R-SERIES LASER SYSTEMS

USER MANUAL

(For R-Series Track Mounted
Diode Pumped Laser Systems)

Spectra-Physics

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Declaration of Conformity

Application of Council Directive 89/336/EEC and 73/23/EEC
Standards to which Conformity is Declared:

EN50082-1, EN55011, EN61010-1, EN60825-1

Manufacturer's Name:
Spectra-Physics Lasers, Inc.

Manufacturer's Address:
1305 Terra Bella Avenue, P.O. Box 7013
Mountain View, CA 94043-7013

Equipment Tested: Lasers

Model(s):
R05-S15-104Q, R2-S-104c, R2-S-106c, R1-S10-104Q, R1-S10-523Q, R1-S12-106Q, R1-S12-532Q, R2-E12-104Q, R2-E12-104Q-16, R2-E12-523Q, R2-V38-104Q, R2-V50-104Q, R2-E20-106Q, R2-E20-532Q, R2-VS5-104Q, R2-I10-104Q.
Above Models with GPIB and Remote Options.
Power Supply 7300X-L2 with Laser Head 7960-L2-S,
Power Supply 7300X-L4-80 with Laser Head 7960-L4-I-80,
Power Supply 7300E-L3-80 with Laser Head 7960-L4-I-80,
Power Supply 7300E-L4-80 with Laser Head 7960-L4-VS,
7960-L4-I, or 7960-L4-I-80.

I, the undersigned, hereby declare that the equipment specified above conforms to Directives and Standards listed.

For: Spectra-Physics Lasers, Inc.
Name: Charles E. Chandler
Title: Vice President and G.M. OEM
Signature: Charles E Chandler

Date: 9/24/97

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Preface

R-Series Laser Systems

This manual describes the installation, operation, and service requirements of the R-Series Industrial Diode Pumped Laser System. Including Power Supply, Laser Heads, Frequency Doubler and Remote Control.

The R-Series Q-switched laser head and the Model 7300 laser diode module emit laser radiation that can permanently damage eyes and skin, ignite fires, and vaporize substances. The Laser Safety section contains information and guidance about these hazards. To minimize the risk of injury or expensive repairs, carefully follow these instructions.

The Service and Repair section is intended to help guide you to the source of common problems. Do not attempt repairs while the unit is under warranty. Instead, report all problems to Spectra-Physics for warranty repair.

We welcome your comments on the content and style of this manual.
Thank you for your purchase of Spectra-Physics instruments.

Quantity	Unit	Abbrev.	Prefixes		
mass	gram	g	tera	(10^{12})	T
length	meter	m	giga	(10^{9})	G
time	second	s	mega	(10^{6})	M
frequency	hertz	Hz	kilo	(10^{3})	k
force	newton	N	deci	(10^{-1})	d
energy	joule	J	centi	(10^{-2})	c
power	watt	W	milli	(10^{-3})	m
electric current	ampere	A	micro	(10^{-6})	μ
electric charge	coulomb	C	nano	(10^{-9})	n
electric potential	volt	V	pico	(10^{-12})	p
resistance	ohm	Ω	femto	(10^{-15})	f
inductance	henry	H	atto	(10^{-18})	a
magnetic flux	weber	Wb			
magnetic flux density	testa	T			
luminous intensity	candela	cd			
temperature	kelvin	K			

FIGURE p-1: SI Units

This product is manufactured under one or more of the following Spectra-Physics Patents:

U.S. PATENT NUMBERS

4,653,056	4,837,771	5,351,121	5,608,742
4,656,635	4,872,177	5,410,559	5,638,388
4,665,529	4,894,839	5,412,683	5,651,020
4,701,929	4,908,832	5,436,990	5,745,519
4,723,257	4,913,533	5,446,749	5,801,403
4,739,507	4,942,582	5,504,762	5,812,583
4,756,003	5,018,152	5,550,852	5,835,513
4,761,786	5,080,706	5,561,547	5,907,570
4,785,459	5,127,068	5,577,060	
4,829,529	5,155,631	5,579,422	

Introduction

CHAPTER ONE

Theory of Operation

Spectra-Physics diode pumped, solid-state lasers use temperature- tuned phased array GaAlAs laser diodes. These diodes replace arc lamps or incandescent light sources as the optical pumping source.

The principal advantages of this approach include:

- Longer lifetime
- More compact size
- Elimination of the need for water cooling
- Elimination of thermal lensing in the active medium.

Laser Head Optical Parameters

The laser head uses a hemispherical cavity design and an axial pump geometry to excite the solid-state laser medium (Figure 1-1). The laser medium is a 5 mm long rod of either neodymium-doped yttrium aluminum garnet (Nd:YAG) or yttrium lithium fluoride (Nd:YLF).

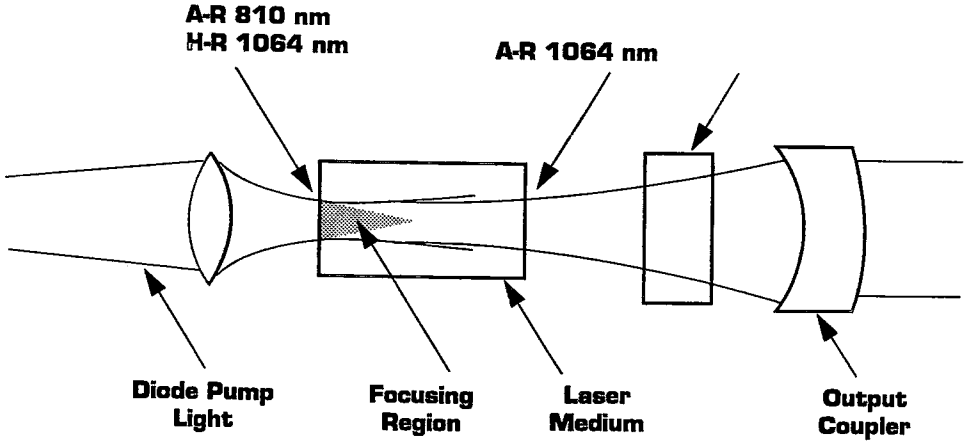


FIGURE 1-1: Optical Schematic of Diode Pumped Nd:YAG Laser

Both ends of the rod are optically polished. Typically, the input end is coated to be a high transmitter in the absorption band of neodymium, and a high reflector in its emission wavelengths. The output end of the rod is antireflection coated at the lasing wavelength. An acousto-optic Q-switch is placed between the laser rod and output coupler. The input-end surface of the rod and the output coupler form the laser cavity.

The laser diode pump light is coupled into the laser medium through a fast lens that matches the pump volume to the TEM_{00}mode volume of the laser cavity. Through this "mode matching," the maximum absorption of the pump wavelength takes place within the TEM_{00}laser mode volume (Figure 1-2). This approach ensures maximum coupling efficiency of the pump light into the laser medium and optimizes laser operation in the TEM_{00} mode.

Pump light is delivered to the laser medium through a flexible optical fiber. This design makes it possible to replace the laser diode pump source without realignment of the laser head to the optical beamtrain

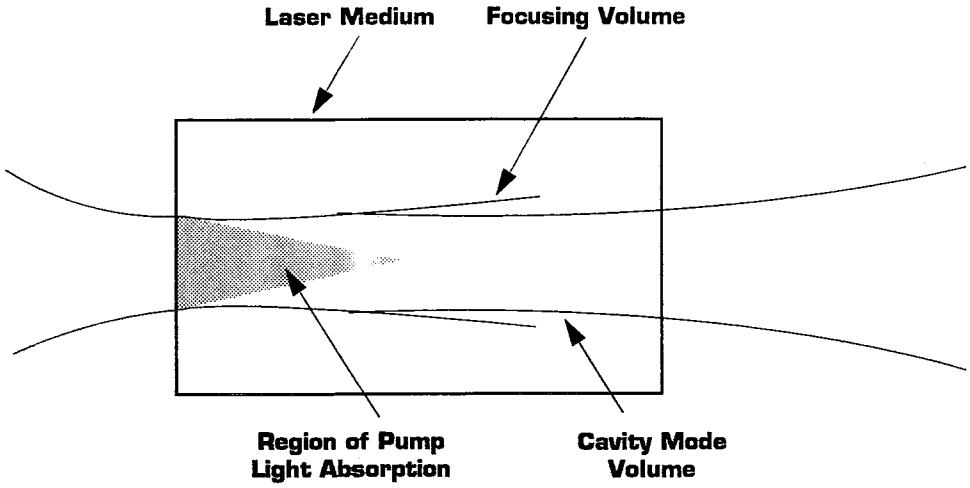


FIGURE 1-2: Mode Matching the Pump Volume

Temperature Tuning of the Laser Diode

The laser diode is located in the Power Supply. For maximum efficiency, the output wavelength of the diode must match the absorption characteristics of the laser medium. The absorption spectrum of Nd:YAG and a depiction of the diode pump wavelength are shown in Figure 1-3. The output spectrum of a conventional pump source for Nd:YAG operation, the krypton arc lamp, is shown for comparison

The process involved in the manufacture of the GaAlAs laser diodes produces a broad distribution of output wavelengths. To match the diode output to an absorption peak of the laser medium, it is necessary to select diodes with outputs near the absorption peak and then temperature tune them for maximum absorption: 0.3 nm of wavelength shift occurs for every 1° C change in temperature of the diode junction. Cooling shortens the wavelength, and heating lengthens it.

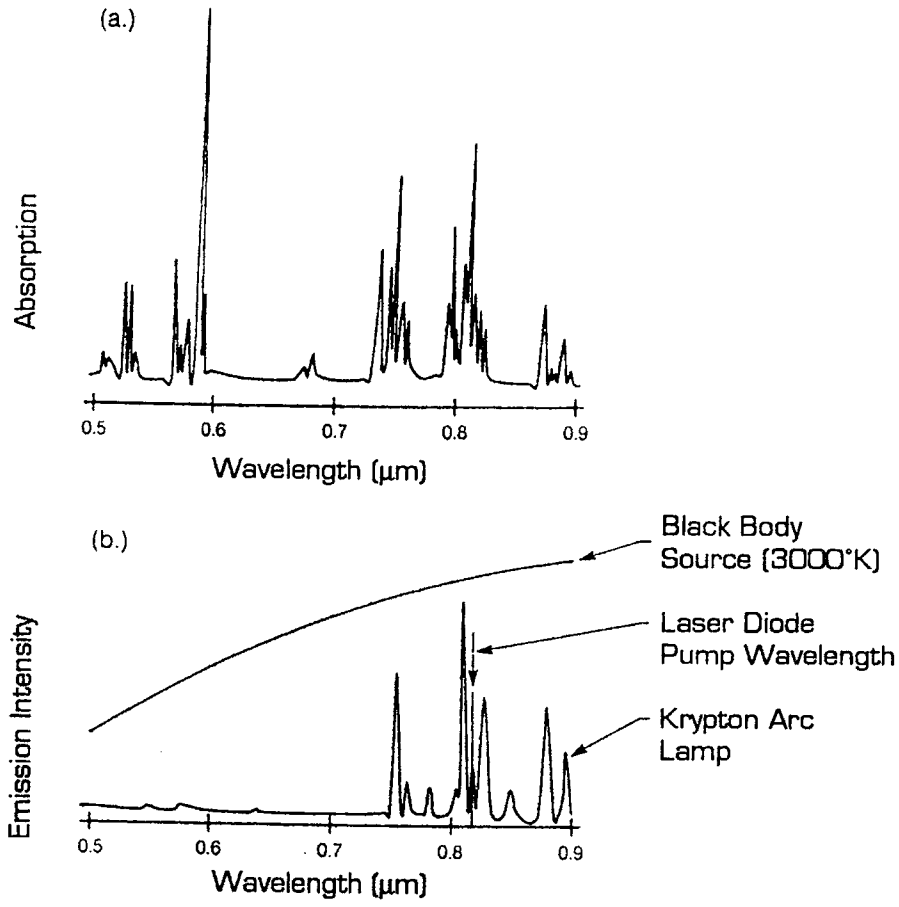


FIGURE 1-3: Nd:YAG Absorption Spectrum (a) and Pump Source Emission Spectra (b)

The R-Series Power Supply uses laser diodes with wavelengths longer than the absorption peak of the laser medium when measured at room temperature. A thermoelectric (TE) cooler brings the diode temperature down until the output wavelength matches the absorption peak.

Cooling the diodes results in slightly lower electrical efficiencies for the system because of the drive current requirements of the TE coolers, but it extends system lifetime by running the diodes at lower temperatures.

The absorption maxima for YAG and YLF are separated by approximately 10 nm. A R-Series Power Supply with diodes optimized for one active medium will not optimally pump laser heads using the other medium.

Q-switch Operation

An acousto-optic Q-switch is the variable loss element in the laser cavity of the laser head. An rf driver in the Power Supply controls the Q-switch, allowing pulse rates from 1 Hz to 10 kHz using the internal clock. Pulse rates to 50 kHz can be generated using an external trigger source. Single Q-switched pulses may also be obtained.

The Q-switch consists of a block of optical quality glass with a piezoelectric transducer bonded to it. When an rf signal is applied to the transducer, an acoustic wave is produced in the glass, causing a variation in the index of refraction by means of the photoelastic effect. This variation acts as a diffraction grating that causes Bragg scattering of the light and results in high loss in the laser cavity. With the rf on, no lasing takes place, and energy is stored in the laser rod. When the rf is switched off, the laser begins to oscillate. A laser pulse builds rapidly to a maximum, then falls as the population inversion is depleted. The rf is then once again applied to the Q-switch so the process can be repeated.

Maximum energy per pulse is achieved when the rf is on long enough to establish a steady-state population inversion, a time that is related to the stored energy and fluorescence lifetime of the laser material at maximum pump levels. The energy per pulse begins to decrease at a pulse rate of around 800 pps for Nd:YLF and at around 1500 pps for Nd:YAG. At higher pulse rates, the energy per pulse falls until, at 10,000 pps, the energy is 20 to 30% of maximum.

The pulse width is similarly affected by pulse rate: it is shortest at the maximum population inversion and lengthens as the pulse rate increases.

System Description

The Laser Head and Power Supply comprise a compact, efficient laser system capable of delivering coherent pulsed energy at two different infrared wavelengths. The Laser Head is chosen by matching its performance characteristics to the requirements of the application. Optional accessories include a frequency doubler for green output , a remote control and a General Purpose Interface Card with RS-232/IEEE 488 compatibility.

The laser diode module in the power supply is available with either one or two laser diodes installed, depending on output power requirements. A flexible, detachable fiber-optic cable couples the output of the laser diode to the laser head, where it pumps the solid-state laser medium.

The laser medium can be a Nd:YAG or Nd:YLF rod depending on the model selected. The laser head is compact, rugged, and contains no user adjustable components.

An rf driver in the Power Supply supplies rf power to the Q-switch in the laser head.

The R-Series system is controlled either manually through the optional Model 7310 remote control or by the user system via the 37-pin D-connector on the back panel. The Power Supply can also incorporate the GPIB/RS232 interface card for interface through a computer.

The system complies with all safety regulations set by the Center for Devices and Radiological Health (CDRH) for a Class IV laser device.

R-Series Power Supply

Components

The Power Supply consists of six main sections:

- DC Power supply
- Diode driver board
- Diode module board
- Motherboard
- Laser diode assembly
- rf driver for Q-switch

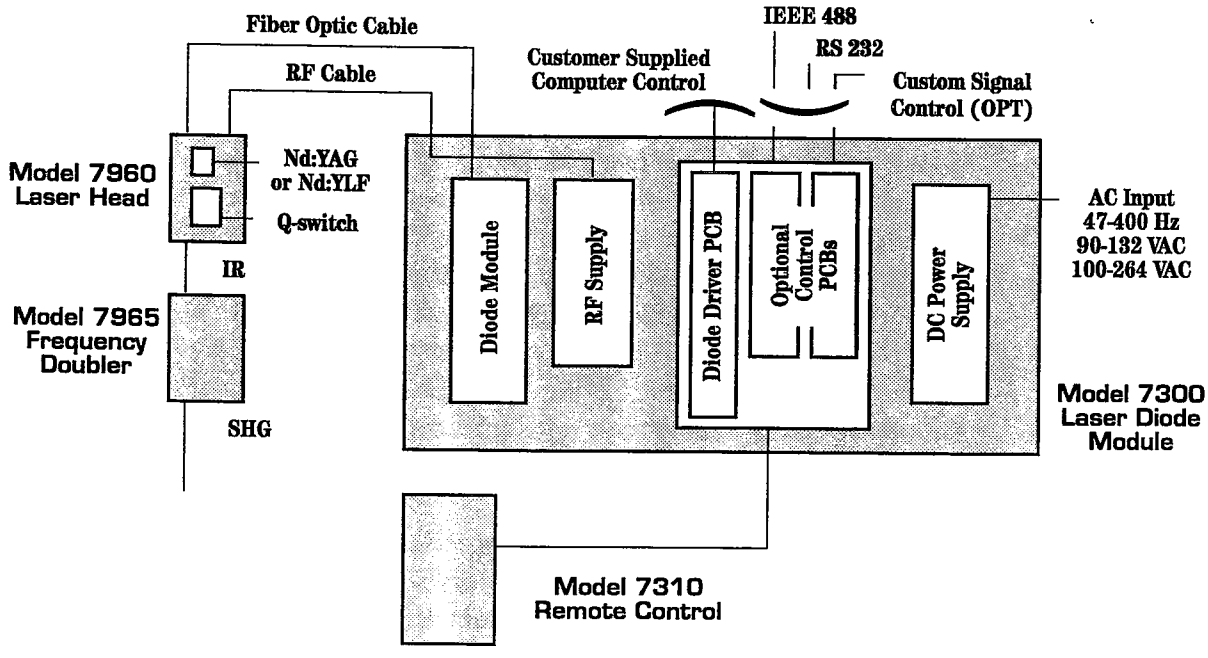


FIGURE 1-4: System Block Diagram Showing Laser Head, Power Supply, and Remote Control Unit.

Component Descriptions

AC/DC Power Supply

The power supply is an autoranging, switching regulator supply for high efficiency and low heat generation. Any AC line voltage between 90 and 264 volts is permitted. The power supply is a self-contained and internally fused component that provides the DC power to operate the system.

Motherboard

The motherboard contains an Intel 80C31 microprocessor, 2KB of nonvolatile static RAM, a 32 KB system PROM and factory-adjusted DIP switches for system configuration. The microprocessor, running the firmware in the system PROM, senses user input and system status and controls the functioning of the system

Diode Driver Board

The diode driver board conditions the input signals and controls the laser either in diode current mode or diode power mode. The diode drive current may be varied continuously from zero to its rated output power.

As the diode ages, more current will be required to produce a given power setting. There is a current limit setting in the power supply to protect the laser diode from damage caused by excessive current. It is preset at the factory at 110% of the rated output power of the diode. A procedure for changing the current limit is given in the manual.

Laser Diode Assembly

The output of the laser diode is collimated and focused inside a separate assembly that serves as a heat sink for both the laser diode and its TE cooler. A small fan directs outside air across the heat sink fins of the laser diode assembly and cools the power supply in the Model 7300. The assembly focuses the optical output of the laser diode into an FC (SMA for 500 mW model) fiber-optic connector that protrudes through the rear panel of the laser diode module. The assembly can be configured with either one or two laser diodes to pump either Nd:YAG or Nd:YLF. When two diodes are installed, the assembly also includes a beam combining dielectric mirror.

Diode Module Board

The diode module board controls the laser diode junction temperature and thus the wavelength setting. A thermistor in the laser diode senses the diode junction temperature and provides feedback to circuitry on the diode module board to operate the TE cooler. If the TE cooler cannot achieve the desired temperature, then this out-of-temperature-range condition will cause the red temperature LED on the diode module board to light.

rf Driver for Q-switch

The rf driver supplies rf power to the Q-switch. The power level is internally set to provide hold-off in the laser cavity and requires no adjustment during operation. The module responds to on/off commands from the microprocessor to produce Q-switched pulses. Alternatively, external triggering can be used. The rf can be turned off completely for cw operation. The microprocessor provides the timing for the rf power module at pulse rates and input conditions set by the operator. When Q-switching, the rf power is turned off for a fixed time period during which the pulse occurs. This time period is not adjustable by the operator and is the same length at all repetition rates. The microprocessor also provides a sync signal, available at the rear panel, for each Q-switched pulse.

System Software

Operation of the system software is outlined in the flow chart shown in Figure 1-5. This diagram is composed of three parts -- system activation, the system loop, and system interrupts. The software architecture consists of several operation-specific routines that are accessed from the system loop.

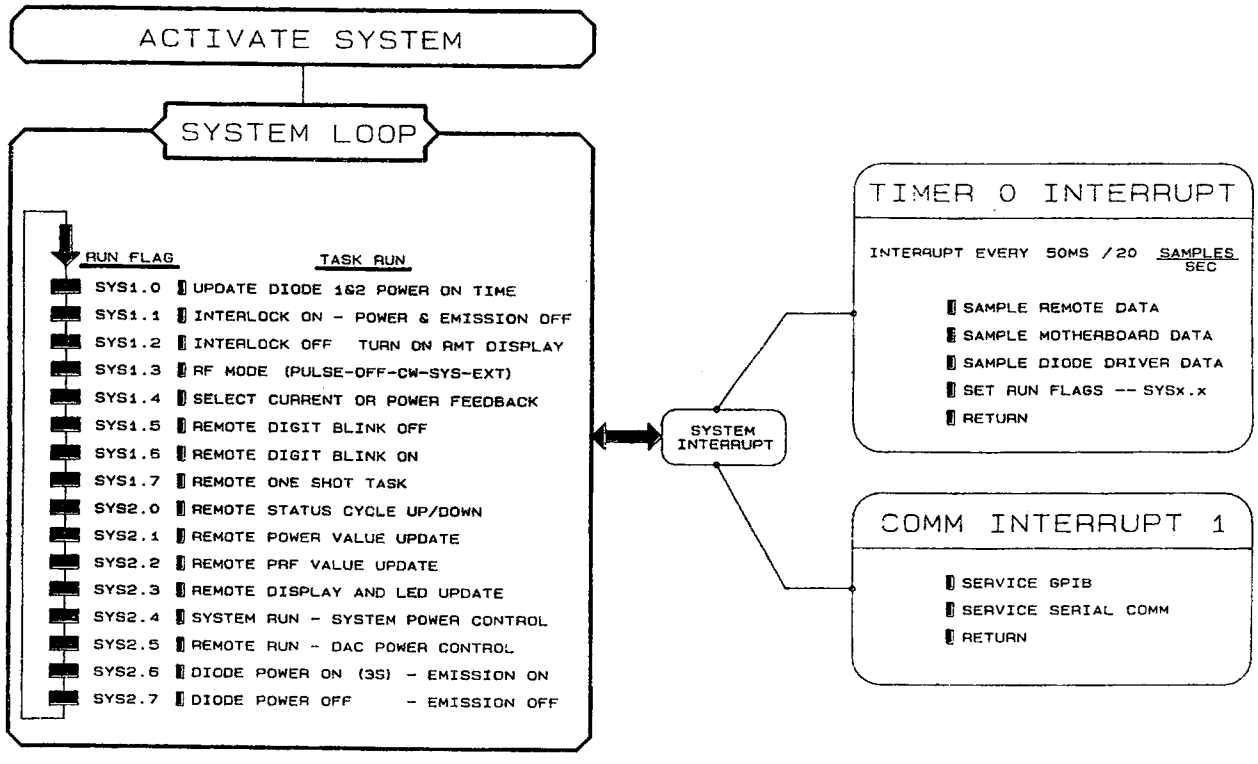


FIGURE 1-5: R-Series Software Flow Chart

During system activation, the microprocessor performs several self- tests to assure proper operation. During these tests, the message "TEST" is displayed on the remote control. System memory and communications are tested for accuracy with write and read operations. If the remote control is detected, then its switch positions are tested. A failure of one of these basic tests will halt system operation. Indication of a failure will be noted on the back-panel connector as TTL high on the SYSTEM FAULT line (J7 Pin 27). If the remote control is installed, an error message indicating the source of the fault will also be displayed.

The microprocessor reads the dip switches on the motherboard that determine the 7300 system configuration. These are set at the factory and should not require adjustment by the user. Figure 1-6 shows the microprocessor dip switch functions.

Switch #	OFF	ON
1	normal operation	system reset
2	Q-switch system	cw system
3	1.0 W diode	500 mW diode
4	asynchronous Q-switch	synchronous
5 & 6	diode driver feedback mode (see below)	
7	diode 1 not present	diode 1 present
8	diode 2 not present	diode 2 present

Switches 5	6	Diode Driver Feedback Mode
off	off	Current
off	on	Unused
on	off	Power
on	on	Unused

FIGURE 1-6: Microprocessor Dip Switch Functions (motherboard sw1)

After system initialization, system loop execution begins. In this loop, software flags are tested to determine if a particular routine requires execution. If the flag tests positive, program execution jumps from the loop to the software routine, returning upon completion. For example, when the SYS1.1 flag is set high, the interlock routine turning off diode emissions and locking out user input is initiated. After the interlock is cleared, execution of the system loop continues by testing the SYS1.2 flag. All of the 7300 system functions are controlled by the microprocessor in this manner.

System interrupts are used to stop execution of the system loop to perform housekeeping functions. Every 50 ms (or 20 times a second) the system loop is stopped by the Timer 0 Interrupt to update the software flags. Data is

obtained from the diode driver, the microprocessor board, and the 7310 remote if it is present. After this interrupt is executed. the system loop continues using new values for the system variables. The GPIB/RS-232 controller option operates in a similar manner, interrupting the operation of the microprocessor to update the system variables.

Electrical System

An overview of the electrical system is shown in Figure 1-7. The system is comprised of several components -- an off-line switching power supply, a microprocessor-based controller board (motherboard). a laser diode assembly, an rf driver module, and the remote control. The two expansion slots for the system originate on the motherboard (J11. and J12). J10 is dedicated to the laser diode driver board, and J11 is committed to the communications board. The remaining expansion slot, J12, is used for the heater controller, or can be customized for specific applications, such as custom interface card.

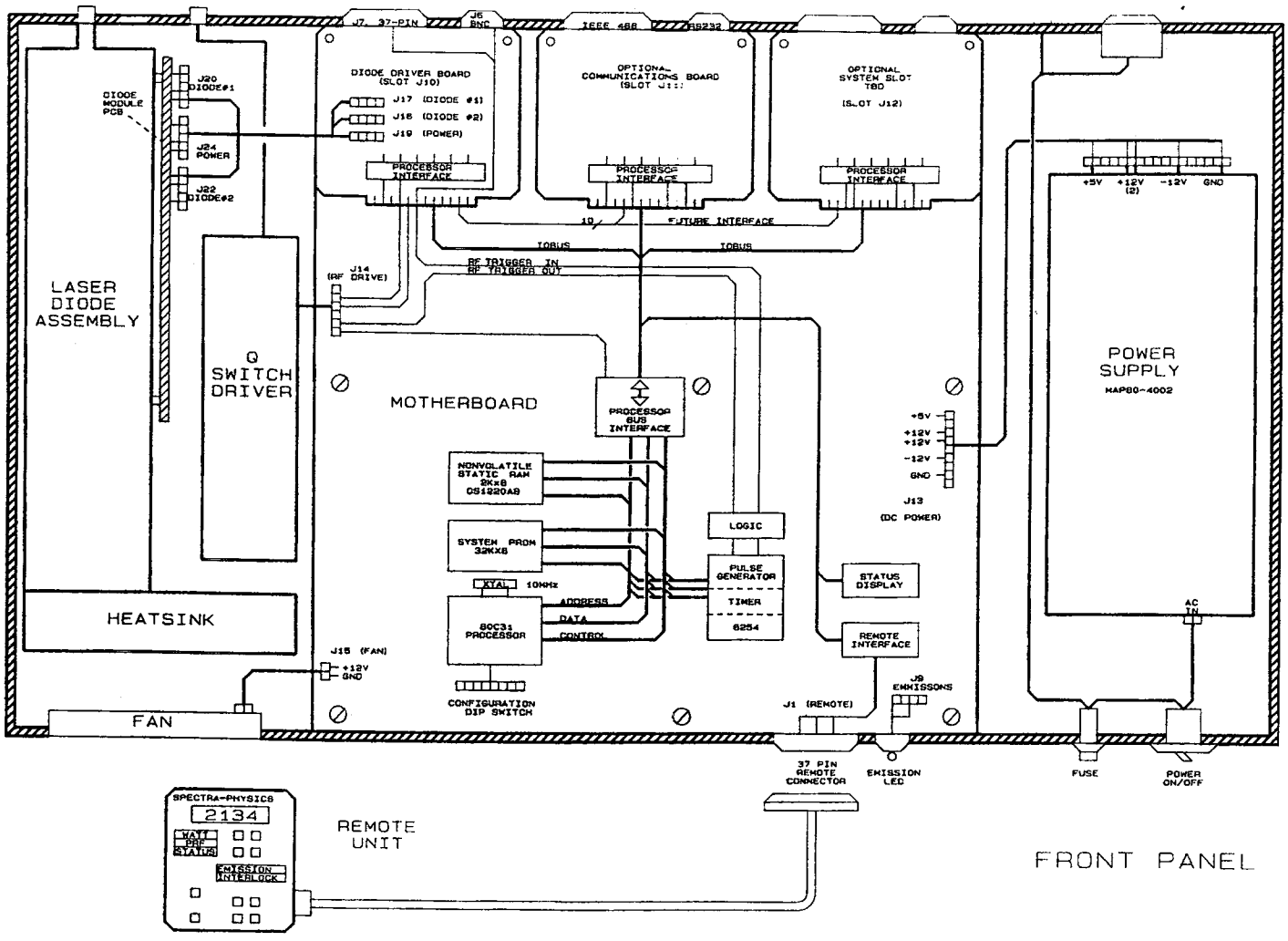


FIGURE 1-7: Electrical System Block Diagram

The off-line switching power supply is located on the right-hand side of the system. To protect the user from exposure to the AC line, the switcher is isolated inside a metal housing. The switcher converts the AC line (90-264V, 47-63Hz) to three, regulated, DC-output voltages (+5V, +12V, and -12V). These outputs are connected from the switcher to the J13 connector on the motherboard via a wire harness. DC power is distributed to the system from the motherboard. Also, the input to the switcher is fused to protect against any power supply faults. The main power switch (key-operated) on the front panel disconnects the AC line from the switching supply and terminates operation of the 7300 system by removing DC power from the motherboard.

The motherboard contains a microprocessor-based controller that regulates the operations of the system. Based on the 80C31 processor, this processor operates with a 10 MHz clock rate and is equipped with a 2 KB, non-volatile SRAM. The processor is capable of retaining data settings after power down because of the SRAM. The operating software for the system is stored on a 32 KB PROM.

The microprocessor interface bus connects the remote control unit and the three expansion slots (J10, J11, and J12) to the microprocessor system. This bus consists of address, data, and control lines that are used to exchange user input data and system output data. The 37-pin connector (J7) on the rear panel utilizes the diode driver board to interface with the processor through expansion slot J10. The communications board allows user input using an IEEE-488 (GPIB) or RS-232 interface via expansion slot J11. If these options do not satisfy a specific need, then the micro-processor interface bus can be accessed through a customized board that plugs into the system slot (J12).

Drive pulses for the rf driver module are generated on the motherboard. The pulses can be initiated using either the remote control unit (microprocessor system clock) or an external source. Using BNC connector J8, the rf driver triggers the laser head to emit Q-switched pulses. When using the remote, the rf driver can pulse the laser head in single-pulse mode or repetitively from 1 Hz to 9.999 kHz. Using either the external BNC connector (J6) or SYSTEM EXT TRIG (J7 pin 9) the laser head may be triggered with an external system. The motherboard also controls the system cooling fan and the front panel diode emissions lamp using J15 and J9, respectively. In addition to user I/O provided through expansion slot J10, the laser diode driver board monitors laser diode performance and adjusts the current drive to both the diode and its thermoelectric cooler (TEC). The system is capable of driving two 1W diodes. An analog-to-digital converter on this board allows real-time readings of laser diode current, power, and temperature. Additionally, diode current or power can be chosen as the control variable with the driver board.

Connector J19 provides power to the laser diode module, and connector J17 (and J18, for a two diode system) relay diode control signals to the module.

The laser diode module produces laser light that is transmitted over a fiber-optic cable to the laser head. The laser diode module board attached to the side of the module contains diode protection circuitry, temperature control circuitry, and photo-diode calibration circuitry. With this circuitry, the diode module calibration for TEC temperature and diode output power is possible at the factory, allowing direct shipping of replacement laser modules to customers. The diode module board is connected to the diode driver board via connectors J20, J22, and J24.

The R-Series Laser Head

The Model 7960 laser head is available in two variations: Nd:YAG, which lases at 1064 nm, and Nd:YLF, which lases at 1047 nm.

The rectangular head has an FC connector at its input end for attaching a fiber-optic cable from the power supply. The fiber-optic cable used and the connector at the power supply vary with the diode power. The 500 mW versions use a 100 micron fiber-optic cable with an SMA connector at the power supply diode module output. The 1W and 2W versions use a 150 micron fiber-optic cable with an FC connection at the power supply.

An input lens focuses incoming pump power onto the laser rod. Both the input lens and the output mirror are permanently aligned for optimum power and the laser head is sealed. No disassembly or alignment of the laser head is possible.

The head also has an SMA electrical connector for attaching an rf cable from the Q-switch driver in the power supply. A 183 cm (72 in.) rf cable with an SMA connector on one end and BNC connector on the other is used.

A safety beam attenuator (shutter) is attached to the output end of the head and is opened and closed by rotating the knurled ring.

R-Series Frequency Doubler

Visible light radiation is attainable by using the external frequency doubler in conjuction with the Q-switched laser head. This doubler can be removed and replaced by the end user, allowing access to both the fundamental and the second harmonic.

The nonlinear material in the doubler is heated. A Controller board is added to one of the option slots in the power supply to regulate the oven temperature.

A cable connects the doubler to the controller board mounted in the power supply.

R-Series Remote Control

An optional hand-held remote control accesses all of the functions of the laser system through a connector on the front panel. It can be used to control the laser during the R & D phase of product development, and as a run box for diagnosis of problems in the field. It can also be used to monitor status variables such as diode pump power and PRF while the laser is being controlled by the user's system through the back panel connector.

R-Series GPIB/RS-232

An optional interface card is available. It gives the power supply both GPIB and RS-232 interface capability.

Laser Safety

CHAPTER TWO

Introduction

Please read this section carefully before installing or operating your laser. To preserve your warranty, we recommend that all service and repair operations be performed by a Spectra-Physics service engineer. If you do plan to service your laser yourself, please follow the procedures in the Service and Repair section of this manual.

DANGER

The Spectra-Physics MR-Series Power Supply, is a Class IV-High Power Laser. The R-Series laser heads and frequency doubler are classified as Class IV High Power Lasers. The output beam from each is, by definition, a safety hazard. Avoid eye or skin exposure to direct or scattered radiation.

The laser diode module in the power supply emits invisible laser radiation from the FIBER-OPTIC CONNECTOR port on the rear panel when the fiber-optic cable is disconnected. When the cable is connected and its beam attenuator cap is removed, the system emits invisible laser radiation from the end of the cable.

When the laser head is connected to the fiber-optic cable and the laser head beam attenuator is open, the system emits invisible pulsed or cw laser radiation from the output end of the laser head.

When the frequency doubler is attached to the laser head and the beam attenuator is open, the system emits visible pulsed laser radiation. If the laser is operated in cw mode, invisible infrared radiation will be emitted.

Follow instructions contained in this manual for proper installation and safe operation of your laser. Refer to the table of Maximum Emission Levels. We recommend the use of protective eye wear whenever possible. Selection depends on the energy and wavelength of the laser beam as well as operating conditions. Consult ANSI, ACGIH, EN or OSHA standards for guidance.

CAUTION

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

DANGER

At all times during installation , operation, maintenance, or service of your laser, avoid exposure to laser or collateral radiation exceeding the accessible emission limits listed in "Performance Standards for Laser Products" United States Code of Federal Regulations, 21 CFR 1040 10(d).

Precautions for Safe Operation of Class IV Lasers

- Never look directly into the laser beam. Even diffuse reflections are hazardous.
- Wear protective eyewear.
- Avoid blocking the output beam or its reflection(s) with any part of the body.
- Set aside a controlled-access area for laser operation; limit access to those trained in the principles of laser safety.
- Post warning signs in prominent locations near the laser operation area.
- Enclose beam paths wherever possible.
- Set up a beam dump to capture the laser beam and prevent accidental exposure.
- Set up experiments so the laser beam is below eye level.
- Maintain a high ambient light level in the laser operation area so that the eye's pupil remains constricted, reducing the possibility of retinal damage.
- Set up shields to prevent reflected beams from escaping the laser operation area.

FIGURE 2-1: Standard Safety Warning Sign

Schedule of Maintenance Necessary to Keep this Laser Product in Compliance with Center for Devices and Radiological Health (CDRH) Regulations

This laser product complies with Title 21 of the United States Code of Federal Regulations, Chapter 1, Subchapter J, Parts 1040.10 and 1040.11, as applicable. To maintain compliance with these regulations, once a year, or whenever the product has been subjected to adverse environmental conditions (e.g., fire, flood, mechanical shock, spilled solvent), check to see that all features of the product identified on the following figures function properly. Also, make sure that all warning labels (Figure 2-2) remain firmly attached.

1. Verify that opening the INTERLOCK circuit on the 37-pin rear connector prevents laser operation.

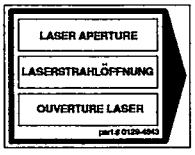
2. Verify that the laser can only be turned on when the key switch (Figure 3-1) is in the ON position, and that the key can only be removed when the switch is in the OFF position.

3. Verify that the emission indicator (Figure 3-1) provides a visible signal when the laser emits accessible laser radiation. Also verify that the signal provides an advance warning sufficient to allow action to avoid radiation exposure.

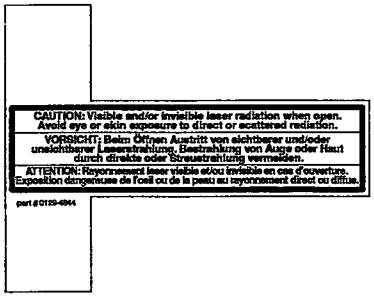
4. Verify that both the cap at the end of the fiber-optic cable and the shutter on the laser head actually block invisible IR laser radiation.

5. Verify that the fiber connector brackets are properly installed and that they prevent the fiber from being disconnected at either end.

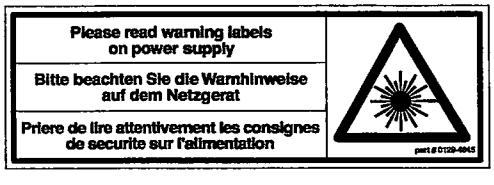
IEC 825-1 Laser Warning, Class 4



IEC 825-1 Laser Aperture Label



IEC 825-1 Service Connection Warning Label



Supplementary Warning Label for Laser Head

FIGURE 2-2: Standard System Safety Labels

Fiber Connector Safety Bracket Installation & Removal

Fiber connector safety brackets are included with each system. Properly installed, the brackets will reduce the risk of accidentally disconnecting the fiber cable while the diode emission is present. A tool must be used to remove the bracket before the fiber can be disconnected. To install the bracket, make sure the fiber cable is attached between the power supply and laser head. Slide the large opening of the bracket over the strain relief of the fiber cable, and secure the bracket with the #6-32 cap screw on the power supply and #4-40 cap screw on the laser head. Follow this procedure for both ends of the fiber. See figures below.

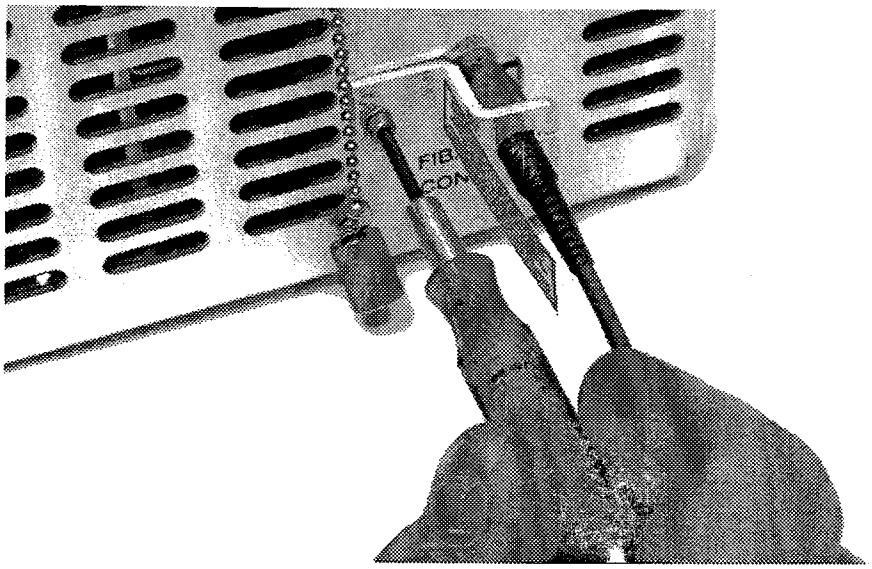


FIGURE 2-3: Fiber Connector Cover Installation for Power Supply

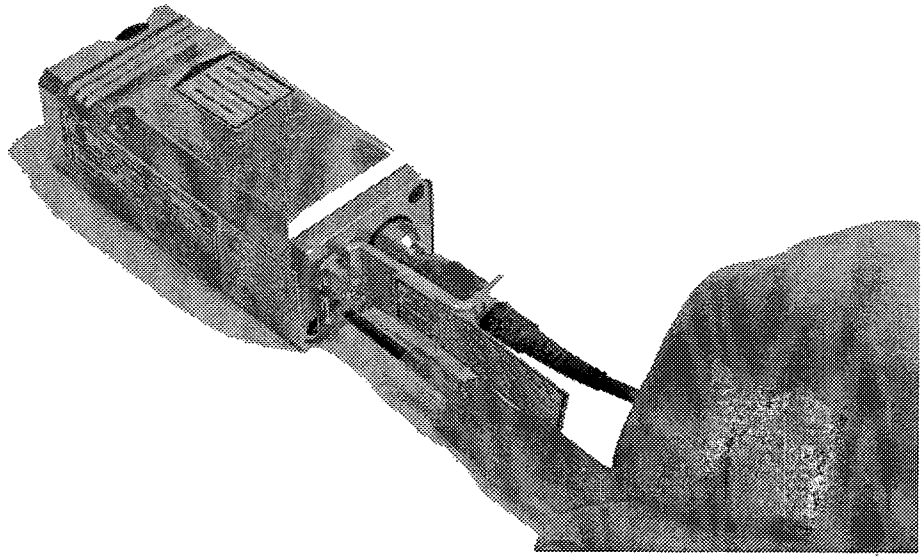


FIGURE 2-4: Fiber Connector Cover Installation for Laser Head

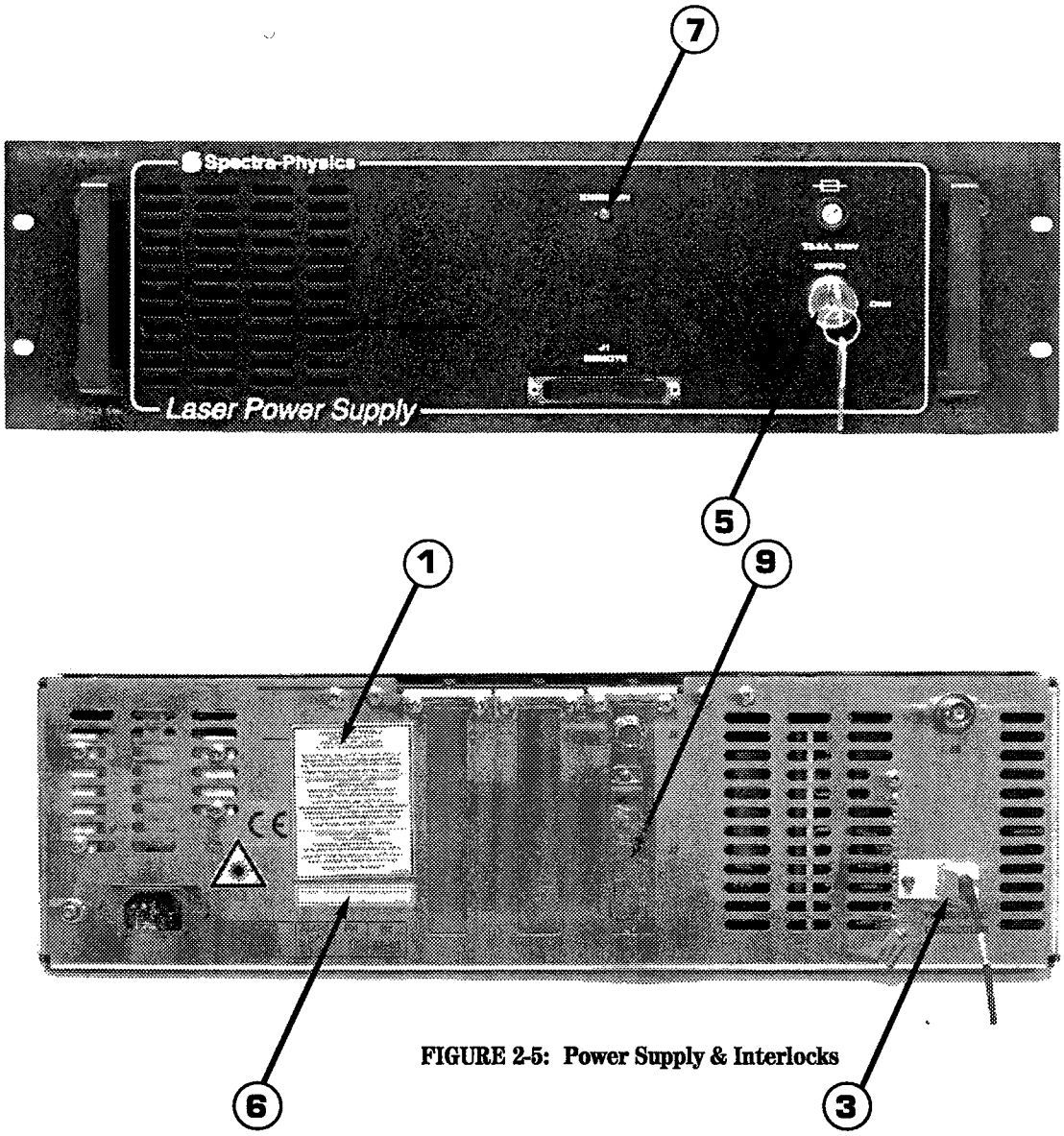


FIGURE 2-5: Power Supply & Interlocks

KEY TO LABELS & INTERLOCKS

Item	Description
1	IEC 825-1 Laser Warning, Class 4
2	EC 825-1 Laser Aperture Label
3	IEC 825-1 Service Connection Warning Label
4	Supplementary Warning Label for Laser Head
5	Keyswitch
6	Manufacturer / Product Identification Label
7	Emission Indicator
8	Beam Attenuator, Laser Head
9	Remote Interlock Connector
10	Frequency Doubler

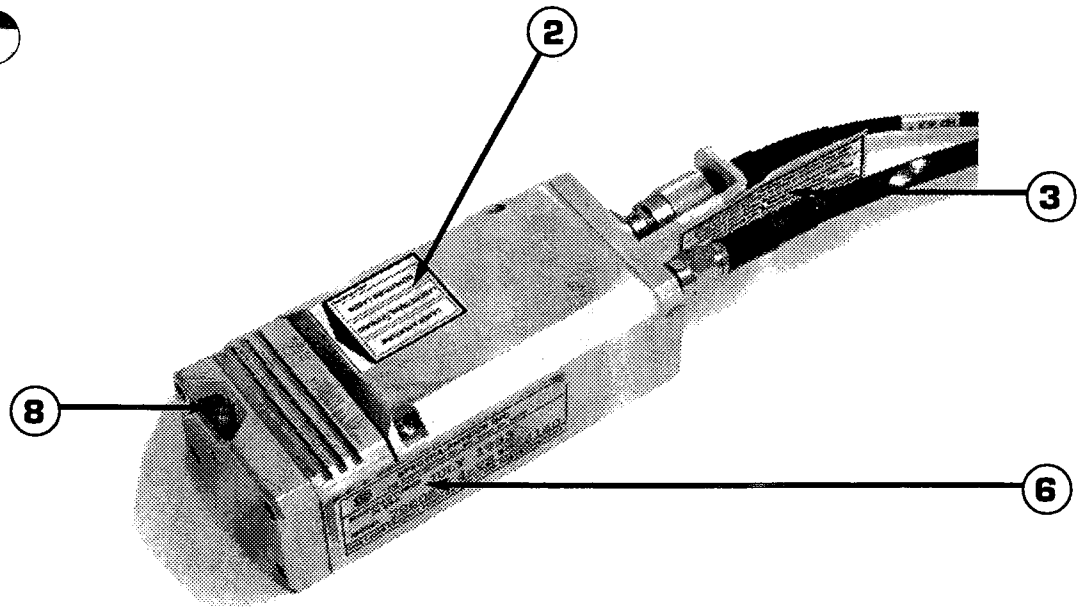


FIGURE 2-6: Typical VS Head, Front View

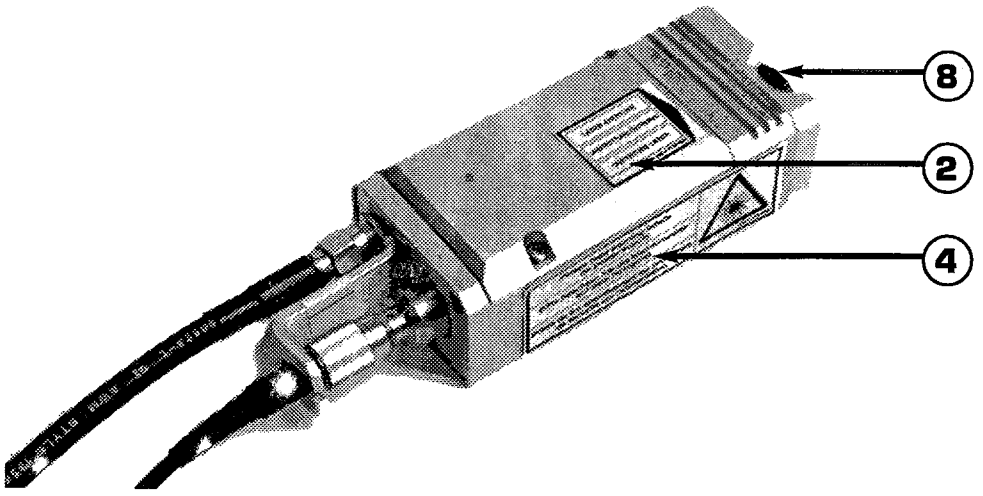


FIGURE 2-7: Typical VS Head, Rear View

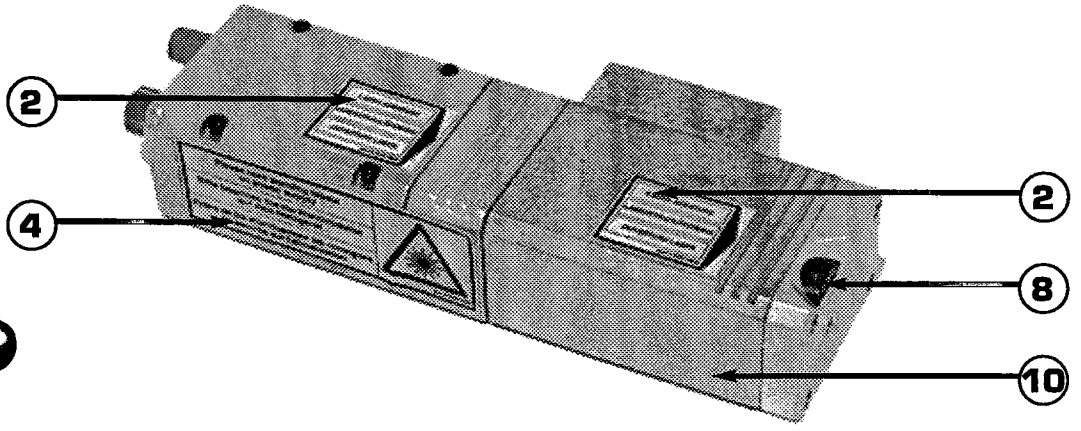


FIGURE 2-8: Typical I-Head with Frequency Doubler

Maximum Emission Levels

The following is a matrix of the maximum emission levels possible for R-Series products. Use this information for selecting appropriate laser safety eyewear and implementing appropriate safety procedures. These values do not imply actual system power or specifications.

	Emission Wavelengths, nm						
Model	1047	1064	523	532	800	Energy	Pulsewidth
R05-S15-104Q	300mW				1W	110 uJ	14 ns
R1-S-104c	500mW				2W		
R1-S-106c		500mW			2W		
R1-S10-104Q	530mW				2W	180 uJ	7 ns
R1-S10-523Q	530mW*		46mW		2W	46 uJ	5 ns
R1-S12-106Q		400mW			2W	100 uJ	11 ns
R1-S12-532Q		400mW*		60mW	2W	60 uJ	7 ns
R2-E12-104Q	1.2W				4W	340 uJ	9 ns
R2-E12-523Q	1.2W*		200mW		4W	200 uJ	8 ns
R2-V38-104Q	360mW				4W	360 uJ	25 ns
R2-V50-104Q	360mW				4W	360 uJ	40 ns
R2-E20-106Q		1.1W			4W	200 uJ	11 ns
R2-E20-532Q		1.1W*		160mW	4W	160 uJ	10 ns
R2-VS5-104Q	800mW				4W	180 uJ	4 ns
R2-I10-104Q	1W				4W	240 uJ	8 ns
7960-L2-S	300mW				1W	110 uJ	14 ns
7960-L4-I-80	1W				4W	240 uJ	8 ns
7960-L4-VS	800mW				4W	190 uJ	4 ns
7960-E-L4-I	1W				4W	240 uJ	9 ns

* These power levels may be accessible when service covers are removed.

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Installation & Operation

CHAPTER THREE

Introduction

The R-Series Power Supply and the laser heads are manufactured in several versions which differ in lasing material, pump power and cavity length. For all versions, the operating instructions are identical except where specifically noted.

Unpacking Your Laser

Your Spectra-Physics R-Series laser system was carefully packed for shipment. If its carton appears damaged in transit, have the shipper's agent present when you unpack.

Inspect each unit as you unpack, looking for dents, scratches, or other evidence of damage. If you discover any damage, immediately file a claim against the carrier and notify your Spectra-Physics representative. Spectra-Physics will arrange for repair without waiting for settlement of your claim.

A typical system consists of:

- Power supply including Q-switch driver
- Laser head with Q-switch
- Fiber-optic cable to deliver diode pump power to laser head
- rf cable to drive Q-switch in laser head
- External power cord
- Instruction manual

Keep the Shipping Container

If you file a damage claim, you may need it to demonstrate that the damage occurred as a result of shipping. If you need to return the unit for service, the specially designed carton assures adequate protection.

Controls & Connections

Please refer when necessary to Figure 1-7 (R-Series Electrical Block Diagram)

Power Supply Front Panel

- **Key Switch** turns on AC power to the system. The key can only be removed in the off position.

- **Green Warning LED** glows when emissions are on or will start within three seconds. Safety precautions must be observed.

- **Remote Control Input** is a 37-pin female D-connector for use with the optional Model 7310 remote control.

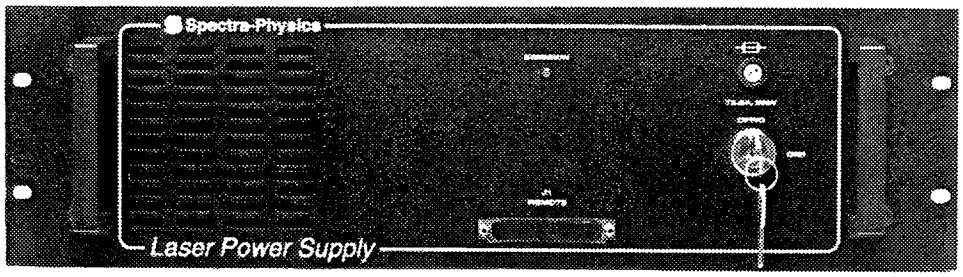


FIGURE 3-1: R-Series Power Supply Front Panel

Power Supply Rear Panel

- **Fiber-optic connector** (SMA or FC) is the output port for the laser diode. The fiber-optic cable to the laser head threads onto this connector.

- **rf Out Connector** (BNC) (J8) accepts an rf cable to the laser head and supplies the rf signal to drive the Q-switch in the laser head.

- **37-pin Male D-connector** (J7) provides an interface to the user system. This interface can be used if the remote control is not connected to the front panel or if the remote control is connected and in SYSTEM mode .

- **External Trigger** (BNC)(J6) allows external control of the pulse repetition frequency (PRF) using a TTL-level signal or voltage source. The Q-switch is pulsed at one pulse per positive-going edge of the trigger signal.

- **Earth/Chassis Ground Lug** is a system ground internally common to AC ground. It should be connected to the ground of the user system.

- **AC Plug** connects the power cord to the laser diode module. Input voltage range is from 90 to 260 V.

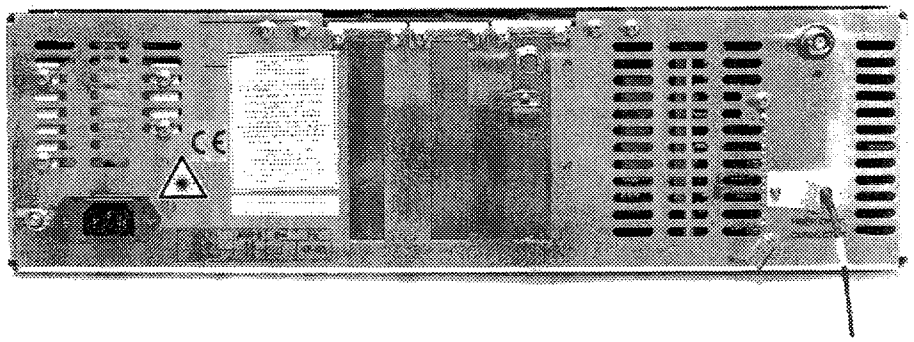


FIGURE 3-2: R-Series Power Supply Rear Panel

Laser Head & Cables

The R-Series laser heads are aligned and sealed at the factory and have no alignment or adjustment controls. The only control is the beam attenuator (shutter) which is opened and closed by rotating the shutter ring. The power supply controls the optical output of the laser diode(s). It does not directly control the optical output of the laser head. Rather, the output from the laser head is proportional to the pump power from the laser diode.

Laser Head Beam Attenuator

The laser head beam attenuator blocks the output beam from the laser head. To open or close the attenuator, turn the knurled ring at the output end of the laser head.

Interlock Connector

Refer to figures 3-5 and 3-6 for connector pin identification. Connect pins 16 and 24 to an external interlock.

Fiber-optic Cable

The fiber-optic cable couples the optical output from the laser diode module to the laser head. The recommended minimum bend radius is 3 cm (1.5 in.). The fiber-optic cable length is approximately 178 cm (70 in.).

Fiber-optic Beam Attenuator

The fiber-optic beam attenuator is a screw-on cap that fits on to the end of the fiber-optic cable to block the output beam.

R-Series Frequency Doubler

The Model 7965 frequency doubler is an accessory to the R-Series Q-switched laser head that is used to generate high peak power outputs in the visible range. The doubler is attached directly to the Q-switched laser head by means of four Allen head screws. The heater controller card is installed in one of the two expansion slots inside the power supply.

Interchangeability of Laser Heads & Frequency Doublers

The frequency doubler is aligned to a specific Q-switched laser head at the factory at the time of manufacture. The frequency doubler will have the same serial number as its mate; it is not interchangeable with other laser heads without realignment at the factory.

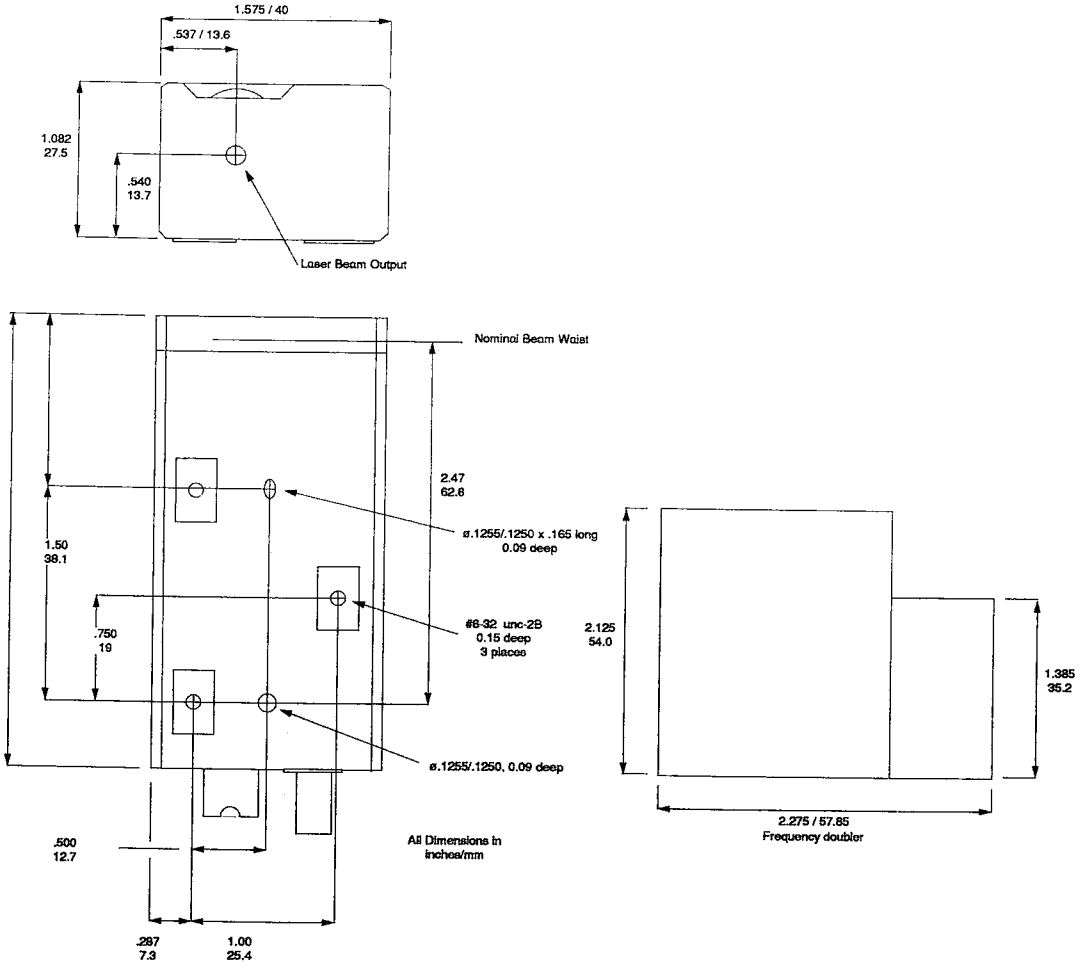


FIGURE 3-3: Typical R-Series Laser Head

Mounting the Laser Head

The laser head has two connections located on the rear face. The SMA connector delivers rf power to the Q-switch. The locking FC connector is used to attach the laser head to the optical fiber.

The laser head can be mounted to any surface, provided it does not distort the body of the laser or act as a thermal impedance. No external heatsinks are required for laser operation, as long as there is free air convection around the laser head. Q-switched laser heads vary in size depending on the model. For convenience, mounting holes are provided on the bottom surface of the

laser (see diagram on datasheet for mounting hole locations). If crushed or distorted due to improper clamping, or if thermally insulated, the laser will be detuned and possibly damaged. Such damage is not covered under warranty.

The laser head mounting surface should be flat and preferably aluminum. If it is not aluminum, large temperature changes may cause differential expansion with consequent misalignment of the laser head.

Mounting the Frequency Doubler

1. Turn off the power supply.
2. Use a 5/64 Allen head screwdriver to remove the four screws holding the shutter assembly to the laser head.
3. Attach the frequency doubler module using a .050 straight shaft (not a ball driver.) Allen head screwdriver inserted through each of the four screwholes located in the four corners of the face of the doubler.
4. Attach the shutter assembly to the frequency doubler.
5. Install the heater controller card in the power supply.
6. Connect heater controller to doubler.

NOTE

Reverse the procedure to return to operation in the infrared. Be sure to replace the shutter assembly for safety as well as protecting the laser head from dust contamination.

Operation of the Frequency Doubler

The laser head and frequency doubler are aligned as a system and they should be used together. If a frequency doubler is purchased after the laser head, the laser head must be returned to the factory so both components can be aligned as a system. Frequency doubling does not change the operating procedures for the system. Once the frequency doubler is installed, the system will deliver only visible Q-switched pulses. A dielectric coating on the output lens of the frequency doubler blocks the IR beam and allows only the visible beam to pass. In cw mode, less than 1% of the total cw infrared output will be passed by the dichroic. As an option, the frequency doubler can be ordered with no dichroic element. In this case, cw infrared and pulsed infrared will be emitted.

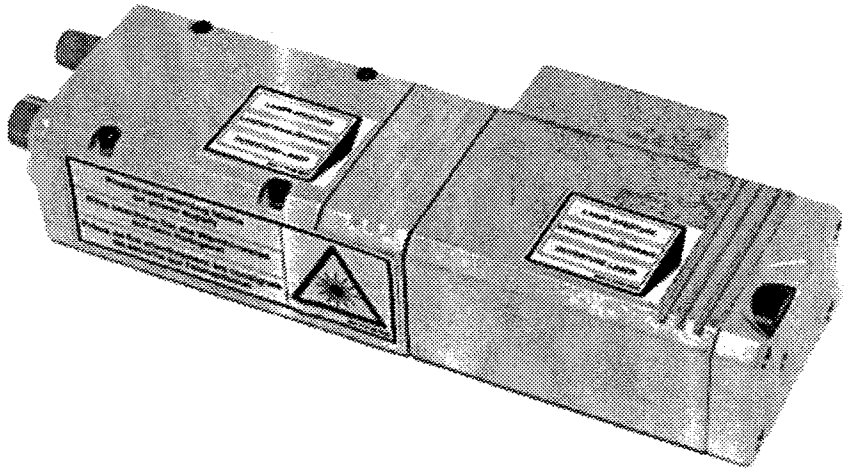


FIGURE 3-3: Frequency Doubler Attached to a S-Style Q-switched Laser Head

When not in use, the frequency doubler should be covered and protected from airborne contamination. Dust or other particulates in the optical path may result in damage to the optical surfaces.

Assembling the System

1. Remove the metal beam attenuator (cap) from one end of the fiber-optic cable by unscrewing the FC connector nut and pulling it out straight and away from the glass fiber end. (You will be pulling against the warning label.) Carefully center, then slide the cable into the fiber-optic connector on the back panel of the laser diode module. Secure it with the retaining nut. ***Finger tight is sufficient. Do not over-tighten.***

2. Following the procedure above, remove the beam attenuator from the other end of the fiber-optic cable. Carefully screw the cable onto the laser head and finger tighten. **Note:** The fiber cable has keyed FC connectors that must be properly inserted into the laser head for full engagement of the connector.

3. Connect the rf driver output of the laser diode module to the Q-switch input of the laser head using the rf cable included with the system. Note that the rf cable has a BNC connector on the end for connection to the laser diode module and an SMA connector on the other end for attaching to the laser head.

4. If you are using the frequency doubler, attach it as previously described.

5. If you are using the remote control, attach its cable to the female connector (J1) on the front panel of the power supply.

6. If you are using the user system interface, attach a suitable cable (not supplied) from the 37-pin D-connector (J7) on the back panel of the power supply to your system.

7. Connect the power cord and plug in the power supply.

The system is now ready to use. Please read the following section completely before turning on the laser system.

Operation

The laser diode in the power supply can operate in two modes. In **power mode** the optical output power of the laser diode is stabilized by sampling the beam and compensating for fluctuations by automatically adjusting the drive current to the laser diode. In **current mode** the drive current to the laser diode is held at a constant level. The laser diode will lase when the drive current is at or above lasing threshold.

The power supply is factory set to operate in power mode. If you would like to operate in current mode, see *Chapter 4 -- Service and Repair* about changing the internal DIP-switch settings.

Pre-start Conditions

Place the laser head so the output beam is directed toward a safe target and verify that the system is correctly assembled.

Turning On the Power Supply

Turn the key switch to the ON position. The cooling fan will turn on. A test sequence will be executed and the unit will go into STANDBY mode with emissions off. The system comes on in the rf ON position. In this condition rf power is continuously applied to the Q-switch, so the system cannot lase.

Method of System Control

Further control of the system requires the use of either the 37-pin user interface or the remote control. First we will describe the 37-pin user interface and then the remote unit.

Operating the Power Supply Through the 37-pin D-connector on the Rear Panel (User Interface)

The R-Series laser system can be controlled and monitored by the user system through the 37-pin connector (J7) on the rear panel. This interface can be used with or without the Model 7310 remote control. Here we describe the interface and how to use it.

For detail refer to the pinout (Figure 3-5) and signal description (Figure 3-6).

Turning on the Laser Diode

Apply an analog voltage on pin 35 (DIODE POWER) to determine diode power (single diode system @ 0.1 watts/volt or with dual diode system @ 0.2 watts/volt). Apply TTL high to pin 12 (DIODE ON). Laser diode emissions will begin after a 3 second delay.

Selecting the Operating Mode

The rf driver can be placed in one of three operating modes. In **standby** mode, rf power is continuously on, preventing lasing. In **cw** (continuous wave) mode, rf power is off, allowing cw lasing. In **pulse** mode, the rf power to the laser head Q-switch is pulsed, allowing pulsed radiation at the pulse repetition frequency (PRF).

Standby Mode

If you are finished using the beam but want to use it again within the next 15 minutes, go to standby. In this condition, rf power to the Q-switch remains on, and power to the laser diode is maintained. In this condition, thermal equilibrium of the system is constant for optimum performance. As long as you do not apply TTL low on pin 9 (SYS EXT TRIG), or TTL high on pin 30 (CW), the system will remain in standby mode.

cw Mode

Apply an analog voltage on pin 35 (DIODE POWER) to determine diode power (see Figure 3-5). Apply TTL high to pin 12 (DIODE ON) to enable diode emission. Apply TTL high to pin 30 (CW). The rf power to the Q-switch will be turned off, allowing cw output.

Q-switched Operation

The laser diode module must be turned on and be optically pumping the laser head before Q-switched pulses can be fired. Apply an analog voltage on pin 35 (DIODE POWER) to determine diode power (single diode system @ 0.1 watts/volt or with dual diode system @ 0.2 watts/volt). Apply TTL high to pin 12 (DIODE ON) to enable diode emission. Pin 9 (SYS EXT TRIG) is internally held high (+5 V). Applying a TTL low will cause the rf drive power

to be turned off momentarily and a single Q-switched pulse to be emitted from the laser head. To obtain a train of laser pulses, generate a trigger pulse train on SYS EXT TRIG at the desired PRF (up to 50 kHz).

The energy per pulse of Q-switched pulses is a function of the optical pump power from the laser diode module. Maximum Q-switched power is attained when the pump power is at the specified maximum. The pump power can be turned up or down while the system is operating. At lower pump powers the energy per pulse decreases and the Q-switched pulse gets broader.

At a given optical pump power, the energy per pulse is constant at rates from single pulse to the pulse rate roll-off value (about 800 pps for Nd:YLF and about 1500 pps for Nd:YAG). At rates above the roll-off value, the energy per pulse falls quickly because there is insufficient time between pulses for the energy to build up fully in the laser rod. Maximum Q-switched energy per pulse is attained at repetition rates below the roll-off value and at maximum optical pump power. Figure 3-4 shows an oscilloscope trace of a typical Q-switched pulse.

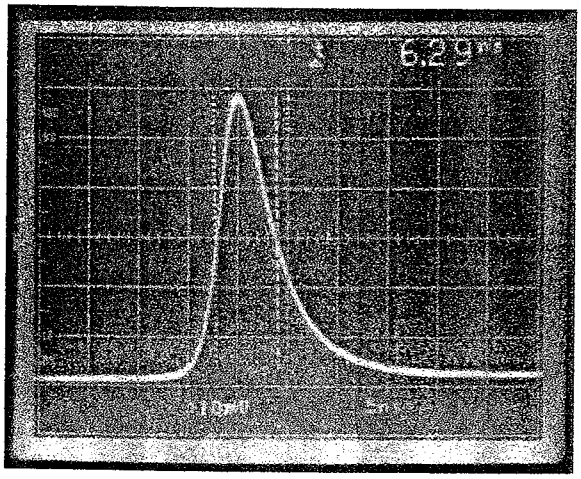


FIGURE 3-4: Oscilloscope Trace of a Typical Q-switched Pulse

Interlocks

To enable laser operation, maintain TTL high on pin 16 (INTERLOCK1). The simplest method is to jumper pin 16 to the +5 V available at adjacent pin 34 (INTERLOCK RTN).

To implement a useful interlock system, connect a switching device, such as a normally closed switch or relay between INTERLOCK1 and INTERLOCK RTN. The switching device might then be attached to the door of the laser

operation area, for example. The interlock function is driven by a TTL-level signal, thus an appropriate signal switching device (as opposed to power switching device) should be used.

Diagnostics

The laser system status can be monitored by the user system. The following status variables can be read from the interface.

- Diode power
- Diode current
- Diode temperature
- Temperature ready
- Limit
- System fault
- Pulse synchronization
- Emission
- System mode

See the following interface description (Figures 3-5 and 3-6) for detail.

Turning off the Laser Diode

Apply TTL low to pin 12 (DIODE ON). Laser diode emissions will immediately stop.

Turning off the Laser System

1. Place the system in standby mode as described above.
2. Close the laser head attenuator.
3. Turn off the key switch.
4. Remove the key. Do not leave the laser accessible to people who are untrained in laser safety or operation.

Description of User Interface & I/O Signals

The following two figures (Figures 3-5 and 3-6) describe the user interface in detail.

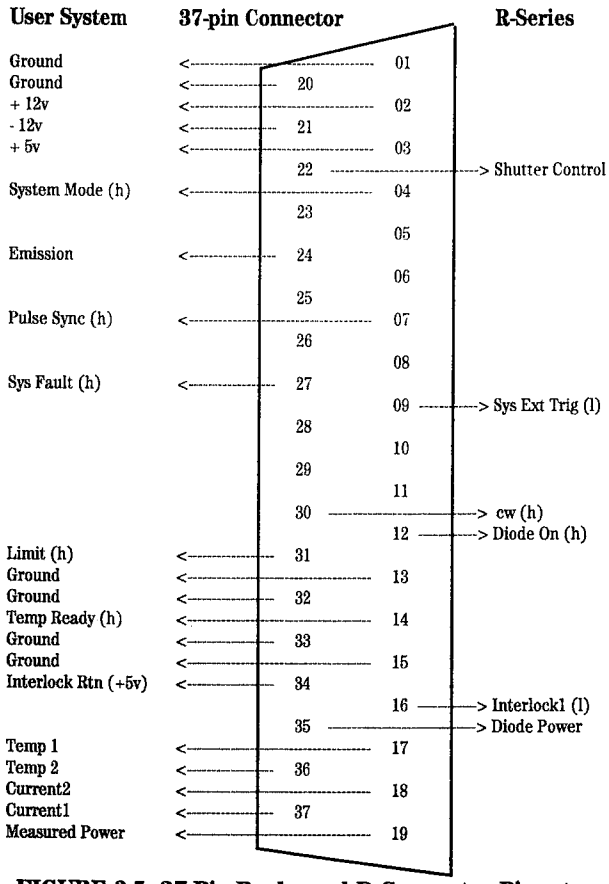


FIGURE 3-5: 37-Pin Backpanel D-Connector Pinout

Pin#	Signal Name	Function
1, 13, 15, 20, 32, 33	GROUND	System grounds
2	+12V @ 50 mA	Available to user.
3	+ 5V @ 50 mA	Available to user.
4	SYSTEM MODE	TTL output which is high when power supply is in SYSTEM mode.
5, 6, 8, 10, 11, 23, 25, 26, 28, 29	NC	No connections to system.
7	PULSE SYNC	TTL output which goes high at the start of each pulse from the rf driver. It may be used to synchronize an oscilloscope.
9	SYS EXT TRIG	User provided trigger. Zero to 50 kHz signal for pulse operation. A transition from TTL high to low triggers a Q-switched pulse.This signal can also be provided at the BNC connector (J6).
12	DIODE ON	TTL input which is pulled high by user system to turn on diode emissions.

FIGURE 3-6: 37-Pin Backpanel Signal Description (continued next page)

14	TEMP READY	TTL output which goes high to indicate that the thermoelectric cooler (TEC) has stabilized at the desired temperature.
16	INTERLOCK1	TTL input which when low shuts off diode power. Connect to adjacent pin 34 (INTERLOCK RTN providing +5V) to enable diode power.
17	TEMP2	Analog output representing diode 2 TEC temperature -5 volts <-------> +5 volts 0 deg. C <-------> +25 deg. C
18	CURRENT2	Analog output representing diode 2 current. 0 volts <-------> +10 volts 0 amps <-------> 2 amps
19	MEASURED POWER	Analog output representing total diode power. 0 volts <-------> +10 volts 0 watts <-------> 2 watts
21	- 12V @ 50 mA	Available to user.
22	SHUTTER CONTROL	Control line for a shutter operated through an optional accessory card.
24	EMISSION	TTL output which is high when diode power is on.
27	SYSTEM FAULT	TTL output which is pulled high when a system fault occurs.
30	CW	TTL input which is pulled high by the user to cause CW emissions.
31	LIMIT	TTL output which is pulled high when the diode power or current is unable to reach the power or current setting. It also goes high when a power supply failure occurs.
34	INTERLOCK RTN	+5 V provided for connection through an interlock switch to INTERLOCK1.
35	DIODE POWER	Analog input which controls the diode power. Single diode @0.1 watts per volt Dual diode @0.2 watts per volt.. 0 volts <----------> 10 volts 0 watts <----------> 1 (or 2) watts
36	TEMP1	Analog output representing diode 1 TEC temperature. -5 volts <------> +5 volts 0 deg. C <------> +25 deg. C
37	CURRENT1	Analog output representing diode 1 current. 0 volts <------> +10 volts, 0 amps <------> 2 amps

FIGURE 3-6: 37-Pin Backpanel Signal Description(continued)

Operating the R-Series Power Supply Using the Remote Control

The optional remote control is a hand-held device that can control the R-Series Power Supply and monitor its status. It can be used either alone or with the 37-pin rear panel user interface. Please read the above section on the user interface for general information about the 7300 system.

Connecting the Remote Control

Attach the remote control cable to the 37-pin D-connector (J1) on the front panel of the power supply. Place the control unit in the cradle provided.

Layout of Remote Unit

The remote control is divided into three sections – CONTROL, DIODE POWER and MODE (See Figure 3-7). The top CONTROL section is used to set the total diode power and the pulse repetition frequency (PRF) and to monitor system status. The middle DIODE POWER section is used to toggle the laser diode on and off. The bottom MODE section is used to control the rf driver to the Q-switch and to transfer control to the user system.

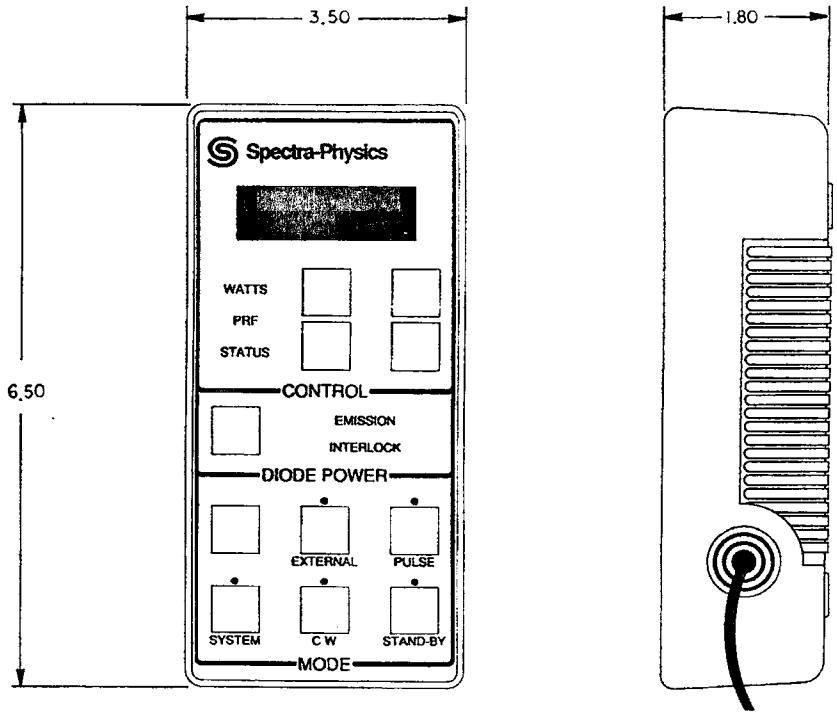


FIGURE 3-7: Layout of R-Series Remote Control

CONTROL Section

The CONTROL section contains a four-digit LED display and four pushbuttons. Press the function selector button to cycle through the three functions performed by the control section. One of the three windows (WATTS, PRF, or STATUS) will be lit to indicate the active function.

DIODE POWER (and INTERLOCK) Section

The DIODE POWER section contains a single pushbutton used to toggle the diode power on and off. It also contains two windows, EMISSION and INTERLOCK.

MODE Section

The MODE section contains five pushbuttons. Use them to select one of the four operating modes of the power supply RF driver or to transfer control from the remote to the user system. Above each button is an LED which shows which mode is currently active.

Startup Conditions

Place the laser head so the output beam is directed toward a safe target and verify that the system is correctly assembled.

Turning on the Laser Diode Module

Turn the key switch to the ON position. A test sequence will be executed and the unit will go into STANDBY mode.

Turning on the Laser Diode

Setting Diode Power

Power (W) is the optical output power of the laser diode, not the power at the end of the fiber-optic cable or out of the laser head. When two laser diodes are installed, the value is the combined power of both diodes.

When the power supply key switch is turned on, the diode power setting will be the same as it was when the key switch was last turned off. To change the power from the previously used setting, press the function selector button in the CONTROL section until WATTS is lit. The power setting in watts will appear in the LED display.

Key in the desired power.

- Use the up-arrow button to increase the power setting.
- Use the down-arrow button to decrease the power setting.
- (Hold a button down for fast scanning.)

Note the difference between the power *setting* and the power *reading*. When the WATTS window in the CONTROL section is lit, the value displayed is the active power *setting* , which can then be changed. When the STATUS window is lit, the PWRT value displayed is a *reading* of the power actually being emitted by the laser diode(s).

Turning on Diode Power

Press the button in the DIODE POWER section of the remote control. The EMISSION window and the green LED on the front panel will light. Three seconds later diode power will go on.

Selecting the Operating Mode

System Mode

Press the SYSTEM button in the MODE section. Control of the power supply is transferred from the handheld device to the user system via the 37-pin rear connector.

See Section *Operating the Power Supply Through the 37-pin D-Connector on the Rear Panel*.

In SYSTEM mode the remote control can be used only to monitor the system status variables as described under *Diagnostics* on the following page.

Standby Mode

If you are finished using the beam but want to use it again within the next hour, go to STANDBY. In this condition, the drive current to the laser diode may remain on but rf driver output is continuously on, preventing laser head emissions.

Pulse Mode

The pulse repetition frequency (PRF) determines the kind of pulsed radiation which will be emitted. Use the remote to set the PRF in the range of 1 to 9999. A PRF of zero (SNGL) permits manually controlled single pulses. Higher frequencies (up to 50 kHz) can be obtained by using the user interface or the external BNC trigger input. See below under Externally triggered pulses.

Setting PRF

Press the function selector button in the CONTROL section until PRF is lit. The PRF setting will appear in the LED display.

Key in the desired PRF.

- Use the digit selector button <-> to select one of the four LED digits.
- Use the up-arrow button to increase the selected digit.
- Use the down-arrow button to decrease the selected digit.
- (Hold an arrow button down to scan quickly through a range.)

Pulse Train
With a set PRF of 1 to 9999, press the PULSE button in the MODE section. The rf driver output will be pulsed at the PRF setting. When diode power is on the laser head will emit Q-switched pulses at the PRF as set.

Single Pulses
With a set PRF of zero (SNGL), the system is in single pulse mode. When diode power is on, the laser head will emit a single pulse each time the down arrow button in the CONTROL section is pressed. At each pulse, the 4-digit LED display will show asterisks (****).

Externally Triggered Pulses
Press the EXTERNAL button in the MODE section. The pulse frequency is now controlled from the rear panel of the 7300. Control is exercised through either of two inputs.

- Pin 9 of the 37-pin connector (J7).
- The BNC connector (J6).

See Section *Operating the Power Supply Through the 37-pin D-Connector on the Rear Panel* for more information on using the external trigger.

Externally Gated Pulses
With a set PRF of 1 to 9999 press the PULSE button in the MODE section. The rf driver output will be pulsed at the PRF setting. Now apply TTL low to either the SYS EXT TRIG input on the 37-pin back panel interface or the BNC trigger input (J6). As long as the ground is maintained, rf output power will be continuously on, preventing laser head emissions.

cw Mode
Press the CW button in the MODE section. The rf driver output will be disabled. The laser head will emit continuous wave (cw) radiation when diode power is on.

Interlock

If the INTERLOCK window lights, then the electrical interlock on the 37-pin interface at the rear of the power supply is open and active. "ILK1" will appear in the 4-digit LED display of the remote. The CONTROL and DIODE POWER sections of the remote control are disabled. Only the STATUS function is enabled. All emissions are turned off. The power supply is placed in STANDBY mode.

To resume normal operation first close the interlock circuit on the 37-pin connector. Then turn on diode power and switch out of STANDBY mode.

See Section *Operating the Power Supply Through the 37-pin D-Connector on the Rear Panel* for more information on the interlock feature.

Diagnostics

The R-Series System status can be monitored with the remote unit to aid in development and problem diagnosis.

Seeing the Status of the R-Series System

Press the function selector button in the CONTROL until STATUS is lit. The LED display will show either the name or the current value of a system status variable. Use the up and down arrow buttons to scroll through the list of status variables and their current values.

Example See the total diode power that is being emitted.

- Press function selector button until STATUS is lit.
- Press the down arrow button until PWRT appears.
- Press the down arrow button once more to show the value of PWRT.

(Note that the value of PWRT is not necessarily the same as the diode power setting. PWRT reflects actual emission and would, for example, be zero with emissions off.)

System Status Variables

Figure 3-8 is a list of system status variables and sample values as they might appear in the LED display of the remote control.

Format:
variable 1 name
variable 1 value
variable 2 name
variable 2 value
. . .
. . .
variable 9 name
variable 9 value

PWRT	Power Total (diode 1 plus diode 2 if installed)
.75W	Watts
HRS	Usage hours on diode 1
0010	Hours
PWR1	Power on diode 1 (= to PWRT for single diode system)
.75W	Watts
CUR1	Current through diode 1
1.58	Amps
TMP1	Temperature at diode 1
+7.3	Degrees Centigrade
MODE	Operating mode of the power supply
STBY	
(CW PULSE EXT SYSTEM)	See MODE section below for description
ADDR	Bus address of optional GPIB card (IEEE 488)
NONE	No GPIB card installed
SYNC	Mode of RF driver
ON (OFF)	ON = synchronous OFF = asynchronous
FDBK	Feedback loop variable currently controlling diode driver
PWR (CURR LOCK)	Diode power (Diode current, Reserved for future use)

FIGURE 3-8: System Status Variables with an Example Display

Turning Off the Laser Diode Power

To turn off diode power, press the button in the DIODE POWER section. Diode emissions will immediately stop. The EMISSION window on the remote unit and the green LED on the front panel of the power supply will go out.

Turning Off the Laser System

Place the system in standby mode as described above. Close the laser head attenuator. Turn off the key switch. Remove the key. Do not leave the laser accessible to people who are untrained in laser safety or operation.

A Sample Session Using the R-Series Remote Control

1. **Connect Remote Unit**
   Make sure the remote control is plugged into the front panel (J1).

2. **Turn AC Power On**
   Turn the key on the front panel clockwise. "TEST" will appear on the 4-digit LED display while the system runs internal checks. The power setting will then appear on the display unchanged from the last time the unit was turned off. The system will go into STANDBY mode with diode power off.

3. **Turn DIODE POWER On**
   Press the button in the DIODE POWER section of the remote control. The EMISSION window and the green LED on the front panel will light. Three seconds later diode power will go on. Because the system is still in standby mode, the laser head will not emit laser light.

4. **Turn cw Radiation On**
   Press the CW button in the MODE section of the remote control. The laser head will emit cw radiation at the set power.

5. **Check the Diode Power**
   Press the function selector button in the CONTROL section until STATUS is lit. Use the arrow keys to scan the status variables for PWRT and the value following.

6. **Check the Diode Current**
   CUR1 (amps) is the drive current to the laser diode. Press the function selector button in the CONTROL section until STATUS is lit. Use the arrow keys to scan the status variables for CUR1 and the value following.

7. **Change the Laser Beam Power**
   Press the function selector button in the CONTROL section until WATTS is lit. Use the arrow keys to change the diode power setting in the LED display. Note that the beam power from the laser head is also changed.

8. **Turn on Q-switched Pulsed Radiation**
   Press the PULSE button. The laser head will now emit pulses at the PRF last set.

9. Change the Pulse Repetition Frequency (PRF)
Press the function selector button until PRF is lit. Use the arrow keys and the digit selector key to change the PRF.

10. Turn on Single-Pulsed Radiation
Set a PRF of zero. The display will show "SNGL". Press the down arrow button to cause a single pulse to be emitted. At each pulse the LED display will show asterisks (****).

11. Turn off AC Power
Turn the key counterclockwise. The system will shut off. Values set for power and PRF will be retained. The next time the system is used these values need not be re-entered.

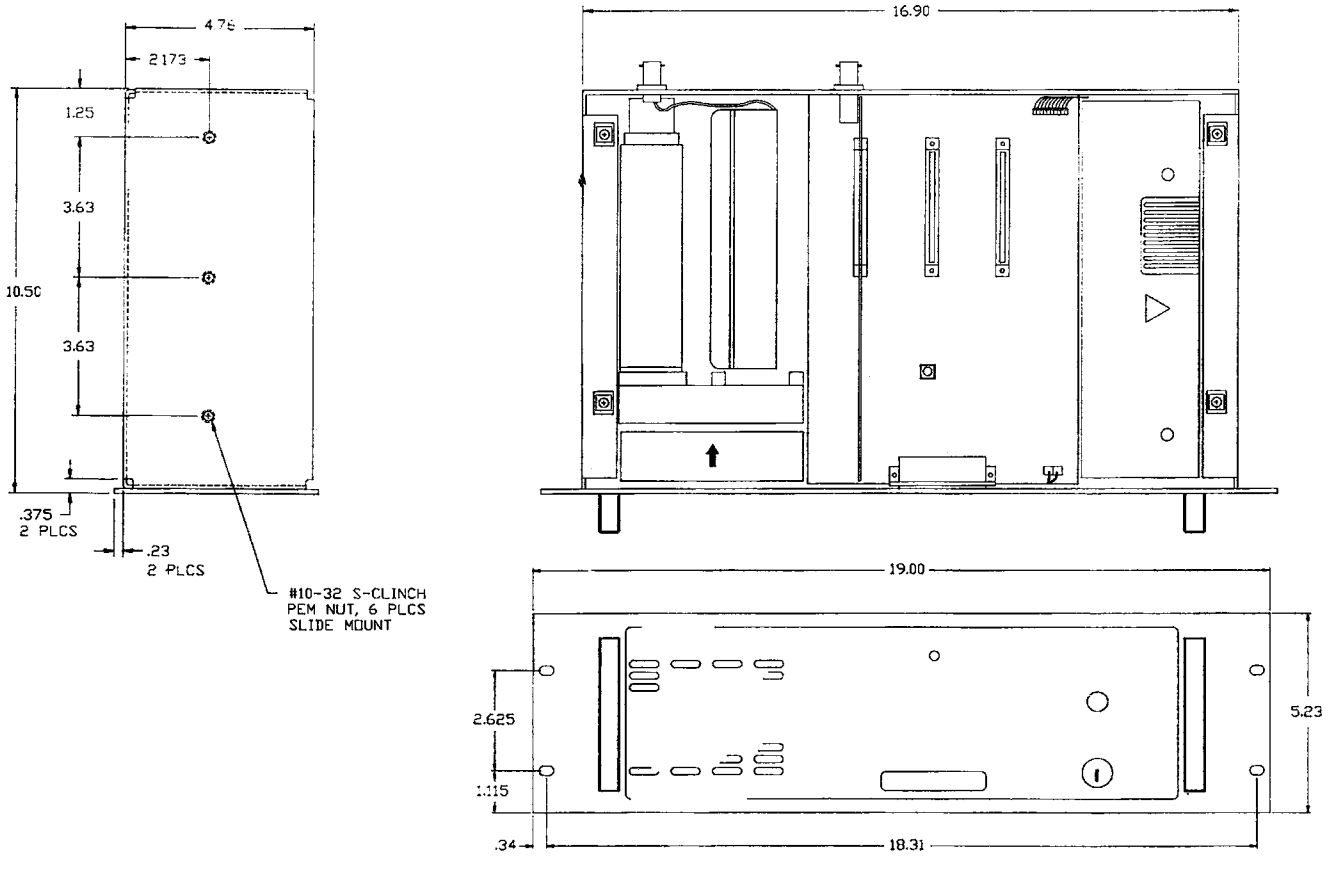


FIGURE 3-9: Power Supply Outline Drawing

Service & Repair

CHAPTER FOUR

Introduction

The R-Series System components are designed with a minimum of field serviceable parts. This chapter contains a troubleshooting guide that covers several possible problem situations that you may encounter. Problems not covered should be addressed to your Spectra-Physics field service engineer. Refer to Customer Service for complete information on this topic.

For reference purposes, this chapter contains a replacement parts list and wiring diagrams for the laser diode module.

Troubleshooting Guide

The key switch does not activate the system.

The power cord is unplugged.
The front panel fuse is blown.
The internal fuse in the power supply is blown. Contact your field service engineer.

The system is on but the remote control does not respond. ILK1 is displayed.

The remote interlock is active. Check interlock circuit.

PULSE is selected on the remote and drive current is turned on to a level above threshold but there is no output from the laser head.

The laser head beam attenuator is closed.
The fiber-optic cable is not securely connected at either the laser diode module or the laser head. Check that the key on the FC connector is properly engaged at both ends of the fiber-optic cable.

Unusual display on the remote control.

Check connection of J1 to remote cable.

The laser emits cw light when PULSE or STANDBY is selected.

rf power is not getting to the laser head. Check the coaxial cable from J8 to the SMA connector on the head.

The remote control switches are locked in STATUS mode and diode power cannot be enabled.

The power supply is in SYSTEM mode. Select another mode for local control.

Low power from the Q-switched pulses.

The pulse repetition frequency (PRF) is set above the roll-off value – about 600 Hz for Nd:YLF and about 1500 Hz for Nd:YAG.

Low power from the laser diode(s).

The diode(s) have aged and cannot deliver the specified power at the current limit set on the diode driver boards. Contact Spectra-Physics service representative

Low power from the laser head after installing the fiber- optic cable.

The shutter is closed.

Low output power from optical fiber. Measure output power from the end of the fiber. Power should be approximately 2/3 of the indicated diode power of the on the Model 7310 Remote Control.

- Tighten optical fiber end connectors.
- Inspect optical fiber ends for damage.

Low output power from laser diodes. See previous symptom.

Diode temperature setting is incorrect.

If still low power, there may be a problem with the laser head. Contact your Spectra-Physics service representative.

There is cw leakage power between the Q-switched pulses or the Q-switched pulses are very noisy.

The rf power needs to be adjusted. Contact your Spectra-Physics service representative.

The system is connected properly for external trigger operation but there is no Q-switched output.

The input signal is not suitable for TTL logic. Check the voltage of the input signal.

Maintenance

Cleaning the Fiber Optic Cable

The fiber-optic cable should normally be left connected at both the power supply and at the laser head. If the cable is disconnected at either end, be careful to keep the end surface of the cable as clean as possible. Use the following procedure if the cable end surface becomes contaminated.

Turn the key to the off position and disconnect the AC power. Hold the cable so the end surface is horizontal. Use dry nitrogen, canned air, or a rubber squeeze bulb to blow dust or lint from the surface. Place a drop of spectroscopic grade methanol (do not use acetone) on the end surface. Lay a sheet of photographic lens tissue on the wetted surface and gently draw it across to remove dissolved contaminants. Try to keep cleaning to a minimum because each cleaning cycle can wear down the tip of the fiber.

Replacing the Fan Filter

Turn the key to the off position and disconnect the AC power. Remove the top cover of the power supply. Slide the old fan filter from the filter holder (Figure 1-7). Clean or replace the filter. Replace the top cover and restore the power.

Replacing a Fuse

Turn the key to the off position and disconnect the AC power. Use a slotted screwdriver to remove the fuse from the fuse holder (Figure 3-1). Replace the fuse. Restore the power.

Replacing a Laser Diode Module

WARNING

This operation is preferably done by a Spectra-Physics field service engineer. If you perform this operation yourself, without completing an Spectra-Physics approved service training course, you risk damaging certain components. The Spectra-Physics warranty will become void.

The procedures are the same for one-diode modules and two-diode modules. When changing from a one-diode setup to a two-diode setup or vice-versa, be sure to adjust appropriately the DIODE1 and DIODE2 dip switches on SW1 of the motherboard (Figure 1-6). Turn the key to the off position and disconnect the AC power. Remove the top cover of the power supply. Ground yourself using a conductive wrist strap to prevent electrostatic discharge which could damage the diode assembly. Remove all cables connected to the diode module board. Remove the fiber optic cable from the back panel. Remove the six screws on the bottom panel that secure the diode assembly to the chassis and lift out the assembly complete with heatsink. Replace the diode module by reversing the disassembly process. If necessary, adjust the dip switch at SW1 as described above.

The diode modules come from the factory fully calibrated. No adjustments should be attempted.

Checking Diode Current Balance

In a two-diode system the current through the two diodes should be equalized. Check this by turning on maximum power and then using the remote control to look at the status variables CUR1 and CUR2. If they are not equal, use the potentiometer at VR1 on the diode driver board to adjust CUR2.

rf Sync/Async Setup

Turn the key to the off position and disconnect the AC power. Remove the top cover of the power supply.

Refer to Figure 1-7 and Figure 1-6 (Microprocessor Dip Switch Functions) to set switch 4 (labeled ZERO) of motherboard SW1 to the desired rf mode (ON = synchronous and OFF = asynchronous mode). Replace the top cover and restore the power.Replace top cover and restore power.

Feedback Mode Setup

Turn the key to the off position and disconnect the AC power. Remove the top cover of the power supply. Refer to Figure 1-7 and Figure 1-6 (Microprocessor Dip Switch Functions) to set switches 5 and 6 (labeled MODE1 and MODE2) of motherboard SW1 to the desired feedback mode. Replace the top cover and restore the power. Replace top cover and restore power.

Replacing the rf Module

Turn the key to the off position and disconnect the AC power. Remove the top cover of the power supply. Disconnect all cables from the rf module. Remove the BNC connector by unscrewing the hex nut attaching it to the rear panel. Remove the plugs at J14, J17, (J18 if installed) and J19. Place the 7300 unit on its side. While holding the rf module, unscrew the three screws holding it to the bottom panel. Lift the rf module free. Install a replacement rf module by reversing the disassembly procedure. Replace the top cover and restore the power.

Adjusting the rf Level

WARNING

This operation is preferably done by a Spectra-Physics field service engineer. If you perform this operation yourself, without completing an Spectra-Physics approved service training course, you risk damaging certain components. The Spectra-Physics warranty will become void.

If the laser head emits cw radiation in standby mode or if the pulse energy in pulse mode is unstable, then the rf level may have to be increased. Remove the top cover of the power supply. Route the rf driver power from **back panel J8 to the laser head** through an in-line Bird 4431 rf power meter or equivalent using a 5 W 25-60 MHz plug-in. With the rf on, measure the forward and reverse rf power. If the forward power is not between 1.0 and 2.0 W or if the reverse power is greater than 0.1 W, then contact your field service representative. Otherwise, proceed to adjust the rf level by monitoring the cw leakage in standby mode or the pulse energy stability in pulse mode. Apply a potentiometer adjuster to the pot on the rf driver board through the access hole in the protective cover. Without exceeding 2.0 W, gradually turn up the rf power until the cw leakage is eliminated or the pulse energy is stabilized. Be sure not to exceed 2.0 W of rf power or damage to the Q-switch may result. Remove the in-line rf meter and replace the top cover.

Replacing the Low Voltage Power Supply

Turn the key to the off position and disconnect the AC power. To avoid the possibility of electrical shock, make certain to disconnect AC power. Remove top cover of the power supply. Remove the two top screws securing the power supply protective cover and remove cover from the power supply. Disconnect the orange 14-pin connector and the red 5-pin connector. Remove the hardware securing the power supply to the bottom panel and remove power supply. Replace power supply unit. Reconnect the cables and attach the power supply protective cover. Replace the top cover and restore the power.

Replacing the Fan Assembly

Turn the key to the off position and disconnect the AC power. Remove the top cover of the power supply. Make certain to disconnect AC power. Remove the two top screws securing the power supply protective cover and remove cover. Disconnect the emission LED plug at J9 on the motherboard. Disconnect the fan plug at J15. Use an Allen wrench to remove the four screws securing the front panel to the chassis.

Remove the hex nut from the inside of the front panel near the top right side of the fan assembly. Carefully move the front panel away from the chassis enough to gain access to the four screws holding the fan assembly to the front panel. Be careful not to stress the cables which are still attached to the front panel. Remove these four screws and lift off the fan assembly. Temporarily replace the front panel and replace the hex loosely to hold it in place. Remove the brackets from the fan assembly. Attach the brackets to the replacement fan assembly and reverse the disassembly procedure. Reconnect the cables and attach the power supply protective cover. Replace the top cover and restore the power.

Updating the Software – PROM Replacement

Turn the key to the off position and disconnect the AC power. Remove the top cover of the power supply. Using a small flat screwdriver or chip removing tool, pry up the label-covered IC at U3 on the motherboard. Replace with a new PROM, being sure to place the chip so that pin 1, identified by a notch at the end of the chip, is to the left (closest to the fan) side of the unit. Check to be sure that no pins are bent under and that each is firmly seated in its slot. Replace the top cover and restore the power.

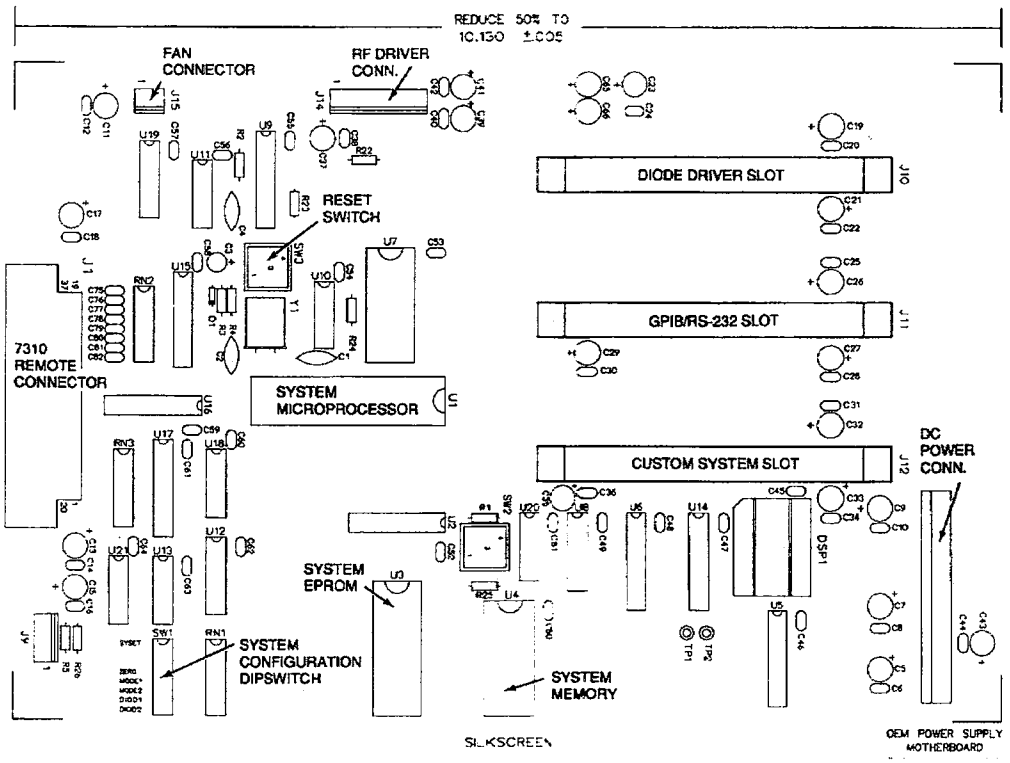


FIGURE 4-1: Power Supply Motherboard

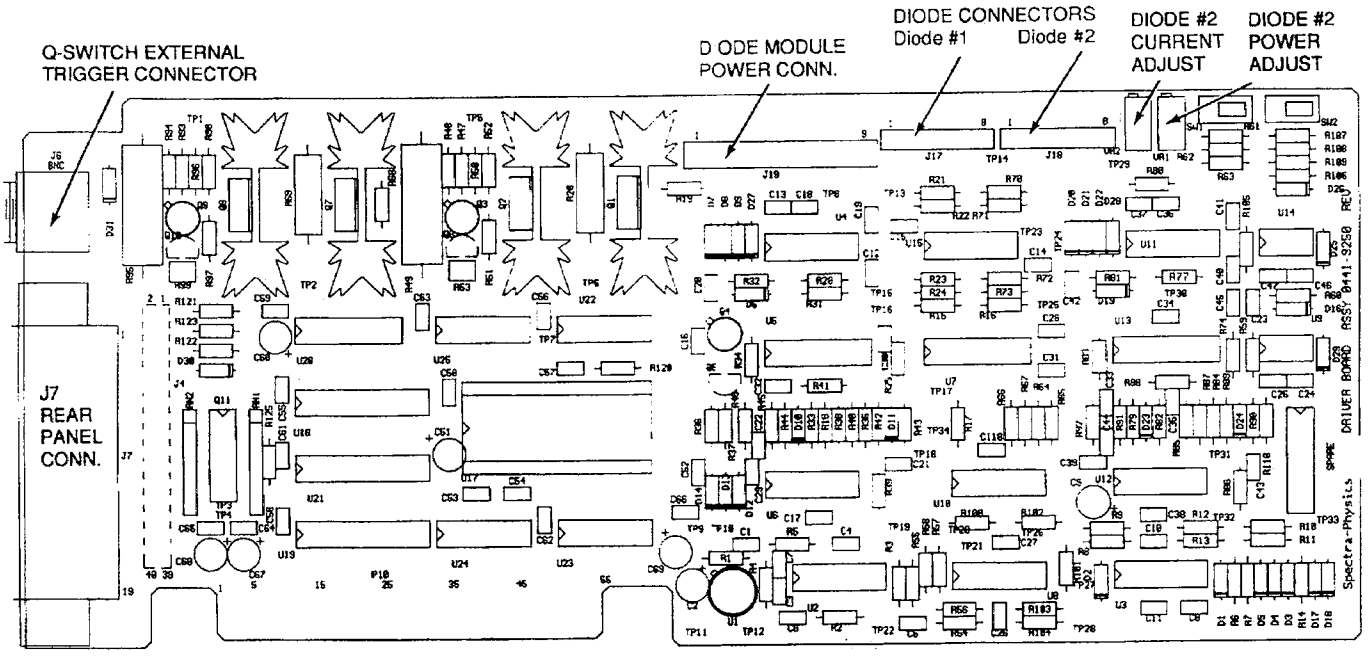


FIGURE 4-2: Power Supply Driver Board

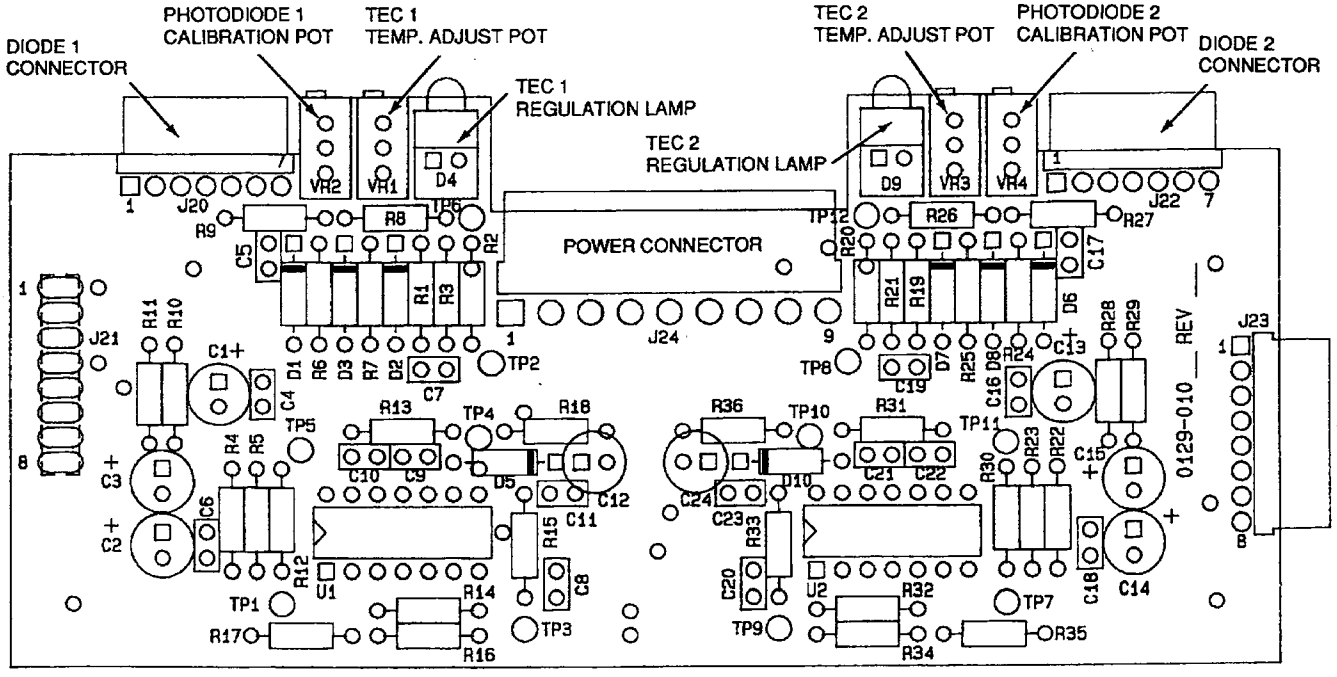


FIGURE 4-3: Power Supply Module Board

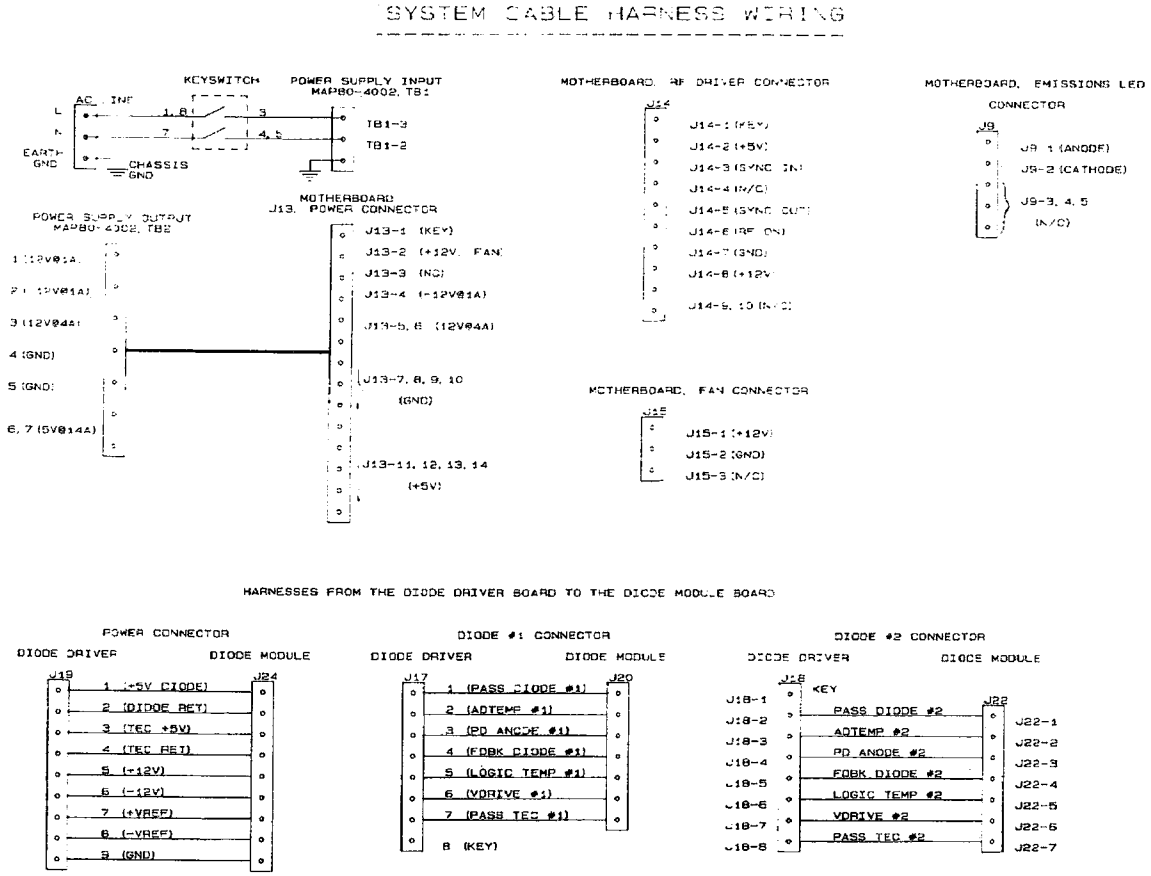


FIGURE 4-4: Power Supply Cable Harness Wiring

Customer Service

CHAPTER FIVE

Introduction

At Spectra-Physics, we are proud of the durability of our products. Our manufacturing and quality control processes emphasize consistency, ruggedness, and high performance. Nevertheless, even the finest instruments break down occasionally. We believe that the reliability record of our instruments compares favorably with that of our competition, and we hope to demonstrate that we provide superior service by providing dependable instruments and, if the need arises, service facilities that can restore your instrument to peak performance without undue delay.

Spectra-Physics maintains major service centers in the United States, Europe, and Japan. Additionally, there are field service offices in major United States cities. When calling for service inside the United States, dial our main office number: 1 (415) 961-2550. To phone for service in other countries, refer to the Service Centers listing located at the end of this section.

Replacement parts should be ordered directly from Spectra-Physics. For ordering or shipping instructions or for assistance of any kind, contact your nearest sales office or service center and give the instrument model and serial numbers. Service data or shipping instructions will be promptly supplied.

Warranty

All components of the R-Series System are warranted to be free of defects in workmanship and materials for one year from the date of shipment. The laser diodes are warranted for a period of one year or 5000 operating hours, whichever comes first. Spectra-Physics will repair or replace instruments that prove to be defective during the warranty period without charge. The obligation of Spectra-Physics is limited to such repair, and does not extend to consequential damages.

The warranty does not apply to devices damaged due to operating conditions outside the limits described in this manual. This warranty is in lieu of all other warranties, express or implied, and does not cover incidental or consequential loss.

Return of the Instrument for Repair

Contact your nearest Spectra-Physics field sales office, service center, or local distributor for shipping instructions, and forward the instrument prepaid to the destination indicated. Special Spectra-Physics packing boxes designed to securely hold instruments during shipment should be used. If shipping boxes have been lost or destroyed, we recommend that you obtain a new one, for a nominal charge, from Spectra-Physics. Spectra-Physics will only return instruments in Spectra-Physics' containers.

Call for the nearest Service Center:

Spectra-Physics Lasers Headquarters

1330 Terra Bella Avenue
Post Office Box 7013
Mountain View, CA 94039-7013
Telephone: 1-800-SPL-LASER
(1-800-775-5273)
Telephone: 1-415-961-2550
Fax: 1-415-964-3584
E-Mail: splaser@ix.netcom.com
http://www.splasers.com

Australia	(03) 9761-5200
Belgium	0800-11257
China	(10) 2562934
France	(01) 69 18 63 10
Germany	(49) 6151 708 240
Japan, Osaka	(06) 941-7331
Tokyo	(81) 3-3794-5511
The Netherlands	(31) 40-2659959
United Kingdom	(44) 1 442 2581 00

GPIB/RS-232

APPENDIX A

Description

The R-Series GPIB/RS-232 interface card is an accessory for the laser power supply which allows external control and sensing of the laser system.

The card plugs into the power supply motherboard and has two interface connectors. The upper connector, J2, connects to a 25-pin GPIB bus cable and the lower connector, J3, connects to a 9-pin RS-232 cable

A DIP switch along the top of the board allows selection of the desired baud rate, parity, GPIB address etc. Located to the left of the DIP switch are three LED diagnostic indicators. The right LED, DS3, indicates the communication interface selected. The LED on indicates RS-232 and the LED should light up when power is first applied to the system. The left LED, DS1, blinks when a character is received and buffered. The center LED, DS2, blinks when a character is transmitted.

The unit designed to utilize either the RS-232 or the GPIB mode. The mode is automatically switched upon reception of a character from the interface utilized.

Installation

Installing Card into Power Supply

Remove the top cover of the power supply by turning the four quarter-turn fasteners. Located the J11 card edge connector on the motherboard of the power supply. This will be the center connector of the three possible interface connectors. Remove the back cover plate next to the J11 connector by loosening the two phillips head retaining screws. Install the GPIB board in the J11 connector and re-install the retaining screws.

Setting DIP Switches

The DIP switch located on the top edge of the GPIB board configures the board for the desired setup. The switch is used both for the GPIB and the RS-232 mode of operation. The switch positions should be set when the system power is off. The switch settings are only checked when power is turned on. The meaning of the switch selections is described as follows:

If you are using the GPIB interface:

S1-1	Talk and listen address (0-31)	
S1-2	" "	
S1-3	" "	
S1-4	" "	S1-=LSB
S1-5	" "	on ->1, off ->0
S1-6	Don't care	
S1-7	" "	
S1-8	" "	

If you are using the RS-232 interface:

Baud Rate

S1-3	S1-2	S1-1	Baud Rate
off	off	off	110
off	off	on	300
off	on	off	1,200
off	on	on	2,400
on	off	off	4,800
on	off	on	9,600
on	on	off	19,200
on	on	on	19,200

Parity

S1-4	S1-5	Parity
x	on	even
on	off	odd
off	off	no

Data and Stop Bits

S1-6

off	8 data bits
on	7 data bits

S1-7

off	1 stop bit
on	2 stop bits

S1-8

Don't care

Connecting the RS-232 Cable

The 9-pin RS-232 port connector is designed to plug directly into an IBM AT style computer. In this case, use a cable wired as shown in Figure A-1. To connect the 7300 to a 25-pin DB-25 connector use a cable wired as shown in Figure A-2. Pre-wired cables and adapters are available to simplify this wiring.

Data flow control is hardware controlled. Data out of the power supply will be held off by a low on pin-7 of the DB-9 connector (RTS). Data into the power supply should hold off on a low at pin-8 (CTS). Pin-9 (RI) and pin-6 (DSR) will both be high when the 7300 is on and ready to communicate.

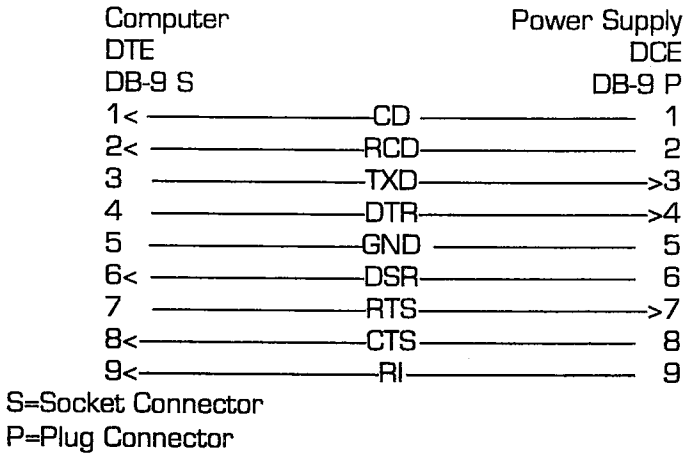


FIGURE A-1: Cable Wiring for a 9-pin RS-232 Port Connector

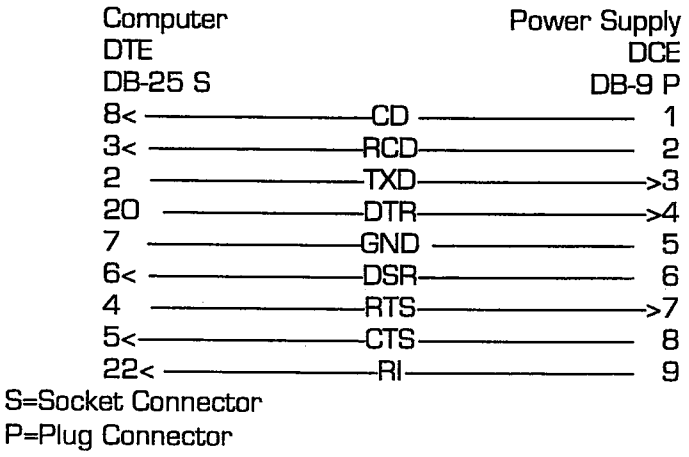


FIGURE A-2: Cable Wiring for a 25-pin DB-25 Port Connector

Connecting the GPIB Cable

The 24-pin GPIB port connector is designed to accept a standard IEEE 488 interface connector and requires no special wiring or setup.

Updating the Software: R-Series Power Supply PROM Replacement

In some cases the power supply software must be changed to accommodate the GPIB/RS-232 Interface Board and in these cases an EPROM will be supplied with the interface board. Check the EPROM version installed in the U3 socket on the motherboard. The incorrect version of the software is labeled 0129-0380 and the correct version of the EPROM is labeled 0129-0465. Replace 0129-0380 with 0129-0465 if necessary. Instructions on replacing the EPROM are contained in Chapter 4, page 4-6.

After the new EPROM has been installed, follow these instructions to clear the laser diode elapsed time counter(s).

1. After turning power on check that DIP switch SW1-1 motherboard is OFF. Turn it OFF if it is ON.
2. Press SW2 pushbutton on motherboard until "HRS1" appears in the DSP1 display on motherboard.
3. Turn DIP switch SW1-1 to ON position.
4. Press SW2 pushbutton once. Notice "0:00" is displayed in DSP1.
5. Turn SW1-1 to OFF position.
6. If you have a two diode system, press SW2 until "HRS2" appears; then repeat steps 4 through6.

Commands

Command Format

Commands to the system consists of strings of ASCII Characters. Command strings are terminated by a carriage return character <CR>, or a semicolon ":". More than one command can be issued in a string; however, characters beyond the 20 character buffer size limit will be ignored. The format of the command strings is as follows:

c..nn<CR>
where "c.." is the command code
"nn" is the numeric data
<CR> is the command terminator

Numeric data must be in a positive integer format 0 to 9999. Maximum string length is 20 characters. Alphabetic command codes may be upper or lower case. Alternatively, with the GPIB interface only, command strings may be terminated by enabling the EOI line with the last character.

List of Commands

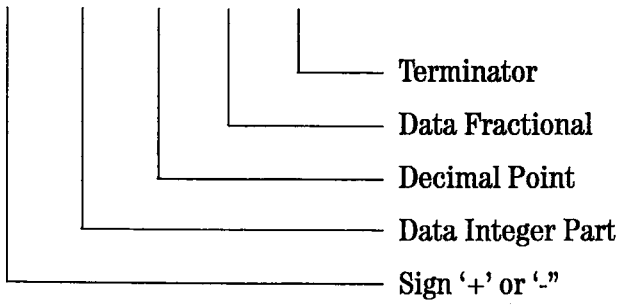
Pnnnn	Sets the total laser diode power to the level in mW. The laser must be in power mode.
Cnnnn	Sets the laser diode current to the level in mA. The laser must be in current mode.
Rnnnn	Sets pulse repetition rate of Q-switched laser to frequency in Hz.
Mn	Sets mode of Q-switched laser: n=0 CW n=1 PULSE n=2 EXTERNAL n=3 STANDBY n=4 SYSTEM
D0	Turns laser diode off.
D1	Turns laser diode on.
An	Sets 3 auxiliary port outputs.
Tn?	Reads laser diode 1 or 2 temperature.
In?	Reads laser diode 1 or 2 current.
Wn?	Reads laser diode 1 or 2 measured power.
En?	Reads laser diode 1 or 2 elapsed time counter.
B?	Reads system status flags.
S?	Reads motherboard DIP switch status.
U?	Reads 37-pin user port input status.
X?	Reads auxiliary port input status.
*L	Enables control from remote control box. Analogous to GPIB bus message "GTL".
*R	Disables control from remote control. Analogous to GPIB bus message "GET".
*C	Clears IO buffers.

Data Formats

The data returned after a read command will be in the following formats:

Temperature, normal response, in degrees Centigrade:

S DD . DD <CR> 7 characters



Temperature +endpoint

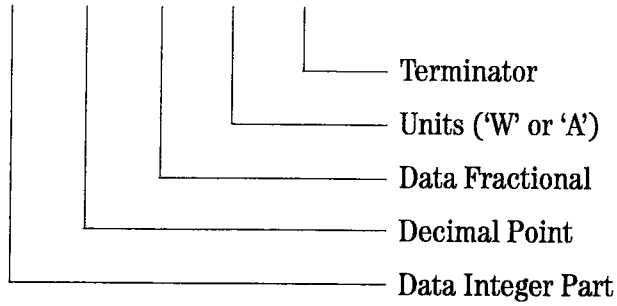
"+OVLOD" <CR>

Temperature -endpoint

"-OVLOD" <CR>

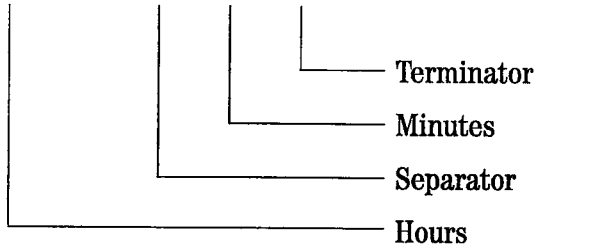
Current or Power in Amps or Watts:

S DD . DD <CR> 6 characters



Elapsed Time in Hours and Minutes:

HHHHHH : MM <CR> 10 characters



Status:

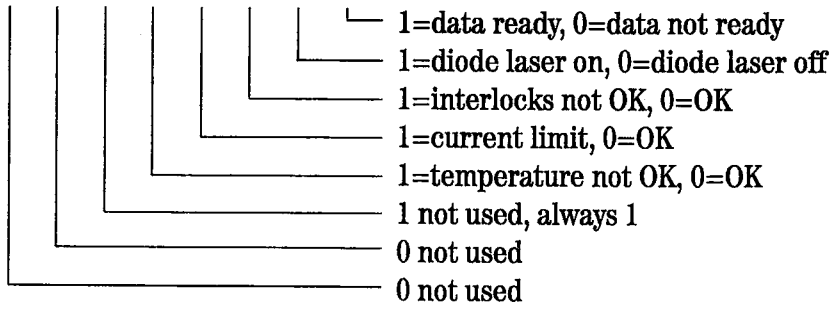
SSS <CR> 4 characters

The SSS is an ASCII coded integer ranging from 0 to 255 that represents status information. The individual bits in the integer returned have the following meaning:

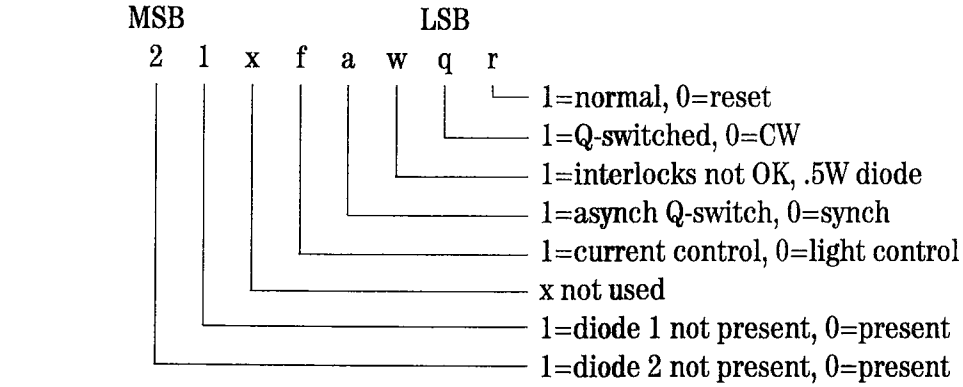
Status of System (response to "B?"):

MSB LSB

x s x t c i l d



Motherboard DIP switch (response to "S?"):

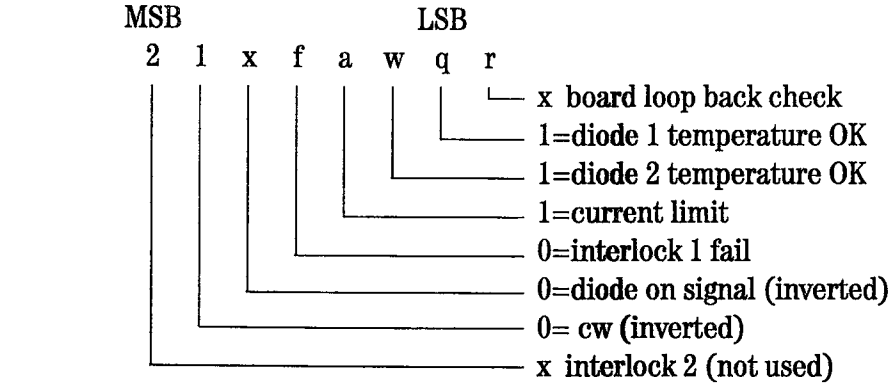


Auxiliary Port (response to "X?"):

MSB... ...NSB LSB

AX9 AX8 AX7 AX6 AX5 AX4 AX3 DTR

User Port Status (response to "U?"):



NOTE

When the GPIB interface is used, the EOI line is enabled with the last character (i.e. the <CR> character) in any of the responses.

GPIB Bus Messages Supported

LLO — Local lockout.
Disables control from remote control box.

GTL — Go to local.
Enables control from remote control box.

GET — Group execute trigger.
Causes one Q-switched laser pulse to be emitted when single shot pulsed mode is selected.

SPE — Serial poll enable.
Returns the binary status of the system. Bits are encoded as shown above for response to the "B?" command.

Basic Programming Example

The following program demonstrates how to use the commands to set and query the laser status using the RS-232 serial port.

```
100 OPEN " COM1:9600,N,8,1" AS #1
110 REM POWER 250 MW, REP RATE 100 HZ, MODE PULSED
120 PRINT #1,"D1"
300 INPUT "PRESS RETURN WHEN READY TO READ DATA:"; A$
400 REM READ DIODE 1 CURRENT
410 PRINT #1, "I1?"
420 INPUT #1, D$
430 PRINT "DIODE 1 CURRENT = ";D$
440 REM READ DIODE 1 TEMPERATURE
450 PRINT #1, "T1?"
460 INPUT #1, D$
470 PRINT "DIODE 1 TEMPERATURE = ";D$
1000 CLOSE #1
```