Invictus

785 nm Diode Laser

OPERATIONS MANUAL

2006137 V1.2

Kaiser Optical Systems, Inc.
371 Parkland Plaza
Ann Arbor, MI 48103

April 2001 V 1.2

Information contained herein is deemed to be accurate at the time of writing. Kaiser Optical Systems, Inc. reserves the right to change the information and specification contained within without notice.

Kaiser Optical Systems, Inc. will provide telephone consultation for this product during normal U.S. East Coast business hours 8:00 AM to 5:00 PM. Under no circumstances does telephone consultation affect the terms of any warranty agreement.

Kaiser Optical Systems, Inc.
371 Parkland Plaza
Ann Arbor, MI 48103

Phone: (734) 665-8083
Fax: (734) 665-8199

E-mail: support@kosi.com
Website: www.kosi.com

CAUTION

The performance of procedures, the use of controls, or the adjusting of the instrument other than as specified in the manual may result in hazardous radiation exposure.

Table of Contents

List of Figures and Tables

Important Symbols Used in This Manual

THIS SYMBOL IS USED TO IDENTIFY IMPORTANT OPERATING INSTRUCTIONS.

THIS SYMBOL IS USED TO ALERT THE USER TO THE DANGER OF EXPOSURE TO HAZARDOUS VISIBLE AND INVISIBLE LASER RADIATION.

Preface

This manual contains information for users concerning the Invictus 785 nm laser.

Users should read this manual carefully before operating the Invictus 785 nm laser for the first time. **Section 1, Safety**, describing the safety features built into the laser along with safety precautions that users should follow, is especially important.

The performance of procedures, the use of controls, or the adjusting of the instrument other than as specified in the manual may result in hazardous radiation exposure.

U.S. Export Compliance

Strict compliance with U.S. export control laws is the policy of Kaiser Optical Systems, Inc.

Export and re-export of instruments manufactured by Kaiser Optical Systems, Inc. are subject to U.S. Export Administration Regulations. These regulations are administered by the Commerce Department. Shipments of certain components are regulated by the State Department under the International Traffic in Arms Regulations.

The restrictions that are applicable vary based on the product involved and its country of destination. When there is uncertainty about the obligations imposed by U.S. law, clarification should be obtained from Kaiser Optical Systems, Inc. or an appropriate U.S. Government agency.

1. Laser Safety

Laser light presents special safety hazards not associated with other light sources. All laser users and others present need to be aware of the special properties and dangers involved in laser radiation. Familiarity with the Invictus 785 nm laser and the properties of intense laser radiation will aid in the safe operation of the Invictus 785 nm laser. Invictus 785 nm laser users are advised to follow the precautions listed in Table 1.1.

The Invictus 785 nm laser should be used in a well-lit room for general safety. Under these conditions, the human eye pupil has a relatively small opening, limiting potentially dangerous laser radiation.

Table 1.1 Summary of Laser Safety Precautions

1. Observe and follow all safety precautions listed in the operator's manual.
2. Restrict the use of the Invictus 785 nm laser to qualified users trained to the appropriate level and knowledgeable in laser safety practices. In addition, inform all personnel working in the area of these precautions.
3. When the laser is operating, all personnel in the room or others who may be exposed to the laser beam should be notified that a laser is in operation.
4. Illuminate warning lights and post warning signs in the area when the laser is in operation.
5. Trained operators should wear protective eyewear designed for the appropriate laser. The eyewear should permit observation of the emission indicator. Note: Laser safety glasses prevent the user from observing the beam but provide no further bodily protection. Therefore use extreme caution even when wearing safety glasses.
6. Never look directly into the laser light source or stare at the diffuse reflected beam.
7. Never sight down the beam into the source.
8. The beam path and optical components used in the operation of the Invictus 785 nm laser should be positioned at an elevation low enough to prevent inadvertent beam-eye contact.
9. Reflections from shiny surfaces, such as watches, rings, window glass, polished surfaces, etc., can redirect laser light in dangerous directions. Whenever the laser light can possibly illuminate a shiny object, consider where the reflected light could go and make sure that a hazardous situation is not created.
10. When operated without the optional fiber optic coupler, contain the laser beam in a directed path as the light will remain collimated over a long distance and presents a potential hazard if unconfined.

Laser beams can cause ignition of certain substances such as volatile chemicals. The two mechanisms for ignition theoretically possible are firstly direct heating of the sample to a point causing ignition (this path may require high laser powers) and secondly heating of a contaminant (such as dusts) to a critical point leading to ignition of the sample.

Electrical Safety

The Invictus 785 nm laser converts nominal 100–240 VAC line voltage into low voltage DC contained inside the laser enclosure. There are no user serviceable parts inside the laser assembly. Only KOSI-qualified personnel familiar with high voltage electronics should open the laser enclosure in order to perform necessary maintenance or service. The warranty will be voided if the laser enclosure is disassembled or removed.

Laser CDRH Features

The Invictus 785 nm laser incorporates the following safety features to conform to the United States Government requirements 21 CFR Subchapter (J) as administered by the Center for Devices and Radiological Health, (CDRH).

It should be noted that the CDRH regulations are only applicable within the United States of America.

Protective Housing. The Invictus 785 nm laser is enclosed in a protective housing to prevent human access in excess of the limits of Class I radiation as specified in the Federal Register, July 31, 1975, Part II, Section 1040.10 (f) (1) and Table 1-A except the output beam, which is Class IIIb.

Hazardous Radiation Exposure. The performance of procedures, the use of controls, or the adjusting of the instrument other than as specified in the manual may result in hazardous radiation exposure.

CDRH Classification. Under CDRH regulations the Invictus 785 nm laser is a Class IIIb laser product, with a theoretical maximum operating power of less than 500 mW CW @ 785 nm. The United States Federal Performance Standard for Laser Products classifies the level of potential laser hazards. Table 1.2 describes the hazard levels associated with different intensities of laser light.

Table 1.2 Potential Hazard Classifications for Continuous Wave (CW) Laser Light

μW	Classification	Description
0.39	Class I	Not considered to be hazardous.
3.90	Class IIa	Not considered to be hazardous if viewed for a period of time not greater than 1000 sec., but considered to be a chronic hazard if viewed for greater than 1000 sec.
1000	Class II	Chronic viewing hazard.
5000	Class IIIa	Depending on irradiance, either an acute intrabeam viewing hazard, or chronic viewing hazard, and an acute viewing hazard if viewed directly with optical instruments.
500,000	Class IIIb	Acute hazard to skin and eyes from direct radiation.

CDRH Compliance. As of May 23, 2000 the Invictus 785 nm laser is certified to comply with the Federal Regulation 21 CFR, Subchapter (J), as administered by the Center for Devices and Radiological Health (CDRH).

Location of CDRH Compliance Labels. CDRH compliance labels are located on the top panel of the laser and on the front panel adjacent to the exit beam aperture, as shown in Figures 1.1 and 1.2. These labels indicate apertures through which laser radiation is emitted, and certification and identification information.

Figure 1.1 Front-end view of Invictus 785 nm laser showing location of CDRH compliance labels.

Figure 1.2 View from above of Invictus 785 nm laser showing location of CDRH compliance labels.

Further Laser Safety Information. For additional information on laser safety, the user is referred to the following publications:

American National Standard for the Safe Use of Lasers, American National Standards Institute, 1980.

Performance Standard for Laser Products. FDA., (FR-40) (148): 32252-32265. Department of Health, Education and Human Service Bureau of Radiological Health, July 31, 1974.

Laser Safety Guide, Laser Institute of American (5th Edition), Toledo, OH 1982.

Safety with Lasers and other Optical Sources. D. Sliney and M. Wolbarsht, Plenum Publishing Company, New York, N. Y., 1980.

2. General Device Description and Specifications

General Description

The Invictus is a 785 nm (NIR) external-cavity-stabilized diode laser, optimized for Raman spectroscopy applications that use multimode fiber optic coupling to the sample. It is available with an optional fiber coupler and Raman probe head accessories. The output power of the laser is rated under the Class IIIb classification as defined by the United States Federal Performance Standard for Laser Products (less than 500 mW).

The laser is packaged into a rugged, compact housing that contains the laser diode, optics, the power supply, and associated electronics. Designed for use in demanding industrial environments, the Invictus is rated for operating ambient temperatures of 0 to 50°C and relative humidity of 0 to 95% (non-condensing).

This device uses forced-air cooling with a fan located in the rear of the laser assembly, so the laser operates without the need for cooling water. The Invictus laser uses a "universal input" switching power supply. Input power can be in the range from 100–240 VAC, 50/60 Hz.

The Invictus 785 nm diode laser is maintenance-free, requiring no routine maintenance by the user. This includes cleaning or optimization either by adjustment or alignment. The laser is operated using a simple on/off key switch or via the remote interlock connector (both located at the rear of the laser as shown in Section 4, Figure 4.3). Power control, system monitoring, and interlock configuration are controlled through keypad-operated menus shown via a liquid crystal display.

The general specifications pertaining to the Invictus 785 nm diode laser are given in Table 2.1.

Table 2.1 General Specifications

Wavelength	784.8±0.1 nm, fixed
Output type	Continuous wave (CW)
Output power	10–400mW, variable
Line width	<1 cm^{-1} (30 GHz), FWHM
Spatial modes	Multiple
Long-term wavelength stability	0.05 nm
Short-term wavelength stability (<1 hr)	0.005 nm
Polarization	Linear, 45 degrees
Beam divergence	<1 mrad x 10 mrad
Beam-pointing stability	<0.5 mrad
Side mode and spontaneous emissions rejection (with optional fiber coupler and 50-micron fiber)	>60dB @ 100 cm^{-1} Raman shift
Operating temperature range	0°C to 50°C
	(32°F to 122°F)
Storage temperature range	-20°C to 55°C
	(-4°F to 131°F)
Operating humidity	0–95% relative humidity
Recommended operating temperature stability (for rated short term stability)	± 1°C
Warm-up time (to rated stability)	20 minutes
Operating voltage	100–240 VAC, 50/60 Hz
Power consumption	50 Watts maximum
Dimensions (height x width x length)	33 x 15 x 10 cm (13 x 5.9 x 4 in.)
Mass (weight)	6.1 kg (13.5 lb)

3. Installation

Prior to unpacking and installation, the user should determine a location for installation that meets the appropriate specification provided in Table 2.1

Unpacking

Prior to unpacking the device, the shipping containers should be inspected for visible damage (mechanical and water). If damage is visible, contact Kaiser Optical Systems, Inc. (or distributors) for further instructions. DO NOT proceed further with unpacking the instrument.

If the container shows no visible sign of damage, the instrument may be unpacked. Carefully remove the device from its container and place on a clean, dry level surface. Using the Kaiser Optical Systems, Inc. shipper list(s) verify the presence of each component.

The shipping container should be retained for use in the event the laser has to be stored or returned to the supplier.

Initial Installation

The Invictus 785 nm laser should be installed in an appropriate location as described in Section 2 and Table 2.1. The Invictus 785 nm laser can be installed in any orientation.

In addition the location selected should be:
1. free of moisture / dust / corrosive vapors
2. isolated from excess vibrations.

Ventilation

The location selected should allow for adequate ventilation around the laser. The intake and exhaust of the air exchange fan (front and rear of the laser) should be free from obstruction and excessive dust.

If the unit is to be mounted in an enclosure, the enclosure must allow for adequate airflow and heat transfer to keep the temperature within the specified operating range.

Laser Mounting

The laser enclosure has four clearance holes for ¼-inch mounting screws, allowing rigid mounting of the laser. The design also allows for the laser to be fixed in position using side-mounted clamps. The locations of the mounting holes are shown in Section 4, Figure 4.2. Hole spacing is 7 inches by 5 inches. Rigid mounting of the laser allows the beam direction to be maintained for both application accuracy and safety (confining the beam to a known path).

Voltage

The input voltage must be in the range of 100–240 VAC (Table 2.1). A "universal input" power supply provides the correct voltage to the internal components.

The supply voltage is recommended to be regulated and free of voltage spikes. It is recommended, but not required, that an uninterruptible power supply (UPS) be used with the instrument. Kaiser Optical Systems, Inc. will not be responsible for damage caused by use of unregulated or unconditioned supply voltages.

Electrical Cables

Connect all electrical cables. The electrical connections should be installed as appropriate in order to meet the local ordinances and / or directives.

External Interlock Circuit

For emission of laser light, the interlock circuit must be engaged. Users may access this circuit through the 4-circuit phone handset connector (RJ-H) on the rear panel (see Figure 4.3). If the laser is powered up and there are no other lockouts (e.g., over-current, over-temperature, etc.), connecting the two outer pins of the INTLK socket will engage the interlock and laser emission will begin after approximately 5 seconds.

Figure 3.1 shows a schematic of the external circuit connection needed to engage the interlock. A 1-meter interlock cable with the black and yellow wires shorted is supplied with the Invictus laser for testing and simple operation. External relays or door switches or other safety switches may be connected to this cable or a similar user-supplied cable to provide any manner of interlocked operation depending on the intended use.

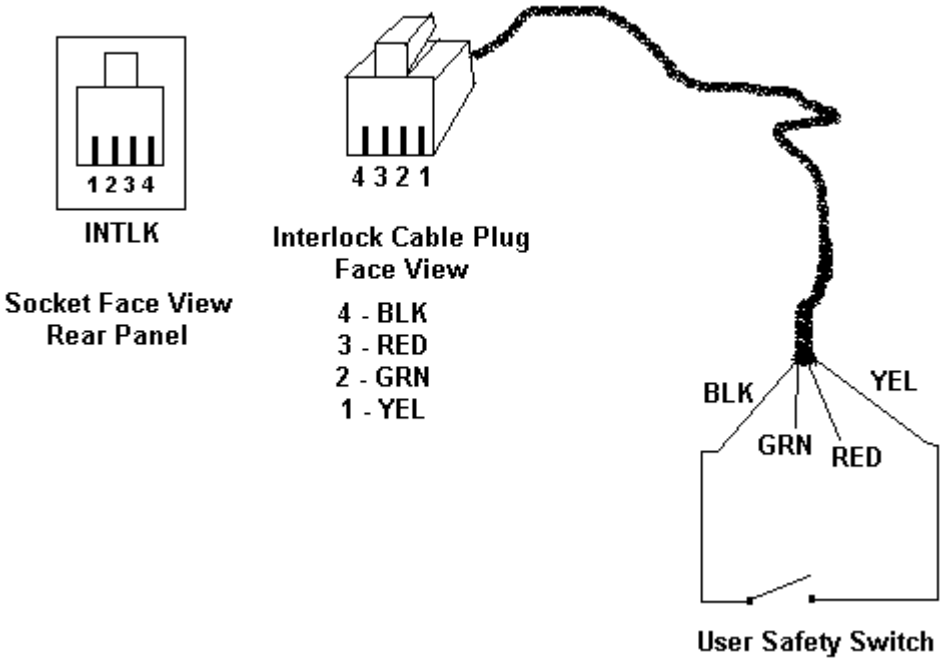

Figure 3.1 Laser Interlock, External Connection.

4. Controls, Status Indicators and Hardware Features

Prior to operation, the user should become familiar with the controls, status indicators, and hardware features of the Invictus 785 nm laser. In Figures 4.1, 4.2, and 4.3, pictures of the front end, the top, and the rear of the laser are shown. The location of the important controls, indicators, and features are clearly marked. Important controls, indicators, and features of the Invictus 785 nm laser are given either below or in Table 4.1 at the end of this section.

Shutter. A shutter is provided on the topside of the Invictus 785 nm laser. The shutter is a manually operated rotary type. The open (l) and closed (0) positions are clearly marked in Figure 4.2. In the closed position, the manually operated shutter blocks all access to laser radiation without turning off the laser.

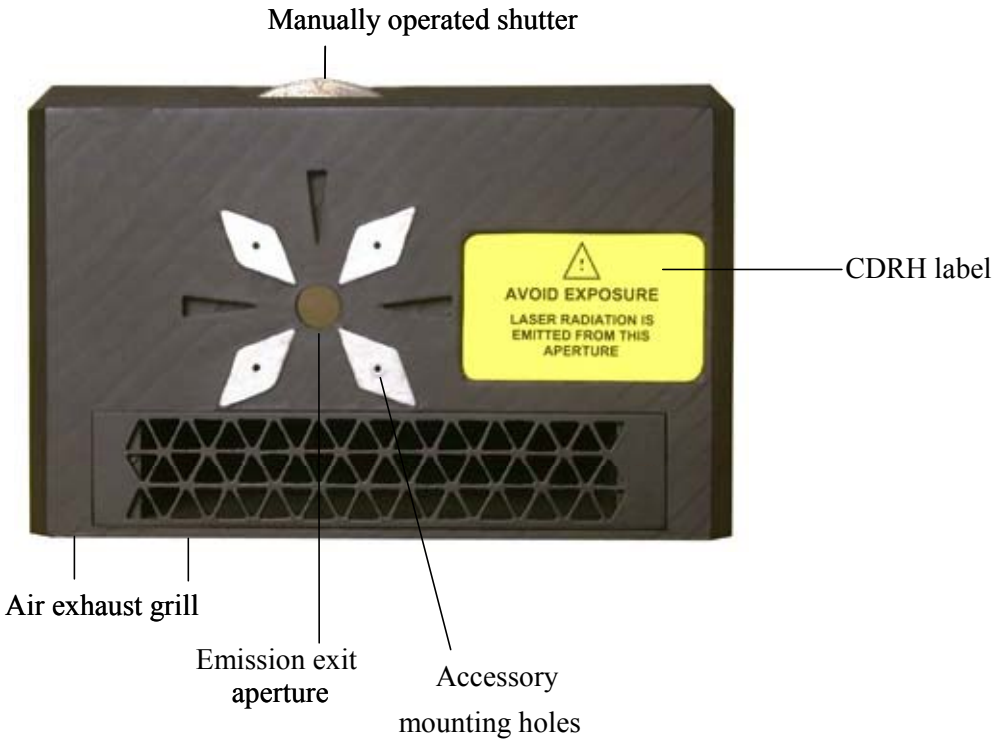

Figure 4.1 Front view of laser showing location of controls, indicators, and features.

Key Control. The laser radiation will not be accessible until the keyswitch, shown in Figure 4.3, is in the ON position. The key cannot be removed when the switch is in the ON position.

Laser Radiation Emission Indicator. Before laser emission occurs, the "Laser On" indicator on the Invictus 785 nm laser enclosure turns on for 10 to 15 seconds. This indicator is visible without operator exposure to the laser emission, even when the

operator is wearing laser safety glasses. The location of the LED light, which serves as the laser radiation emission indicator is shown in Figure 4.3.

Figure 4.2 Top view of laser showing location of controls, indicators, and features.

Liquid Crystal Display (LCD) Screen. The LCD panel is a 2x16 alphanumeric character display with yellow-green backlight. Combined with the keypad, it allows the user to set and display power output, set and display interlock options, provides status indications and even troubleshooting information. All available display screens are shown in **Section 5, Operation**.

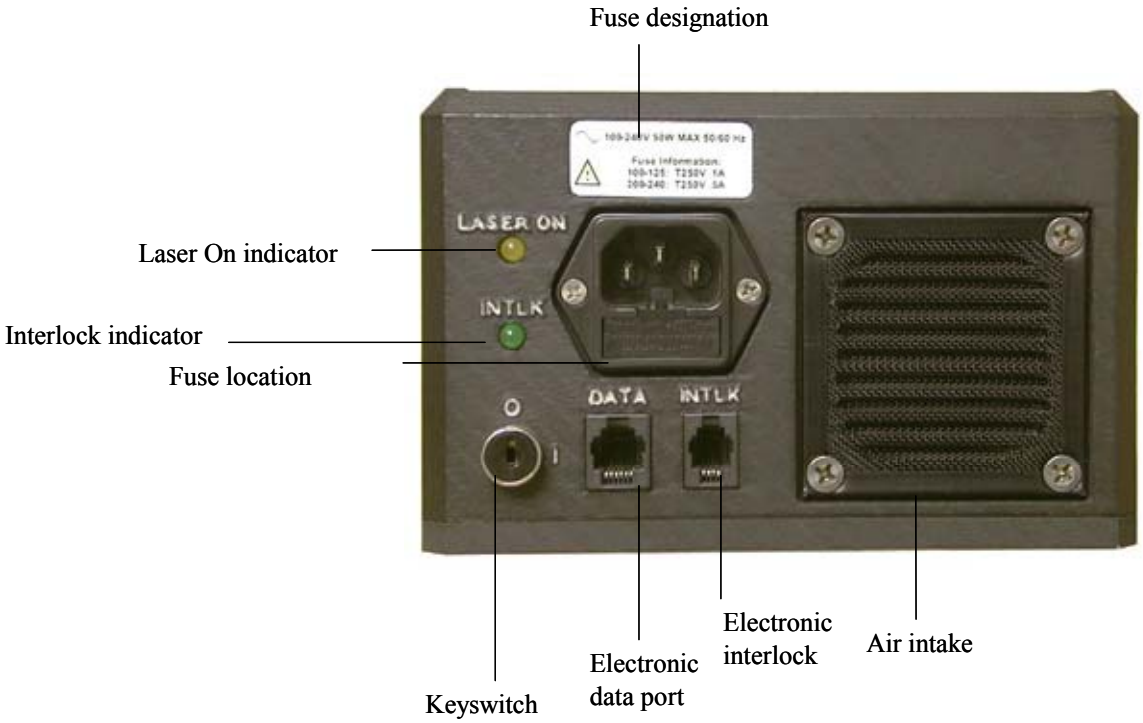

Figure 4.3 Rear view of laser showing location of controls, indicators, and features.

Keypad. The 4-button keypad on the top of the laser, next to the liquid crystal display, allows access to laser power control, interlock options and status displays. Figure 4.4 shows the icons for each of the keys. The lowest key (menu icon) descends down through the various display menu options. The upper key (light and up arrow icon) turns on the backlight for 30 seconds and moves back up through the display menu. The middle buttons (+ and – icons) step through menus and change parameters when allowed in certain menu screens.

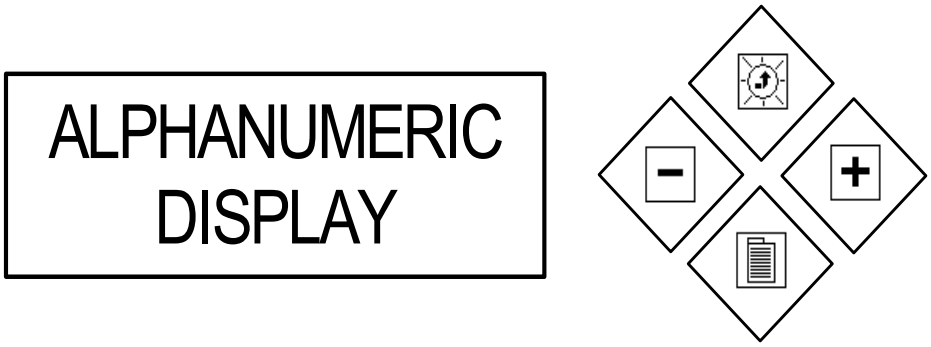

Figure 4.4 Alphanumeric display and keypad layout.

Table 4.1 External Features

Connections	
AC power	A standard three-conductor AC power cord interface is located on the rear panel.
Fuse	Protective line fuse. Two types of fuses are used in this device. Selection is dependent on the local supply voltage. Appendix A, Table A.1 describes the two types of fuses available. In addition a label on the rear of the laser enclosure also provides similar information on fuse types.
Laser safety interlock port	Four-circuit telephone handset connector (RJ-H) located on the laser rear panel (Fig. 4.3) labeled INTLK. Pins 1 and 4 (the outer two) must be connected to engage the interlock and permit laser emission.
Data port	This port is currently used only at the factory during laser assembly. The user should not attempt to interface with this data port.
Emission port	The laser emission port is on the front of the laser, indicated by a CDRH compliant label, and centered on four diamond-shaped raised pads for fiber coupler mounting.
Controls	
Keyswitch	This functions as the ON/OFF switch for the laser and is located on the rear panel. The key cannot be removed with the laser on.
Key pad	These four buttons on the top panel adjacent to the LCD alphanumeric display allow the user to set power, interlock option, display status and troubleshoot.
Shutter	Mechanical rotary style shutter located on the top of the laser housing. The shutter location is shown in Figure 4.2. When the shutter is closed the laser continues to operate but the laser light is physically prevented from exiting the laser housing. 0: Closed position, l: Open position.

Table 4.1 External Features (continued)

Indicators/Information	
Alphanumeric display	A 2x16 alphanumeric character display with backlight is located on the top of the laser adjacent to the control keypad. It displays power output, status of key systems (e.g. laser diode and TE cooler) and troubleshooting information. The display functions are accessed via the keypad as outlined in Figure 5.1.
Laser On LED indicator	This yellow indicator is labeled LASER ON and is located at the rear of the laser enclosure (Figure 4.3). The indicator LED turns on when the keyswitch is turned on, the power cable is plugged in, and the power is turned on. The laser indicator LED is also used to warn the operator of possible laser emission. Laser emission occurs 10 to 15 seconds after the indicator lights.
Laser safety interlock indicator	Green LED labeled INTLK on rear panel (Figure 4.3), lights when external interlock circuit is engaged through the electronic interlock port *AND* there are no other lockouts (e.g., over-temperature, diode over-current, etc.) When LED lights, laser emission will begin within approximately 5 seconds.
Laser emission warning label (CDRH)	This label is located on the front of the laser (Figure 4.1) and warns of possible laser radiation emission.
Laser emission warning / manufacturing information label	This label on the top panel describes the CDRH laser class of this device, and information specific to the laser manufacture, including serial number and date of manufacture.
Voltage/fuse information label	This label is located on the rear of the laser (Figure 4.3) and contains information on the appropriate fuse for the local line voltage.
Mechanical Interfaces	
Laser mounting holes	Four clearance holes to accommodate ¼″ socket cap screws are located on spacing of 7″ x 5″ for mounting to standard tapped grid tables. The mechanical configuration alternatively allows clamping at these locations.
Fiber coupler mounting holes	Four 4-40 tapped holes are provided on the front panel surrounding the laser aperture for mounting an optional fiber optic coupler.
Fan intake	The air intake for fan-assisted cooling is located at the rear of the laser assembly (Figure 4.3). The intake is covered with a protective screen. This screen should be cleaned periodically by brushing the grill to prevent dust build-up from outside.
Air exhaust	The air exhaust for fan assisted cooling is located at the front of the laser (Figure 4.1).

5. Operation

Verify that the Invictus 785 nm laser has been installed in an appropriate location as described in Section 2 and Table 2.1.

Prior to operating the laser, the user should:

1. **Become familiar with the Laser Safety section (Section 1) of this manual**
2. **Be aware of possible laser hazards**
3. **Have access to appropriate safety equipment**
4. **Verify that the output beam will be appropriately contained**
5. **Notify other personnel in the area that a laser is going to be operated**

The Invictus diode laser is a complete laser system with safety interlocks and a CDRH-required keyswitch. The Invictus laser's micro controller, keypad and LCD display provide numerous operating options and diagnostics and parameter monitoring. Figures 5.1 and 5.2 show flowcharts of all the user "screens" available. Each box shows the text displayed on the LCD. The diamond-shaped icons indicate which of the four buttons on the keypad should be pressed to proceed through the screen menus. The bold screen indicating POWER OUT is the one that will normally be displayed under most conditions after a successful startup. Changing the output power or interrogating the parameters of the laser require moving up-down-left-right through the display screens.

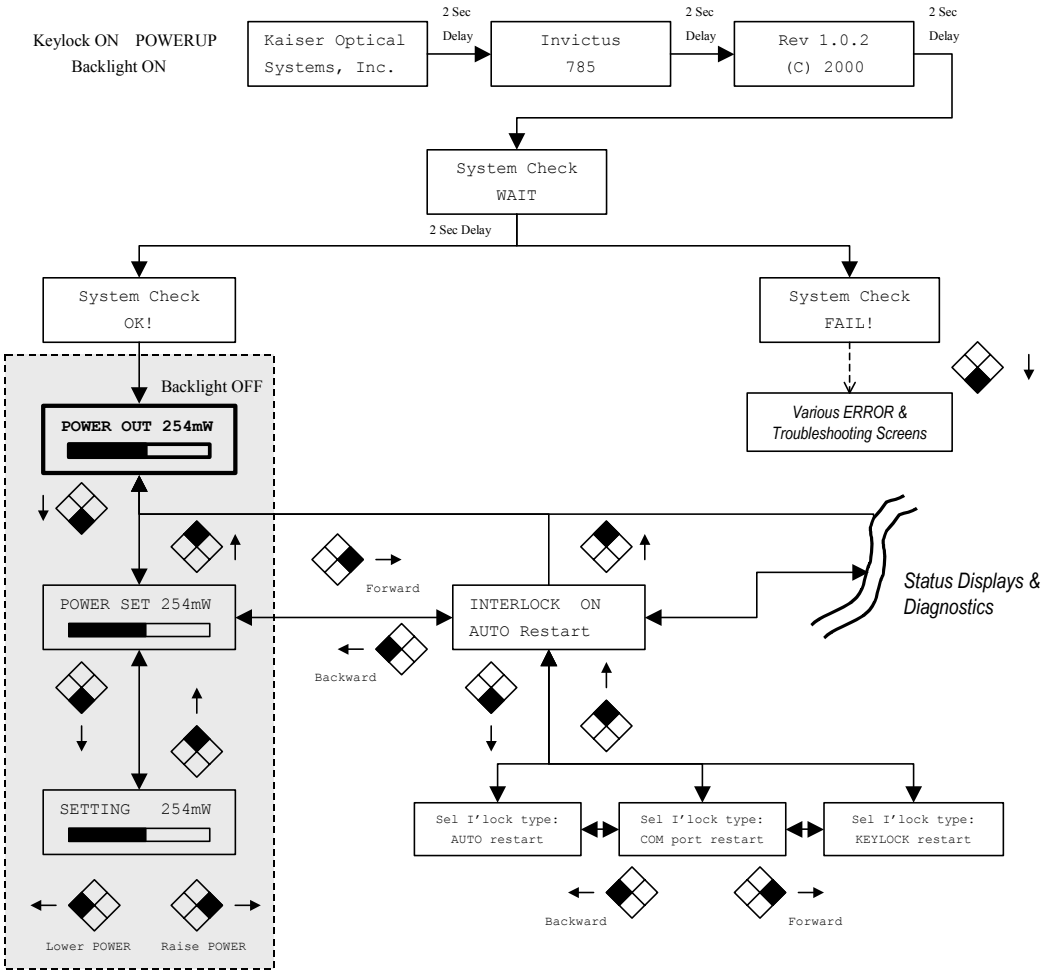

Figure 5.1 Invictus Laser Keypad Interface Flow Chart – Normal Operation.

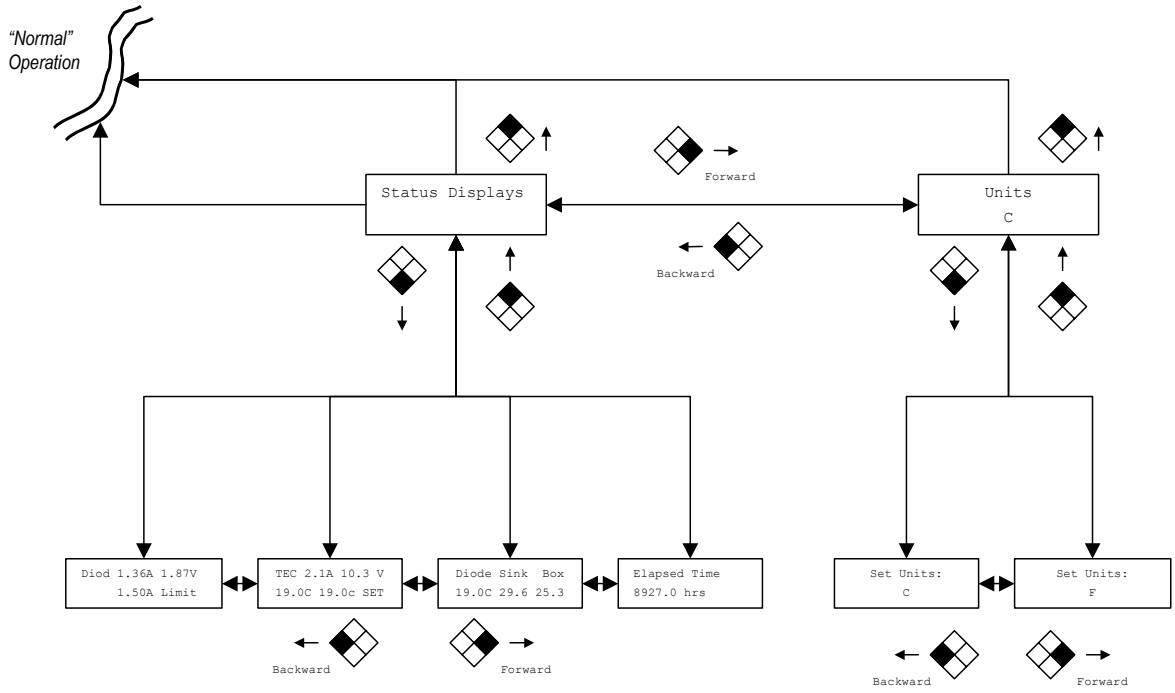

Figure 5.2 Invictus Laser Flow Chart – Status Displays and Diagnostics.

Shutter Operation. A manual shutter is required for CDRH-compliant laser systems. Invictus uses a rotating thumbwheel located on top near the front of the laser enclosure to block the beam from exiting the aperture. Before laboratory operation, close the laser shutter by rotating the wheel to '0'. Once the laser is powered up and operational, OPEN the shutter by rotating the wheel to 'I' and the beam will exit the aperture in front. In industrial use where Invictus is part of a larger system, the manual shutter would normally be left open and other electromechanical shutters and interlocks would control the beam's exit.

Power-up. On the rear panel, turn the keyswitch clockwise to 'I' to power up the unit. As seen in Figure 5.1, four screens will be displayed in sequence with 2-second delays between each. This allows time for the system to start cooling the laser diode and to perform other checks. After these screens are complete, the laser will indicate either "System Check OK!" or "System Check FAIL!" If OK and the safety interlock is engaged (pins 1 and 4 of INTLK connector shorted), the laser will enable the diode drive and the screen will show "POWER OUT xxx mW" with a bar graph roughly indicating the fraction of full scale power. The power output in mW is approximate, within 10%, based on the factory-calibrated full-scale output. Note that the displayed power output corresponds to the collimated beam at the laser exit aperture, not the power coupled into a fiber, which will be lower and can vary greatly among different types of fiber. If FAIL!

is shown, use the lowest button on the keypad to descend into additional screens for fault indications and troubleshooting help.

Adjusting Power Output. In normal operation, the laser's LCD display will show "POWER OUT xxx mW" with a bar graph (the shaded box in Figure 5.1). Adjust the laser's output power by pressing the lowest keypad button twice to descend to the "SETTING xxx mW" screen. The backlight will come on for easier viewing. Hold the right or left keypad buttons to raise or lower the power output, respectively. After about 30 seconds the backlight will turn off and the new power value will be saved in non-volatile memory, so this power level will be retained and used if the laser is shut off and restarted.

Safety Interlock. The Invictus laser is equipped with an electronic safety interlock to prevent accidental exposure to the high-power beam. As mentioned in Section 3, an external door switch or other safety "trip" circuit may be connected to the INTLK connector on the rear panel of the laser. Whenever this circuit is open, the interlock is disengaged and no beam will exit the aperture. The green INTLK LED on the rear panel will extinguish and an LCD display will indicate "Interlock OFF". When the circuit is closed, the laser beam will re-energize according to the interlock option selected. Invictus is equipped with three user-selectable options for restarting the beam:

1) **AUTO**–Laser beam re-energizes after 5-to-10 second delay, FACTORY DEFAULT
2) **COM port**–A serial command sent to Invictus will restart the beam.
3) **KEYLOCK**–Key must be cycled off and on to restart the laser beam.

Note: As of April 2001, Option 2 is not implemented

Figure 5.1 shows the keypad sequence needed to access these interlock restart options. Once an option is selected, the option will be stored in non-volatile memory after approximately 30 seconds. This new option will be in effect even if the laser is powered off and restarted again. **If the laser does not turn on as per the interlock setting, refer to Section 6, Troubleshooting, for user-approved corrective action.**

6. Troubleshooting

The Invictus 785 nm diode laser is designed to be maintenance-free, requiring no user intervention. The expected lifetime is on the order of thousands of hours. If a problem is encountered during regular operation, there are a number of corrective actions that the user can take. A list of these actions is provided in Table 6.1. If these actions fail to correct the problem the laser may need to be returned to the supplier. Kaiser Optical Systems, Inc. will provide telephone consultation for this product during normal U.S. East Coast business hours 8:00 AM to 5:00 PM. [phone: (734) 665-8083]. After consultation KOSI (or its distributors) will determine if the product needs to be returned. Information on returning the laser is provided in **Appendix B, Warranty**.

For additional Troubleshooting information concerning the use of the Invictus 785 nm laser with a KOSI universal fiber coupler the user is referred to **Appendix D, Optional Fiber Optic Coupler.**

Table 6.1 Troubleshooting

Problem	Probable Cause	Corrective Action
Laser doesn't turn on	Input voltage not applied	Plug in AC power cord Ensure voltage is available
	Blown Fuse	Replace fuse[1]
	Interlock broken	Check for interlock integrity[2] Check that interlock is attached[2]
	CDRH delay	Wait for 20–40 seconds
No detectable laser emission	Laser not powered up	Power up laser
	Shutter closed	Open shutter
	Environmental specification exceeded	Correct environmental condition[3]
Low power	Shutter not fully open	Open shutter
	Laser power turned down	Turn laser power up
	Inaccurate power meter	Verify accuracy of power meter
	Damaged or contaminated fibers	Clean fibers[4]
	Poorly aligned fiber coupler	Align coupler[4]

Problem	Probable Cause	Corrective Action
Laser fan not running	Fan blades blocked	Clean fan blades
	Fan broken or disconnected	Return to supplier
Air not exhausting from laser enclosure	Air intake blocked	Clear air intake
	Fan blades blocked	Clear fan blades
	Fan broken or disconnected	Return to supplier
Laser emission indicator off and laser on	Indicator LED failed	Return to supplier[5]
Interlock light on or off		

1. Refer to **Appendix A, Spare Parts**, Table A1 – Fuse.

2. Refer to **Section 4, Controls, Status Indicators and Hardware Features**, Table 4.1 – for information on the electronic laser interlock

3. Refer to **Section 2, General specification**, Table 2.1 – for information on environmental operating conditions.

4. Refer to **Appendix D, Optional Fiber Optic Coupler**

5. Contact the supplier for return information **Appendix B, Warranty** and **Appendix E, Approved Distributors**

Appendix A. Spare Parts

The Invictus 785 nm diode laser is maintenance-free, requiring no routine maintenance by the user. This includes cleaning (other than periodic cleaning of the fan intake grill) or optimization either by adjustment or alignment (other than alignment of the fiber coupler option, if present).

There are no user serviceable parts inside the laser assembly. Only KOSI-qualified personnel familiar with high-voltage electronics should open the laser enclosure in order to perform necessary maintenance or service.

The performance of procedures (including service), the use of controls, or the adjusting of the instrument other than as specified in the manual may result in hazardous radiation exposure. The warranty will be voided if the laser enclosure is disassembled or removed.

A list of common parts that may be ordered/installed by the user are given in Table A1.

Table A.1 Replacement Parts List

Part Number	Description
6060005	250V 1A time-delay-fuse (for 100–120 VAC, 2 required)
6060017	250V 0.5A time-delay-fuse (for 220–240 VAC, 2 required)
6177504	Spare key
6060003	Power cord (U.S. style)
2006136	Jumper kit: One short interlock jumper for use when the remote interlocking function is not being used. One long interlock cable for connection to a remote interlock device.
2006137	Operator’s manual for Invictus 785 nm laser

Appendix B. Limited Warranty

Kaiser Optical Systems, Inc. (KOSI) warrants that the product will be free from defects in materials and workmanship when delivered, and will perform in accordance with KOSI specifications on the date of delivery and under normal usage for a period of one year from the date of delivery. KOSI makes no warranty or representation with respect to the quality, performance, merchantability, or fitness for a particular purpose of this product. In no event will KOSI be liable for direct, indirect or consequential damages resulting from any defect in the product or manual even if advised of the possibility of such damages. In particular, but not exclusively, KOSI shall have no liability for any business interruption, loss of business profits, manufacturing degradation, loss of property or personnel.

Kaiser Optical Systems, Inc. will provide telephone consultation for this product during normal U.S. East Coast business hours 8:00 AM to 5:00 PM. Under no circumstances does telephone consultation affect the terms of any warranty agreement.

If the product fails to meet the standards set out in the warranty, KOSI will, at its discretion, repair or replace it. Contact KOSI or the appropriate dealer to obtain the following information: a Return Material Authorization (RMA) number, information regarding any applicable charges, and the address to which the product must be sent. No merchandise will be accepted by KOSI for any reason without an accurate RMA clearly displayed on the shipping label or documentation of the returned merchandise.

Kaiser Optical Systems, Inc.
371 Parkland Plaza
Ann Arbor, MI 48103

Phone: (734) 665-8083 Fax: (734) 665-8199

E-mail: support@kosi.com Website: www.kosi.com

This warranty does not include damage, misuse, negligence, improper installation, unauthorized repair, or adjustments conducted by non-KOSI-authorized operators. Removal of the laser enclosure constitutes immediate termination of the KOSI-offered warranty.

The warranties and remedies set out above are exclusive and in lieu of all other warranties of merchantability, fitness for a particular purpose, and any other warranty whether express, implied, or statutory. No KOSI dealer, value-added reseller, agent, or employee, other than an officer of the company, is authorized to make modification, extension, or addition to this warranty. In the event that any portion of these warranties and remedies are deemed unenforceable, the remaining portions will continue to apply and be enforceable.

Appendix C. Glossary of Terms and Abbreviations

°C	**degrees centigrade or Celsius**
°F	**degrees Fahrenheit**
µW	**microwatts**
AC	**alternating current**
amp	**amperes**
CDRH	**Center for Device and Radiological Health**
CFR	**Code of Federal Regulation**
cm	**centimeters**
CW	**continuous wave**
DC	**direct current**
EMI	**electromagnetic interference**
FCC	**Federal Communications Commission**
Hz	**hertz**
kg	**kilograms**
lbs.	**pounds**
LED	**light-emitting diode**
m	**meters**
mm	**millimeters**
mW	**milliwatts**
nm	**nanometers**
rms	**root mean square**
VAC	**volts, alternating current**

Appendix D. Optional Fiber Optic Coupler

Introduction

Laser light presents special safety hazards not associated with other light sources. All laser users and others present need to be aware of the special properties and dangers involved in laser radiation. Familiarity with the Invictus 785 nm laser and the properties of intense laser radiation will aid in the safe operation of the Invictus 785 nm laser. It is assumed at this point that the user has read **Section 1, Safety**. Invictus 785 nm laser users are advised to follow the precautions listed in Table 1.1.

The integration of the universal fiber coupling assembly to the Invictus laser prevents collimated emission from emerging from the fiber coupling assembly. The fiber coupler is mounted to the front of the laser assembly using four setscrews (location shown in Figure 3.1). Removal of the KOSI universal fiber optic coupler will invalidate any warranty on the injector. The removal of the fiber optic coupler will result in hazardous collimated laser radiation exposure.

Laser safety eyewear is not supplied with the Invictus 785 nm laser. It is the customer's responsibility to supply the correct laser safety eyewear to anyone who will be exposed to the laser radiation. Reputable distributors of laser safety eyewear can recommend the best product for a user's specific needs. The Invictus 785 nm laser should be used in a well-lit room for general safety. Under these conditions, the human eye pupil has a relatively small opening, limiting potentially dangerous laser radiation.

The magnitude of the potential optical hazard from the fiber coupled Invictus 785 nm laser is determined by the maximum average optical power from the fiber optic cable output that could be transmitted through the iris and impinged on the retina. The potential hazard, therefore, varies with the optical distance between the fiber optic cable output and the human eye that is looking directly into the beam.

Laser beams can cause ignition of certain substances such as volatile chemicals. The two mechanisms for ignition theoretically possible are firstly direct heating of the sample to a point causing ignition (this path may require high laser powers) and secondly heating of a contaminant (such as dusts) to a critical point leading to ignition of the sample.

CDRH Features

The universal fiber coupler used in the Invictus 785 nm laser incorporates the following safety features to conform to the United States Government requirements 21 CFR Subchapter (J) as administered by the Center for Devices and Radiological Health, (CDRH).

It should be noted that the CDRH regulations are only applicable within the United States of America.

Protective Housing. The fiber coupler lens is enclosed in a protective housing to prevent human access in excess of the limits of Class I radiation as specified in the Federal Register, July 31, 1975, Part II, Section 1040.10 (f) (1) and Table 1-A except the output beam, which is Class IIIb.

Hazardous Radiation Exposure. The performance of procedures, the use of controls, or the adjusting of the instrument other than as specified in the manual may result in hazardous radiation exposure.

CDRH Classification. Under CDRH regulations the Invictus 785 nm laser when used with the universal fiber coupler is a Class IIIb laser product, with a theoretical maximum operating power of less than 500 mW CW @ 785 nm. Table 1.2 describes the hazard levels associated with different intensities of laser light.

Location of CDRH Labels. Refer to Figure D.1 for descriptions and locations of all CDRH required labels. These include warning labels indicating apertures through which laser radiation is emitted, and labels of certification and identification.

Installation of KOSI fiber coupler

It is required that a trained member of either Kaiser Optical Systems, Inc. (KOSI) or one of its distributors be present for both initial inspection and installation of your KOSI fiber optic coupler onto the Invictus 785 nm laser.

A list of the current approved distributors, distributor location, and KOSI offices are provided in Appendix E.

CAUTION

Removal of the KOSI universal fiber optic coupler will invalidate any warranty on the injector. The removal of the fiber optic coupler will result in hazardous collimated laser radiation exposure.

Optimization of the KOSI Fiber optic Laser Coupler

Fiber coupler. On the front of the Invictus 785 nm laser (see Figure D.1), a black box somewhat larger than 2 inches on a side connects the fiber optic cable to the laser.

Figure D.1 Invictus 785 nm laser showing location of the universal fiber coupler.

The KOSI universal fiber optic coupler is installed at the factory and contains no user-serviceable parts.

Disassembly or removal of the coupler from the laser will result in collimated laser emission being put out into the environment and will invalidate warranty. Only KOSI-trained personnel (or distributors) should remove the fiber coupler.

User Optimization. If laser light is not emerging from the fiber optic cable, check to make sure that the laser power switch has been turned on, the power cable is attached, and that the laser shutter is open.

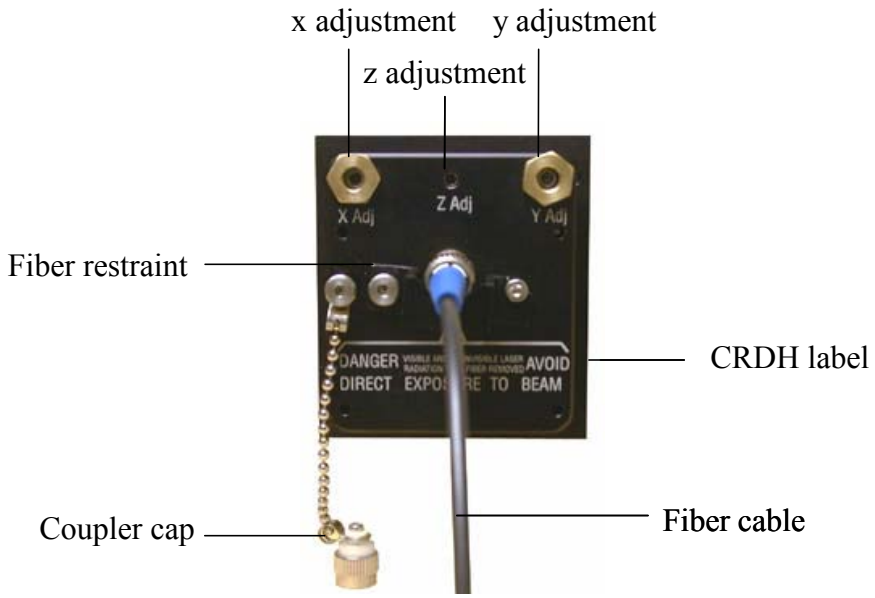

Figure D.2 KOSI fiber coupler assembly (view from the front)

Table D.1 Typical Fiber Power outputs using KOSI fiber coupler with the Invictus 785 nm Laser.

Fiber Core (microns)	Fiber Type	Power Output, mW
50	Graded index, NA = 0.20	175
62.5	Graded index, NA = 0.28	250
100	Graded index, NA = 0.29	275
100	Step index, NA = 0.29	290
5	Single-mode, NA = 0.12	10

If laser light is emerging from the fiber optic cable at a lower power level than expected, it may be necessary to adjust the laser coupling to the fiber optic cable. This procedure is given below and is similar for both single-mode and multi-mode fiber optic cables. Note: the Invictus 785 nm laser is a multi-mode laser, and as such has very low coupling efficiency into a single-mode fiber. A laser power meter is required for this operation.

1. Three setscrews on the front of the injector translate the focused beam in the x, y, and z dimensions with respect to the optical fiber (see Figure D.2). To optimize the coupling of the laser to the fiber optic cable, use a 5/64″ ball driver to first adjust the x and y setscrews separately for maximum laser power at the output of the fiber optic cable. These adjustments can be quite sensitive if a single-mode fiber is being used because the laser spot size is similar to the core diameter of the fiber optic cable. In most cases, this adjustment should be all that is needed to regain laser power intensity. If the power intensity is now near maximum, skip steps 2 and 3.

2. Now use the same ball driver to adjust the z set screw located in the center at the top of the injector. This changes the distance between the focused laser light and the end of the fiber optic cable (the z direction).

3. Once the laser power has been maximized in the z direction, recheck the x and y directions.

If the problem persists, the fibers should be inspected and possibly cleaned.

Cleaning and Inspection of a fiber optic cable

To achieve optimum performance, the fiber optic cable may require occasional cleaning. Contaminants, such as airborne particulates or surrounding vapors, may collect on the fiber face. Laser radiation absorbed by contaminants located on the fiber face can burn the fiber surface, shortening the life of the fiber optic cable. Contaminants on the optical surfaces can also degrade the apparent overall performance of the fiber coupled Invictus 785 nm laser by reducing optical throughput. The fiber surfaces may be inspected and cleaned as follows:

1. Turn off or shutter the Invictus laser.

2. Carefully disconnect the fiber optic cable.

3. Inspect the face of the fiber optic cable using a FC-compatible fiber-scope or a microscope. Illumination of the opposite end of the cable is very helpful by back-illuminating the fiber face. Dark deposits indicate the need for cleaning. Burn marks indicate that the fiber has been damaged. If this has occurred, contact the supplier for a replacement cable or polish the damaged face if expertise and equipment are available.

4. Gently wipe the fiber optic cable face with a clean tissue moistened with a mixture of detergent and water.

5. Remove the detergent residue with a clean lens tissue soaked with water.

6. Moisten a clean lens tissue with reagent-grade methanol and gently wipe across the fiber optic face to remove the water residue.

7. Inspect the clean face of the fiber optic cable. If a deposit is still obvious repeat steps 2–6. If the contaminant cannot be removed or additional damage is evident to the fiber optic cable face, contact the supplier for replacement.

Appendix E. List of Approved Distributors

For UK and Eire
Clairet Scientific Ltd.
17 Scirocco Close

Moulton Park Industrial Estate
Northampton, NN3 6AP
UK
Tel: 01604-494411
Fax: 01604-494499

For South Korea
Doo Ree Tech, Inc
Room 303, Seikang Bldg
430-4 Jangan-Dong
Dongdaemun-Ku
Seoul, 130-101
South Korea
Tel: 011 82 22 242 1877
Fax: 011 82 22 242 1879

For Japan
S.T. Japan, Inc
1-14-10 Kakigawa-Cho
Nihonbashi Chuo-Ku
Tokyo, 103
Japan
Tel: 011-81-3-3666-2561
Fax: 011-81-3-3666-2658

Appendix E (continued) List of Kaiser Optical Systems Offices

For installation in North America
Kaiser Optical Systems, Inc.
371 Parkland Plaza
Ann Arbor, MI 48103
USA
Tel: 1-734-665-8083
Fax: 1-734-665-8199

For installation in mainland Europe
Kaiser Optical Systems, SARL
5 Allée du Moulin Berger - 2ème Etage
69130 Ecully
France
Tel: (33) 4 37 49 90 73
Fax: (33) 4 37 49 91 03

For installation in the rest of the world
Kaiser Optical Systems, Inc.
371 Parkland Plaza
Ann Arbor, MI 48103
USA
Tel: 1-734-665-8083
Fax: 1-734-665-8199