Series 48 Lasers

Model Numbers:
G48-1-28(W)
G48-2-28(W)
G48-5-28W

Operation and Service Manual

SYNRAD

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Introduction

Thank you for purchasing a Series 48 laser from Synrad, Inc. The Series 48 family of lasers incorporate the latest developments in sealed, carbon dioxide devices, combining the best features of both waveguide and free space CO_2 laser technology. Combining these innovations with state-of-the-art control electronics and RF power supplies makes Series 48 lasers an ideal solution for a wide range of scientific, industrial, and medical marking and cutting applications.

All information necessary to safely operate and maintain the laser is provided in this manual. The information is organized in several chapters and is arranged as follows:

Chapter 1 Safety and Regulatory Compliance
Chapter 2 Theory of Operation
Chapter 3 Physical Features
Chapter 4 Interface Requirements
Chapter 5 Unpacking and Setup
Chapter 6 Operating Instructions
Chapter 7 Maintenance and Troubleshooting
Chapter 8 Return for Factory Service

In addition to the information contained in the chapters described above, supporting data has been provided in several appendices located after Chapter 8. In the event additional information is required for your application, please contact Synrad at 1-800-SYNRAD-1.

Please read this manual completely before using your laser. To prevent injury to personnel or damage to the laser, follow all safety precautions, handling, and setup instructions as described herein.

Chapter 1
Safety and Regulatory Compliance

1.1 CDRH Requirements/Safety Features

Series 48 lasers are designed to comply with requirements imposed by the Radiation Control for Health and Safety Act of 1968. Under this act, the Food and Drug Administration issued a performance standard for laser products, 21 CFR 1040.10 and 1040.11. This performance standard was developed to protect public health and safety by imposing requirements upon manufacturers of laser products to provide indication of the presence of laser radiation, by providing the user with certain means to control radiation, and by assuring adequate warnings to all personnel of the potential hazard, through use of product labels and instructions.

Federal regulations require that all laser products manufactured on or after August 2, 1976, be certified as complying with the performance standard. The manufacturer must demonstrate the product's compliance with the standard prior to certification or introduction into commerce by furnishing to the Center for Devices and Radiological Health (CDRH) reports pertaining to the radiation safety of the product and the associated quality control program. Failure to provide the required reports or product certification is a violation of Section 360B of the Radiation Control and Health and Safety Act of 1968.

Product features incorporated into the design of the Series 48 lasers to comply with CDRH safety are integrated as panel controls or indicators, internal circuit elements, or input/output signal interfaces terminated at a DB9 connector installed on the side panel of the laser. Specifically, these features include a keyswitch (Keyswitch version), remote interlock for power on/off, a laser aperture shutter switch, a fault output signal to indicate failure of the internal electronics (control board or RF driver) or an overtemperature condition, and a 5-second delay between power on and lasing. Incorporation of certain features is dependent on the laser version (OEM or Keyswitch).

All product features are summarized in Table 1.1. The table indicates the laser version on which a feature is available, the type and description of the feature, and if the feature is required (REQ) by and complies (COM) with CDRH regulations.

In addition to the above described safety features, common safe operating practices should be exercised at all time when actively lasing. To prevent exposure to direct or scattered laser radiation, follow all safety precautions specified throughout this manual. Use of controls or adjustments or performance of procedures other than those specified herein may result in exposure to hazardous invisible laser radiation, damage to, or malfunction of the laser. Severe burns will result from exposure to the laser beam. Always wear safety (or prescription) glasses with side shields to reduce the risk of damage to the eyes when operating the laser.

Safe operation of the laser requires the use of an external beam block to safely block the laser from traveling beyond the desired work area. Use a fire-brick or similar non-scattering, non-combustible material as the beam block. **NEVER** use organic material or metals as the beam blocker; organic materials, in general, are apt to combust or melt and metals act as specular reflectors.

Table 1.1
Series 48 Safety Features

FEATURE	VERSION	TYPE	DESCRIPTION	CDRH REQ[1]	CDRH COM[2]
Keyswitch	Keyswitch	Panel Control	ON/OFF switch to provide DC power to the internal circuitry of the laser. Key cannot be removed in the ON position.	Yes	Yes
Power Indicator	OEM/ Keyswitch	Panel LED (Green)	Indicates that DC power is available for the laser. LED illuminates when keyswitch is turned to ON and/or remote interlock is closed.	Yes	Yes
Lase Indicator	OEM/ Keyswitch	Panel LED (Red)	Indicates that laser is in Lase mode. LED illuminates when laser beam is active. The brightness of the LED is related to TTL duty cycle. Higher duty cycles (higher laser output) produce brighter illumination.	Yes	Yes
5-Second Delay	OEM/ Keyswitch	Circuit Element	Disables laser output for 5 seconds after keyswitch is turned to ON position and/or remote interlock is closed.	Yes	Yes
Power Fail Reset	Keyswitch	Circuit Element	Disables laser if input power is removed and then later reapplied (power failure) while the keyswitch and/or remote interlock are still closed. Operator must manually reset the keyswitch and/or remote interlock to restore normal operation.	Yes	Yes
Remote Interlock	OEM/ Keyswitch	Circuit Element (DB9 Interface)	Allows user to turn the laser on/off from a remote location. Laser is shipped with function disabled.	Yes	Yes
Overvoltage Protection	OEM/ Keyswitch	Circuit Element	Disables internal circuitry if input voltage exceeds 36V. Operator must manually reset the keyswitch and/or remote interlock to restore normal operation.	No	---
Reverse Voltage Protection	OEM/ Keyswitch	Circuit Element	Internal diode that protects internal circuitry from reverse input voltages.	No	---
Fault Shutdown	OEM/ Keyswitch	Circuit Element (DB9)	Allows user to configure system to automatically disable laser system operation if a failure event occurs. Laser is shipped with function disabled.	No	---
Fault Signal	OEM/ Keyswitch	Output (DB9)	Indicates failure of internal control/RF circuitry, or existence of an overtemp or overvoltage condition.	No	---
Warning Labels	OEM/ Keyswitch	---	Labels attached to various external locations of the laser housing to warn personnel of potential hazards.	Yes	Yes

(1) REQ - required by CDRH.
(2) COM - complies with CDRH.

1.2 EMI Compliance

Series 48 lasers are designed to comply with certain Federal Communications Commission (FCC) and European Union (EU) directives that impose product performance requirements relating to electromagnetic compatibility (EMC) and product safety characteristics for industrial, scientific, and medical (ISM) equipment. The associated directives and specific provisions to which compliance is mandatory for Series 48 lasers are identified and described in Para. 1.2.1 and Para. 1.2.2.

1.2.1 Federal Communications Commission (FCC) Requirements

The United States Communication Act of 1934 has vested the Federal Communications Commission (FCC) with the authority to regulate industrial, scientific, and medical (ISM) equipment that emit electromagnetic radiation in the radio frequency spectrum. The purpose of this regulation is to prevent harmful electromagnetic interference from affecting authorized radio communication services in the frequency range from 30 MHz to 1 GHz.

The FCC regulations which govern ISM equipment are fully described in Code of Federal Regulations (CFR) 47, Part 18, Subpart C. Series 48 lasers have demonstrated performance characteristics that have met or exceeded the requirements of CFR 47, Part 18, Subpart C.

1.2.2 European Union (EU) Requirements

The European Union's electromagnetic compliance (EMC) directive 89/336/EEC is the sole directive developed to address EMI issues in electronic equipment. In particular, the directive calls out European Norm (EN) documents which define the emission and immunity standards for specific product categories. For Series 48 lasers, the standard EN55011 defines the radiated RF emissions limit. The generic standard EN50082-1 defines immunity requirements published by the International Electrotechnical Commission (IEC). Refer to Table 1.2 for a summary of EU performance requirements pertaining to Series 48 lasers.

Table 1.2
European Union Directives

DIRECTIVE	SCOPE	PROVISION
EN55011	Limits and methods for measurement of radio frequency disturbance characteristics for industrial, scientific, and medical (ISM) equipment.	Emitted RF Radiation shall not exceed limits described in document CISPR11[2].
EN50082	Generic standard governing ISM performance relating to radiated emissions and ESD sensitivity, and immunity to transient bursts.	Immunity to electrostatic discharge levels defined in document IEC801, Part 2. Equipment shall operate normally when exposed to RF emissions at levels described in document IEC801, Part 3. Immunity to electrical fast transient bursts at levels defined in document IEC801, Part 4.

After a product has met the requirements of all pertinent EU directives, the product can bear the official compliance mark of the European Union depicted in Fig. 1.1.

Figure 1.1
European Compliance Mark

Series 48 lasers have demonstrated performance characteristics that have met or exceeded the requirements of the EMC directive 89/336/EEC.

1.3 Declaration of Conformity

A Declaration of Conformity is provided (refer to Fig. 1.2) to certify that EMC performance levels of Series 48 lasers are compliant with applicable EU directives and standards.

DECLARATION OF CONFORMITY

Applicable EU Directive(s):	89/336/EEC	(EMC Directive)
Applicable Standards/Norms:	EN55011	Radiated, Class A, Group 1
	EN50082-1	Generic Immunity:
	IEC801-2	Electrostatic Discharge
	IEC801-3	RF Radiated
	IEC801-4	Fast Transients

Manufacturer: Synrad, Inc.
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Mukilteo, WA 98275

Model Number	Serial Number (Compliant Unit)	Date of Compliance
48-1-28	ENG001	Aug. 10th, 1995
48-2-28	ENG002	Aug. 10th, 1995
48-5-28	ENG003	Aug. 30th, 1995

Synrad, Inc. hereby declares that the equipment specified above conforms to the above Directive(s) and Standard(s).

Figure 1.2
Declaration of Conformity

1.4 Warning Labels/Placards

Each Series 48 laser is shipped with several different types of labels attached to the laser chassis. These labels identify apertures from which laser radiation is emitted, power output levels, and precautions relating to performance characteristics. Refer to Appendix A (Pages A2 - A4) for label location diagrams.

1.5 Operation and Service Manual Precautionary Notations

There are two types of precautionary notations used throughout this manual.

WARNING

A WARNING notation is used to identify a process or procedure that could result in exposure to laser radiation.

A WARNING is used to identify a process or procedure that could result in exposure to laser radiation. Warning notations will be formatted as follows:

CAUTION

A CAUTION notation is used to identify a process or procedure that could result in damage to the laser if not properly performed.

A CAUTION is used to identify a process or procedure that could result in damage to the laser if not properly performed and will be formatted as follows:

Chapter 2
Theory of Operation

2.1 Technical Specifications

Technical information regarding Series 48 performance characteristics is summarized in Table 2.1.

Table 2.1
Series 48 Specification Table

CHARACTERISTICS	MODEL 48-1-28(W)	48-2-28(W)	48-5-28W
Wavelength	10.57 to 10.63 microns		
Power Output: Guaranteed[1]	10W	25W	50W
Power Stability	±10%	±5%	
Mode Quality	TEM_{OO} equivalent: 95% purity		
Beam Diameter/Divergence	3.5mm/4mR		
Polarization	Linear-vertical 50:1 extinction minimum		Random
Modulation/Rise or Fall Time	To 5 kHz/150µsec		
Electrical Control	TTL input (+3.5 V) to 20 kHz		
Electrical Input	28-32 VDC, 8 A max.	28-32 VDC, 16 A max.	28-32 VDC, 32 A max.
Cooling Water [2]: Heat Load, Maximum Flow Rate Temperature	 300 0.5 GPM 18 - 20°C	 500 0.8 GPM 18 - 20°C	 1000 1.5 GPM 18 - 20°C
Thermal Shutdown	60°C ±1.5°C		
Beam Exit	1.09 inch from top plate, center		1.22 from top plate
Weight	9 lb. (4.1 kg)	18 lb. (8.2 kg)	44 lb. (20 kg)
Dimensions (W x H x L)[3]: inches millimeters	 2.8 x 3.89 x 17 71 x 99 x 432	 2.8 x 3.89 x 32 71 x 99 x 813	 5.6 x 4.32 x 35 142 x 110 x 890

(1) The output power level is guaranteed for 12 months regardless of operating hours.
(2) Lasers with output power ≥ 50W must be water cooled. Lasers with output power < 25W can be either water or air cooled depending on their duty cycle. For duty cycles > 50%, water cooling is strongly recommended. Note that water cooling iimproves power stability at any duty cycle.
(3) For overall height dimension, add 0.25 in to allow for top cooling fins.

2.2 Technology Overview

Series 48 lasers incorporate the latest technology in sealed carbon dioxide devices, combining the best features of both waveguide and free space CO_2 laser technology. The all-metal laser tube construction (U.S. Patent #4,805,182) features the ruggedness, stable optical support, and small size of waveguide lasers. Its larger bore (4.8 mm) eliminates the high optical power density of waveguide lasers with their predisposition to optical degradation and incorporates the mode purity and easy optical alignment of free space TEMoo lasers. Low cost is achieved by using simple extruded and welded aluminum structures packaged together with compact, state-of-the-art RF power supplies.

The 48 Series lasers emit a laser beam with a wavelength of 10.6μm. The beam shape is square at the laser output aperture, changing to circular at distances of approximately 1 meter or more from the laser. The laser beam diverges due to diffraction at a full angle of 4 milliradians, with the beam waist at the output aperture of the laser.

The method of RF excitation on which Series 48 operation is based provides excellent discharge stability, easily controlled output power and modulation, and convenient interfacing to automated systems. Coupling between the RF driver and the laser is based on switching and transmission line technology (U.S. Patent # 5,008,894). The frequency of RF drive is approximately 45 MHz and is factory calibrated to match the resonant frequency of the plasma tube.

Power control of the laser beam is achieved by pulse width modulation of the RF drive circuit. Modulation control can be used to turn the laser on and off at time intervals synchronized with automated processing equipment. It can also be used to control the average power by adjusting the pulse width (duty cycle) at a fixed modulation frequency.

For more detailed descriptions of physical and electrical operating characteristics, refer to Para. 2.3 and 2.5 respectively.

2.3 Description of Physical Operation

The laser consists of an RF excited plasma tube with an adjustable mirror on each end, mounted together with the RF drive assembly in a single aluminum chassis. Refer to Figure 2.1 for a schematic depicting the physical components of the laser.

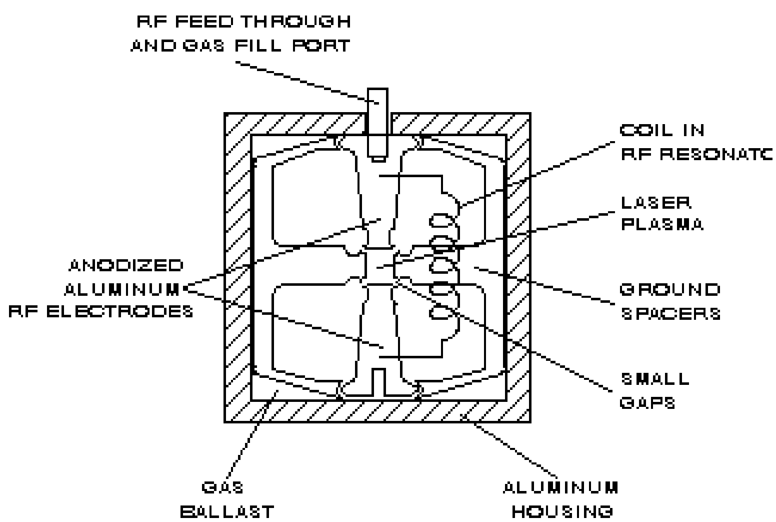


Figure 2.1
Physical Schematic

2.3.1 Plasma Section

The plasma tube is made of 2 inch square cross-section extruded aluminum tubing with pre-machined ends welded on. The mechanical and electrical arrangement of the internal electrode structure (U.S. Patent #4,805,182 and others) is shown schematically in Fig. 2.1. The RF drive power is applied between the lower electrode and the plasma tube. The internal resonant circuit induces RF drive on the upper electrode that is 180 degrees out of phase with that of the lower electrode. Thus the voltage between the two RF electrodes is roughly twice that on either electrode, causing the plasma to form only in the 4.8 mm square bore region. The two side walls confine the plasma but carry negligible current. The RF electrodes are anodized to assure uniform distribution of RF power throughout the excitation volume. Waste heat is conducted away by all four metal sides of the bore to the outer walls of the plasma tube, where it is transferred to the chassis.

In contrast to waveguide lasers that have a closed bore periphery, the Series 48 lasers have four 0.02 inch slots (small gaps) extending longitudinally along the length of the bore (refer to Fig. 2.1). These slots are used for electrical insulation between the two pairs of orthogonal electrodes. However, these slots are also effective for diffusion cooling of the laser gas. Typically, the lasers are more efficient when operated at 90% to 95% duty cycle (refer to Fig. 2.2). No significant power increase occurs above 95% duty cycle.

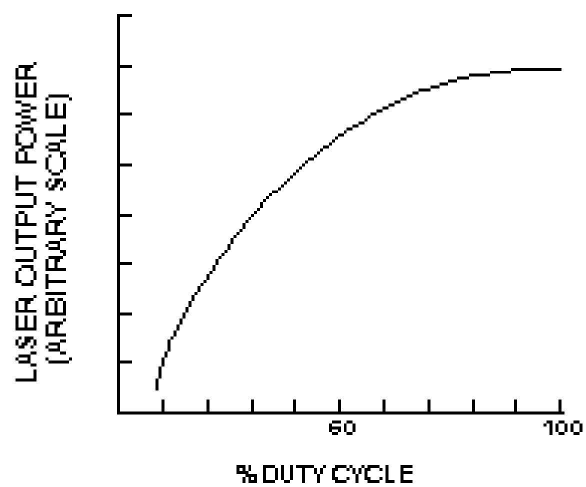


Figure 2.2
Average Laser Output Verse Percent Duty Cycle

2.3.2 Optical Resonator

The optical resonator consists of a 3 meter radius of curvature total reflector and a flat ZnSe output coupler with reflectivities of 95% or 92%. The mirrors are held on with Viton (fluorocarbon) elastomeric o-rings for factory adjustment by means of three bristol head 4-40 screws. No epoxy is used for sealing. The screws are secured by adhesive after alignment.

The 4.8 mm bore, in conjunction with the mirror curvature selected, limits the output beam to TEMoo modes when the mirrors are properly aligned. Small variations in output power (up to 10%) are seen during warm-up as the cavity mirror spacing changes due to thermal expansion of the plasma tube. The output wavelength remains at or near 10.6 µm (10.57 to 10.63 µm).

The beam shape is square at the laser output aperture, changing to circular at distances of approximately 1 meter or more from the laser. The laser beam diverges due to diffraction at an angle of 4 milliradians (refer to Fig. 2.3). The beam has a near gaussian profile in the far field (0.6m or more).

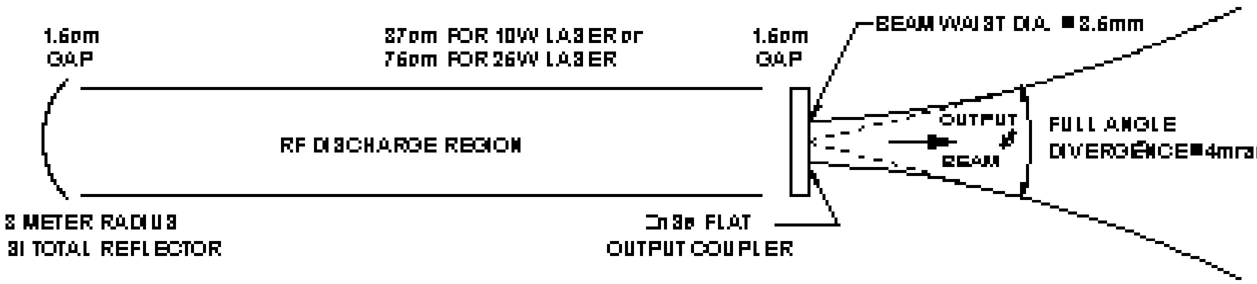


Figure 2.3
Beam Characteristics

2.4 Laser Power Control

To effectively control output power of Series 48 lasers, pulse-width modulation (PWM) is used to vary the average voltage applied to the internal RF amplifier stage(s) which controls the RF drive applied to the laser electrodes. The required modulation source signal (refer to Fig. 2.4) and the capabilities to control and vary that signal are provided by Synrad's UC-1000 Laser Controller (refer to Appendix B for more information on the UC-1000). Using an alternate method to control laser output power requires consideration of key characteristics of Series 48 lasers as described in the following paragraphs.

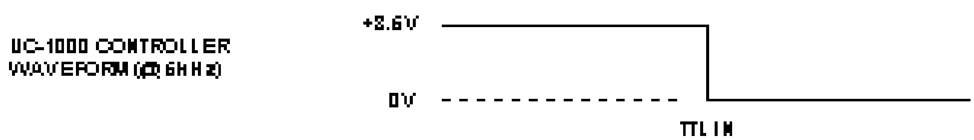


Figure 2.4
Typical TTL Drive Signal

2.4.1 Tickle Pulse

All Series 48 lasers require a 1µs 'tickle' pulse normally delivered at a 5kHz clock frequency from the UC-1000. If the user is supplying on/off TTL pulses directly to the laser without a tickle pulse, the response time from the user's command pulse until laser emission is unpredictable and can vary between 10 and 100µs. This is due to the finite time required to create a plasma state within the laser tube, and depends heavily on the amount of time that the laser is off (no command signal) before a pulse is applied. This inconsistent and unstable firing can cause problems in precision industrial uses where even microsecond delays in firing are important. The tickle signal pre-ionizes the laser gas so that it is just below the lasing threshold. Any further increase in pulse width will add enough energy to the plasma to cause laser emission. In this way, the laser can now respond predictably and almost instantaneously to the user's command signal, even when there is considerable time delay (laser off time) between applied pulses.

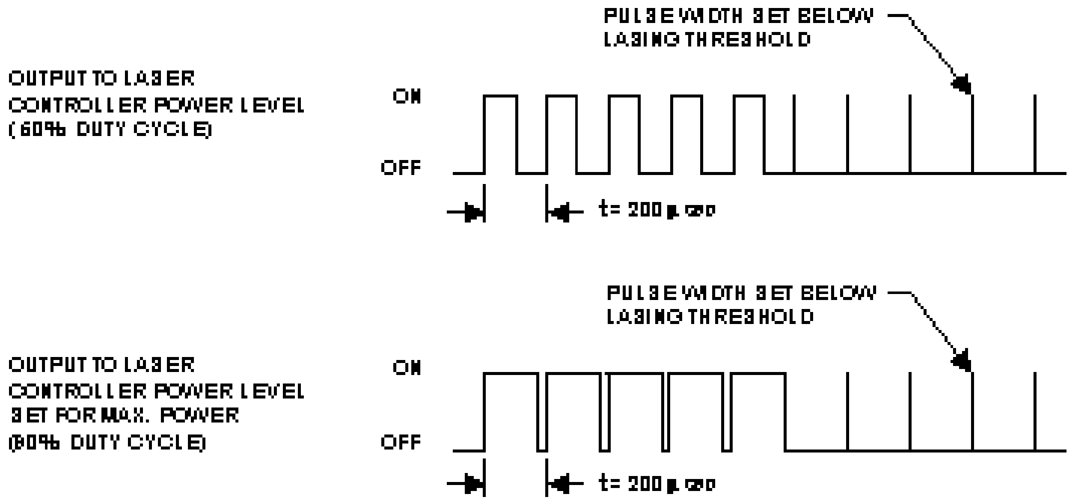


Figure 2.5
Output to Laser Controller Power Level

2.4.2 PWM (Clock) Frequency

Series 48 lasers are designed to operate at clock frequencies up to 20kHz. The choice of clock frequency depends on the application. For most applications, the UC-1000 frequency of 5kHz has proven to work well. Since the laser output follows the clock input with a time constant of ≈100µs, the laser output cannot precisely follow the TTL input beyond clock frequencies of 5kHz with a duty cycle greater than 50% (5kHz = [1/100µs] x 50%). However, for applications that cannot tolerate the on/off nature of optical beam response but still need adjustable power levels, it is recommended to use clock frequencies up to 20kHz. At 20kHz, the optical response no longer follows the TTL input and is very nearly a DC value with just a small amount of ripple present. Typically, the depth of modulation (defined as the peak-to-peak waveform value divided by the peak value) at 50% duty cycle is 90 to 100% at 2kHz and 60 to 80% at 5kHz. Refer to Fig. 2.6 for waveforms.

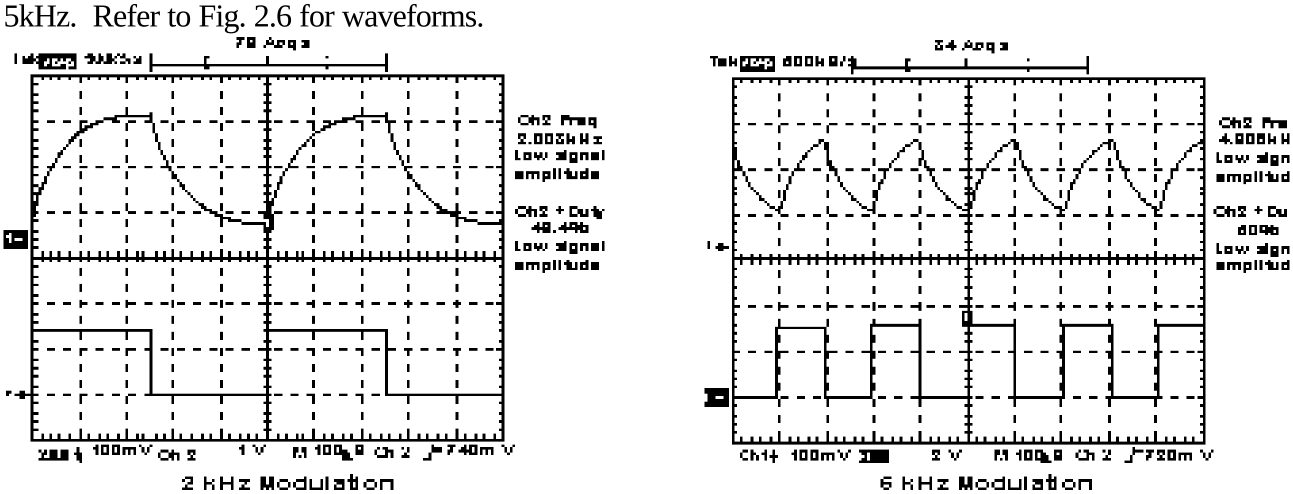


Figure 2.6
Modulation Waveforms

For high speed applications that require a clock frequency beyond 20kHz, consult the factory for more information.

2.4.3 Low Frequency On/Off Pulsing

If the user wishes to pulse the laser on and off at low frequencies (<500Hz), a standard UC-1000 controller set at 3kHz or 5kHz produces a spike (overshoot) of laser power for each low frequency turn-on pulse. For applications where this overshoot is unacceptable, Synrad's SSC-1000 Spike Suppression Controller can be used instead of the UC-1000. For more information, consult the SSC-1000 data sheet provided in Appendix C.

2.5 Description of Electrical Operation

Control of laser operation and power output levels is essentially performed using a single PCB. The Control PCB connects the modulated signal to the RF amplifier. It also provides electronics to monitor performance of RF control and output circuitry, provide outputs to an externally accessible connector, and performs input power protection (refer to Fig. 2.7).

Functional differences between model types generally relate to the number of RF channels. Model 48-1 operation uses a single RF electrode requiring a single modulated RF drive input from the Control PCB. The 48-2 uses 2 RF electrodes and requires 2 RF channels and the 48-5 uses 4 electrodes and 4 RF channels (2 Control PCB's). For the purpose of this description, a single channel will be described. Model specific details relating to differences in electrical characteristics will be individually discussed.

2.5.1 PWM Control Circuitry

The TTL modulation source signal must be provided externally to the laser and connected to the panel-mounted BNC-style connector labeled CTRL (refer to Fig. 2.7). This signal is connected to an opto-isolator, the output of which is applied to the PWM switch control circuit. The PWM switch control circuit gates the PWM switch off and on at the frequency and duty cycle controlled by the modulation source. When the PWM switch closes, 30VDC is applied to the RF module amplifier.

The PWM control circuit provides on/off gating of the PWM switch unless disabled by the 5-second delay, shutter switch, or the overtemp comparator circuits. If any of these inputs are active (high), the PWM switch control circuit is disabled, preventing the modulation signal from being applied to the PWM switch.

The 5-second delay disables the PWM output to the RF amplifier for a period of 5 seconds after the panel-mounted keyswitch and/or remote interlock is closed (power ON). After time-out occurs, the output goes low to remove the disable from the PWM switch control circuit. The shutter switch disable allows the laser output to be temporarily interrupted during active lase modes. This is an electro-mechanical switch which physically blocks the exit aperture and electrically interrupts power to the RF module by disabling the PWM switch control circuit.

The overtemp disable occurs for chassis temperatures above 60°C. The output of a chassis-mounted thermistor is connected to the inverting input of the overtemperature comparator. Under normal temperature conditions the output of the comparator is low. If the chassis temperature increases above 60°C (because of insufficient or loss of cooling), the comparator output goes high which disables the PWM switch control circuit interrupting the 30V PWM output to the RF amplifier. The

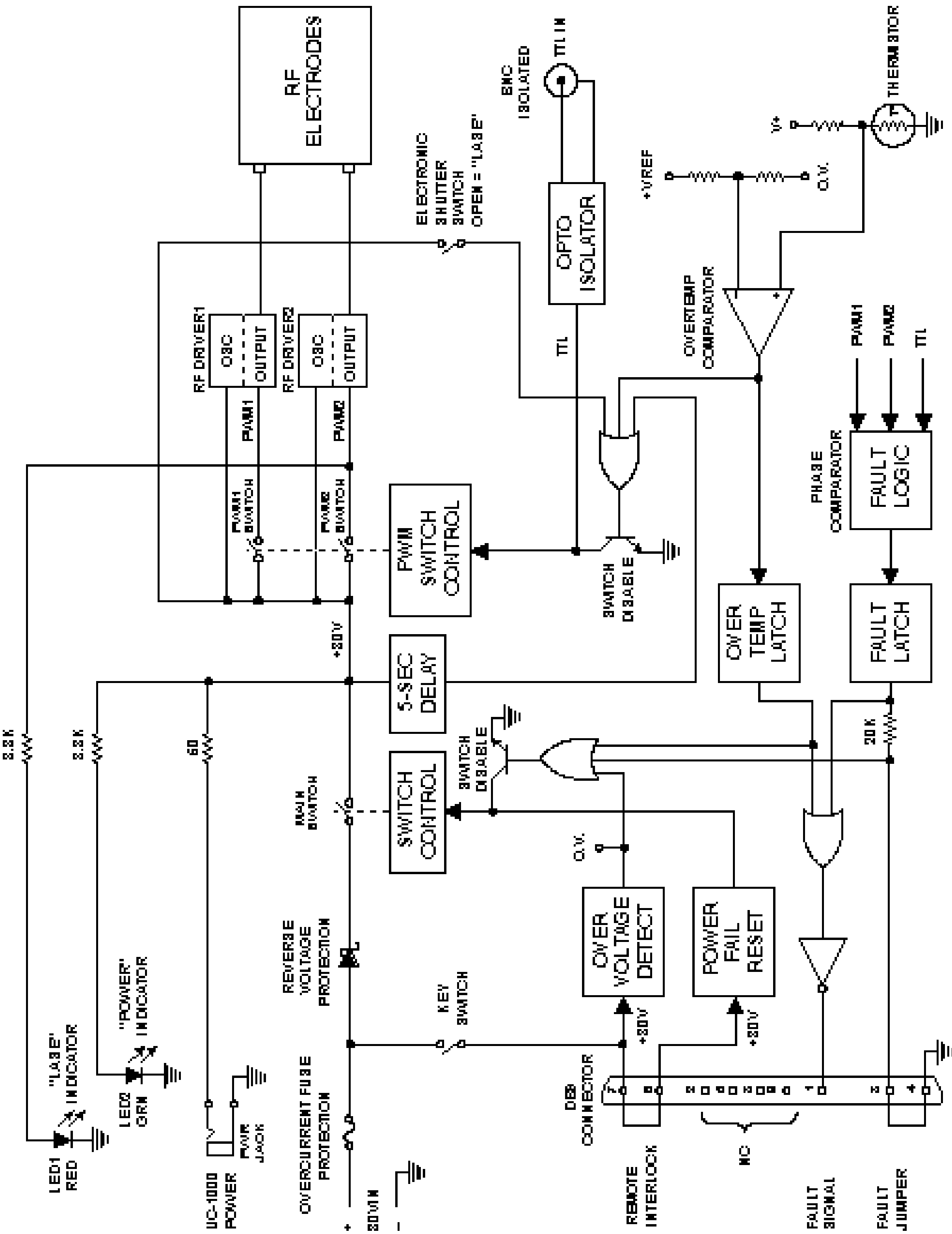


Figure 2.7
Electrical Functional Block Diagram

output of the overtemp comparator is also connected to the overtemp latch. During overtemp conditions, the overtemp latch transitions high and disables the main switch control circuit (main switch open) interrupting power from the internal circuitry of the laser. The output of the overtemp latch is also used for fault monitoring (refer to Para. 2.5.3). If an overtemperature condition occurs, power to the laser should be turned off to allow chassis temperature to decrease below the 60°C threshold.

2.5.2 Input Power Protection/Monitoring

The power input circuit consists of a panel-mounted fuse for overcurrent protection, a Schottky diode for reverse voltage protection, a panel-mounted keyswitch, and a normally-open MOSFET transistor (main) switch.

The output of the keyswitch is connected to the overvoltage detect circuit and the power fail reset circuit via the DB9-installed, remote interlock jumper. Note that the remote interlock jumper can be removed to allow the user to insert a remotely located relay or switch in series with the keyswitch. By permanently closing the keyswitch, the user can turn the laser on and off from a remote location.

On/off gating of the main switch is controlled by the main switch control circuit. This circuit gates the main switch on unless disabled by power fail (keyswitch version only), overvoltage, or certain fault conditions (refer to Para. 2.5.3). When the main switch is gated on, 30V is applied to the panel-mounted, green, power-on LED; the shutter switch; the 5-second delay circuit; and the PWM switch.

For keyswitch versions, until the keyswitch is closed, the main switch control circuit is disabled by the power fail reset circuit. When the keyswitch is closed, the disable is removed and the main switch closes applying power to the functional circuits of the control board. If a power-fail condition occurs during laser operation, the power-fail reset circuit will disable the main switch control circuit which turns the main switch off. Subsequent to power-fail conditions, the keyswitch must be recycled to reset the power fail latch, and return the laser to normal operating mode.

For OEM versions, the power fail function is disabled by an internal shunt on the Control PCB. If an input power failure occurs when lasing, the OEM system integrator must ensure his system provides the necessary safeguard to prevent the laser from resuming in lase mode upon return of power input to normal levels.

The overvoltage disable occurs when the DC voltage input to the laser exceeds 36V. The overvoltage detect circuit will disable the main switch control circuit which turns the main switch off. The main switch will be latched off until the keyswitch is recycled.

2.5.3 Fault Monitoring/Indications

The Control PCB monitors certain aspects of laser operation relating to overtemperature/overvoltage conditions and phase differences between TTL drive and PWM output signals. If any fault condition occurs (except for power fail function when disabled), the associated latch trips and issues a shutdown override to the main switch control circuit which turns the main switch off. The outputs of the fault latches are also connected to an OR gate and inverted to force the fault signal (DB9 pin 1) to 0V to indicate a fault condition.

The failure shutdown override is associated with out of tolerance phase differences and indicates failure of MOSFET switch(es), related drive circuitry, or the RF amplifier(s). The failure shutdown override is disabled by the installation of a jumper between DB9 pins 3 and 4. Regardless of whether the disabling jumper is installed, the fault signal will still show 0 V for this type of fault.

2.5.4 RF Driver

RF power is provided by an oscillator/amplifier power module delivering 120 watts to each set of electrodes. The frequency of RF drive is approximately 45 MHz tuned to match the resonant frequency of the plasma tube. The RF module consists of a power oscillator using a Motorola MRF 148 MOSFET driving a push-pull final amplifier using two MRF 174 MOSFET's in saturation (refer to Fig. 2.8). The coupling network between the RF drive amplifier and the electrodes consists of a quarter-wave, 50 ohm cable driven directly by the two MOSFET's using a 1:1 balun. This method inverts changes in the laser impedance to facilitate breakdown and plasma stability and matches the laser impedance to the drive transistors (covered by U. S. Patent # 5,008,894). The transmission line also rejects the odd harmonics generated by the MRF 174 switches.

The power MOSFET's operate essentially as switches. RF rise time is 0.5 µsec to deliver 1000 V peak to the discharge electrodes. The RF module can be controlled down to a drive pulse width of 1 µsec to provide the tickle signal (refer to Para. 2.4.1). The RF drive is not on a frequency authorized for significant incidental radiation (ISM bands around 27 and 40 MHz). The power module must therefore be shielded effectively which is accomplished by integrating the plasma tube and drive into a single assembly.

2.6 Duo-Lase® Operation (48-5 Only)

The 48-5-28W laser combines two standard, sealed laser tubes for twice the output of a standard laser. The output beams from two 25 watt sealed CO_2 tubes are combined optically to provide a single, diffraction-limited beam at 50 watts.

All power and control functions between the two laser sections are totally independent, essentially achieving fail-safe operation for applications that can be served with the power of one laser. Any one electronic or laser tube failure will only affect that section, leaving the second channel unaffected and available for temporary use.

The optical combining technique is based on the fact that each laser is linearly polarized, allowing the use of a polarization sensitive beam combiner to achieve 98% efficiency in combining the two beams. The two components of the resulting beam are spatially parallel and colinear. The normal temporal and spatial variations of a single laser are reduced by combining the output of two lasers. Output polarization is random and therefore superior for many cutting applications.

The laser is self-contained requiring only the application of power, cooling water, and a control signal. It is therefore ideally suited for overhead installation where the laser is gantry-mounted. No RF cable runs are required.

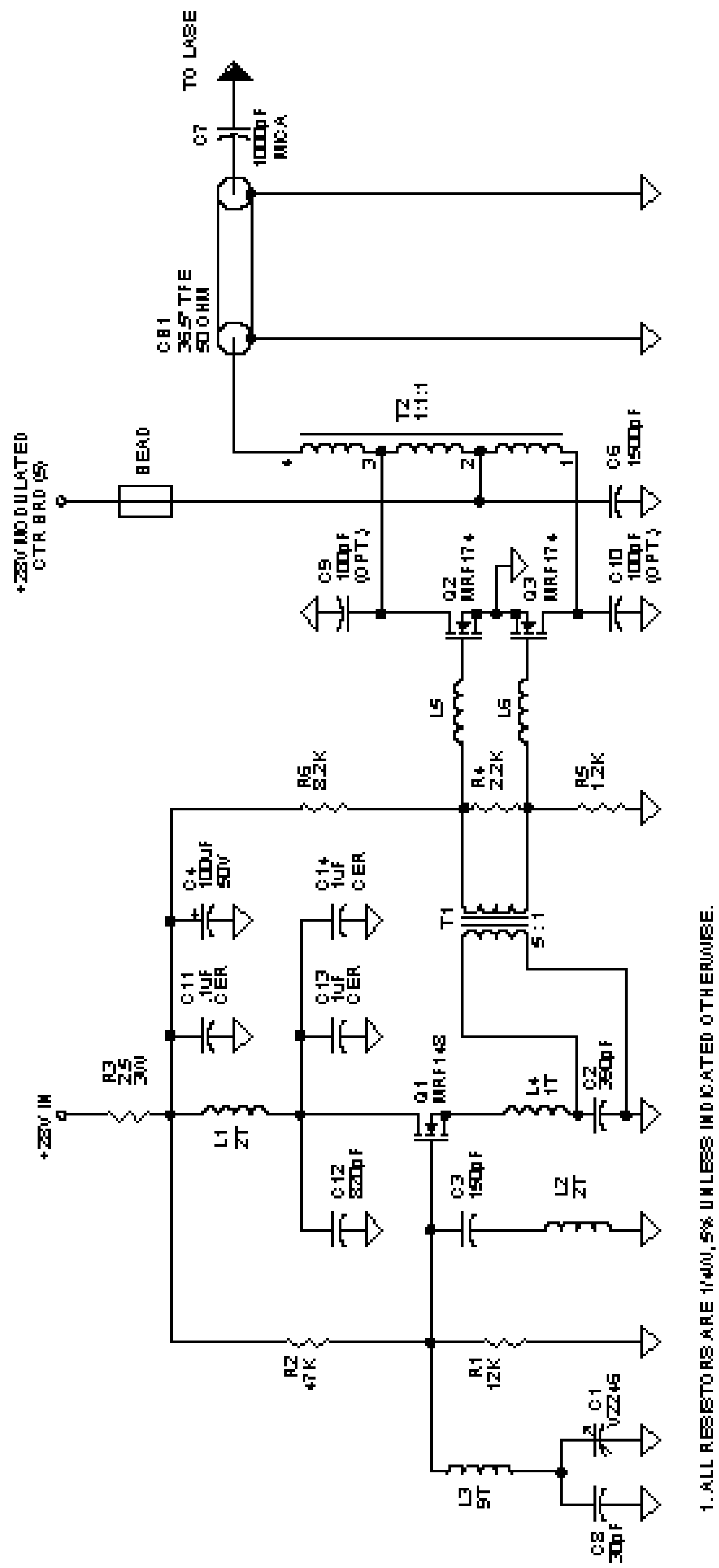


Figure 2.8
RF Driver

Chapter 3
Physical Features

The physical features of the Series 48 lasers are shown in Figure 3.1 (48-1 and -2) and Figure 3.2 (48-5) and described in the following paragraphs.

3.1 Controls and Indicators

3.1.1 Shutter Switch

The shutter switch is a mechanical shutter that closes the laser aperture. The shutter also actuates independent micro-switches that interrupt power to the laser section(s). The shutter should not be used to partially block the beam or to control output power. The shutter is standard on both OEM and Keyswitch versions.

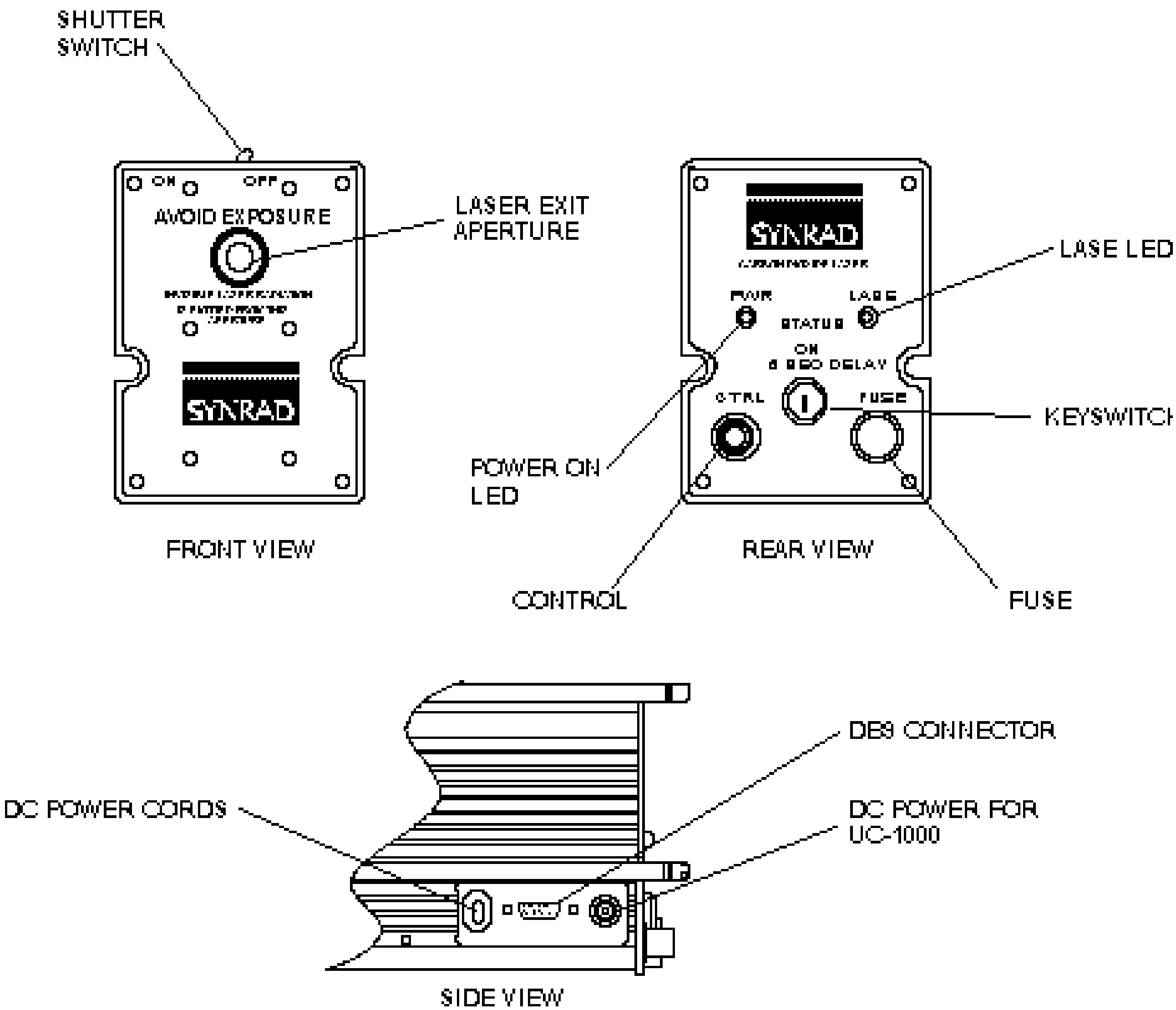
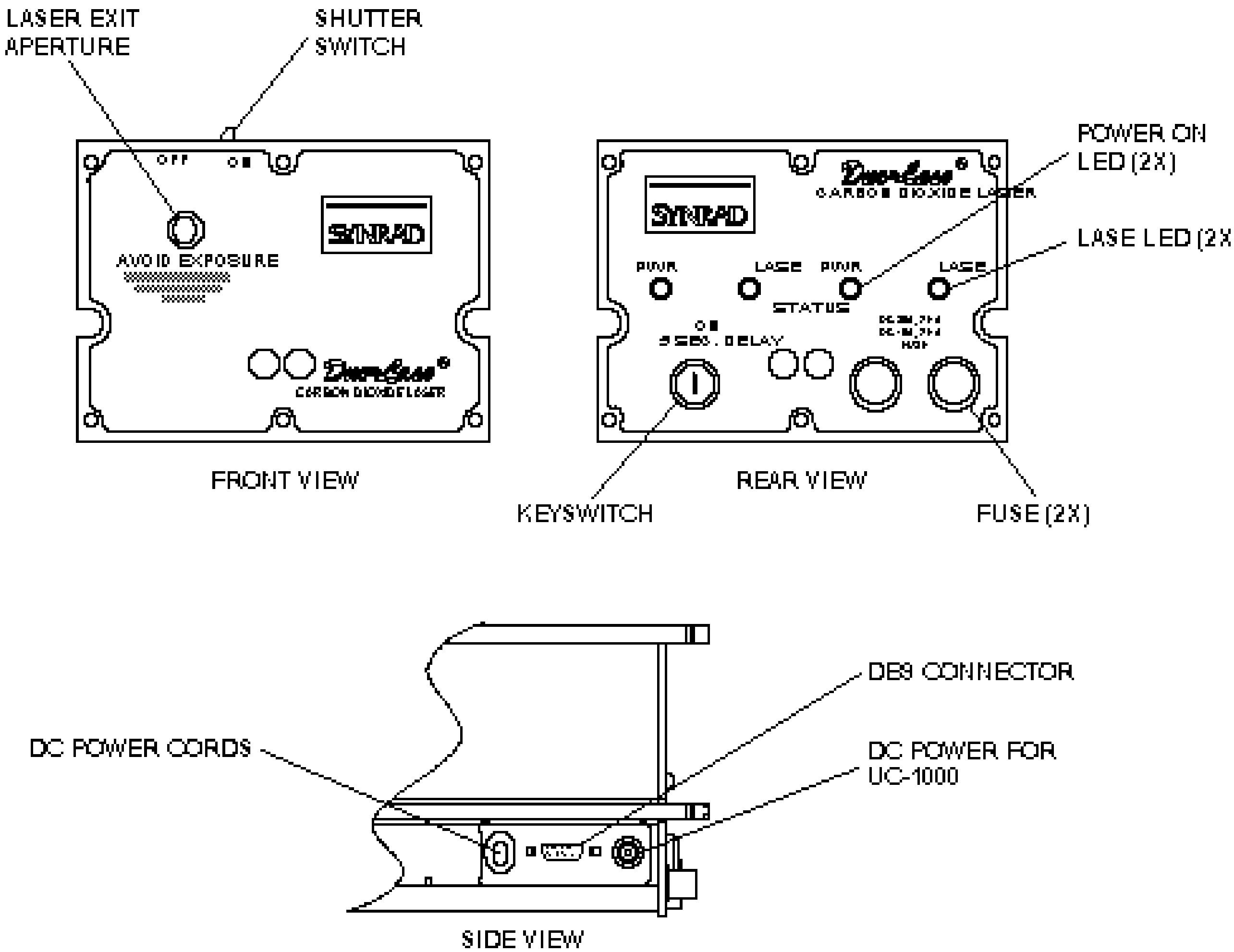


Figure 3.1
48-1/2 Physical Features Location Diagram



PRELIMINARY: SUBJECT TO CHANGE

Figure 3.2
48-5 Physical Features Location Diagram

3.1.2 Power On LED

The PWR LED is a panel mounted green LED that illuminates when the keyswitch is turned to the ON position to indicate that power is applied to internal circuitry. This LED is standard on both OEM and Keyswitch versions.

3.1.3 Lase LED

The LASE LED is a panel mounted red LED that illuminates to indicate Lase mode of operation. If the TTL signal is present, the red indicator light turns on after a 5 second delay and becomes brighter as the TTL duty cycle is increased. This LED is standard on both OEM and Keyswitch versions.

3.1.4 Keyswitch

The panel mounted keyswitch is used to turn the laser on. The keyswitch cannot be removed when the keyswitch is in the ON position. For OEM lasers, a plug is installed in place of the keyswitch.

3.1.5 Fuse

The panel mounted fuse(s) provides overcurrent protection for the internal circuitry of the laser. The required fuse type is a fast blow, 3AB or 3AG with the following current ratings:

48-1	10 Amp
48-2	20 Amp
48-5	30 Amp (2)

3.2 DB9 Connector

The DB9 connector is a 9-pin, subminiature-D connector that provides the interconnect for fault, shutdown, and remote interlock interface signals. Refer to Chapter 4 for more detailed information on use of the DB9 connector.

3.3 TTL Control Input

The CTRL connector is a panel mounted BNC-style connector that accepts the TTL level control signal. The output of the UC-1000 is attached to this connector. For pure CW operation, a straight +5V signal can be applied through this connector.

3.4 DC Power Input

The black and red DC power input cables provide 30VDC operating power to the laser. Standard length is 60 inches.

3.5 UC-1000 DC Power

The UC-1000 Power Connector is installed in the side panel of the laser housing and provides an optional power source to the UC-1000. Current is limited by a 50 ohm resistor in series with the line. Power is active after 28 - 32VDC is applied to the DC power cords. The UC-1000 can also be provided with a wall transformer for 115VAC operation.

3.6 Laser Aperture

The laser aperture is the opening from which the laser beam is emitted when lasing. The beam shape is square at the laser output aperture, changing to circular at distances of approximately 1 meter or more from the laser. The laser beam diverges due to diffraction at a full angle of 4 milliradians, with the beam waist at the output aperture of the laser.

3.7 Mounting of Optical Accessories

The front faceplate of Series 48 lasers are designed with a 6-hole mounting pattern (refer to Outline/Mounting diagrams in Appendix A) to provide a convenient method for mounting standard beam delivery components available from Synrad. When considering other components not specifically designed as Series 48 options, please consult factory for restrictions as excessive weight may cause damage to the laser.

Chapter 4
Interface Requirements

4.1 UC-1000 Power Controller

Operation of Series 48 lasers requires an external controller that can provide the necessary TTL drive signal as the modulation source. The Synrad UC-1000 Controller has been designed to provide control of the laser output from a remote source. The UC-1000 requires 28VDC at 80mA from a wall plug transformer/rectifier or can be connected to the UC-1000 Power connector on the side panel of the laser via the power cord provided with the UC-1000. Refer to Appendix B for more information on the UC-1000 Controller.

4.2 DC Power Supply

4.2.1 48-1/48-2 Model

The 48-1 and 48-2 lasers require Synrad power supplies (DC-1 and DC-2, respectively). If substituting power supplies, use a well-regulated DC power supply in the range of 28 to 32 V with no more than 3 V overshoot under modulation load. Laser current is about 8 A for the 48-1 and 16 A for the 48-2. The use of short leads is recommended. In the case of longer runs, use twisted wire to minimize the voltage drop in the cable due to inductance.

4.2.2 48-5 Model

The 48-5 laser requires Synrad power supply DC-5. If substituting, use a well-regulated DC power supply in the range of 28 to 32 V with no more than 3 V overshoot under modulation load. Use appropriate connections to withstand maximum current loads of up to 32 A. The use of short leads is recommended. In the case of longer runs, use twisted wire to minimize the voltage drop in the cable due to inductance.

4.3 DB9 Connector

All 48 Series lasers are equipped with a female DB9 connector (see Fig. 4.1) mounted to the sidewall of the laser. It provides the user with a convenient method for monitoring fault conditions (overtemperature, control/RF circuitry failure), adding remote interlock (relay or switch) capability, and configuring the system for shutdown in case of control/RF circuitry failure. The DB9 pin assignments and functions are described in Table 4.1.

As shipped, the laser will have a DB9 male connector plugged into the panel-mounted DB9 female to allow normal operation of the laser. The DB9 male will have a plastic cap covering the internal pins and shorting jumpers (see Fig. 4.1) will be installed between pins 3/4 and pins 6/7 to disable those functions.

If the user wants to take advantage of the DB9 functions, they must manufacture a connecting cable and then configure its connections for proper operation. A spare DB9 male connector and cover hood is included with each laser to facilitate easy cable manufacture.

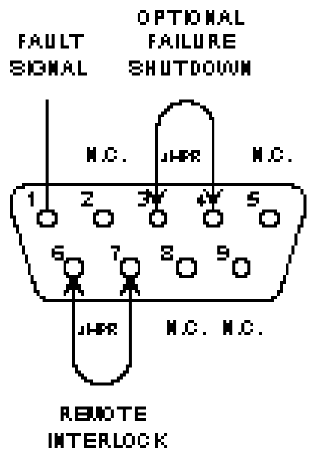


Figure 4.1
DB9 Connector Interface

Table 4.1
DB9 Connector Pin Assignments

PIN NO.	SIGNAL NAME	DESCRIPTION	PURPOSE
1	FAULT SIGNAL	Indicates failure of internal control/RF circuitry or existence of an overtemperature/overvoltage condition. Signal will transition from +15V to 0V to indicate fault condition. Signal is connected to pin through a 10 kΩ current limiting resistor.	Provides user with control signal to disable external systems in the event of a failure in laser electronics or an overtemp/overvoltage condition (> 60°C).
3, 4	OPTIONAL FAILURE SHUTDOWN	Laser is shipped with a jumper installed between pins 3 and 4 to disable failure shutdown function. Note that regardless of whether jumper is installed, the fault signal (pin 1) will change to 0V if the internal electronics fail.	Pins 3/4 jumpered: only overtemp/overvoltage condition will shut laser off. Pins 3/4 not jumpered: both overtemp/overvoltage and internal electronics failure will shut laser off.
6, 7	OPTIONAL REMOTE INTERLOCK	Allows a remotely located relay or switch to be connected in series with the laser keyswitch. As shipped, the pins 6 and 7 are jumpered to disable the remote interlock function and allow laser to function normally using the keyswitch for on/off control.	Allows user to turn the laser on/off from a remote location.
2, 5, 8	N.C.	---	

4.4 Cooling Requirements

The electronics in the Series 48 lasers are mounted opposite the laser tube in the smaller section of the "H" bay and share the same cooling removal as the plasma tube. Typical efficiency of CO_2 laser plasma tubes operating in a TEMoo mode is 10% to 12% (radiation out to RF power in). Conversion efficiency of DC electrical power to RF is about 60%. Off-the-shelf AC-to-DC switch mode supplies are typically 85% efficient. The overall "wall plug" efficiency of these lasers is therefore about 6% to 8%. A considerable amount of heat must be removed even at the 10 W and 25 W laser output power level. Since the RF oscillator operates and generates heat whenever the laser is plugged in, cooling should be applied even when the laser is in standby mode. The thermal transport design for cooling the Series 48 lasers has been made adaptable to a wide variety of user applications and laser operating requirements.

CAUTION
Condensation and water damage can occur if cooling water is below dew point.

4.4.1 48-1/48-2 Cooling

Heat load for the 48-1 is 200 watts and for the 48-2 is 400 watts. In all but very low duty cycle applications, external cooling must be applied to the laser chassis; this may take the form of either forced air or water cooling.

Air cooling is accomplished by placing four 4.69 inch fans at the side of the laser and directing air flow perpendicular to the laser cooling fins (refer to Fig. 4.2). This method will produce sufficient cooling when operating at any duty cycle including CW mode (100% duty cycle). Minimum delivery requirement of the cooling system is 500 cubic feet per minute (CFM) of free air for the 48-1 (125 CFM per fan) and 1000 CFM for the 48-2 (250 CFM per fan). Consult the factory for optimum design.

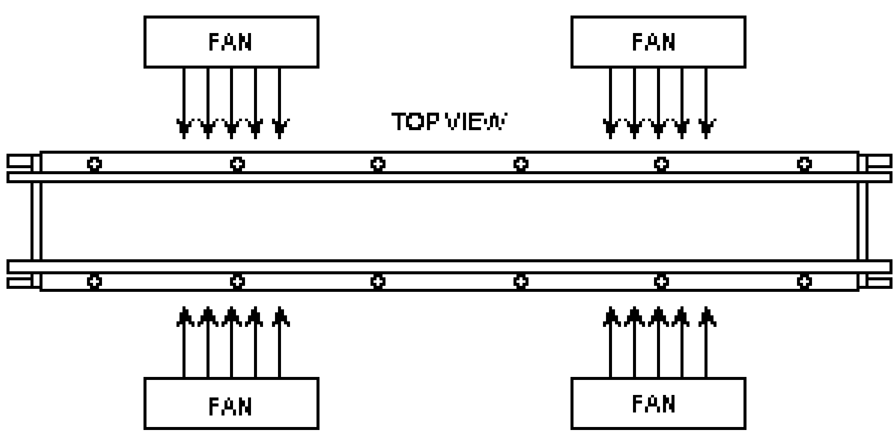


Figure 4.2
Placement of Cooling Fans

When using water cooling, the recommended flow rate is between 0.5 and 0.8 gallons per minute for the 48-1 and the 48-2 models respectively, at an inlet temperature of 18 to 25°C. Heat removal from the cooling water is required and can be accomplished using a Neslab (Tel. Ph.: 1-800-258-0830) RTE111D chiller. Water cooling is designed to provide sufficient cooling at up to 100% duty cycle.

Water enters the central 1/4 inch cooling tubes and exits through the top mounted cooling tubes. Both circuits must be used in parallel to maintain thermal balance. A cooling intake and exit manifold using a quick-disconnect Camozzi system (refer to Fig. 4.3) is shipped as a kit with the laser. The cooling kit also includes quantities of both straight- and elbow-fittings. The two "U" shaped connections should be installed on the front. The quick disconnect fittings can be removed from the tubing by compressing the front ring of the fitting against the body. Other compatible Camozzi fittings can be ordered from local supply houses such as Fittings, Inc. at (206)767-4670.

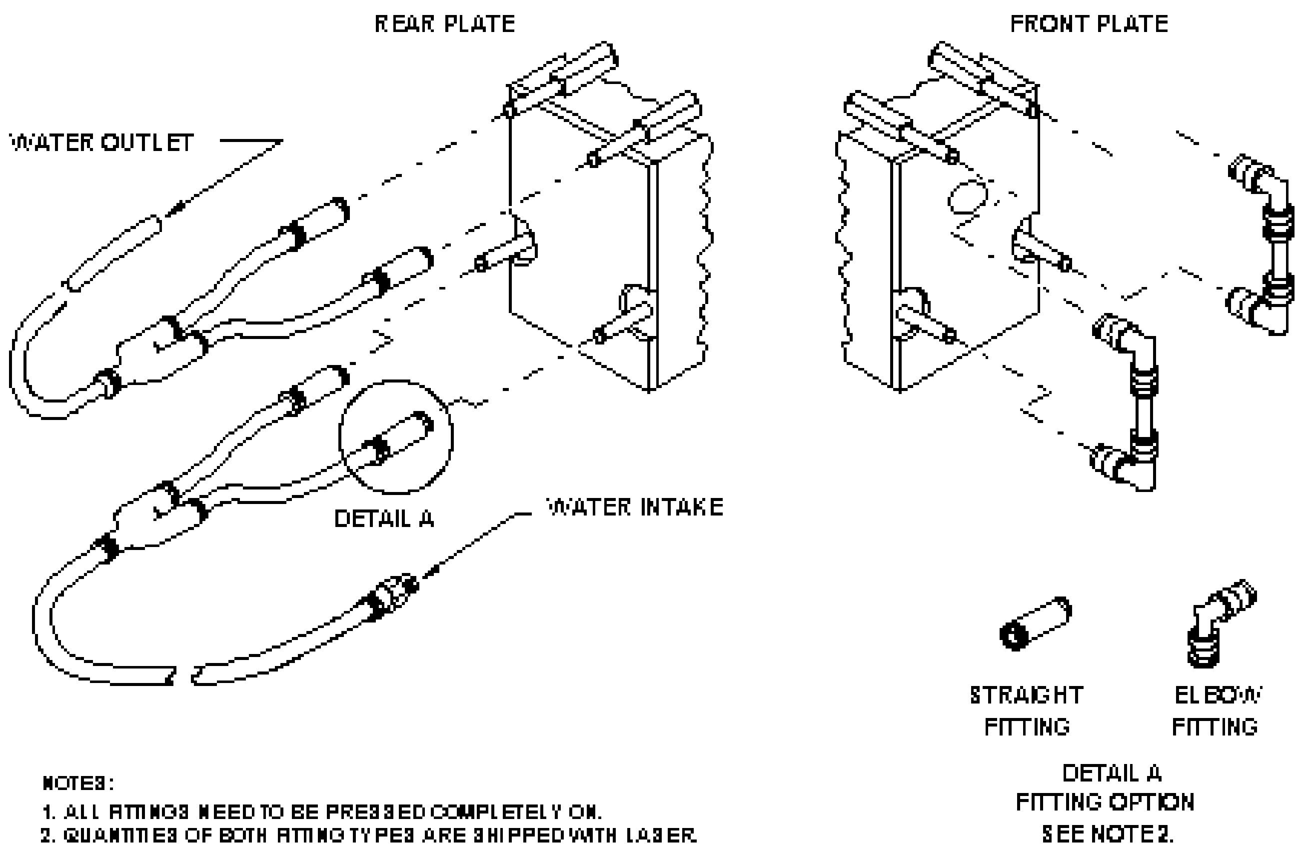


Figure 4.3
48-1/2 Laser Cooling Kit

4.4.2 48-5 Cooling

The 48-5 heat load is 800 watts and requires water cooling to prevent damage to the laser. Cooling water between 18 and 25°C maximum at a minimum flow rate of 1.5 GPM must be used. Heat removal from the cooling water is required and can be accomplished using a Neslab (1-800-258-0830) CFT33D, PD-2 chiller. Heat rejection at maximum continuous power is about 1.2 kW. **Air cooling is not sufficient for this model.**

The cooling water intake is at the central side tubes plus one central tube located on the rear of the laser. Exit is from the two top tubes and one of the central tubes. The front central tubes are "jumpered" using a twin fitting and plug, while the front side and top are also jumpered at each side using two right angle fittings.

A cooling intake and exit manifold using a quick-disconnect Camozzi system (refer to Fig. 4.4) is shipped as a kit with the laser. The cooling kit also includes quantities of both straight- and elbow-fittings. The quick disconnect fittings can be removed from the tubing by compressing the front ring of the fitting against the body of the fitting. Other "Camozzi" fittings can be ordered from local supply houses such as Fittings, Inc. at (206)767-4670.

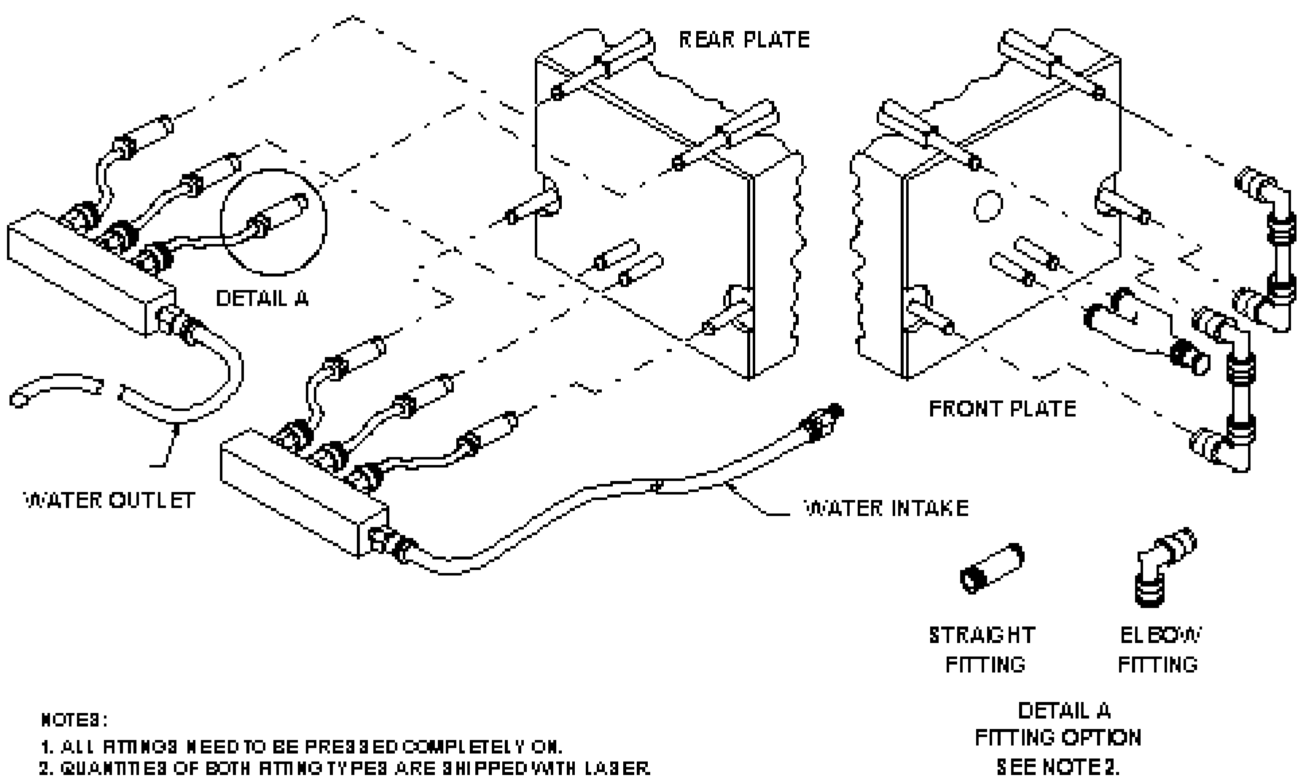


Figure 4.4
48-5 Laser Cooling Kit

Chapter 5
Unpacking and Setup

5.1 Unpacking/Initial Inspection

Place the shipping container on a sturdy, level surface and open the top of the box. Verify that the following items are included in the container:

Series 48 Laser
Operation and Service Manual
Fuse(s): One 10 Amp (48-1)
One 20 Amp (48-2)
Two 30 Amp (48-5)
DB9 Female Connector
DB9 Hood
Cooling Kit
Warranty Registration Card
Final Test Data Report

Do not discard the shipping container or the foam packing since these are required if the laser is ever returned to Synrad for factory service.

Carefully remove the Series 48 Laser from the container and remove the outer foam packing material.

Inspect the laser housing for any visible signs of shipping damage. Verify that all external labels and placards are attached to the housing (refer to Appendix A for label location diagrams). Contact Synrad if the laser housing is damaged or if any of the required materials, labels, or placards are missing.

5.2 Mounting

The recommended mounting orientation for Series 48 lasers is horizontal. If this cannot be accomplished, the lasers may be mounted at an angle of >20° to the vertical. Consult the factory for limitations if laser is to be mounted in a vertical orientation.

The laser may be hard-mounted to equipment by removing several of the bottom panel screws and replacing these with longer ones to secure the laser to optical assemblies. Use a minimum of 4 screws (Model 48-1) or 6 screws (Model 48-2/48-5) in a symmetrical pattern to properly distribute mounting forces. Do not remove the cover. This method is only recommended as long as the screws do not support the weight of the laser in service or in shipping. For a more sturdy attachment, the laser may be clamped to optical assemblies by applying clamping forces between top and bottom cover screws. Do not apply clamping forces on center line. Refer to Appendix A (Pages A5 - A7) for appropriate outline/mounting diagrams.

5.3 System Interconnections

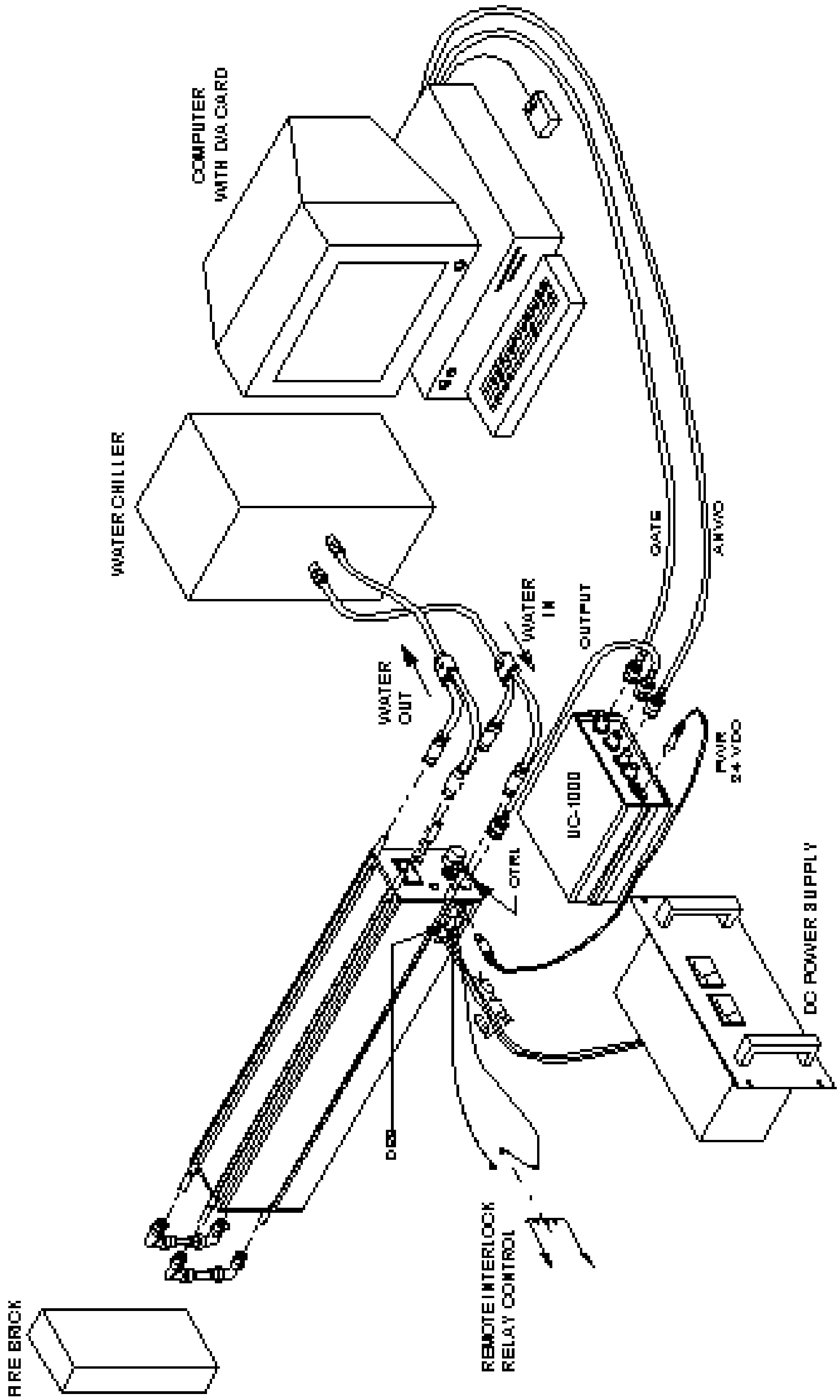


Figure 5.1
System Interconnection Diagram

Chapter 6
Operating Instructions

6.1 General

The operating instructions provided in this section are based on the use of a Synrad UC-1000 Laser Controller. If using an alternate method of laser control, please consult the factory for information regarding key aspects of laser operation.

6.2 Turn-On/Check-Out

WARNING

Harmful laser radiation is emitted through the laser exit aperture when performing the following procedure.

1. Confirm DB9 jumper configuration as required for your application (refer to Para. 4.3).
2. Verify UC-1000 POWER and external DC power supply switches are set to OFF.
3. Verify all electrical and cooling interconnects have been accomplished according to Para. 5.3.
4. Place beam block in front of exit aperture.
5. Set mechanical shutter on laser to the ON (open) position.
6. Set external DC power supply switch to the ON position.
7. Verify green PWR LED on laser illuminates.
8. Turn laser keyswitch to ON position and/or close the remote interlock. Verify green PWR LED on laser illuminates.
9. Set the UC-1000 to MAN (manual mode). Set UC-1000 POWER ADJ control to MIN and set UC-1000 POWER switch to ON. Verify the red power ON LED on the front panel of the UC-1000 illuminates.
10. Verify red LASE LED on the laser illuminates (dimly) after approximately 5 seconds.
11. Slowly rotate UC-1000 POWER ADJ control towards MAX and and verify intensity of red LASE LED on laser increases as UC-1000 output is increased.
12. Measure laser output power using a laser power meter (such as Synrad's PW-250 Power Wizard) to verify output is consistent with respective power rating for laser model (refer to Table 2.1 for power ratings).
13. Turn off laser power (set keyswitch to off or open remote interlock circuit as appropriate).
14. Set UC-1000 power switch to OFF.
15. Set mechanical shutter switch to OFF.
16. Turn off external DC power supply.

6.3 Operation in Pulsed Mode

In applications such as marking and cutting, the laser is required to pulse on and off in sync with an external pulsing control signal (typically from a computer or function generator operating in the range from 0 to 20kHz). To operate the laser in pulsed mode, perform the following procedure.

1. Perform Para. 6.2, Steps 1 through 8.
2. Set the UC-1000 front panel mode switch to MAN (manual mode).
3. Adjust the UC-1000 front panel POWER ADJ control to the desired power level. (If a duty cycle of 100% is required, consut factory for modification instructions.)
4. Connect the pulsing control signal to the GATE connector on the rear panel of the UC-1000.
5. The laser system is now configured to operate in the pulsed mode. As the control signal pulses TTL high (>3.5VDC), the UC-1000 will turn the laser on at a power level corresponding to the UC-1000 POWER ADJ switch setting. When the control signal pulses TTL low (<0.5VDC), the UC-1000 output/duty cycle will approximate 0V and will force the laser to turn off.

6.4 Operation in Continuous Wave (CW) Mode

In some applications, such as high speed marking, the finite turn off time of the laser due to modulation causes a series of dots that may be visible on the marking surface instead of a “clean” line. Operating the laser in CW mode will prevent this from occuring, however there will be a slight decrease in laser efficiency when the duty cycle is increased beyond 95% (refer to Fig. 2.2). To operate the laser in CW mode, a constant +5VDC signal can be connected to the TTL input of the laser. This constant source will force the internal switching electronics to remain on providing continuous and uninterrupted laser output power. Note that in CW mode, laser power output cannot be adjusted using the UC-1000. If laser power needs to be adjusted, refer to Para. 2.3.2 for information regarding high frequency operation.

The UC-1000 can be modified to achieve 100% duty cycle operation if required for your application. Consult the factory for requirements and details.

6.5 PC Control of Laser

To control on/off pulsing of the laser (pulsed mode), a signal providing TTL-level pulses is connected to the GATE connector on the rear panel of the UC-1000. Typically, this signal would be generated using an add-in digital I/O card and controlling software.

If the user wishes to control laser power using a computer, either a 0 - 10V analog voltage or a 4 - 20mA analog current can be connected to the UC-1000 ANV (analog voltage) or ANC (analog current) BNC connectors, respectively. To generate the analog voltage, a digital-to-analog (D/A) card capable of generating 0V (laser off) to 10V (maximum power) must be installed. To generate the analog current, a D/A card capable of generating 4mA (laser off) to 20mA (maximum power) must be installed. Controlling software is required for both configurations.

Chapter 7
Maintenance and Troubleshooting

Table 7.1
Series 48 Troubleshooting Table

FAULT	PROBABLE CAUSE
Laser beam is off	1. Check power source, key switch, and optical shutter to verify that they are properly set. Allow for the built-in five second delay between turning on electrical power and initiation of laser tube excitation. 2. Check fuses. 3. If laser is warm, allow it to cool and recycle source power to see if the thermal cutout was activated. 4. Check for proper input signal. Laser does not operate unless an input signal to the CTRL jack is present. 5. Return key switch to "Off" position for a few seconds, or recycle source power to reset circuits. 6. If laser tube will not start, factory servicing of laser may be required.
Laser power is low	1. Check waveform of TTL signal if modulation is used. 2. Check input voltage level (28 VDC). 3. Use mode screen (ceramic tile can be used) to verify circular optical beam shape at a distance of 3 to 5 feet from laser. If beam spot is not circular and stable, the optical mirror alignment is out of adjustment. See below. 4. If laser power is below specification, laser gas may need to be replaced, or one of the drivers is defective. Contact factory.
Laser spot is not circular or does not stay circular	1. The optical mirrors are adjusted at the factory to give a TEMoo output beam that is circular 3 feet or more from the output aperture. Severe mechanical forces on the chassis may shift the original alignment of the mirrors temporarily or permanently. No attempt should be made to realign the laser. Return to factory.
Laser power is intermittent or varies in response to input pulses	1. Verify that the UC-1000 controller or equivalent has "tickle" pulses of proper duration. (Refer to Chapter 2).

Chapter 8
Return for Factory Service

In the event the Series 48 Laser requires return for factory service, Synrad must be contacted prior to shipment of the laser for a return authorization number. The return authorization number must be included on all shipping documentation included with the returned laser. The following information is required by Synrad to issue a return authorization number:

Name of company
Name and phone number of individual requesting return of the Laser
Model number
Serial number
Brief description of the fault

Return the laser in the original packing material and shipping container. Write the return authorization number on the outside of the shipping container.

SERVICE REQUEST

Company Name____

Contact Name____

Company Address____

Telephone #____________________________ Fax#___________________________________

Date originally received____

Date returned____

RA#____

Serial#____

Describe reason for repair____

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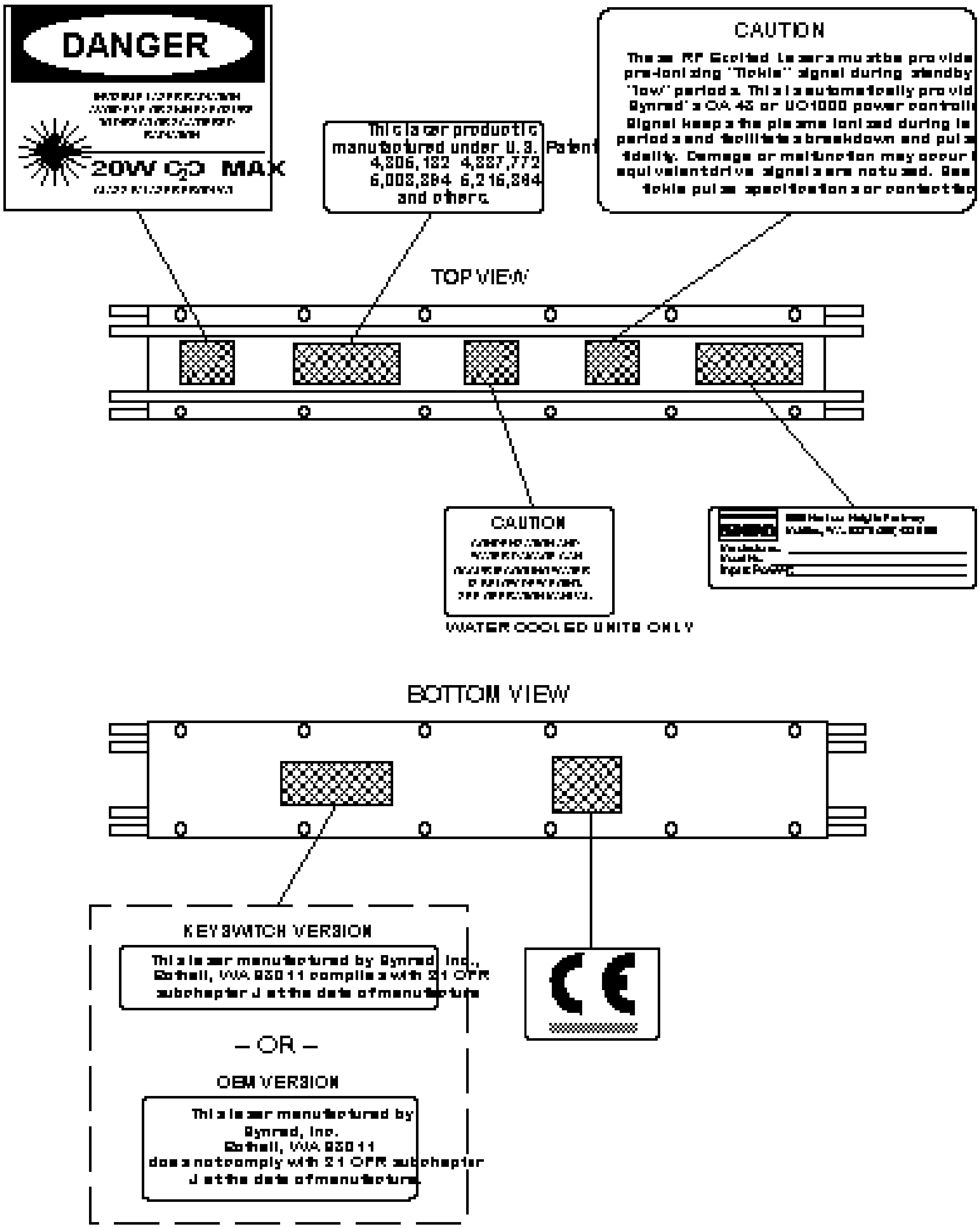
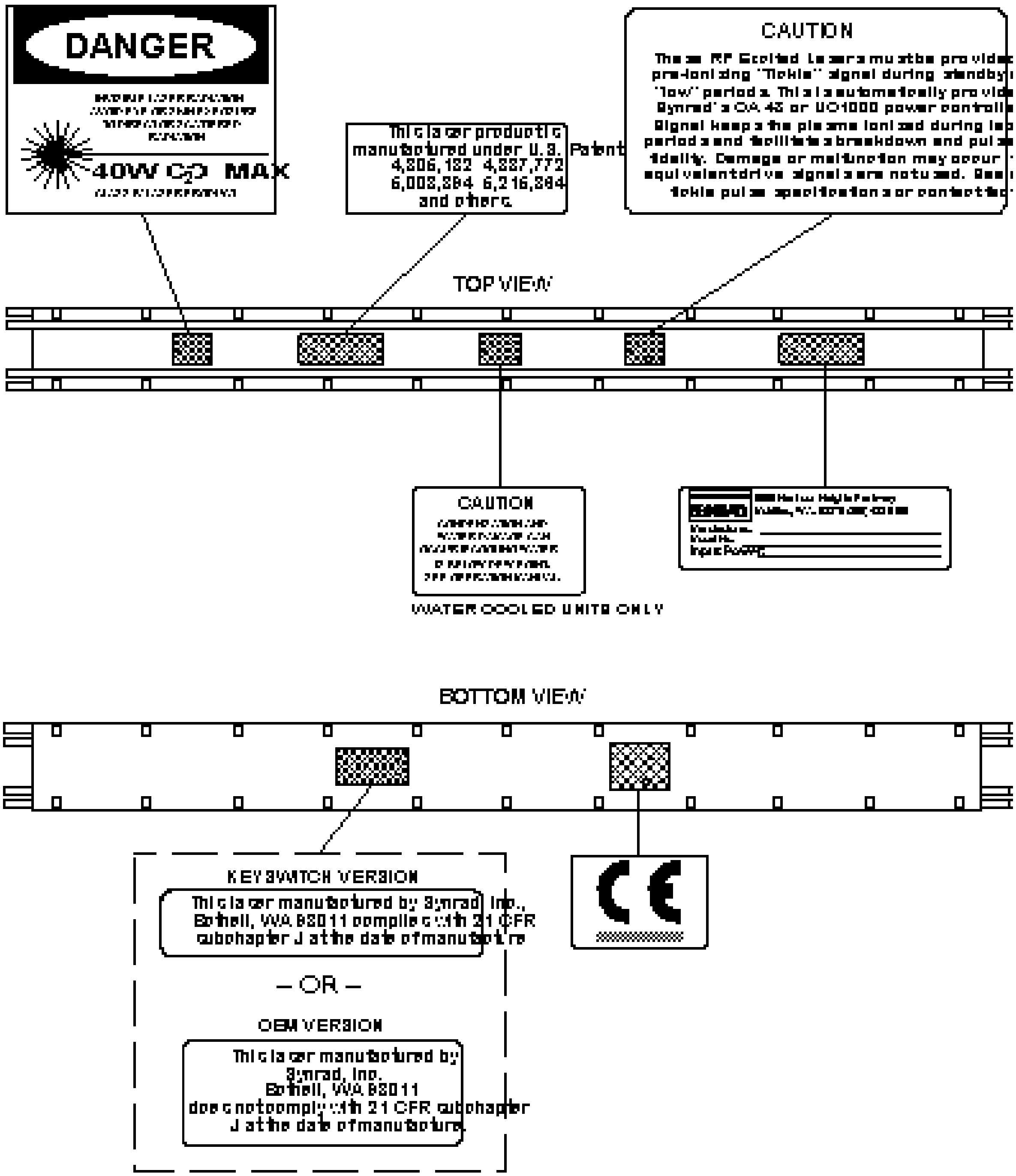
Should you need to return a laser for repair, please call SYNRAD for an RA# at (800) SYNRAD-1.

Appendix A
Supporting Documentation

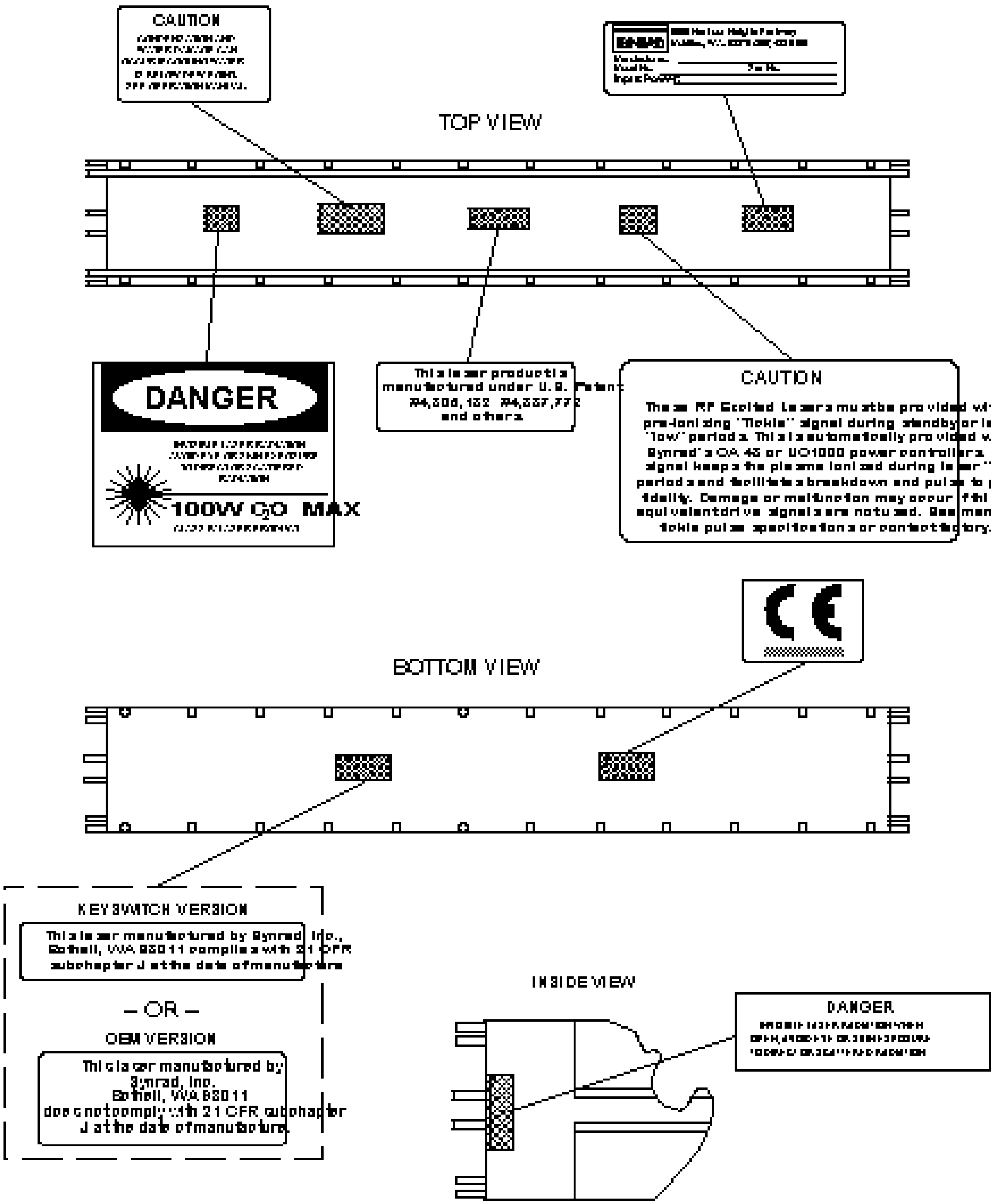
List of Supporting Documentation



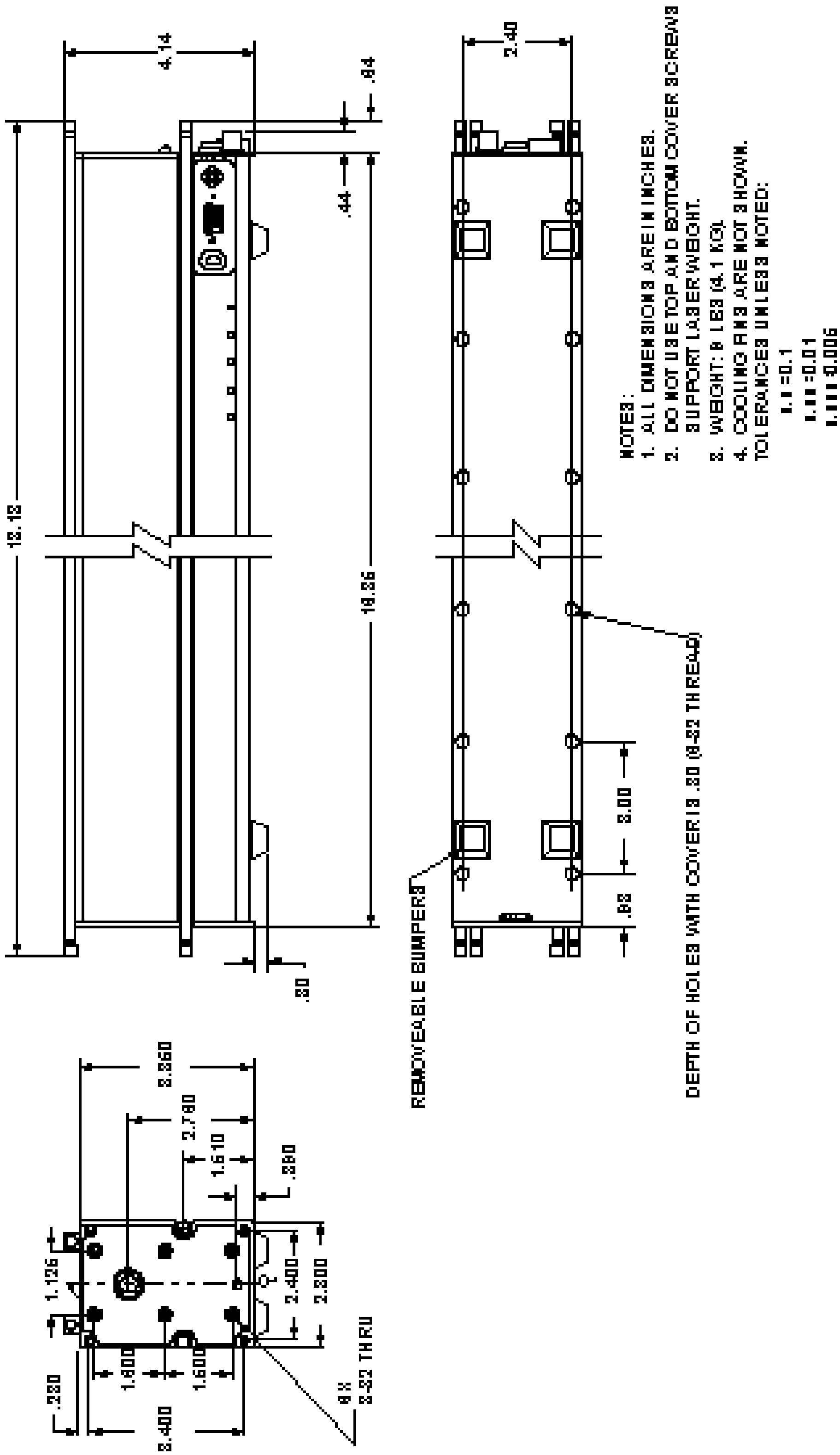
48-1 Label Location Diagram



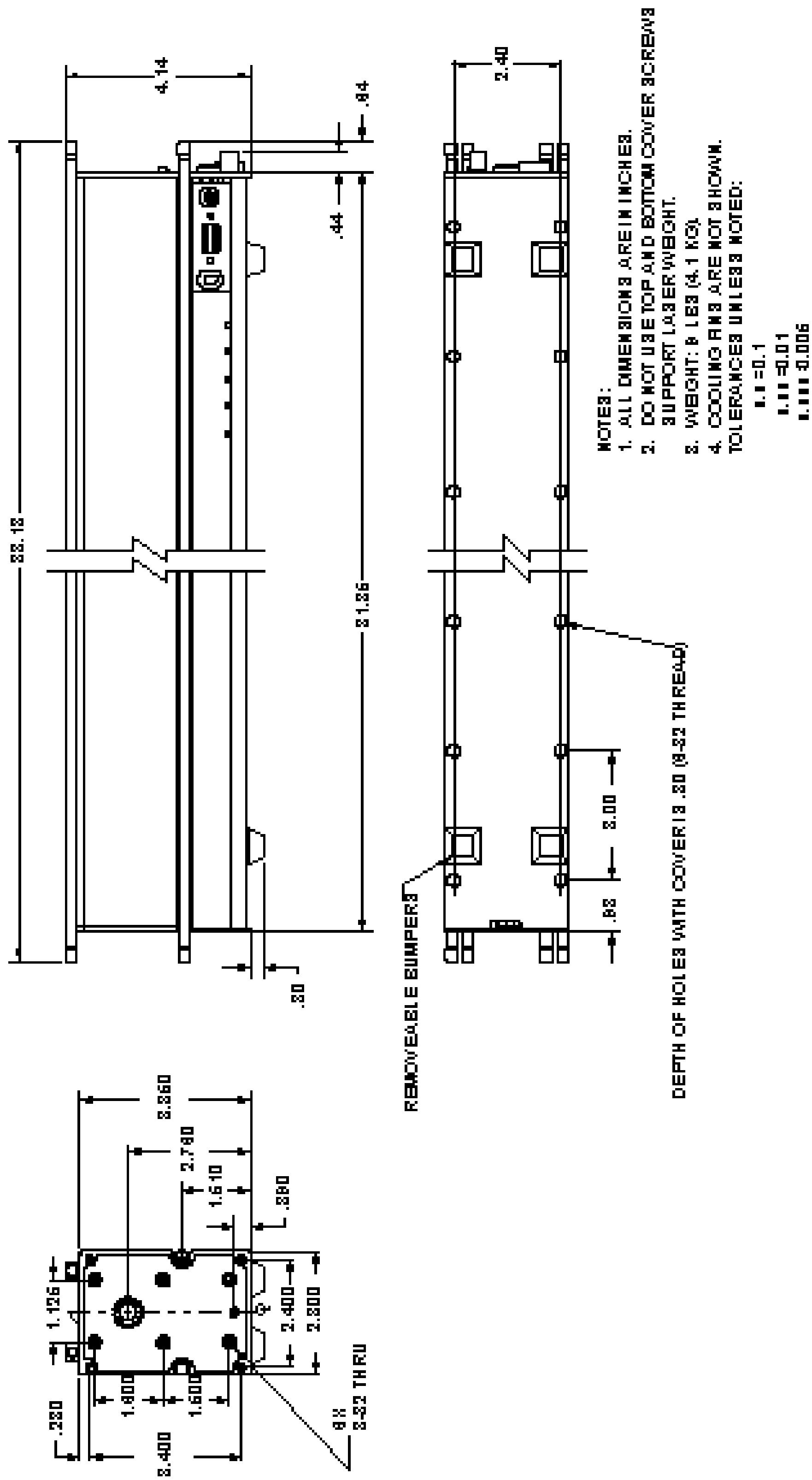
48-2 Label Location Diagram



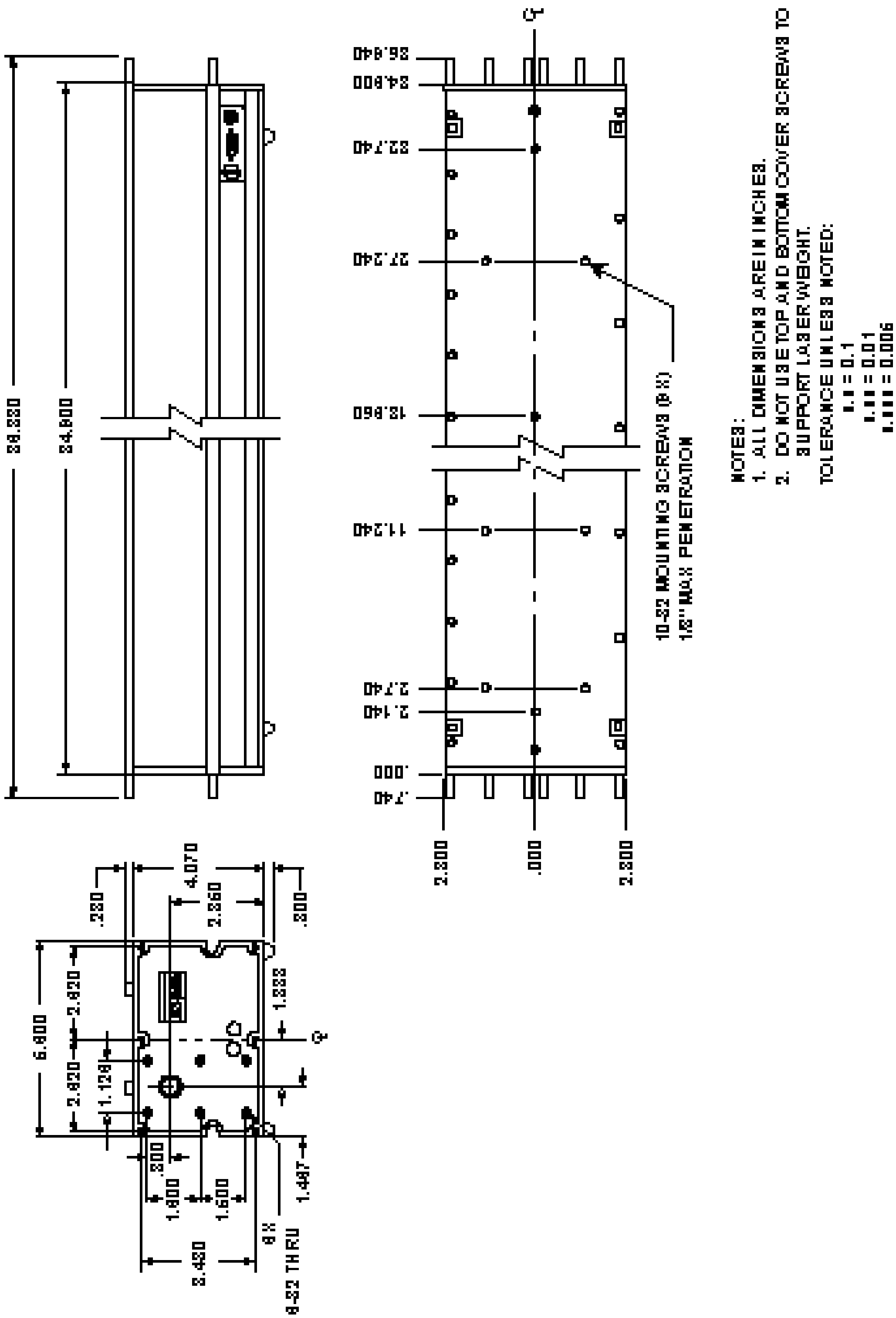
48-5 Label Location Diagram



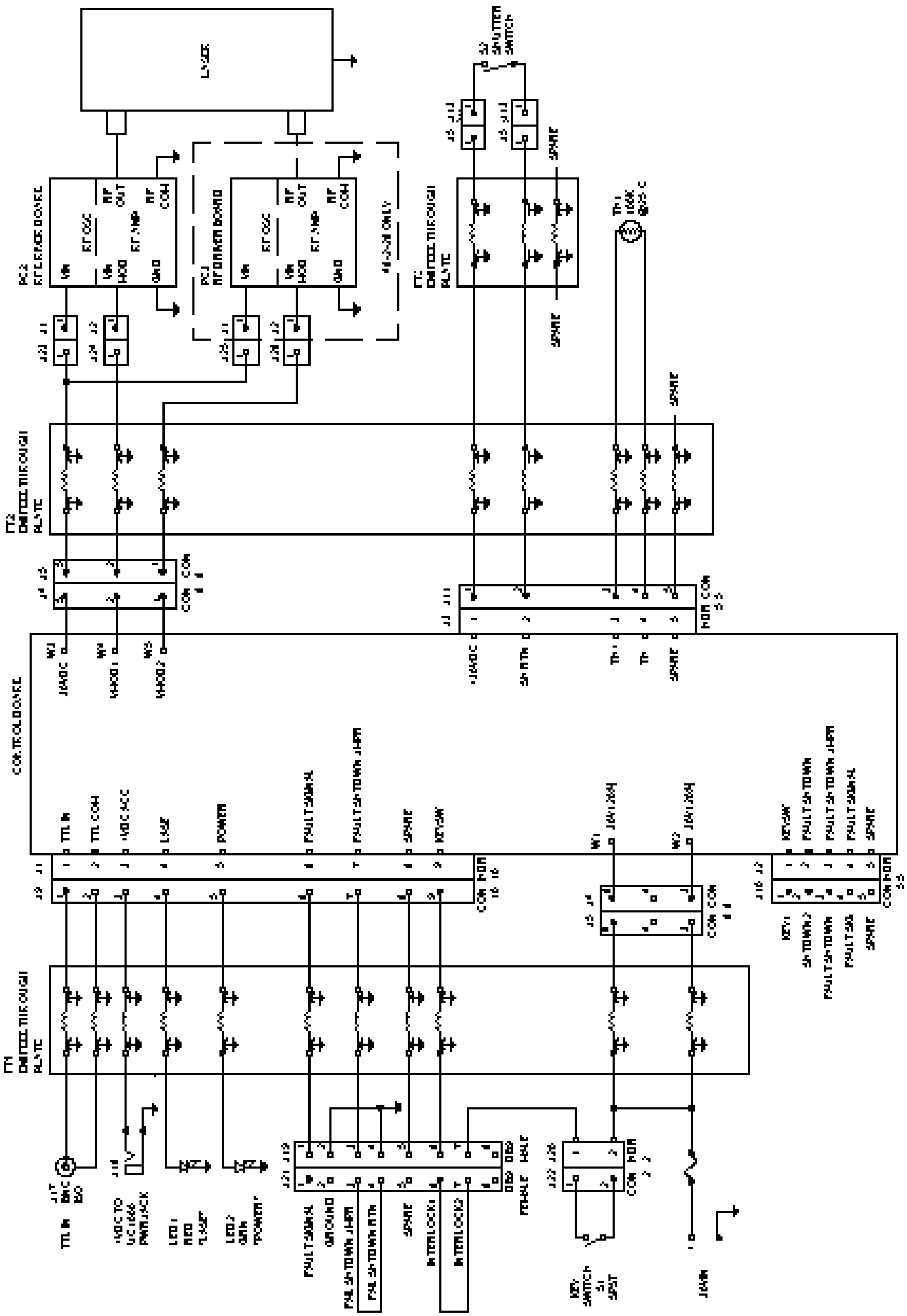
48-1 Outline/Mounting Diagram



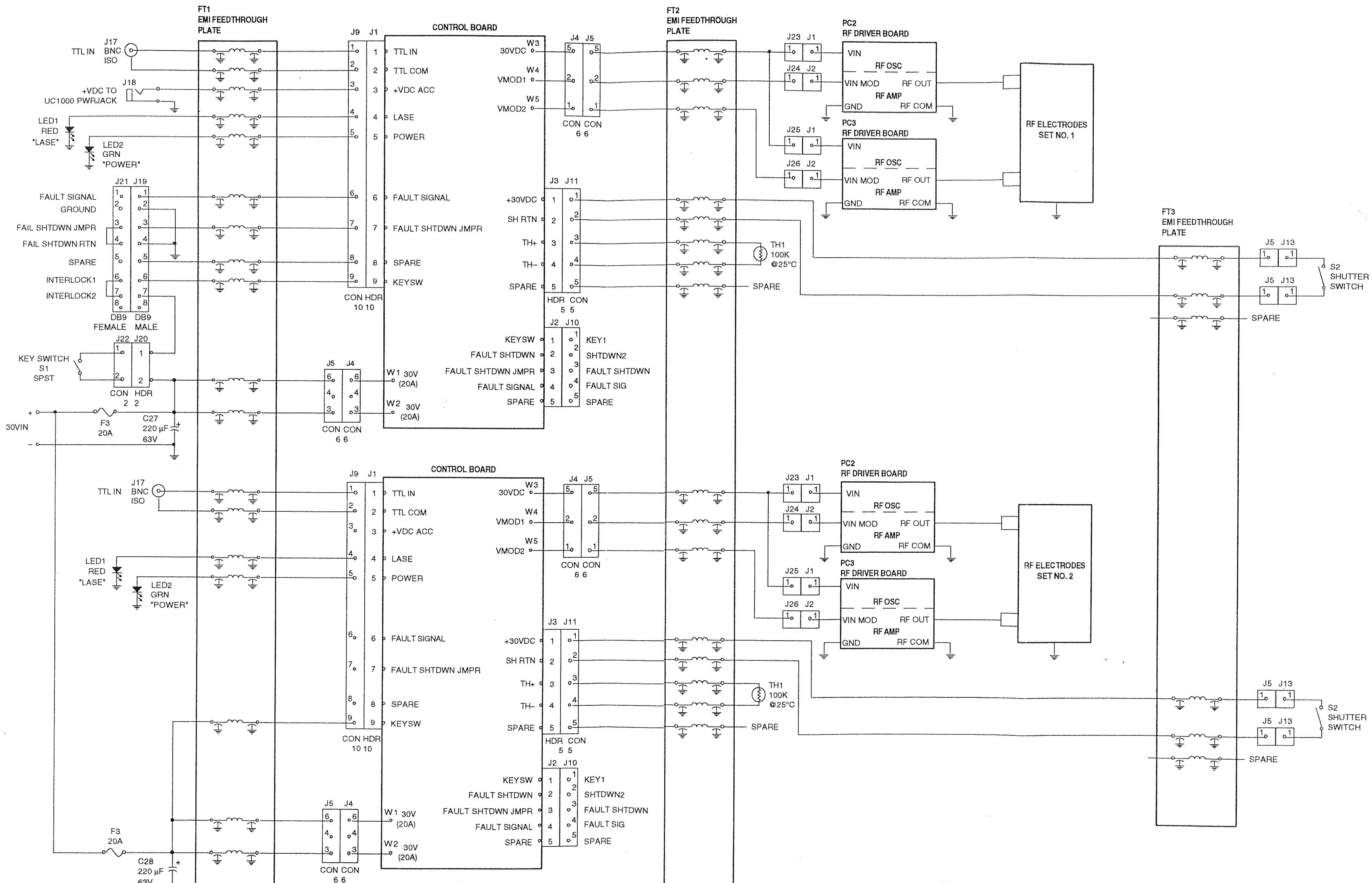
48-2 Outline/Mounting Diagram



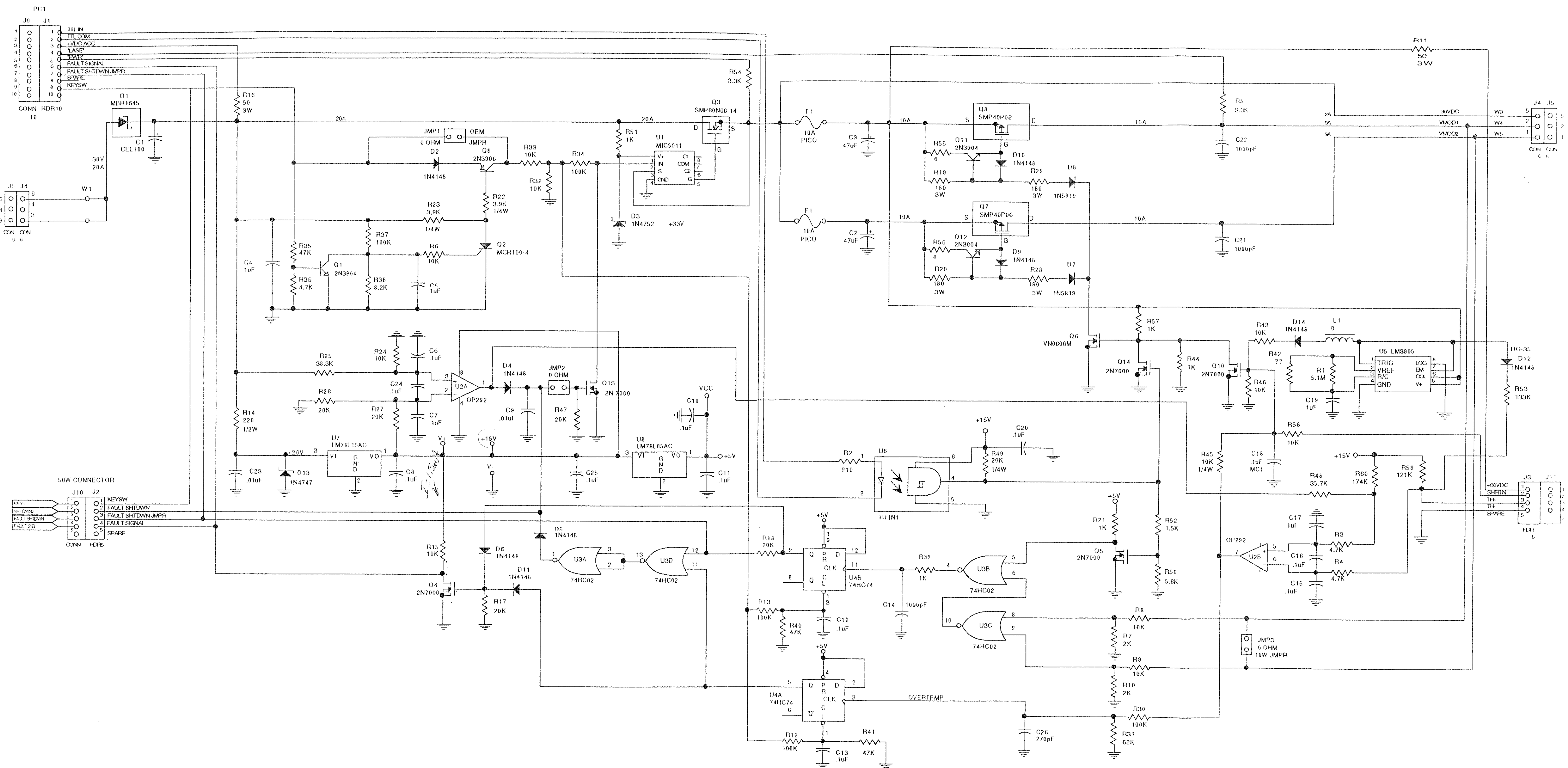
48-5 Outline/Mounting Diagram



48-1/2 Interconnect Diagram



48-5 Interconnect Diagram



Schematic, Control Board

System Options/Accessories

Brewster Window and Rear Sampling Mirrors

Rear Sampling Mirrors are not available for 48-5 lasers.

BR-1	Brewster Window and Adaptor (Set of 2)
SM-1	Sampling Mirror on New Laser (Series 48)
SM-1R	Sampling Mirror Retrofit (Series 48)
TMS-1	Turning Mirror and Support

Beam Expander and Visible Diode Pointer

BX2.5	Beam Expander, 2.5X
DP	Red Laser Diode Pointer for Series 48 Lasers

Laser Power Control

UC-1000	Universal Controller (Unit is shipped with 115VAC to 27VDC wall transformer. Wall transformers for other line voltages (220, etc.) are not supplied by Synrad.)
SSC-1000	Spike Suppressor Controller
48-CL[(1)]	Closed Loop Stabilization Kit (Series 48)

DC Power Supplies

DC-1	48-1-28(W)
DC-2	48-2-28(W)
DC-5	48-5-28W

Laser Power Meters and Probes

PW-250	Power Wizard®, 250 Watts Maximum
PW-2	Power Wizard®, 2 Watts Maximum
SY10	10 Watt Continuous Power Probe
SY30	30 Watt Continuous Power Probe
SY150	150 Watt Continuous Power Probe
SY300	300 Watt Continuous Power Probe
SY5100	Analog Laser Power Meter
SY5200	Analog/Digital Programmable Power Meter

Laser Safety Glasses

LSG	Laser Safety Goggles
LSS	Laser Safety Spectacles

System Options/Accessories (Continued)

Beam Delivery Components

LMS-1.25	Laser mounting System
PET-4	Path Enclosure Tube, 4" Length
PET-10	Path Enclosure Tube, 10" Length
BBA-1.25	Beam Bender Assembly
VAS-1.25	Vernier Adjust Spacer
GJM-1.5	Gas Jet Manifold 1.5" focal length (incl. ZnSe focusing lens)
GJM-2.5	Gas Jet Manifold 2.5" focal length (incl. ZnSe focusing lens)
GJM-4.0	Gas Jet Manifold 4.0" focal length (incl. ZnSe focusing lens)
ATA	Articulated Arm Assembly (incl. laser mounting system)
ATK-1.0	Alignment Tool Kit

Turning Mirrors

F1	1" Diameter Adjustable Turning Mirror/Mount
RAM	Right Angle Silicon Mirror, .70 x .65 x .08"

Zinc Selenide Focusing Lenses

ML2.5	2.5" Focal Length Lens, Meniscus, 1.1" dia.
PCL1.5	1.5" Focal Length Lens, Plano-convex, 0.6" dia.
PCL2.5	2.5" Focal Length Lens, Plano-convex, 0.6" dia.

Right Angle Focusing Assemblies

RAL2.5	2.5" Focal Length, Minimum Spot Size .006"
RAL1.5	1.5" Focal Length, Minimum Spot Size .004"
RAL.7	0.7" Focal Length, Minimum Spot Size .002"

SH Series Scanning Heads

Includes 3X Beam Expander(2) and Flat Field Focusing Lens Assembly

For $C0_2$ lasers:

SH3-U	Unfocused (no final focusing lens incl.)
SH3-200C	110 x 110 mm Field Size, 176 µm spot size, 200 mm efl
SH3-125C	70 x 70 mm Field Size, 110 µm spot size, 125 mm efl
SH3-69C	38 x 38 mm Field Size, 60 µm spot size, 69 mm efl
SH3-125CT	95 x 95 mm Field Size, 150 µm spot size, Telecentric lens

For YAG lasers:

SH3-U	Unfocused (no final focusing lens incl.)
SH3-550Y	305 x 305 mm Field Size, 65 µm spot size, 550 mm efl
SH3-250Y	138 x 138 mm Field Size, 30 µm spot size, 250 mm efl
SH3-125Y	69 x 69 mm Field Size, 15 µm spot size, 125 mm efl

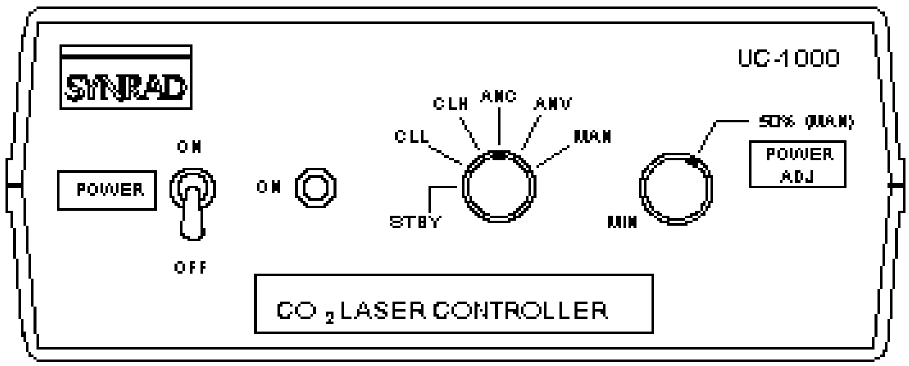
(1) Each closed loop kit includes a UC-1000.

(2) Optional Beam Expander Ratios: 4, 5, 6, 7.5, and 10X.

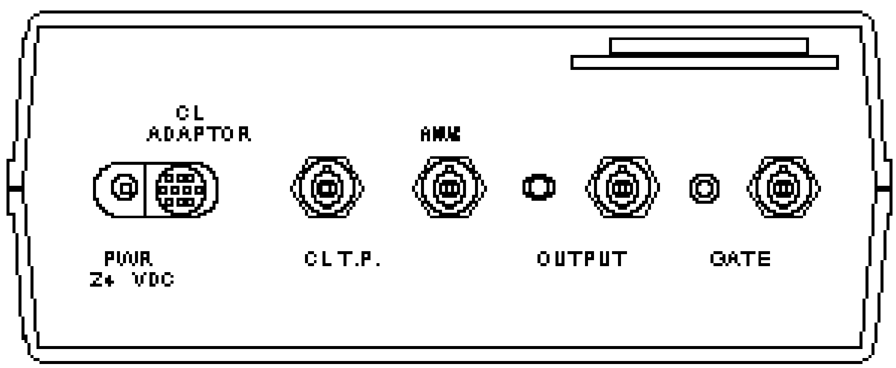
Appendix B
UC-1000 Laser Controller

UC-1000 Laser Controller

The UC-1000 was designed to serve as a general purpose interface between user signals and Synrad's complete line of CO_2 lasers. For additional information, consult the UC-1000 manual.



Front Panel



Rear Panel

UC-1000 Power Controller

UC-1000 Operating Modes

The UC-1000 operating modes are selectable by means of a front panel, six-position rotary switch. The operating modes are as follows:

Standby: In this mode, only the 1 µsec wide tickle pulse is generated. This tickle signal allows the laser plasma to be ionized without resulting in emission.

Closed Loop Low Gain (CCL): Closed loop operation of the laser can provide better than ±2% power stability. This is achived by splitting a portion of the outgoing laser power to a thermo-pile detector. The amplified signal is compared against a reference and regulates the output duty cycle (pulse width). Reference level is established by a front panel-mounted power control potentiometer. Operation in the closed loop mode requires a 48-CL laser-mounted power sensor. The 48-CL can be user added, in the field, to any Series 48 laser.

Closed Loop High Gain (CLH): Same as CCL but with higher internal gain.

Remote Current Control (ANC): In this mode, a 4-20 mA DC current is applied to the UC-1000 at J5. It controls laser power between zero and maximum. This is the standard industrial control interface allowing loop supervision. Input impedance is low.

Remote Voltage Control (ANV): In this mode, a 0 to 10VDC voltage controls power between zero and maximum. This is high impedance input.

Manual Mode (MAN): Laser power control is accomplished with a front panel-mounted potentiometer.

Gate Function

GATE connector (BNC) provides input for a gate signal to turn the laser on and off in response to an external pulse train. The on laser power level is set by the operating controls or remote inputs. In the off position, tickle is still provided to the laser. The gate function can be used in all five active modes. A TTL high turns the laser on. A choice of input connectors is provided, either BNC or sub-miniature phono.

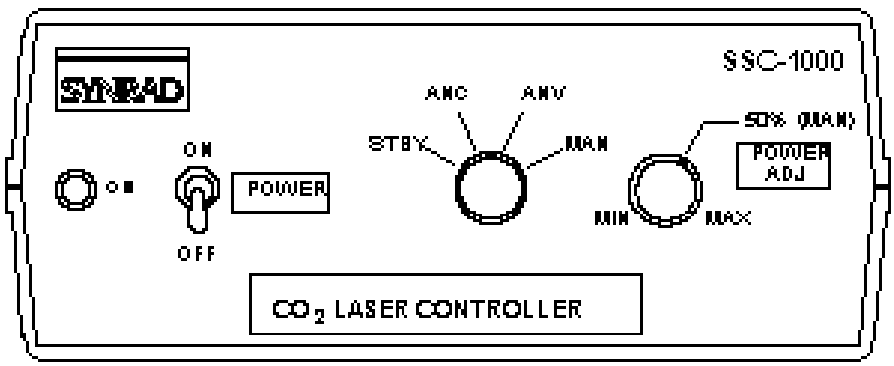
Internal Switches

By removing the top cover (screws accessible from the bottom), the clock rate can be changed from a nominal of 5 kHz (required for operation of Series 48 lasers) to 3 or 7.5 kHz. For more details, consult the UC-1000 manual.

Appendix C
SSC-1000 Spike Suppressor Controller

SSC-1000 Spike Suppressor Controller

The SSC-1000 is a laser power controller designed to provide a general purpose interface between the user's control signals and Synrad's complete line of CO_2 lasers. It provides functions that are similar to Synrad's UC-1000 controller, but is functionally different in that the SSC-1000 operates at a higher clock rate and is designed to suppress the laser's overshoot spike which occurs at low modulating gate frequencies (< 500 Hz).



SSC-1000 Spike Suppressor Controller

Operating Modes and Inputs/Outputs

There are four operating modes supported by the SSC-1000: Standby, Remote Current Control, Remote Voltage Control, and Manual Control. In each mode, a pre-ionizing tickle pulse is provided to keep the plasma ionized during laser "low" or "off" periods. This facilitates plasma breakdown and pulse-to-pulse fidelity without causing laser emission. The four modes are explained as follows:

Standby: This mode is used for initial start-up of the laser, or for a temporary pause in operations. There is no laser emission in this mode since only the tickle pulse is present.

Remote Current Control (ANC): In this mode, the laser power is controlled by a DC current applied to the ANV/ANC input. Power output will begin above 4mA and will reach a maximum at 20mA. This is the standard industrial control interface allowing loop supervision.

Remote Voltage Control (ANV): In this mode, the laser power is controlled by a DC voltage applied to the ANV/ANC input. Power output will begin above 0V and will reach a maximum at 10V.

Manual Mode (MAN): In this mode, the laser power is controlled by varying the power adjust knob on the front panel.

Power Input

The input power connector is used in conjunction with the supplied "wall plug" transformer/rectifier to convert the 115VAC line into a nominal 24VDC (@400mA max). For line voltages other than 115VAC, compatible transformers can be purchased that will convert the voltage into 24VDC. Alternatively, power can be provided from any 24V to 32VDC source.

ANV/ANC Input

The BNC connector is the remote voltage or current input to be used while in the ANV/ANC mode of operation.

Output

Two connectors are used to supply the SSC-1000 signals to the laser. One is a subminiature phone jack and is used in conjunction with the white cable supplied with the unit. Alternatively, a BNC output can be used with shielded coaxial cable of up to 25ft in length.

Gate Input

There are two connectors which are TTL compatible inputs that allow the user to turn the laser on and off at a frequency determined by an externally applied pulse train. A TTL high signal will turn the laser "on." During this "on" period, the manual, power adjust knob or the ANV/ANC control signal is used to vary the laser from maximum down to zero power (tickle signal only). The maximum allowable gate frequency is around 2kHz.