FQ Series Diode Pumped Solid State lasers

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Contents

FQ Series Diode Pumped Solid State Laser

1. Basic Operation

The FQ 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

Connect the mains supply of the appropriate voltage to the Power Supply by the

Connector the RF BNC lead from the PSU to the laser head.

Connect the 9-way serial cable supplied to the RS232 D-connector on the rear of the Power Supply, and the USB serial converter (supplied).

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**

Shutter closed

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 Q-switched at 6 KHz with a diode current of 50%:

IDLE	**(Laser current ramps to IDLE setting)**
ISET 50	**(sets current of diode to 50% of ILIM)**
FREQSRC 0	**(set Q-switch operation to internal)**
FREQ 6000	**(set Q-switch repetition frequency to 6 KHz)**
SHUTTER 1	**(opens shutter)**

1.2 To stop the Laser in normal operation

Use:

SHUTTER 0 (closes shutter)

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.

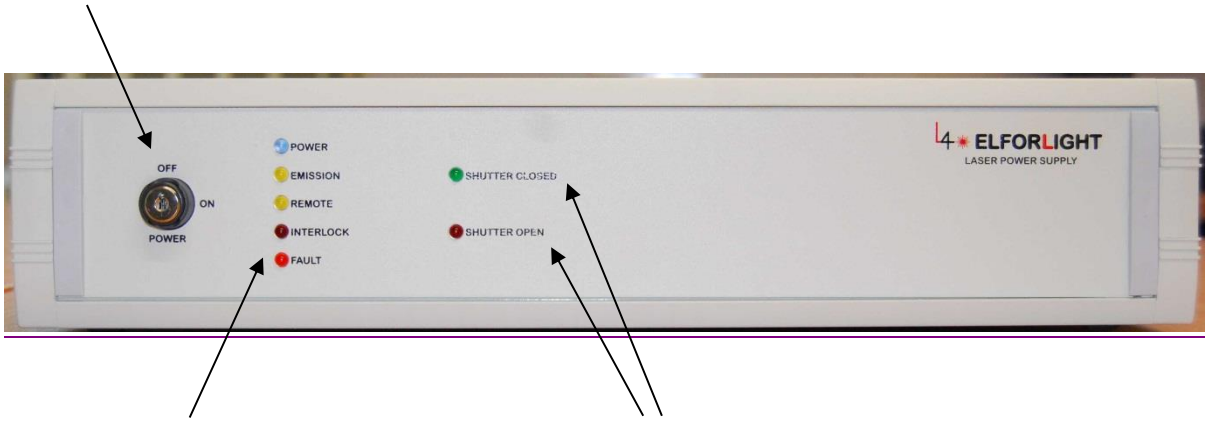
NOTE: TO PROTECT THE LASER CRYSTAL(S) THE LASER DIODE CURRENT IS RAMPED UP AND THEREFORE THERE IS A TIME DELAY BEFORE LASER OUTPUT IS OBSERVED AFTER A CURRENT DEMAND (RS232) OR A LASER ON COMMAND (RS232).

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

2. Front Panel controls and indicators

Fig 1. Front Panel

Keyswitch



Status indicators **Shutter 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 (Green)

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 remote 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 shutter (if specified) is closed and the laser closed 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, shutter fault or other condition. The nature of the fault may be determined through software.

Shutter open (Green)

Indicates that the electromechanical shutter is open and therefore laser output is possible.

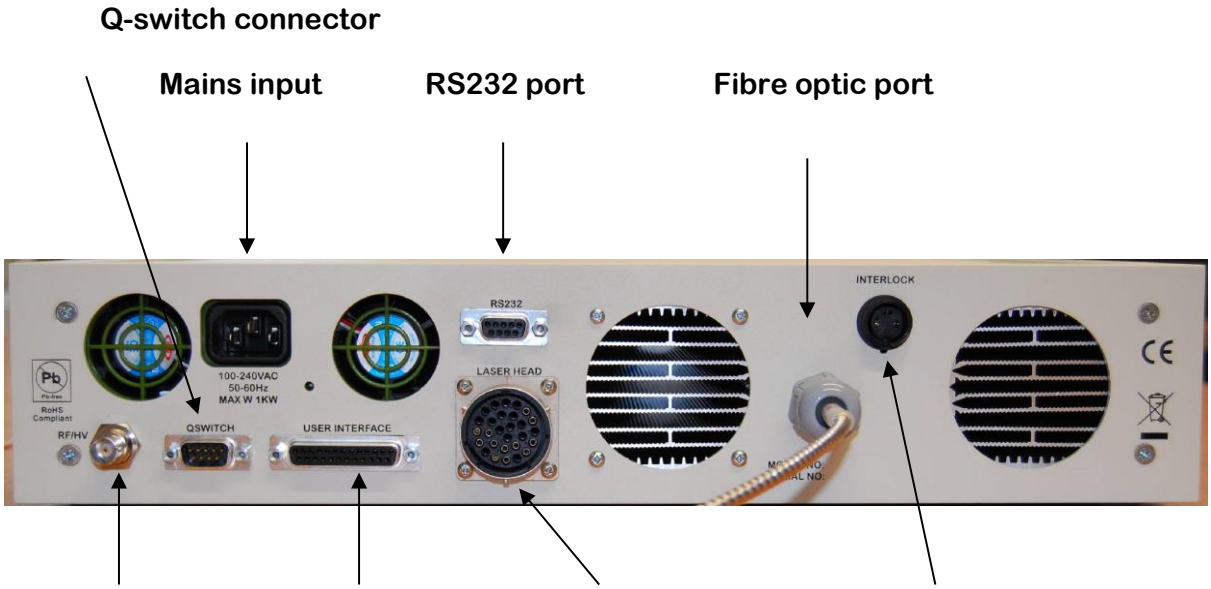
Shutter closed (Red)

Indicates that the electromechanical shutter is closed and therefore laser output is not possible.

The shutter is opened and closed by software commands. There is redundancy in the facility for sensing of the shutter position, in that it is sensed at both open and closed positions. Any conflict between requested or actual position generates a fault and shuts the laser down safely.

3. Rear Panel connections

FIG 2. Rear Panel



3.1 Features

External interlock connect or

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 and pin 5 through connected, pin 3 at PC to pin 8 at laser (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 standard IEC mains connector. Universal input 100 - 240 VAC, 50/60Hz.

RF/HV

The supplied BNC cable conveys RF to drive the acousto-optic Q-switch.

4. System components and features

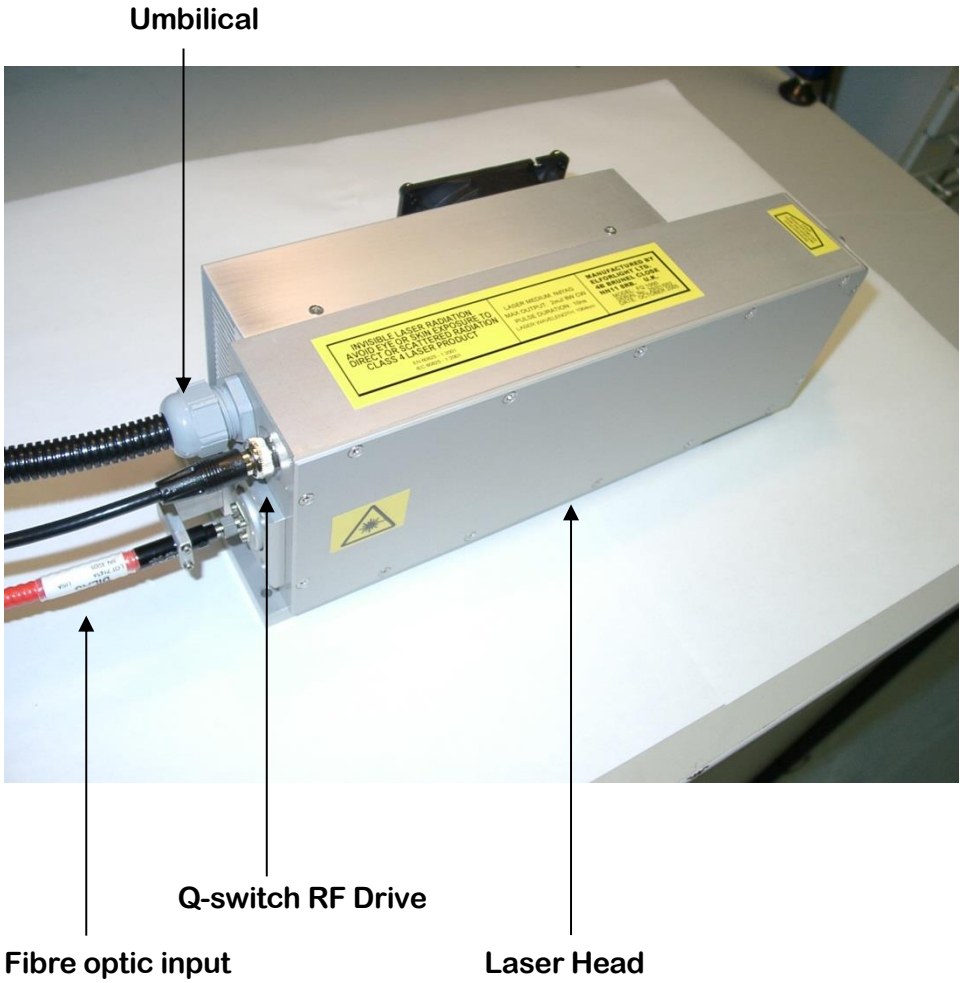
4.1 Laser Head Fig 3.

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, (YAG, YVO4 or YLF) 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 laser head is sealed with an RF tight gasket material to reduce the possibility of RF emission and to prevent ingress of contaminants.

In harmonic systems, 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 electro mechanical 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, oven control board and Q-switch pulse generation boards.. 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 closes the shutter, 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 laser has an electromechanically operated shutter, which has been tested to several million operations. When the shutter is closed, total emissions are within the level of Class 1 equipment.

The shutter is opened and closed by software commands, The shutter position is sensed by micro switches. There is redundancy in sensing of the shutter position, in that it is sensed at both open and closed positions. If the shutter jams open, an error situation is created which shuts the laser down.

5. Q-switched operation

5.1 Introduction

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 acousto-optic (A-O) deflector, to which a modulated RF signal is applied. A transducer on the A-O crystal creates an acoustic wave in the crystal, which forms a diffraction grating which deflects the impinging light beam. The Q-switch is then in the lossy condition- "closed". When the RF signal is rapidly reduced to zero, the grating collapses, and light can pass through the crystal un-deviated. This "opens" the Q-switch, allowing the pulse to build up and exit the laser.

The pulse is emitted after a delay of several microseconds, as the acoustic wave must decay in the deflector, while the pulse builds up from spontaneous emission. The exact build up time of the pulse therefore depends on the gain stored in the laser medium, which is a function of how hard it is being pumped by the laser diode and of the Q-switch repetition rate: The higher the gain, the shorter the build-up time. The lower the repetition rate, the shorter the build-up time.

5.2 Q-switch controls

The laser can be operated in one of two modes, controlled by software or connections to the Q switch interface connector on the rear panel.

In CW mode, no RF is applied to the Q-switch, and a Continuous Wave (CW) beam is output. In harmonic systems, very little frequency conversion will be seen in CW mode due to the low peak power. In addition, the beam quality and stability will not necessarily be very good as the cavity is optimised for Q-switched operation. CW operation is achieved by pulling pin 12 on the user interface connector to 0 volts (connect pin 14 to pin 5 or 9)

In Internal Q mode the laser is Q-switched at a factory set frequency. This mode of operation is selected from software. The default mode is internally triggered Q. NOTE: The maximum repetition frequency in internal mode is 85kHz. For higher frequencies external triggering must be used.

In externally triggered Q mode, a TTL signal is applied to pin 2 with respect to pin 5 or 9 of the Q switch interface connector. The laser triggers on the falling edge. A delay of typically 1 to 2 µsec occurs before laser output, depending on pump level and repetition rate.

In both Q-switched modes, the "Sync Out" (pin 6 wrt pin 5 or 9 of the Q switch interface connector) provides a 5 volt synchronisation signal for triggering other equipment. This line should be terminated in high impedance. (>50 Ohms).
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 1KHz for YAG.

6. 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

6.1 Classification

Elforlight FQ Series lasers are classified as class 4 lasers by the BS EN 60825-1:1994 and by the United States Center 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.***

6.2 Emission

The laser emits CW light at 532nm. 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 2m 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.***

6.3 Indicators

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

6.4 External interlock

The FQ and FC 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 – eg. 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.

6.5 Beam Stop

Depending on model, the laser is equipped with either a beam stop plug for the output aperture or an electro mechanically operated shutter. The former is secured to the laser head by a short chain, and when inserted into the output aperture will block the laser beam. The electro mechanically operated shutter is controlled through software, from the front panel or user interface connector - see description of the laser system.

6.6 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 COM20 from the list then click OK.

Close all remaining open menus.

Copy Laser.ht from the Elforlight supplied CD to your PC's desktop.

Double click on the Laser.ht icon to commence communication.

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

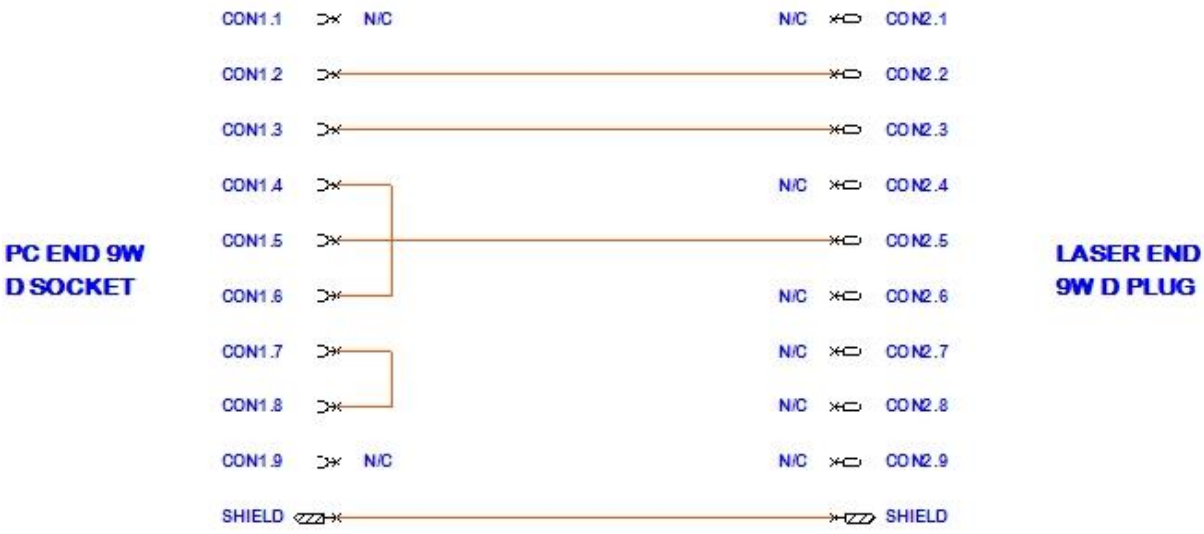
9600 baud, 1 start bit, 8 data bits, no parity, 1 stop bit

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 (<=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 up 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.

FBMODE

FBMODE<enter>	**Display feedback mode (option only)**
FBMODE 0<enter>	**Set light feedback mode**

FBMODE 1<enter> Set current feedback mode (default)

HELP

HELP<enter> Display list of RS232 commands

HELP text<enter> Elaborate on command “text”

HENE

HENE<enter> Display HeNe marker beam status (HeNe option only)

HENE 0<enter> Switch HeNe OFF

HENE 1<enter> Switch HeNe ON

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<=n<=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.

ISET

ISET<enter> Display working current value

ISET n<enter> Set working current value. 0<=n<=100.0 % of ILIM

O

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

SHUTTER

Open, close, or query shutter status

SHUTTER<enter> Query shutter status

SHUTTER 0<enter> Close shutter

SHUTTER 1<enter> Open shutter

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 Lasing medium

4 SHG option

5 THG option

6 Etalon 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

Acousto Optic Q-Switch Commands

B

BEAM

BEAM<enter> Display BEAM setting

BEAM 0<enter> Stop laser beam with AO Q-Switch, RF full on

BEAM 1<enter> Allow CW or QSW laser emission, RF off or modulated

F

FREQ

FREQ<enter> Display AO Q-Switch frequency

FREQ n<enter> 10.00 <= n <= 100000.00 Hz

FREQSRC

FREQSRC<enter> **Display AO Q-Switch control**

FREQSRC 0<enter> **Set AO Q-Switch control to internal**

FREQSRC 1<enter> **Set AO Q-Switch control to external**

When the QSW control is set to external, the user controls QSW operation with TTL level inputs.

These are made available on a 9 way D type plug on the rear of the unit.

QSW/CW	**Hi = QSW Mode,**	**Lo = CW Mode**
GATE	**Hi = Beam off,**	**Lo = Beam on**
TRIG.Q	**Trigger input, 1 shot or 10Hz to 100kHz, triggers on –ve going edge**	
	TTL pulse train, duty cycle 10% to 80%	

All inputs have pull up resistors, and so default to the logic "Hi" setting if left unconnected or floating by an open drain/collector driver circuit.

i.e. QSW, Beam off

R

RFMODE

RFMODE<enter> **Display RF mode**

RFMODE 0<enter> **Set RF mode to CW**

RFMODE 1<enter> **Set RF mode to QSW**

External Q-Switch Interface

9 Way D-Type Plug

Pin	Function
1	+5V
2	Trig.Q
3	Gate
4	QSW/CW
5	0V
6	Sync_Out
7	N/C
8	FAULT
9	0V

Notes:

All input signals are internally pulled up to +5V by a 4k7 Ohm resistor

Input and output signals are TTL compatible.

Input voltage levels must not exceed +5V or damage will occurr.

Input signals are active low, i.e. they are asserted when driven to logic low level or connected to 0V.

The +5V outputs are NOT designed to power up external equipment.

QSW/CW Pin 4

Selectes between QSW or CW laser mode.

Floating or driven high = QSW

Grounded or driven low = CW

Trig.Q Pin 2

Trigger input for QSW mode.

Laser is triggered on falling edge of pulse waveform.

Waveform may be single pulse or pulse train.

Duty cycle not critical, say 10/90 to 90/10 %

Ensure falling edge of TTL waveform is fast and clean.

Frequency range: single pulse to 100kHz

Gate Pin 3

When this input is left floating or driven to logic high, full RF is applied to the AO-Qsw itch and laser emission is prevented.

When this input is grounded or driven to logic level low, the RF will either be:

Turned off in CW mode

Modulated by the Trig.Q input

WARNING:

DO NOT USE THIS FUNCTION AS A SAFETY SHUTTER !

Sync Out Pin 6

This is an active low signal that mirrors the RF envelope.

External equipment may be triggered on the falling edge.

FAULT Pin 8

Fault output.

This output is driven low if there is a fault detected in the QSW electronics.

e.g. High temperature

0V Pin 5 & 9

System ground made available to external electronics.

+5V Pin 1

System +5V, DO NOT USE!

Defaults

The unit defaults to external Q-Switch control on power up.

If you want to use internal Q-Switch control, use the RS232 software commands:

FREQSRC 0	**internal**
FREQSRC 1	**external**

Figure 6. HyperTerminal example