

***USER'S MANUAL
DPSS LASER
TITAN SERIES
Covers Models: Txx-yy and CW***

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Laser Test Data Included Separately

SAFETY AND COMPLIANCE

Before operating this equipment, users should refer to ANSI Standard Z136.1 that outlines precautions for safe operation of laser equipment and specifically recommends that:

1. Users should have initial eye examinations prior to operating laser equipment followed by periodic re-examinations.
2. Users should use appropriate eye protection when operating laser equipment.

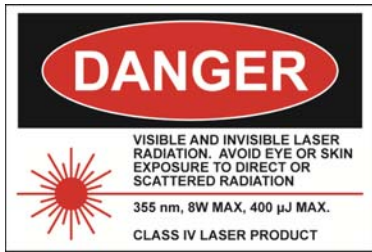
The standard is available from the Laser Institute of America (LIA), telephone number (407) 380-1553.

This equipment is powered by a high voltage power supply capable of high current output. There are no user serviceable components in this system.

This laser complies with FDA radiation performance standards, 21 CFR subchapter J.



WARNING: HAZARDOUS LASER RADIATION. AVOID DIRECT EXPOSURE TO THE BEAM. DO NOT STARE AT SCATTERED OR REFLECTED LIGHT. STRICT OBSERVANCE OF THE FOLLOWING WARNING LABELS IS ADVISED.



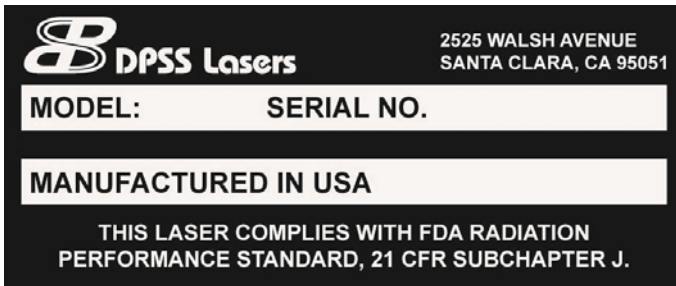
This laser has a maximum output of 8W at 355nm. This label is displayed on the side of the laser head.



This label is affixed to the laser head cover next to the laser emission indicator.



This label is affixed to the back of the power supply.



This Serial Number/Model Number label is located on the back of the laser head, power supply, and cooling system.



This label is affixed next to the laser output port shutter.

LIMITED WARRANTY

All mechanical, electrical and optical parts and assemblies when operated under normal conditions and in accordance with the product instructions are warranted to be free from defects in workmanship and materials for the first full year following delivery of the equipment. The following warranty conditions shall apply to all laser systems, unless amended in writing by DPSS Lasers Inc.

ADJUSTMENT – No electrical, mechanical or optical adjustments to the laser system are permitted, unless expressly authorized by DPSS Lasers Inc.

PARTS AND LABOR - New or factory-built replacements for defective parts will be supplied for one (1) year from date of delivery of the equipment. Replacement parts are warranted for the remaining portion of the original warranty period. There will be no charge for repair of products under warranty where the repair work is done by DPSS Lasers Inc. However, DPSS Lasers Inc. shall not be responsible for any shipping or transportation charges, which shall be the sole responsibility of the customer.

NOT COVERED – Damage due to abuse, improper installation or application, alteration, accident, negligence in use, improper storage, transportation or handling is not covered by this warranty. This warranty shall not apply where the original equipment identifications have been removed, defaced or altered.

DAMAGE IN SHIPMENT - Your laser product should be inspected and tested as soon as it is received. The product is packaged for safe delivery. If the product is damaged in any way, you should immediately file a claim with the carrier or, if insured separately, with the insurance company. DPSS Lasers Inc. will not be responsible for damage sustained in shipment.

CLAIMS ASSISTANCE - Call DPSS Lasers Inc. Customer Service or your local distributor for assistance. Give our representative the full details of the problem. Helpful information or shipping instructions will be provided. If requested, estimates of the charges for non-warranty or other service work will be supplied before work begins. Products being returned for repair must be shipped in their original shipping cartons to avoid damage.

DISCLAIMER - THIS WARRANTY SHALL BE IN LIEU OF ALL OTHER WARRANTIES EXPRESS OR IMPLIED AND SHALL BE IN LIEU OF ALL WARRANTIES OF FITNESS AND MERCHANTABILITY. DPSS Lasers Inc. SHALL NOT BE LIABLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES OF ANY NATURE OR KIND WITH RESPECT TO ANY PRODUCTS OR SERVICES SOLD OR RENDERED HEREUNDER AND UNDER NO CIRCUMSTANCES WILL DPSS Lasers Inc.'s LIABILITY EXCEED THE COST OF REPAIR OR REPLACEMENT OF THE DEFECTIVE ITEM OF EQUIPMENT. DPSS Lasers Inc. NEITHER ASSUMES NOR HAS AUTHORIZED ANY OTHER PERSON TO ASSUME FOR IT ANY OTHER LIABILITY.

PRODUCT DESCRIPTION

The Titan Series DPSS laser (US patent # 6,002,695) is a high repetition rate, Q-switched, Diode pumped Nd: Vanadate system, employing intra-cavity doubling and tripling for efficient ultra-violet generation. With specified average powers of one-tenth watt (0.1W) to three watts (5.0W) at 355nm and at repetition rates from 30 kHz to 300 kHz, the DPSS laser is specifically designed to meet the needs of the OEM system designer. Combining the power conversion efficiency of diode pumped solid state technology with proprietary laser cavity design and a sealed housing, the Titan Series is ideally suited to industrial environments.

The laser requires only regular household electrical power, no external water-cooling and operates at or near room temperature. Thermoelectric coolers transfer heat to the cast aluminum base while a closed cycle cooling system transfers the heat to the room air. A proprietary mechanical design, utilizing stress-relieved components, eliminates cavity alignment for the life of the laser. The laser output is horizontally polarized and the mode is TEM₀₀.

The Titan Series DPSS laser has been designed for materials working applications including metals, organics, and inorganics. Specific applications include micromachining/ablating of various metallic and non-metallic materials, polymerization of photopolymers, micro-hole drilling, marking and bio-fluorescence.

STANDARD SPECIFICATIONS, TITAN SERIES DPSS LASER:

Nd:YVO₄, Frequency Tripled, Q-switched Laser

OPTICAL (variations based on model number):

• Wavelength	354.7	nm
• Average power	0.1 – 5.0	W
• Pulse length	20 - 100	nsec
• Repetition rate (factory set)	30 - 300	kHz
• Mode	M ² <1.30	TEM ₀₀
• Beam diameter (1/e ²)	2.0	mm
• Beam divergence (full angle)	<0.3	mrad
• Polarization, linear, vertical	>100:1	
• Beam pointing stability at constant temp	<50	µrad
• Power stability over eight hours	<5	%
• First pulse suppression	Yes	

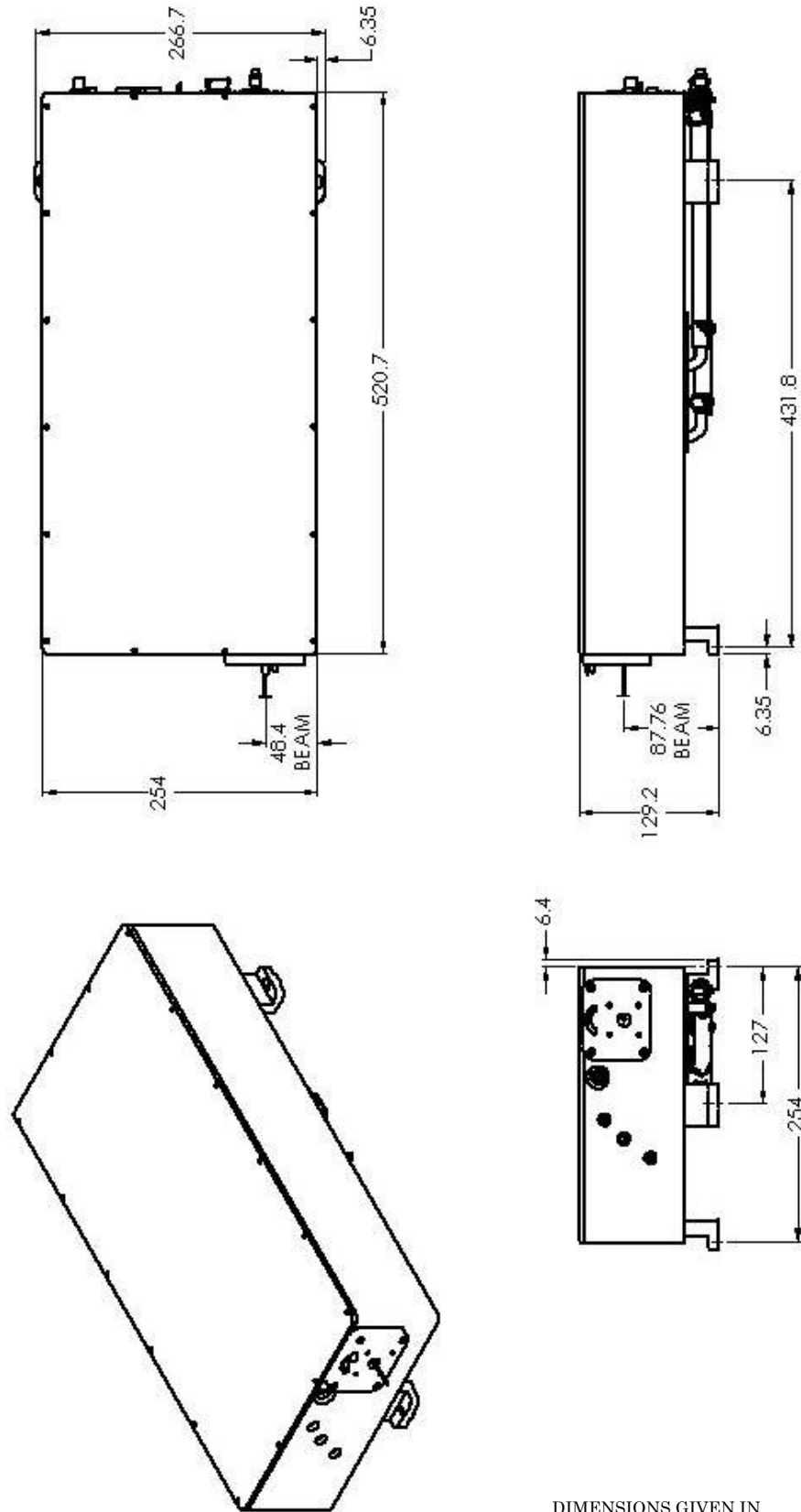
ELECTRICAL:

• Input voltage	90-240, 50-60Hz	VAC
• Power consumption (max)	900	W
• Ambient operating temperature (non-condensing)	10-35	°C

PHYSICAL:

• Laser head dimensions in inches (LWH)	52.1 x 25.4 x 12.9	cm
• Laser head weight	15.9	kg
• Laser power supply dimensions in inches (LWH)	33.0 x 45.5 x 13.7	cm
• Laser power supply weight	10.5	kg
• Cooling system dimensions in inches (LWH)	28.7 x 22.4 x 38.9	cm
• Cooling system weight	9.1	kg

FIGURE 1



DIMENSIONS GIVEN IN

SYSTEM INSTALLATION

INCOMING INSPECTION:

Immediately upon receipt, the laser should be unpacked and inspected for shipping damage. If none is evident, test for satisfactory operation.

REQUIRED TOOLS FOR INSTALLATION:

- Water, 2 quarts (distilled)
Use: Laser coolant.
- Isopropyl alcohol, ½ cup
Use: Laser coolant additive.
- Safety glasses for all persons present. (OD>5+ @ 355nm)
Use: Laser eye safety.
- Calibrated laser power meter – Coherent FieldMate / LD10 or equivalent
Use: Verifying laser performance.
- One fluorescent card or business card. Matte surface.
Use: Beam diagnostics and alignment.
- 3/16” Allen driver (optional)
Use: Attaching the laser to the work surface if needed.

UNPACKING:

Open the box and check the packing list. Verify that all materials are present.



Note: Retain all packing materials.

After unpacking, inspect the box and all components of the laser for damage. If any damage is found, contact the carrier for immediate on-site inspection. All claims for damage should be directed to the carrier. Call DPSS Lasers Inc. Customer Service for additional information.



WARNING: THE USE OF CONTROLS, ADJUSTMENTS, OR PERFORMANCE OF PROCEDURES OTHER THAN THOSE SPECIFIED HEREIN MAY RESULT IN HAZARDOUS RADIATION EXPOSURE.



Note: **DO NOT** remove any covers or panels unless specified.

VENTILATION:

Provide adequate ventilation such that the ambient temperature of the air is in the range of 20-30°C. This is the preferred operating temperature range for the laser. The lasers will operate satisfactorily over a greater range, 10-35°C, but derated power may be experienced. It is important that air inlets on the back and sides of the laser power

supply and cooling unit are not obstructed and that the exhausted hot air is not allowed to recirculate into the air inlets.

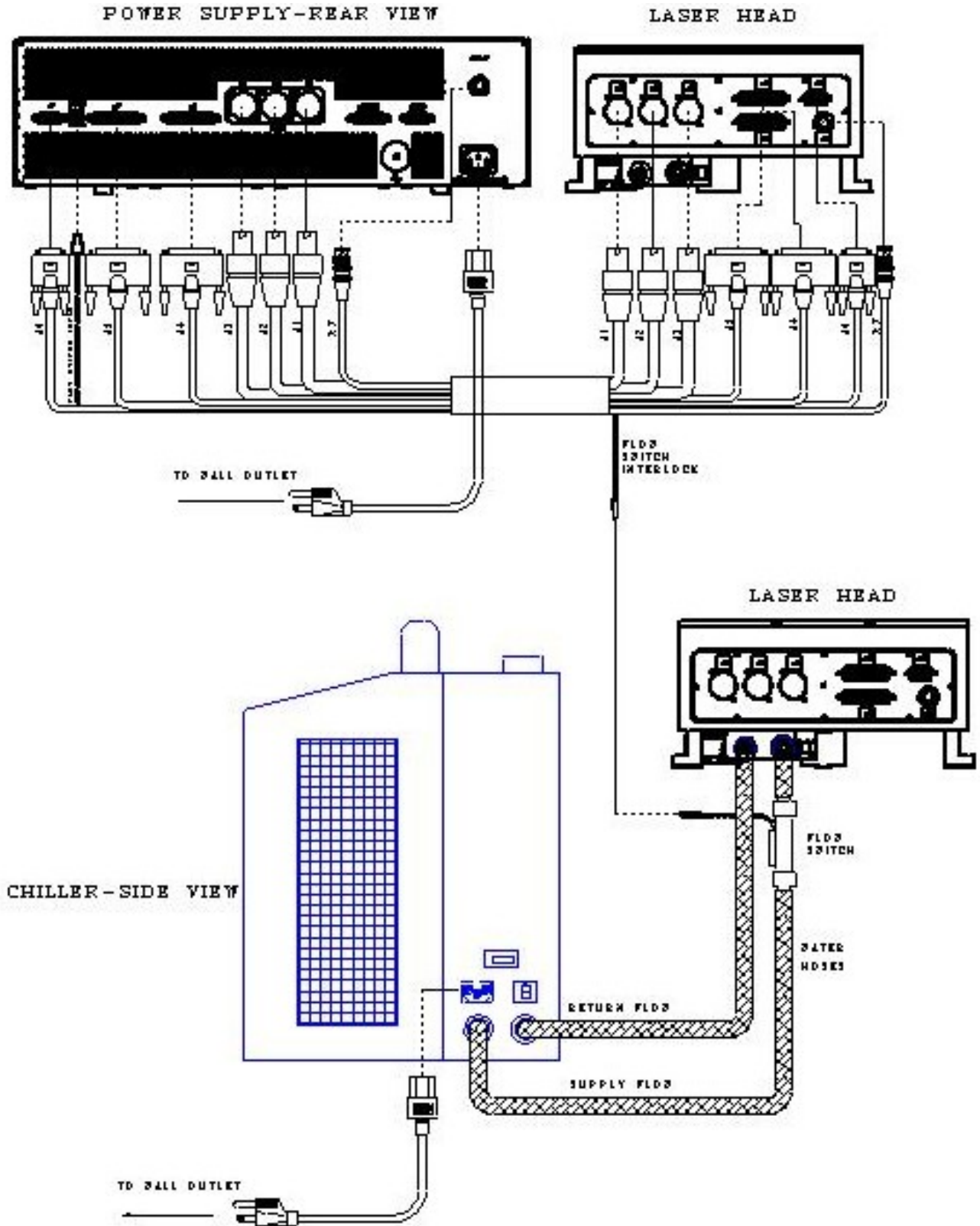
MOUNTING:

The laser head is designed to be mounted in any orientation. For testing purposes, the laser can simply stand on a table on its feet. For permanent installation, the laser should be mounted to the user's system or optical bench. The dimensions of the mounting feet are shown in the outline drawings in the Product Description chapter (see Figure 1). The mounting feet are designed to provide mechanical isolation between the laser resonator structure and the mounting surface. This feature prevents any lack of flatness of the mounting surface, bending of the surface, or differential thermal expansion from affecting the laser mirror alignment. When all three feet are rigidly attached to the mounting surface, the laser will not move. Do not attempt to mount the laser by the base itself or some manner other than with the feet or other DPSS Lasers Inc. approved mounting device.

POWER REQUIREMENTS:

The laser power supply and cooling system are universal input devices. They will operate at any standard AC line voltage, worldwide (90 – 240 VAC). All models operate at 50Hz or 60Hz input.

FIGURE 2



CONNECTING THE COOLING SYSTEM (Refer to FIGURE 2):

The laser system is supplied with two water hoses. A flow sensor is attached to one hose at the male end (SUPPLY). Connect this end of the hose to the female port on the laser head. Connect the other end of this hose (SUPPLY) to the port on the cooling system marked with an arrow pointing down.

Connect the second hose (RETURN) to the remaining male port at the laser head. Connect the other end to the remaining port on the cooling system marked with an arrow pointing up.

Remove plastic filler cap for the water reservoir on the cooling system.

Fill the reservoir with 1/2 cup Isopropyl Alcohol and top off with distilled water.



Note: Isopropyl/distilled water solution is permitted for use in all “distilled only” locations.



Note: The water level will drop when the unit is first turned on as air in the hoses and cold plate is replaced with water. The reservoir will need to be topped off with distilled water. If the cooling unit displays a low fluid alarm during this time, simply cycle the power OFF and ON again to reset.

CONNECTING THE LASER CABLES (Refer to FIGURE 2):

Place the laser head on a table. Close the shutter. The mechanical laser output shutter is located on the front bezel of the laser head. Slide the shutter lever to the right or left until it clicks into place. When the lever is in the center, the shutter is open.

Locate the electrical umbilical that connects the laser head to the power supply. Secure each connector to its corresponding mate at the laser head indicated by the following labels: RF, J1, J2, J3, J4, J5, J6, INTLK and finally connect the two-pin red interlock cable to its mating connector on the flow sensor in the water hose.

Repeat the above step with the free end of the umbilical bundle at the power supply end. The red, 4-pin connector will connect to the “INTLK” location at the power supply.

With the cooling system switch in the OFF position, connect one end of an AC power cable into the cooling system and then into a suitable AC power outlet.

With the key switch in the OFF position (“0”), connect the AC power cable into the rear of the power supply and then into a suitable AC power outlet.

SYSTEM CONTROLS

GENERAL DESCRIPTION:

Before attempting to operate the laser, familiarize yourself with its various controls. The power supply (PS) consists of five control loops—Diode current, Diode temperature, Vanadate temperature, Doubler temperature, and Tripler temperature—and control functions for user interfacing.

The PS receives user input from the front panel via 6 buttons as well as input via a hardware remote and RS-232. These inputs will determine the state of the laser system. There are three laser states:

STAND BY—Laser emits no light

ON—For q-switched lasers, laser emits low level CW light.
For CW lasers, laser emits CW light at specified power.

Q-SWITCHED—Laser emits high power q-switch light at specified power



Note: The Q-SWITCHED state and its relevant settings are not used in the Titan Infinity CW laser system.

POWER SUPPLY CONTROLS (Refer to FIGURE 3 and TABLE 1):

FIGURE 3

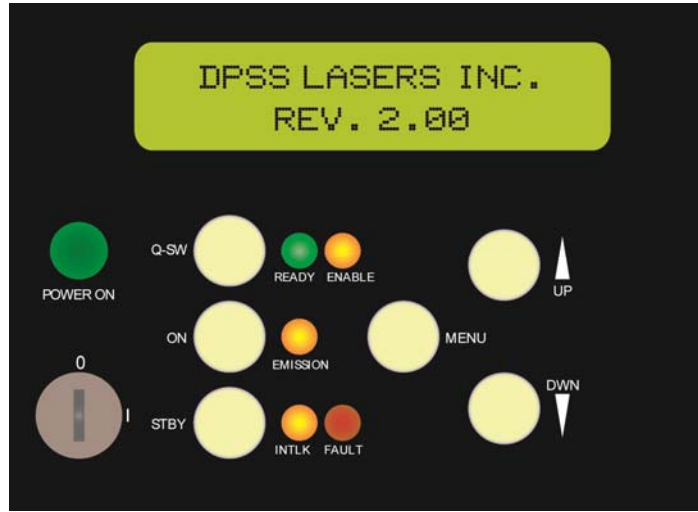


TABLE 1

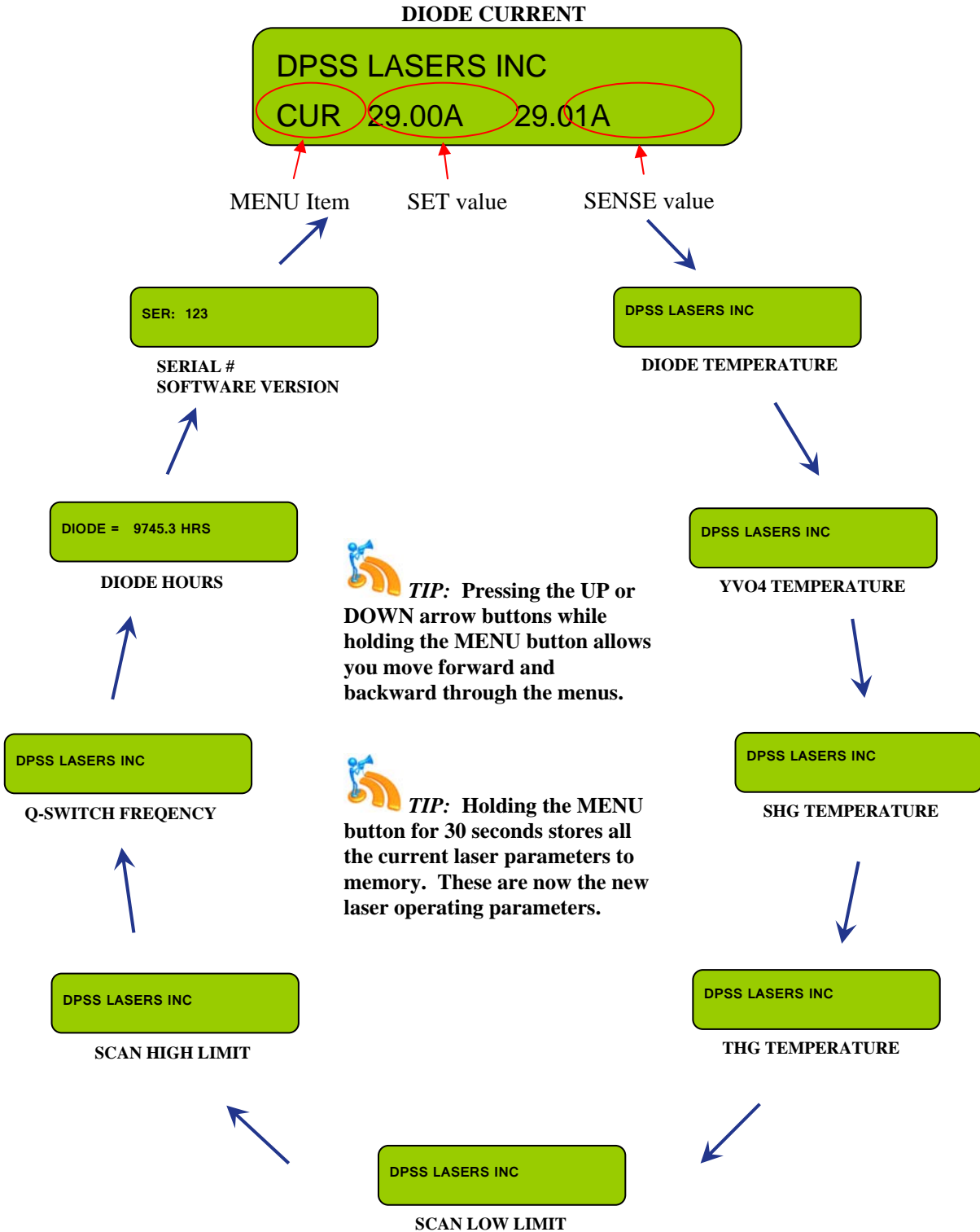
ITEM	DESCRIPTION	FUNCTION
LCD	Display 20 char x 2 lines	Displays messages and menu items.
POWER ON	Green LED	ON when AC line voltage is connected.
KEYSWITCH	Locking key switch	Enables power to all electronic control systems.
Q-SW	Q-switch button	Toggles between CW mode and Internal Rep Rate mode.
READY	Green LED	Flashes during warm-up, steady afterwards.
ENABLE	Amber LED	ON when internal q-switch frequency is active.
ON	Laser ON button	Turns laser diode ON.
EMISSION	Amber LED	ON when diode is active.
STBY	Standby button	Turns laser diode OFF. Resets non-persistent faults.
INTLK	Amber LED	ON when interlock is open. Flashes during boot-up.
FAULT	Red LED	ON when fault is present.
MENU	Menu button	Cycles to the next menu item.
UP	Up button	Increases selected parameter.
DOWN	Down button	Decreases selected parameter.



TIP: With the exception of the remote, the front panel input buttons override all other commands.

LCD MESSAGES AND FORMAT:

The LCD displays the laser status as well as error messages and menu items. The display jumps to the relevant menu item when a command is input via the state buttons on the front panel or a command is issued via RS-232. The possible menu items and the format of the display are illustrated below.



TURNING ON THE LASER SYSTEM FOR THE FIRST TIME

Refer to Figure 3.



WARNING: Install a power meter or beam block in front of the output of the laser before turning on the laser. Place the power meter or beam block a few inches from the laser output aperture to avoid contaminating the output window with ablated material.



WARNING: If the laser beam strikes any semi-glossy or reflective surfaces, dangerous and potentially blinding reflections or scatter can result. Never work around the laser or enter a room where the laser is operating without wearing laser safety glasses.

Turn on the Cooling system. Verify that the water in the reservoir is bubbling vigorously and fill the reservoir as necessary. Allow the system to run for two minutes to ensure that all air has been purged from the hoses. Verify that the “manifold temp” on the cooling system display is moving toward the 18.0°C set temperature. Check the system for any water leaks.



Note: The Cooling system temperature is factory set to 18.0°C. No further adjustment of the set temperature is recommended or required. Check water level and top off every 2-3 months.

If provided, turn on the master power switch at the rear of the power supply. The large green power indicator LED at the front on the power supply should be illuminated.

Turn the key switch to the ON position. Make sure the power switch on the cooling system is in the ON position and note that the cooling system turns on and the water in the reservoir begins circulating. The INTLK LED will flash for 15 seconds during boot-up and then extinguish. If the INTLK LED remains illuminated after 15 seconds, refer to the troubleshooting section of this manual for instructions.

Press the STANDBY button at the front of the power supply to clear any initial faults. If the FAULT LED remains illuminated, refer to the troubleshooting section of this manual for instructions. The laser system is now ready for operation.

To turn on the laser, press the ON button. The EMISSION LED will illuminate, the READY LED will flash for 90 seconds and then remain illuminated. This indicates that the laser system is ready to output radiation.



Note: Although the laser is capable of emitting radiation after 90 seconds, the internal components may take some time to reach optimum performance, generally 20 minutes to reach 80% power and 60 minutes to reach 100% power. It is normal for the output beam to “appear” and “disappear” several times within the first 20 minutes.

For q-switched lasers, to initiate pulsed laser operation, press the Q-SW button. The ENABLE LED will illuminate and the LCD will display the internal repetition rate at which the laser is q-switching.



TIP: Remember to open the laser shutter to allow the beam to exit the laser aperture.



Note: Under normal conditions, CW UV radiation will be emitted from the output aperture when the laser is on and the q-switch is disabled.

DAILY OPERATION OF THE LASER SYSTEM

TURN ON PROCEDURE:

Turn on the cooling system.

Turn the key switch clockwise to the ON position to turn the power supply on.

After the INTLK LED stops blinking and turns off, press the ON button. The EMISSION LED will illuminate.

After the READY LED stops blinking and is steadily illuminated, press the Q-SW button. The ENABLE LED will illuminate. CW lasers will already be emitting UV and no further action is required.

When performing a cold start, the first twenty minutes of operation may exhibit large power fluctuations while the laser reaches 80% output. Over the next forty minutes, the laser power should rise from 80% to 100% of specified power. After this period, the laser output should be stable and ready to use.

The laser beam can be tracked by briefly placing a matte finish white card in the beam path. Move the card continuously to prevent burning the card. Do not place the card in the beam any closer than one foot from the output aperture of the laser.

The DPSS Lasers Inc. Titan Series laser system is designed to operate continuously for the lifetime of the laser with very little maintenance.

SHUTDOWN PROCEDURE:

Press the Q-SW button. The ENABLE LED will extinguish.

Press the STBY button. The EMISSION LED and READY LED will extinguish.

Turn the key switch counter-clockwise to the OFF position to turn the power supply off.

Turn off the Cooling system.



TIP: In order to minimize the time required for the laser to warm up from a cold start to stable operation, the cooling system can be left continuously on to maintain the laser at a stable temperature.



Note: To extinguish the pulsed output beam for short periods of time (minutes/hours), the system can be set to the CW mode by pressing the Q-SW button. The system can later be returned to the pulsed output state by again pressing the Q-SW button and entering the ENABLE mode.



Note: To extinguish the pulsed output beam for long periods of time (several days), the laser can either be switched off, or set to the STANDBY mode by pressing the STBY button. To restart the laser, follow the turn-on procedure above.



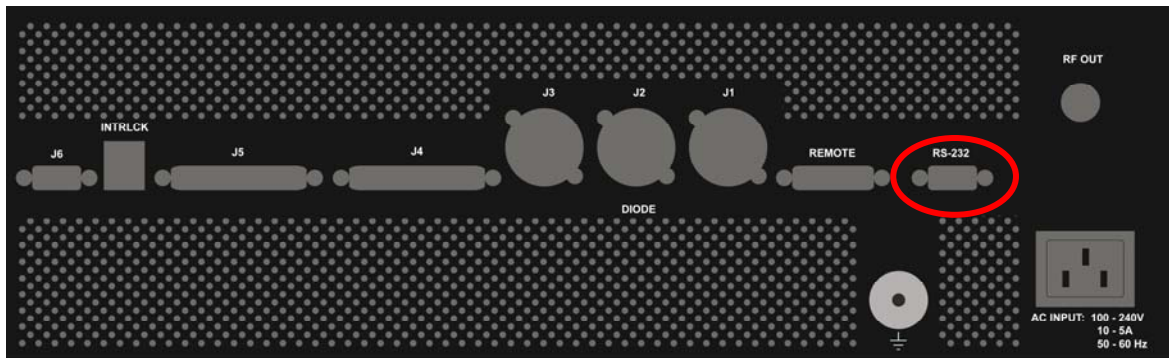
Note: At any time, complete laser extinction can be achieved either by pressing the STBY button, switching the key switch to the OFF position, or unplugging the AC line cord. Additionally, any fault detected by the system, will immediately extinguish all laser radiation.

REMOTE OPERATION

The 3500 DPSS laser with Smart PS can be controlled remotely via either a TTL connection or RS-232 interface. The system is equipped with a connector dedicated to each of these functions at the rear of the power supply, labeled REMOTE and RS-232 respectively (see Appendix III for more details).

RS-232 CONNECTION:

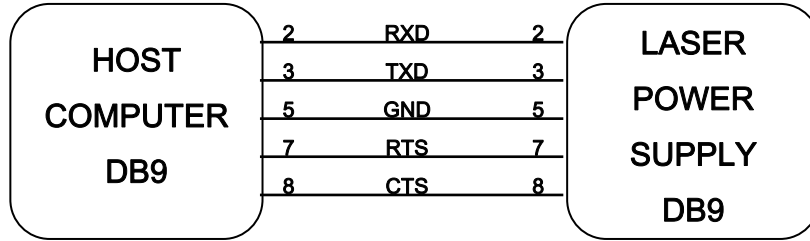
FIGURE 4



The laser can be controlled remotely over an RS-232 serial communications interface (see Figure 4). The nature of the serial connection and the communications taking place over it are described below.

<u>Parameters</u>	<u>DCE, no handshaking</u>
Baud Rate	9600
Data bits	8
Parity	none
Stop Bits	1
Flow Control	none
Other Signal Connections	RTS and CTS

The pin configuration is DB9 at both ends of the connection with a "straight through" cable as shown.



LASER COMMAND LANGUAGE:

Instructions to the laser consist of a string of ASCII characters followed by a carriage return or by a carriage return / line feed. The line feed is optional. If a line feed is sent after the carriage return, it is ignored. The laser will allow either all Upper Case or all Lower Case characters. It will not allow Mixed-Case characters to be entered.

Instructions fall into two categories: Commands and Queries. Commands are executed by the laser, which acknowledges completion of the command by transmitting a <CR><LF>. For queries the laser returns the requested information in ASCII string form terminated by <CR><LF>.



Note: Both commands and queries signal completion by transmitting the <CR><LF>. Any characters transmitted to the laser during execution of an instruction (i.e., before the laser has transmitted the <CR><LF>) will be ignored by the laser.

The laser responds to illegal or unrecognized instructions by transmitting:

SYNTAX ERROR<CR><LF>

Commands specifying a value outside the allowable range for the parameter will cause the laser to return the following response followed by the maximum or minimum allowable value. In such a case, the present value will remain unchanged until an allowable value is entered.

NO MAX VALUE = XX.XX<CR><LF>

or

NO MIN VALUE = XX.XX<CR><LF>



TIP: A short-form list of commands and queries can be found in Appendix III.

<i>Command</i>	<i>Format</i>
B1	Reboots the processor.
CS=<value1>	Set the current for Laser Diode to <value1> (0.00 <= <Value1> <= Max Current) where Max Current is determined by X41.
G0	Set Q-Switch to continuous wave (CW) operation

G1	Set Q-Switch to pulse mode, using internal repetition rate set at Q=<value2>
LASER=N	N = 0: set the laser to STAND-BY. N = 1: turn laser ON locally.
Q=<value2>	< value2> < 3, set the laser to CW mode < value2> = 3, set the laser to external Q switch control < value2> > 3, set the laser to internal Q-switch control, set internal Pulse Repetition Frequency to <value2> (20 – 300 KHz).
RLST	Restore laser settings (temperature set-points, current set-point and scan limits) from Last Stored Parameters.
SCANLO=< value3>	0.100 <= < value3> <= SCANHI
SCANHI=<value4>	SCANLO <= < value4> <= 3.000
SLST	Save current laser settings (temperature set-points, current set-point, and scan limits) into Last Parameters memory.
TSn=<value5>	Set the temperature value for device 'n' to <Value5> Degrees C. <Value5> is entered in deg C 15.00 – 60.00. - n = 1: Laser Crystal - n = 2: Doubler Crystal - n = 3: Tripler Crystal - n = 4: Diode

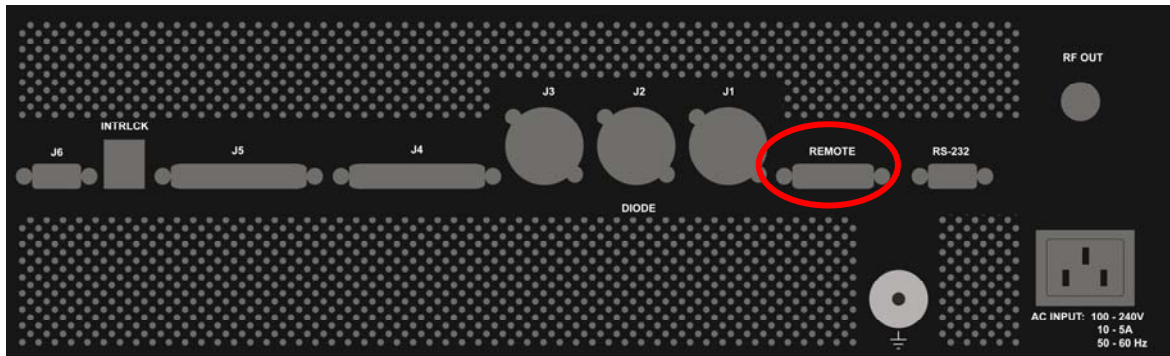
Queries

?C1	Laser Diode Current in Amps. Format: NN.NN A
?CS1	Laser Diode Set-Point Current in Amps. Format: NN.NN A
?X41	Max Diode Set Current in Amps Format: NN.NN A
?G	Returns zero if Q-Switch in continuous wave (CW) mode, else returns 1.
?HOURS	The number of hours of cumulative laser diode operation, to nearest tenth of an hour. Format: NNNNN.N hours
?LASER	Returns 0 if the laser is in stand by, else 1-4, if the laser is ON
?Q	Returns internal PRF (in KHz). Format: NNN KHz

?Tn	Temperature of device ‘n’ in °C. Format XX.XX °C. n=1: Laser Crystal n=2: Doubler Crystal n=3: Tripler Crystal n=4: Diode
?TSn	Temperature Set-Point of device ‘n’ in °C. Format XX.XX °C. n=1: Laser Crystal n=2: Doubler Crystal n=3: Tripler Crystal n=4: Diode
?F	Fault Buss Status 0=No Faults 1+message=Fault
?V	Firmware revision number. Format X.XX

TTL REMOTE CONNECTION:

Figure 5



The connector on the power supply labeled “REMOTE” can be used to externally control the laser through TTL level signals (see Figure 5). The following is a description of the functions of the pins on the ‘REMOTE’ connector. Refer to Appendix III for schematic and more information on this topic.

Pin-1 NA

Pin-2 ‘LASER ON’: This is an input pin and is normally HI at +5V and can be pulled LO (grounded) to start the laser and energize the laser diode. This takes the system from the ‘STANDBY’ mode to the ‘WARM

- UP' countdown sequence (READY LED blinking, then illuminated). This pin must be used in conjunction with PIN-8
- Pin-3** 'FAULT': This is an output pin and is normally LO. When a fault is indicated, this pin will be set HI to +5V and remain HI until the fault has been reset by pressing the STBY button or the system power has been cycled. When a fault is indicated, all internal current drive and loop control is terminated.
- Pin-4** NA
- Pin-5** 'EMISSION': This is an output pin and is an open collector when the diode is not energized. Once the diode is energized through any of the control methods, a transistor conducts this pin to GND.
- Pin-6** NA
- Pin-7** 'Q-SWITCH': This pin is the input for an externally generated repetition rate and is normally held LO. While the q-switch ENABLE LED is NOT illuminated, the system can be q-switched through this input. A TTL square wave signal at this pin will q-switch the laser at the frequency of the input. See note below and Appendix III for more information.
- Pin-8** 'REMOTE DETECT': This is an input pin and is normally HI at +5V. Pulling this pin LO (grounded) locks out the front panel controls and enables the use of PIN-2 to turn the laser ON/OFF.
- Pin-9** 'GND SIGNAL': This pin is a signal GND reference. All inputs should be referenced to this ground.
- Pin-10** NA
- Pin-11** NA
- Pin-12** NA
- Pin-13** NA
- Pin-14** NA
- Pin-15** 'GND EARTH': This pin is an earth GND reference.



Note: Minimum duty cycle at the Ext frequency input (PIN-7) is 10%. For greatest stability a 50% duty cycle is recommended. Laser pulse width is not derived from the Ext frequency input. This is controlled internally. As the frequency is lowered, energy per pulse will increase until a maximum energy is reached at 30 KHz. The system will accept lower pulse frequencies, down to a single pulse, but the maximum energy per pulse is limited to a 30 KHz pulse (See Appendix IV). Single pulses can be generated at all repetition rates by introducing a train of two pulses at the desired energy (frequency)—the first pulse is suppressed and the second pulse produces an optical pulse of the desired energy.

STORING YOUR LASER

DPSS Lasers Inc. has designed the Titan Series DPSS laser for maximum reliability and flexibility. However, if you plan to store your laser for an extended period of time, there are a few steps that you can take to ensure that your laser will always turn on at peak operating performance.

Unplug the system.

Disconnect the cables between the laser head and power supply.

Disconnect the hoses and drain the water from the laser head.

Wrap the units in their plastic bags and pack them in their original shipping container.

Store the system in a cool dry place, preferably free from dirt and contamination.

Following the above procedure will insure outstanding performance from your laser, even after long periods of storage. If you have any questions regarding this procedure or the care of your laser during prolonged storage, please call DPSS Lasers Inc., Customer Service.

TROUBLESHOOTING

The information in this section is intended to be used as an aid to the user in assessing problems with the operation of the laser and as a guide to assist experienced users in resolving routine problems. If there is any question about the procedures contained in this section or associated hazards, call DPSS Lasers Inc., Customer Service.



WARNING: These procedures could result in exposure to hazardous laser radiation or bright light sources. Procedures should be performed only by persons who are familiar with the hazards involved and with the use of appropriate safety equipment.



WARNING: Do not remove any covers from the laser unless specified.

- 1) **Unauthorized removal of covers from the laser will void all warranties.**
- 2) **There are no user serviceable components within the laser head or power supply.**
- 3) **Inexperienced handling of the components in the laser can cause severe damage.**

TROUBLESHOOTING GUIDE:

PROBLEM	POSSIBLE CAUSES	SOLUTION
Power-ON light not illuminated.	<ul style="list-style-type: none"> • Line cord not connected • Main power switch at rear of power supply not on (if equipped) 	<ul style="list-style-type: none"> • Connect line cord to power supply and suitable AC power source • Turn on main power switch at rear of power supply.
Fault light ON at first turn on	<ul style="list-style-type: none"> • Interlock open 	<ul style="list-style-type: none"> • Check all user installed interlocks

<p>and cannot be reset</p>	<ul style="list-style-type: none"> • J4, J5 cables in wrong positions at power supply or laser head • Cooling system not turned on • Power supply boot-up (15 seconds) not complete • Flow switch interlock connector not plugged in at power supply or laser head • Water hoses interchanged at Cooling system • Cooling system pump malfunction • Laser head over temperature • Power supply over temperature 	<p>for proper operation.</p> <ul style="list-style-type: none"> • Check J4 and J5 connectors at power supply and laser head for correct connection • Turn on Cooling system. • Wait 30 seconds and press STANDBY button to clear fault • Open Cooling system reservoir and verify that water is bubbling vigorously. • Verify that the flow switch interlock cable (red twisted pair) is connected at power supply and laser head. • Reverse water hose connections at Cooling system • Touch laser baseplate to verify that it is close to room temperature. • Touch power supply enclosure and verify that it is close to room temperature • Ensure that exhaust air is not recirculating through power supply or Cooling System.
<p>Fault light ON after laser is operating.</p>	<ul style="list-style-type: none"> • Interlock open • Cooling system water not flowing • Laser head over temperature • Power supply over temperature 	<ul style="list-style-type: none"> • Check all user installed interlocks • Open Cooling system reservoir and verify vigorous bubbling action of water • Verify that laser baseplate is at or near room temperature • Verify that the power supply chassis is at or near room temperature • Ensure that there is adequate ventilation for the Cooling system and the power supply
<p>No pulsed laser output after 5 minutes (assumes no faults detected and system running with laser READY and q-switch ENABLE)</p>	<ul style="list-style-type: none"> • Shutter not open • REMOTE connector connected but not activated • RF BNC cable not connected at power supply or laser head 	<ul style="list-style-type: none"> • Open shutter on laser head • If REMOTE is being used, verify signals to remote connector. • Verify that RF BNC cable is connected at power supply and laser head
<p>Low output power after one hour warm-up</p>	<ul style="list-style-type: none"> • Beam path partially blocked • Ambient temperature too high • Cooling system not regulating 	<ul style="list-style-type: none"> • Verify that shutter is fully open • Verify that ambient temperature is within acceptable operating limits • Verify that Cooling system is maintaining set temperature
<p>Power oscillation shortly after turn-on</p>	<ul style="list-style-type: none"> • It is normal for the laser output power to oscillate slightly during the first hour of operation 	<ul style="list-style-type: none"> • Allow laser to warm-up for one hour prior to use.

Power oscillation after several hours of operation	<ul style="list-style-type: none"> • Ambient temperature changing dramatically • Cables J4 or J5 not seated well • Cooling system malfunction 	<ul style="list-style-type: none"> • Verify that ambient temperature remains within acceptable operating limits. • Verify that cables J4 and J5 are well connected at power supply and laser head. • Verify that Cooling system is maintaining set temperature.
Poor beam quality	<ul style="list-style-type: none"> • Contaminated or damaged optics external to the laser head • Contamination or damage to laser output window 	<ul style="list-style-type: none"> • Check optics in optical path for contamination or damage • Turn off laser system and clean laser output window according to cleaning instruction in Service Appendix
Scattered green emission with UV output	<ul style="list-style-type: none"> • It is normal for some green light to be emitted with the UV output 	<ul style="list-style-type: none"> • If necessary, an aperture or filter can be placed one foot away from the laser head to block this green emission
Strong UV emission when q-switch is DISABLE	<ul style="list-style-type: none"> • REMOTE is being used • Q-SW button stuck on front panel 	<ul style="list-style-type: none"> • Verify signals going to remote connector • Check for proper button operation

LCD ERROR MESSAGES:

MESSAGE	POSSIBLE SOLUTION
MAIN PARAMETER CHECKSUM ERROR	J6 connector not connected
LAST PARAMETER CHECKSUM ERROR	J6 connector not connected
FACTORY PARAMETERS CHECKSUM ERROR	J6 connector not connected
FRAM WRITE ERROR	J6 connector not connected
LOCAL FAULT	Chiller not turned on, Flow switch not connected, J4 or J5 not connected or reversed
DIODE OVER CURRENT	Diode current limit set too low
DIODE TEMPERATURE FAULT	Chiller not regulating, Bad or broken cable or pin
CRYSTAL TEMPERATURE FAULT	Bad or broken cable or pin (J4/J5)
DOUBLER TEMPERATURE FAULT	Bad or broken cable or pin (J4/J5)
TRIPLER TEMPERATURE FAULT	Bad or broken cable or pin (J4/J5)

If the problem cannot be resolved using the troubleshooting guide above, please contact a DPSS Lasers Inc., Customer Service Representative at either your local distributor or directly through the DPSS Lasers Inc., Customer Service Department. For contact information, refer to the Support page of this manual.

APPENDIX I

COMMON LASER TERMS:

The following is a list of the parameters that characterize the laser beam emitted from a DPSS laser:

Wavelength - Electromagnetic energy is transmitted in the form of a sinusoidal wave. The wavelength is the physical distance covered by one cycle of this wave; it is inversely proportional to frequency. In the case of the DPSS laser, the wavelength is expressed in nanometers.

Repetition Rate – Defined as the number of optical pulses emitted from the laser per second.

Pulse Length – The interval duration of each pulse from the laser. The pulse length is the measured length in time at half of the maximum amplitude of the pulse (FWHM).

Average Power – The product of the energy per pulse (joule) and the repetition rate (pulse frequency in Hertz); expressed in Watts.

Spatial Profile - In the case of the DPSS laser, the output beam is close to Gaussian or TEM₀₀ in shape. The beam is circular in cross-section and the amplitude is $E(r) = E(0) \exp[-(r/w)^2]$, where r is the distance from the beam center and w is the radius at which the amplitude is 1/e of its value on the axis; w is called the beam width. Sometimes the ‘Spatial Profile’ of the laser is referred to as the ‘Mode’ of the laser.

Beam Diameter - As the beam in the DPSS laser is approximately TEM₀₀, the beam diameter is defined as the calculated distance between two exactly opposed points on the beam where the energy has dropped to 1/e² of its peak center energy. It can also be viewed as the diameter of a circular aperture through which 86% of the total energy of the beam will pass.

Divergence – The change in beam diameter with distance of an initially collimated beam. It is expressed as an angle in milliradians (mrad).

Polarization – The direction of the electric field vector in the laser beam. The polarization vector is always in the plane at right angles to the direction of the beam. In the case of the DPSS laser, the polarization is vertical. The value given to polarization is expressed as a ratio of the amount of vertically polarized to horizontally polarized light present in the beam.

Beam Pointing Stability - The full angle through which the far field beam moves, measured in microradians (urad).

APPENDIX II

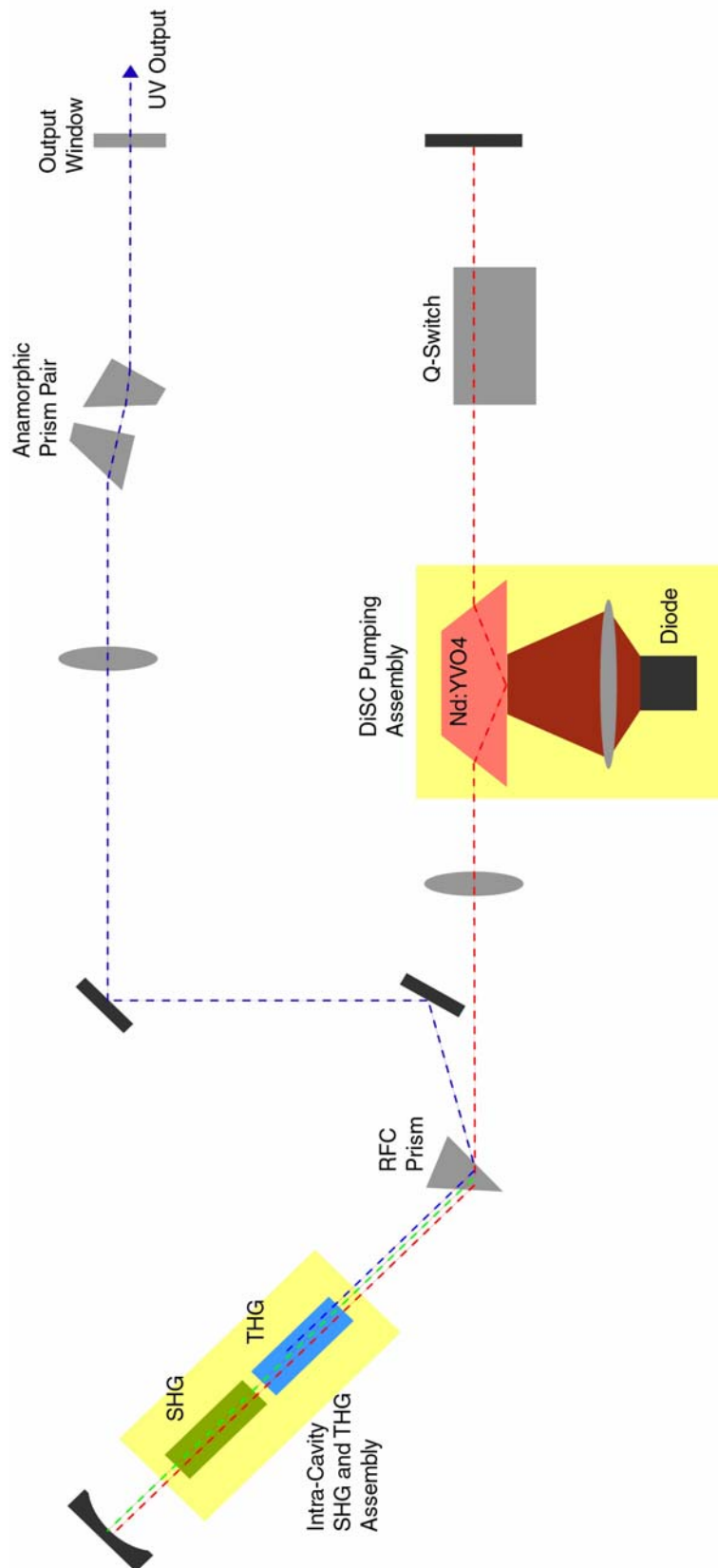
DPSS LASER THEORY:

A laser is an optical device that amplifies light by means of stimulated emission of radiation. The output of a laser is electromagnetic radiation (light). By placing a gain medium between two mirrors to form a light amplifier or resonator, laser light is generated. The light bounces back and forth between the two mirrors of the resonator extracting energy from the gain medium on each pass. In the case of the DPSS (Diode Pumped Solid State) laser, a Vanadate crystal is used as the gain medium, and is supplied energy or 'pumped' by an 808nm laser diode (Refer to Figure 6). This 808nm light is absorbed by the gain medium and converted to light of approximately 1064nm in wavelength. The generated wavelength is defined by an atomic energy transition of the Neodymium ions present in the host Vanadate medium. The Vanadate gain medium provides adequate amplification to overcome the losses in the laser resonator (from the mirrors, gain medium and other optical elements) and deliver useful power.

The 808nm laser diode emits light in a continuous wave (CW) mode. That is, the light is emitted continuously as long as the electrical power to the diode is maintained. The Vanadate and laser resonator convert the continuous wave output of the diode into a more useful output for the end user. The generated 1064nm light from the resonator will be continuous as well and therefore low in peak power. In order to generate a more useful output with higher peak powers, an acousto-optical Q-switch is placed in the resonator. In this case, 'Q' stands for the 'quality' of the resonator. The quality of the resonator determines how well the cavity will generate light or more precisely, the threshold level at which the laser will operate for a given gain in the gain medium. In short, the Q-switch is an electronically controlled light valve within the resonator. It stops the operation of the resonator by briefly spoiling its quality. When the resonator is not lasing, the Vanadate gain medium continues to receive energy from the continuous wave laser diode and a buildup of energy in the Vanadate occurs in the form of an electron state population inversion. Once the Vanadate has absorbed as much of the 808nm energy as it can, the Q-switch is electronically opened and lasing is allowed in the resonator. As a result of the high amount of stored energy in the Vanadate, the resonator at this point generates light very rapidly and at high peak powers. The resulting output is near infrared 1064nm light in the form of a pulse about 40 nanoseconds long (0.000000040 seconds). Once the energy is depleted from the Vanadate, the Q-switch is closed and the gain is allowed to build up in the Vanadate for the next pulse. The rate at which the Q-switch opens and closes determines the repetition rate of the laser. For the DPSS laser, this is typically 30 kilo-Hertz (30,000 pulses/second).

Although the near infrared 1064nm light is useful for some applications, it is often preferable to convert this light to shorter wavelengths using harmonic conversion. In the case of the DPSS laser, crystals are placed within the resonator to combine photons of light to produce different wavelengths. The first process is to convert some of the 1064nm infrared light into 532nm green light using a crystal commonly known as a 'doubler.' (Note that two times 532nm is 1064nm.) In essence the doubler crystal combines two photons of 1064nm to form one photon of 532nm light. Exiting the crystal are two superimposed beams, one at 1064nm and one at 532nm. These two beams enter a second crystal in the cavity called a 'tripler' and through a similar process, a photon of residual 1064nm and a photon of 532nm light are combined to form a new photon of 355nm light. The three beams, - residual 1064nm, residual 532nm and useful 355nm - exit the tripler crystal superimposed. A prism is used to physically separate the beams and the 355nm beam is directed to the output port of the laser with a pair of mirrors. The 532nm beam is dumped and the 1064nm beam stays within the resonator to form the laser cavity. Finally, the 355nm output beam may be optically manipulated with lenses and prisms to give the correct beam shape and size for the application.

FIGURE 6



APPENDIX III

CONTROLLING THE LASER REMOTELY:

Depending on the specific needs of your application, remote control of your laser system can be achieved by either RS-232 communication or TTL level wired connections. RS-232 communication offers greater flexibility and the ability to integrate the laser system into your application software seamlessly. For time-critical applications that depend on precise timing between signaling and laser action, the TTL wired connection is the better choice because the TTL connection minimizes latency time within the system, allowing for more precise laser control. A hybrid of these two control system can also be implemented for the greatest flexibility in integration.

Table 2 describes the command and query format of the RS-232 remote communication. This is a short-form version of the command set for users that are already familiar with the syntax. For more in-depth information, refer to the earlier section on Remote Operation.

TABLE 2—RS-232

COMMAND	QUERY	DESCRIPTION	FORMAT/NOTES
B1		PS Reboot	Reboots Processor
	?X41	Max Diode Current	xx.xx A
CS=xx.xx	?CS1	Diode Set Current (A)	Set from 0.00 to Max Current (X4)
	?C1	Diode Current Sense	xx.xx A
TS1=xx.xx	?TS1	Set Vanadate Temperature C	Set from 15.00 to 40.00 C
TS2=xx.xx	?TS2	Set Doubler Temperature C	Set from 15.00 to 60.00 C
TS3=xx.xx	?TS3	Set Tripler Temperature C	Set from 15.00 to 60.00 C
TS4=xx.xx	?TS4	Set Diode Temperature C	Set from 15.00 to 40.00 C
	?T1	Vanadate Temperature Sense C	xx.xx C
	?T2	Doubler Temperature Sense C	xx.xx C
	?T3	Tripler Temperature Sense C	xx.xx C
	?T4	Diode Temperature Sense C	xx.xx C
SCANLO=x.xx x		Set Scanner Low Limit	Set from 0.100 to SCANHI
SCANHI=x.xxx		Set Scanner High Limit	Set from SCANLO to 3.000
Q=<value>	?Q	Set Q-switch Frequency (KHz)	Set from 30 – 300 kHz
	?HOURS	Diode Hours	To nearest 0.1 hours
SLST		Save to Last Settings	Saves current parameters to Last Settings
RLST		Restore Last Stored Laser Settings	Restore from Last Parameters Location
LASER=x	?LASER	Laser Emission Control	0=Standby/Reset Faults, 1=LaserON
G0		Q-Switch Disable	CW operation
G1		Q-Switch Enable	Q-switch at set rate
	?G	Q-Switch Mode	0=CW, 1=Q-Switching
	?V	Firmware S/N	17 Character ASCII
	?F	Returns Faultbus Status	0=No Faults, 1+Indicated Fault=Fault

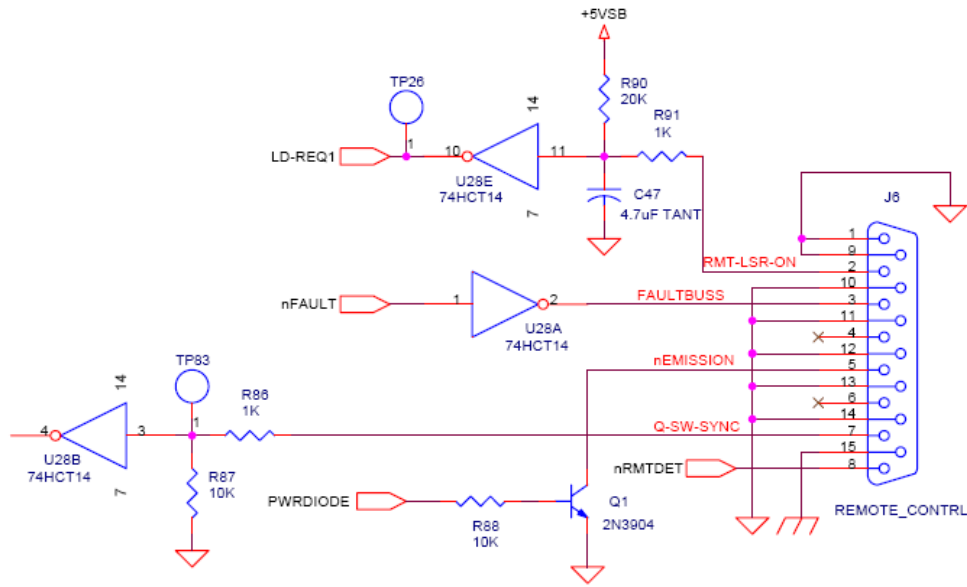


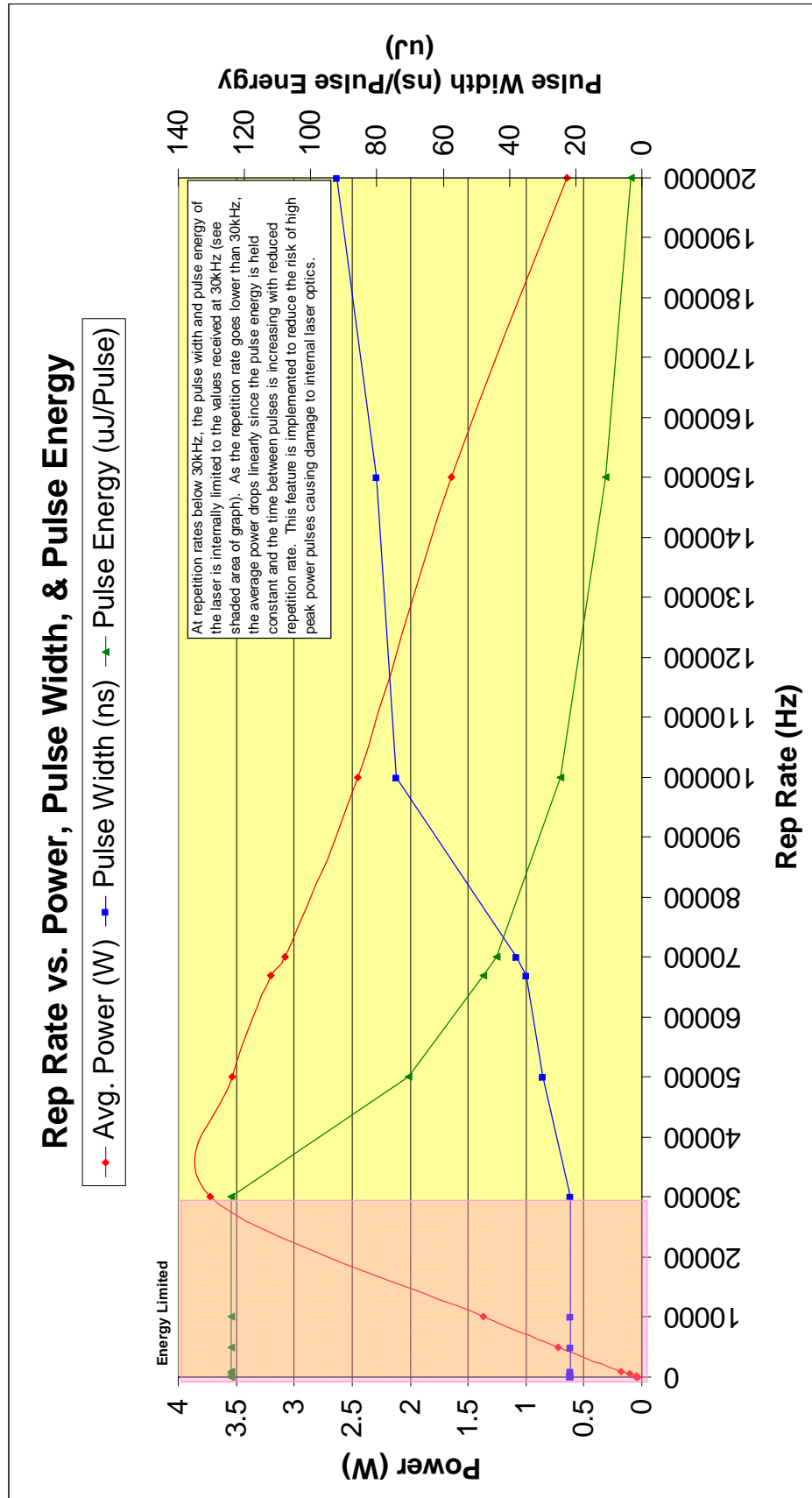
Table 3 describes the individual pin functions of the TTL remote. Refer to the schematic above for further detail.

TABLE 3—TTL REMOTE

PIN	FUNCTION	TYPE	DESCRIPTION
1	NA	--	--
2	LASER ON	INPUT	ACTIVE LEVEL LO TO ENERGIZE LASER DIODE. USE WITH PIN-8.
3	FAULT	OUTPUT	ACTIVE LEVEL HI WHEN FAULT IS DETECTED.
4	NA	--	--
5	EMISSION	OUTPUT	OPEN COLLECTOR WHEN DIODE IS ENERGIZED (80mA SINK MAX)
6	NA	--	--
7	Q-SWITCH	INPUT	*EXTERNAL FREQUENCY INPUT: 30KHz – 300KHz (50% DUTY CYCLE)
8	REMOTE DETECT	INPUT	ACTIVE LEVEL LO TO ENABLE USE OF PIN-2.
9	GND SIGNAL	PWR	REF. SIGNAL GROUND
10	NA	--	--
11	NA	--	--
12	NA	--	--
13	NA	--	--
14	NA	--	--
15	GND EARTH	PWR	EARTH GROUND

* Minimum duty cycle at the Ext frequency input (PIN-7) is 10%. For greatest stability 50% duty cycle is recommended. Laser pulse width is not derived from the Ext frequency input. This is controlled internally. As the frequency is lowered, energy per pulse will increase until a maximum energy is reached at 30 KHz. The system will accept lower pulse frequencies, down to a single pulse, but the maximum energy per pulse is limited to a 30 KHz pulse (See Appendix IV). Single pulses can be generated at all repetition rates by introducing a train of two pulses at the desired energy (frequency)—the first pulse is suppressed and the second pulse produces an optical pulse of the desired energy.

APPENDIX IV



SUPPORT

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