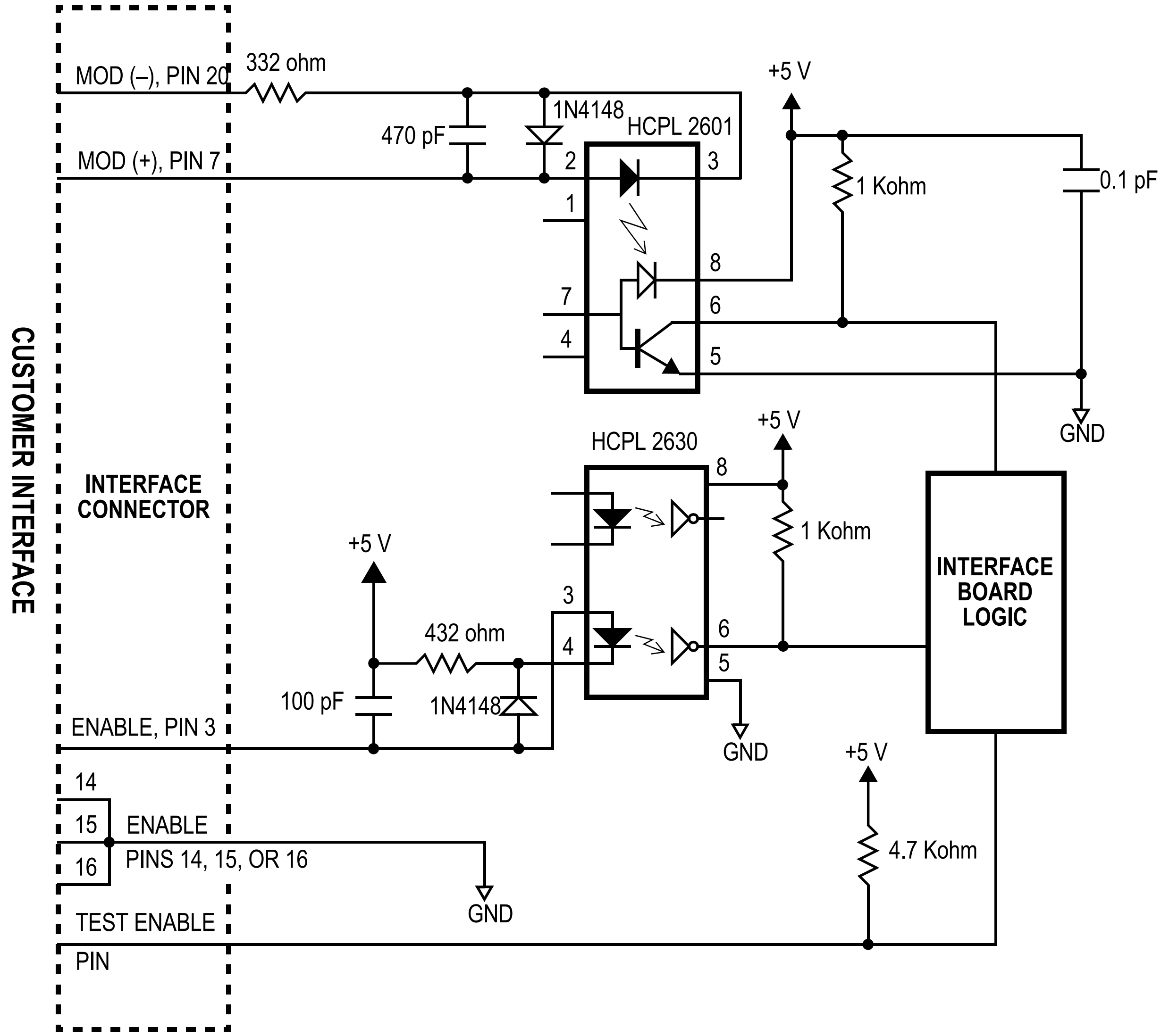


Figure 4-1. Input Circuit of RF Amplifier

Output Signal Recommendation

There are six output signals from the RF amplifier that indicate the status of the RF amplifier and laser tube. These six outputs provide useful information to the user on the function of the laser system. Figure 4-3 shows a schematic of the output circuits located in the RF amplifier interface circuit. Although monitoring of these six outputs is not required, it is strongly recommended for the overall ease of use of the complete system.

Their purpose is to warn the user of potential faults and can assist in the diagnosis of several types of operating problems. A common situation when these warnings are useful is when incorrect pulse widths and pulse periods have been selected. One example would be

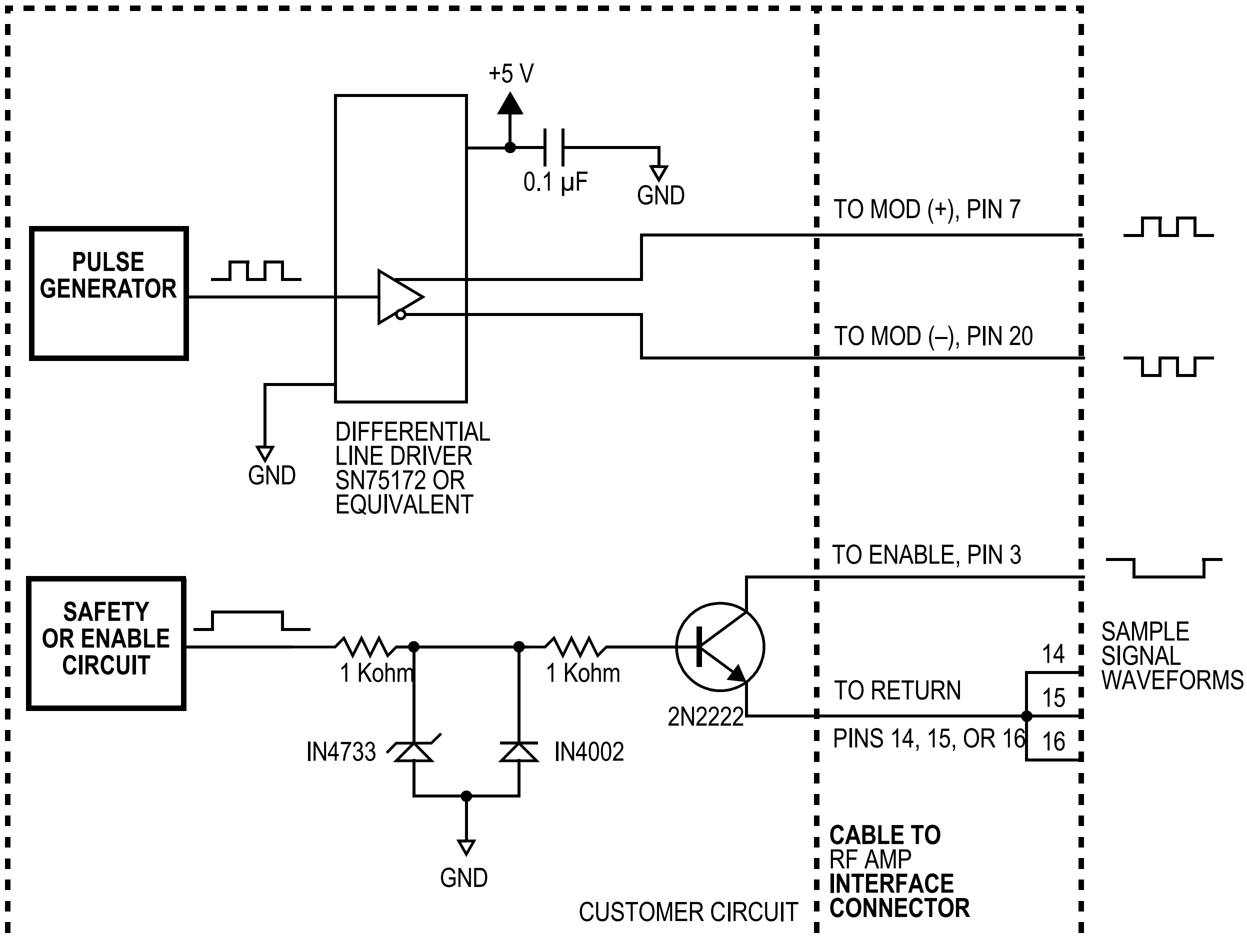


Figure 4-2. Typical Drive Circuit for RF Amplifier

Table 4-3. Examples of Line Drivers Meeting RS-422A

Device Part Number	Description	Manufacturer
SN75172	Quad Driver	Texas Instruments
AM26LS31C	Quad Driver	AMD
MC3487	Quad Driver	Motorola
SN75174	Quad Driver	Texas Instruments
SN55ALS192	Quad Driver	Texas Instruments
SN55ALS194	Quad Driver	Texas Instruments
SN55158	Dual Driver	Texas Instruments
SN75ALS191	Dual Driver	Texas Instruments

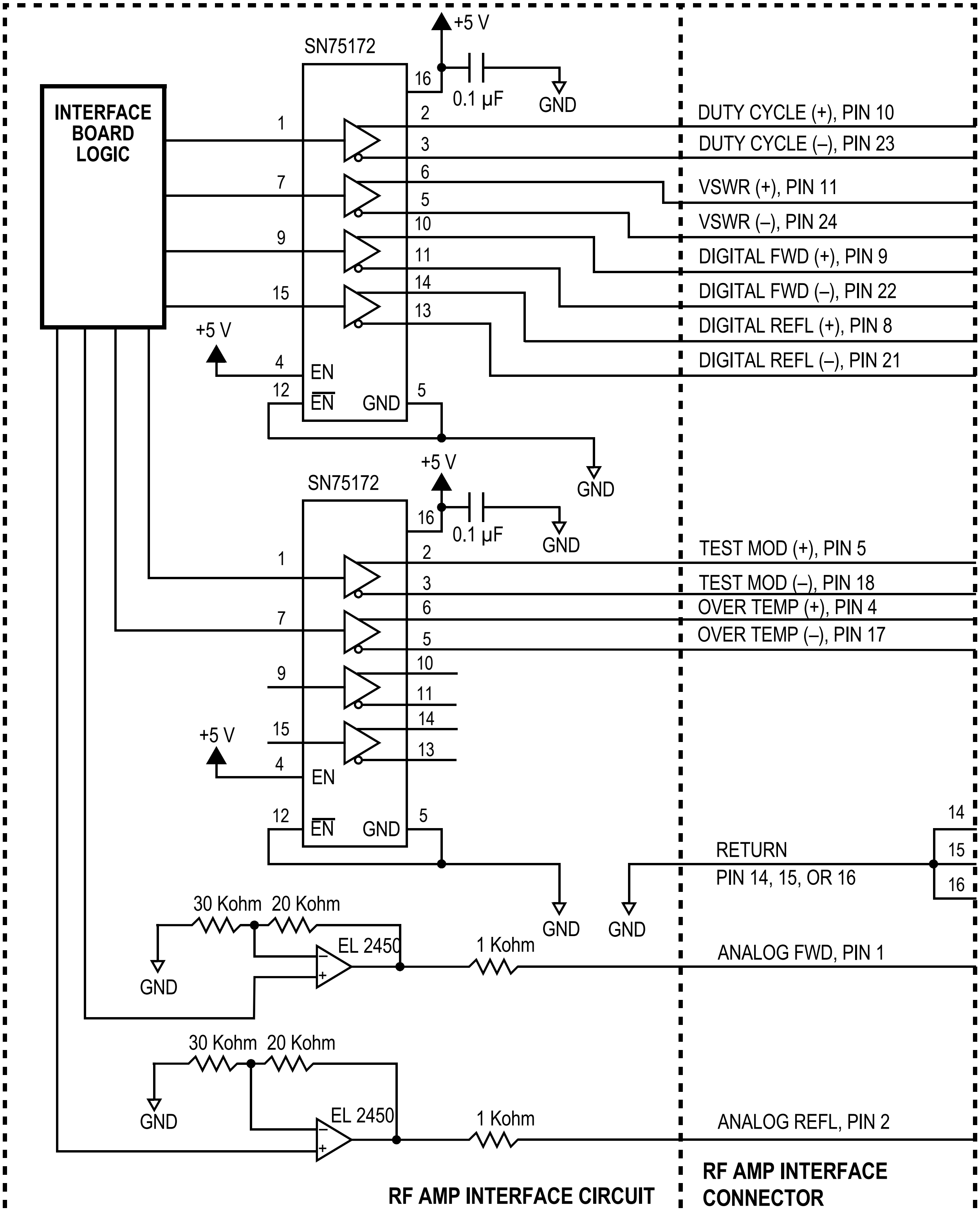


Figure 4-3. Output Circuit of RF Amplifier

selecting a duty cycle of 70% and the user observing unstable laser performance. The warning indicator DUTY CYCLE LIMIT will show the error and make it possible to rapidly correct this problem.

Output Signal Description

The DUTY CYCLE LIMIT and the VSWR LIMIT warnings indicate when the control circuitry in the RF amplifier is activated and limiting the operation of the RF amplifier. When these functions are activated, the output power of the laser can be unstable or much lower than expected. If there is a DUTY CYCLE LIMIT warning, then check the MODULATION pulse width and pulse period to ensure that they are not exceeding maximum duty cycle limit or 1000 µs pulse width.

The VSWR LIMIT indicates that the ratio of the reflected RF voltage to the forward RF voltage has exceeded a preset limit. This typically indicates a problem with the tube. In some transient starting situations, the VSWR LIMIT warning will be activated. We recommend checking the status of this indicator about 100 ms after starting the MODULATION signal. If the warning signal persists during stable operation, the most likely source is a problem with the laser tube. The unit should be replaced if the laser power is low.

The DIGITAL FORWARD warning indicates that the forward RF voltage is below a preset limit. As with the VSWR limit, it is recommended to start monitoring this warning 100 ms after starting the laser MODULATION signal. If the warning persists during continuous operation of the laser, then the source of the problem is the laser head. The unit should be replaced if the laser power is low.

The DIGITAL REFLECTED warning indicates that the reflected RF voltage is above a preset limit. As with the DIGITAL FORWARD and DUTY CYCLE LIMIT warnings, it is recommended to monitor this indicator about 100 ms after starting the MODULATION signal. If the warning persists during continuous operation of the laser, then the source of the problem is the laser head. The unit should be replaced if the laser power is low.

Monitoring Circuit Example

An example of a monitoring circuit that can be connected to the output of the RF amplifier interface circuit is indicated in Figure 4-4. Suitable input devices are shown in Table 4-4.

The Diamond output circuits shown in Figure 4-3 is designed to use line receivers meeting the requirements of EIA Standard RS-422A. Common mode voltages on the drive signals should be kept as low as possible and cannot exceed ±15 Volts relative to the laser system ground. Examples of line receivers are shown in Table 4-4. It is recommended that the OVER TEMP outputs also be monitored.

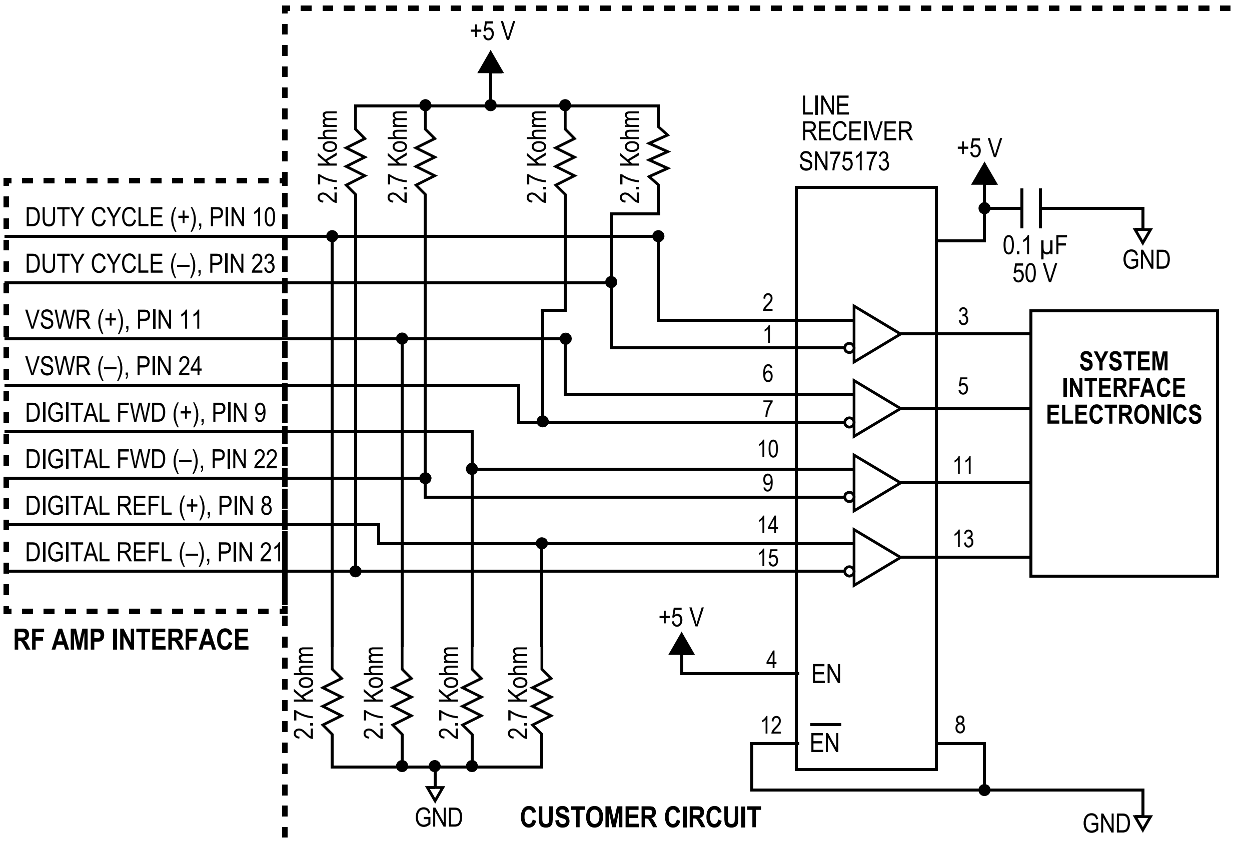


Figure 4-4. Typical Monitoring Circuit

Table 4-4. Examples of Line Receivers Meeting RS-422A

DEVICE PART NUMBER	DESCRIPTION	MANUFACTURER
SN75173	Quad Receiver	Texas Instruments
AM26LS32A	Quad Receiver	AMD
MC3486	Quad Receiver	Motorola
SN75175	Quad Receiver	Texas Instruments
SN55ALS193	Quad Receiver	Texas Instruments
SN55ALS195	Quad Receiver	Texas Instruments
SN55157	Dual Receiver	Texas Instruments

Test Function Operation

The test function provides a method to check the operation of the input circuit of the RF amplifier interface. Enabling the test function provides a pulse width of 100 µs at a pulse period of 1000 µs. Using this test function will operate the RF amplifier and make it possible for laser operation. Ensure that when this function is used that all personnel are in a safe location and that the laser beam is suitably blocked.

When using the test circuit ensure that all personnel are not in the beam path and that the laser beam is suitably blocked.

A schematic of the test circuit and connections that will enable its operation are shown in Figure 4-5. Both the ENABLE and the TEST ENABLE functions must be connected to the RETURN for the laser to operate. For purposes of safety one of these switches should be a momentary switch.

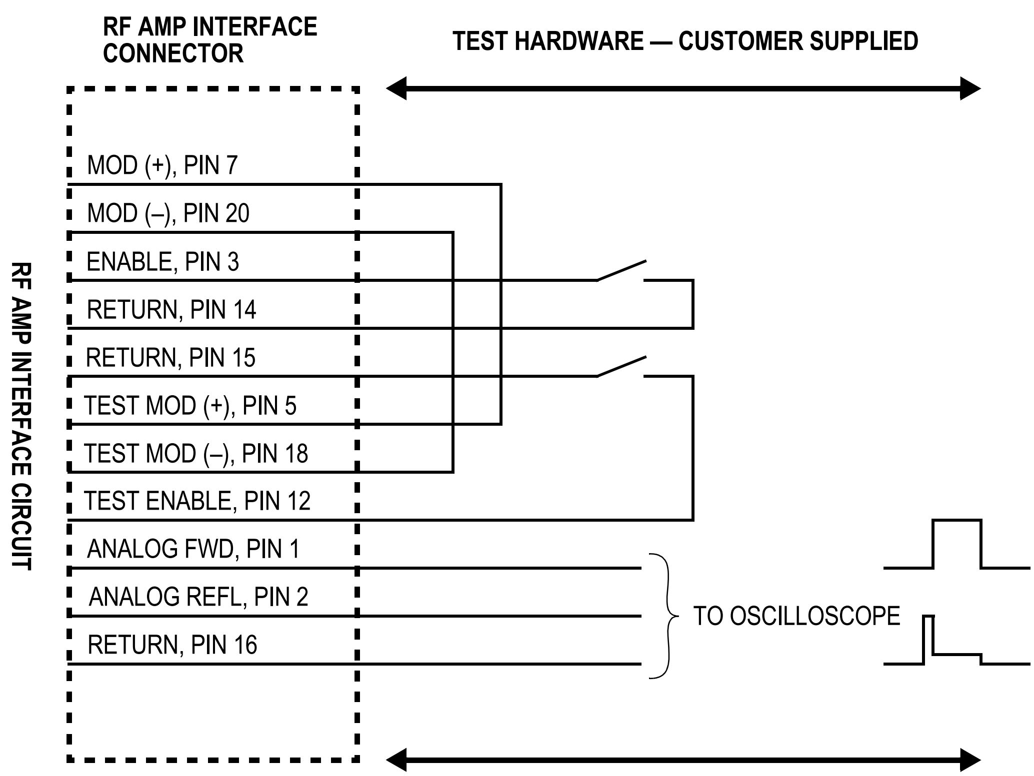


Figure 4-5. Interface for Test Function

The test function provides a reliable method to check the function of the RF amplifier interface circuit, the output of the RF amplifier, and the output of the laser. If there is a problem with the interface circuitry, then the RF amplifier and the laser will not operate when the test circuit is connected as shown in Figure 4-5. The output of the RF amplifier can be monitored by observing the ANALOG FORWARD signal. It should be as shown in Figure 4-6 with peak voltage of 4.0 V when observed on a oscilloscope.

Output Signal Waveforms

The output waveforms of the DUTY CYCLE LIMIT, VSWR LIMIT, DIGITAL FORWARD, and DIGITAL REFLECTED are shown in Figure 4-6 through Figure 4-10 along with the ANALOG FORWARD output and the MODULATION input signals. The ANALOG FORWARD signal is shown to clearly indicate when RF power is being delivered to the laser tube under a variety of conditions. The first set of waveforms is for normal operation without any warnings activated and the following three set are warnings in the active condition. All of these signals are at the noted pinout indicated beside the figure and referenced to ground. An active VSWR LIMIT is shown in Figure 4-9 and notes that the ANALOG FORWARD signal shows that the tube is operating at 10% duty cycle when MODULATION signal is at a 30% duty cycle. A similar situation is shown in Figure 4-10 for a DUTY CYCLE LIMIT in the active state. The MODULATION signal is at a 67% duty cycle while the tube is actually operating at an average of 60% duty cycle. Similar limiting of the pulse width will also occur when the pulse width is longer than 1000 µs.

It is recommended to sense the status of the output signals from the RF amplifier on the trailing edge of the MODULATION signal. All of the output signals are present for 1 to 5 µs after the MODULATION(+) signal makes the transition from the TTL high to the TTL low state. There are transient starting conditions that will activate these warnings. If possible design the monitoring system of the these warning signals to neglect the first 100 ms of operation after the laser has been off for a period of time longer than a few seconds. This will minimize the number of false warnings.

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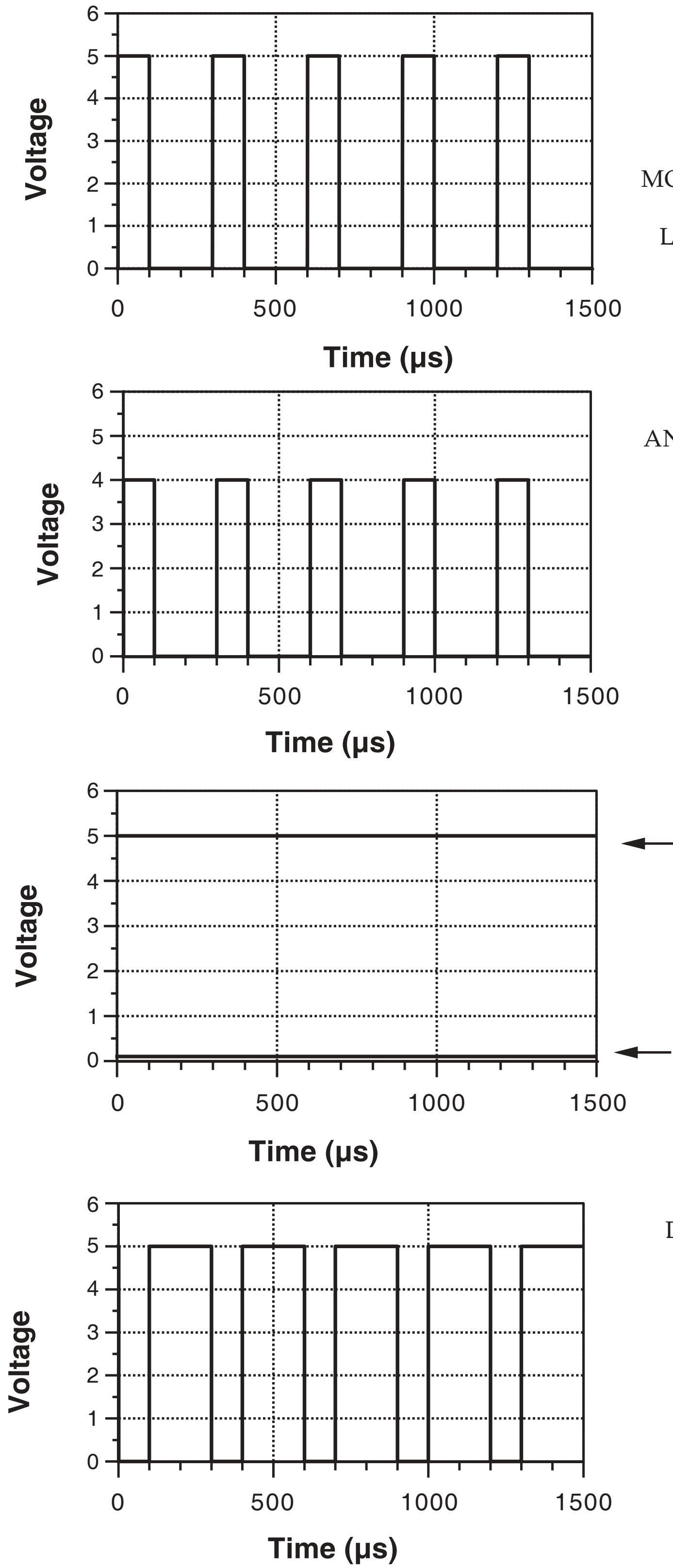
Pulse width = 100 µs
Pulse period = 300 µs



MODULATION(+) signal
Pin 7 vs Pin 14
Laser ON= TTL High

ANALOG FORWARD
Pin 1 vs Pin 14
Laser ON= TTL High

DIGITAL REFLECTED RF(+)
Pin8 vs Pin 14

DUTY CYCLE LIMIT(+)
Pin 10 vs Pin 14
and
VSWR LIMIT(+)
Pin 11 vs Pin 14

DIGITAL FORWARD(+)
Pin 9 vs Pin 14

Figure 4-6. RF Amplifier Output Signals – Normal Operating Conditions

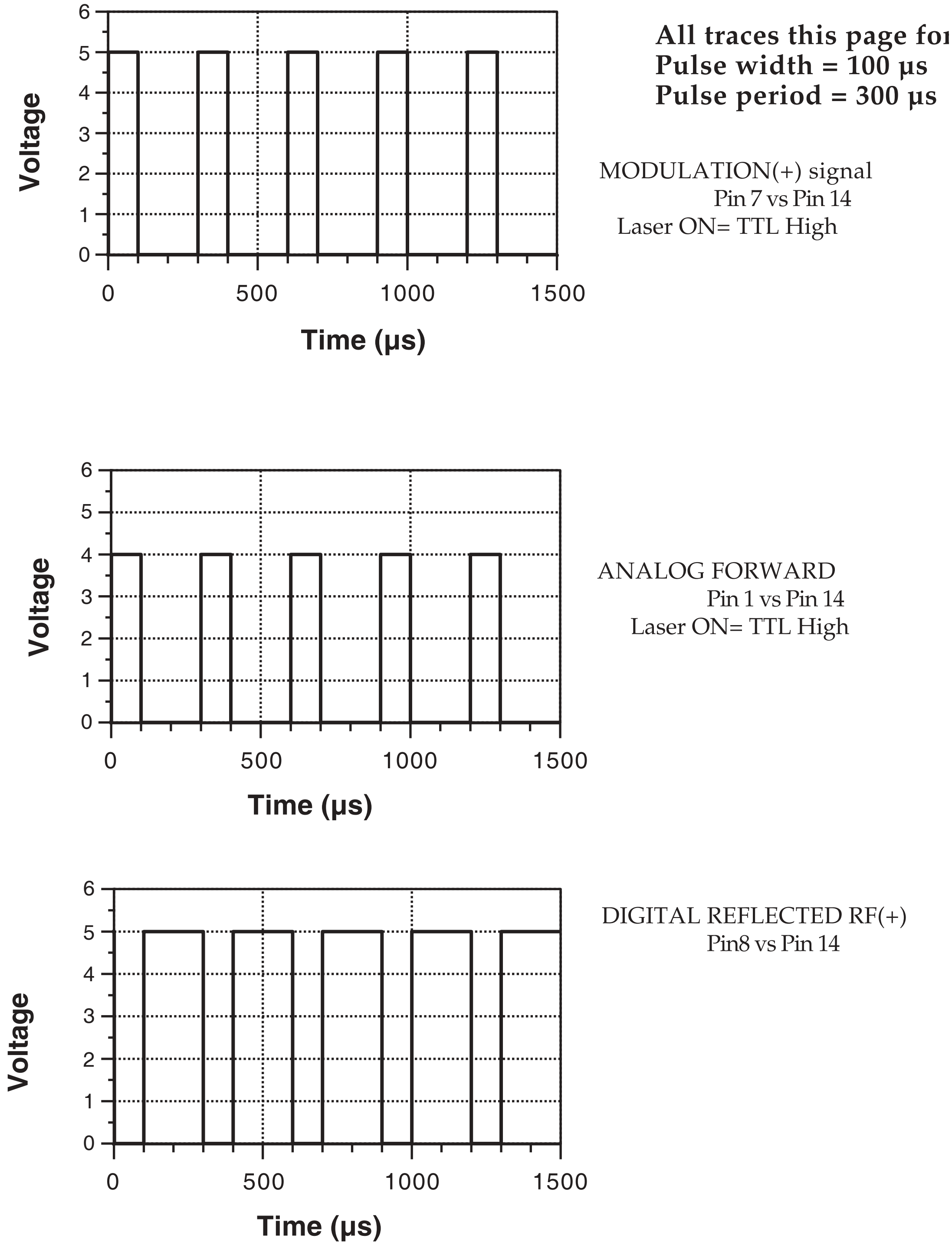
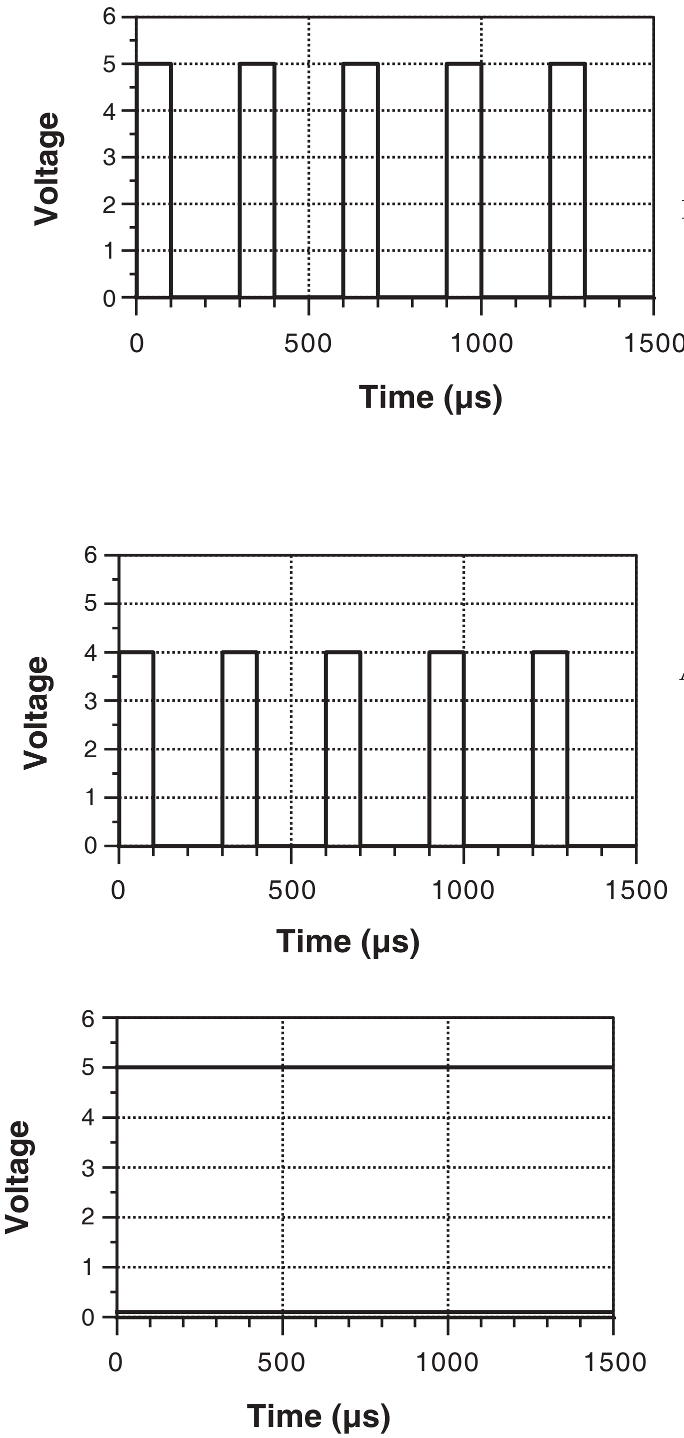


Figure 4-7. RF Amplifier Output Signals for Active State of DIGITAL REFLECTED Signal (Failed Condition)



All traces this page for
Pulse width = 100 µs
Pulse period = 300 µs

MODULATION(+) signal
Pin 7 vs Pin 14
Laser ON= TTL High

ANALOG FORWARD
Pin 1 vs Pin 14
Laser ON= TTL High

DIGITAL FORWARD RF(+)
Pin 9 vs Pin 14

Figure 4-8. RF Amplifier Output Signals for Active State of DIGITAL FORWARD Signal (Failed Condition)

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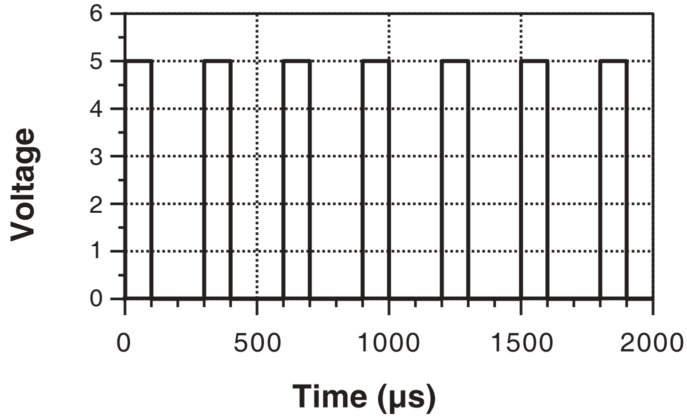
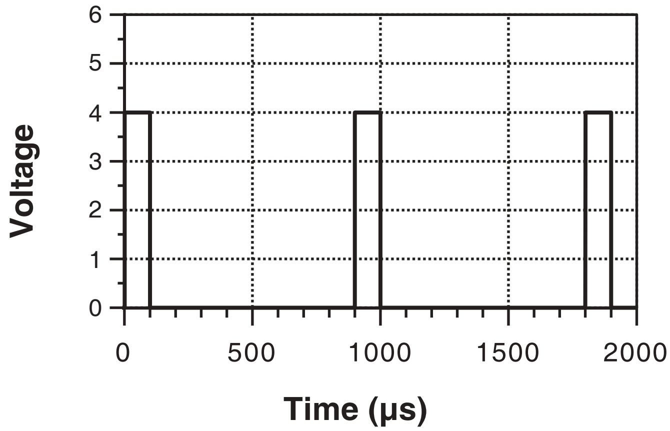
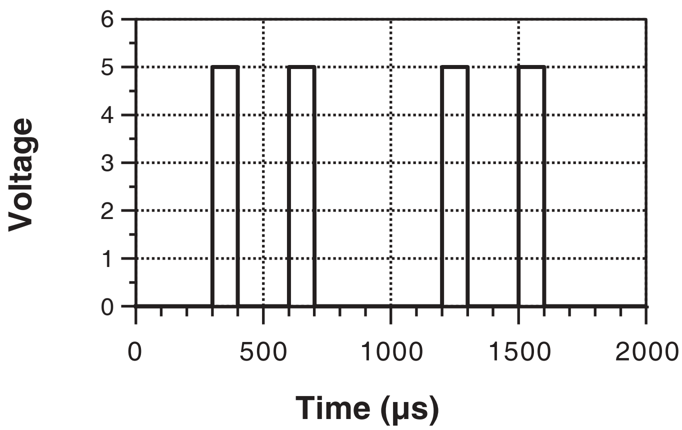
Pulse width = 100 µs
Pulse period = 300 µs



MODULATION(+) signal
Pin 7 vs Pin 14
Laser ON= TTL High



ANALOG FORWARD
Pin 1 vs Pin 14
Laser ON= TTL High



VSWR LIMIT(+)
Pin 11 vs Pin 14

Figure 4-9. RF Amplifier Output Signals for Active State of VSWR LIMIT Signal (Failed Operating Condition)

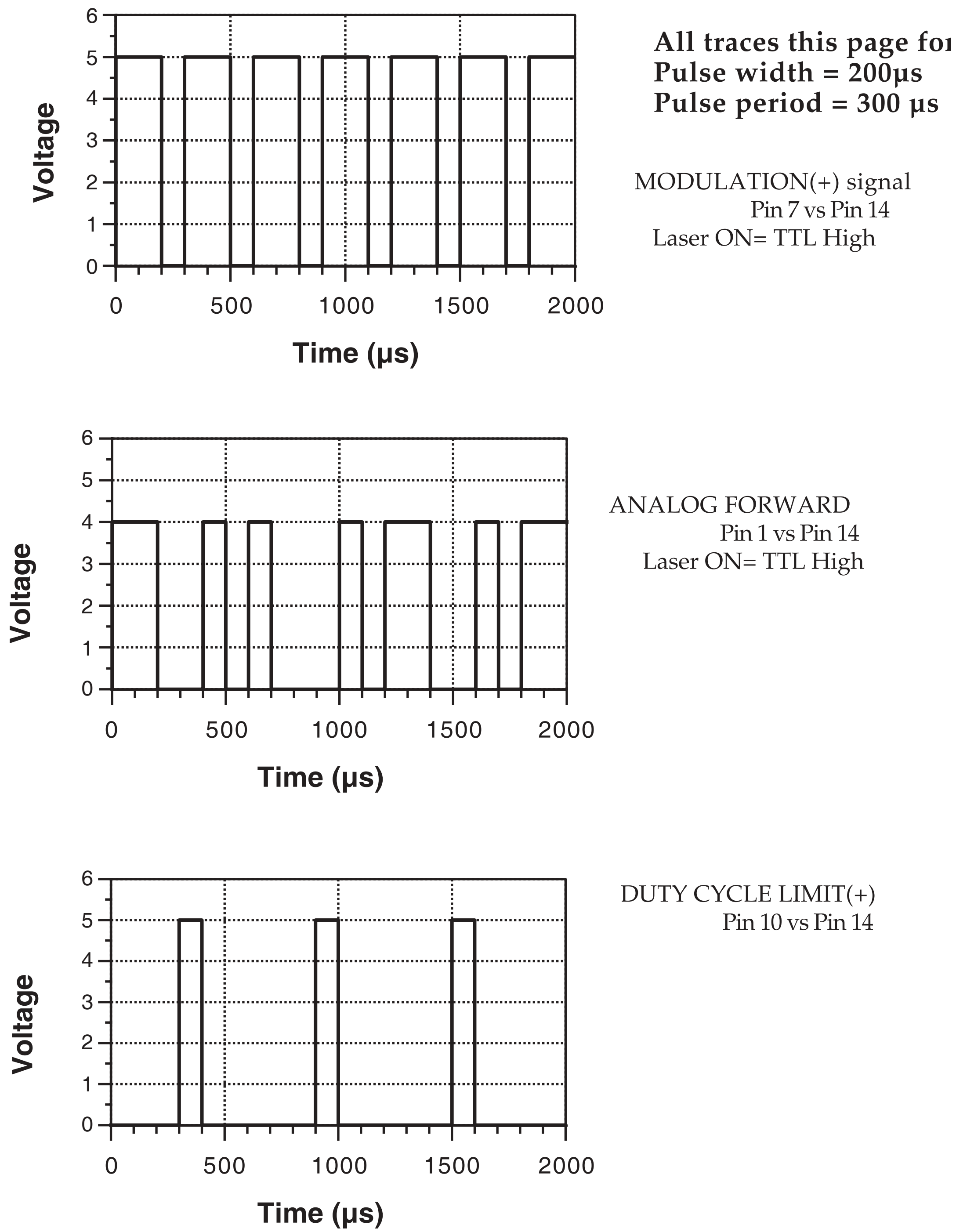


Figure 4-10. RF Amplifier Output Signals for Active State of DUTY CYCLE LIMIT Signal (Failed Operating Condition)

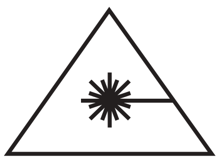
CHAPTER FIVE: OPERATION

Introduction

This chapter provides startup and shutdown procedures, and a description of the Diamond controls, indicators, and interface connectors.

Startup Procedure

This procedure assumes that the laser has been installed in accordance with the procedures in Chapter Three, Utility Requirements and System Installation.

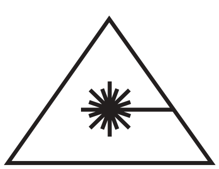


Ensure all personnel in the area are wearing laser safety glasses appropriate for the wavelengths and power levels produced.

Refer to Chapter Six, Maintenance and Troubleshooting, to resolve any faults or problems encountered during startup.

Before proceeding, ensure all safety practices are in effect including those in Chapter Two of this manual, and that the laser is directed in a safe manner so that the output beam will not strike an unintended target.

1. Place a suitable power meter head or a beam stop in front of the laser to block the output beam.
2. Turn on the laser system cooling water. To avoid over-pressurization of the cooling system, open the drain valve before opening the supply valve. Check the system interlock to ensure the water flow switch is closed.



Failure to perform the next step could result in the beam exiting the laser when power is applied.

3. Ensure the laser functions in Table 5-1 are observed.
4. Turn on the facility circuit breaker and facility On/Off switch if installed.

Table 5-1. Laser Turn-on Functions

FUNCTION	COMMENT
DC power supply	Off
Modulation enable	Off. Table 4-2 lists pinouts for the RF amplifier. The RF amplifier is disabled when pin 3 is not connected to return.
Pulse width	200 µs. A 200 µs pulse width in combination with a 6000 µs pulse period is recommended for initial turn-on. This combination should result in 15 to 30 Watts output power.
Pulse period	6000 µs. A 6000 µs pulse period in combination with a 200 µs pulse width is recommended for initial turn-on. This combination should result in 15 to 30 Watts output power.

5. Turn on the DC power supply. Table A-3 lists pinouts for the DC power supply. The following should occur:
   - The preionizer in the laser head starts.
   - The +48 V indicator on the DC power supplies turn on.
6. Enable the RF amplifier by connecting the ENABLE function to RETURN. From initial cold system wait for a period of 20 seconds after applying DC before applying modulation command.
7. Turn on the modulation signal. Adjust the output as required. Refer to the paragraph below entitled, Adjusting the Diamond Output, for additional information.

Adjusting the Diamond Output

The Diamond can operate using various pulse formats which allows full user control of the output depending on the application. Parameters that can be controlled by the operator that affect the output include:

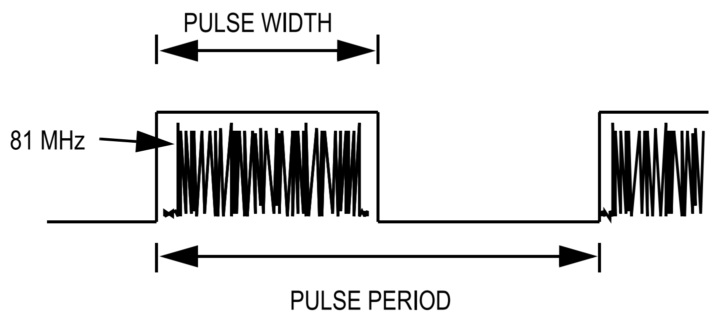
- Pulse period: 10 µs minimum
  (or pulse frequency: 100 kHz maximum)
- Pulse width: 3 to 1000 µs

Varying one or both of these parameters impacts the following output characteristics:

- Average output power
- Peak pulse power (pulse energy)
- Duty cycle (range: 0 to 60%)

The total number of possible input parameter variations and the resulting output is quite large. The following discussion provide graphs and examples of many of the possibilities:

A graphical definition of the pulse width is shown in Figure 5-1. During the time interval of the pulse width, the RF power is directed to the laser head. In the Diamond laser system, the RF frequency is 81 MHz. The pulse width is the time that the RF is turned on and the pulse period is the time between the leading edges of these repetitive pulses. Another way to describe the pulse period is the pulse frequency which is just the inverse of the pulse period. A pulse period of 1,000 μs corresponds to an operating frequency of 1000 Hz.

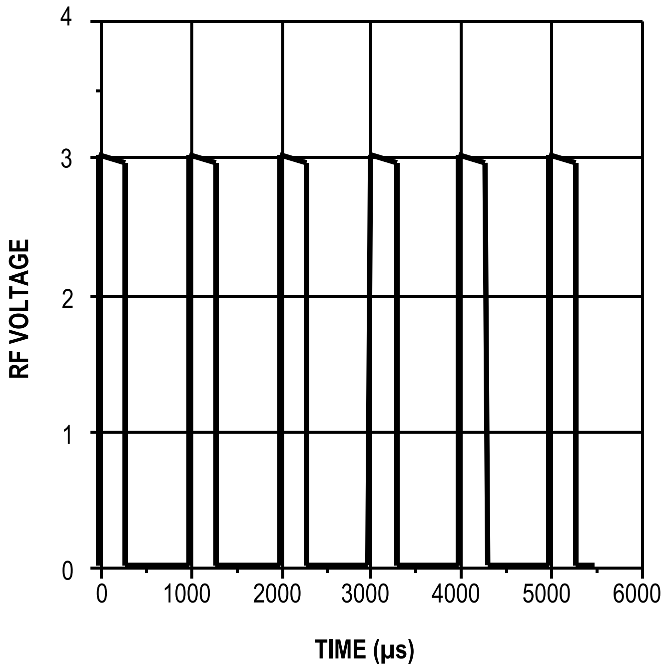


$$\text{DUTY CYCLE} = \frac{\text{PULSE WIDTH}}{\text{PULSE PERIOD}} \times 100\%$$

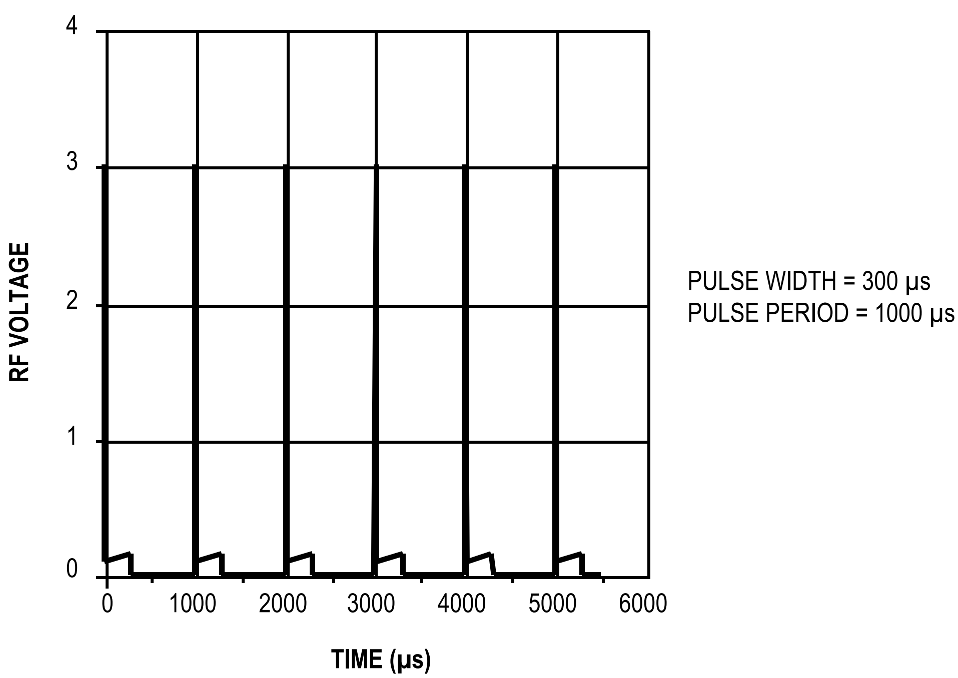
Figure 5-1. Typical Pulse/Modulation

In order to have an efficient laser, all the power that is developed by the RF amplifier must be delivered to the laser tube. In practice, over 95% of the power that is developed by the RF amplifier is delivered to the laser tube and the remaining power is reflected back toward the RF power supply. The waveforms of the forward RF voltage directed to the tube and then reflected are shown in Figure 5-2. These parameters are important in the function of the Diamond laser system and they have several related warning functions discussed in Chapter Four.

In order to adjust the laser power, two different alternatives are possible and these are shown in Figure 5-3. The center illustration shows the starting condition with a 100 μs pulse width, a pulse period of 1000 μs and a typical output of about 40 W. One method to increase the laser power is to increase the pulse width and leave the pulse period the same. This is illustrated in the top trace in Figure 5-3. Under these conditions the pulse width has been



A. FORWARD RF



B. REFLECTED RF

Figure 5-2. Laser Tube Forward and Reflected Voltage Waveforms increased to 200 µs and the output power has increased to about 80 W. The other method to increase the laser power, is to decrease the pulse period while leaving the pulse width the same. The lower trace of Figure 5-3 shows the reduced pulse period of 500 µs and the same pulse width of 100 µs. The output power would increase to about 80 W.

Figure 5-4 and Figure 5-5 show the output power at different pulse widths for the G-100 and G-150 respectively. Each curve in these plots represents different pulse periods or operating frequency. Changing the pulse width has the effect of moving along one of the lines labeled with a pulse period. Changing the pulse period has the effect of moving vertically on this chart.

There are a large number of pulse widths and pulse periods that can deliver the same average output power. The correct pulse parameters depend on the specific application. Often the effective speed of the beam on the sample will determine the desired pulse period. As the speed increases, then the pulse period will need to be decreased. Often there are other factors such as edge finish which will be important in selecting both the pulse parameters and the average operating power for a specific process. As the pulse width is varied, there are also effects on the peak power available from the laser. The range of the peak power is illustrated in Figure 5-7. Generally, the peak power increases as the duty cycle decreases.

The form of the instantaneous output power is shown on Figure 5-6a. Each laser pulse has a 90 µs rise time to full power and on the trailing edge a similar 90 µs decay time from full power to no laser output. For laser pulses of several hundred microseconds duration, there is little impact on the laser performance due to this rise and fall time. But for pulses of about 100 µs and less, the actual laser output is more triangular in shape than square as shown in Figure 5-6b. The advantage of this characteristic is at the short pulse periods, the peak processing power decreases due the rise and fall time. This leads to more process control for many applications. As the pulse period is reduced for these triangular shaped peaks, the bases of the triangles merge into each other. This has the effect of being a quasi CW performance for these short pulse widths. This effect has been observed for pulse period of 100 µs and a pulse width of about 50 µs.

The high effective processing power of the Diamond laser results from its square-wave pulse performance. The primary variables of the effective processing power are the pulse width and the duty cycle. Figure 5-7 shows the range of the peak power during a pulse for various pulse widths. The pulse power is the average power during a single pulse. Increasing the duty cycle has the effect of moving vertically down on this graph.

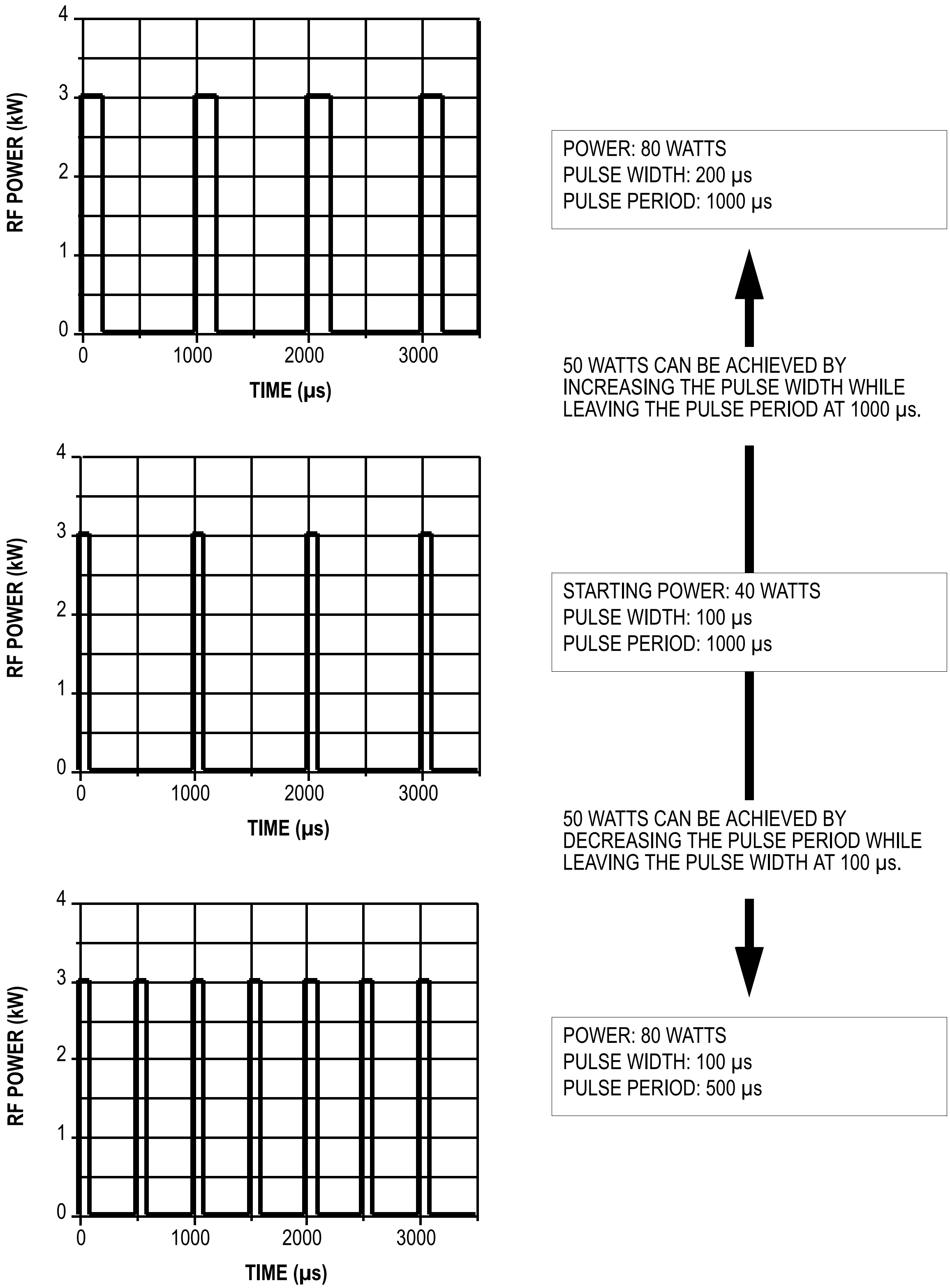


Figure 5-3. Example of Changing Laser Power

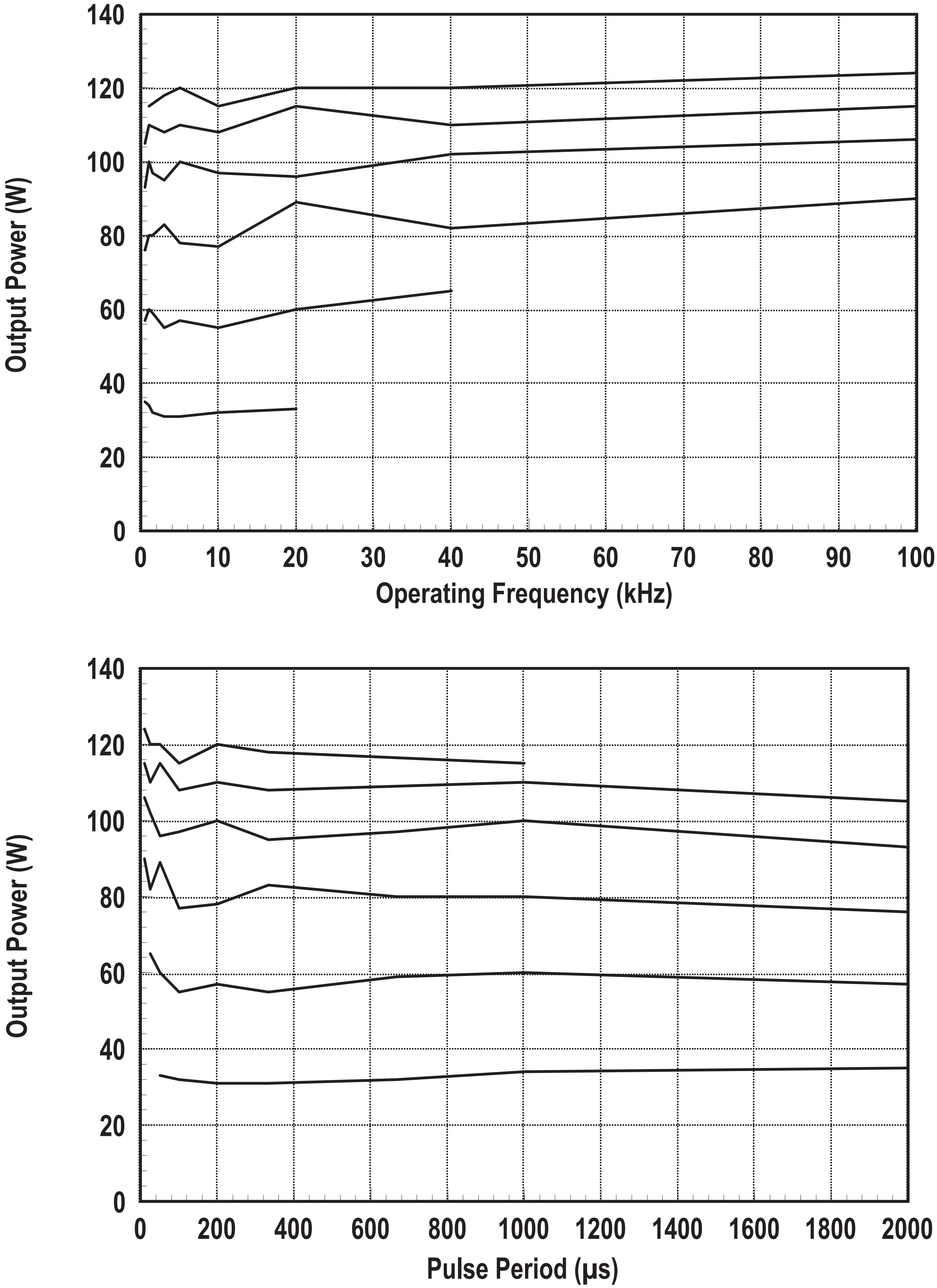
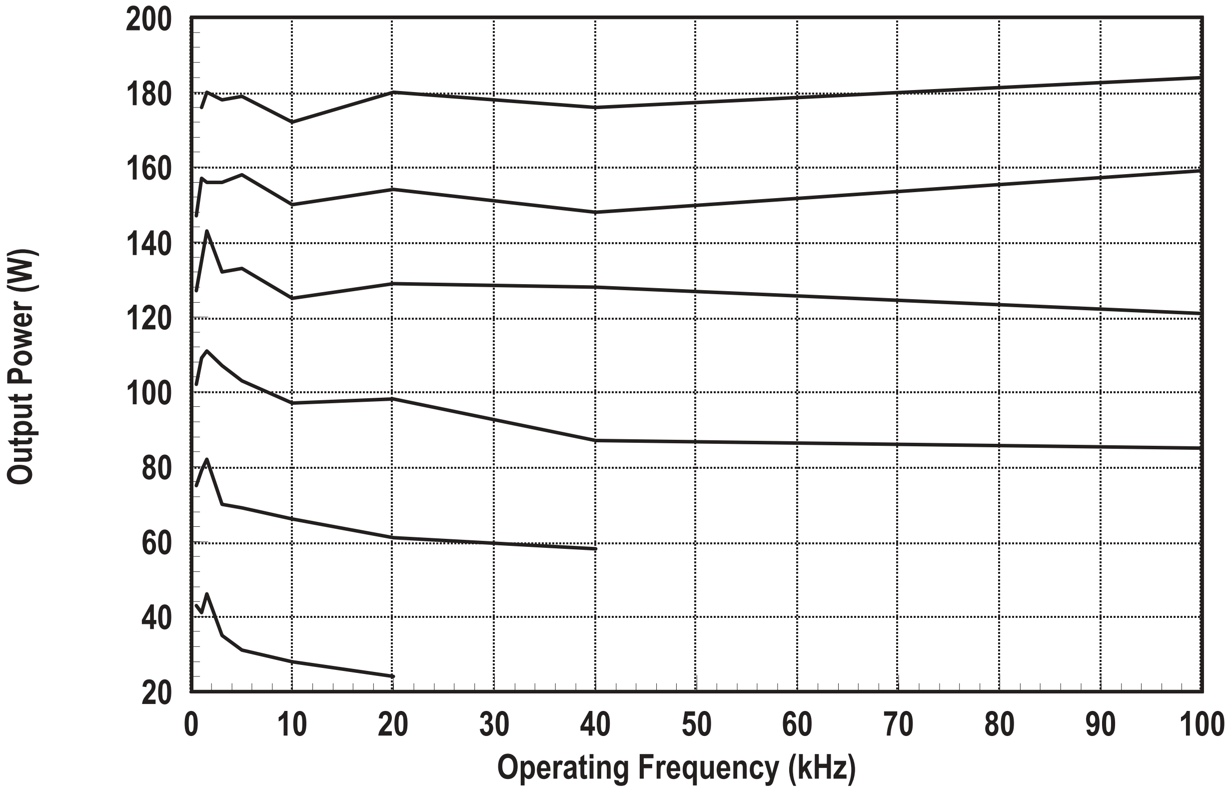


Figure 5-4. Typical Diamond G-100 Laser Output Power



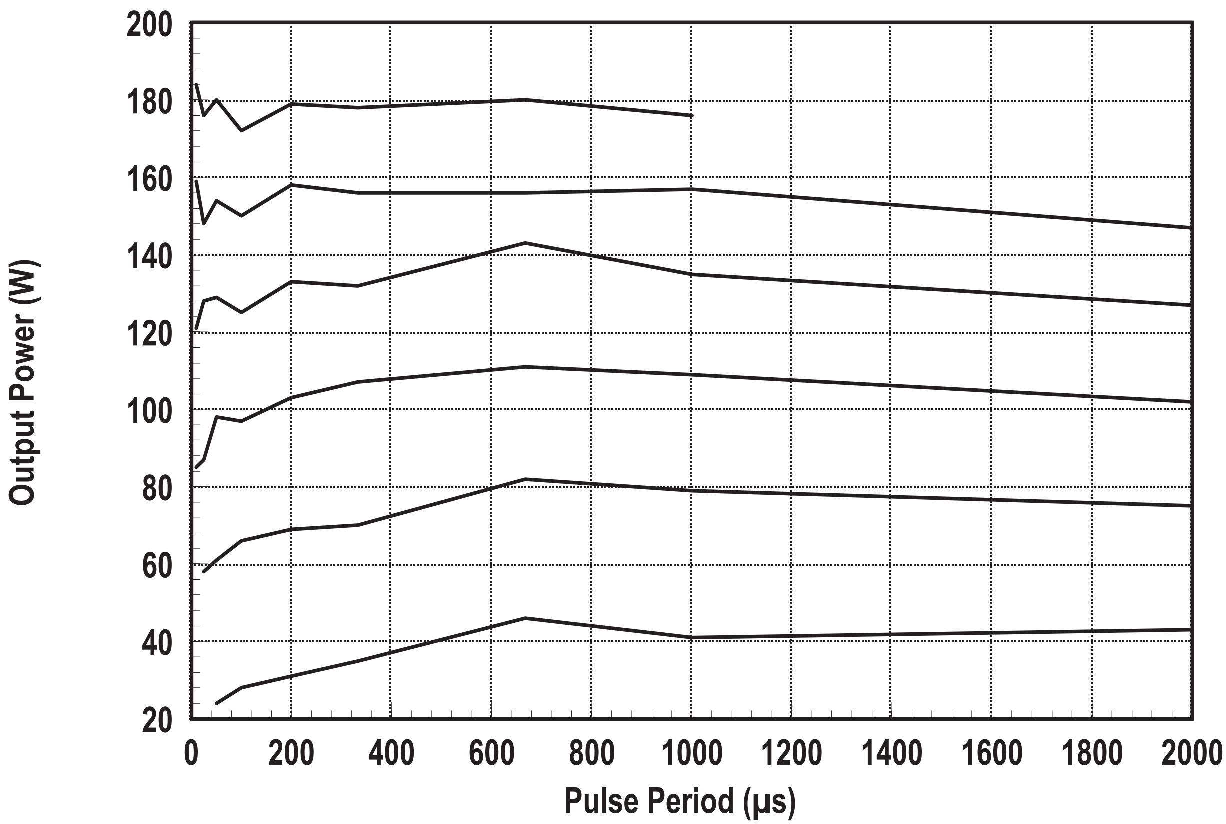
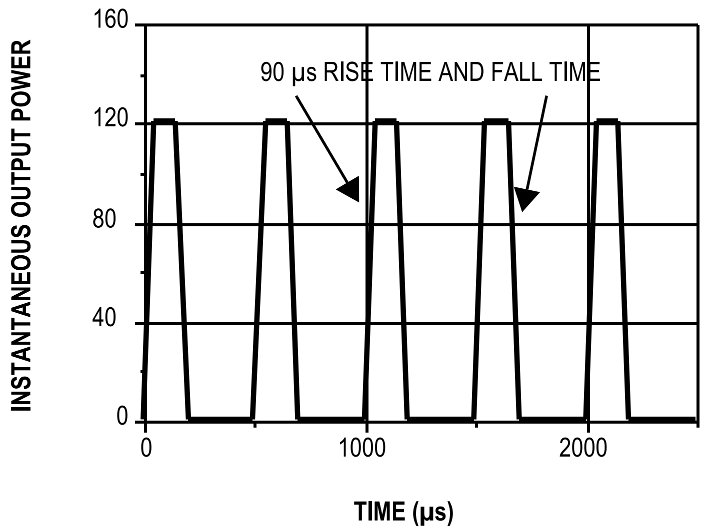
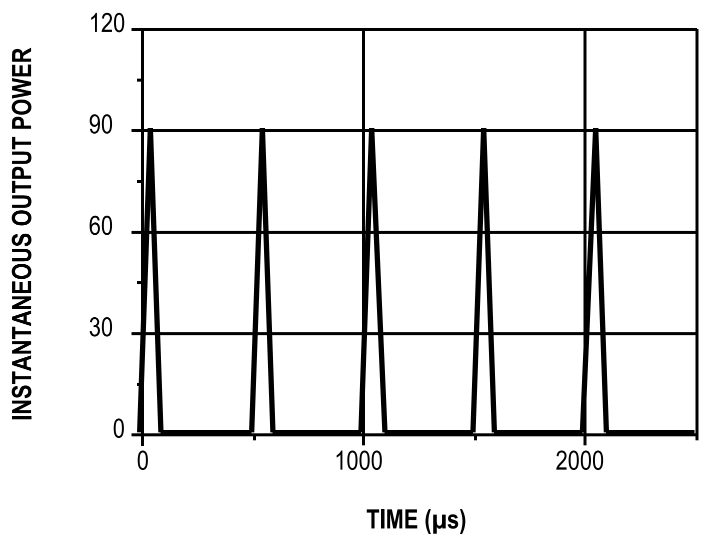


Figure 5-5. Typical Diamond G-150 Laser Output Power

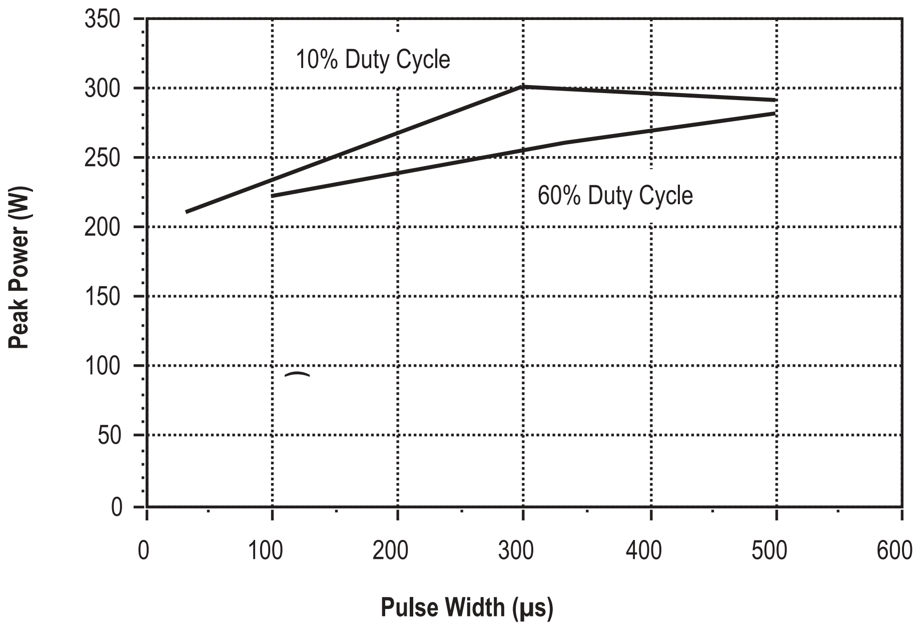


A. PULSE WIDTH: 200 µS, PULSE PERIOD: 500 µS

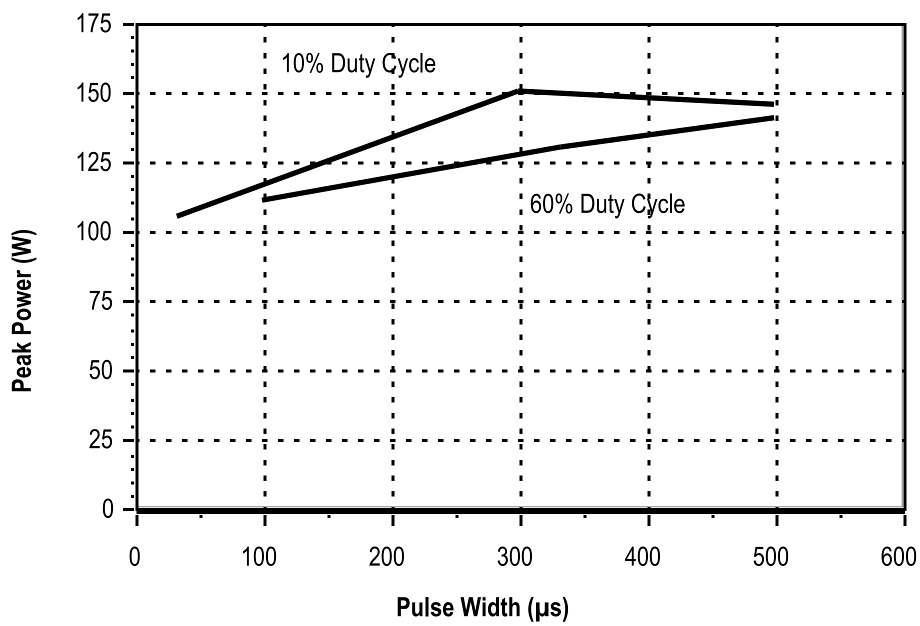


B. PULSE WIDTH: 50 µS, PULSE PERIOD: 500 µS

Figure 5-6. Instantaneous Laser Output Power G100 Showing Rise and Fall Times



A. G-150 Peak Power at 10% and 60% Duty Cycle

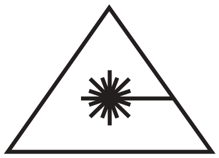


B. G-100 Peak Power at 10% and 60% Duty Cycle

Values shown are typical values obtained from a typical Diamond laser with less than 500 hours of operation. They are not intended to reflect performance for each individual laser.

Figure 5-7. Effective Processing Power vs. Pulse Width

Shutdown Procedure



Failure to perform the next step could result in the beam exiting the laser when power is applied during turn-on.

1. Set the laser system functions as indicated in Table 5-2. This step is all that is required for temporary shutdown when operating in a normal environment. If the humidity is high or for full system shutdown, complete the following steps.
2. Turn off the facility circuit breaker and facility on/off switch if installed.
3. Wait approximately 30 seconds for the system to cool down, then turn off the laser system cooling water.

Table 5-2. Control Unit Settings for Laser Shutdown

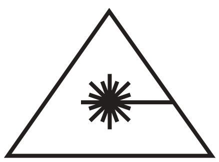
CONTROL UNIT SWITCH	INDICATION
Output beam	Position a beam or suitable power meter to block the output beam.
Modulation	Off.
DC power supply	Off (the +48 VDC indicator turns off.)

CHAPTER SIX: MAINTENANCE AND TROUBLESHOOTING

Introduction

This chapter contains preventive maintenance procedures, troubleshooting, and corrective actions. The electrical interface that these are based on include the mandatory functions and the recommended warning functions. Without these functions available in some form, troubleshooting the laser system is extremely difficult.

This chapter includes troubleshooting procedures for the DC power supply option provided by Coherent.



To perform the procedures in this chapter, there is potential access to laser output power. Follow the below listed safety guidelines:

Safety Guidelines

- Perform the shutdown procedure before performing functions that will lead to laser output.
- Ensure the laser beam is directed at a power absorber or into a power meter.

Preventive Maintenance

Monthly inspection of water and electrical connections will assist in keeping the laser system in good operating condition.

Water System Inspection

Inspect water hoses, fittings, and connections for signs of wear, cuts, nicks, corrosion, or leaks. Water connections are located on the laser head. In addition, inspect laser system connections to facility water supply and drain lines. Repair water leaks and replace worn hoses immediately.

Optics Inspection and Cleaning

Since the optical train is sealed, periodic inspection and cleaning of optical components is not required. Periodic maintenance of the beam delivery optics will be required.

Purge Gas Filter Kit (option)

Regular maintenance of the purge gas filter kit is required to ensure maintaining the required quality of the purge gas entering both the laser head and the beam delivery optics.

On a weekly basis:

- Inspect filters and gas lines for any sign of leaks or damaged purge tubing. Repair leaks and replace any damaged purge tubing.
- The coalescing filters will collect both liquid oil and water and will automatically discharge this liquid when it reaches a specific level. Push the float at the bottom of the filter bowl to make sure that it moves freely.

Every six months:

- Replace filter cartridges in side filter assemblies. Replace more frequently if required. Remember the DX filter is first and the BX is the second filter as shown in Figure 3-1. To change the filter, first turn off the laser and turn off the purge gas. Remove the bowl of the DX filter and clean out bowl. Replace the DX filter and replace the bowl. Perform the same steps now for the BX filter.

Electrical Inspection

Do not remove the DC power supply cover or covers on the laser at any time. These units contain no user serviceable components.

Perform the shutdown procedures prior to performing the electrical inspection. Disconnect the DC power supply line cord from facility power.

- Inspect electrical connections to ensure good contact.
- Also check that wiring and insulation are in good condition, free of cuts, nicks, and excessive wear. Look for discoloration on the wire insulation, a sign that excessive heat is building up in the wire. In addition, inspect the wiring to your connector and the facility AC hook-up for signs of overheating.
- Inspect electrical connections inside the laser head.
- Ensure the DC connections at both the DC power supply and at the RF amplifier are securely connected.

Troubleshooting

Charts 1 through 4 provide troubleshooting flow charts with supplemental information referenced to the numbered paragraphs that are also part of the chart.

When troubleshooting the Diamond laser system, ensure that the laser output beam will be safely contained.

One practical method to determine power is by using a Coherent FieldMaster with a head capable of 150 Watts. There are a variety of manufacturers who can provide power meters. A 100 µs pulse width and 1000 µs pulse period will provide approximately 30 Watts of power.

Table 6-1. System Faults and Warning Indications

FAULT INDICATION	EXPLANATION/REMEDY
The DIGITAL FORWARD signal (pins 9 and 22) at the RF amplifier DB25 connector is active.	If this condition persists during continuous operation, RF power from the RF amplifier to the laser tube is lower than a factory set level indicating a potential problem with the RF amplifier. This signal should be checked 100 ms after starting the modulation signal. If the problem persists and laser power is low, replace the laser.
The DIGITAL REFLECTED signal (pins 8 and 21) at the RF amplifier DB25 connector is active.	If this condition persists during continuous operation, reflected RF power from the laser tube to the RF amplifier is greater than a factory set level indicating a potential problem with the tube. This signal should be checked 100 ms after starting the modulation signal. If the problem persists and laser power is low, replace the laser.
The VSWR LIMIT (pins 11 and 24) at the RF amplifier DB25 connector is active.	The VSWR LIMIT indicates that the ratio of the reflected RF voltage to the forward RF voltage has exceeded a preset limit. This typically indicates a problem with the tube. In some transient starting situations, the VSWR LIMIT warning will be activated. Check the status of this signal about 100 ms after starting the modulation signal. If the problem persists and laser power is low, replace the laser.
The DUTY CYCLE LIMIT (pins 10 and 23) at the RF amplifier DB25 connector is active.	The duty cycle is limited to 60% and the pulse width must be <1000 µs. Exceeding 60% duty cycle or a pulse width in excess of 1000 µs will cause this function to become active. Increase the modulation pulse period or reduce pulse width to correct this problem.
The OVER TEMPERATURE (pins 4 and 17) at the RF amplifier DB25 connector is active.	The cooling water temperature has exceeded the maximum temperature of 60°C (140°F). At this point the laser modulation is inhibited and there is no laser output. Check the water flow rate and decrease the inlet water cooling temperature. The inlet water temperature should not exceed a maximum of 35°C (95°F).

Chart 1. Laser Does Not Start (No Output Beam)

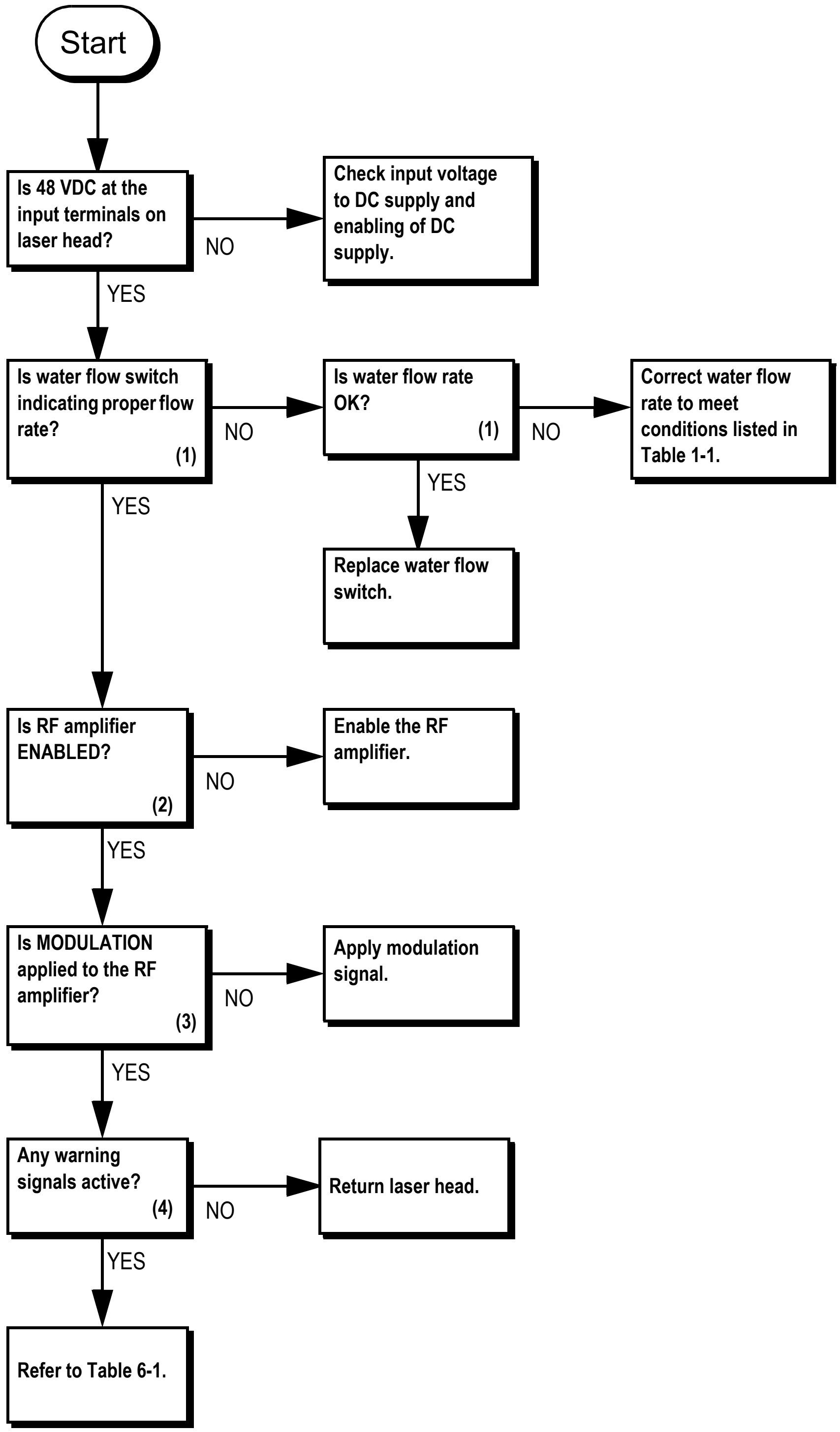


Chart 1. Laser Does Not Start (No Output Beam) (Continued)

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

Failure to use the water flow switch to inhibit laser operation when water flow is below minimum requirement can result in catastrophic damage to the laser and could result in voiding the warranty.

[1] There are two common methods of determining water flow rate. The simplest and most accurate method is to install an in-line flow meter in the return line. The alternate method which is described below uses a calibrated water bucket at the point water enters the drain or returns to closed loop cooling.

If water flow rate is below or only slightly above (+10%) specification, increase the water flow. If water flow fluctuates, investigate water uses which are connected to your water source. For example, a device on the same water line may cause a sudden drop in supply water flow.

If the laser system is connected to a closed-loop cooling system, the water flow rate test may not give a valid result. If the drain back-pressure of the closed-loop system is too high, the water flow rate through the laser system will not be as high as your measurement indicates. In this case, increase the input pressure of water going to the laser system or increase diameter of cooling water hoses.

An alternate method for determining if a closed-loop cooling system is causing the problem is to connect the laser system to a facility water supply to determine if this corrects the problem

[2] Use the ANALOG FORWARD signal as a monitor of the RF amplifier performance. The output is approximately +3 V when the RF amplifier is turned on and should have the same duration as the modulation pulse width. To enable the RF amplifier, the ENABLE function at pin 3 should be connected to the RETURN at pin 14.

[3] Use the ANALOG FORWARD signal as a monitor of the RF amplifiers performance. The output is approximately +3 V when the RF amplifier is turned on and should have the same duration as the modulation pulse width. Ensure that the MODULATION signal to the amplifier is present and that the signal at ANALOG FORWARD has the same pulse width and pulse period as the MODULATION signal.

[4] Warning signals monitored at the RF amplifier DB25 connector are listed below:

- Digital forward
- Digital reflected
- VSWR limit
- Duty cycle
- Over temperature

Chart 2. Low Output Power

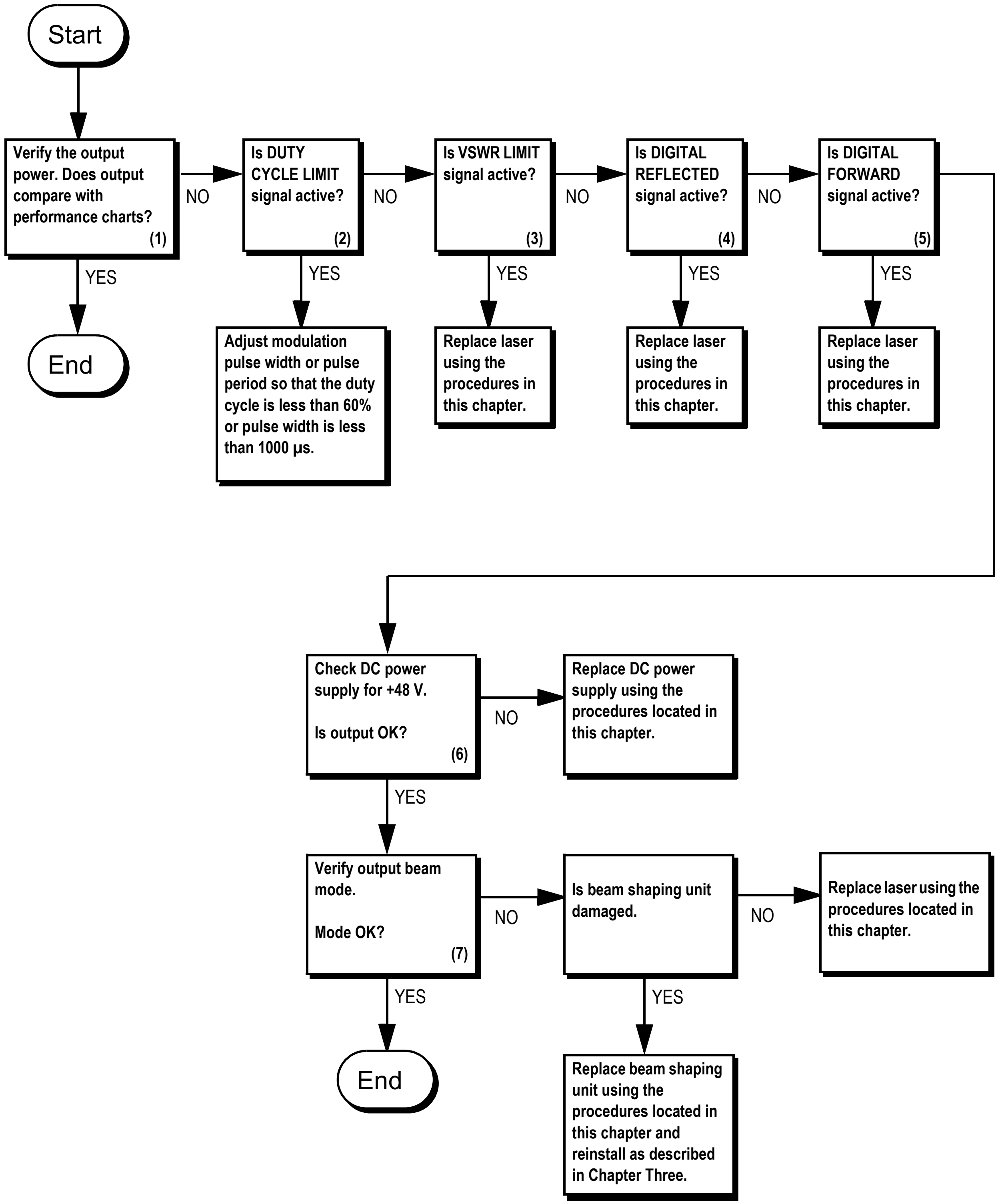


Chart 2. Low Output Power (Continued)

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

[1] The following must be considered when evaluating system output:

- An accurate power meter capable of handling the output power must be used. The power meter should be verified using a known good source or be calibrated on a periodic basis.
- Note that output power may degrade with tube age. For example, a tube with 4000 operating hours may not have the same output power as the same tube with 300 hours.

[2] The DUTY CYCLE LIMIT indicates that the selected duty cycle exceeds 60% or the selected pulse width is greater than 1000 μs. Correct the problem by reducing the pulse width or increasing the pulse period.

[3] The VSWR LIMIT indicates that the ratio of the reflected RF voltage to the forward RF voltage has exceeded a preset limit. In some transient starting situations, the VSWR LIMIT warning will be activated. Check the status of this signal about 100 ms after starting the modulation signal. If the warning signal persists during stable operation and laser power is low, replace the laser using the procedures in this chapter.

[4] When the DIGITAL REFLECTED signal at the RF amplifier DB25 connector is active during continuous operation, reflected RF power from the laser tube to the RF amplifier is greater than a factory set level indicating a potential problem with the tube. This signal should be checked 100 ms after starting the modulation signal.

[5] When the DIGITAL FORWARD signal at the RF amplifier DB25 connector is active during continuous operation, RF power from the RF amplifier to the laser head is lower than a factory set level indicating a potential problem with the RF amplifier. This signal should be checked 100 ms after starting the modulation signal.

[6] Measure the output of the DC power supply across the lugs on the RF amplifier. Refer to Figure 4-8 for the location of the lugs. If the LED on one of the DC power supplies is not lit, that power supply is not producing full power. Replace the DC power supply to achieve full power operation.

[7] Check mode quality as follows:

- Turn off modulation to the laser.
- A low output power setting (200 μs pulse width, 6000 μs pulse period) of 15 to 20 Watts is recommended.
- Position a mode card approximately 3 meters in front of the output beam. A thermal image plate can also be used to inspect mode.
- Apply a single modulation pulse to the laser. The output beam will mark the mode card. Inspect the card for asymmetric mode.

  If there are rings or partial rings surrounding the central beam, the laser beam is misaligned to the optical system and might require re-alignment. Re-alignment is a factory procedure which requires the system to be returned to Coherent.

Chart 3. Unstable Output Power

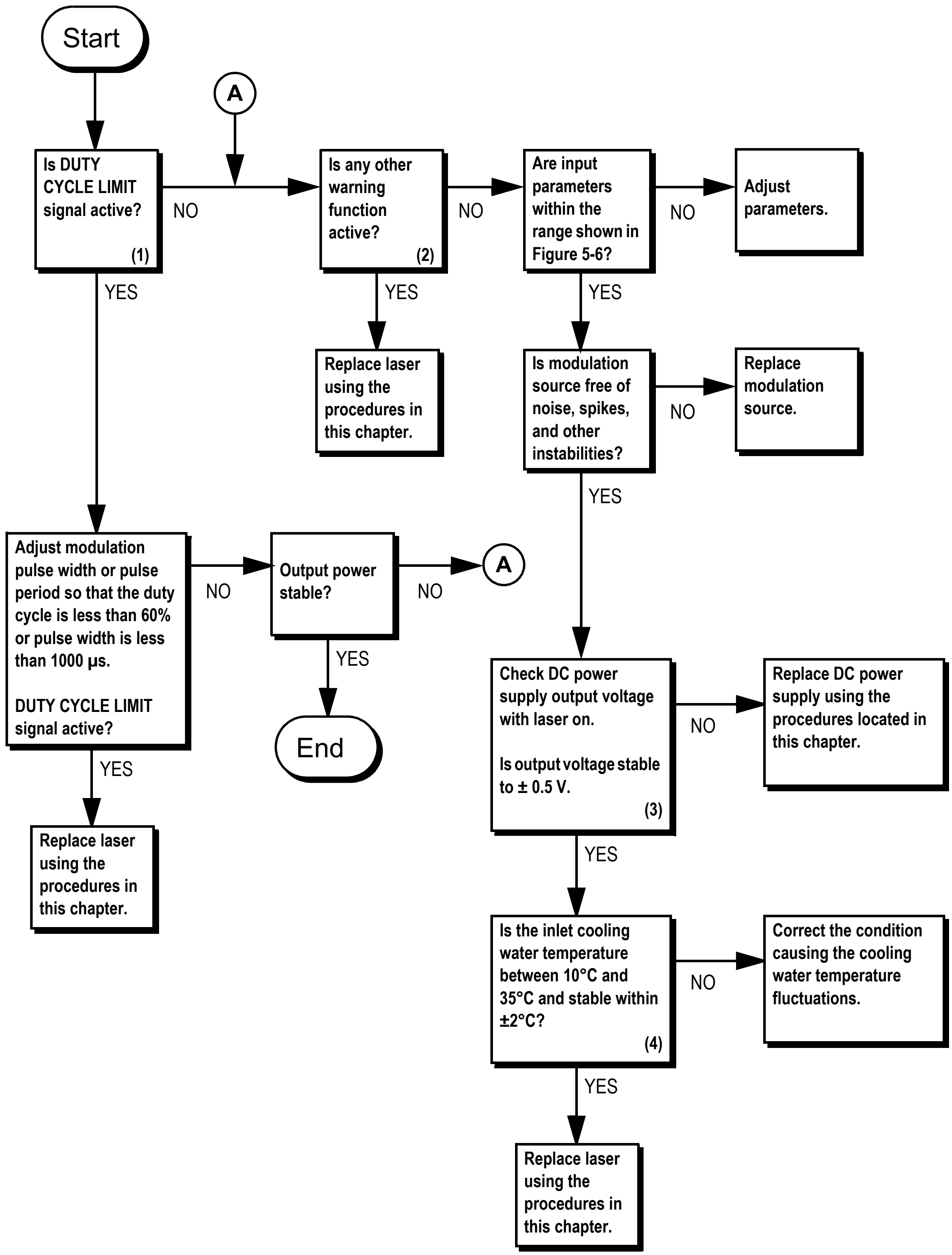


Chart 3. Unstable Output Power (Continued)

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

[1] The DUTY CYCLE LIMIT signal can be monitored at pins 10 (+) and 23 (–) at the RF amplifier DB25 connector. When this signal is active, the modulation selected is >60% or the pulse width exceeds 1000 µs. Reduce the duty cycle to <60% to or reduce the pulse width to <1000 µs to eliminate this problem. Reduce the duty cycle by lowering the pulse width or pulse period settings, or by lowering a combination of both settings.

[2] The VSWR LIMIT indicates that the ratio of the reflected RF voltage to the forward RF voltage has exceeded a preset limit. This typically indicates a problem with the tube. In some transient starting situations, the VSWR LIMIT warning will be activated. Check the status of this signal about 100 ms after starting the modulation signal. If the warning signal persists during continuous operation, and the laser power is low or unstable, return the laser to Coherent using the procedures in this chapter.

When the DIGITAL FORWARD signal at the RF amplifier DB25 connector is active during continuous operation, RF power from the RF amplifier to the laser head is lower than a factory set level indicating a potential problem with the RF amplifier. This signal should be checked 100 ms after starting the modulation signal. If the warning signal persists during continuous operation, and the laser power is low or unstable, return the laser to Coherent using the procedures in this chapter.

When the DIGITAL REFLECTED signal at the RF amplifier DB25 connector is active during continuous operation, reflected RF power from the laser tube to the RF amplifier is greater than a factory set level indicating a potential problem with the tube. This signal should be checked 100 ms after starting the modulation signal. If the warning signal persists during continuous operation, and the laser power is low or unstable, return the laser to Coherent using the procedures in this chapter.

[3] Measure the output of the DC power supply across the terminals labeled +48 VDC and 48 VDC RETURN on the laser head. Refer to Figure 4-4 for the location of the lugs. Operate laser over a range of duty cycles from 10% to 59%.

[4] There are two common methods of determining water temperature. A simple, economical, and most accurate method is a multi meter temperature accessory attached to a water hose fitting. The alternate method which is described below consists of touching the inlet water hose.

Check inlet water temperature by touching the cooling water inlet hose attached to the laser head. If the hose is warm to the touch, inlet water may be too hot for the system to turn on, or the system may shut down after a short operating period. Request that facilities personnel correct this problem. Refer to the specifications for correct inlet water temperature.

Chart 4. Degraded Mode Quality

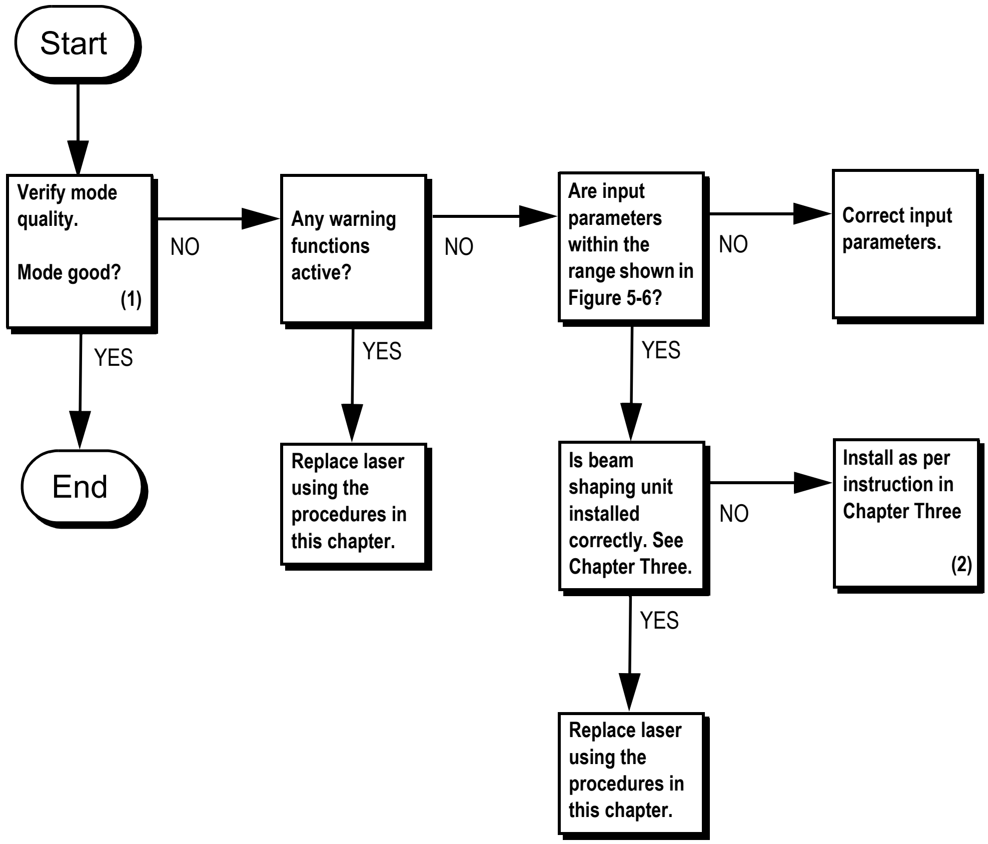


Chart 4. Degraded Mode Quality (Continued)

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

[1] Check mode quality as follows:

- Turn off modulation to the laser.
- A low output power setting (200 μs pulse width, 6000 μs pulse period) of 15 to 20 Watts is recommended.
- Position a mode card approximately 3 meters or more in front of the output beam. A thermal image plate can also be used to inspect mode.
- Apply a single modulation pulse to the laser. The output beam will mark the mode card.

  If there are rings or partial rings surrounding the central beam, the laser beam is misaligned to the optical system and might require re-alignment.

[2] The location of the beam shaper and beam expander units are factory set to ensure the laser output is pointing in a specific direction. No adjustment is required. Likewise the beam expander option is factory set to give a minimized beam divergence. However should the separation of the two lens expander optics have been adjusted the expander second lens can be moved by rotating the final lens barrel either in or out. After loosening the lock nut. tighten the lock nut once a satisfactory location has been found.

Note: Ensure that the laser is switched OFF while any adjustment to the lens position is made.

Replacement Procedures

[ ] Call your local representative or Coherent service for an RMA number to purchase or obtain a replacement laser or beam shaper/beam expander.

[ ] If damage is limited to the beam shaper or expander units only, remove and package the unit in the original shipping box and return independent of laser. Complete the failure description form.

[ ] Alternatively, if laser is damaged, complete the failure description form.

[ ] Shut down laser in accordance with Chapter Five.

[ ] Ensure all water and electrical inputs are shut down.

[ ] Disconnect the control line (25 pin cable)

[ ] Disconnect the 48 VDC input line.

[ ] Disconnect the water lines and if available, blow out the water input lines with compressed air. This ensures that the internal water lines will not freeze during shipping.

[ ] Return the laser and package in the original shipping box. It is important for Coherent to receive the laser without any additional damage caused by shipping or mishandling.

APPENDIX A: DC POWER SUPPLY OPTION

Introduction

The DC power supply detailed in this appendix has been specially designed to provide the peak current required by the G-100 and G-150 lasers. The peak current required by the lasers are often a life limiting factor for typical DC power supplies designed to provide the average current requirements of the laser. This appendix provides the details for mounting, connecting input power, and controlling the DC power supply.

Input Power Connections

The input power connections to the DC power supply require three wires of the size given in Table A-1. Remove the cover over the input power terminals and connect the wires as indicated by the labels.

Table A-1. Specifications for DC Power Supply Option

PARAMETER	SPECIFICATION	
GUARANTEED PERFORMANCE	**G-100**	**G-150**
ELECTRICAL REQUIREMENTS FOR OPTIONAL DC POWER SUPPLY		
Input voltage	200-240 VAC Single Phase	
Input current (maximum)	15 Amps	
Recommended fuse or circuit breaker	20 Amps	
Line frequency	50 to 60 Hz, Power-factor corrected	
Wire gauge (minimum)	12 AWG	
Wire cross sectional area (minimum)	3.3 mm^2	
Maximum air inlet temperature (filtered air recommended)	40°C (104°F)	
WEIGHT		
Optional DC Power Supply	17.2 pounds (7.8 kg)	

Output Power Connections

The terminal bar on the DC power supply labeled “V1 +” should be connected to the laser head at the terminal labeled “+48 VDC”. The terminal bar labeled “V1 –” should be connected at the laser to the terminal labeled “48 V RTN”. The wires should be the correct diameter to carry the average laser current specified in Table 1-1. The maximum recommended length of the wires is 18 inches. Twisting the wires together minimizes inductance in the wires and provides for optimum operation of the laser.

With customer supplied DC system it is recommended that the 48 VDC return terminal be connected to the ground terminal of the input power terminals

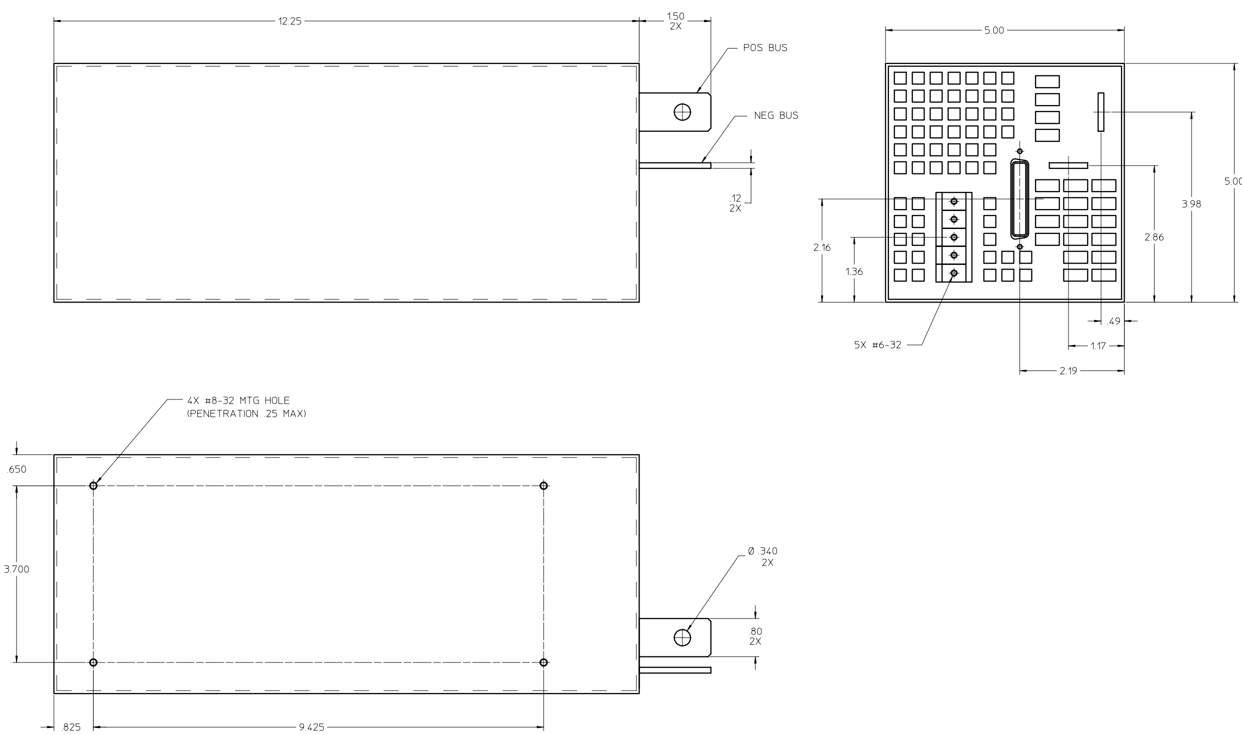
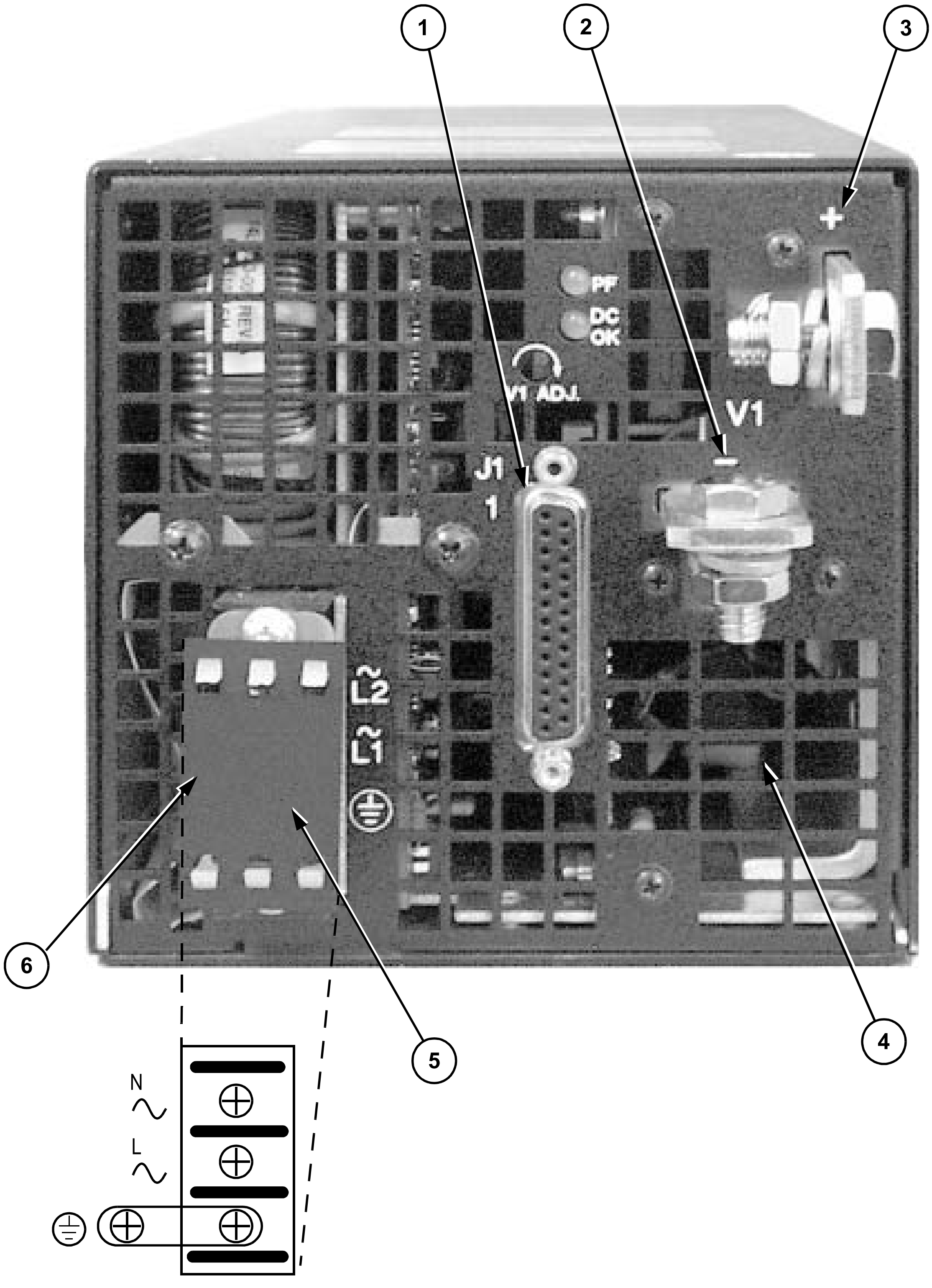


Figure A-1. DC Power Supply Option Dimensions and Mounting Locations



1.	Control cable connector	4.	Cooling air exhaust
2.	48 VDC return	5.	Input power terminals
3.	+48 VDC output	6.	Ground

Note: It is recommended that the 48 VDC return to ground terminal of the input power terminal.

Figure A-2. DC Power Supply Option Indicators and Connectors

Table A-2. DC Power Supply Option Indicators and Connectors

ITEM	CONTROL	FUNCTION
1	Control cable connector	Provides for control and monitoring of the DC power supply using a DB25 connector. Refer to Table 4-3 for a list of signals.
2	48 VDC return	48 V return. Connect to lug labeled FROM DC SUPPLY (–) on the RF amplifier.
3	+48 VDC output	Provides a +48 VDC output. Output current from the DC power supply is 62 Amps. Connect to RF amplifier at lug labelled FROM DC SUPPLY +.
4	Cooling air exhaust	Provides cooling air for the DC power supply. No other cooling is required. Cooling fans must not be obstructed in installation. Inlet is at rear of DC supply
5	Input power terminals	Connect input power lines here. Replace cover after making connections.
6	Ground	Connect the ground wire of the input power here.

DC Power Supply Control Connections

There is a DB25 pin connector on all the DC power supplies. The function of the various terminals of the 25 pin connector is shown in Table A-3. Note that only the functions shown in the schematic Figure A-3 need to be used to turn on the +48 V from these supplies.

Connecting the REMOTE ENABLE (pin 8) and +5 V LOGIC (pin 5) in the 25 pin cable assembly will cause the DC power supplies to turn on. These leads can be tied into the main interlock circuit of the end users system. One suggestion is to connect this output in series with the water flow switch contacts as part of an interlock system. It can provide up 50 mA of current at 5 VDC and is on as soon as the AC power is applied. Note that if an over-current or over-voltage situation occurs, the DC supplied must have the AC input power turned off and then back on to reset the DC supply and also reset the +5 V logic voltage.

Table A-3. DC Power Supply DB25 Connector Pinouts

Pin Number	Function	Description
5	+ 5 V logic	5 V, 50 milliampere source for external use. Referenced to logic common, pin 20. This voltage turns on when AC power is applied to the DC power supply.
8	Remote enable	DC power supply enable signal. Connecting +5 V from pin 5 enables the DC power supply. No connection disables the power supply.
9	Enable return	Return external enable signal used when
10	Current monitor	Analog output proportional to output current. 5.0 Volts full scale. Linear over 10 to 100% load.
11	margin reference	Provides for a 5% increase in output voltage.
12	Margin	Used in conjunction with pin 11 for +5% or –5% margin.
15	– V sense	Provides for local or remote voltage sensing.
16	+ V sense	Provides for local or remote voltage sensing.
20	Logic common	Logic power common for pin 5.

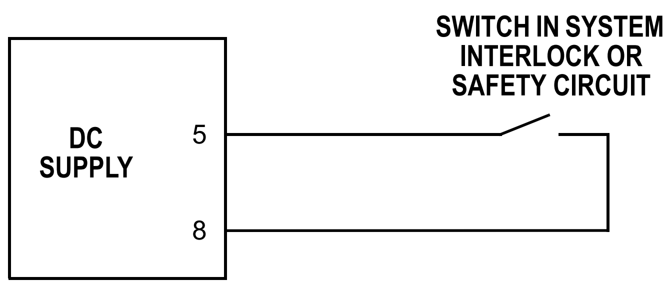


Figure A-3. DC Power Supply Control Connections

APPENDIX B: DIAMOND G-100i

This appendix details the specifications of the Diamond G-100i laser with output at 9.4 mm. Beyond this primary difference, there are very little differences to the Diamond G-100. Coherent has developed this laser to meet the needs of the material processing applications that have better material interaction than the standard Diamond G-100 laser. The following tables shows the output specification while all the utility requirements are the same as the Diamond G-100 as presented in Table 1-1.

Note that the pulse rise and fall time is faster for the G-100i than for the Diamond G-100. In some applications especially involving high line or surface speeds this could be an important improvement in performance.

Table B-1. Diamond G-100i Specifications

PARAMETER	SPECIFICATION
GUARANTEED PERFORMANCE	
Average output power (1)	100 watts
M2—transverse mode quality	<1.5
Power range(1)	10 to 100 watts
Pulse frequency range	0 -100 kHz
System life time (2)	1 year
TYPICAL PERFORMANCE	
Peak effective power	100 to 275 watts
Optical pulse rise time	< 90 µs
Optical pulse fall time	< 80 µs
Pulse energy range	10 to 200 mJ
Pulse period (minimum)	10 µs
Modulation pulse width range	2 to 1000 µs
Output power stability (3)	< ± 8%
Beam waist diameter ($1/e^2$)	1.8 ± 0.6 mm
Beam divergence (full angle)	11 ± 0.9 mrad
Beam pointing stability(4)	< 200 µrad
Beam ellipticity	2 : 1
Beam polarization (parallel to baseplate)	Linear > 100 : 1
Wavelength	9.4 ± 0.3 µm
Tube shelf life	> 1 year

The above specifications subject to change without notice

(1) Guaranteed at 500 µs pulse width at 60% duty cycle with the inlet cooling water temperature at 25°C. Allow a 1%/°C power derating for inlet cooling water temperature to a temperature of 35°C.

(2) See Appendix D for the full system warranty.

(3) Measured as ±(Pmax – Pmin)/2Pmax from a cold start at 25°C for the output power range for pulse width ≥ 2 µs.

(4) Full angle within a ± 5°C inlet cooling water temperature range.

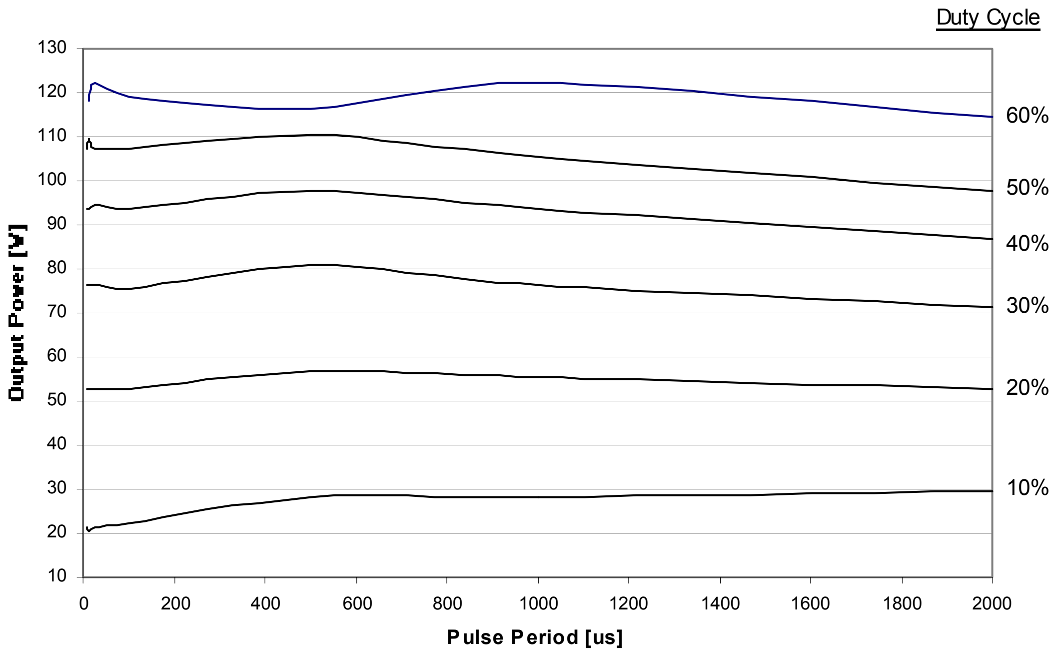


Figure B-1. Typical Laser Output Power as a Function of Pulse Period for Different Duty Cycles

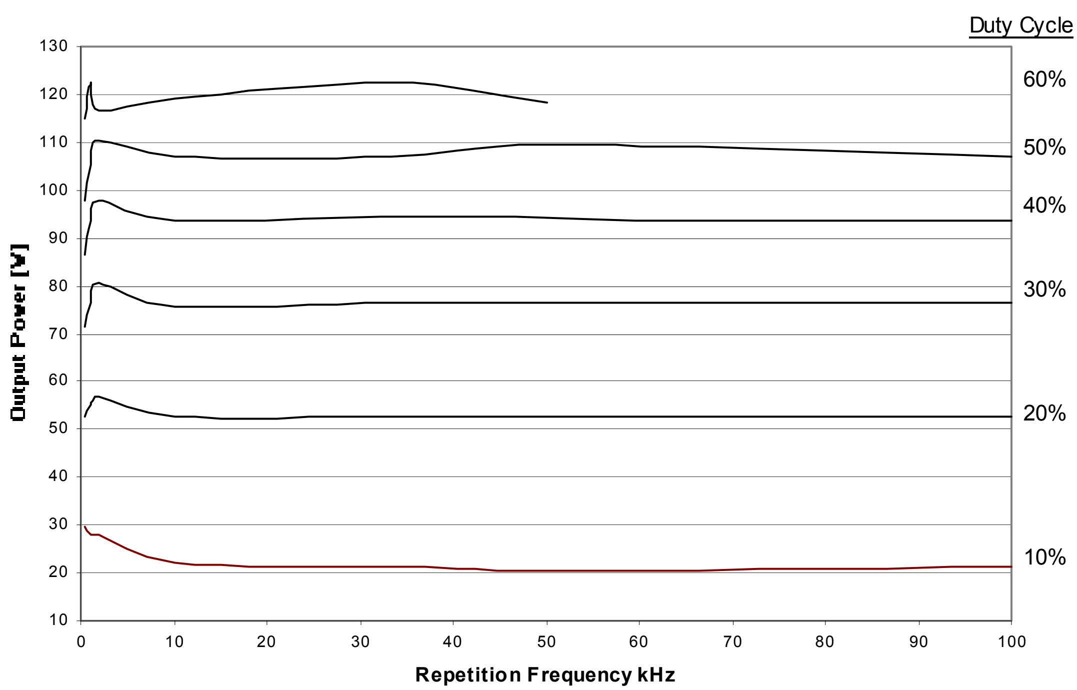


Figure B-2. Typical Laser Output Power as a Function of Pulse Repetition Frequency for Different Duty Cycles

APPENDIX C: PARTS LIST

The following parts can be ordered by contacting Coherent Customer Service at 1-800-367-7890 (within USA) or 1-408-764-4557 (outside USA) or your local Coherent representative.

Table C-1. Parts List

DESCRIPTION	PART NUMBER
G-100 Laser	0170-996-00
G-150 Laser	1013456
Beam shaping assembly G-150	1049515
Beam expander assembly G-150	1049516
Alternative Foot support – Does not support beam shaping or expander assembly (one of each is necessary)	0171-249-00 0171-250-00
DC power supply (option)	1042309
G-100i Laser	0176-571-00
Laser purge filter kit (option)	0174-849-00
Replacement DX filter element	2603-0152
Replacement BX filter element	2603-0153
Additional Teflon tubing (specify length required)	2521-0210

APPENDIX D: WARRANTY

Diamond Laser Warranty

Coherent, Inc. warrants to the original purchaser that the Diamond laser system conforms to the specifications published by Coherent and is free from defects in materials and workmanship.

For specific warranty terms and conditions for your Diamond laser system, refer to your sales contract.

Diamond Laser systems are warranted for parts and labor for a period of fifteen (15) months. Warranty begins from the date of shipment.

Diamond Laser systems do not include installation in the purchase price.

Conditions of Warranty

For warranty service requiring the return of any product to Coherent, the product must be returned to a service facility designated by Coherent. The Buyer is responsible for all shipping charges, taxes and duties.

Parts replaced under warranty shall become the property of Coherent and must be returned to Coherent, Inc., Santa Clara, or to a facility designated by Coherent. All laser systems must be carefully packed in a suitable shipping container(s). Coherent does not assume responsibility for components broken in shipment due to improper packaging or handling. The Buyer will be obligated to issue a purchase order for the value of the replaced parts and Coherent will issue credit when the parts are received.

Responsibilities of the Buyer

Damage to the Diamond laser caused by failure of Buyer's utilities or the Buyer's failure to maintain an appropriate operating environment, is solely the responsibility of the Buyer and is specifically excluded from any warranty.

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

Limitations of Warranty

The foregoing warranty shall not apply to defects resulting from:

1. Components or accessories with separate warranties manufactured by companies other than Coherent.
2. Improper or inadequate maintenance by Buyer.
3. Buyer-supplied interfacing.
4. Operation outside the environmental specifications of the product.
5. Improper site preparation and maintenance.
6. Unauthorized modification or misuse.

Coherent assumes no responsibility 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 systems may contain reconditioned parts. Repaired or replaced parts are warranted for the duration of the original warranty period only. This warranty does not cover damage due to misuse, negligence or accidents, or damage due to installations, repairs or adjustments not specifically authorized in writing by Coherent.

GLOSSARY

%	Percent
$1/e^2$	Beam diameter parameter = 0.13534
°C	Degrees centigrade or Celsius
°F	Degrees Fahrenheit
µm	Micrometers = 10^{-6} meters
µrad	Microradians = 10^{-6} radians
µsec	Microseconds = 10^{-6} seconds
Ω	Ohms
AC	Alternating current
Amp	Amperes
BNC	Type of connector
$CaCO_3$	Calcium carbonate
CDRH	Center for Devices and Radiological Health (U.S. Government)
CFR	Code of Federal Regulation
cm	Centimeters = 10^{-2} meters
CO_2	Carbon dioxide
DC	Direct current
DVM	Digital voltmeter
FPT	Female pipe thread
gpm	U.S. Gallons per minute
hex	Hexagon
Hz	Hertz or cycles per second (frequency)
kg	Kilograms = 10^3 grams
kHz	Kilohertz = 10^3 hertz
kPa	Kilopascals = 10^3 pascals
kV	Kilovolts = 10^3 volts
kW	Kilowatts = 10^3 watts
LED	Light emitting diode
lpm	Liter per minute
mA	Milliamperes = 10^{-3} Amperes
mg	Milligrams = 10^{-3} grams
MHz	Megahertz = 10^6 Hz
mJ	Millijoules = 10^{-3} Joules
mm	Millimeters = 10^{-3} meters
mrad	Milliradians = 10^{-3} radians (angle)
ms	Milliseconds = 10^{-3} seconds
mW	Milliwatts = 10^{-3} Watts (power)
N_2	Nitrogen

nm	Nanometers = 10^{-9} meters (wavelength)
NPT	American national standard taper pipe thread (American National Standards Institute, B2-1-1968)
Ø	Phase
PE	Protective Earth
psi	Pounds per square inch
RF	Radio frequency
RMS	Root mean square (effective value of a sinusoidal wave)
STD	Standard
TTL	Transistor-to-transistor logic
UV	Ultraviolet
V	Volts
VAC	Volts alternating current
VDC	Volts direct current
VSWR	Voltage, standing wave ratio
W	Watts

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Diamond™ G-100/150 Laser OEM Manual

Coherent Part Number 1040186, RevAA