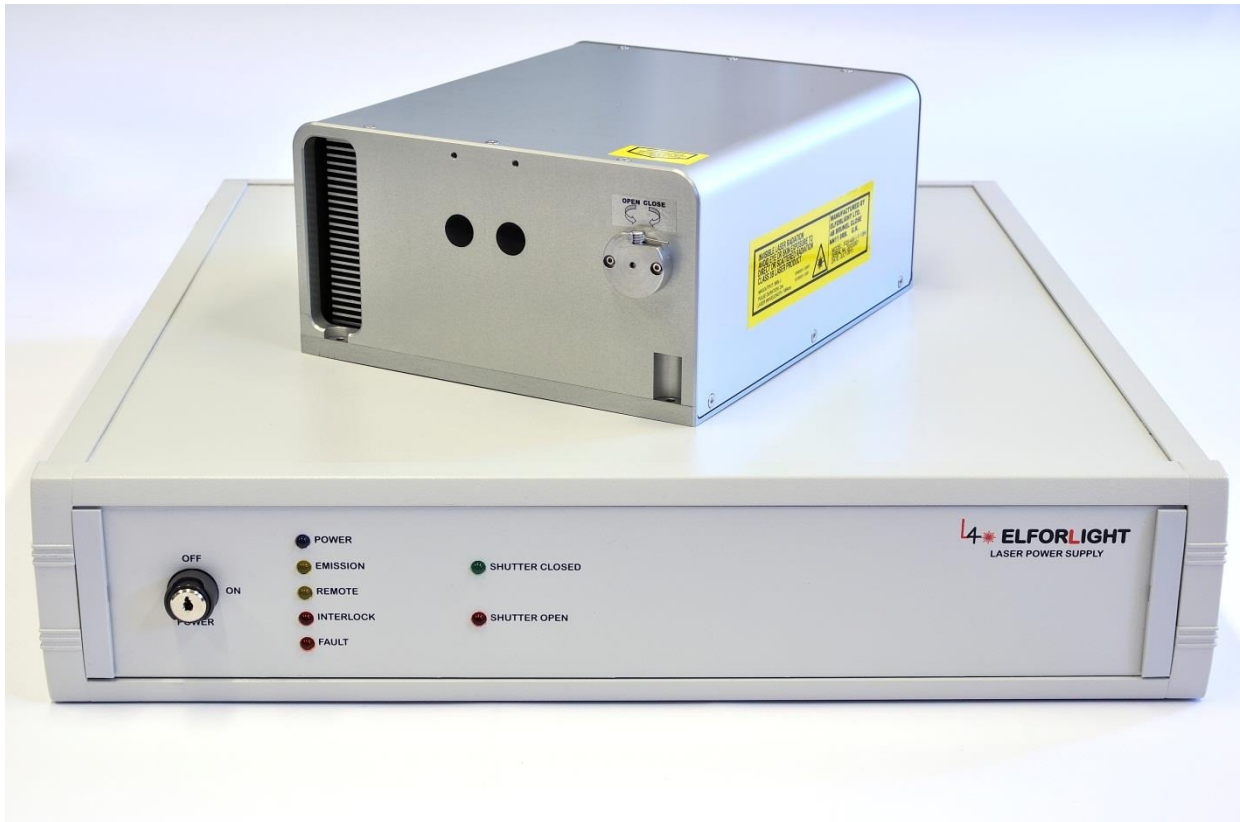


## FQS Series Diode Pumped Solid State lasers



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# FQS Series Diode Pumped Solid State Laser

## 1. Basic Operation

The FQS Series Lasers are microprocessor controlled, and designed for simple, user friendly operation from most PC type computers through the serial (RS232) port.

Ensure that the Laser Head is connected correctly to the Power Supply by means of the umbilical cable supplied.

*NB: Care should be taken to correctly align the connector before pushing home and turning the locking ring. The pump diode fibre is permanently connected between the laser head and power supply.*

Connect the mains supply of the appropriate voltage to the Power Supply by the connector on the rear panel.

Connect the 9-way serial cable supplied to the RS232 D-connector on the rear of the Power Supply and a computer (via a USB serial converter if required).

### 1.1 Operation through RS232

**Before laser operation it is necessary to follow the set up procedure for your PC as shown in appendix 1**

The connection detail for the RS232 cable is given later in this manual.

Ensure that the external interlock circuit is closed, either by use of the supplied shorted connector (temporarily for test only), or via a user supplied door or enclosure protection circuit.

Boot the computer, if not already running, and run a dumb terminal program such as HYPERTERMINAL (supplied with Win 98/ME/2000/XP) and accessible from the Windows Start Menu and following:

Programs > Accessories > Communication > HyperTerminal

Turn the front panel key switch to the "On" position.

By default, the laser starts up with parameters set as follows:

- \* Control by RS232 mode
- \* Interlock latch is reset (operation possible if external interlock contacts are closed)
- \* Diode current(s) set to zero
- \* Diode and oven temperatures controlling

## **WAIT AT LEAST 5 MINUTES FOR THE SYSTEM TO REACH THERMAL EQUILIBRIUM.**

Enter the required commands through the dumb terminal program, i.e. HYPERTERMINAL. As a minimum, the diode current(s) must be set and the shutter opened. For example to run the laser with a diode current of 50%:

**IDLE** (Laser current ramps to IDLE setting)

**ISET 50** (sets current of diode to 50% of ILIM)

*Test data supplied with the laser will indicate power output for a given % current setting.*

### **1.2 To stop the Laser in normal operation**

Use:

**ISET 0** (Ramps current down to 0%)

### **1.3 To shut down the laser IN EMERGENCY SITUATION ONLY**

Use:

**OFF** (Stops emission, sets diode current to zero, turns crowbar on). Alternatively, simply turn off at the keyswitch.

The full command structure for the laser is given in the appended programmer manual. The commands can, of course, be embedded into the user's own software for control of the laser with other equipment.

**NOTE: TO PROTECT THE LASER CRYSTAL(S) THE LASER DIODE CURRENT IS RAMPED UP AND THEREFORE THERE IS A TIME DELAY BEFORE LASER OUTPUT IS OBSERVED AFTER A CURRENT DEMAND (RS232) OR A LASER ON COMMAND (RS232).**

**THE OFF COMMAND DOES NOT RAMP THE CURRENT AND SHOULD BE USED ONLY FOR EMERGENCIES.**

## 1.4 Q-Switched Operation

Q-switching is a process whereby the quality factor- or "Q" of the laser is switched rapidly from a lossy state to a low loss state, whilst the laser medium is being continuously excited. This has the effect of storing energy in the lossy state, and releasing the energy in a short, high energy pulse when the loss is removed.

This is achieved in practice by use of an electro-optic (E-O) Q-switch which is comprised of a polariser, a waveplate and a Pockels Cell. In the low "Q" state the voltage across the Pockels Cell is 0V. On application of a suitable trigger signal the voltage across the Pockels Cell is switched to the quarter wave voltage and a laser pulse is generated. There is a finite pulse build-up time (that is a delay between when the trigger signal is applied and when the laser pulse is generated). This build up time varies depending on laser pulse energy and pulse repetition rate but at specified output this build up time is approximately 130nsec at 1 kHz repetition rate.

## 1.5 Q-Switch Control

The Q-switch can be controlled internally via software commands with the signal taken from the rear panel TTL output BNC to the head. It can also be controlled externally via the external trigger input on the head. See Appendix 2 for software commands relating to the Q-switch. This trigger signal will control the pulse repetition rate.

The pulse energy, pulse length and pulse build up time will be seen to vary with repetition rate: as the repetition rate is increased, the pulse energy decreases, the pulse broadens and the build-up time increases. This is due to the variation of the gain that can be built up in the time between pulses. As repetition rate is decreased, a limit is reached for increasing energy when the pulse separation approximates to the upper state lifetime of the lasing material. This is at about 1 KHz for YAG.

## 2. Front Panel controls and indicators

Fig 1. Front Panel

Keyswitch



Status indicators

## 2.1 Keyswitch

The key switch is used to activate the laser system. The key is removable in the “Off” position, but captive in the “On” position. When the system is to be left unattended, the key should be removed and stored in a safe place. The key switch functions by activating the switch mode power supply generating the voltages for laser operation.

## 2.2 Indicators

### Power (Blue)

Indicates that the system has mains power applied, the internal switch mode power supply is generating the correct voltages and the microprocessor is functioning.

### Emission (Yellow)

Confirms that the laser is ready to lase or is lasing. This means that power is applied, the keyswitch is in the “On” position, and the interlock chains are intact.

### Remote (Yellow)

Indicates that the laser is running under RS232 control.

### Interlock (Red)

Indicates that the interlock chain is open. This consists of the external interlock connector, and internal thermal switches. When an interlock open condition is detected, the laser shuts down in a safe condition.

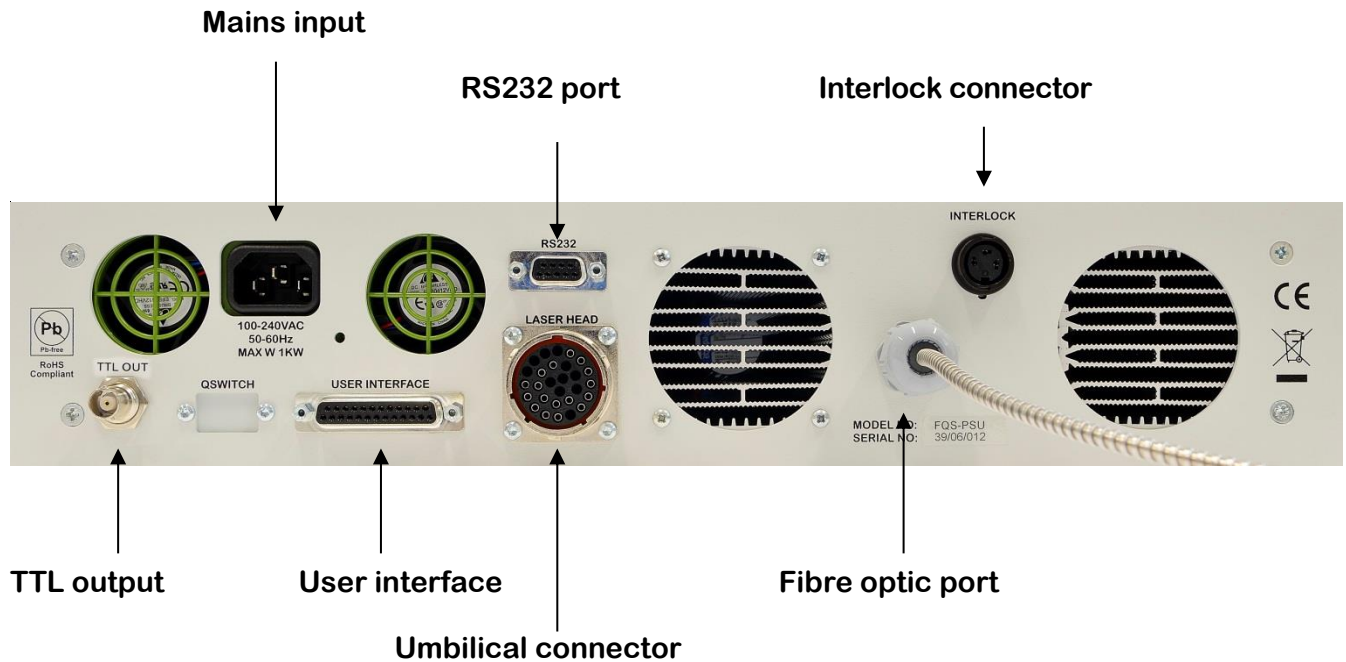
It will be necessary to reset the interlock latch by turning the key off then on so that the laser will power up again after remaking the interlock.

### Fault (Red)

Indicates that a fault condition exists. This may be an over temperature indication, electronics fault or other condition. The nature of the fault may be determined through software.

### 3. Rear Panel connections

FIG 2. Rear Panel



#### 3.1 Features

##### *External interlock connector*

The external interlock connector gives access to the laser system interlock chain. Contact closure is required between pins 1 and 3. The system is supplied with a connector with a shorting link fitted. This should be used for test purposes only. The link should be replaced /rewired with wiring through an external door or enclosure switch once the laser system is installed.

**Do NOT** apply an external voltage to the connector. Contact closure is all that is required, eg. by relay contacts.



### *RS 232 Connector*

9 way D-socket, pins 2, 3, 5 through connected, (see Fig 1). Connects to computer serial port.

### *Umbilical connector to laser head.*

Takes 28 pin QM connector (umbilical cable supplied).

### *Fibre optic port*

The pump laser diode light is fed to the laser head via a 3m armoured fibre optic cable (supplied).

### *Mains input*

Takes a standard IEC mains connector. Universal input 100 - 240 VAC, 50/60Hz.

### *User interface*

This is currently reserved for connection of the optional remote pendant.

### *TTL output*

BNC connector for internally generated TTL trigger signal to laser head.

## **4. System components and features**

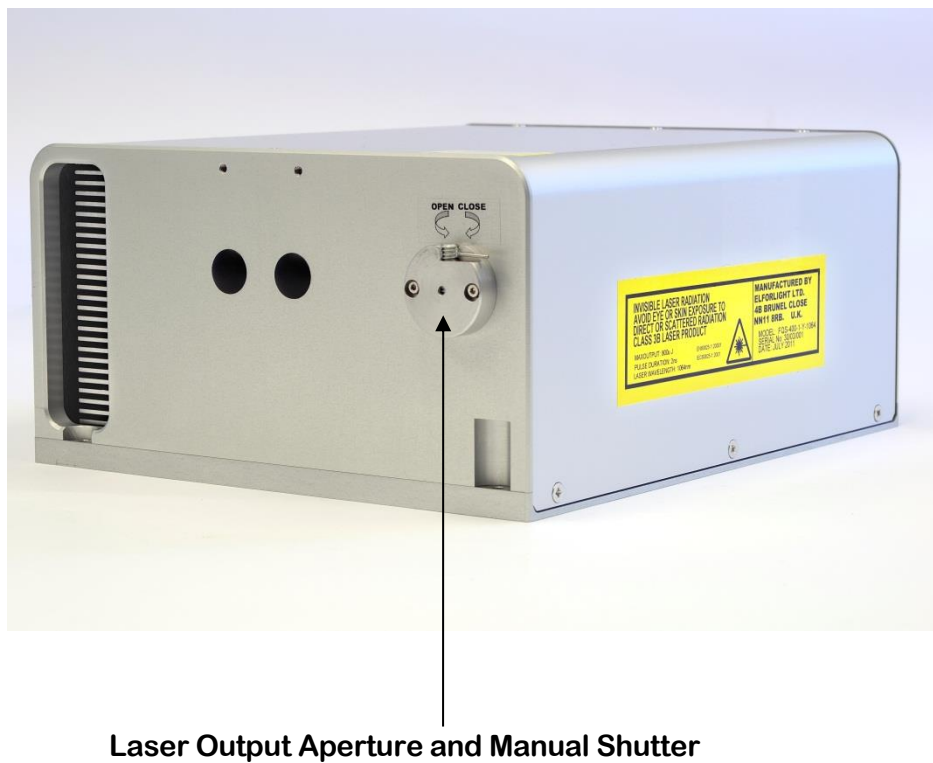
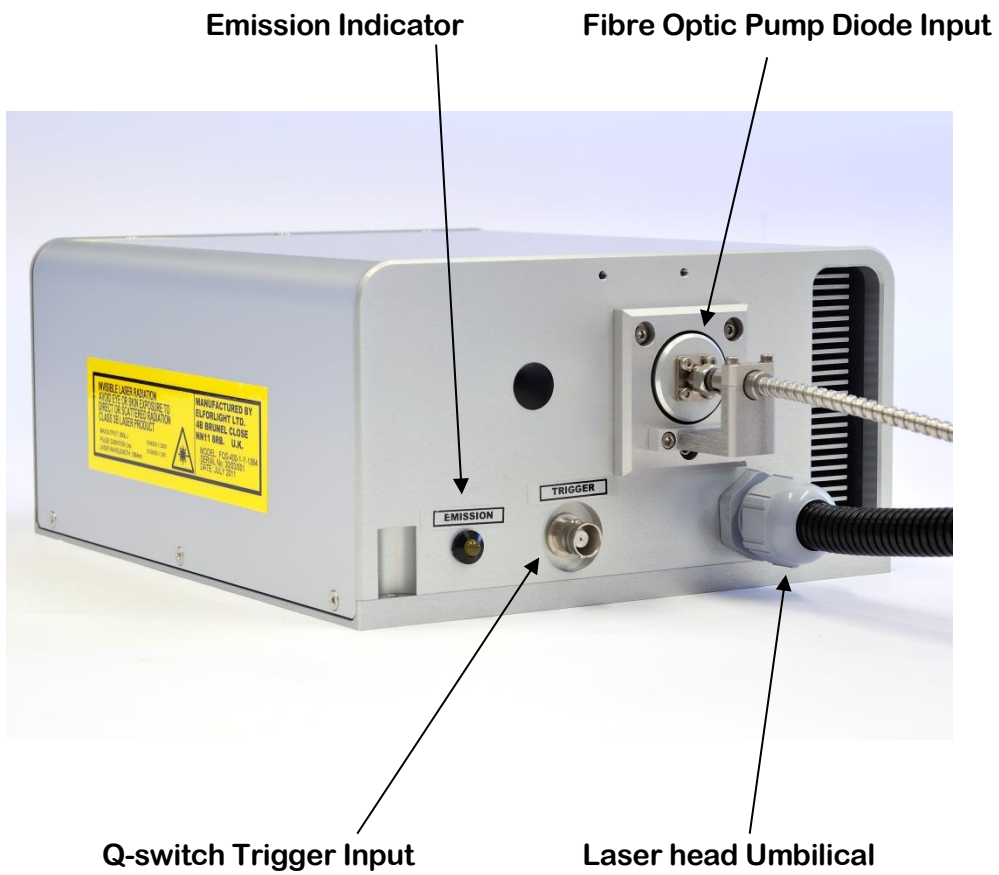
### **4.1 Laser Head Fig 3.**

A picture of the laser head is shown below. A fibre optic cable is used to deliver the pump beam to the laser gain material and the laser cavity optics. Consequently the laser head does not contain the pump laser diode. This is situated inside the power supply unit. The Q-switch and the Q-switch drive electronics are situated in the laser head. The Q-switch is triggered via the BNC connector on the laser head. This requires a trigger voltage of 5VDC (TTL). This signal can be derived externally by the customer or internally via the TTL output BNC on the rear panel. The laser head is sealed with a gasket material to reduce the possibility of the ingress of contaminants.

The frequency doubling and tripling crystals are housed in the laser head, with appropriate focusing optics. The crystals are held in temperature controlled ovens.

Finally, the output beam passes through the manually operated shutter, and exits the laser through an appropriate window or filter, depending upon wavelength and output specification.

Fig 3. The Laser Head



#### 4.2 Power supply Fig 4. and Fig 5.

The power supply is housed in a 2U high 19" case. (Bench top mounting case optional). This case contains the switchmode power supply which delivers the required DC voltages, the microprocessor board, diode current control board, TEC and oven control board. The power supply also contains the fibre coupled pump laser diode together with the necessary thermal management. The microprocessor board, as well as providing the RS232 interface capability and controlling laser operation, monitors safety and protective features. In addition, there are fail-safe hardware controls built in to protect the laser diode in the event of a failure of the microprocessor core. (See also front and rear panel control / connector sections).

Fig 4. The Power Supply (front view)



Fig 5. The Power Supply (rear view)



### 4.3 Interlock

The external interlock requires contact closure between pins 1 and 3 of the rear panel connector. The connector is supplied with these pins shorted out, but the link can be replaced with an external loop, for example to a door switch.

Once the interlock is tripped, the system ceases to deliver current to diode, and switches in the protective circuitry across the diode. It will be necessary to reset the interlock latch by turning the key off then on so that the laser will power up again after remaking the interlock.

### 4.4 Shutter

The FQS series lasers have a manually operated shutter/beam stop on the output aperture of the laser head. The shutter status indicators on the front panel of the power supply are therefore inoperative.

## 5. LASER SAFETY

This handbook contains a description of controls, adjustments and procedures for normal operation of the laser. **CAUTION** - Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure

### 5.1 Classification

Elforlight FQS Series lasers are classified as class 4 lasers by the BS EN 60825-1:1994 and by the United States Centre for Device and Radiological Health (CDRH). This designates potential danger of eye or skin damage by exposure to direct or scattered radiation. ***This means that they are considered in the most dangerous class of lasers, and the laser output radiation should be treated with extreme caution.***

### 5.2 Emission

The laser emits Q-switched radiation at 1064, 532, and 355nm(model dependant). Average powers up to 10 Watts may be generated. The laser power supply also contains a laser diode emitting radiation at 808 nm. The laser diode source is situated inside the power supply and is fibre coupled to the laser head by means of a 3m armoured fibre optic cable. No pump laser diode radiation is emitted from the laser head. ***On no account should any attempt be made to disconnect the fibre optic cable from the laser head while the laser is powered up.***

### **5.3 Indicators**

An emission indicator on the front panel of the power supply, duplicated on the laser head, indicates that laser emission is possible.

### **5.4 External interlock**

The FQS series laser system is provided with an external interlock facility, which is available on the socket on the rear of the power supply. This connector requires contact closure to enable laser operation. The laser is supplied with a shorted connector, but it is recommended that the short be replaced by a link into an external interlock chain – e.g. a room door switch or enclosure cover switch.

The laser will shut down in a safe fashion if the interlock chain is broken. It will be necessary to reset the interlock latch by turning the key off then on so that the laser will power up again after remaking the interlock.

### **5.5 Safety precaution during laser operation**

The laser should be used in an enclosed area with access restricted to trained personnel. The area should be clearly labelled and the entrance marked with the class of laser (Class 4).

Only trained personnel should be allowed to use the laser.

The key must be inserted in the key switch on the laser power supply front panel and turned to enable the laser to operate. The key is captive in the operational position. As such, the key should be removed from the laser when not in use, and / or unattended, and stored in a safe place.

Eye and skin exposure to direct or scattered laser radiation is hazardous and should be considered potentially extremely harmful.

Suitable eye protection should be worn at all times whilst laser output is possible.

The laser beam path should be terminated with a non-reflecting beam stop. Beam paths should be enclosed where possible, and should not be at eye level if practical.

Care should be taken that all external mirrors and optics used are securely positioned and fixed to prevent movement. Care should be taken at all times to prevent stray reflections from surfaces.

## Appendix 1

This procedure details how to set up the (OPTIONAL) supplied USB serial converter and configure Windows to communicate correctly with the laser using HyperTerminal.

### Windows 98/ME/2000/XP

Follow the instructions supplied with the USB serial converter to install the necessary drivers onto your operating system.

Connect the converter to a free USB port on your PC.

Click Start, Control Panel then double click on the System icon.

Click the Hardware tab then the Device Manager button.

Click on the + sign next to Ports (Com & LPT).

Find the Prolific USB-to-Serial Comm Port and right click on it.

Select Properties then the Port Settings tab.

Click the Advanced button then open the drop down menu next to COM port number.

Select an appropriate COM from the list then click OK.

Close all remaining open menus.

Run Hyperterminal (or other RS232 terminal software) and configure the port as below (RS232 Protocol)

## Appendix 2

### RS232 Commands: Quick Start Guide.

The laser system can respond to simple ASCII commands.

To enter RS232 control mode, switch on the laser at the mains and turn the keyswitch to the "ON" position.

The yellow led marked "Remote" on the front panel will be ON.

## RS232 Protocol

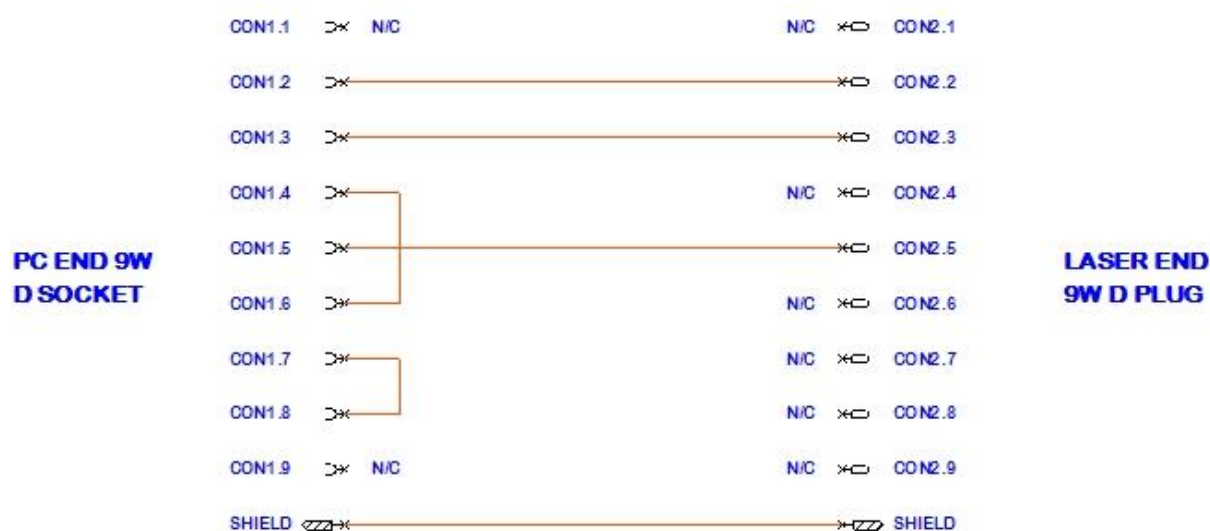
9600 baud, 1 start bit, 8 data bits, no parity, 1 stop bit

no hardware handshaking, no software handshaking

In the event that your PC has no serial port available, please use the USB to serial converter supplied. Consult the documentation, but it is recommended to select a low number for the COM port ( $\leq 4$ ) for certain dumb terminal emulators. You may have to enter control panel / system / hardware on your PC to do this.

## RS232 Cable

A cable is supplied, but if you wish to make your own cable, please use the connections shown below:



Do NOT connect to or link any other pins on the Laser end plug, as you may cause the laser to enter flash programming mode.

## Terminal Emulation

The laser may be controlled simply by a dumb terminal emulator program outputting ASCII text on the RS232 port.

Simple TTY emulation is supported by Windows HyperTerminal or by your favourite dumb terminal program. Alternatively, you may wish to embed RS232 outputting commands in custom software running on your PC.

### RS232 Commands.

These are listed in alphabetical order.

Not all commands may be available depending on the type of laser purchased, e.g. AO Qswitch commands.

<enter> represents CR or LF, ASCII code 13 (0X0D) or 10 (0X0A) respectively

Simple editing codes such as backspace ASCII 8 (0X08) are supported.

Commands may be typed in lower or upper case. The laser software will convert commands to upper case before parsing.

### User Commands

#### ALL

ALL<enter>            Display laser system status

#### FAULT

FAULT<enter>        Display cause of fault

FAULT 0<enter>      Clear fault condition

If the red fault LED is lit on the front panel, use the FAULT command to find out the cause.

To attempt to clear the fault, use the FAULT 0 command.

#### HELP

HELP<enter>           Display list of RS232 commands

HELP text<enter>    Elaborate on command "text"



## **IDLE**

**IDLE<enter>** Set laser diode current to idle value.

**IDLE n<enter>** Set idling current value. N is % of ILIM, 0..100.0

## **IMON**

**IMON<enter>** Display current flowing through laser diode

## **ILIM**

**ILIM<enter>** Display current limit for laser diode

**ILIM n pw<enter>** Set current limit for laser diode.  $0 \leq n \leq 10.0$  pw = “\*\*\*\*\*”

This parameter is factory set and must not be changed by the user.

## **INTLK**

**INTLK<enter>** Display latched interlock status

**INTLK 0<enter>** Clear interlock fault

**INTLK 1<enter>** Test interlock, simulate interlock broken

If the red INTERLOCK led on the front panel is lit, the software interlock latch can be cleared by the INTLK 0 command.

## **ISSET**

**ISSET<enter>** Display working current value

**ISSET n<enter>** Set working current value.  $0 \leq n \leq 100.0$  % of ILIM

## **OEM**

**OEM<enter>** Display original equipment manufacturer information

## **OFF**

**OFF<enter>** Stop emission, laser diode off, current zero

## ON

ON<enter> Ramp diode current to working value

## TEMP

TEMP<enter> Show temp set points and monitor for active channels

TEMP a<enter> Show temp set points and monitor for all channels

TEMP b<enter> Show temp monitor for heat-sinks etc

TEMP c<enter> Show temperature for channel c

TEMP 0 t pw<enter> Set all channel set-points to t'C

TEMP c t pw<enter> Set channel c set-point to t'C

c is channel number 1..6

- |   |                |
|---|----------------|
| 1 | Laser Diode    |
| 2 | Laser Head     |
| 3 | SHG option     |
| 4 | THG option     |
| 5 | Further option |
| 6 | Further option |

t is temperature in 'C, 15.0 to 50.0

pw is password "\*\*\*\*\*"

Temperature set-points have been optimized at the factory. There should be no need for the user to change them.

## VER

VER<enter> Display Firmware Version

## Q-Switch Commands

### BEAM

- BEAM<enter>      Display BEAM setting
- BEAM 0<enter>    Disable TTL output to rear panel BNC
- BEAM 1<enter>    Enable TTL output to rear panel BNC (default)

### FREQ

- FREQ<enter>      Display TTL Q-Switch frequency
- FREQ n<enter>    10.00 <= n <= 5000.00 Hz