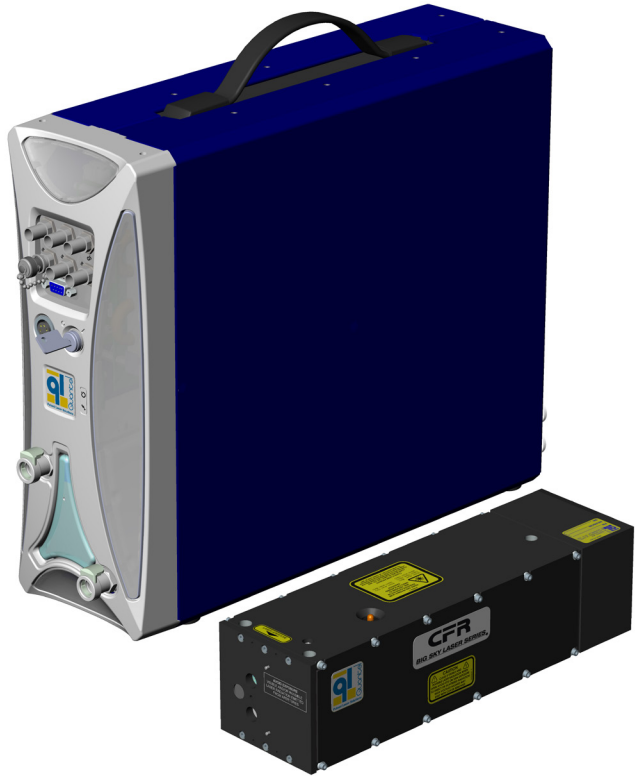
Quantel

User Manual *CFR*

Version K | # DOC00013 April 30, 2015



CFR

BIG SKY LASER SERIES

CE

Tough ■ Rugged ■ Reliable ■ Simply easy to use

Quantel

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CFR User Manual

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CFR

BIG SKY LASER SERIES

User Manual

Document # DOC00013

Version K

April 30, 2015

USER MANUAL

Authorization Memorandum

I have carefully assessed the User Manual for the CFR.
This document has been completed in accordance with the requirements of Quantel.

MANAGEMENT CERTIFICATION

Patrick Quero, April 30, 2015

Quality Director & Regulatory Affairs - Quantel Group

This manual is provided in digital form to conserve paper.
If you need to print this document, please remember to select two-sided printing to help keep paper use to a minimum.

CONTENTS

LASER SAFETY

1.0 Hazard Information

Hazard information includes terms, symbols and instructions used in this manual or on the equipment to alert operating and service personnel to the recommended precautions in the care, use and handling of Class IV laser equipment.

2.0 Terms & Warning Symbols

DANGER	Imminent hazards which, if not avoided, will result in serious injury or death.
WARNING	Potential hazards which, if not avoided, could result in serious injury or death.
CAUTION	Potential hazards which, if not avoided, could result in minor or moderate injury.
CAUTION	Potential hazards which, if not avoided, could result in product damage.
NOTE	Points of particular interest for more efficient or convenient equipment operation; additional information or explanation concerning the subject under discussion.
WARNING: LASER RADIATION	Avoid exposure of eyes or skin to direct or diffused laser radiation. Permanent eye damage or blindness may occur.
WARNING: HIGH VOLTAGE	Electric shocks and burns from capacitor discharge or power circuits could lead to serious injury or even death.

3.0 Acronyms and Abbreviations

AEL: Accessible Emission Limits

BNC: Bayonet Neill-Concelman RF connector often used with coaxial cable

CFR: Compact Folded Resonator

GRM: Gaussian-Reflectivity Mirror

HSP: High Spectral Purity

ICE: Integrated Cooling and Electronics (Laser Power Supply)

I/O: Input/Output

IR: Infrared

KTP: Potassium Titanyl Phosphate

LASER: Light Amplification by Stimulated Emission of Radiation

MVAT: Motorized Variable Attenuator

Nd:YAG: Neodymium-doped Yttrium Aluminum Garnet

NLO: Nonlinear Optic

OPO: Optical Parametric Oscillator

PRF: Pulse Repetition Frequency

PFN: Pulse Forming Network

RB: Remote Box

UHP: Ultra High Purity

WS: Wavelength Separation

Dimensions listed in this manual are:
U.S. Standard Units inches [SI Metric mm].

4.0 General Hazards

The following descriptions are of general hazards and unsafe practices that may result in product damage, severe injury or death. Other more specific warnings and cautions are presented as appropriate throughout this manual.

	**DANGER Serious Personal Injury**	This Class IV laser configures to emit 1064nm, 532nm, 355nm, 266nm or 1.57µm laser radiation. Do not allow laser radiation to enter the eye by viewing direct or reflected laser energy. Laser radiation may be reflected from various surfaces; care should be taken to avoid inadvertent reflection of laser energy while working with the laser. Wear appropriate protective eye-wear when working in an area with an exposed laser beam. Avoid looking directly into the laser output aperture or at reflections of the beam from other surfaces.
	**DANGER Serious Personal Injury**	This product is not intended for use in explosive, or potentially explosive, atmospheres.
	**WARNING Serious Personal Injury**	U.S. customers should refer to and follow the laser safety precautions described in the American National Standards Institute (ANSI) Z136.1-2014 document, Safe Use of Lasers. Procedures listed in this Standard include the appointment of a Laser Safety Officer (LSO), operation of the product in an area of limited access by trained personnel, servicing of equipment only by trained and authorized personnel, and posting of signs warning of the potential hazards. European customers should appoint a Laser Safety Officer (LSO) who should refer to and follow the laser safety precautions described in EN 60825-1,2007 – Safety of Laser Products
	**WARNING Serious Personal Injury**	Materials processing with a laser can generate air contaminants such as vapors, fumes, and/or particles that may be noxious, toxic, or even fatal. Material Safety Data Sheets (MSDS) for materials being processed should be thoroughly evaluated and the adequacy of provisions for fume extraction, filtering, and venting should be carefully considered. Review the following references for further information on exposure criteria: ANSI Z136.1-2014, Safe Use of Lasers, section 7.3. U.S. Government's Code of Federal Regulations: 29 CFR1910, Subpart Z. Threshold Limit Values (TLVs) published by the American Conference of Governmental Industrial Hygienists (ACGIH). It may be necessary to consult with local governmental agencies regarding restrictions on the venting of processing vapors.

5.0 Other Hazards

The following hazards may be considered typical for this product:

- Risk of exposure to hazardous laser energy and injury through failure to follow appropriate laser safety procedures.
- Risk of exposure to hazardous laser energy through unauthorized removal of protective covers.
- Risk of exposure to hazardous or lethal voltages through unauthorized removal of protective covers.
- Risk of injury when lifting or moving the unit.

6.0 Safe Operation of the Laser

1. Never look at the direct beam from the laser or one of its reflections. No visual alignment should be made when the electric power supply of the laser is ON. Permanent eye damage or blindness may result.
2. Always wear appropriate protective eyewear. Refer to **Protective Eyewear on page 4** for important wavelength information. Refer to **Additional Safety Information on page 4** for additional standards information.
3. Prevent exposing any part of the body to the beam. Never block the laser beam with any part of the body.
4. Limit work area access to the required personnel only. Only use the laser in supervised areas, which are clearly marked and have supervised access.
5. Remove all objects with a reflecting or shiny surface from the work area, as well as all flammable materials.
6. Do not wear reflective jewelry while using the laser, as it may cause hazardous reflections.
7. Maintain a high level of ambient lighting in the laser operation area so the eye pupil remains constricted, reducing the possibility of hazardous exposure.
8. Place warning signs at all work area accesses. The signs must be appropriate and clearly visible. It is recommended that work area accesses be interconnected to the Laser Remote Interlock.
9. During normal operation, the laser area (work area) must be marked off by screens, walls or other means that ensure that laser beams outside the area are less than the AEL (class 1 type laser). These screens must **not** be covered by materials that may reflect the laser wavelength. They must not be flammable, nor may they, when exposed to the direct laser beam (even only for several seconds), allow laser radiation greater than the AEL limit to pass.
   A warning area limited by barriers is necessary to warn all people of the potential risk that lies within the laser area.
10. Only qualified people may operate the laser. When not in use, the laser must be completely inoperable. This may be done by removing the laser key, for example. It must be impossible for unauthorized people to operate the laser.
11. Aiming laser radiation at individuals, vehicles, aircraft or any other flying object is prohibited by federal regulations.
12. Due to the risk of electric shock, the power supply must be switched off and disconnected from the Laser Head prior to any maintenance operation. Electric shocks or burns resulting from the power supply may cause serious injury or death.
13. Operate the laser at the lowest possible beam intensity, given the requirements of the intended application.
14. Increase the beam diameter wherever possible to reduce beam intensity and thus reduce the hazard.
15. Use an IR detector or energy detector to verify that the laser beam is off before working in front of the laser.
16. Provide enclosures for the beam path whenever possible.
17. Set up an energy absorber to capture the laser beam, preventing unnecessary reflections or scattering.

7.0 Protective Eyewear

Always wear appropriate protective eyewear when operating the laser.

Choose eye protection that is suited to the operation of the laser, taking into consideration emission wavelength, power/energy, and viewing conditions. See energy density ratings, safety reference EN 207, and OSHA's online technical manual for information on selecting proper eye protection.

CFR System Information for Protective Eyewear Selection

Wavelength (nm)	Maximum Energy Density (J/m^2)
1574	2600
1064	13000
532	7900
355	3900
266	2500

8.0 Additional Safety Information

There are several public resources for good laser safety information.

United States

- The American National Standards Institute (ANSI) Z136.1-2014 document Safe Use of Lasers prescribes procedures intended to promote safety in using lasers. The document describes practices such as the appointment of a Laser Safety Officer (LSO), operation of the equipment only by trained personnel and in an area of limited access, equipment servicing only by trained and authorized personnel, and appropriate use of warning signs to increase awareness of potential hazards.
- The Occupational Safety and Health Administration (OSHA) provides an online Technical Manual (located at www.osha.gov/dts/osta/otm/otm_iii/otm_iii_6.html). Specifically, Section III, Chapter 6 and Appendix III contain specific laser safety information.
- The Laser Institute of America (LIA) has a comprehensive web site (located at www.laserinstitute.org).

Europe

- Norm EN 60825-1 - Safety of laser products, Part 1: Equipment classification, requirements and user guide
- Norm EN 207 - Personal eye protection - Filters and eye protectors against laser radiation
- Norm EN 208 - Personal eye protection - Eye protector for adjustment work on lasers and lasers systems

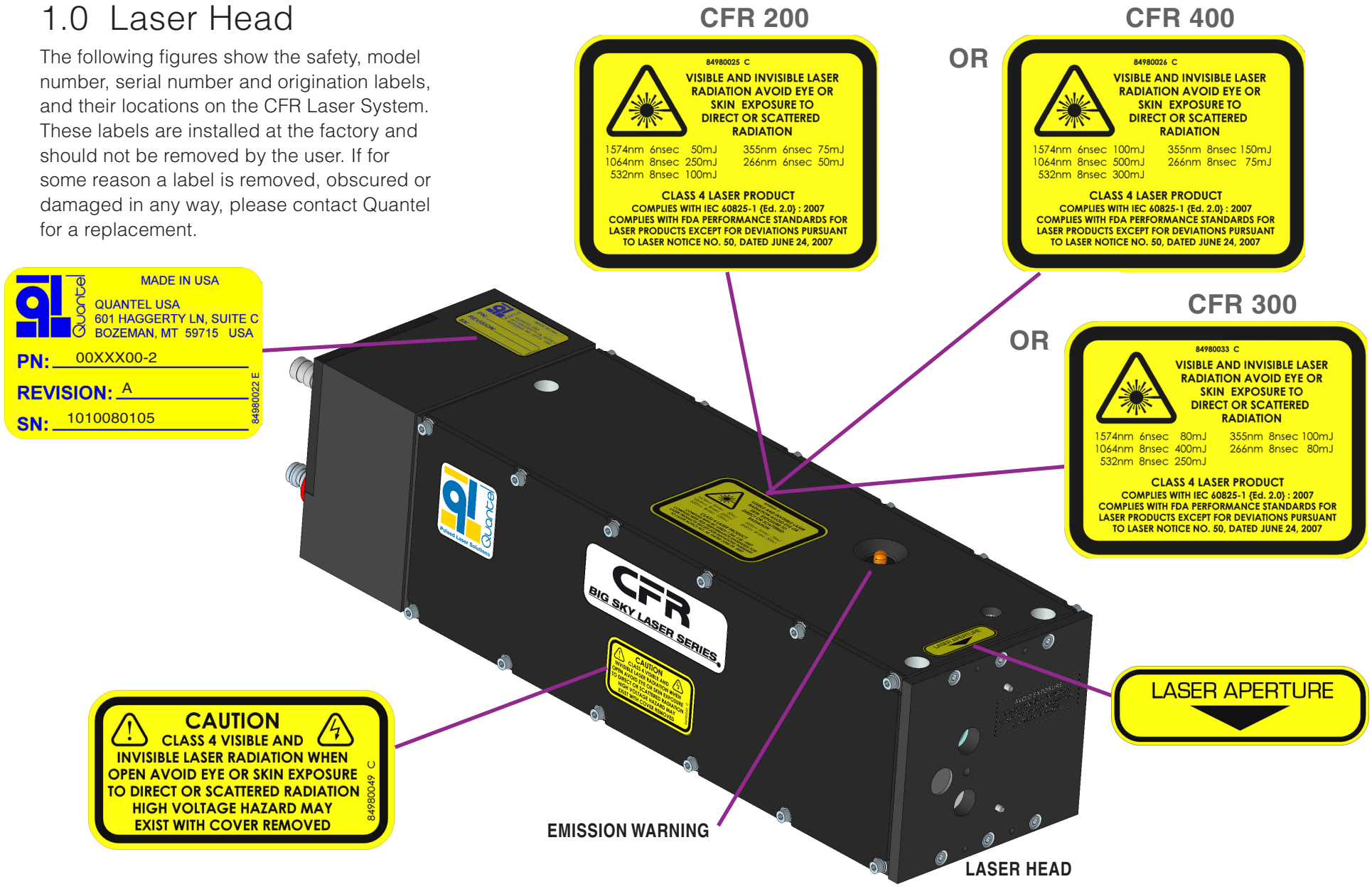
9.0 Disposal

This product contains material that is considered hazardous industrial waste. If for any reason a laser is rendered unusable and is not repairable, Quantel recommends that disposal of the system follow all appropriate guidelines for such hazardous waste to prevent environmental degradation. This product, must be disposed of separately from domestic household waste.

SAFETY LABELS

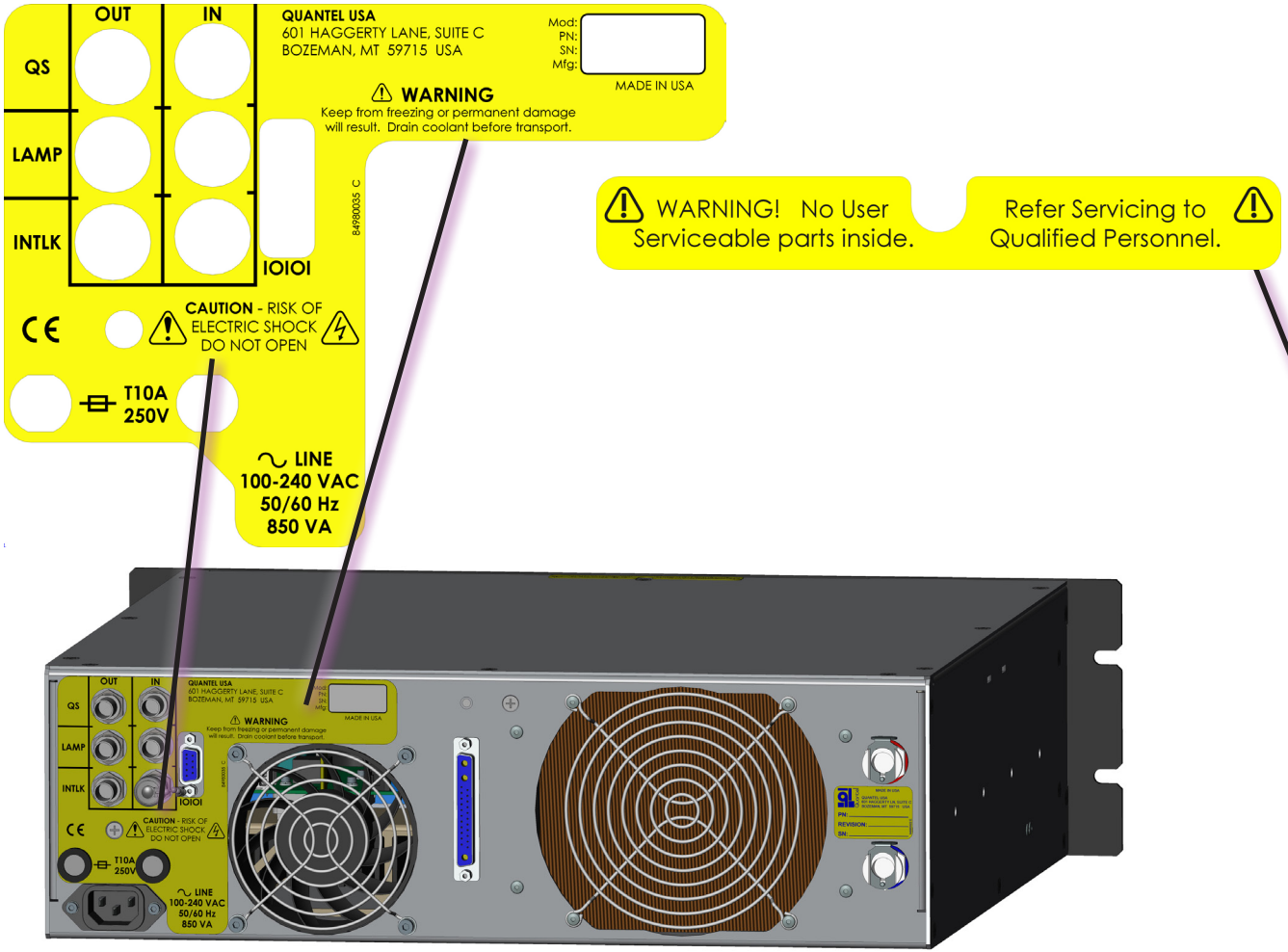
1.0 Laser Head

The following figures show the safety, model number, serial number and origination labels, and their locations on the CFR Laser System. These labels are installed at the factory and should not be removed by the user. If for some reason a label is removed, obscured or damaged in any way, please contact Quantel for a replacement.

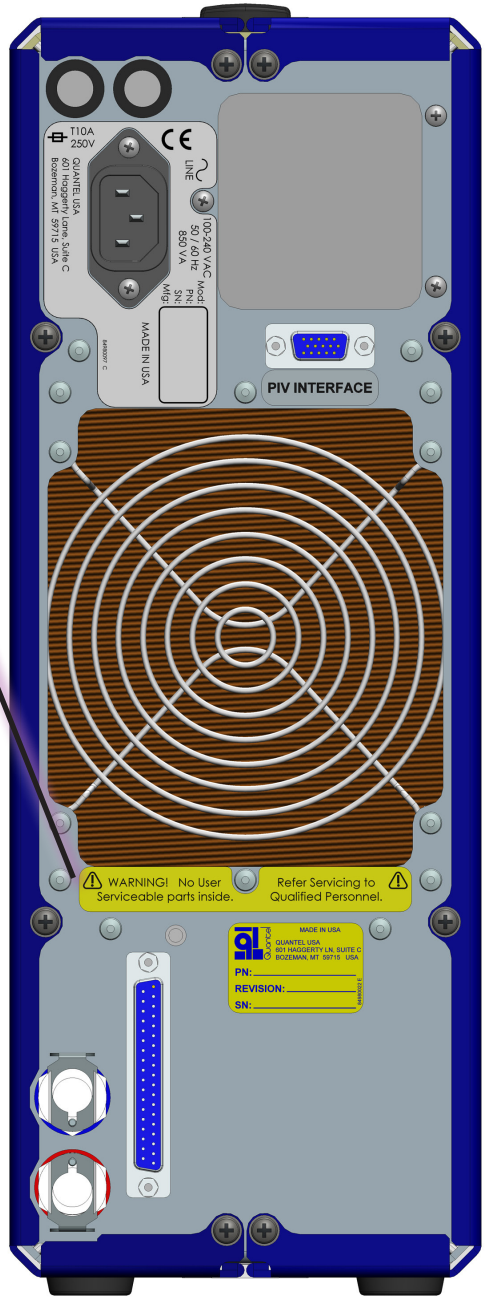


2.0 ICE450

The following images show the safety labels, and their locations on the CFR Laser System. These labels are installed at the factory and should not be removed by the user. If for some reason a label is removed, obscured or damaged in any way, please contact Quantel for a replacement.



19" RACK ICE450 BACK PANEL

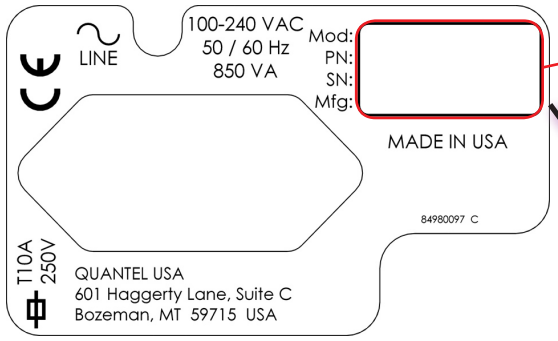


ICE450 BACK PANEL

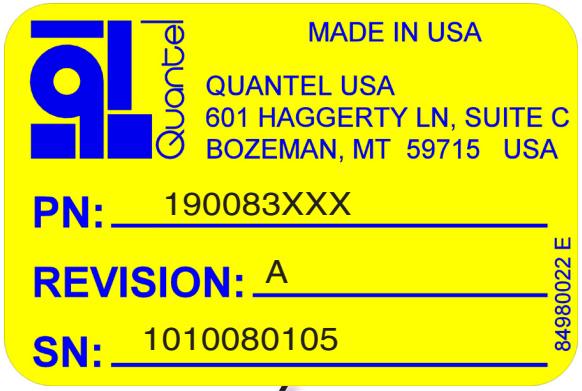
3.0 Part/Serial Numbers

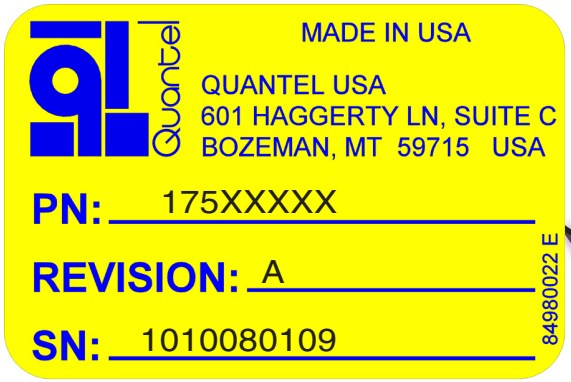
The CFR Laser System has the following labels with product serial numbers and information:

- **System Origination Labels**
  (located on the ICE450 upright or rack style)
- **Part Number Labels**
  (located on the Laser Head and ICE450



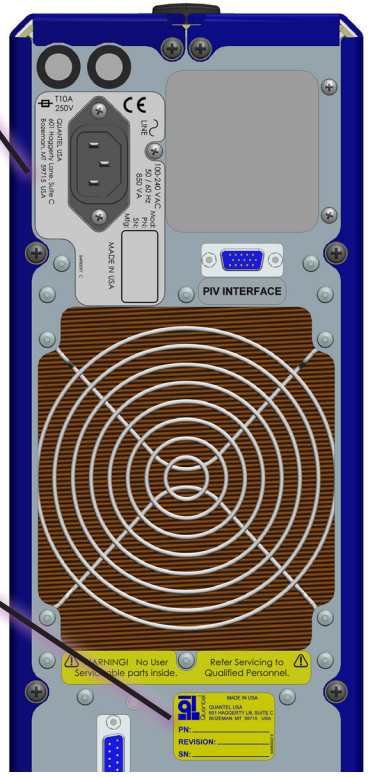
Have this serial number ready when you call customer service.





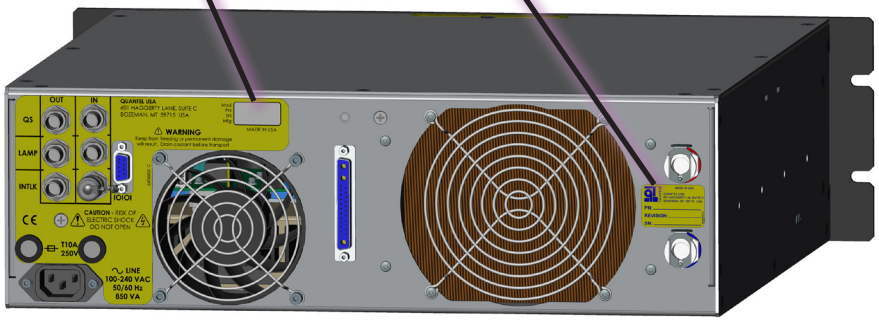
SYSTEM ORIGINATION LABEL

LASER HEAD PART NUMBER LABEL



ICE450 LABEL LOCATION

Have this serial number ready when you call customer service.



RACK ICE450 LABEL LOCATION

SETUP

1.0 Mounting the Laser Head

Secure the Laser Head to a flat mounting surface using three (3) 8-32 UNC or M4 screws with a minimum length of 7/16" (10mm). It is important that the mounting surface be flat, to prevent distortion of the Laser Head and subsequent misalignment of the resonator. The hole and slot allow mating to dowel pins in the mounting surface.

Note: See details for WS2, WS3 wavelength separation, High Purity and OPO options under **Optional Equipment starting on page 57** and **Drawings starting on page 68**.

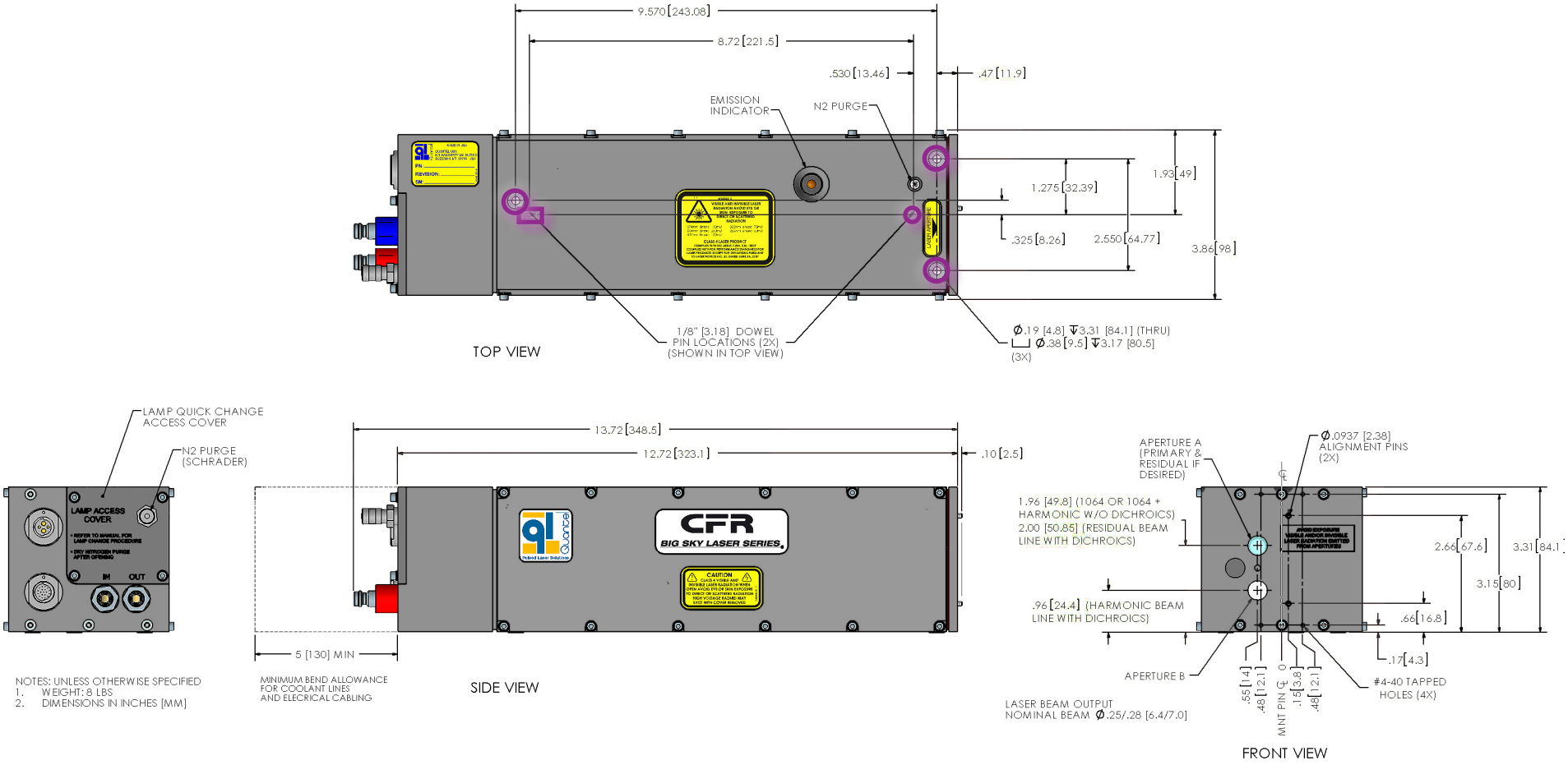


Figure 1: Laser Head Exterior Feature Locations

2.0 Connecting

Standard Upright CFR System

CAUTION: Do not power up the laser system before thoroughly reading the installation and operation instructions.

1. Verify that the ICE Key Switch is turned OFF.
2. Connect the I/O cable between the ICE rear panel and the Laser Head. All connectors are unique and keyed to ensure proper connection. Secure all non-locking connectors using the captive fasteners.

CAUTION: These connections carry high voltage and high current. Ensure that the connectors are fully inserted and the collars or screw locks are fully engaged or interlock faults may result.

3. Remove the blue plastic shipping covers from the coolant ports. Keep them for reuse.
4. Connect the coolant lines between the back panel of the ICE and the Laser Head. Connect red to red and blue to blue. Coolant flows from the ICE into the Laser Head via the blue hose and returns to the ICE via the red hose.
5. Verify that the Emergency Stop switch on the Remote Box is in the OUT position.
6. Connect the Remote Box to the ICE front panel.
7. Connect the AC Mains power cable from the ICE back panel to 100-240 VAC, 50/60 Hz power.

CAUTION: Ensure the system is connected to the proper voltage. The voltage rating is marked on the ICE back panel. Operating the system at the incorrect voltage may damage the system. Ensure that the power outlet used is properly grounded.

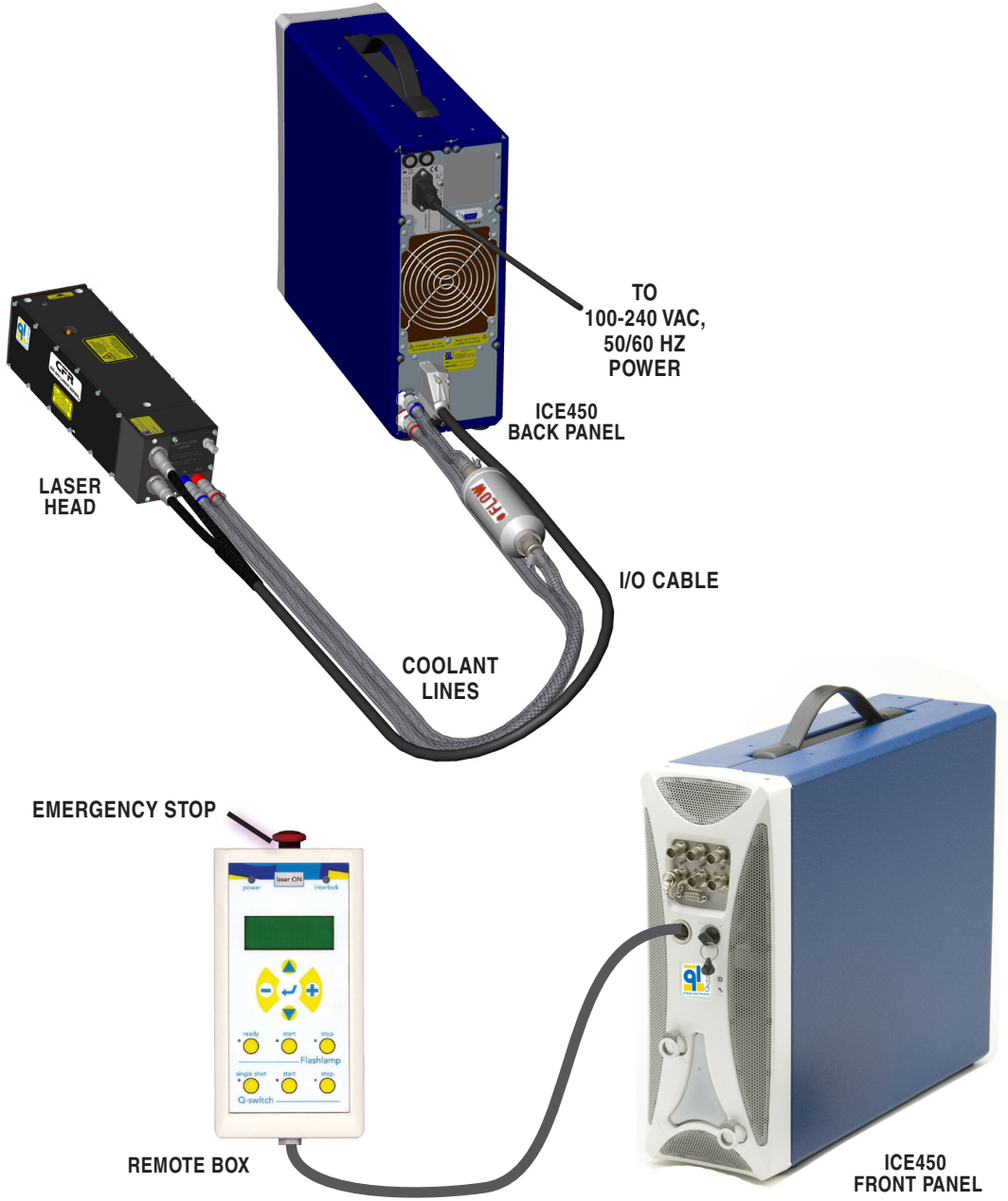


Figure 2: Connecting a Standard CFR System

Connecting a Rack ICE450

CAUTION: Do not power up the laser system before thoroughly reading the installation and operation instructions.

1. Verify that the ICE Key Switch is turned OFF.
2. Connect the I/O cable between the ICE rear panel and the Laser Head. All connectors are unique and keyed to ensure proper connection. Secure all non-locking connectors using the captive fasteners.

CAUTION: These connections carry high voltage and high current. It is necessary to fully insert the mating connector and fully engage the collars or screw locks or interlock faults may result.

3. Remove the blue plastic shipping covers from the coolant ports. Keep them for reuse.
4. Connect the coolant lines between the back panel of the ICE and the Laser Head. Connect red to red and blue to blue. Coolant flows from the ICE into the Laser Head via the blue hose and returns to the ICE via the red hose.
5. Verify that the Emergency Stop switch on the Remote Box is in the OUT position.
6. Connect the Remote Box to the ICE front panel.
7. Connect the AC Mains power cable from the ICE back panel to 100-240 VAC, 50/60 Hz power.

CAUTION: Ensure the system is connected to the proper voltage. The voltage rating is marked on the ICE back panel. Operating the system at the incorrect voltage may damage the system. Ensure that the power outlet used is properly grounded.

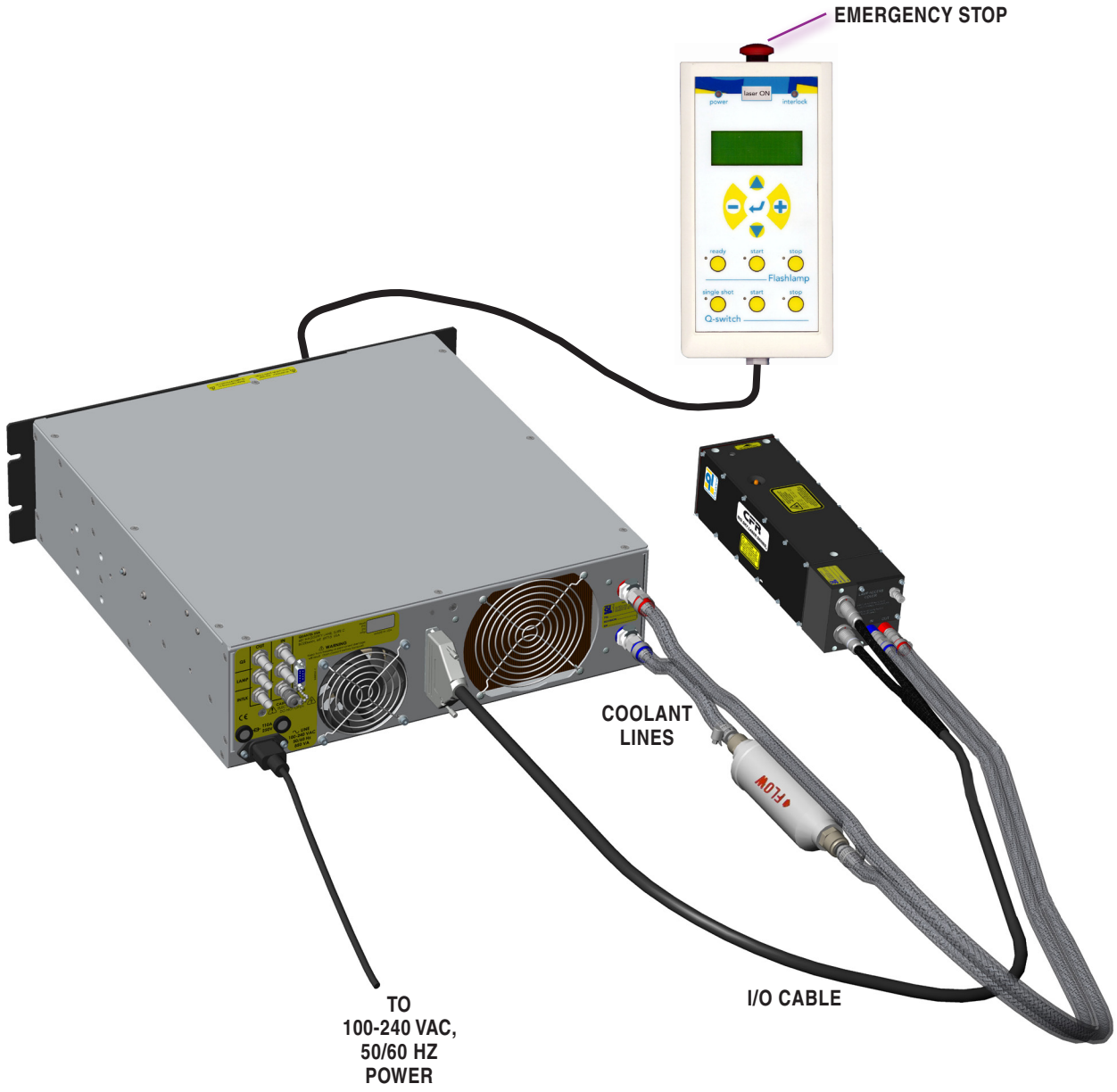


Figure 3: Connecting a Rack ICE450 CFR System

3.0 Filling the Standard ICE450

CAUTION: Do not operate the system until it has been filled. Running the pump without coolant may damage the pump.
Do NOT disable the coolant pump. The ICE 450 uses an internal heat exchanger to aid in cooling power components. Even when the laser is not operating, components are active and require cooling.

Complete all preliminary steps prior to laser operation, including visual inspection for damage, filling coolant, properly connecting all cables, and performing all laser safety precautions.

Always drain the system before shipping or storage. See **Draining the ICE450 starting on page 75**

Use only distilled water with 1MΩ-cm to 5MΩ-cm resistivity.

1. Connect the fill/drain tube and vent tube to the fill/drain bottle. Press firmly until you hear the fitting snap into place.
2. Connect the fill/drain tube to the ICE front panel Fill/Drain fitting. Connect the vent tube to the ICE Vent fitting.
3. Remove the cap and fill the bottle with the approved coolant.
4. Raise the bottle higher than the ICE reservoir. Keep the fill bottle cap loose.
5. Allow coolant to flow into the ICE reservoir until it rises into the vent tube.
6. Turn the Key Switch ON (“I”) to power the system.
   The pump turns ON automatically when the system is powered ON. Coolant from the ICE reservoir flows into the coolant lines. When the coolant falls below the minimum level, the pump automatically turns OFF and the reservoir-level window lights blink.
7. Using the Remote Box System menu, set the pump to Fill mode. See **Pump on page 27**.
8. Refill the bottle. Continue adding coolant until the level is well above the reservoir-level window minimum mark. When the fluid level is sufficient, the pump automatically turns ON and again fills the lines with coolant.

Note: If more than three pump cycles are needed to fill the lines, turn the power OFF. Wait five seconds, then turn the system ON again.
The reservoir-level light remains ON whenever the coolant is above the required minimum.

9. Filling is complete when the coolant level is stable and the pump remains ON.
10. Using the Remote Box System menu, set the pump to Normal mode. See **Pump on page 27**.
11. Replace the fill/drain bottle reservoir cap.
12. Disconnect the fill/drain bottle from the ICE front panel. The tubing from the fill/drain bottle may leak. Have a container ready.
13. Purge air bubbles from the Laser Head by tilting it vertically with the coolant circulating for 10 seconds.
14. Ensure that any air trapped inside the pump-cavity is removed. Do this by repeating the process of cycling the pump and tilting the laser head until no air remains (about 2 minutes).

Note: Any time the Laser Head has been disconnected and reconnected, follow this procedure to purge all of the air from the Laser Head and coolant lines before operating the laser.

15. Remove the protective cover from the Laser Head aperture before operating.

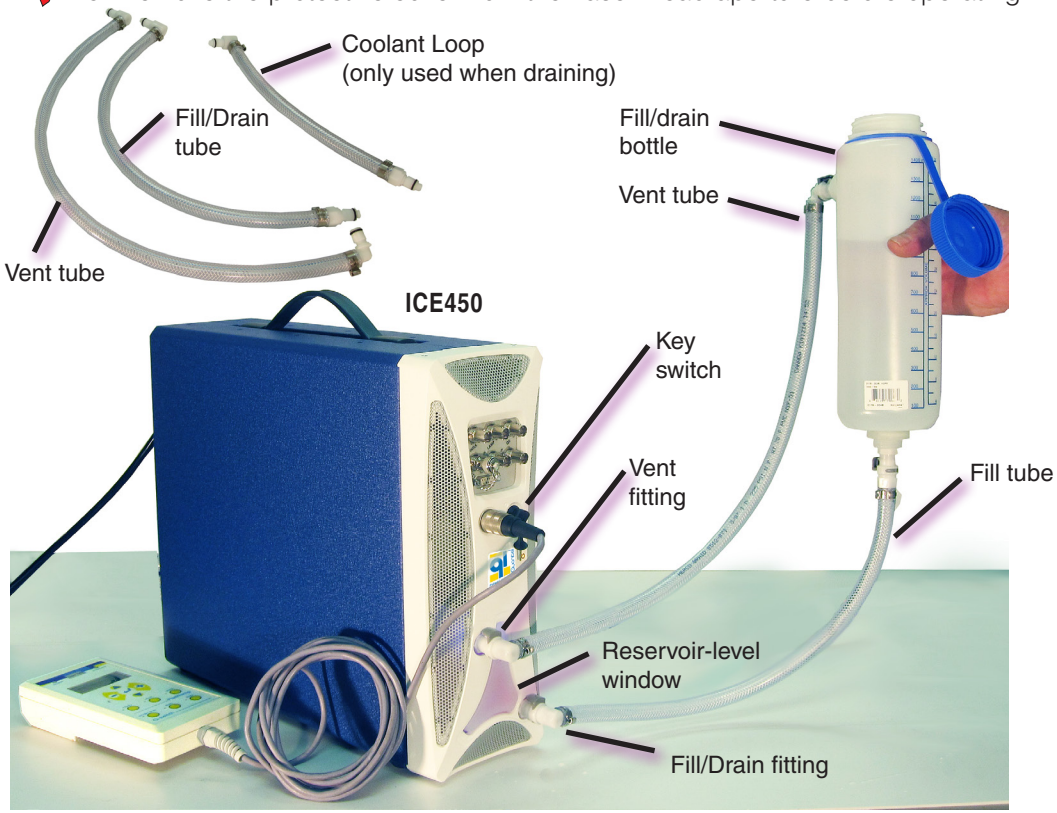


Figure 4: Filling a Standard ICE450

4.0 Filling the Rack ICE450

CAUTION: Do not operate the system until it has been filled. Running the pump without coolant may damage the pump.

Complete all preliminary steps prior to laser operation, including visual inspection for damage, filling coolant, properly connecting all cables, and performing all laser safety precautions.

Always drain the system before shipping or storage. See **Draining a Rack ICE450 on page 77**.

Use only distilled water with 1MΩ-cm to 5MΩ-cm resistivity.

1. Connect the fill/drain tube and vent tube to the fill/drain bottle. Press firmly until you hear the fitting snap into place.
2. Connect the fill/drain tube to the ICE front panel Fill/Drain fitting. Connect the vent tube to the ICE Vent fitting.
3. Remove the cap and fill the bottle with the approved coolant.
4. Raise the bottle higher than the ICE reservoir. Keep the fill bottle cap loose.
5. Allow coolant to flow into the ICE reservoir until it rises into the vent tube.
6. Turn the Key Switch ON (“I”) to power the system.
   The pump turns ON automatically when the system is powered ON. Coolant from the ICE reservoir flows into the coolant lines. When the coolant falls below the minimum level, the pump automatically turns OFF and the reservoir-level window lights blink.
7. Using the Remote Box System menu, set the pump to Fill mode. See **Pump on page 27**.
8. Refill the bottle. Continue adding coolant until the level is well above the reservoir-level window minimum line. When the fluid level is sufficient, the pump automatically turns ON and again fills the lines with coolant.

Note: If it takes more than three pump cycles to fill the lines, turn the power OFF. Wait five seconds, then turn the system ON again. The reservoir-level lights remain ON whenever the coolant is above the required minimum.

9. Filling is complete when the coolant level is stable and the pump remains ON.
10. Replace the fill/drain bottle reservoir cap and disconnect the fill/drain bottle from the ICE front panel.
11. Purge air bubbles from the Laser Head by tilting it vertically with the coolant circulating for 10 seconds.
12. Ensure that any air trapped inside the pump-cavity is removed. Do this by repeating the process of cycling the pump and tilting the laser head until no air remains (about 2 minutes).

Note: Any time the Laser Head has been disconnected and reconnected, follow this procedure to purge all of the air from the Laser Head and coolant lines before operating the laser.

13. Remove the protective cover from the Laser Head aperture before operating.

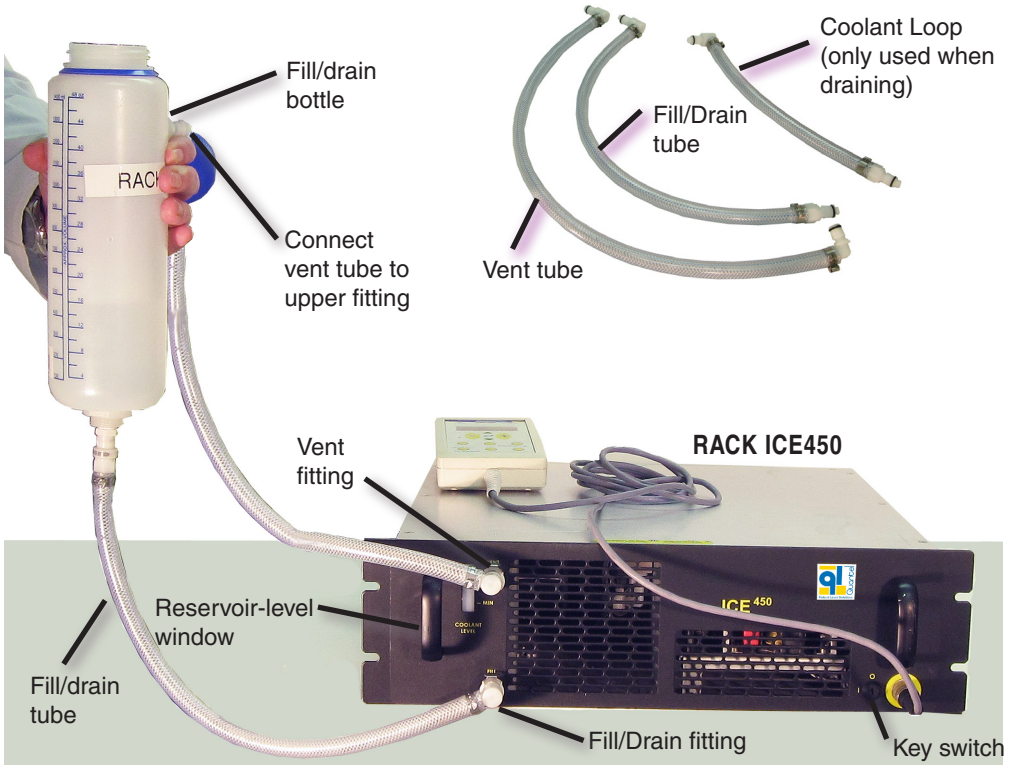


Figure 5: Filling a Rack ICE450

FUNCTIONS

1.0 ICE450 Front Panel Controls

Key Switch

ON: To turn the ICE450 ON, rotate the key to the ON (“I”) position. With the Key Switch in the ON position, the laser system is ready for use. The key is not removable when in the ON position.

OFF: To turn the ICE450 OFF, rotate the key to the OFF (“O”) position. Remove the key to keep unauthorized personnel from operating the laser.

Power ON Indicator

This indicator illuminates when the Key Switch is ON and the unit is connected to 100–240VAC, 50/60 Hz AC Mains power. The indicator light is amber colored to ensure visibility through laser safety goggles.

Emission Warning

When high voltage is activated, or when the simmer supply enables, this indicator illuminates as a warning that laser output is possible. The indicator light is amber colored to ensure visibility through laser safety goggles. The user must observe laser safety precautions when the Emission Warning indicator is ON.

Remote Box Interface (RB)

Use this input to connect the Remote Box for access to settings and operating parameters.

Note: The Emergency Stop button is on the Remote Box. The Remote Box must be connected to the ICE450 or the laser will not operate.

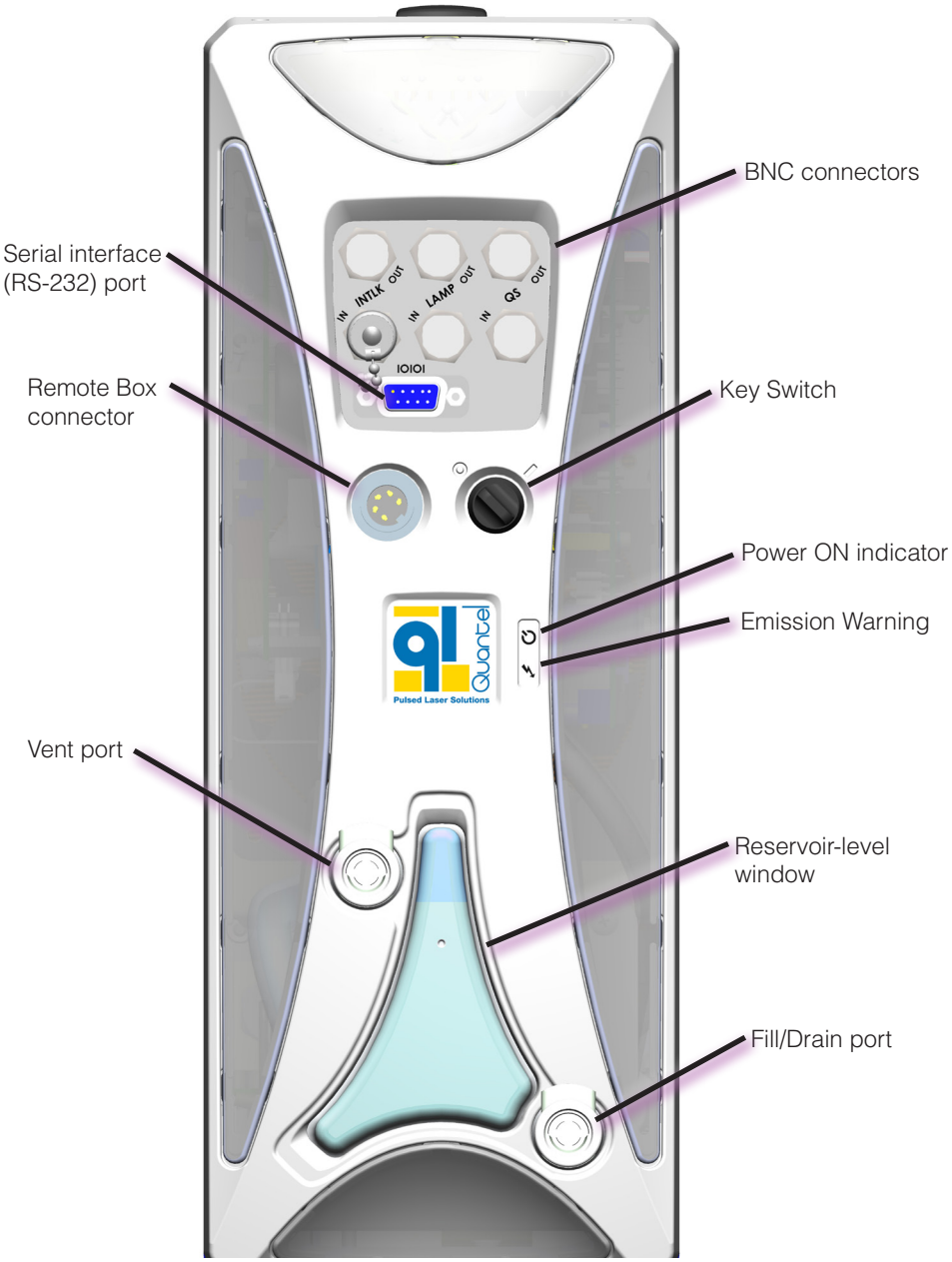


Figure 6: ICE450 Front Panel

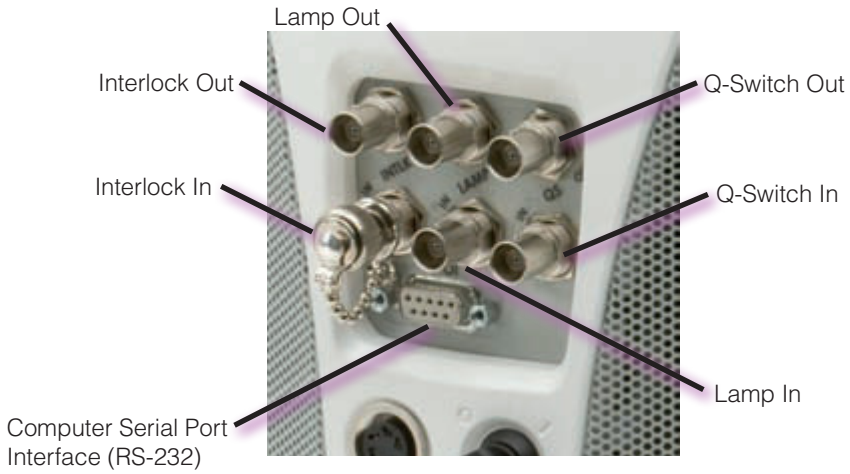


Figure 7: BNC Connector Locations ICE450

BNC Connectors

Interlock In (Remote Interlock): Use this BNC to connect an external safety shutdown switch. For the laser to operate, this connector must be shorted. When this circuit is open, the ICE450 high voltage is disabled and discharges in less than 5 seconds. Install the attached BNC shorting cap on this connector if this function is unnecessary.

Note: Multiple safety switches must be in a series connection.

Interlock Out: Use this BNC output to connect an external laser-warning indicator. The signal output is low (pulled to ground) when the laser is disabled. When the laser high voltage is enabled, this connection outputs +15 VDC and up to 150mA.

CAUTION: This output is not short-circuit protected.

Lamp In: This is a 50Ω-terminated input. A signal applied to this BNC connector causes the flashlamp to fire if External Flashlamp Trigger Mode is selected using the Remote Box or the serial interface. The source of this signal must be capable of supplying a pulse with the following characteristics: (See **External Trigger Signal Requirements on page 53** for details.)

- Amplitude: +5V, acceptable range: {3.0V-5.0V}
- Pulse-width: 100µsec minimum

Lamp Out: Use this BNC connector to synchronize with the laser flashlamp trigger signal. Flashlamp firing corresponds with the rising edge of this positive signal, which is 5V, 50mA max, and greater than 10µS pulse width.

Q-Switch In: This is a 50Ω-terminated input. A signal applied to this BNC connector causes the Q-Switch to trigger if External Q-Switch Trigger Mode is selected using the Remote Box or the serial interface. The source of this signal must be capable of supplying a pulse with the following characteristics (See **External Trigger Signal Requirements on page 53** for details.)

- Amplitude: +5V, acceptable range: {3.0V-5.0V}
- Pulse-width: 100µsec minimum

Q-Switch Out: This BNC connector allows synchronization with the laser Q-Switch trigger. The Q-Switch trigger corresponds to the rising edge of this positive signal (5V, 50 mA max, and greater than 10µS pulse width).

Computer Serial Port Interface (RS-232): Use this DE-9S D-Sub connector to operate the system by remote computer control using the standard RS-232 interface. See **Software on page 36** for details on port configuration and the command set.

Note: To disable remote computer control, press any button on the Remote Box.

2.0 ICE450 Rear Panel

AC Mains Power

AC Mains Power Input: Industry standard IEC 60320-power connector for AC Mains power at 100-240 VAC, 50/60 Hz, 850VA.

Fuses: These fuses disconnect the ICE450 from AC Mains power in the event of an electrical fault. The label next to the fuse holder specifies the fuse type and rating.

CAUTION: Replace the fuses with the specified fuse only. See **Replacing the ICE450 Fuses on page 80**. Failure to do so may result in equipment damage or personal injury. For your safety, disconnect the power cord before servicing fuses.

Coolant Ports

Coolant OUT Port: Connect the blue coolant line to provide coolant to the Laser Head.

Coolant IN Port: Connect the red coolant line to provide the coolant return from the Laser Head.

Rear Panel Options

See **Optional Equipment on page 57** for more details.

Auxiliary I/O Connection Ports: (Available on some models.) System Interlock, Lamp Sync, Q-Switch Sync, and RS-232 Port connectors are factory-installed options.

PIV Interface: (Available on some models.) A DA-15S-HD, D-Sub connector provides fault interlock and serial communications between the Master and Slave ICE450 in a dual enclosure PIV system. Contact **Quantel Customer Service** for more information.

External I/O Port #1: The CBD25W3F, D-Sub mixed contact connector provides the interface to the Laser Head.

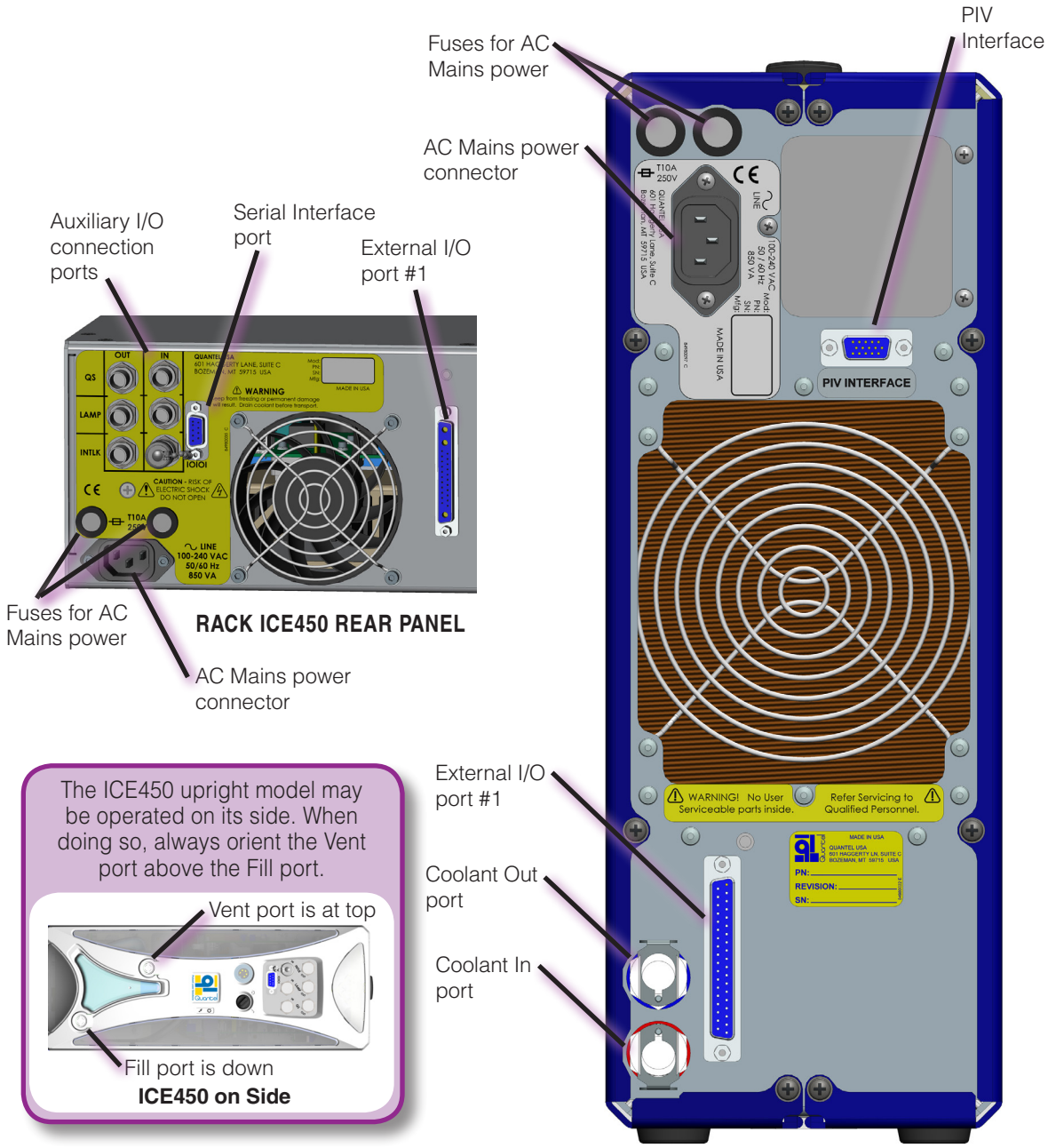


Figure 8: ICE450 Rear Panel

OPERATION

1.0 Safety

CAUTION: Obey all safety procedures described in the Safety section of this manual.

CAUTION: Wear eye protection. Obey safety precautions as though the system is capable of lasing at anytime.

2.0 Precautions

Follow these guidelines to avoid laser damage.

- Store the laser in a dust-free environment. Keep the Laser Head covered when not in use. This protects the output window from dust and particulate.
- The Laser Head is sealed using low-outgassing materials. Silicone and similar sealing, bonding or insulating materials should not be used in close proximity to the Laser Head since these substances will outgas and could contaminate the output window, causing laser damage.
- Avoid back reflections. Back reflections of even a small percentage of the output energy can damage optical components in the Laser Head.

  Example: An uncoated convex lens or a glass disk calorimeter reflects about 4% of the incident energy. While the reflection may seem harmless, it can perturb the resonator operation and degrade the near-field beam intensity profile and damage laser optics. It may also affect the resonator holdoff, causing prelasing and catastrophic optical damage. In some cases, even anti-reflection coated glass optics reflect enough energy to damage laser optics. It is best to use only quality optics coated for the operating wavelength.

CAUTION: To avoid laser damage, minimize back reflections of the output beam. When reflections are unavoidable, direct them away from the optical axis of the system by canting the optics off-axis. Failure to do so can cause laser damage and void the warranty.

3.0 Remote Interlock

The Remote Interlock BNC connector (Interlock IN) provides an interface for an external safety shutdown switch. The Remote Interlock can be connected to a lab door or other system outputs for safety purposes. When using the Remote Interlock, only an isolated switch, such as a relay, should be used in order to avoid ground loops. If external safety switches are used, it is important that they are connected in series.

The Remote Interlock connection must be completed in order to operate the laser. If an open circuit occurs, the ICE high voltage is disabled and the Fault indicator shows illuminated.

The system is shipped with the BNC shorting cap attached on this connector. Leave this connector in place if this function is not needed.

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

4.0 Emission Warning

The Emission Warning indicator illuminates when the electronic shutter is ON (Open).

5.0 Electronic Shutter

CAUTION: If the electronic shutter is ON (Open), take precautions as though the laser is capable of lasing, regardless of any other status.

The ICE450 provides control of the electronic shutter via the Remote Box or through serial commands.

From the Remote Box Main menu, scroll to

>Shutter ON/OFF

Use the “Increase/Decrease Value” buttons to toggle between ON and OFF.

OFF (Closed)	OFF closes the shutter. The Emission Warning indicator on the Laser Head is off when the shutter is off.
ON (Open)	ON indicates the shutter is open. The Emission Warning indicator on the top of the Laser Head illuminates when the shutter is open. The laser is capable of firing.

Shutter Function		
	with Shutter set to OFF	**with Shutter set to ON**
Q-switch start button	Pressing Q-switch start does **not** automatically open the shutter. Use the Remote Box menu to control the shutter.	Pressing Q-switch start begins Q-Switch operation and lasing output occurs. The shutter remains in the current state (Open).
Q-switch stop button	Q-Switch operation ceases. The shutter remains in the current state (Closed).	Q-Switch operation ceases. The shutter remains in the current state (Open).
Flashlamp start button	Flashlamp operation starts. The shutter remains its its current state (Closed).	Flashlamp operation starts. The shutter remains its its current state (Open).
Flashlamp stop button	Flashlamp operation stops. The shutter remains its its current state (Closed).	Flashlamp operation stops. The shutter switches to OFF (Closed).

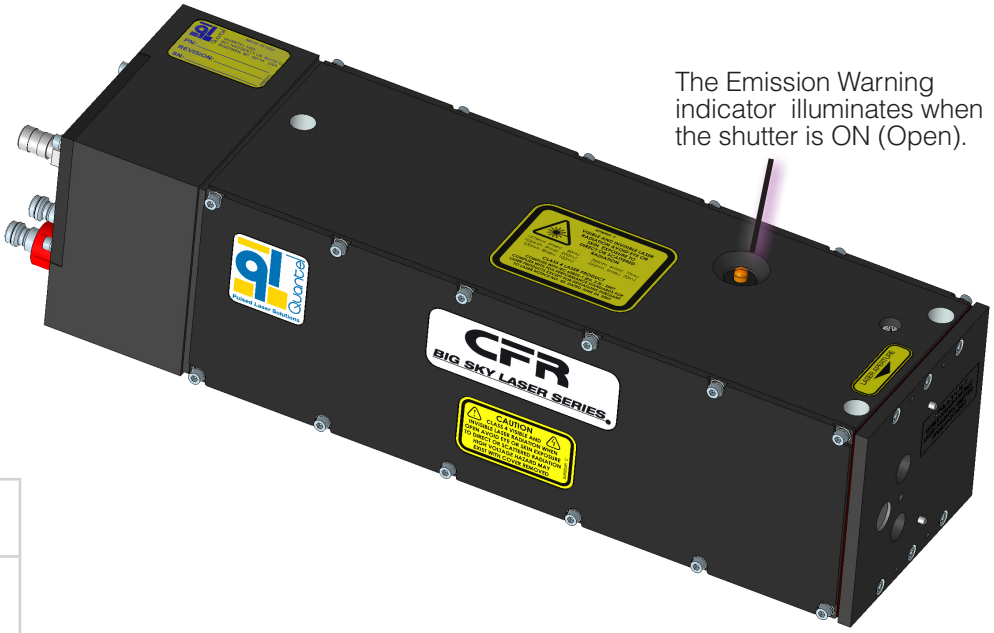


Figure 9 Emission Warning Indicator

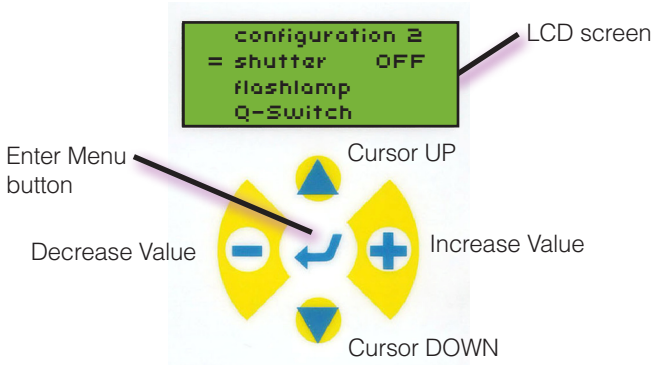
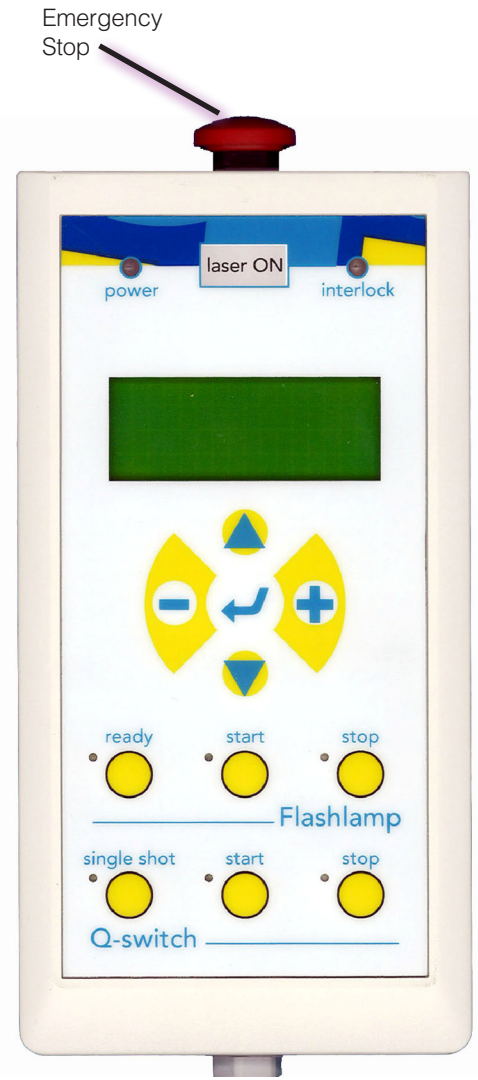


Figure 10 Shutter Option from Remote Box Main Menu

6.0 Remote Box

Emergency Stop (E-Stop)	Push this button in to stop lasing. E-Stop disables high voltage and discharges the PFN capacitor. Pull the button out to clear the interlock and allow the system to operate.
Power Indicator	This light shows orange when the main power line is connected and the Key Switch is in the ON position.
Interlock Indicator	When an interlock condition is detected, the laser system ceases operation and discharges high voltage (in under 5 seconds). A message flashes, indicating the detected interlock. Once the condition is corrected, the Interlock indicator is illuminated, showing that the ICE450 is fully operational. Refer to **Troubleshooting on page 18** for a complete list of the interlocks and suggestions to correct the fault condition causing them. **Continuous orange light:** Indicates that the Key Switch is ON and no interlock conditions exist. **Blinking orange light:** Indicates a security safety interlock condition exists.
Laser ON Indicator	This light is orange when the flashlamp(s) are operating (flashing or simmer current). It warns the user to observe laser safety precautions.



REMOTE BOX FUNCTIONS

Flashlamp Stop	Press this button to stop flashlamp operation.
Flashlamp Start	Press this button to start flashlamp operation.
Flashlamp Ready	Press this button to simmer the flashlamp. **Note:** A flashlamp discharge will occur as part of the simmer initiation process.
Q-Switch Single Shot	Press this button to emit a single Q-switch pulse.
Q-Switch Start	Press this button to start Q-Switch operation.
Q-Switch Stop	Press this button to stop Q-switch operation.
LCD Display	Displays menu selections for various system parameters.
Cursor Up	Press this button to scroll the cursor up on the display.
Cursor Down	Press this button to scroll the cursor down on the display.
Increase Value	Press this button to increase the value of a parameter.
Decrease Value	Press this button to decrease a value.
Enter Menu	Press this button to select a new menu on the display.

7.0 Remote Box Navigation

Use the LCD display to select CFR Laser System functions.

The Cursor: The cursor "**>**" is used to navigate the Remote Box menu.

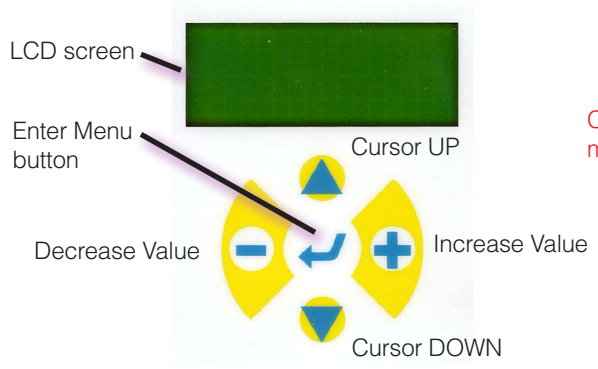
Moving the Cursor: Use the "Cursor Up/Down" buttons to move the cursor to the next line in the current menu. The LCD screen shows only four items. Move the cursor to scroll to items that are not visible on the display.

Selecting a Menu Item: There are three menu levels. Use the "Enter Menu" button to access sub-menus (➔). With the cursor in front of an item, press the "Enter Menu" button to show the corresponding menu. "Enter Menu" lines have a small arrow on the right side in the diagram. Example: Position the cursor at the Flashlamp item and press the "Enter Menu" button.

Note: Use the "Enter Menu" button to initiate action items such as Save, to store a configuration.

Change Values/Settings: Use the "Increase/Decrease Value" buttons to change a setting. Examples: To change the QS mode, position the cursor at this item, then press the Increase/Decrease Value button to switch between AUTO, BURST and SCAN. To decrease the FLQS dly, with the cursor at this item, press the "Decrease Value" button. In the diagram, items allowing value adjustment or mode selection options are shown highlighted.

See **Remote Box Menu, Detailed Descriptions**.



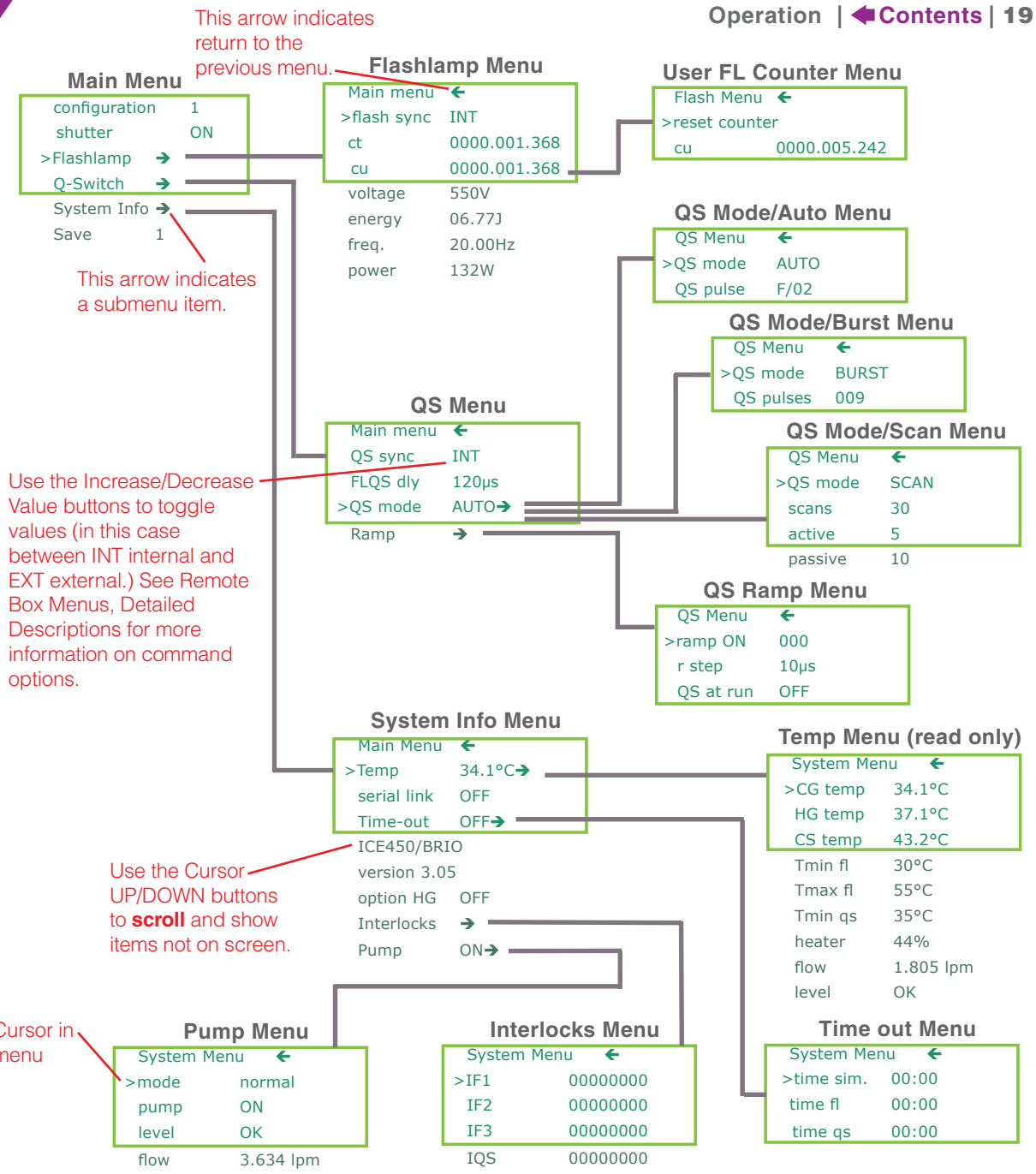


Figure 11 BASIC MENU Structure For the Remote Box

8.0 Remote Box Menu, Detailed Descriptions

After power-up and initialization, the Remote Box displays the Main menu.

Main Menu

Because the LCD can display only four lines at a time, there sometimes are additional lines that are not visible until you scroll the cursor down to view them.

Note: Command lines that must be **scrolled into view** are shown here dimmer than the commands that are first visible when the menu is first entered.

```
configuration    1
shutter          ON
Flashlamp        ➔
Q-Switch         ➔
System Info      ➔
save             1
```

All items in the Main menu except “configuration #”, “save #” and “shutter” are used to access the corresponding sub-menus. See the descriptions that follow.

Configuration

The “configuration #” selection allows you to load a saved configuration. There are up to four user-defined configurations available. Each configuration includes all the available adjustable laser parameters such as laser energy and pulse repetition frequency. To load a previously saved configuration, use the “Increase/Decrease Value” buttons.

```
>configuration   1
shutter          ON
Flashlamp        ➔
Q-Switch         ➔
System Info      ➔
save             1
```

Saving Configurations

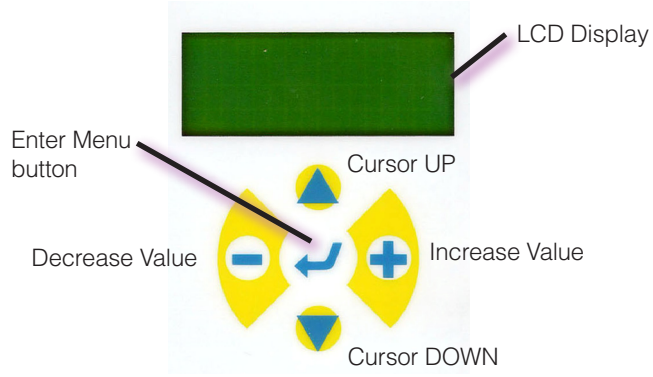
The “save #” selection allows you to save a configuration. Saved configurations preserve all the laser parameters in the ICE450 non-volatile memory. Once saved with a configuration number, these parameters may be recalled at any time, even after the system has been powered off.

```
configuration    1
shutter          ON
Flashlamp        ➔
Q-Switch         ➔
System Info      ➔
>save            1
```

Once you are satisfied with all the parameters for a laser setup, use the following steps to save the configuration:

1. From the Main menu, scroll to select “save #”.
2. Use the “Increase/Decrease Value” buttons to set the desired configuration number for the setup you will save.
3. Press the “Enter Menu” button.

A message appears confirming that you have successfully saved the configuration.



REMOTE BOX BUTTONS

Shutter Options

From the Main menu, scroll to “shutter”.

configuration	1
>shutter	ON
Flashlamp	➔
Q-Switch	➔
System Info	➔
save	1

Use the “Increase/Decrease Value” buttons to toggle between ON and OFF. See **Shutter Function on page 17** for details.

Flashlamp Menu

To access the Flashlamp menu, from the Main menu, scroll to “Flashlamp” and press the “Enter Menu” button. The Flashlamp menu contains the following items:

Main Menu	➔
>flash sync	INT
ct	0000.001.368
cu	0000.001.368
voltage	710V
energy	13.86J
freq.	10.00Hz
power	152W

Main Menu: Select this item to return to the Main menu from the Flashlamp menu.

flash sync: Use “flash sync” to switch between Internal and External flashlamp trigger modes. Press the “Increase/Decrease Value” buttons to switch between INT (internal) and EXT (external).

INT (internal): The flashlamp pulses at the frequency specified in the “freq.” item.
Example: The “Flashlamp Ready” button on the Remote Box is pressed to cause the flashlamp to fire at 20 Hz.

EXT (external): The flashlamp fires when a valid signal is applied to the “Lamp In” connector on the ICE front panel.

ct: Select “ct” to show the total number of times the flashlamp has fired since the ICE450 was manufactured. You cannot change this setting.

cu: Select “cu” (user count) to show how many times the flashlamp has fired since the “cu” parameter was reset by the user. It is important to reset this value whenever the flashlamp is replaced.

To reset “cu” user count:

From the “Main” menu, scroll to the “Flashlamp” item and press the “Enter Menu” button to show the new menu.

Scroll the cursor to “cu” in the new menu.

Press the “Enter Menu” button.

This will clear and set the value to zero.

voltage: Select the “voltage” item to display the electrical energy in Volts delivered to the flashlamp.

energy: Select “energy” to display the electrical energy in Joules delivered to the flashlamp. This is equal to the energy stored in the PFN capacitor. The energy is equal to $\frac{1}{2}CV^2$, where C is the capacitor value and V is the voltage on the capacitor. This energy is adjustable within a range allowed by factory settings.

freq.: Select “freq.” to display the flashlamp operating frequency in Hz. When in Internal synchronization, the ICE450 fires the flashlamp at this frequency. In External synchronization, the ICE450 compares the frequency of the external trigger with this setting. If the External trigger frequency is too low or too high for the factory settings, the flashlamp will be disabled.

power: Select “power” to show the product of the flashlamp energy and frequency in watts.

Q-Switch Menu

To enter the “Q-Switch” menu from the Main Menu, scroll to “Q-Switch” and press the “Enter Menu” button.

The Q-Switch menu contains:

Main menu	←
QS sync	INT
FLQS dly	180µs
>QS mode	AUTO→
Ramp	→

Main menu: Select this item to return to the Main menu from the Q-Switch menu.

QS sync: Select “QS sync” to choose between Internal and External Q-Switch synchronization. Press the “Increase/Decrease Value” buttons to switch between INT (internal) and EXT (external).

INT (internal): Uses Internal mode, where the ICE450 generates Q-Switch pulses synchronous to the flashlamp fire order at the time delay specified by “FLQS delay”.

EXT (external): The Q-Switch fires when a valid signal is applied to the QS-In BNC connector.

FLQS dly: Use “FLQS dly” to adjust the delay between the flashlamp pulse and the Q-Switch pulse.

Scroll to “FLQS delay” and press the “Increase/Decrease Value” buttons to change the delay value.

QS mode: Use the “QS mode” item to select one of three Q-Switch operating modes: AUTO, BURST, SCAN.

Note: These features are available only in Internal Q-Switch synchronization. In External synchronization, the External Q-Switch trigger source controls the Q-Switch pulse. See **External Trigger Signal Requirements on page 53** for more information.

AUTO mode: In “AUTO” mode the Q-Switch pulses on every flashlamp pulse by default. An additional adjustment in “AUTO” mode is “QS pulse”.

The “QS pulse” setting causes the Q-Switch to pulse on every second, third, fourth, etc., flashlamp pulse. Use the following steps to adjust the “QS pulse” function:

To Set “QS pulse”: Position the cursor on “QS mode” and use the “Increase/Decrease Value” buttons to change to “AUTO”. Then press the “Enter Menu” button to show the QS AUTO mode menu. It contains the following items:

QS menu	←
>QS mode:	AUTO
QS pulse	F/01

QS menu: Press the “Enter Menu” button to select this item to return to the Q-Switch menu,

QS pulse: This item allows you to change the ratio of flashlamp pulses to Q-Switch pulses. It is displayed as F/N. The Q-Switch fires once every N times the flashlamp fires.

Example: If this setting is “1”, the Q-Switch fires every time the flashlamp fires; if “2”, the Q-Switch fires every second time the flashlamp fires and so forth. The range of acceptable values for QS pulse is 1 to 99.

Example: If QS pulse is set to 50, the flashlamp will fire 49 times without a Q-Switch pulse.

This feature may be used to ensure that the resonator is thermally stable before the Q-Switch is fired.

BURST mode: Burst mode allows you to specify a group or "burst" of Q-Switch pulses that fire sequentially with every flashlamp pulse. These can range from one single shot to 999 Q-Switch pulses each time you press the "Q-Switch Start" button on the Remote Box. Burst mode requires that the Q-Switch be set to Internal sync.

To select Burst mode, position the cursor at "QS mode", then use the "Increase\Decrease Value" buttons to change to "BURST" mode. Finally press the "Enter Menu" button to show the QS BURST mode menu. It contains the following items:

```
  QS menu      ←
>QS mode:      BURST
  QS pulses    001
```

QS menu: Scroll to this item and select it by pressing the "Enter Menu" button to return to the Q-Switch menu.

QS pulses: Use this item to set the number of Q-Switch pulses that occur for each burst cycle. The range of acceptable values for QS pulses is 1 to 999. When the flashlamp is running, the set Burst mode will be used when the Q-Switch Start button on the Remote Box is pressed. Below is a timing diagram for Burst mode (QS pulse = 3):

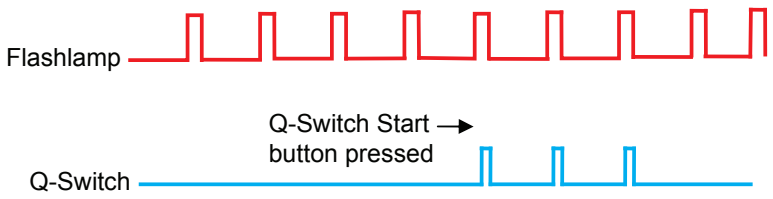


Figure 12 Example Timing Diagram for Burst Mode (QS Pulses = 3)

SCAN mode: Select Scan mode to specify a group or "scan" of Q-Switch pulses to be repeated for a predetermined number of times or indefinitely. Each Scan consists of a group of active and passive Q-Switch pulses. Scan mode requires that the Q-Switch be set to Internal sync.

To adjust the SCAN parameters, from the Q-Switch menu, position the cursor at the "QS mode" item. Use the "Increase/Decrease Value" buttons to change to "SCAN" mode. Finally press the "Enter Menu" button to show the QS SCAN mode menu.

Active pulses are flashlamp pulses that have an associated Q-Switch pulse and therefore cause laser light to be emitted.

Passive pulses are flashlamp pulses that have no Q-Switch pulse and therefore produce no laser emission.

```
  QS menu      ←
>QS mode:      SCAN
  scans        10
  active       3
  passive      2
```

QS menu: Select this item to return to the Q-Switch menu.

The range of acceptable values for the following three parameters is 1 to 99.

scans: Use this item to enter a value for the number of times to repeat the group of active or passive Q-Switch pulses. After the total number of scans is complete, the Q-Switch is disabled.

active: Use this item to set the number of active Q-Switch pulses for each Scan group.

passive: Use this item to set the number of passive Q-Switch pulses for each group.

Note: If the Total Scans parameter is set to 99, Q-Switching is not disabled and the defined scan operates indefinitely.

Scan Mode Example (scans 10, active 3, passive 2): With the flashlamp running, press the “Q-Switch Start” button on the Remote Box. Three active Q-Switch pulses will occur followed by two “passive” flashlamp pulses. This pattern will repeat ten times. Each of the ten “Scan” groups will consist of three flashlamp pulses with an associated Q-Switch pulse followed by two flashlamp pulses without a Q-Switch pulse. Shown below is a timing diagram that illustrates Scan mode.

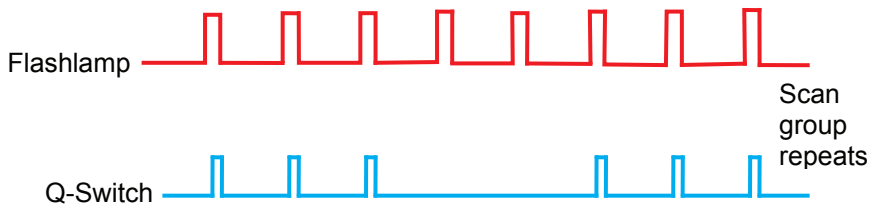


Figure 13 Example Timing Diagram for Scan Mode (QS Pulses = 3)

Ramp: In all Q-Switch modes, whenever the ramp count is not set to zero, the Q-Switch delay “ramps” down from an initial value to a final value.

The initial Q-Switch delay is given by the FLQS dly setting (from the Q-Switch menu), added to the product of the number of ramp steps multiplied by the ramp size. The final Q-Switch delay is equal to the FLQS dly setting. Each time the Q-Switch pulses, the Q-Switch delay is decreased by the step size until it reaches its final value. If the ramp count is set to zero, no ramping occurs and therefore the Q-Switch delay is always the final value as specified by the FLQS dly setting.

To set the ramp settings, from the Q-Switch menu, scroll the cursor to the “Ramp” item and press the “Enter Menu” button to show the Ramp menu items:

QS menu	←
>ramp ON	000
r. step	010µsec
QS at run	OFF

QS menu: Scroll to this item and press the “Enter Menu” button to return to the Q-Switch menu.

ramp ON: Use this to specify the number of ramp steps. If this setting is zero, no ramping occurs.

r. step: Use this to specify the ramp step size in microseconds.

QS at run: Set this item to ON, to cause the Q-Switch to **automatically** start after you start the flashlamp and the safety delay (typically 8 seconds) expires. With “QS at run” set to ON, you do not have to press the Q-Switch Start button located on the Remote Box to for lasing to begin.

CAUTION: Setting “QS at run” to ON is a potential safety risk as the system lases without you pressing the Q-Switch Start button. This feature has been intentionally located at the bottom of this third-level menu to reduce the chance that it will be activated accidentally.

System Info Menu

From the Main menu, scroll to the “System Info” item and press the “Enter Menu” button to access the “System Info” menu items:

```
 Main Menu      ←
>Temp           34.1°C➔
 serial link    OFF
 Time-out       OFF➔
 ICE450/BRIO
 version 3.05
 option HG      OFF
 Interlocks     ➔
 Pump           ON➔
```

Main Menu: To return to the Main menu scroll the cursor to the “Main Menu” line and press the “Enter Menu” button.

Temp: This item displays the coolant temperature measured within the reservoir. The “Temp” item also provides a submenu when the “Enter Menu” button is pressed. The “Temp” menu shows the following items:

```
 System menu    ←
>CG temp        34.1°C
 HG temp        37.1°C
 CS temp        43.2°C
 Tmin fl        30°C
 Tmax fl        55°C
 Tmin qs        35°C
 heater         44%
 flow           1.805 lpm
 level          OK
```

Temp Submenu items:

System menu: Use the “Enter Menu” button to select this item to return to the System Info menu.

CG temp: Displays the Cooling Group (coolant) temperature within the reservoir.

HG temp: Displays the temperature of the Harmonic Generator, if installed.

CS temp: Shows the temperature of the Charger-Simmer electronics and is useful for diagnostics.

Tmin fl: Shows the minimum allowable coolant temperature for the flashlamp to operate. This is set at the factory.

Tmax fl: Shows the maximum coolant temperature. This is a factory setting. If the measured temperature is above this, an interlock condition occurs and the flashlamp will not operate.

Tmin qs: Shows the minimum coolant temperature for Q-Switch operation. This is set at the factory.

heater: Shows the duty cycle of the heater element that warms the coolant.

flow: Shows the flow rate of the coolant.

level: Shows “LOW” if the coolant level in the reservoir is too low.

serial link: Set to enable (ON)/disable (OFF) the RS-232 serial communications link. The default setting is ON at power-up, enabling the RS-232 communications link. For safety reasons, when any button on the Remote Box is pressed, the serial link is disabled (OFF) giving priority to the Remote Box.

To re-enable the serial communications, use the Remote Box to select “serial link” and set it to ON.

Note: If you are unable to communicate with the ICE450 using the serial link, check the serial link setting from the System Info menu.

Time-out: This selection provides a submenu. With “Time-out” enabled (ON) the ICE450 turns off the flashlamp simmer, flashlamp fire and Q-Switch at user-defined time intervals.

To use “Time-out”:

- First, set “Time-out” to ON using the Increase/Decrease Value” button.
- With the cursor at “Time-out”, press the “Enter Menu” button to show the Time-out menu:

```
System menu ←
>time sim.    00.00
 time fire    00.00
 time QS      00.00
```

System menu: Select this to return to the System Info menu.

Use the “Increase/Decrease Value” buttons to adjust the time (minutes.seconds) that each of the following is ON:

time sim.:

time fire.:

time QS:

ICE450: The ICE450 item on the System Info menu displays the Power Supply type (ICE450) and the model of Laser Head that it is configured to operate.

version #.##: The “Version #.##” line displays the firmware version of the ICE450.

option HG: The “option HG” item turns the Harmonic Generator temperature monitor ON or OFF. When option HG is OFF, the ICE450 assumes that a harmonic generator is not connected; it ignores the HG temperature feedback. When the option HG is ON, the ICE450 monitors the harmonic generator temperature feedback and flags an interlock fault if the temperature falls below 18 °C.

Interlocks: This selection provides a submenu. Use the “Interlocks” selection to determine the status of interlock conditions.

To show the “Interlocks” menu, from the System Info menu, position the cursor at the “Interlocks” item and press the “Enter Menu” button. The Interlocks submenu contains the following items:

```
System menu ←
>IF1   00000000
 IF2   00000000
 IF3   00000000
 IQS   00000000
```

System menu: Select to return to the System Info menu.

Each bit of the four interlock bytes indicates a different fault condition. A “1” is indicated in the corresponding bit location for that particular fault.

IF1: system interlock byte 1	IF3: system interlock byte 3
IF2: system interlock byte 2	IQS: Q-Switch interlock byte

For detailed descriptions and suggestions for corrective action, please refer to **Troubleshooting on page 84**.

Pump: This selection from the System Info menu shows the Pump submenu.

```
System menu ←
>mode  normal
 pump  ON
 level OK
 flow  2.575 lpm
```

System menu: Select to return to the System Info menu.

mode: Select “normal” for the pump to restart up to three times when the coolant level rises after dropping below the minimum. Select “fill” for filling systems with very long coolant lines. This lets the pump re-start up to 30 times. Selecting “drain” ignores the flow and level indications and turns on the pump for 30 seconds.

pump: Use this to “manually” turn the pump ON or OFF.

level: This displays the coolant level as “OK” or “LOW”.

flow: This shows the measured flow rate of the coolant in liters per minute.

CAUTION: Do not disable the coolant pump for long periods, even when the flashlamp is not operating. Doing so can damage the ICE450.

The ICE450 uses an internal heat exchanger to aid in cooling power components. Those components are active and dissipating power if the Key Switch is ON, even if the laser is not operating.

Turning the coolant pump OFF significantly reduces the component cooling. If left in this state for any long period (within hours), the internal PFC power supply can overheat and fail.

9.0 Operating Modes

The ICE450 provides three modes each for flashlamp firing and Q-Switching:

- Manual Modes
- Automatic Mode
- External Modes

10.0 Manual Modes

WARNING: Do not perform laser emission (Q-Switching) when using Manual modes.

WARNING: Follow all safety precautions, whether using a Manual mode or Automatic mode. During laser operation, everyone present in the laser room must wear eye protection appropriate for the specific output wavelengths.

Simmer/Flashlamp Test Mode

Simmer/Flashlamp Test Mode is useful for verifying power supply and flashlamp function.

1. Press the "Flashlamp Ready" button on the Remote Box to initiate simmer current in the flashlamp. The ICE450 generates a flashlamp discharge as part of establishing simmer.
2. Verify that the Emission Warning indicator is illuminated on the Laser Head.
3. When the Remote Box "Ready" indicator is on, press the "Flashlamp Ready" button a second time to generate another flashlamp discharge.

Single-shot Mode

Single-shot mode fires the Q-Switch one time, producing a single pulse of light from the laser. This mode is useful while aligning the experimental setup. To use this mode QS Sync must be set to INT. To obtain a single-pulse emission from the laser:

1. Verify that the flashlamp is running.
2. Use the Remote Box to open the Laser Head shutter by setting Shutter to ON.
3. Press the "Q-Switch Single Shot" button on the Remote Box.

The Q-Switch Single Shot indicator light on the Remote Box will blink once and one laser pulse will be generated.

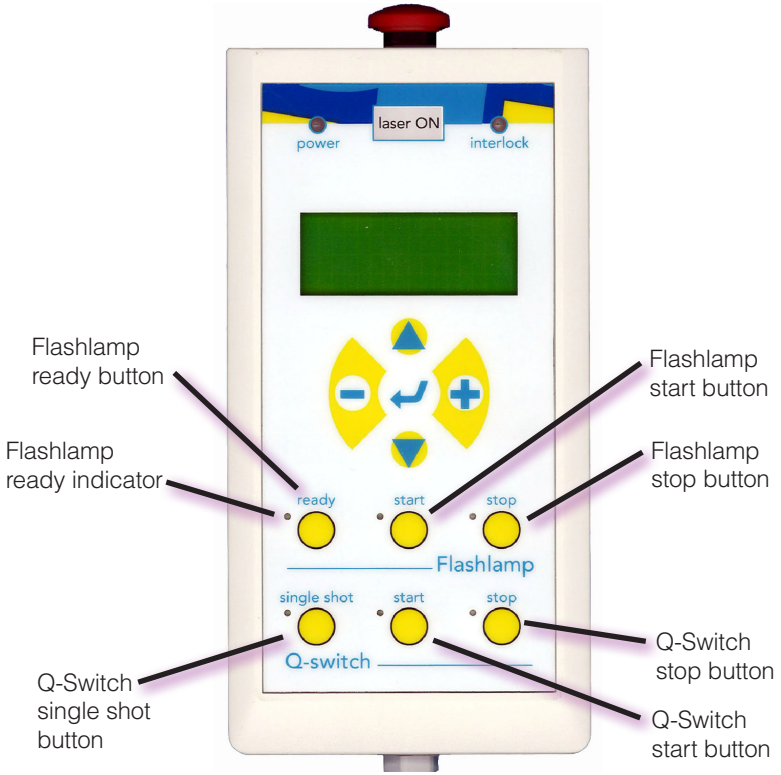


Figure 14 Remote Box Buttons

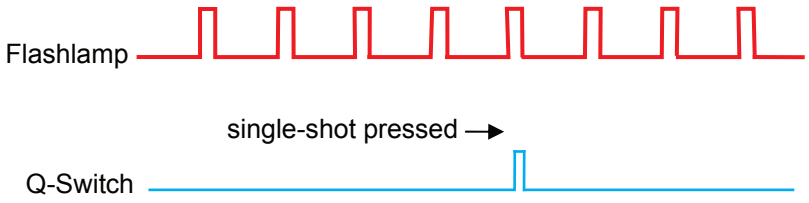


Figure 15 Timing Diagram: Single-Shot Mode

11.0 Automatic Mode (INT/INT)

Configuring Automatic Mode (INT/INT)

To configure the ICE450 in Automatic mode:

1. Use the Flashlamp menu to set flash sync to INT.
2. Use the Q-Switch menu to set QS sync to INT.

With these settings, when the “Q-Switch Start” and the “Flashlamp Start” buttons are pressed, the ICE450 automatically generates the flashlamp discharge pulses and Q-Switch pulses; there is no need for an external signal generator.

The ICE450 generates flashlamp pulses at the rate specified by the “freq.” setting from the Flashlamp menu. This setting is adjustable for stable resonator type laser heads.

Note: For GRM type Laser Heads, the frequency may only be adjusted to ± 10% of the frequency set at the factory. Refer to the **Declaration of Conformity on page 99** that was shipped with your system for the frequency value set for your system.

The ICE450 may be set to generate Q-Switch pulses internally. They occur after the flashlamp pulse at a time specified by the “FLQS dly” set from the Q-Switch menu. Adjusting this delay is one method of adjusting the optical energy of a laser pulse.

Operating in Automatic Mode (INT/INT)

To obtain continuous emission of laser pulses, from the Remote Box:

1. Use the Remote Box Main menu to open the Laser Head shutter by setting Shutter to ON.
2. Press the “Flashlamp start” button
3. Press the “Q-Switch start” button.

The corresponding indicator lights and the Emission Warning LED on the Laser Head will blink.

To cease laser emission:

1. Press the “Q-Switch stop” button or press the “Flashlamp stop” button.
2. Use the Remote Box Main menu to close the Laser Head shutter by setting Shutter to OFF.

Note: Pressing the “Flashlamp stop” button also sends the command to close the shutter. Pressing the “Q-Switch stop” button does not close the shutter.

The corresponding indicator on the Remote Box and the Emission Warning indicator on the Laser Head will stop flashing.

In Q-Switch Auto mode, the ICE450 generates a Q-Switch pulse in conjunction with every flashlamp discharge. Below is a timing diagram showing Auto mode:

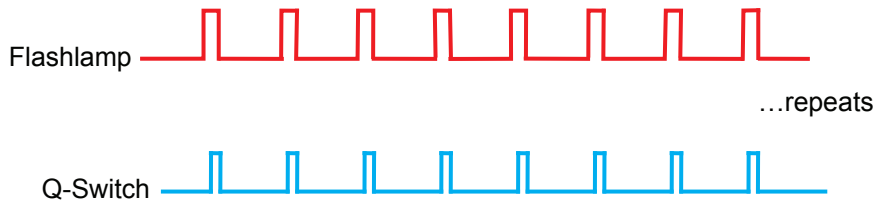


Figure 16 Automatic Mode: Timing Diagram

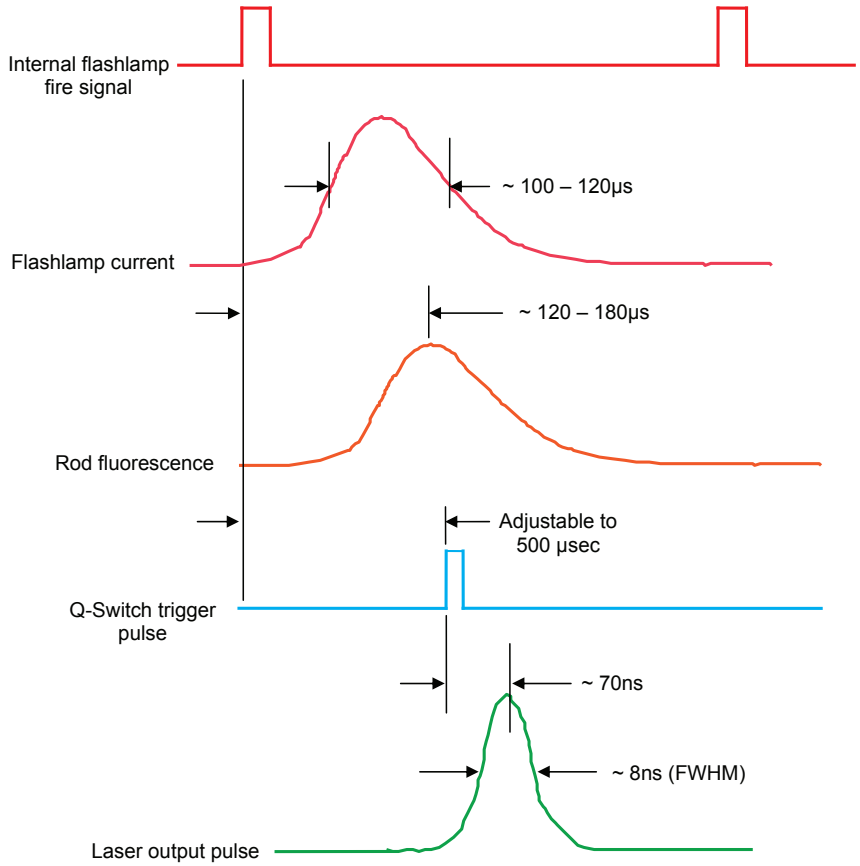


Figure 17 Automatic Mode Timing for Flashlamp and Q-Switch Signals
Timing diagram showing flashlamp and Q-Switch trigger signals generated by the ICE450 in Automatic mode and their resultant laser waveforms.

Note: The diagram is for illustration only. The time and amplitudes are not to scale.

Divide By N (Auto-Ratio) Feature: This Q-Switch mode causes the Q-Switch to fire once for every specified number of flashlamp pulses.

To use Divide By N (Auto-ratio):

- From the Q-Switch menu, use the Auto Mode menu to increase the Auto-ratio value to a number greater than one.

The Auto-ratio value is the number of flashlamp pulses to the number of active Q-Switch pulses. An example is shown in the timing diagram below, where the Auto-ratio value is set to three:

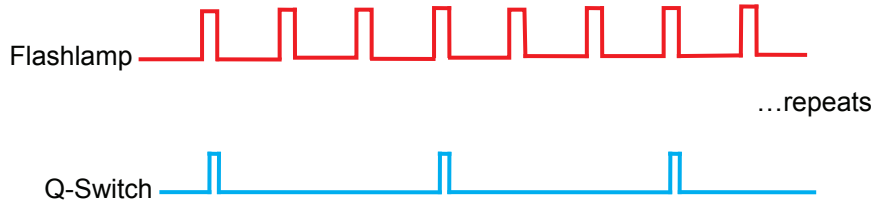


Figure 18 Divide By N (Auto Ratio) Q-Switch Mode Timing (value set to 3)

12.0 External Modes (EXT)

WARNING: For GRM Laser Heads, Quantel configures the Pulse Repetition Frequency (PRF) at the optimum rate specified by the customer.

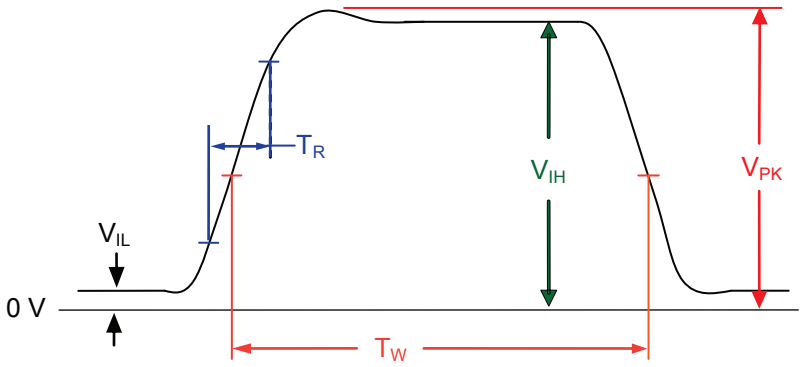
For a GRM laser in External Mode, the PRF must be equal to the initial setting (within ±10%). For stable resonator Laser Heads in External Mode, the PRF is variable to the maximum of the factory setting. Refer to your **Data Summary Sheet** for the values set for your system. This sheet was shipped with your system.

Note: The rising edge of the input trigger pulse is the active edge. For low jitter operation, the rise time must be as fast as possible (much less than 1µsec.)

To maintain a fast rise time and therefore minimal jitter, the Q-Switch input is not optically isolated and does not have protection circuitry.

WARNING: Do not apply voltages greater than 5V in order to prevent damage to sensitive components.

For External flashlamp and Q-Switch synchronization, the applied trigger signals must exhibit the required characteristics as shown in the diagram. The delay between flashlamp and Q-Switch synchronization signals may range up to 500µs. In order to optimize laser operation (maximum energy), this delay must be measured and adjusted.



Symbol	Parameter	Min.	Max.	Unit
VIL	Input low voltage	0.0	0.8	V
VIH	Input high voltage	3.0	5.0	V
TR	Rise time		1	µs
TW	Pulse width	100		µs
VPK	Peak voltage		5.5	V

Figure 19 Required Characteristics–Flashlamp and Q-Switch Trigger Input Signals

External Mode Triggering Methods

The following pages describe the three different triggering methods for External Mode synchronization. The three methods for External Mode synchronization are using :

- Flashlamp External Q-Switch Internal
- Flashlamp Internal Q-Switch External
- Flashmap External Q-Switch External

WARNING: Refer to the **External Trigger Signal Requirements on page 53** for proper external flashlamp and Q-Switch trigger pulse requirements.

Flashlamp Setting	Q-Switch Setting	Triggering Method Result
External	Internal	An external trigger signal initiates the flashlamp pulse. The ICE450 generates a synchronous Q-Switch pulse at a user-defined (or factory-set) time delay. To use this mode: 1. From the Main menu, select the Flashlamp menu. 2. Set flash sync to EXT. 3. Return to the Main menu and select the Q-Switch menu 4. Set QS Sync to INT.

Flashlamp Setting	Q-Switch Setting	Triggering Method Result
Internal	External	The ICE450 generates the flashlamp pulse signal. The Q-Switch trigger signal is generated by an external source. This provides better resolution for the Q-Switch delay than is available from the ICE450 internal setting. Typically, you will connect to the BNC “Lamp Out” and use this signal to synchronize your external signal generator supplying the Q-Switch pulse. The Lamp Out signal is a copy of the actual flashlamp trigger. To use this mode: 1. From the Main menu, select the Flashlamp menu. 2. Set flash sync to INT. 3. Return to the Main menu and select the Q-Switch menu. 4. Set QS Sync to EXT.

Flashlamp Setting	Q-Switch Setting	Triggering Method Result
External	External	An external source generates both the flashlamp trigger and the Q-Switch trigger.

To use this mode::

1. From the Main menu, select the Flashlamp menu.
2. Set flash sync to EXT.
3. Return to the Main menu and select the Q-Switch menu.
4. Set QS Sync to EXT.

The Q-Switch activates at the same time as the external Q-Switch trigger input.

Note: In "**Bypass 0**" mode, there is a processing delay of 500 µsec between the external flashlamp trigger input and the flashlamp activation. To compensate for this interval, you must add 500 µsec to the total time between your flashlamp input and your Q-Switch input. See **Figure 20** which shows an example of this delay, and the compensated Q-Switch signal.

In "**Bypass 1**" mode, there is a processing delay of only approximately 0.5 µsec between the external flashlamp trigger input and the flashlamp activation. See **Figure 21** which shows an example of this delay, and the compensated Q-Switch signal.

Note: The 100 µsec Q-Switch delay shown in **Figure 20** and **Figure 21** is only an example. Refer to the Data Summary sheet that shipped with your system for the optimized Q-Switch delay. You can query the Q-Switch delay using the "W" command. See the Software section for details.

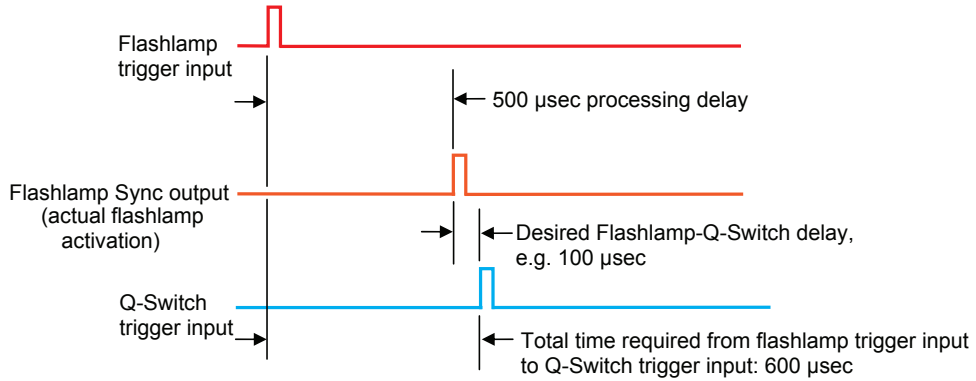


Figure 20 Example Signal Timing For External/External Mode Bypass 0

In this example, the desired Flashlamp-to-Q-Switch delay is 100 µsec. In Bypass 0 mode there is a 500 µsec processing delay, therefore the external Q-switch trigger must occur 600 µsec after the rising edge of the external Flashlamp trigger.

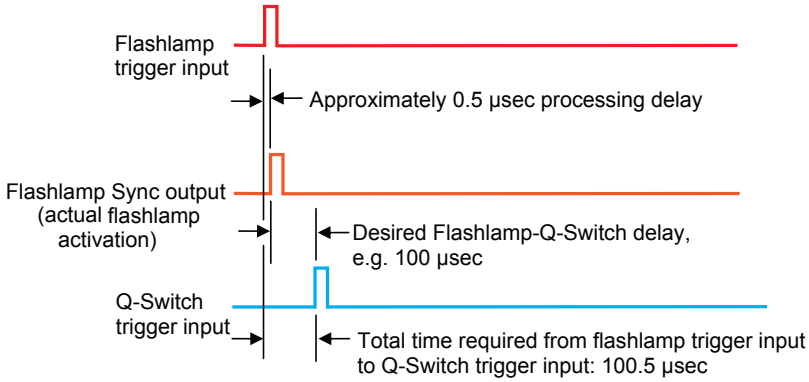


Figure 21 Example Signal Timing For External/External Mode Bypass 1

In this example, the desired Flashlamp-to-Q-Switch delay is 100 µsec. In Bypass 1 mode there is only approximately a 0.5 µsec processing delay, therefore the external Q-switch trigger must occur 100.5 µsec after the rising edge of the external Flashlamp trigger.

Example Start-Up Procedure

WARNING: The following steps result in laser light emission from the output aperture of the Laser Head. During laser operation, everyone present in the laser room must utilize eye protection appropriate for the specific output wavelengths.

Note: Verify that you removed the protective cover from the aperture.

To start the laser system, follow this procedure:

1. Turn the Key Switch located on the ICE450 front panel to ON (“I”).
2. As the Key Switch is turned to ON, verify that the “power” and the “interlock” indicators on the Remote Box illuminate. If not, check the Remote Box for interlock fault messages. If necessary, see **Troubleshooting on page 84** to remedy the issue.
3. Use the Remote Box menus to select the desired operating mode. If using an External mode, connect the external signal generator to the appropriate “Lamp In” and/or the “Q-Switch In” BNC connector(s) on the ICE450.

Note: If you have purchased a system with the Heater option, wait approximately 10-15 minutes until the coolant temperature reaches the preset value for flashlamp operation before continuing.

4. Press the “Flashlamp Ready” button on the Remote Box. The corresponding “ready” LED and “LASER ON” indicators on the Remote Box as well as the “Emission Warning” Indicator on the ICE450 front panel illuminate.
5. Press the “Flashlamp Start” button on the Remote Box. The corresponding flashlamp “start” LED will blink.
   - In Internal mode, the flashlamp begins flashing at the frequency set from the Flashlamp menu.
   - In External mode, the flashlamp will flash at the frequency determined by the external signal generator.
6. Use the Remote Box Main menu to open the Laser Head shutter by setting Shutter to ON.
7. Press the Remote Box Q-Switch “start” button to activate the Q-Switch.
8. Verify that the corresponding Q-Switch “start” LED blinks. In External Mode, the Q-Switch will fire as timed by the external signal.
9. To stop laser emission, press the Q-Switch “stop” button.
10. Verify that the Q-Switch “start” LED turns off.
11. Stop the flashlamp by pressing the Flashlamp “stop” button.
12. Verify that the Flashlamp “start” and “ready” LEDs turn off.
13. Use the Remote Box to Close the Laser Head shutter by setting Shutter to OFF.

13.0 Shutdown Procedure

To shut down the laser system, follow this procedure:

1. Press the Remote Box Flashlamp “stop” button.
2. Verify that the Remote Box Flashlamp “start” and “ready” LEDs and the Q-Switch “start” LED are off.
3. Verify the ICE450 front panel “Emission Warning” indicator is off.
4. Use the Remote Box Main menu to Close the shutter on the Laser Head by setting Shutter to OFF.
5. Turn the Key Switch located on the ICE450 front panel to OFF (“0”).
6. Disconnect the power cord from the ICE450 AC Mains power if you will not be using the system for an extended period.

14.0 Decreasing Output Energy

Operation at a decreased energy level is useful when starting an experimental setup or testing equipment. A simple way to decrease the laser output energy is to increase the delay between the flashlamp and Q-Switch to a value that is higher than optimal. You can do this using the Remote Box.

CAUTION: Quantel advises against decreasing the energy of the flashlamp(s) to reduce the output energy. Decreasing the energy of the flashlamp(s) will cause a change in beam characteristics. Divergence and position of the focal points may cause damage to the laser's internal optics.

To adjust the output energy using the Remote Box:

1. From the Main menu, select the Q-Switch menu.
2. Select FLQS dly (Flashlamp/Q-Switch delay).
3. Press the "Increase/Decrease Value" buttons to set the desired value for the output energy.

15.0 Increasing Output Energy

WARNING: Do not attempt to modify the pumping power by using the Remote Box to increase the flashlamp energy This energy has been factory set for optimal laser performance.

Increase the flashlamp energy with the Remote Box only if the flashlamp efficiency decreases. Please contact **Quantel Customer Service** to determine the cause of the efficiency decrease.

SOFTWARE

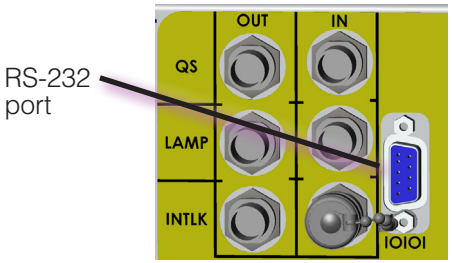
1.0 Serial Interface

The primary communications and control is via the RS-232 port located on the ICE450 front panel (Rack ICE450 back panel). The ICE can be set to lock out front panel key control and avoid conflict with RS-232 communications.

The serial communications configuration is:

- 9600 baud
- 8 data bits
- no parity
- 1 stop bit
- no flow control
- The CFR uses only Tx and Rx for its communications
- No hardware handshaking is utilized

ICE450 SERIAL CONNECTION



RACK ICE450 SERIAL CONNECTION

The RS-232 serial interface is on at power-up.

As a safety feature, when any button on the Remote Box is pressed, the serial link is disabled (OFF) to give priority to the Remote Box.

To re-enable serial communications, use the Remote Box to select the System menu and set the “serial link” item to ON.

Note: If you are unable to communicate with the ICE450 using the serial link, check the System menu, serial link setting.

To send a command: Enter a command from the command set, followed by a carriage return, CR (‘\r’, 0x0D) and line feed, LF (‘\n’, 0x0A), in that order.

Note: The characters of a command can be upper or lower case.

To query a value: Send the command with no extra characters followed by a carriage return and line feed. The ICE450 responds by sending a CR, LF and a 15-character string of information, which is an ASCII-formatted representation of the requested value with as many spaces as required to make the string 15 characters.

To set a value: Send a command followed immediately by the value (no space), then followed by a carriage return (CR) and line feed (LF).

The ICE450 will respond with the new value if it is valid or with the old value if the new value is invalid.

Each command has a unique response structure. These are given in the Serial Command Reference section.

Minimum delay between commands: The minimum allowable time between commands depends on the commands used; in general, you should provide a delay of 150 msec between commands.

Unrecognized commands: If a command is sent that the ICE450 does not recognize, the ICE450 will respond with the message “`cmd not found`”.

Use of Terminal Emulator: To simplify corrections, the protocol allows backspaces to erase the last-sent character. To improve readability when using a terminal emulation program, such as HyperTerminal, enable the “Backspace sends ctrl-H, space, and ctrl-H” setting.

Graphical User Interface: The ICE450 may be controlled via a serial COM port from the PC using the GUI.

2.0 Serial Command Reference

Feature	Operation	Command	Response format	Description
Shutter Commands	Shutter Control, query Example: SHC↵ `shc: open` Shutter Control, set Example: SHC0↵ `shc: close`	SHC SHCn *where "n" is 0 to close the shutter or 1 to open it*	`shc: nnnn` `shc: nnnn` *where "n" is "close" or "open"*	Command to open or close the shutter. The response to a query is the previously entered setting, **NOT** feedback about the shutter. For example: SHC↵ response `shc: open` indicates the prior shutter set command was SHC1.
Flashlamp Commands	Fire, Internal Sync Example: A↵ `fire auto`	A	state string	Sets the flashlamp into "Internal" sync mode and to start flashing. The response to this command is the state string (see the description for the "ST" command located in the Status Commands section). If the flashlamp is able to start flashing, the response will be "fire auto". If not, the response will indicate the state.
	Fire, External Sync Example: E ↵ `fire ext`	E	state string	Sets the flashlamp into "External" sync mode and to start flashing. The response to this command is the state string. If the flashlamp is able to start flashing, the response will be "fire ext". If not, the response will indicate the state.
	Simmer Example: M↵ `simmer`	M	state string	Sets the flashlamp into Simmer mode. The response to this command is the state string. If the flashlamp is able to start simmering, the response will be "simmer". If not, the response will indicate the state.
	Stop Flash Example: S↵ `standby`	S	state string	Stops the flashlamp from flashing and turns off the simmer. The response to this command is the state string, and it should be "standby".

↵ indicates entering the command. This can be done by sending a carriage return character, CR ('\r', 0x0D) and line feed character, LF ('\n', 0x0A), in that order.

Feature	Operation	Command	Response format	Description
Flashlamp Commands (continued)	Flashlamp Energy, query Example: EJ↵ `energy 06.77 J` Flashlamp Energy, set Example: EJ600↵ `energy 06.00 J`	EJ EJnnnnn *where nnnnn is the desired in hundredths of joules*	energy xx.yy J *where "xx.yy" is the energy in joules*	If the ICE450 has been configured to allow energy settings (using the "FSM" factory command), this command queries or sets the flashlamp energy. The energy is the electrical energy stored in the flashlamp capacitor, calculated as ½CV².
	Flashlamp Frequency, query Example: D↵ `freq 021.00Hz` Flashlamp Frequency, set Example: D2200↵ `freq 022.00Hz`	D Dnnnnn *where nnnnn is the desired frequency in hundredths of hertz*	freq xxx.yyHz *where "xxx.yy" is the present frequency setting in hert*	Queries or sets the flashlamp firing frequency. This is the rate at which the flashlamp fires when in Internal Synchronization mode. When the flashlamp is in External Sync, the external trigger frequency compares with this setting.
	Flashlamp Count, query Example: F↵ `ct LP0000012345`	F	ct LPnnnnnnnnn	Queries the total number of flashlamp firings since shipment from the factory.
	User Flashlamp Count, query Example: UF↵ `cu LP0000012345`	UF	cu LPnnnnnnnnnn	Queries the number of flashlamp firings since the resetting of the count. Reset the flashlamp count with every flashlamp replacement.
	Reset User Flashlamp Count Example: UF0↵ `cu LP0000000000`	UF0	cu LP0000000000	Resets the number of flashlamp firings. Send this command after replacing the flashlamp.
	Flashlamp External Trigger Delay Bypass, query Example: BYPASS↵ `bypass:off` Flashlamp External Trigger Delay Bypass, set Example: BYPASS1↵ `bypass:on`	BYPASS BYPASSn *where n is 0 for off, 1 for on*	bypass: nnnn *where "nnnn" is "off" (500 µsec delay) or "on" (0.5 µsec delay).*	Queries or sets the external flashlamp trigger delay bypass. When BYPASS is set to 0 (off), there is a 500 µsec delay between the rising edge of the external tirgger input and the rising edge of the flashlamp synch internal trigger. When BYPASS is set to 1 (on), there is only a 0.5 µsec delay. The response to a query is the current state of the bypass (on or off). The BYPASS command only takes effect when transitioning from Stop to Fire. Note: The delay bypass is only valid if Q-Switch Trigger mode is set to external (QE). If the Q-Switch trigger mode is set to internal (QI) there will be a 500 µsec delay.

Feature	Operation	Command	Response format	Description
Q-Switch Commands	Fire Q-Switch, set Example: CC↵ `fire auto qs`	CC	state string	Starts the Q-Switching. The response to this command is the state string.
	Fire Q-Switch Single Shot Example: OP↵ `fire auto qs`	OP	state string	Initiates a single Q-Switch. The response to this command is the state string. **Note:** This functions only when Q-Switch mode is set to INT.
	Stop Q-Switch Example: CS↵ `fire auto`	CS	state string	Disables the Q-Switch. The response to this command is the state string.
	Q-Switch Delay, query Example: W↵ `delay 123 µs` Q-Switch Delay, set Example: W144↵ `delay 144 µs`	W Wnnn *where nnn is the Q-Switch delay in microseconds*	delay nnn µs *where nnn is the Q-Switch delay in microseconds*	Queries or sets the Q-Switch delay setting. This is the amount of time, in microseconds, between the flashlamp activation and the Q-Switch pulse when the Q-Switch is in Internal sync mode.

Feature	Operation	Command	Response format	Description
Q-Switch Commands (continued)	Q-Switch Internal Sync Example: QI↵ `QS sync: INT`	QI	QS sync: INT	Sets the Q-Switch to Internal sync mode.
	Q-Switch External Sync Example: QE↵ `QS sync: EXT`	QE	QS sync: EXT	Sets the Q-Switch to External sync mode.
	Q-Switch Sync Example: QSSYNC↵ `QS sync: EXT`	QSSYNC	QS sync: aaa *where "aaa" is either "INT" or "EXT"*	Queries the Q-Switch sync mode.
	Q-Switch Mode, query Example: QSM↵ `QS mode : 1` Q-Switch Mode, set Example: QSM3↵ `QS mode : 3` *indicating "scan" mode*	QSM QSMn	QS mode : n *where "n" is "1", "2", "3" or "4"*	Queries or sets the Q-Switch operating mode. The mode parameter for this command is encoded, with "1" meaning "auto," "2" meaning "burst", "3" meaning "scan". • 1 auto: The Q-Switch runs at every flashlamp pulse. • 2 burst: The Q-Switch runs for only a specified number of flashlamp pulses. • 3 scan: There are a specified number of "active" flashlamp pulses followed by a specified number of "passive" pulses, repeating for a "total" number of scans.

Feature	Operation	Command	Response format	Description
Q-Switch Commands (continued)	Q-Switch Auto Ratio, query Example: QSF↵ `QS rep-rate F/04` Q-Switch Auto Ratio, set Example: QSF3↵ `QS rep-rate F/03`	QSF QSFnn *where "nn" is the rate setting*	QS rep-rate F/nn *where "nn" is the rate setting*	Queries or sets the Q-Switch auto ratio. In "Auto" mode with Internal Q-Switch sync selected, the Q-Switch will fire at a rate equal to or less than the flashlamp rate. This setting specifies the number of times the flashlamp fires without causing a Q-Switch firing. If this setting is "1", the Q-Switch will fire every time the flashlamp fires. If it is "2", the Q-Switch will fire every second time, etc. The range of acceptable values for QSF is 1 to 99.
	Q-Switch Burst Count, query Example: QSP↵ `burst QS 020` Q-Switch Burst Count, set Example: QSP100↵ `burst QS 100` *indicating that the Q-Switch will fire 20 times after start-up*	QSP QSPnnn	burst QS nnn *where "nnn" is the burst count*	Queries or sets the number of Q-Switch pulses to fire when in Burst mode. In "burst" mode with Internal Q-Switch sync selected, the Q-Switch will fire this many times, then stop. The range of acceptable values for QSP is 1 to 999.
	Q-Switch Scan Parameters, query Example: Q↵ `Q 11 22 33` Q-Switch Scan Parameters, set Example: Q051099 ↵ `Q 05 10 99` *sets parameter to use 5 passive pulses and 10 active pulses in a scan, repeating forever (because total scans=99 has a special function*).* *Take careful note of the format for these values. Following the letter "Q" you must have a two-digit string representing the number of passive pulses, then (with no space), a two-digit string representing the number of active pulses, then (with no space), a two-digit string representing the total number of scans. If any of these numbers is less than 10, the first digit of the two-digit string must be 0.*	Q Qppaatt	Q ppaatt *where:* *"pp" is the passive count,* *"aa" is the active count, and* *"tt" is the total count*	Queries or sets the Scan parameters. In Scan mode with Internal Q-Switch sync selected, a scan consists of a series of active pulses followed by a series of passive pulses. • Active flashlamp pulses have an associated Q-Switch pulse. • Passive flashlamp pulses have no Q-Switch pulse. The Total Scans parameter sets the number of "scan" cycles composed of active pulses and passive pulses, before the Q-Switch is disabled. *If the Total Scans parameter is **99**, Q-Switching is not disabled. The maximum value for all of these settings is 99.

Feature	Operation	Command	Response format	Description
Status Commands	State, query Example: ST↵ `fire ext qs e`	ST	“system state”	Queries the system “state”. The response to this command is the “state string” that tells you the basic state of the laser, including: • “standby”: This is the state string when the laser is not firing and not simmering. • “simmer”: This the state string when the laser is only simmering. • ”fire auto”: This is the state string when the flashlamp is firing in Internal sync mode. • ”fire ext”: This is the state string when the flashlamp is firing in External sync mode. • If the flashlamp is firing, and the Q-Switch is enabled, the word “qs” is added, and if the Q-Switch sync mode is External, the letter “e” will be added. For example, if the flashlamp is firing in External sync mode and the Q-Switch is running in External sync mode, the state string will be ”fire ext qs e”. • ”fire auto qs”: This means the flashlamp is firing in Internal sync and the Q-Switch is operating in Internal sync. • ”fire ext qs”: This means the flashlamp is firing in External sync and the Q-Switch is operating in Internal sync. Note: HyperTerminal can be configured to send CR-LF when the keyboard’s “enter” key is pressed. Sending just CR-LF will also cause the ICE450 to respond with the state string.

Feature	Operation	Command	Response format	Description
Status Commands (continued)	Status Word, query Example: WOR↵ `I 0 F 2 S 1 Q 6` Indicates there are no interlocks (I 0), the flashlamp is in Internal sync mode and is running (F 2), the simmer is established (S 1), and the Q-Switch is in External sync and is running (Q 6)	WOR	I a F b S c Q d	This command is included for compatibility with the Brilliant ICE450. It queries for a code that indicates the state of the laser. The response is: I a F b S c Q d, where: a: “0” = No interlocks present; “1” = Interlocks present b: ”0” = The flashlamp is in Internal sync mode and is not running; ”2” = The flashlamp is in Internal sync mode and is running; ”4” = The flashlamp is in External sync mode and is not running; ”6” = The flashlamp is in External sync mode and is running. c: “1” = Simmer is established; “0” = Simmer is not established d: ”0” = The Q-Switch is in Internal sync and is off; ”1” = The Q-Switch is in Internal sync and is in single mode; ”2” = The Q-Switch is in Internal sync and is running; ”4” = The Q-Switch is in External sync and is off; ”6” = The Q-Switch is in External sync and is running.
	Interlock Fault Byte 1, query Example: IF1↵ `IF1 00 01 00 00` *indicates Laser Head housing is opened* **Note:** For more information about the interlocks, refer to **Troubleshooting on page 84**.	IF1	IF1 ab cd ef gh	Queries Interlock Fault Byte 1. The response string contains ASCII-encoded 1’s or 0’s indicating either a fault (1) or okay (0) condition exists. The format of the string is as follows: IF1 ab cd ef gh, where the letters correspond to the following interlocks: a: “1” if e-stop button is pressed “0” if not b: “1” if bnc interlock is open “0” if not c: “1” if Laser Head thermostat is open “0” if not d: “1” if Laser Head housing switch is open “0” if not e: “1” if ICE450 housing switch is open “0” if not f: “1” if there is an Internal bus error “0” if not g: “1” if there is an External bus error “0” if not h: “1” if flashlamp timeout “0” if not

Feature	Operation	Command	Response format	Description
Status Commands (continued)	Interlock Fault Byte 2, query **Note:** For more information about the interlocks, refer to **Troubleshooting on page 84**. Example: IF2↵ `IF2 00 00 01 00` *indicates low coolant flow*	IF2	IF2 ab cd ef gh	The response string contains ASCII-encoded 1's or 0's indicating that either a fault or okay condition exists. a: "1" if heater thermostat is open "0" if not b: "1" if charger temperature is over the maximum temperature setting "0" if not c: "1" if coolant temperature is under the minimum temperature setting "0" if not d: "1" if coolant temperature is over the maximum temperature setting "0" if not e: "1" if coolant level is low "0" if not f: "1" if coolant flow is low "0" if not g: "1" if charger, coolant, or harmonic generator temperature is below the minimum setting "0" if not h: "1" if flashlamp power setting is too high "0" if not
	Interlock Fault Byte 3, query Example: IF3↵ `IF3 00 10 00 00` *indicates simmer stopped*	IF3	IF3 ab cd ef gh	The response string contains ASCII-encoded 1's or 0's indicating that either a fault or okay condition exists. a: "1" if no end of charge prior to fire order (PSU charge error) "0" if not b: "1" if voltage is over setting "0" if not c: "1" if no simmer sensed "0" if not d: "1" if external flash signal frequency is too low "0" if not e: "1" if external flash signal frequency is too high "0" if not f: "1" if there is a capacitor discharge problem "0" if not g: "1" if there is simmer timeout "0" if not h: "1" if the PIV slave indicates master unit has interlock and vice versa "0" if not

Feature	Operation	Command	Response format	Description
Status Commands (continued)	Q-Switch Interlock Byte, query Example: IQS↵ `IQS 01 00 00 00` *indicates coolant is too cold*	IQ	IQS ab cd ef gh	The response string contains ASCII-encoded 1's or 0's indicating that either a fault or okay condition exists. a: "1" if in the 8-second forced delay after flashlamp starts — "0" if not b: "1" if coolant temperature is too low — "0" if not c: "1" if Q-Switch timeout — "0" if not d: "1" if shutter is closed — "0" if not e: not used — "0" if not f: not used — "0" if not g: not used — "0" if not h: not used — "0" if not
	First Interlock Example: IF↵ `IF2 00 00 01 00`	IF	??? ab cd ef gh	Queries the interlock that caused a laser shutdown. The response is that of IF1, IF2, IF3 or IQ depending on which one caused the shutdown. In the case of multiple causes, priority is from IF1 down to IQ.
Temperature Commands	Cooling Group Temperature Example: CGT↵ `temp. CG 45 d` *indicating the coolant temperature is 45°C*	CGT	temp. CG nn d	Queries the temperature of the coolant in degrees Celsius
	Harmonic Generator Temperature Example: HGT↵ `temp. SHG 75 d` *indicates the harmonic generator temperature is 75°C*	HGT	temp. SHG nn d	Queries the temperature of the harmonic generator in degrees Celsius
	Charger/Simmer Temperature Example: CST↵ `temp. CS 55 d` *indicates the charger/simmer temperature is 55°C*	CST	temp. CS nn d	Queries the temperature of the charger/simmer controller in degrees Celsius

Feature	Operation	Command	Response format	Description
Temperature Commands (continued)	All Three Temperatures, query Example: T3↵ `T3 372 553 771` *indicates the coolant temp (CGT) is 37.2°C, the SHG temp is 55.3°C, and the CS temp is 77.1°C*	T3	T3 xxx yyy zzz *"xxx" is the CG T in °C/10* *"yyy" is the SHG T in °C/10* *"zzz" is the CS T in °C/10*	Queries all three temperatures at once. Reports CG, SHG and CS temperatures in tenths of degrees Celsius in a single string. A space character separates the temperatures.
	Pump Control, query Example: PUMP↵ `pump : on` Pump Control, set Example: PUMP0↵ `pump : off`	PUMP PUMPn *where "n" is the new setting:1 for on, 0 for off.*	pump : sss *where "sss" is "on" or "off"*	**Turns** the coolant pump on or off. When queried, it responds with the on/off state of the pump. **CAUTION:** Do not disable the coolant pump for long periods, even when the flashlamp is not operating. Overheating power components can damage the ICE450 within hours.
	Pump Mode, query Example: PMOD↵ `pmod: normal` Pump Mode, set Example: PMOD1↵ `pmod: fill` *sets the pump to "fill" mode*	PMOD PMODn *where n is the new setting: 0 for normal, 1 for fill, and 2 for drain.*	pmod: sss *where "sss" is "normal", "fill", or "drain"*	Queries or sets the coolant pump mode. Values can be: • 0: Normal mode—the pump will shut off if the coolant level is low and cause an interlock. • 1: Fill mode—the pump shuts off until the level is OK, then it turns on again (this facilitates filling long coolant umbilical lines). • 2: Drain mode—level and flow are ignored, and the pump stays on for thirty seconds at a time (the pump can be re-started). When queried, the response is a string representing the present pump mode.
	Coolant Level, query Example: LEV↵ `level: low` *indicates the coolant level is low*	LEV	level: sss *sss is either "low" or "ok"*	Queries the coolant level status
	Coolant Flow Rate, query Example: FLOW ↵ `FLOW 2.440` *indicates the flow rate is 2.44 lpm*	FLOW	FLOW m.nnn lpm *where "mm.nnn" is the flow rate*	Queries the coolant flow rate in liters per minute (lpm)

Feature	Operation	Command	Response format	Description
Config	Configuration, query Example: CFG `configuration 1` Configuration, set Example: CFG2 `configuration 2` *recalls stored configuration 2*	CFG CFGn *where "n" is the new configuration*	configuration n *where "n" is the stored configuration number*	Queries the configuration number or sets a new configuration. Setting a configuration "n", recalls a saved configuration from the nonvolatile memory (eeprom).
	Save Configuration, set Example: SAV2 `Save config. 2` *saves the current settings as configuration "n"*	SAVn	Save config. n *where "n" is the configuration number*	Saves the current settings into nonvolatile memory at the configuration number specified. The configuration number can be between 1 and 4.
	Firmware Version, query Example: X `ICE450 3.17`	X	ICE450 x.yy *where "x.yy" is the version number*	Queries the firmware version.
Config	Configuration, query Example: CFG↵ `configuration 1` Configuration, set Example: CFG2↵ `configuration 2` *recalls stored configuration 2*	CFG CFGn *where "n" is the new configuration*	configuration n *where "n" is the stored configuration number*	Queries the configuration number or sets a new configuration. Setting a configuration "n", recalls a saved configuration from the nonvolatile memory (eeprom).
	Save Configuration, set Example: SAV2 `Save config. 2` *saves the current settings as configuration "n"*	SAVn	Save config. n *where "n" is the configuration number*	Saves the current settings into nonvolatile memory at the configuration number specified. The configuration number can be between 1 and 4.

3.0 Quick Reference

Operation	Command
Fire, Internal Sync	A
Simmer	M
Flashlamp Voltage	V
Fire Q-Switch	CC
Stop Q-Switch	CS
Q-Switch Internal Sync	QI
Q-Switch Sync	QSSYNC
Q-Switch Mode	QSM
Q-Switch Burst Count	QSP
Q-Switch Auto Run	QOF
Status Word	WOR
Interlock Byte 2	IF2
Q-Switch Interlock Byte	IQ
Cooling Group Temperature	CGT
Charger/Simmer Temperature	CST
Configuration	CFG
Uptime	T

Operation	Command
Fire, External Sync	E
Stop Flash	S
Flashlamp Energy	EJ
Flashlamp Frequency	D
Fire Q-Switch Single Shot	OP
Q-Switch Delay	W
Q-Switch External Sync	QE
Q-Switch Auto Ratio	QSF
Q-Switch Scan Parameters	Q
Shutter Command	SHC
State	ST
Interlock Byte 1	IF1
Interlock Byte 3	IF3
First Interlock	IF
Harmonic Generator Temperature	HGT
All Three Temperatures	T3
Save Configuration	SAV
Flashlamp External Trigger Delay Bypass	BYPASS

TECHNICAL SPECIFICATIONS

1.0 General Specifications

Power input:

- 100-240VAC, 50/60Hz, 850VA; Power Factor Corrected (PFC)
- AC mains supply voltage shall not fluctuate more than ±10% of nominal voltage.
- User serviceable power input fuses, both lines fused: 10A, 250V, Time Delay, 5mm x 20mm, and Ceramic Tube.
- Universal type IEC 320 power line connector for detachable cord.

Cooling System:

- Air-cooling of the Power Supply is required. Airflow is front to back.
- Coolant: *Either* distilled water *or* 50/50 mixture by volume of Reagent Grade Ethylene Glycol/distilled water if ordered with the Ethylene Glycol option.
- Coolant temperature regulation—the system is designed to regulate to 38°C, with input power sufficient for the ambient conditions present, regardless of the input power. Coolant temperature regulation depends on factors such as ambient temperature, operating voltage, and the average operating power of the laser (which may vary from about 65W up to 450W).

Output Power	Operating Voltage	Ambient Temperature	Measured Temperature Rise
150W	230VAC	28°C	10.2°C
200W	230VAC	28°C	10.7°C
300W	230VAC	28°C	13.5°C

- De-Ionizing (DI) cartridge inline with the ICE450 coolant lines maintains coolant conductivity at 1.0µS m-1 (resistivity 1.0MΩ m).
- DI cartridge contains a particle filter.
- Coolant connectors are shut-off quick-disconnect style.
- Coolant vent and fill port are accessible from the front panel for filling and draining the coolant.
- Coolant flow is 2.2 CLPM minimum with pressure drop of +/- 10%.

Environmental Conditions:

- Ambient temperature range: 10°C to 40°C for specified system performance specifications.
- Storage Temperature Range: 5°C to 50°C.
- Altitude: 3048m (10,000 ft) maximum altitude.

Regulatory Compliance:

- Complies with the Restriction of Hazardous Substances Directive (RoHS) 2002/95/EC.
- Electromagnetic Compatibility (EMC).
- Conforms to EMC Directive 89/336/EEC and Low Voltage Directive 73/23/EEC.
- Refer to the **Declaration of Conformity on page 99** for applicable standards tested relating to electromagnetic emissions and immunity.

Safety:

- Conforms to EN 61010-1 and IEC 61010-1 general safety requirements for electrical equipment for measurement, control, and laboratory use.
- Installation/over voltage category II; Pollution degree; 2 Standard environmental rating.
- Enclosure degree of protection rated IEC 60529 IPX0.
- Conforms to Laser Emission Equipment standard EN 60825-1 and Federal Laser Product Performance Standard, 21 CFR Part 1040.10 (FDA-CDRH) except for deviations pursuant to CDRH Laser Notice 50.

Installation:

Standard ICE450 operates in upright or horizontal position

- Dimensions (H x W x L): 14” x 5¼” x 18” [35.6cm x 13.3cm x 45.7cm]
- Weight: 29.0lbs [13.2kg] without coolant; approx. 31.6lbs [14.3kg] with coolant.

19-inch 3U Rack ICE450 used for equipment racks

- Dimensions (H x W x L): 5¼” x 19” x 20¼” [13.3cm x 48.3cm x 51.4cm].
- Weight: 28.6lbs [13.0kg] without coolant; approx. 30.2lbs [13.7kg] with coolant.

Quantel reserves the right to modify the specifications without notice.

2.0 Data Summary Sheet

Your system was shipped with a Data Summary Sheet that lists important information about your system. Refer to your Data Summary Sheet for the specific values for minimum and maximum limits, Q-Switch delay, and other information that may be unique to your configuration.

Data Summary

System SN:	Your info here	**Laser SN:**	Your info here
System WO #:	Your info here	**Laser PN:**	Your info here
System PN:	Your info here	**Power Supply SN:**	Your info here

Beam Parameters	Principal	Residual		
	XXXnm	XXXnm	XXXnm	*
Energy (mJ)	XXX	XXX	XXX	*
Near Field Beam Diameter (mm)	XXX	XXX	XXX	*
Pulse Width - FWHM (nsec)	XXX	XXX	XXX	*
Divergence at 86.5% (mrad)	XXX	XXX	XXX	*

Hold-off (steady state):	XXX	J	PRF Min Limit:	XXX	Max Limit: XXX Hz
Hold-off (turn-on):	XXX	J	High Voltage Limit:	XXX	V = XXX J
Threshold:	XXX	J	Cap.	XXX	µF

Power Supply Setting	Pulse Rate (Hz)	Energy In (Joules)	Qsw Fire-every (# pulses)	Qsw Delay (µsec)	Qsw Turn-On Delay (# pulses)	Qsw Ramp (# pulses)	Q-Sw. (OFF)	Shutter (OFF)
Configuration #1	XXX	XXX	X	XXX	X	X	X	X
Configuration #2	XXX	XXX	X	XXX	X	X	X	X
Configuration #3	XXX	XXX	X	XXX	X	X	X	X
Configuration #4	XXX	XXX	X	XXX	X	X	X	X

Notes, Special Features, Precautions, etc…

IMPORTANT: CUSTOMER PLEASE READ!

- ☐ Be sure to fill cooler with distilled water.
- ☐ Cooler filled with 50:50 Ethylene Glycol and Distilled Water mix.

10-F-027 Rev. AA

3.0 RS-232 Communications

Communications

Baud Rate 9600

Data Bits: 8

Stop Bits: 1

Parity: None

Flow Control: None

Serial Cable Wiring

The host computer or serial converter device must incorporate a 9-pin D-Subminiature RS-232 connector (DE-9). The cable to the ICE450 should not exceed 20m for RS-232 applications. Note that many varieties of serial converters are available from third-party suppliers to convert from RS-232 to RS-485/RS-422, USB, Ethernet and so on, depending on your interface requirements.

The ICE450 requires only a minimal three-wire connection for RS-232 communications although a standard full DTE-DCE cable may be used in most cases. A few things to note regarding the ICE450 DE-9 connector interface include:

- A loop back jumper is pre-wired from RTS (Pin 7) to CTS (Pin 8).
- Pin 9 provides a +5V (100mA maximum) fused output in reference to serial ground (SGND, Pin 5) for customer use.

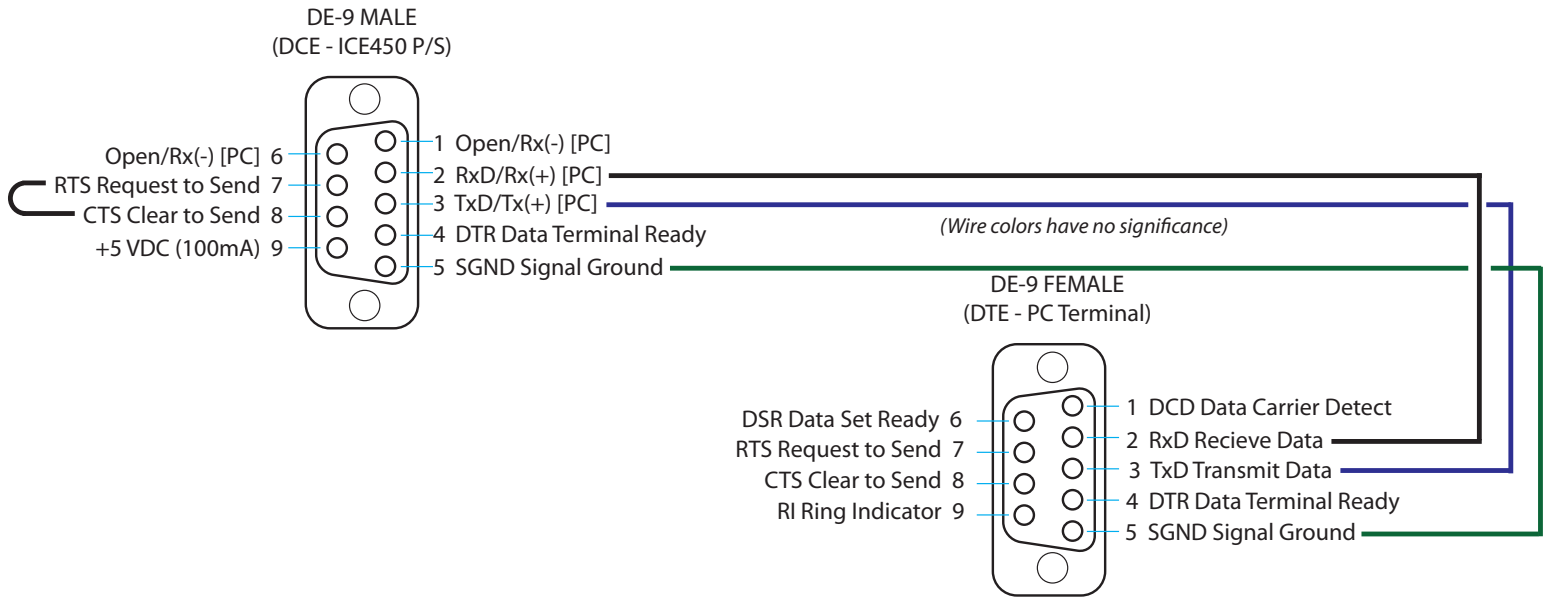


Figure 22 Wiring Diagram for RS 232 Interface

Example: a minimal three-wire RS-232 cable from the Data Terminal Equipment (DTE) to Data Communications Equipment (DCE).

4.0 External Trigger Signal Requirements

External triggering will not function properly unless the external signal applied to the ICE450 input connector meets the specified requirements:

- The signal generator must be set up to drive the ICE450 50Ω input. Figure 23 shows a signal generator driving the external trigger input of the ICE450.
- The external flashlamp input to the ICE450 has an impedance of 50Ω. In order for Vi to be 5V, the signal generator must drive 50mA into the trigger input.
- If it is not clear that the signal generator is driving the signal properly, measure the trigger signal using the method shown in Figure 24. Connect to the trigger signal circuit using a BNC "tee". Verify that the oscilloscope input is in high-impedance mode (greater than 1 MΩ).
- The duration of the signal must be at least 100µs. If the signal from the external generator does not meet the required parameters, adjust or replace the generator until it does.
- Figure 25 shows the required characteristics of the flashlamp trigger signal.

CAUTION: To maintain a fast rise time and therefore minimal jitter, the Q-Switch input is not optically isolated and does not have over-voltage protection circuitry. Do not apply voltages greater than 5V to prevent damage to sensitive components.

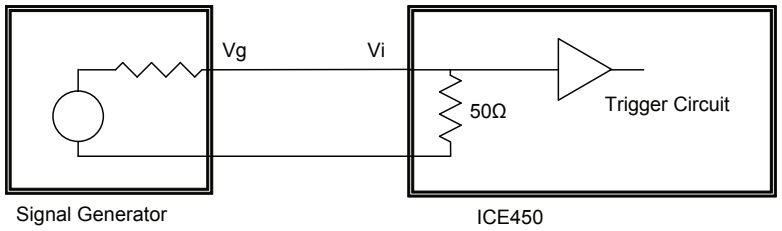


Figure 23 Signal Generator to Trigger Circuit

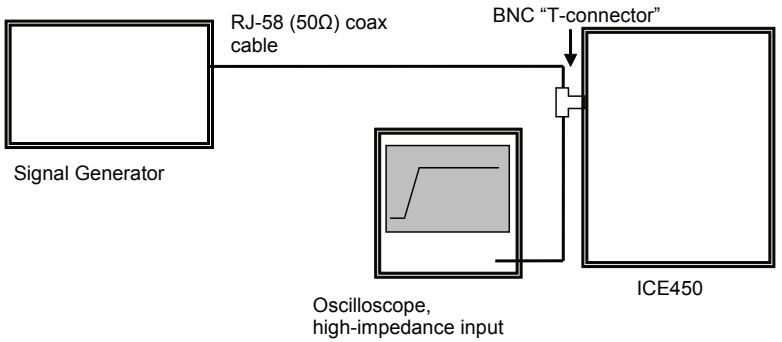


Figure 24 Preferred Method of Measuring Trigger Signal

Symbol	Parameter	Min.	Max.	Unit
VIL	Input low voltage	0.0	0.8	V
VIH	Input high voltage	3.0	5.0	V
TR	Rise time		1	µs
TW	Pulse width	100		µs
VPK	Peak voltage		5.5	V

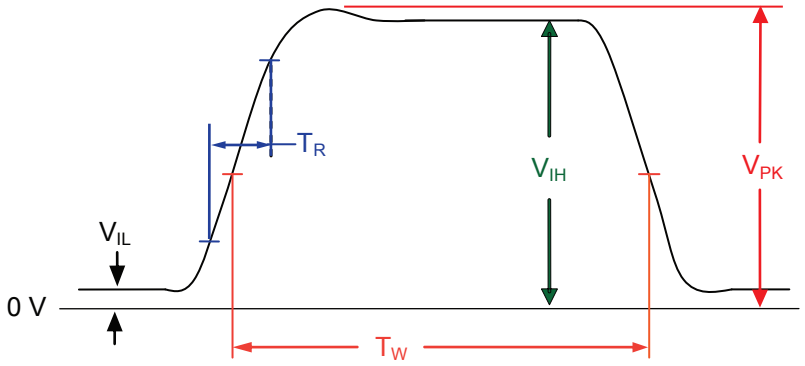


Figure 25 Required Characteristics of Flashlamp and Q-Switch Trigger Input Signals

5.0 Timing Diagrams

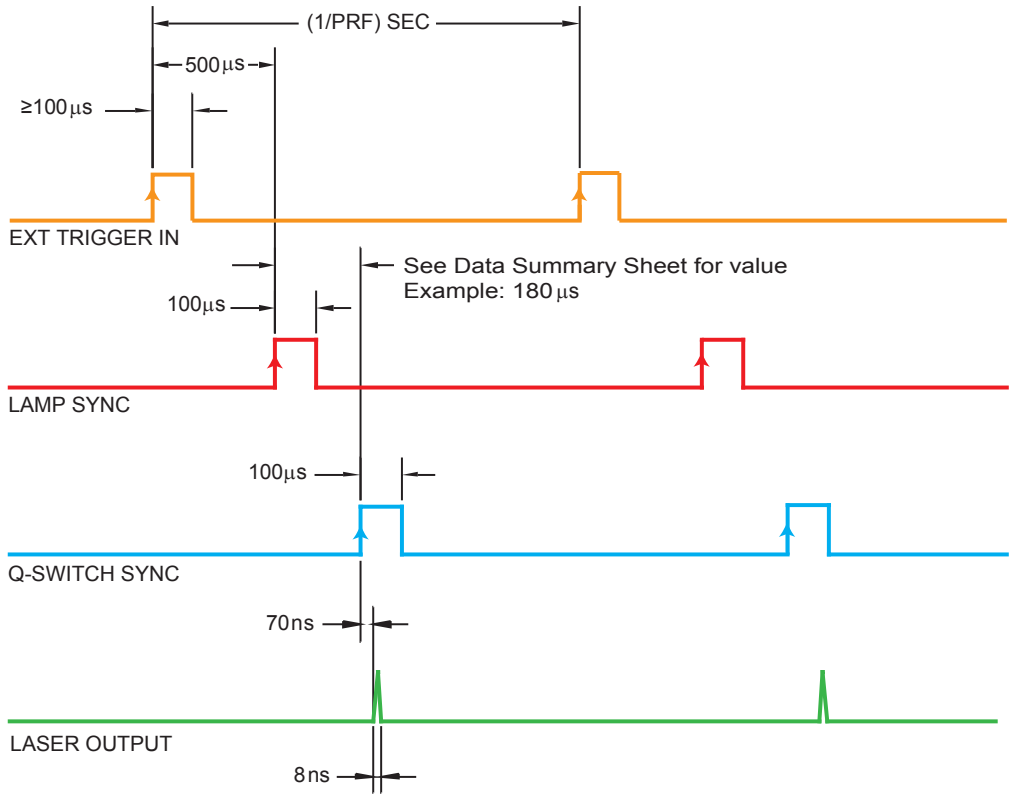


Figure 26 Typical Timing Diagram (External Flashlamp/Internal Q-Switch)

Note: See the Operations section for additional examples. For BYPASS mode see **Bypass Mode Diagram on page 33**.

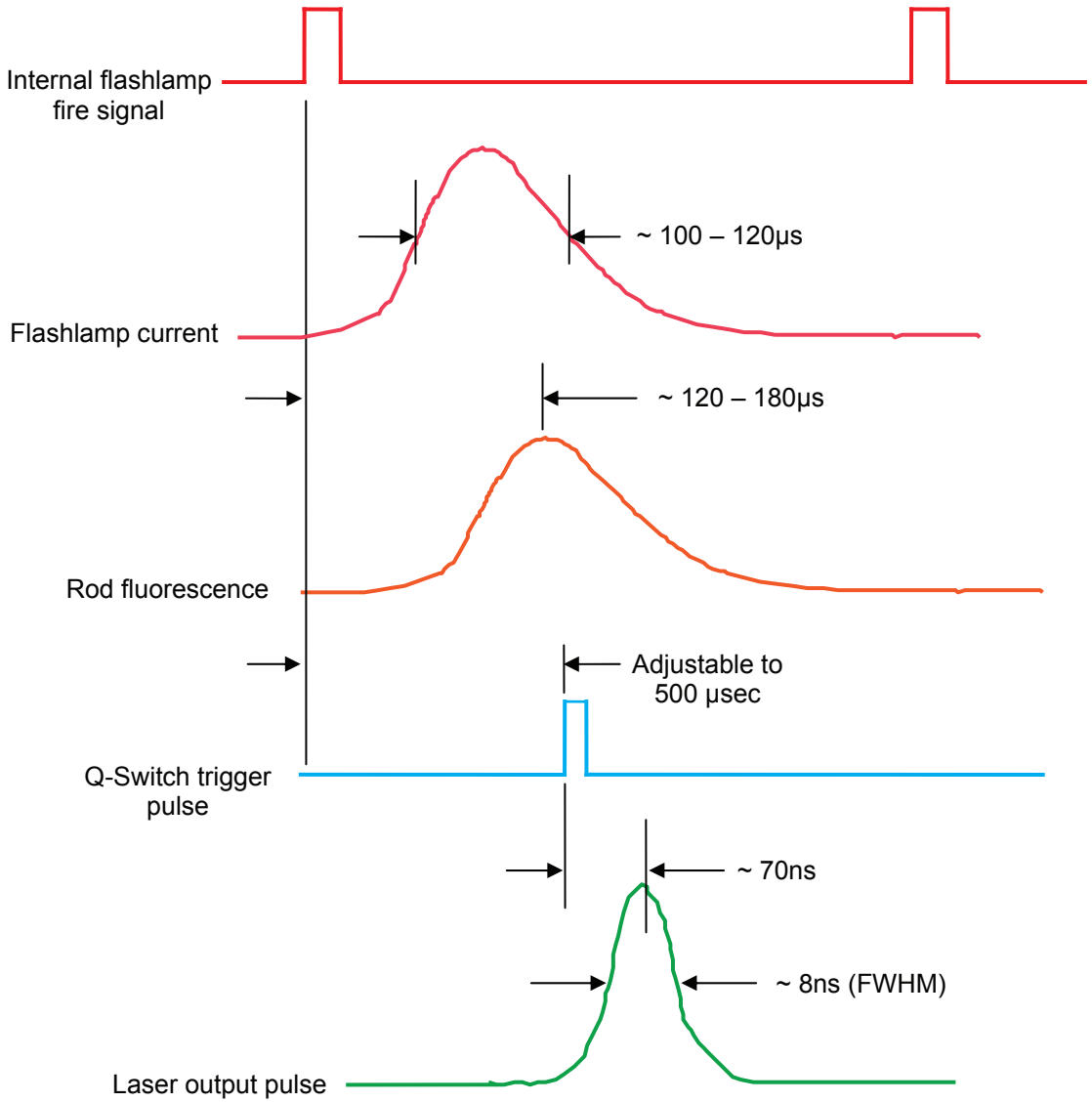


Figure 27 Timing Signals in Automatic Mode

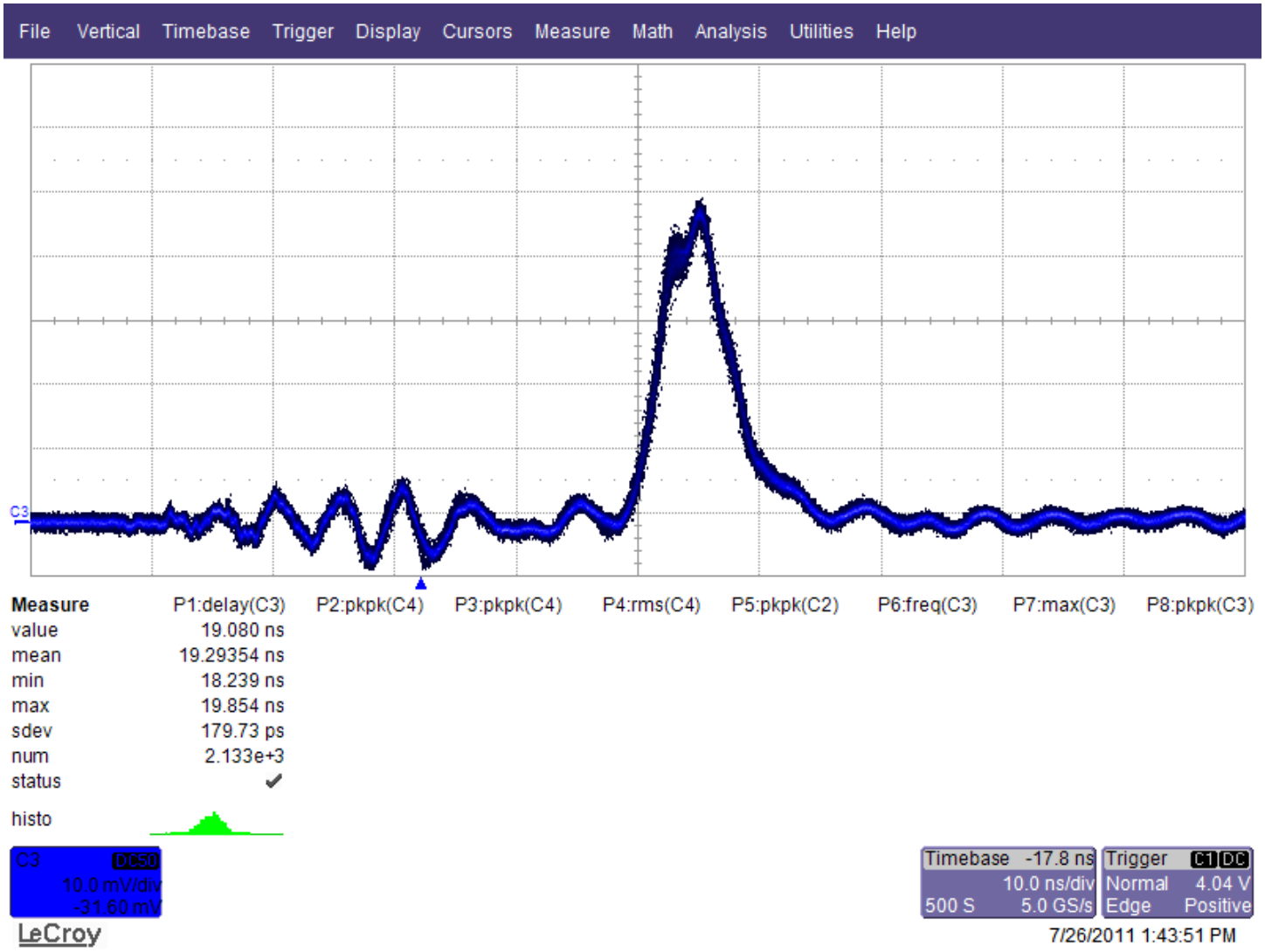


Figure 28 Jitter: Laser Light Output with Respect to Q-Switch Sync Output

OPTIONAL EQUIPMENT

1.0 Harmonic Generation Modules

The 1064, 532, 355 and 266 nm harmonic generation options are contained within the standard CFR housing. Harmonic generation modules are factory aligned, sealed and purged.

Second Harmonic Generation (SHG)

The CFR uses a temperature-controlled doubler module (typically KTP) inside the standard CFR Laser Head to generate 532 nm radiation. When the system is initialized there is a short warm-up time for the oven. The 532 nm laser radiation mixed with residual 1064 nm exits the Laser Head from Aperture A. With a KTP doubler the output polarization of the 532 nm laser light is vertical and the 1064 nm light is elliptical. A wavelength separation module may be added to cause the wavelengths to exit separate apertures.

Third Harmonic Generation (THG)

Doubler and tripler ovens, mounted inside the CFR, are used to generate 355 nm laser radiation. A doubler module (see SHG) is used to generate 532 nm radiation. The 532 nm radiation is then mixed with the residual 1064 nm radiation to produce 355 nm light. The 355 nm laser radiation mixed with residual 1064 nm and 532 nm exits the Laser Head from Aperture A. The output polarization of the 355 nm laser radiation is vertical, the 532 nm is horizontal and the 1064 nm is elliptical. A wavelength separation module may be added to cause the wavelengths to exit separate apertures.

Fourth Harmonic Generation (FHG)

Doubler and quadrupler ovens, mounted inside the CFR, are used to generate 266 nm laser radiation. A doubler module (see SHG) is used to generate 532 nm radiation. The 532 nm radiation is doubled again to produce 266 nm light. The output polarization of the 532 nm light is horizontal, and the 266 nm light is vertical. A wavelength separation module may be added to cause the wavelengths to exit separate apertures.

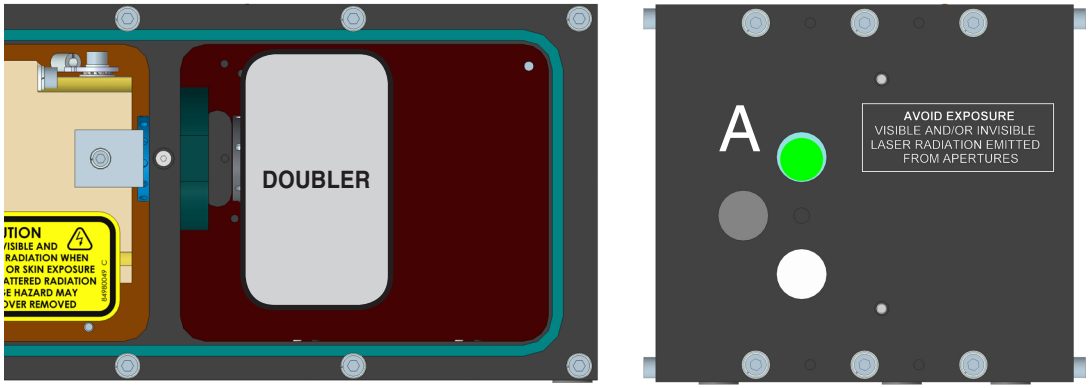


Figure 29 **SHG**

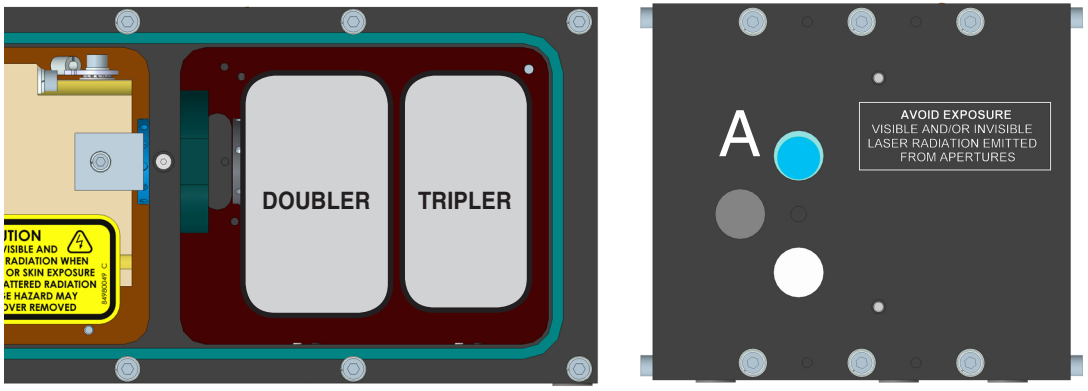


Figure 30 **THG**

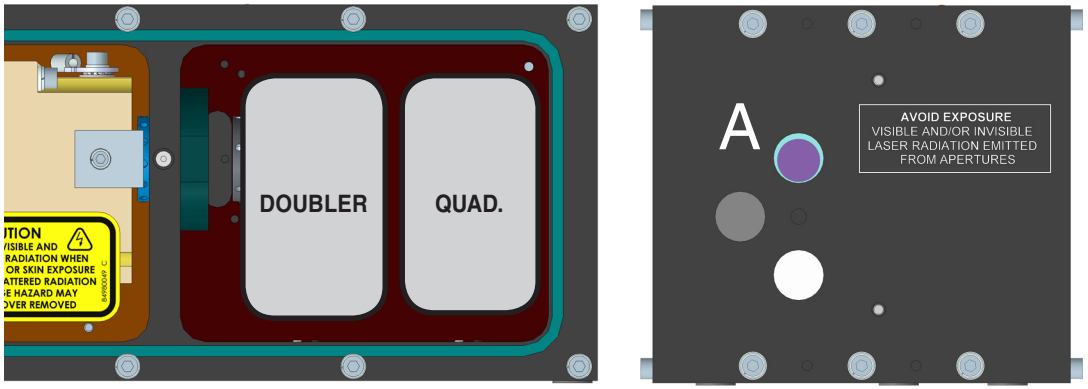


Figure 31 **FHG**

2.0 Wavelength Separation

Wavelength separation is achieved using dichroics or harmonic beam splitters. Most dichroics are located in a module added to the front of the CFR housing, with the exception of WS2 for SHG (532nm) which are installed inside the CFR housing.

Harmonic generation modules are located inside the CFR housing. See **Drawings starting on page 68** for sizing details. All wavelength separation options come with a rotatable beam dump.

Without wavelength separation, any combination of 1064 nm, 532 nm, 355 nm or 266 nm laser radiation all exit from Aperture A on the Laser Head.

The following configurations are available for wavelength separation:

	with SHG (532nm)	with THG (355nm)	with FHG (266nm)
WS1 wavelength separation single aperture	SHG with WS1 causes the 532 nm to exit the Laser Head from Aperture B. The 1064 nm is dumped internally. (See Figure 32.)	THG with WS1 causes the 355 nm to exit the Laser Head from Aperture C. The 1064 nm and 532 nm are dumped internally. (See Figure 33.)	FHG with WS1 causes the 266 nm to exit the Laser Head from Aperture C. The 1064 nm and 532 nm are dumped internally. (See Figure 33.)
WS2 wavelength separation	SHG with WS2 causes the 532 nm radiation to exit from Aperture B and the 1064 nm to exit from Aperture A	THG with WS2 causes the 355 nm to exit from Aperture C, and 1064 nm + 532 nm to exit from Aperture A.	FHG with WS2 causes the 266 nm beam to exit from Aperture C, and the 1064 nm + 532 nm to exit from Aperture A.
WS3 3 wavelength separation	not used with SHG	THG with WS3 cause each of the 3 wavelengths to exit a different aperture simultaneously; 1064 nm exits from Aperture A, 532 nm exits Aperture B and 355 nm exits Aperture C. The beam block can be rotated to select a particular wavelength.	THG with WS3 causes each of the 3 wavelengths to exit a different aperture simultaneously; 1064 nm exits from Aperture A, 532 nm exits Aperture B and 266 nm exits Aperture C. The beam block can be rotated to select a particular wavelength.
WSP wavelength purity separation	Using WSP, only the desired wavelength (532, 355 or 266) is emitted and always from Aperture A. WSP uses 4 dichroics for highest spectral purity.		

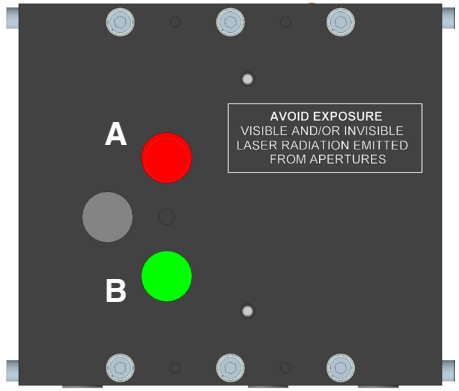


Figure 32 CFR

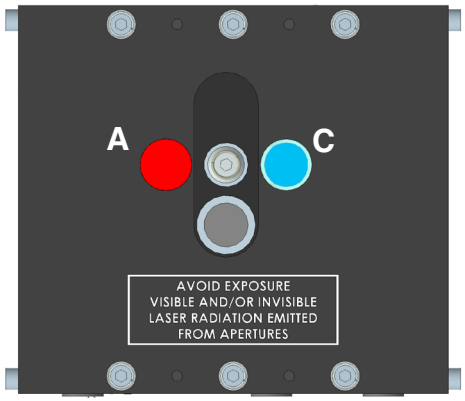


Figure 33 CFR with 2 Dichroics

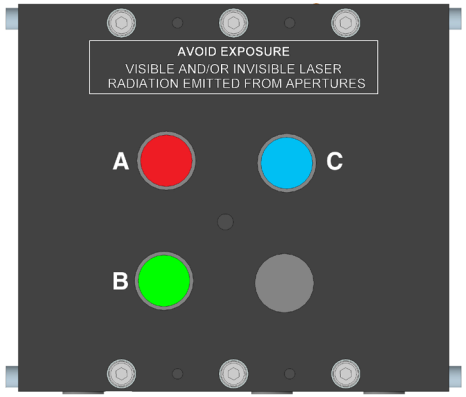


Figure 34 CFR with WS3

3.0 Rotatable Beam Dump

The CFR can also be supplied with a beam dump on the front of the Laser Head for selecting one wavelength while blocking the other two.

To change to a particular aperture:

1. Turn the laser off.
2. Pull the beam dump out.
3. Rotate the opening in the beam dump to the corresponding aperture on the Laser Head. The beam dump snaps into position when properly located. The remaining apertures will be blocked, allowing only the selected wavelength to exit the Laser Head.

4.0 Optical Parametric Oscillator (OPO)

The KTP OPO module converts incident 1064 nm radiation to more eyesafe 1.57 µm radiation. The OPO unit is not wavelength controllable and consequently there is no oven or adjustment required. The residual 1064 nm light is dumped internally.

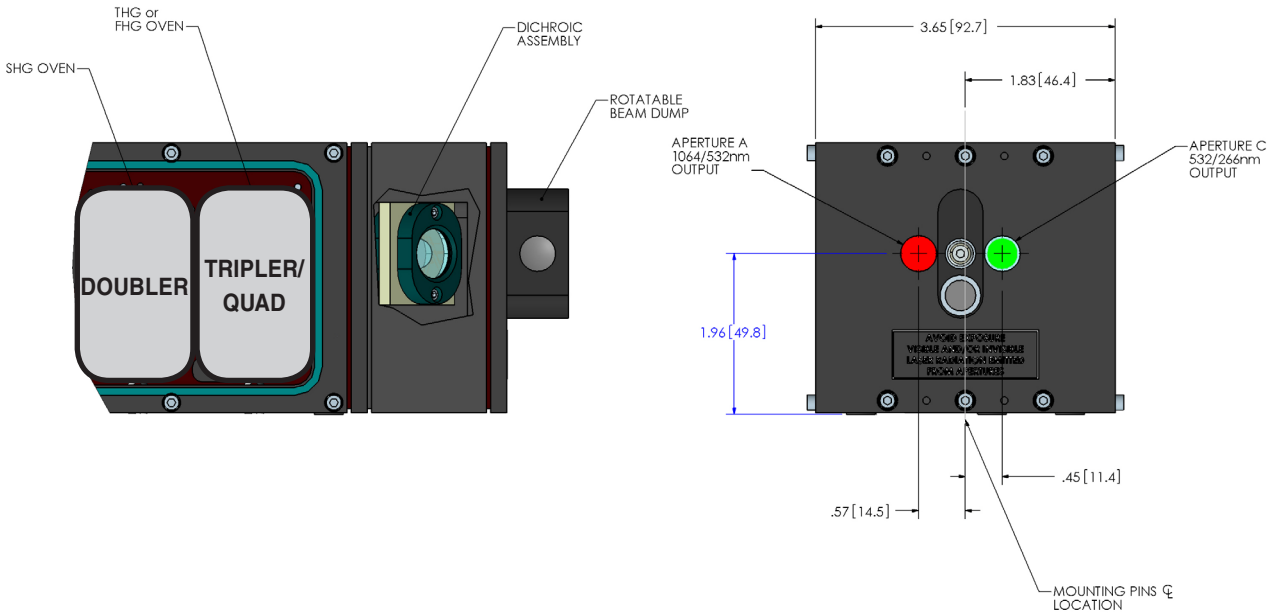


Figure 35 Rotatable Beam Block

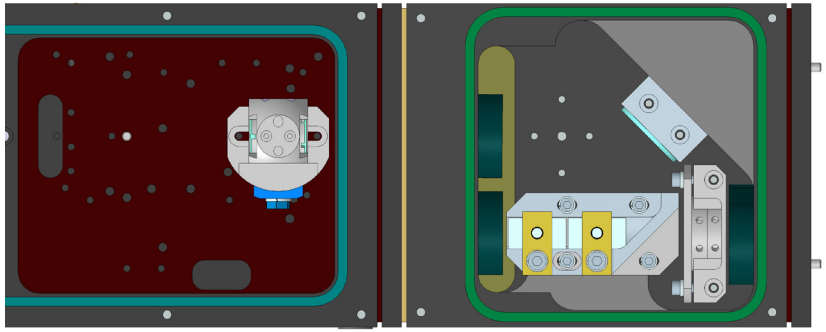


Figure 36 OPO Module

5.0 Variable Attenuator (MVAT)

The CFR Laser System may be equipped with a motorized variable attenuator. The assembly is contained within the Laser Head and is isolated from dust, moisture and other external environmental factors.

The MVAT is controlled via an RS-232 interface. This interface connector is located on the I/O cable between the Laser Head and ICE450. It is a separate and independent interface from the standard RS-232 interface that controls the ICE450.

Any communications program such as HyperTerminal is acceptable for the RS-232 communications. A standard 9-pin RS-232 cable (not included with system) is required. Hyperterminal software is not included in Windows 7® operating system. Windows 7® users must obtain their own program that provides similar functionality.

Before using the MVAT you will need to set up a computer or other terminal device to control the MVAT remotely via RS-232 serial communication.

MVAT SETUP AND CONNECTIONS

1. Turn off system power.
2. Connect the MVAT cable to the RS-232 COM port on your computer/ terminal device using a standard 9-pin RS-232 serial cable (not included).

Note: Do not plug the MVAT serial cable into the ICE450. The MVAT is controlled by a user supplied computer, not through the ICE450.

Note: The RS-232 protocol is used to communicate with the MVAT. The MVAT utilizes a “minimum three wire” configuration. See the RS-232 wiring diagram in Figure 37.

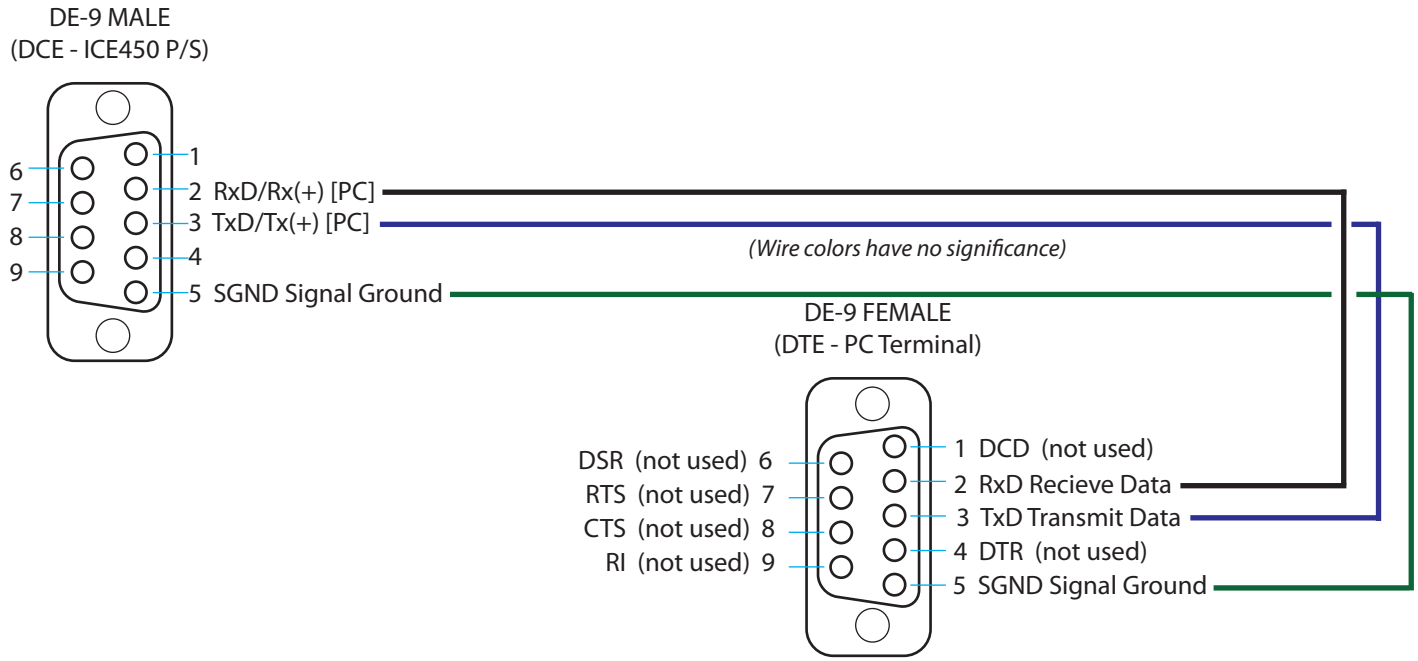


Figure 37 MVAT RS-232 Wiring Diagram

6.0 MVAT Command Set

MVAT serial command protocol is: ;**AT:[COMMAND] XX** **Note:** When typing a command, do not type the brackets [ ].

Example: ;**AT:TF 50.25**

Feature	Operation	Command	Response	Description
MVAT	Echo, set Example: EC0↵ *turns echo off* Echo, query *Example: EC?↵* **echo 1** *response indicates echo is on*	ECn EC?	0 or 1 *"0" turns off echo;* *"1" turns echo on*	Turns on/off the "Echo" feature. With Echo on, all characters that are received by the MVAT's RS-232 receiver are echoed back to the sender. This is frequently useful when diagnosing communications problems. Echo is always "off" at power-up.
	Transmission, Floating-Point Percent, set Example: TF34.25↵ *Sets transmission to 34.25%.* Transmission, Floating-Point Percent, query Example: TF?↵ *Responds with the last-set transmission, in floating point format*	TFn TF?	xx.yy *1-6 character string representing a floating-point value* *Parameter range is 0–100*	Requires a parameter in floating-point format to set the desired transmission percentage. The resulting transmission is given by: transmission = parameter.
	Transmission, Hexadecimal Percent, set Example: APFF↵ *Sets transmission to 100 percent.* Example: AP7F↵ *Sets transmission to 50 percent* (0x7F/0xFF) = 0.5 Transmission, Hexadecimal Percent, query Example: AP?↵ *Displays last-set transmission, in hexadecimal format.*	APnn AP?	0 to FF *Parameter range is 0-FF*	This low resolution command is included only to allow backward compatibility. This instruction requires a one-byte parameter in hexadecimal format that represents the user's desired transmission. The resulting transmission is given by: transmission = 100 (parameter / 0xFF).
	Version Number, query Example: VN↵ *Responds 1.17, indicating the firmware version is 1.17.*	VN	n.nn	Queries the MVAT firmware version number. A question mark (?) is not required for this query; but it is still acceptable.

7.0 Hyperterminal Setup for MVAT

Hyperterminal software is not included in Windows 7® operating system. Windows 7® users must obtain their own program that provides similar functionality.

Note: A terminal communications program is required for sending RS-232 commands to the MVAT. Use the steps below to set up HyperTerminal:

The example shown here is using Windows XP®.

1. Open HyperTerminal by clicking on the Windows Start Menu. Click Run. Type: `hypertrm` and click OK.

   Give the connection a name (for example, ATTN) and click OK.

2. From the Connect To dialog box, verify that Connect Using shows the COM port to which the MVAT pigtail is connected (for example, COM 2) then click OK.

   Click Properties from the File menu.

3. Change the COM port settings to the following, then click OK.

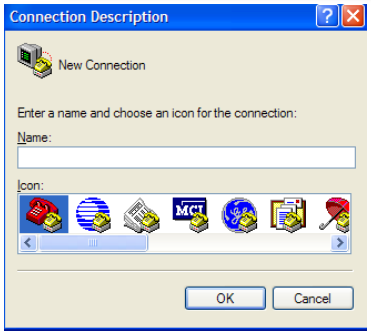
   - Baud Rate: 19200
   - Data Bits: 8
   - Parity: None
   - Stop Bits: 1
   - Flow Control: None

4. Click Properties from the File menu of the HyperTerminal dialog box. Select the Settings tab. Click the ASCII Setup button at the lower right of the dialog box.

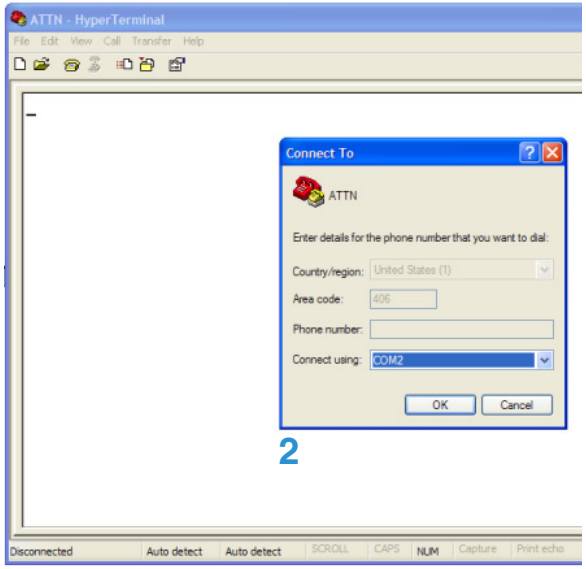
5. Under the ASCII Setup select the following options, then select OK twice:

   - Send line ends with line feeds
   - Echo typed characters locally
   - Append line feeds to incoming line ends
   - Wrap lines that exceed terminal width

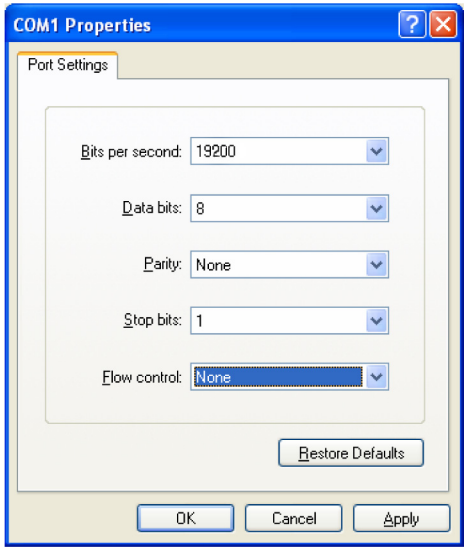
6. HyperTerminal is now set up to communicate with the MVAT. From the Hyperterm dialog box, click File, then click Save to store the connection configuration before exiting.



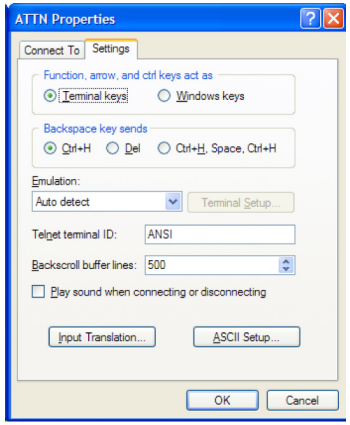
1



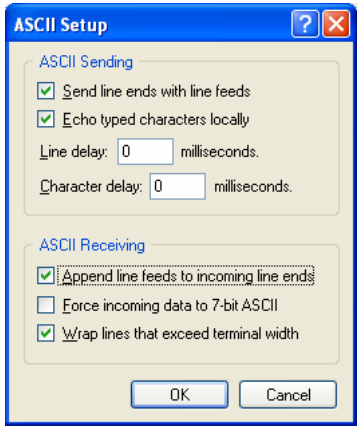
2



3



4



5

DUAL LASER SYSTEMS

1.0 TWINS CFR Laser/Dual ICE450 Power Supply

Note: Your laser should be configured to operate at full energy and Pulse Repetition Frequency (PRF).

Note: If control of the system is handled via RS-232: The characters @2 must be entered prior to Laser 2 commands. Example: @2E Result: Externally Fire Laser 2.

Note: It may take up to 30 minutes for desired energy output to occur.

Note: If Laser #1 is not powered up, then no harmonic converter output will be seen from Laser #2.

2.0 Dual PIV System Setup

CAUTION: Do not power up the laser system before thoroughly reading the installation and operation instructions.

1. Verify that the Key Switches on both ICE are turned OFF.
2. Connect the I/O cable between the ICE #1 rear panel and Laser Head #1. All connectors are unique and keyed to ensure proper connection. Secure all non-locking connectors using the captive fasteners.

CAUTION: These connections carry high voltage and high current. Ensure that the connectors are fully inserted and the collars or screw locks are fully engaged or interlock faults may result.

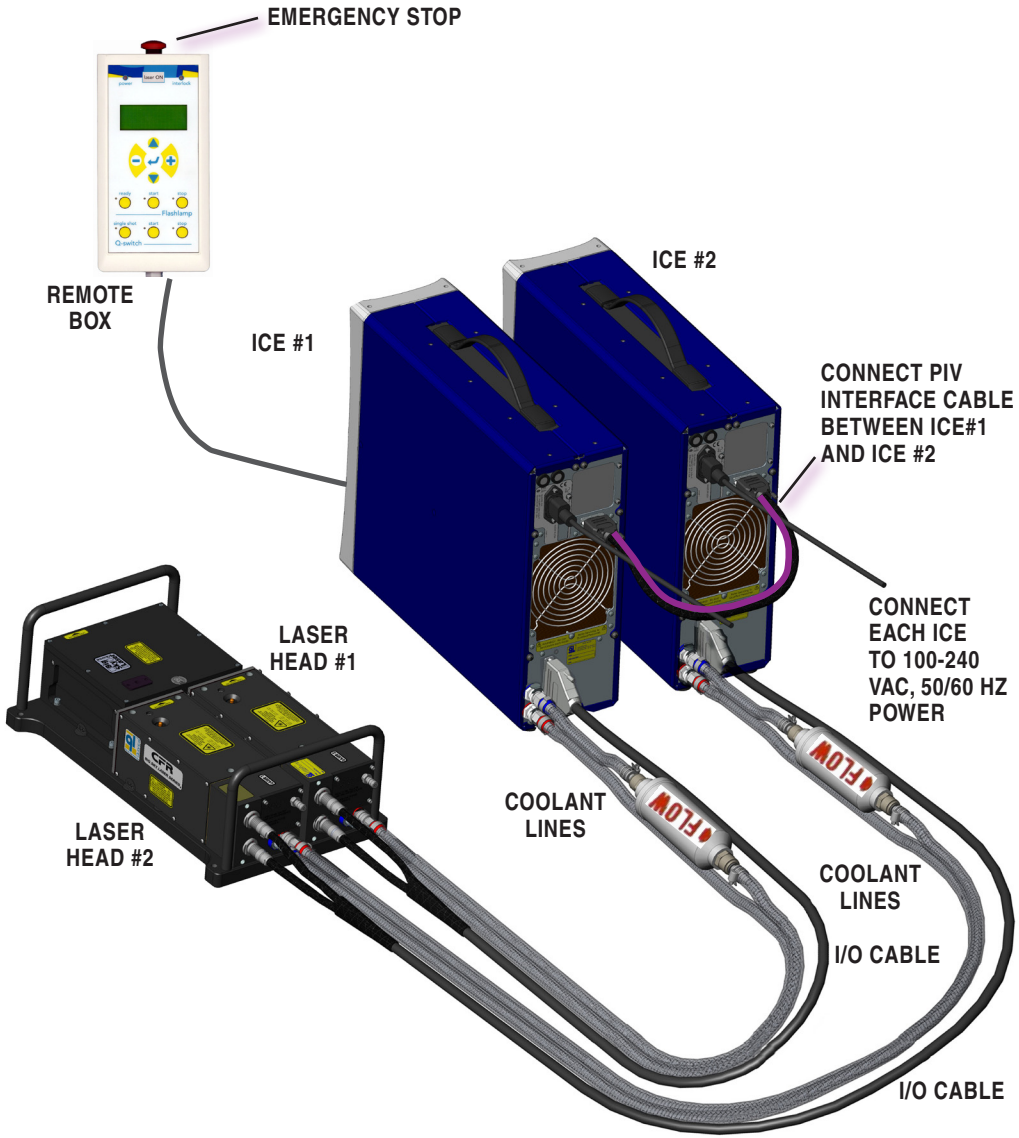
3. Remove the blue plastic shipping covers from the coolant ports. Keep them for reuse.
4. Connect the coolant lines between the back panel of the ICE #1 and Laser Head #1. Connect red to red and blue to blue. Coolant flows from the ICE into the Laser Head via the blue hose and returns to the ICE via the red hose.
5. Repeat steps 2 through 4 to connect similar cables between ICE #2 and Laser Head #2.
6. Connect the PIV Interface Cable from ICE #1 to ICE #2 and tighten the thumb screws.
7. Verify that the Emergency Stop switch on the Remote Box is in the OUT position.
8. Connect the Remote Box to the ICE #1 front panel.

CAUTION! Never operate the Laser System without the I/O Cable connectors fully inserted and the thumb screws tightened.

9. Connect the AC Mains power cables from each of the ICE back panels to 100-240 VAC, 50/60 Hz power.

CAUTION: Ensure the system is connected to the proper voltage. The voltage rating is marked on the ICE back panel. Operating the system at the incorrect voltage may damage the system. Ensure that the power outlet used is properly grounded.

10. Follow the procedure for filling the coolant reservoirs. See **Preparing the Cooling System on page 11**.



Note: Cycle the coolant through both systems until all air pockets are eliminated.

3.0 Final Setup Steps

1. Secure the Laser Heads to a flat mounting surface.

Note: Mounting on a flat surface prevents distortion which causes misalignment within the Laser Head.

2. Short the remote interlock connectors. The laser system has been shipped with these shorting connectors already in place. Connect the remote interlock to a lab door interlock, or other system interlocks for safety.
3. Remove the protective cover from the aperture of each Laser Head before operating.

4.0 PIV External Trigger Connection

Note: This Laser System is designed to be controlled by external Flash Lamp triggering only. Refer to the **External Trigger Signal Requirements on page 53** for trigger pulse requirements. Two modes are available for External Triggering:

- External Flashlamp/Internal Q-Switch (Mode 1)
- External Flashlamp/External Q-Switch (Mode 2)

To trigger Flashlamps externally and Q-Switches internally (Mode 1):

1. Provide a two-channel Pulse Generator (PG).
2. Connect a BNC cable from PG CH:1 to “Lamp IN” on the ICE450 Power Supply #1 front panel.
3. Connect a BNC cable from PG CH:2 to “Lamp IN” on the ICE450 Power Supply #2 front panel.

To trigger both the Flashlamps and the Q-Switches externally (Mode 2):

1. Provide a four-channel Pulse Generator.
2. Connect a BNC cable from PG CH:1 to “Lamp IN” on the ICE450 Power Supply #1 front panel.
3. Connect a BNC cable from PG CH:2 to “Lamp IN” on the ICE450 Power Supply #2 front panel.
4. Connect a BNC cable from PG CH:3 to “QS IN” on the ICE450 Power Supply #1 front panel.
5. Connect a BNC cable from PG CH:4 to “QS IN” on the ICE450 Power Supply #2 front panel.

MODE 1: EXTERNAL FLASHLAMP/INTERNAL Q-SWITCH TRIGGERING SETUP

5.0 Dual Laser System Operation

CAUTION! Do not fire the system before reading the System Data Summary and the User's Manual that was included with your system. Use of controls and adjustments, or performing procedures other than those specified may result in hazardous radiation exposure, electric shock, or laser system damage and may void the warranty. Follow all precautions for eye protection and safety practices. Consult the Safety section of this manual.

Note: See **Operation on page 16** for more detail.

1. Refer to the System Data Summary and verify all settings on the Remote Box.
2. Press the Flashlamp Start button on the Remote Box and verify both flashlamps start flashing.

Lasing begins when the Q-Switch Start button on the Remote Box is pressed. The Emission Indicator LEDs on top of the Laser Heads will illuminate to indicate lasing once the shutters are opened.

Note: It may take up to 30 minutes for desired energy output to occur

Note: If Laser #1 is not powered up, then no harmonic converter output will be seen from Laser #2.

Dual System Pulse Timing:

CH1 :: FL#1 = t0

CH2 :: FL#2 = t0 + [10 to 100µS] (typical)

CH3 :: QS#1 = t0 + 500µS (processing delay) + FLQS delay (See details in **Q-Switch Menu on page 22**)

CH4 :: QS#2 = t0 + [10 to 100µS] + 500µS + FLQS delay

Pulse Width, Amplitude, & Rep Rate:

Refer to your **Data Summary Sheet** and to the **External Trigger Signal Requirements on page 53**.

Dual System Start Up Procedure

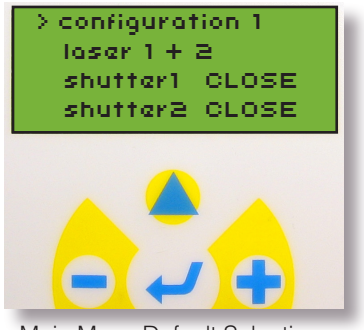
Note: The Remote Box is configured to control both lasers (1+2) by default.

Note: Control of laser 2 will have a noticeable delay.

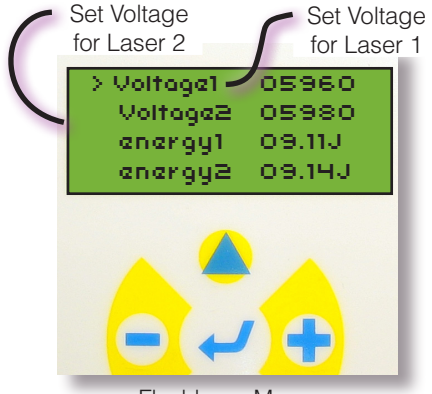
1. Ensure that the red Emergency Stop button on the Remote Box is pulled out.

To return to the default laser 1+2 selection.

2. Turn both ICE450 ON.
3. Verify the Main Menu appears on the Remote Box.
4. The default laser selection (1+2) controls both lasers together. There will be a "1" and "2" entry for each laser in each menu.



Main Menu Default Selection:
laser 1 + 2



Flashlamp Menu:
with laser 1 + 2 selections

6.0 Controlling One Laser of a Dual System

To control only one laser separately from the other:

1. From the Main menu, position the cursor (>) at the laser item (showing 1+2 or 2).
2. Press the plus or minus (+/-) button until laser 1 is selected. The Remote Box now controls only laser 1.

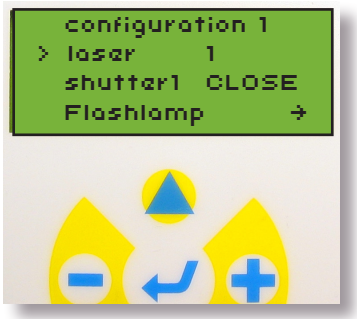
To control Laser 2:

1. From the main menu, position the cursor at the laser item (showing 1+2 or 1).
2. Press the plus or minus (+/-) button until laser 2 is selected. The Remote Box now controls only laser 2.

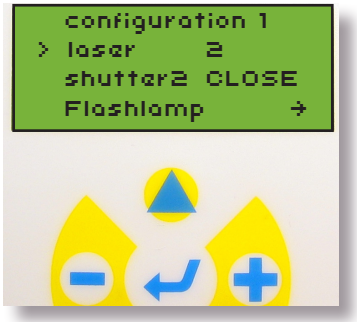
When operating Laser 2 with the Remote Box, there will be a slight delay due to latency in communication between the two power supplies.

7.0 Software Note for Dual Systems

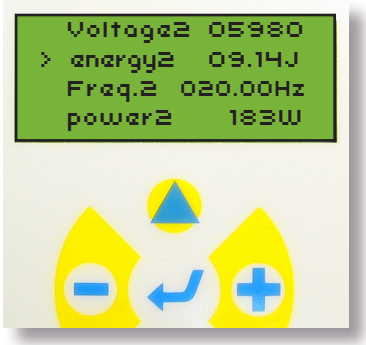
Note: If RS-232 connection is used to control of the system via a remote computer, the characters @2 must be entered prior to Laser 2 commands. Example: @2E = Externally Fire Laser 2.



Main Menu: Use "–" button to change selection to laser 1



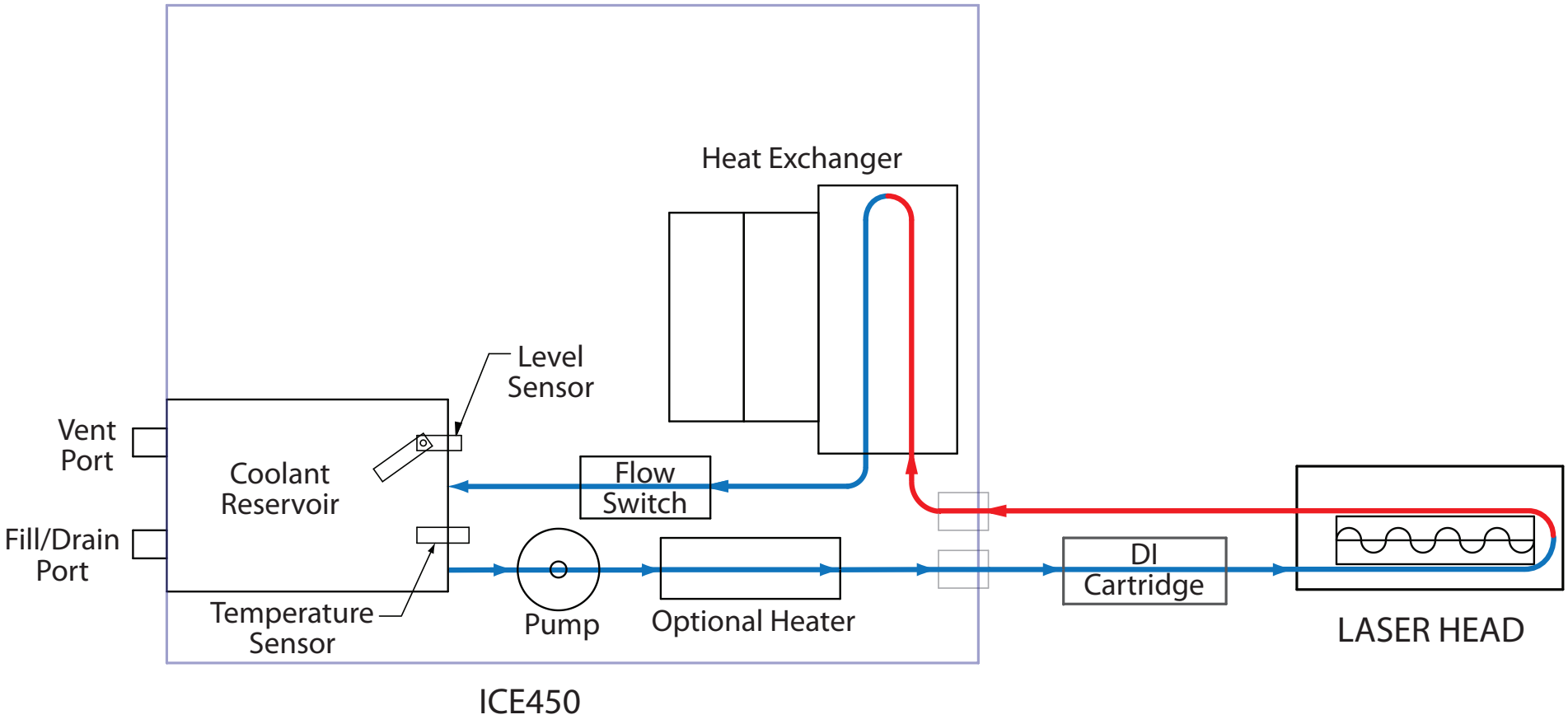
Main Menu: Use "+" button to change selection to laser 2



Flashlamp Menu: Selections are only for laser 2

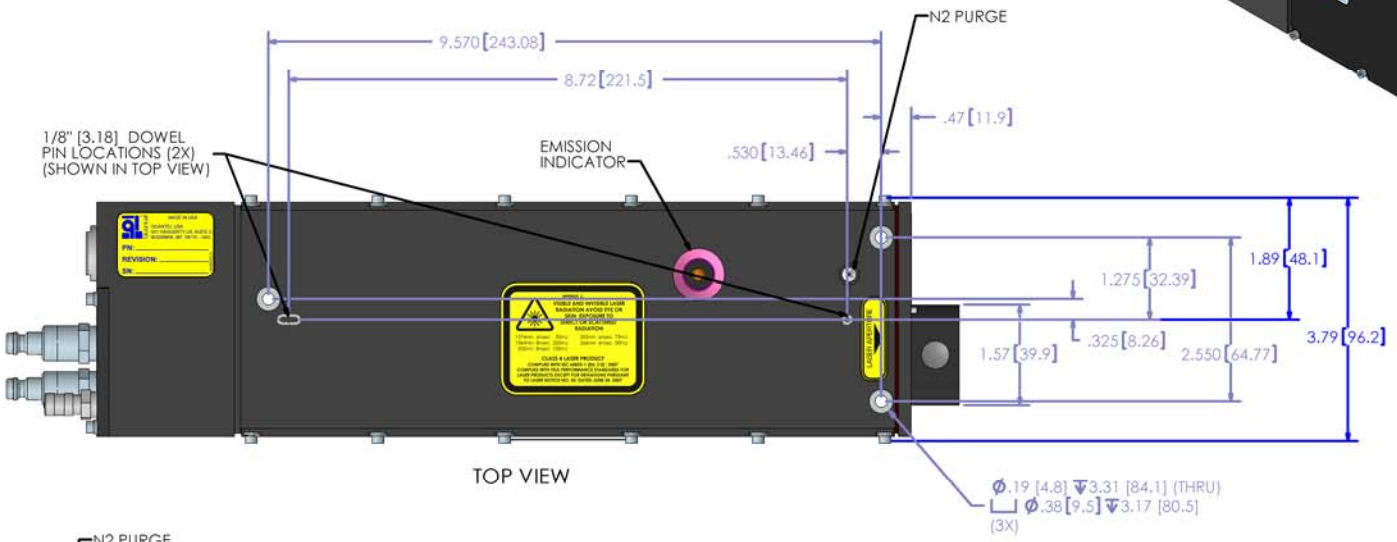
DRAWINGS

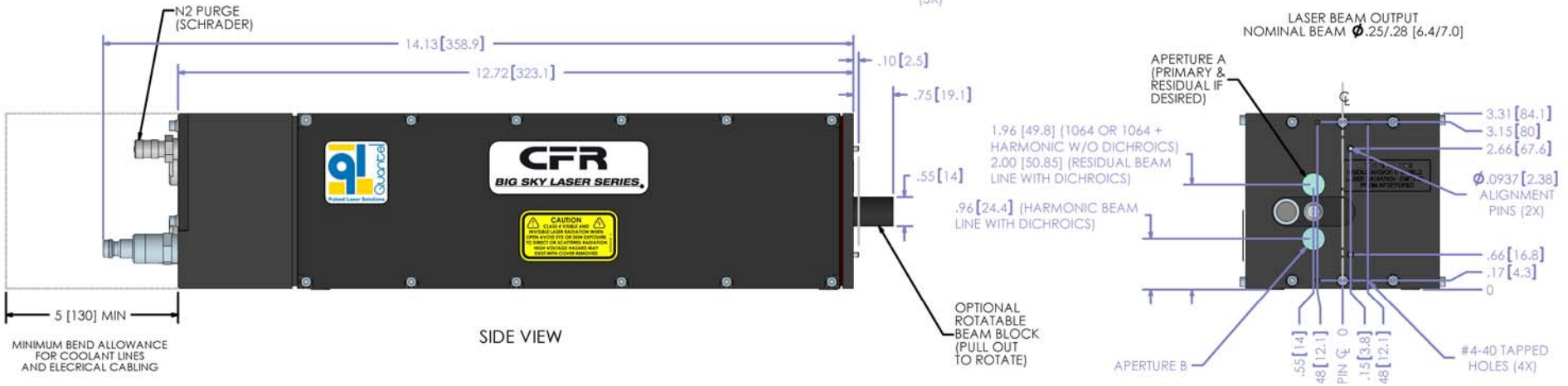
1.0 Cooling System Diagram



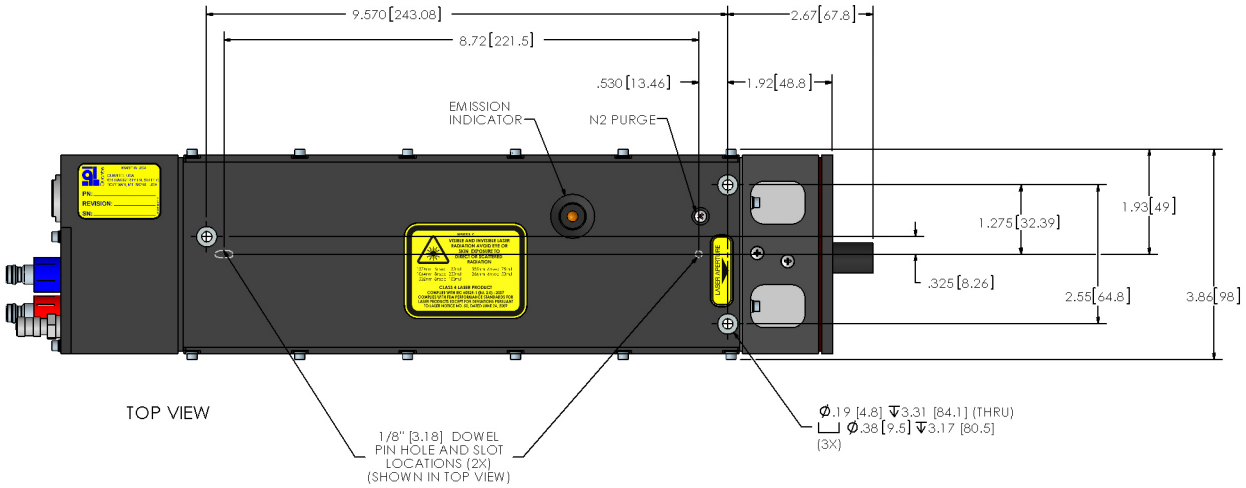
COOLING SYSTEM DIAGRAM: CFR LASER SYSTEM

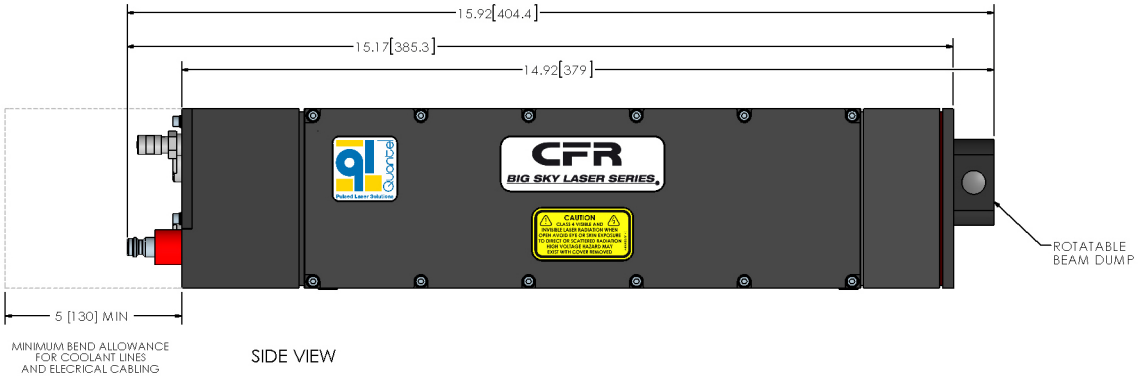
2.0 Laser Head

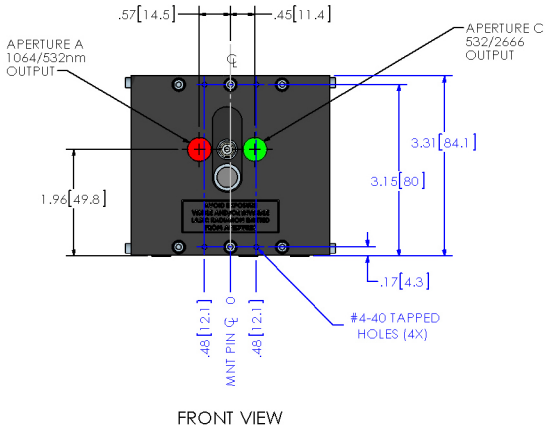




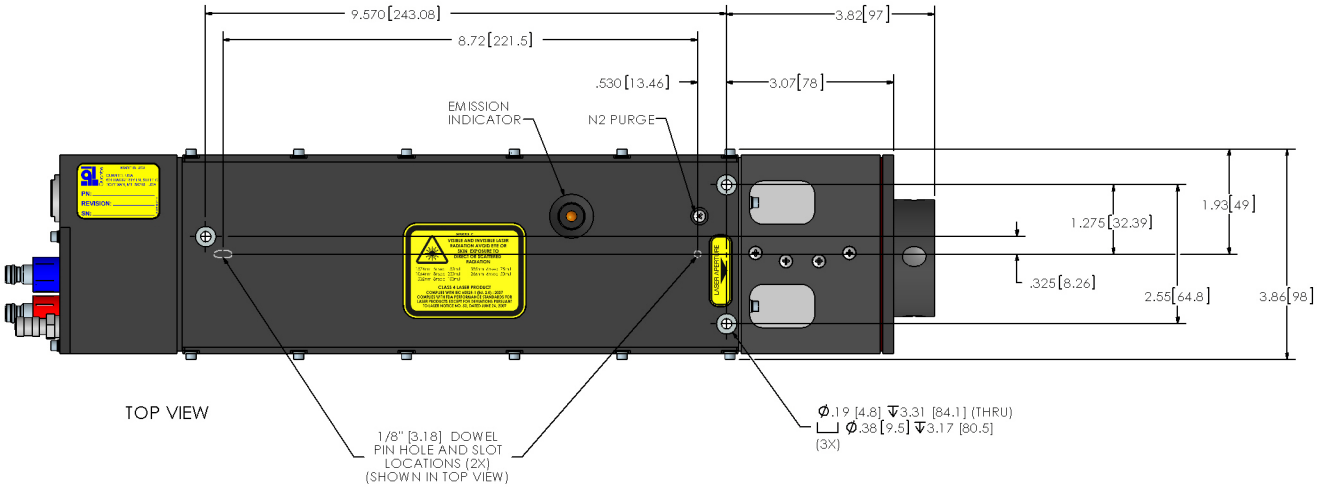
3.0 Laser Head with Wavelength Separation

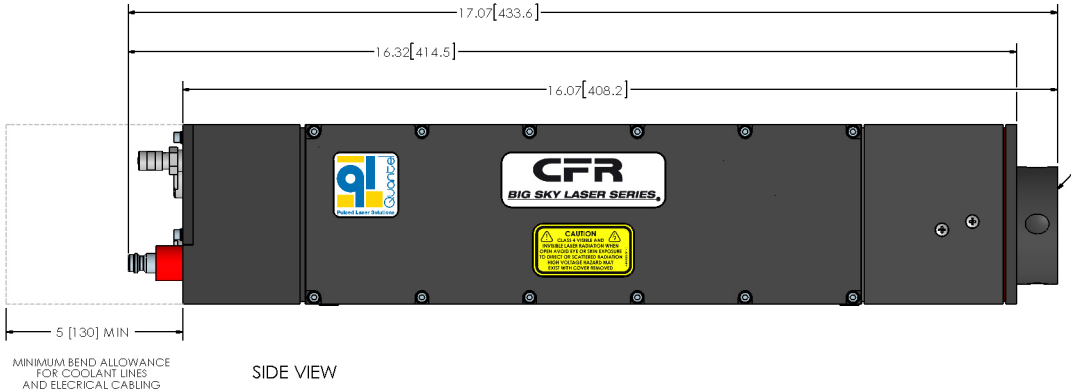


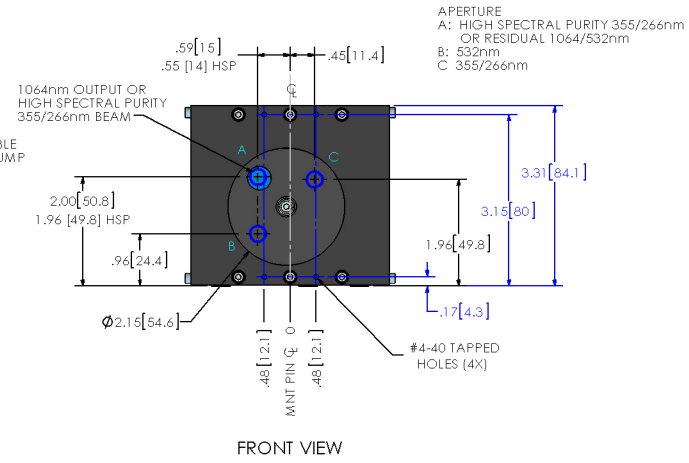




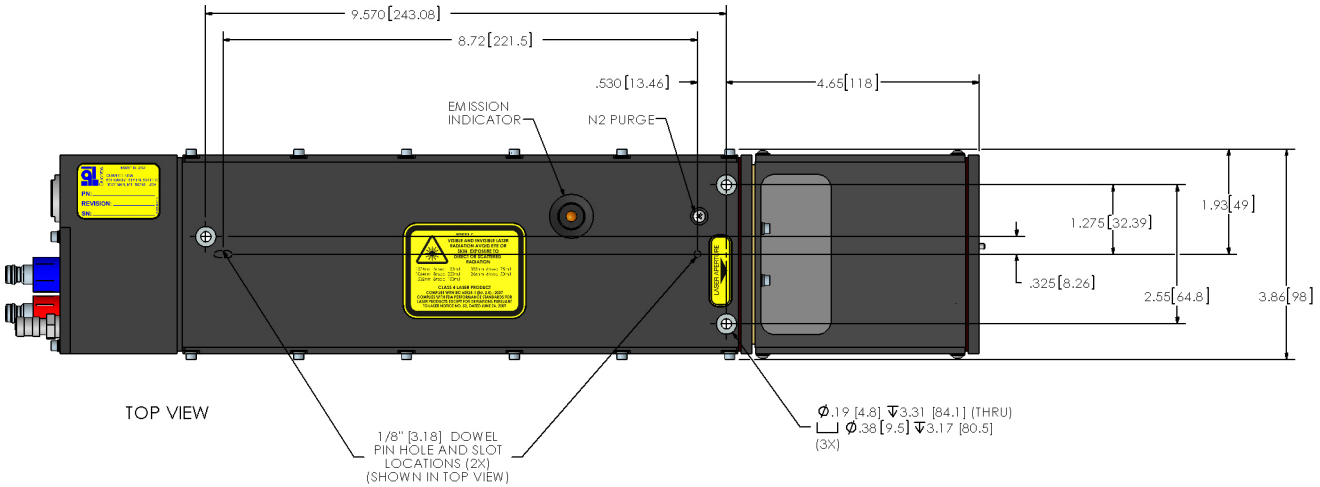
4.0 Configurations for High Spectral Purity (WSP) *WSP does not use a Rotatable Beam Dump* and 3 Aperture Wavelength Separation (WS3) *Rotatable Beam Dump is supplied with WS3*

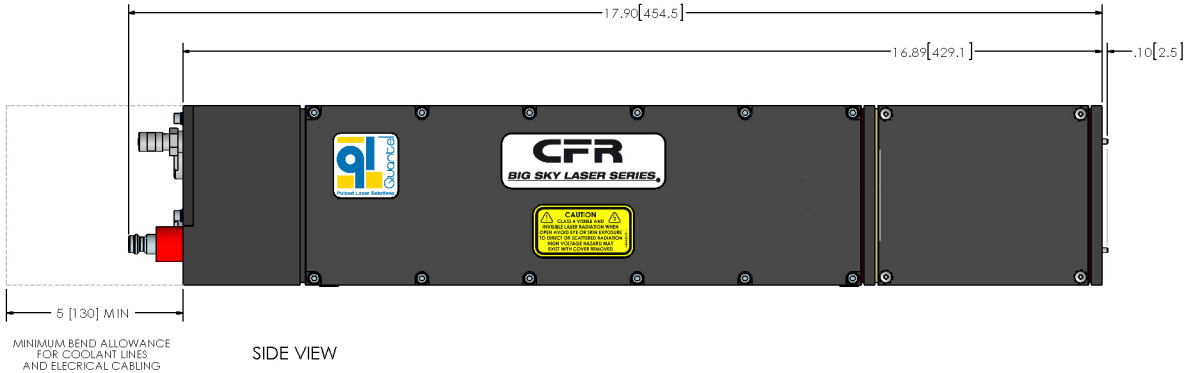


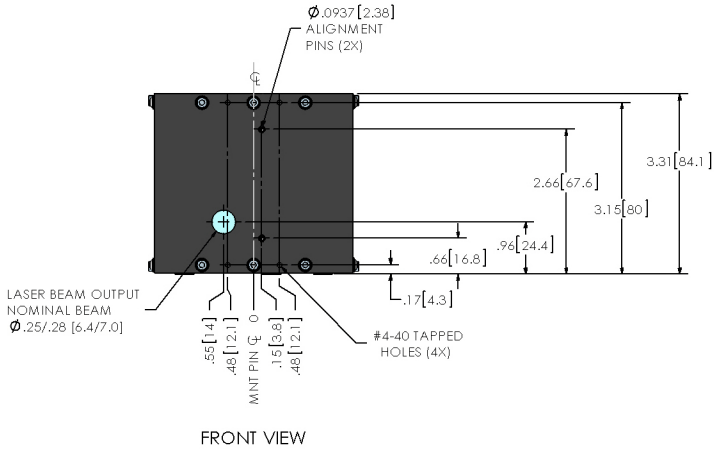




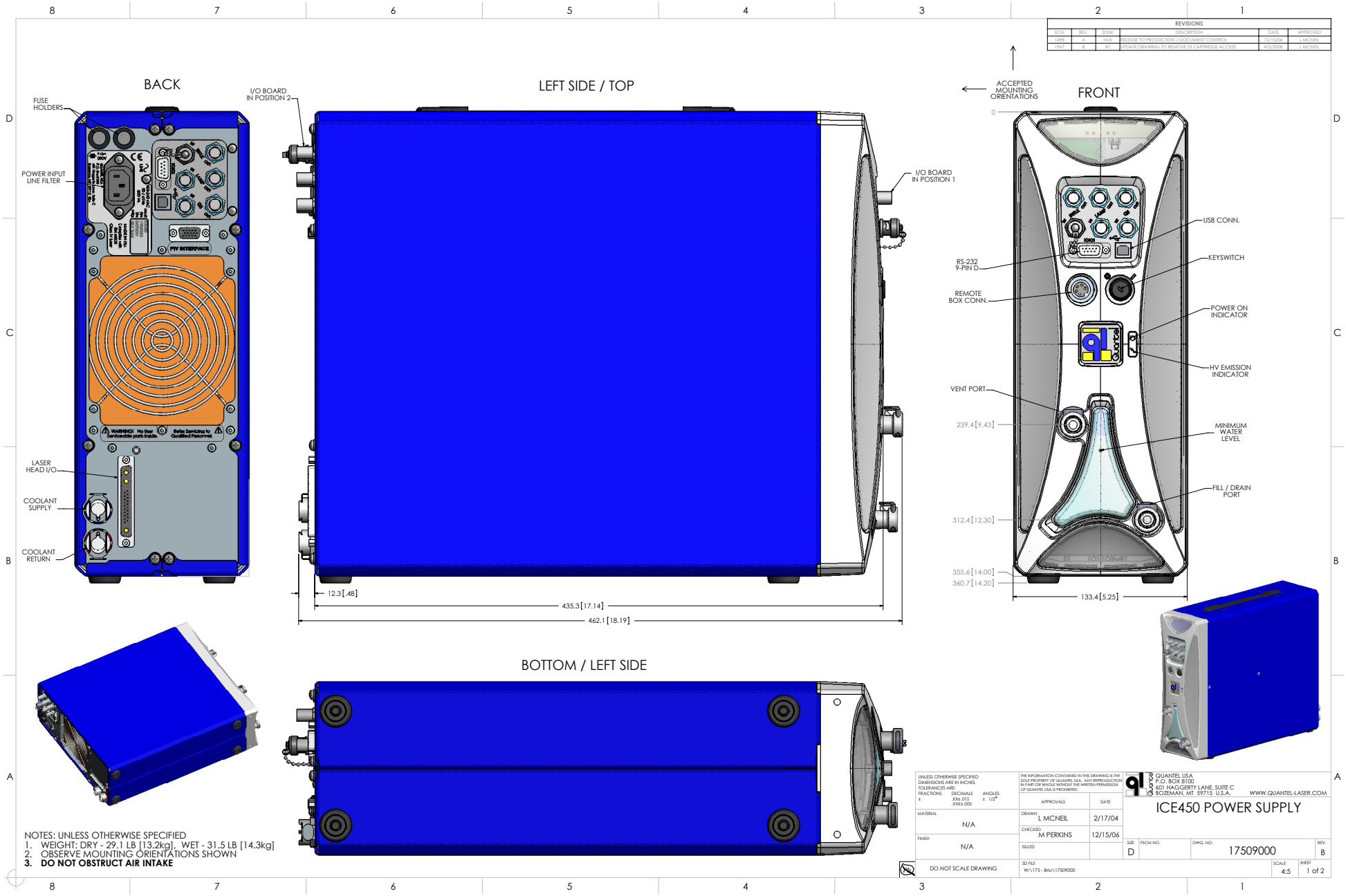
5.0 OPO Option





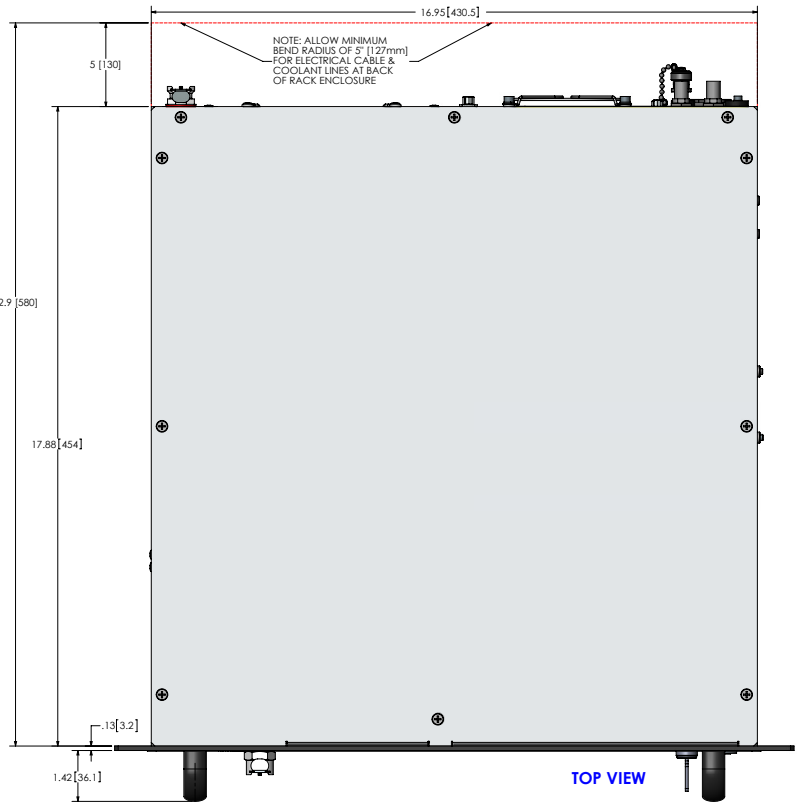


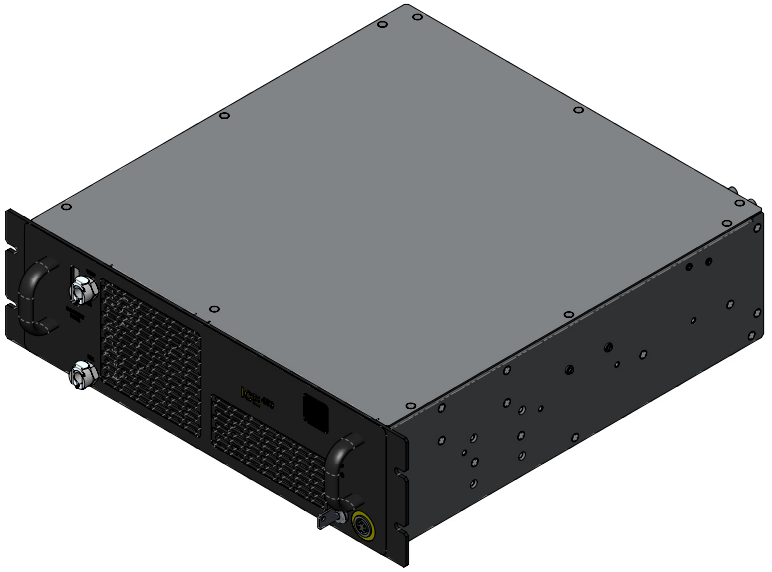
6.0 ICE450

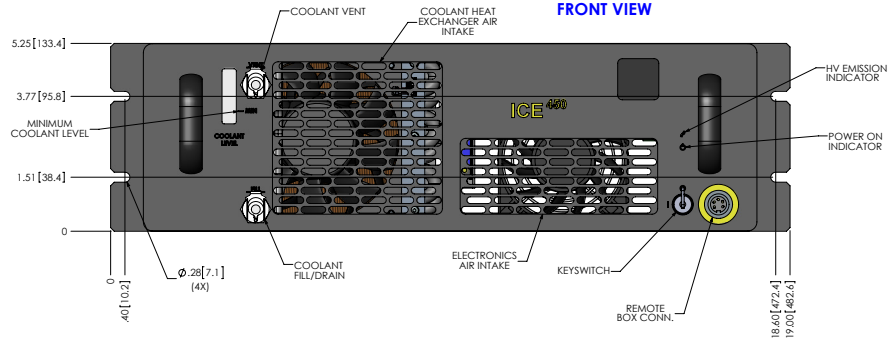

REVISIONS
ECN REV. ZONE DESCRIPTION DATE APPROVED
1498 A N/A RELEASE TO PRODUCTION / DOCUMENT CONTROL 12/15/06 L MCNEIL
1967 B B7 UPDATE DRAWING TO REMOVE DI CARTRIDGE ACCESS 4/2/2008 L MCNEIL
BACK
FUSE HOLDERS
POWER INPUT LINE FILTER
LASER HEAD I/O
COOLANT SUPPLY
COOLANT RETURN
I/O BOARD IN POSITION 2
LEFT SIDE / TOP
I/O BOARD IN POSITION 1
12.3 [.48]
435.3 [17.14]
462.1 [18.19]
ACCEPTED MOUNTING ORIENTATIONS
FRONT
0
USB CONN.
RS-232 9-PIN D
KEYSWITCH
REMOTE BOX CONN.
POWER ON INDICATOR
HV EMISSION INDICATOR
VENT PORT
239.4 [9.43]
MINIMUM WATER LEVEL
FILL / DRAIN PORT
312.4 [12.30]
355.6 [14.00]
360.7 [14.20]
133.4 [5.25]
BOTTOM / LEFT SIDE
NOTES: UNLESS OTHERWISE SPECIFIED
1. WEIGHT: DRY - 29.1 LB [13.2kg], WET - 31.5 LB [14.3kg]
2. OBSERVE MOUNTING ORIENTATIONS SHOWN
3. DO NOT OBSTRUCT AIR INTAKE
QUANTEL USA
P.O. BOX 8100
601 HAGGERTY LANE, SUITE C
BOZEMAN, MT 59715 U.S.A.
WWW.QUANTEL-LASER.COM
ICE450 POWER SUPPLY
DRAWN L MCNEIL 2/17/04
CHECKED M PERKINS 12/15/06
SIZE D
DWG. NO. 17509000
REV. B
SCALE 4:5
SHEET 1 of 2

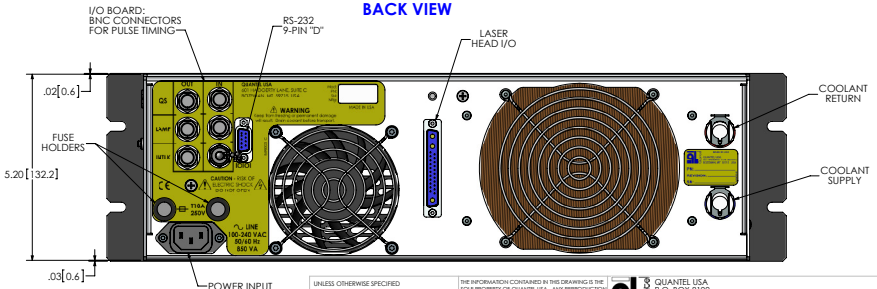
Quantel | CFR

7.0 ICE450, RACK









REVISIONS

ECN	REV.	ZONE	DESCRIPTION	DATE	APPROVED

NOTES: UNLESS OTHERWISE SPECIFIED
1. UNIT IS CE AND ROHS COMPLIANT
2. WEIGHT: DRY - 29 LB [13.2 kg], WET - 31 LB [14.1 kg]
3. MOUNT IN ORIENTATION SHOWN
4. DO NOT OBSTRUCT AIR INTAKE (WITH CABINET DOORS, ETC.)

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ARE:
FRACTIONS ± | DECIMALS .XX± .015 .XXX± .005 | ANGLES ± 1/2°

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	APPROVALS	DATE
MATERIAL N/A	DRAWN L MCNEIL	9/25/08
FINISH N/A	CHECKED M PERKINS	9/25/08
DO NOT SCALE DRAWING	ISSUED	

QUANTEL USA
P.O. BOX 8100
601 HAGGERTY LANE, SUITE C
BOZEMAN, MT 59715 U.S.A.
WWW.QUANTEL-LASER.COM

3D FILE W:\175 - Brio\ICE450_Rack\17559000

ASSY, POWER SUPPLY, 19" RACK x 3U ICE450

SIZE	FSCM NO.	DWG. NO.	REV.
D		17559000	1

SCALE 3:5 SHEET 1 of 1

MAINTENANCE

CAUTION: Inadequate cooling system maintenance may result in coolant contamination and/or system damage.

1.0 Scheduled Maintenance

Perform the following maintenance procedures on a regular schedule:

- ❑ Turn the Key Switch ON to operate the pump and circulate coolant for at least 30 minutes every month when the laser is not in use.
- ❑ Inspect the coolant level in the reservoir through the reservoir-level window on the ICE450.
- ❑ Replace the Deionizing cartridge every 6 months and each time the flashlamp is replaced to maintain coolant integrity.
- ❑ Replace the flashlamp after every 50 million shots.

2.0 Draining the ICE450

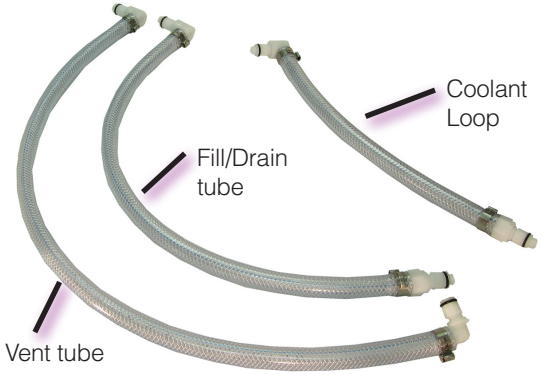
CAUTION: Remove ALL coolant. Coolant trapped within the system may freeze and cause irreversible damage to the internal components.

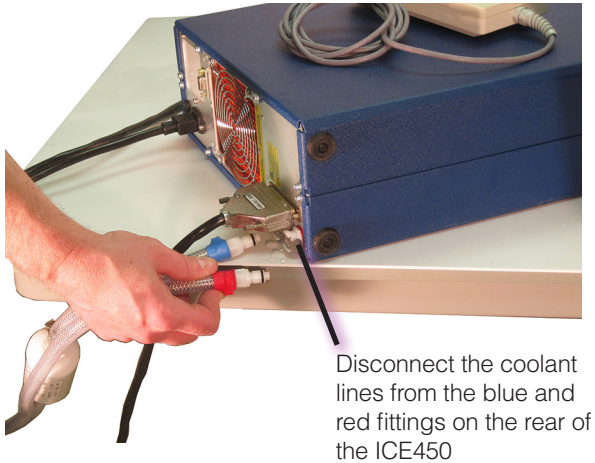
Note: For the standard ICE450, as opposed to the rack mount version, you must position the ICE450 onto its side with the Fill/Drain port down (Vent up).

Note: It is useful to have a second person assist in draining the ICE450. You will need a suitable container to hold the drained liquid.

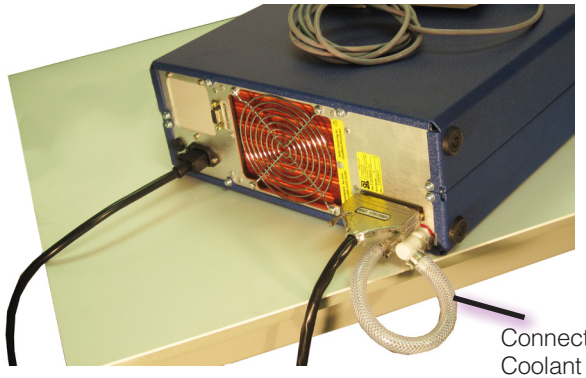
Use the following procedure to drain the system:

1. Turn the Key Switch OFF.
2. Position the ICE450 on its side with the Fill/Drain port down (Vent port up).
3. Turn the Key Switch ON.
4. Use the Remote Box Pump menu to turn the Pump OFF.
5. Disconnect the coolant lines from the back of the ICE450 and from the Laser Head.
6. Connect the supplied Coolant Loop between the blue and red fittings on the ICE450 rear panel.





Disconnect the coolant lines from the blue and red fittings on the rear of the ICE450



Connect Coolant Loop

7. Connect the empty Fill/Drain bottle. The tube from the bottom of the bottle connects to the Fill/Drain port. The tube from the top of the bottle connects to the Vent port.
8. Hold the bottle lower than the ICE450 reservoir. Loosen the cap on the Fill/Drain bottle to allow the coolant to flow freely.

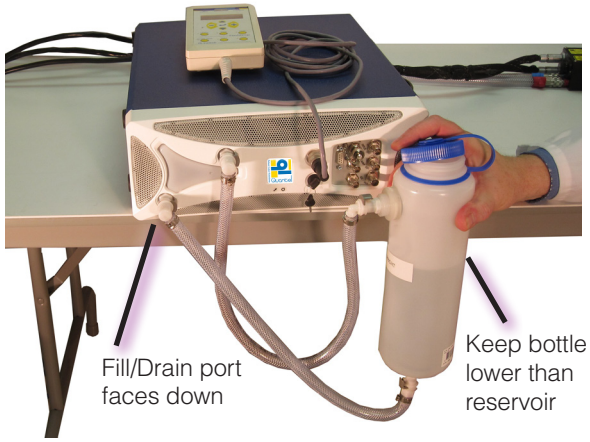
Note: Do not raise the bottle above the reservoir or the coolant will flow back into the reservoir.

9. Once the reservoir is empty, use the Remote Box System menu and change the Pump to Drain mode (see **Pump on page 27**).

Note: The pump will run for 30 seconds and turn OFF automatically.

10. After the pump automatically stops, tilt the ICE450 forward toward the front panel to drain any remaining coolant into the bottle.
11. Turn the Key Switch to OFF.
12. Disconnect the Fill/Drain bottle and the Coolant Loop from the ICE450.
13. To prepare the system for shipment, wipe all residual coolant droplets from all coolant ports prior to placing the ICE450 in a plastic bag. This helps prevent moisture condensing on sensitive parts during shipment.
14. Gravity-drain the Laser Head by tilting it so that coolant flows out from the lower drain port and into your container.
15. Gently blow dry nitrogen through the blue coolant connector to empty any remaining coolant.
16. Place the blue plastic covers that originally shipped with the system over the ports on the Laser Head to prepare it for shipping or storage.

Note: The trace amount of coolant remaining in the system after following this procedure is not a concern.



Tilt the ICE450 so the front panel is lower than the rear panel to drain any remaining coolant into the Fill/Drain bottle.

Disconnect the tubing from the Laser Head. Tilt Laser Head to drain. Gently blow dry nitrogen through the blue coolant connector to empty any remaining coolant.

3.0 Draining a Rack ICE450

CAUTION: Remove ALL coolant. Coolant trapped within the Power Supply may freeze and cause irreversible damage to the internal components.

Note: It is useful to have a second person assist in draining the ICE450. You will need a suitable container to hold the drained liquid.

Use the following procedure to drain the system:

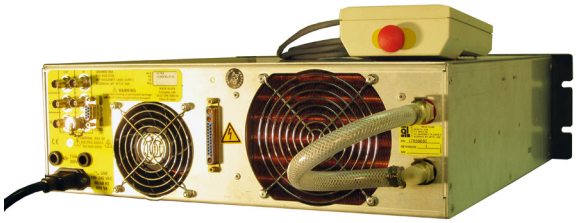
1. Turn the Key Switch ON.
2. Use the Remote Box Pump menu to turn the Pump OFF.
3. Disconnect the coolant lines and I/O cables from the back of the Rack ICE450 and from the Laser Head.
4. Connect the supplied Coolant Loop between the blue and red fittings on the Rack ICE450 rear panel.
5. Connect the empty Fill/Drain bottle. The tube from the bottom of the bottle connects to the Fill/Drain port. The tube from the top of the bottle connects to the Vent port.
6. Hold the bottle lower than the Rack ICE450 reservoir. Loosen the cap on the Fill/Drain bottle to allow the coolant to drain into the bottle.

Note: Do not raise the bottle above the reservoir or the coolant will flow back into the reservoir.

7. Use the Remote Box System menu and change the Pump to Drain mode (see **Pump on page 27**).

Note: The pump will run for 30 seconds and turn OFF automatically.

8. After the pump automatically stops, fully drain the reservoir into the bottle by tilting the Rack ICE450 forward toward the front panel.
9. Turn the Key Switch to OFF.
10. Disconnect the Fill/Drain bottle, tubes, and the Coolant Loop.
11. Replace the cap on the Fill/Drain bottle.



12. To prepare the system for shipment, wipe all residual coolant droplets from all coolant ports prior to placing the ICE450 in a plastic bag. This helps prevent moisture condensing on sensitive parts during shipment.
13. Gravity-drain the Laser Head by tilting it so that coolant flows out from the lower drain port and into your container.
14. Gently blow dry nitrogen through the blue coolant connector to empty any remaining coolant.
15. Place the blue plastic covers that originally shipped with the system over the ports on the Laser Head to prepare it for shipping or storage.

Note: The trace amount of coolant remaining in the system after following this procedure is not a concern.

Draining the Hoses

1. The coolant hoses should now be detached from the back of the ICE450 and the Laser Head.
2. Connect the coolant change connectors to the stainless steel connectors on the ends of the coolant hoses. Place the end of the coolant hoses in your container.
3. Press in on the white plastic top of the connector to allow air into the hoses. Do not cover the entire end of this connector, or the coolant will not drain. Raise the end of the hose while pressing in on the connector top to drain the entire length of the hose.

The coolant is now drained and the ICE450 is ready to refill, store or transport.

Inspect the Drained Coolant

Inspect the discarded coolant for clarity. The coolant should be very clear and free from contaminants. There should be no organic contaminants (such as algae) or large particles in the waste coolant.

- Black particulate is typically a sign of pump wear.
- Green coloration may be a sign of organic contamination.

CAUTION: All contaminants need to be removed from the coolant loop prior to operating the laser. Please contact **Quantel USA** if you suspect contaminated coolant.

Refilling the Reservoir (unless transporting)

1. To refill the cooling system, remove the coolant change connectors (if installed).
2. Reconnect the coolant lines between the Laser Head and ICE450.
3. Refill the reservoir using the standard process. See **Filling the Standard ICE450 on page 11** or **Filling the Rack ICE450 on page 12**.

4.0 Replacing the DI Cartridge

The ICE deionization (DI) cartridge is located on the blue coolant line. This cartridge should be replaced every six months and each time the flashlamp is replaced to maintain coolant integrity.

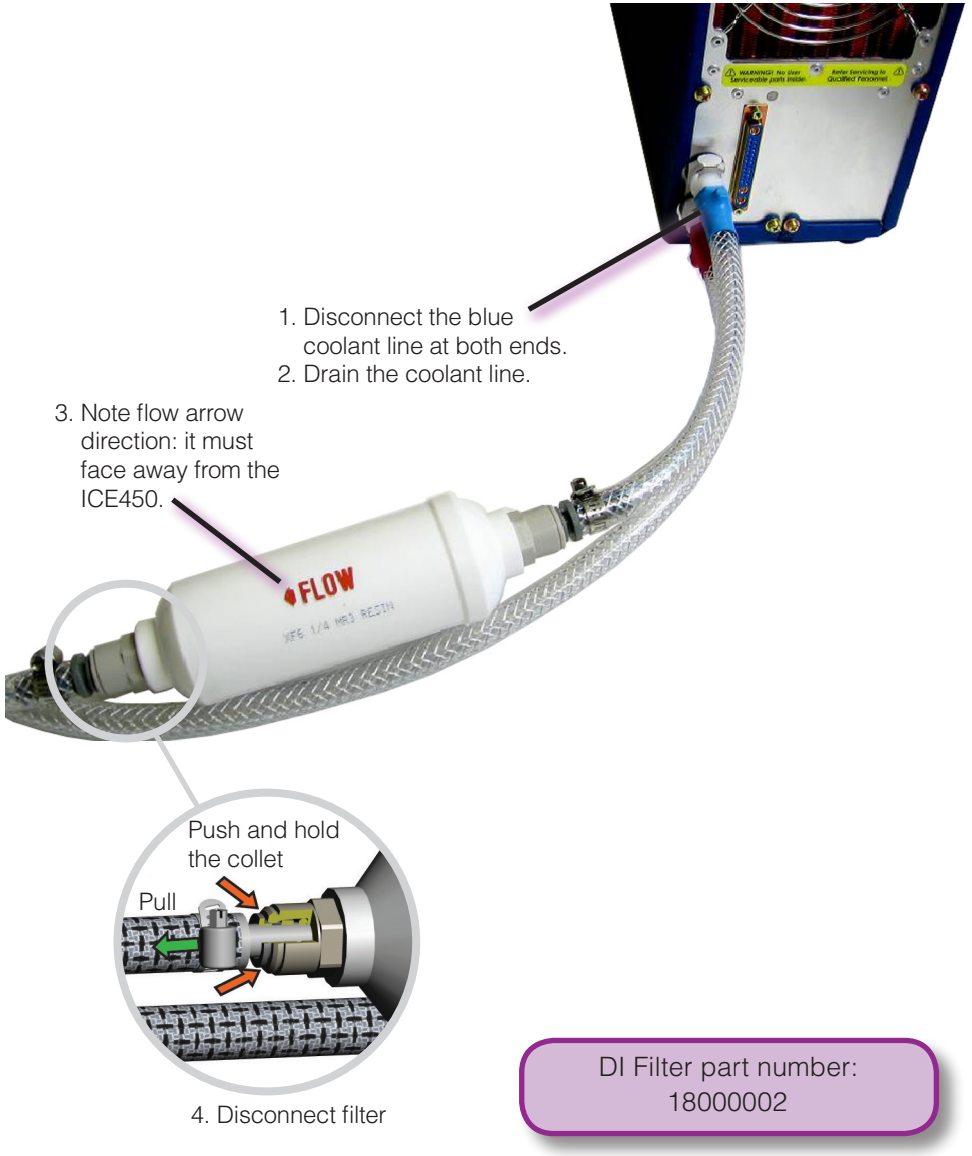
Deionizing the coolant helps maintain low coolant conductivity. The conductivity of the coolant should be less than 1.0 µS.cm-1 (or conversely have a resistivity ≥ 1.0 MΩ.cm). This ensures the electrical field generated by the trigger transformer ionizes the gas inside the flashlamp and reliably establishes the simmer current. Coolant that is not properly deionized may prevent the lamp from simmering and may overheat and damage the trigger transformer.

CAUTION: Before proceeding, verify that the ICE450 Key Switch is OFF. Unplug the AC Mains power cord.

1. Disconnect the blue coolant lines from the back of the ICE450 Power Supply and from the Laser Head.
2. Drain the coolant from the blue line into a suitable container.
3. Locate the DI filter cartridge and note the flow arrow direction before removing.
4. Push the collet in against the face of the cartridge fitting. With the collet held in this position, remove the tube stem.

CAUTION: Failure to follow this process causes the collet teeth to damage the surface of the O-ring of the internal coolant line fitting.

5. With the flow arrow for the new cartridge oriented correctly (away from the ICE), push the tube stems into the fittings on the new cartridge until they hit the internal stop.
6. Test the cartridge installation by attempting to pull the coolant lines out of the cartridge. Ensure that the tube stem is fully inserted before continuing to the next step.
7. Reconnect the coolant lines to the back of the ICE450 and to the Laser Head, then refill any lost coolant.



DI CARTRIDGE INSTALLATION

5.0 Transporting the System

CAUTION: Your system must be COMPLETELY drained before transporting to prevent damage to the Laser Head or ICE.

Preparing a Standard System for Shipping

1. Drain the system using the procedure given for **Draining the ICE450 on page 75**.
2. Install the shipping cover over the output of the Laser Head.
3. Install the blue coolant port covers.
   The system is now drained and ready to store or ship.

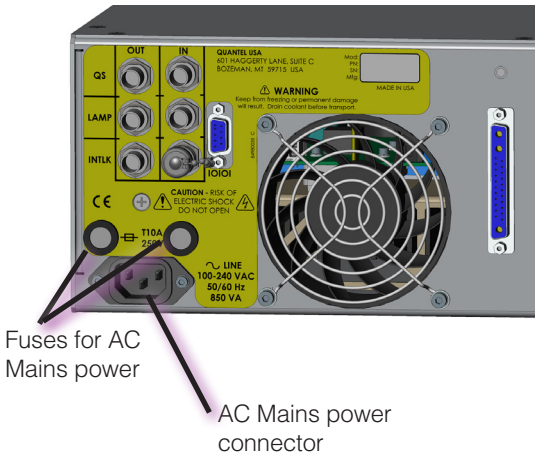
Preparing a 19" Rack CFR System for Shipping

1. Drain the ICE using the procedure given for **Draining a Rack ICE450 on page 77**.
2. Install the shipping cover over the output of the Laser Head.
3. Install the blue coolant port covers.
   The system is now drained and ready to store or ship.

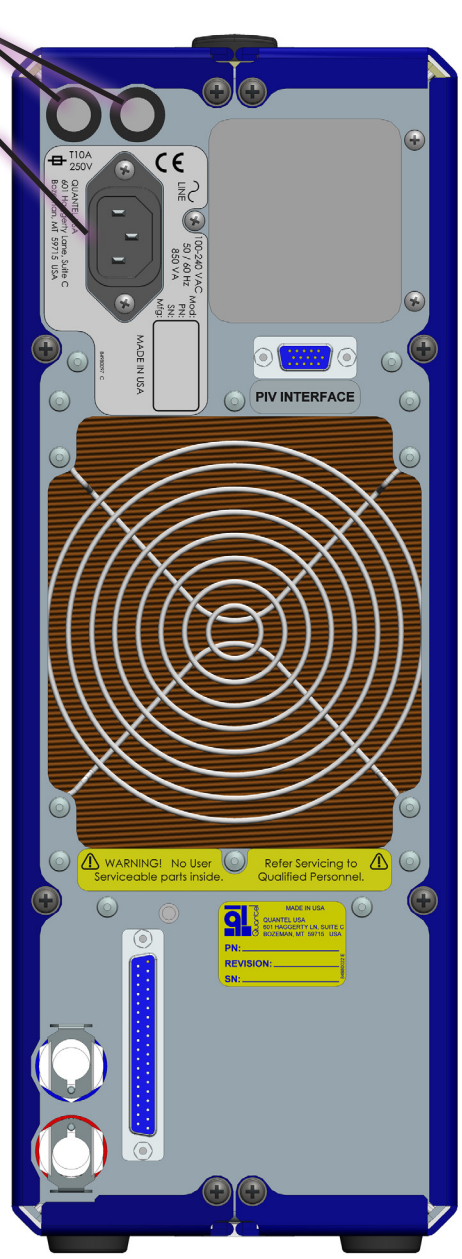
6.0 Replacing the ICE450 Fuses

These fuses disconnect the ICE450 from AC Mains power in the event of an electrical fault. The label next to the fuse holder lists the specified fuse type and rating. Use 5 X 20 mm, 10A, 250V T-LAG fuses, Bussmann S505-10-R or equivalent, Quantel part number: 70850123LF.

CAUTION: Only replace the fuses with the specified fuse. Failure to do so may result in equipment damage or personal injury. For your safety, disconnect the power cord before servicing fuses.



RACK ICE450 FUSE LOCATIONS



STANDARD ICE450 FUSE LOCATIONS

Fuse part number:
70850123LF

7.0 Flashlamp Replacement

For optimal performance, the flashlamp should be replaced approximately every 50 million shots. See page 78 for information on viewing the shot counter.

Note: Gradual lamp degradation is normal. Lamp degradation requires increases in input energy levels to maintain the original output level.

Lamp Removal

CAUTION: Failure to follow these procedures may flood the Laser Head with coolant, may result in personal injury, and will void the warranty.

CAUTION: Keep the Laser Head horizontal throughout the lamp change process! If tilted, coolant left in the pump cavity will drain into the laser cavity, permanently damaging laser components.

CAUTION: Handle the flashlamp with talc-free, rubber finger cots or gloves only.

Before starting:

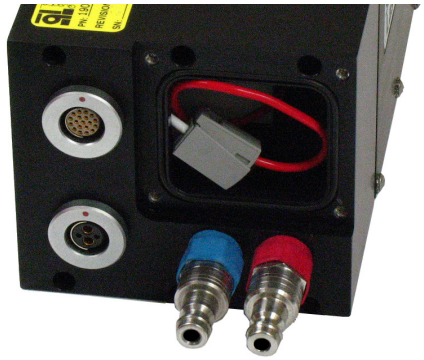
- Ensure that the ICE450 Key Switch is OFF.
- Disconnect the electrical cables and coolant lines.
- Ensure that the coolant is completely removed from the Laser Head. See **Draining the ICE450 on page 75** or **Draining a Rack ICE450 on page 77**.
- Place Laser Head with its bottom surface resting horizontally on a flat surface as shown in Figure 1.

1. Remove four screws from the lamp access cover on the Laser Head.
2. Remove the cover to reveal the lamp wiring connection block.
3. Squeeze the connection block to release the red lamp wire.
4. Use needle-nose pliers to grip the red wire. Apply leverage against the housing and pull straight out on the red wire until the lamp comes loose from its seal.
5. Pull straight back on the red wire to expose the lamp end.
6. Keep the Laser Head flat and firmly pull the lamp end outward.

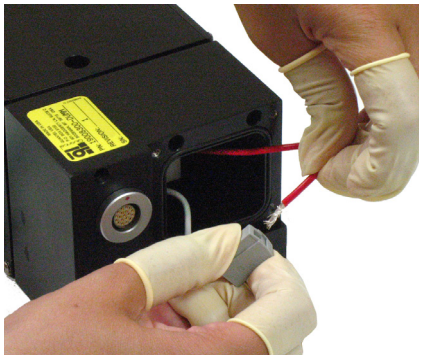
Note: The lamp may be difficult to break loose from the o-rings that seal the coolant. Pull firmly to release the lamp.

CAUTION: It is very important to pull straight and evenly to avoid breaking the lamp!

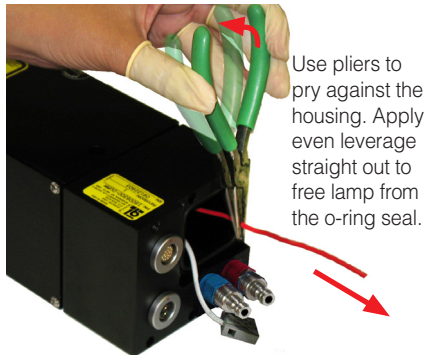
1. Remove four screws



2. Remove the lamp access cover.

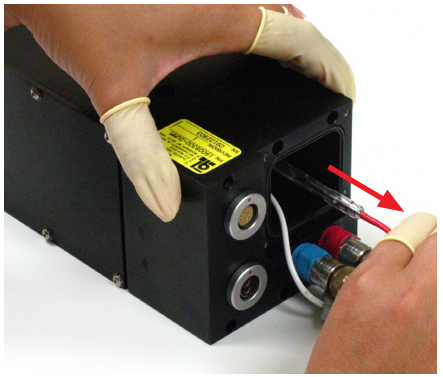


3. Squeeze the connection block to release the red lamp wire.

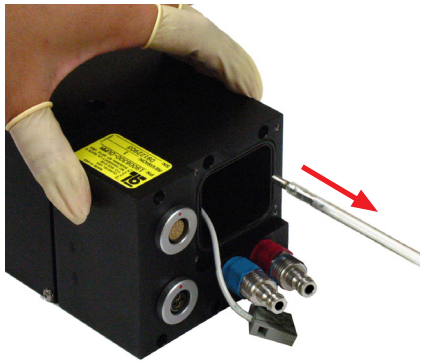


Use pliers to pry against the housing. Apply even leverage straight out to free lamp from the o-ring seal.

4. Use needle-nose pliers to apply strong yet even pressure against the housing to loosen the lamp from its seal.



5. Pull straight back on the red wire to expose the lamp.



6. Grasp the exposed end of the lamp and firmly pull straight back to remove it.

Lamp Insertion

CAUTION: Keep the Laser Head horizontal throughout the lamp insertion process! If tilted, coolant left in the pump cavity will drain into the laser cavity, permanently damaging laser components.

- Before starting, clean the new lamp with methanol or isopropyl alcohol.
- Locate the lamp insertion tool.

Note: While the lamp is very slightly damp from the methanol or alcohol, it slides more easily through the seals inside the Laser Head.

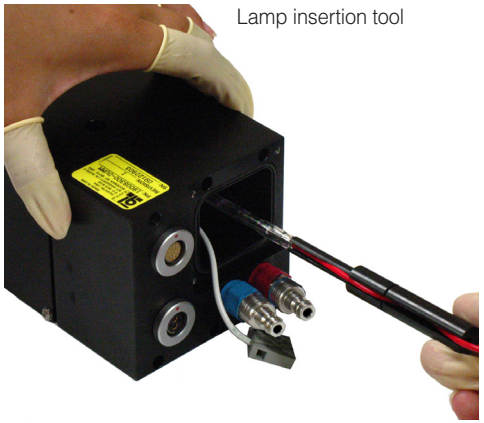
1. Fit the new flashlamp into the lamp insertion tool. Use the tool to slide the lamp into the Laser Head. Press with straight and even pressure to avoid breaking the flashlamp. You will feel the lamp make a solid contact when completely installed. When fully inserted, the groove on the back of the lamp insertion tool will align with the housing. If you are unsure the lamp is fully seated, pull the lamp out approximately 1/2" [12mm] and reseat it.
2. Squeeze the connection block to insert the red wire that extends from the flashlamp. Tug on the red wire where it extends from the connection block to verify it is making proper connection. Reinsert it if necessary.
3. Neatly coil the connection block and wire in the space provided.
4. Replace the lamp access cover. Verify that the O-ring seal is properly installed between the lamp access cover and the Laser Head.
5. Purge the Head with dry nitrogen. See **Nitrogen Purge for the CFR on page 83**.

CAUTION: Operation of the pump with a flashlamp that is not fully seated will flood the Laser Head and cause permanent laser damage. Operation of the pump with a flashlamp that is not properly installed voids the warranty. Permanent laser damage may result if the flashlamp wire is not properly reconnected. If there is any doubt about this lamp insertion process, please call Quantel USA Customer Service.

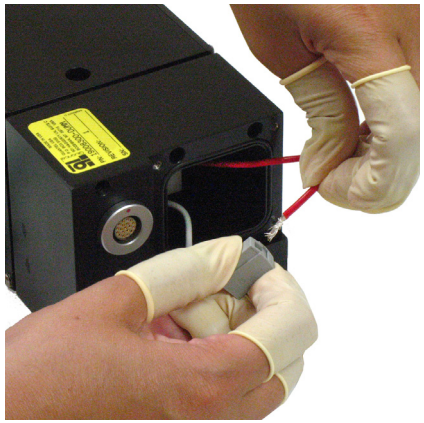
Resetting the Shot Counter

After replacing the flashlamp, follow these steps to reset the shot counter.

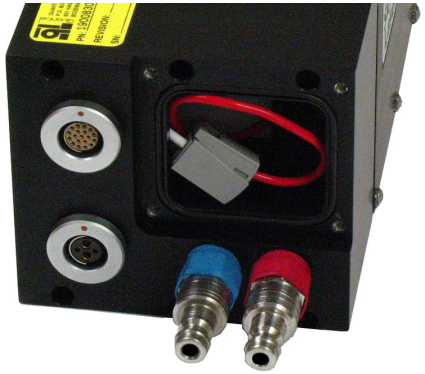
1. From the Remote Box Main menu, select Flashlamp and press the "Enter Menu" button to show the Flashlamp menu.
2. Scroll the cursor to the "cu" item.
3. Press the "Enter Menu" button. to reset the value to zero.



1. Using the tool, slide the lamp into the Laser Head.

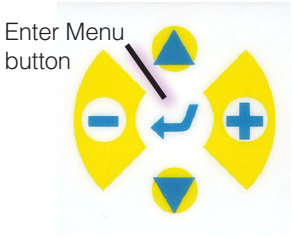


2. Squeeze to open the connector and insert the red wire into the connection block. Tug the wire to test the connection.



3. Neatly coil the wires in the space provided.

4. Replace the Lamp Access Cover using 4 screws.

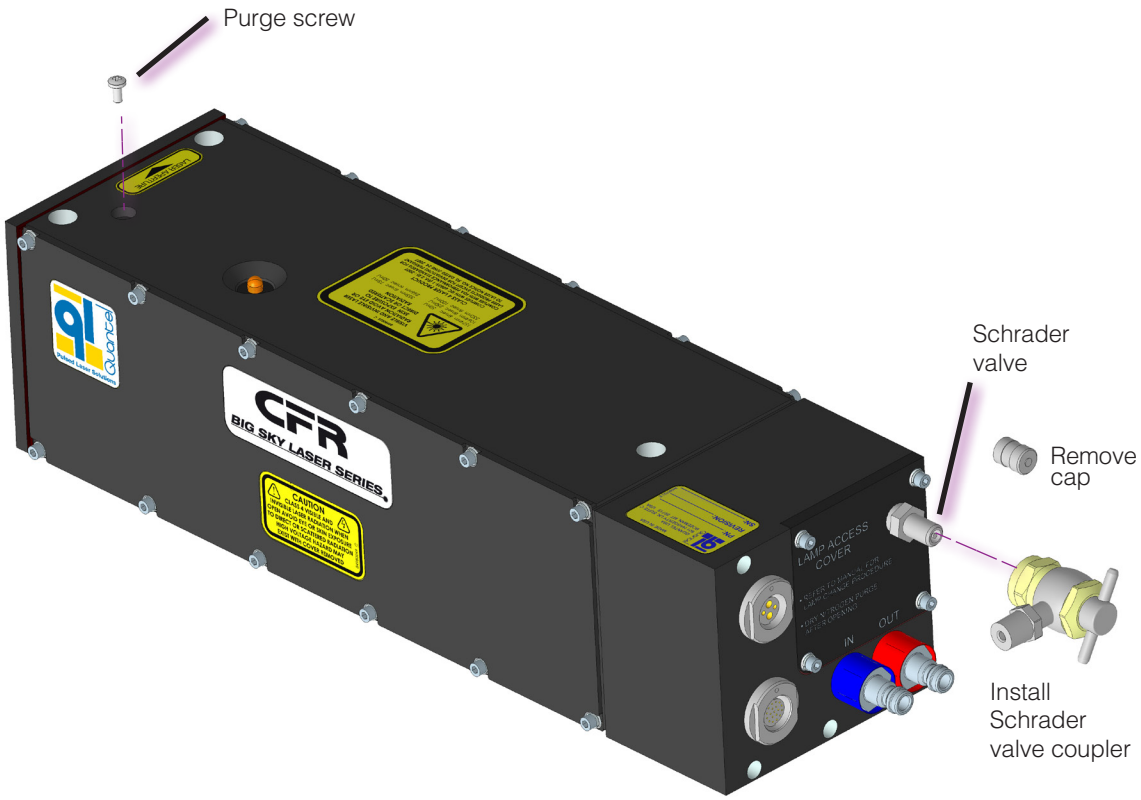


Flashlamp part number: 19005515-1

8.0 Nitrogen Purge for the CFR

The Laser Head has been factory purged with UHP (Ultra High Purity) dry nitrogen to prevent condensation on the laser optics. If any cover or access screw is removed for any reason, the Laser Head should be purged again with UHP nitrogen.

1. Remove the nitrogen purge/seal screw from the top of the Laser Head.
2. Remove the cap from the Schrader valve. Attach the Schrader valve coupler supplied in the Accessories Kit to the Schrader valve.
3. Connect 5 psi (.345 bar) UHP dry nitrogen to the Schrader valve coupler/Schrader valve.
4. Flow UHP dry nitrogen through the Laser Head for 5 to 10 minutes. Shut off the nitrogen flow.
5. Replace the screw in the purge hole used as the exit port for the dry nitrogen.
6. Remove the Schrader valve coupler from the Laser Head.
7. Replace the cap on the Schrader valve.



TROUBLESHOOTING

The ICE is designed to control the laser and warn the user of problems that may occur. The microprocessor-based system monitors the laser system and automatically shuts down if a fault occurs. Software limits have been factory selected to protect the laser system against damage. The following section may help you correct or identify the problem before calling Quantel Customer Service.

www.quantel-laser.com

Contact Us

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Phone: +33-1-6929-1700
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service@quantel.fr

QUANTEL USA, Inc. (North America)
601 Haggerty Lane
Bozeman, MT 59715 USA
Service toll free: +1-800-914-8216
Fax: +1-406-522-2007
CustomerService@quantelusa.com

1.0 General Information

No *internal* parts of the ICE450 are user serviceable. The only items on an CFR laser system that may be serviced by the user are:

- DI cartridge, see **Replacing the DI Cartridge on page 79**
- Flashlamp, see **Flashlamp Replacement on page 81**
- 10A Fuses see **Replacing the ICE450 Fuses on page 80**

All other service or repair of the ICE450, Laser Head or Laser Head optical alignment issues require a qualified Quantel technician or trained Field Service Representative.

Basic troubleshooting can help you resolve:

- security system faults, such as external safety interlocks
- connection issues

If a failure occurs at start-up or during operation, use the Key Switch to shut the laser OFF. Then use the troubleshooting methods presented next to resolve the issue.

2.0 Interlocks

The ICE450 constantly monitors the system for potentially hazardous conditions. If any of these conditions exist, the laser operation ceases and the Remote Box shows a message indicating the interlock condition. The “IF” command can also be used to query interlock conditions via the serial interface (See details in **Software on page 36**).

NOTE: To clear an interlock message, press the “Cursor Up” or “Cursor Down” button on the Remote Box.

NOTE: Contact Quantel USA for any repair actions necessary beyond those described in this manual. Attempts to adjust, repair or replace any portion of the laser system may damage the system and void the warranty

3.0 Resolving Interlock Fault Conditions

Interlock Value	ICE Front Panel Message	Possible Cause	Solution/Suggestion	Description
IF1 10000000	emergency stop button pushed	The red Emergency Stop button on the Remote Box is pushed in.	Pull the red Emergency Stop button out. If pulling the button out does not resolve the issue, there may be an open circuit in the Remote Box, cable, or internal harness. Call Quantel Customer Service.	The Emergency Stop button on the Remote Box is a required safety feature. The switch is normally closed. When the button is pressed, the circuit opens, generating an interlock fault condition.
IF1 01000000	BNC Intlk in on ICE450 front panel (On the Rack ICE450, the "INTLK In" BNC connector is on the back panel.)	The "INTLK In" connector on the front panel is open.	• Connect the shorting plug to the "Interlock In" BNC on the ICE450 front panel. • Verify that the shorting plug is connecting properly. If the shorting plug is OK, the issue may be an internal connection. Call Quantel Customer Service.	The "INTLK in" BNC is a normally closed circuit provided for you to add a simple external safety circuit to stop the laser if a door to the lab opens. An open circuit condition on this input indicates an interlock fault.
IF1 00010000	Laser Head housing opened	I/O cable is not connected.	Ensure the I/O cable is fully seated.	There is a security interlock that detects the circuit continuity of the I/O cable between the ICE450 and the Laser Head.

NOTE: To clear an interlock message, press the "Cursor Up" or "Cursor Down" button on the Remote Box.

Interlock Value	ICE Front Panel Message	Possible Cause	Solution/Suggestion	Description
IF1 00001000	Power Supply housing opened	Removal of one of the ICE450 side covers occurred.	• Replace the cover. If that does not resolve the issue, there may be a faulty switch or an open circuit within the ICE450. Call for technical assistance.	The ICE450 has a normally-open switch installed on each side cover. When the side covers are installed properly, the switches are depressed.
IF1 00000100	controller bus error	Problem in the controller system relating to its internal communications.	Contact Quantel Customer Service.	The ICE450 system controller has two buses used to communicate with system circuitry. A problem with either bus causes an interlock fault condition.
IF1 00000001	flashlamp disabled time out delay expired	Flashlamp timeout has expired.	Disable timeouts or change the flashlamp timeout to 00:00.	The flashlamp time-out interlock is a user-defined parameter. Refer to the **System Info Menu on page 25** for details.
IF2 10000000	heater over temp	Heater coolant is too hot. The protective thermal switch opened when the coolant neared 70°C.	• Turn off power to the ICE450 and allow it to cool down. If this does not resolve the issue, the heater thermostat circuit may need repair. Call Quantel Customer Service.	A heater element (in some models) warms the coolant to regulate coolant temperatures in low-power applications. A normally-closed thermal switch on the heater block prevents cooling function damage.

NOTE: To clear an interlock message, press the “Cursor Up” or “Cursor Down” button on the Remote Box.

Interlock Value	ICE Front Panel Message	Possible Cause	Solution/Suggestion	Description
IF2 01000000	charger/simmer over temp	The charger inductor is too hot. This may be due to poor air flow around the system. Possible circuit damage.	• Turn OFF power to the ICE450 and allow it to cool. • Ensure that air flow is not obstructed at the front or back of the ICE450. If the interlock condition persists, there may be a problem with the charger circuitry. Call Quantel Customer Service. **Note:** A temperature reading of 17.9°C indicates an open circuit. Notify Quantel Customer Service in this case.	The temperature sensor on the charger-inductor coil prevents damage to circuitry. This interlock activates at approximately 70°C. Allow the system to cool in order to reset the interlock.
IF2 00100000	low coolant temperature	The coolant is not warm enough for proper operation.	• Allow time for the coolant to warm. The low-temperature setting may need to be reduced or the heater minimum power setting may need adjustment. The heater circuit may have failed. Call Quantel Customer Service for these issues. **Note:** A reading of 17.9°C indicates a temperature feedback open circuit. Notify Quantel Customer Service in this case.	To protect optics and ensure reliable laser performance, the coolant temperature must meet minimum requirements. A sensor located in the coolant reservoir monitors the temperature and provides interlock protection when the temperature is not within the specified range.
IF2 00010000	high coolant temperature	The coolant is too warm for proper operation.	• Turn off the ICE450 and allow it to cool. The high-temperature setting may need to be increased or the cooling fans may have failed. Call Quantel Customer Service for these issues.	To protect optics and ensure reliable laser performance, the coolant temperature must be below the set maximum value. A sensor located in the coolant reservoir monitors the coolant temperature and provides interlock protection.

NOTE: To clear an interlock message, press the “Cursor Up” or “Cursor Down” button on the Remote Box.

Interlock Value	ICE Front Panel Message	Possible Cause	Solution/Suggestion	Description
IF2 00001000	low coolant level ICE cooling	• System is low on coolant • Changing to longer coolant lines requires additional coolant • The ICE450 is horizontal with the wrong side facing up	• Ensure coolant is properly filled after draining the coolant system. Follow the instructions in **Maintenance starting on page 75**. • If operating the ICE450 horizontally, ensure the coolant fill port is below the vent port. See front and back panel labels. There may be a leak or the level-detect switch may be faulty. Call Quantel Customer Support.	A coolant level float style switch is located in the coolant reservoir. When this interlock is sensed, in addition to the displayed message on the Remote Box, the reservoir backlights will flash.
IF2 00000100	low coolant flow	• Coolant line is obstructed preventing proper flow • Flow sensor is damaged or stuck.	• Examine the coolant lines. Ensure they are not kinked or otherwise obstructed. • Ensure the coolant line connectors are fully engaged and locked. • Ensure the pump is toggled ON from the Remote Box. The pump or the flow sensor may require repair. Notify Quantel Customer Service.	A flow-rate sensor located in the ICE450 coolant loop triggers an interlock condition when the flow rate is less than 2.2 lpm (+/- 10%).
IF2 00000010	defective temp. sensor	One or more of the three feedback thermistor circuits (coolant, charger/ simmer, and harmonic generator) is faulty or is running too cold.	• Ensure all temperatures are above 18 °C. • If the system does not include a harmonic generator, make sure the HG option is turned off from the System Info menu. **Note:** A reading of 17.9°C indicates a temperature feedback open circuit. Notify Quantel Customer Service in this case.	A defective temperature sensor interlock appears if any one of the three temperature feedback signals (CG, CS or HG) is abnormal.
IF2 00000001	power too high	Voltage or frequency settings are too high, resulting in power too high.	Reduce voltage, energy, or frequency until the power is less than 450W. Verify this and save the configuration.	The ICE450 calculates the power delivered to the lamp. If the power per shot is more than 450W, this interlock is activated. **Note:** Under normal conditions you are prevented from adjusting the settings too high. The interlock prevents serious problems.

NOTE: To clear an interlock message, press the “Cursor Up” or “Cursor Down” button on the Remote Box.

Interlock Value	ICE Front Panel Message	Possible Cause	Solution/Suggestion	Description
IF3 10000000	PSU charge error	The charger did not have time to fully charge before another Fire signal was received.	• Reduce the frequency or voltage/energy of the firing signal. • Verify the Laser Head I/O cable connectors are fully inserted and tightened. • Inspect the high voltage/high current contacts for damage caused by arcing. Due to firmware priorities, if the Charger/ Simmer overtemperature interlock trips during flashlamp operation, a PSU charge error may display on the Remote Box if the charge cycle is disabled before the microprocessor is notified. Refer to IF2 01000000 for details. If the error persists, please contact Quantel Customer Service.	The system controller must receive an “end of charge” feedback signal from the charger, prior to the Fire order for flashlamp discharge. If not, a PSU charge error interlock occurs. The “end of charge” feedback indicates the PFN capacitor has charged to the desired voltage.
IF3 01000000	voltage over setting	This indicates a problem with the charging system.	**CAUTION:** This is a potentially serious safety issue. Please contact Quantel Customer Service.	This interlock indicates that the Pulse Forming Network (PFN) capacitor voltage actual value exceeds the programmed voltage by 5% or more.
IF3 00100000	simmer stop	The simmer current either failed to be established, or it failed to stay active.	• Verify that the connections to the Laser Head are secure. • View the flashlamp shot count. Replace the flashlamp if necessary.	The flashlamp simmer current is constantly monitored. If the simmer current fails to establish or “blows out”, then this interlock is activated.
IF3 00010000	low frequency	The external trigger input frequency is less than frequency minimum value.	Decrease the frequency of the external signal generator or increase the setpoint for frequency. Contact Quantel Customer Service for details on disabling frequency checking.	When operating in External flashlamp triggering mode, the ICE450 compares the input trigger frequency to the programmed frequency as viewed on the Remote Box. An interlock condition occurs if they do not match.

NOTE: To clear an interlock message, press the “Cursor Up” or “Cursor Down” button on the Remote Box.

Interlock Value	ICE Front Panel Message	Possible Cause	Solution/Suggestion	Description
IF3 00001000	high frequency	The external trigger input frequency is more than the maximum frequency value.	Either increase the frequency of the external signal generator or decrease the set-point frequency. Contact Quantel Customer Service for details on disabling frequency checking.	When operating in External flashlamp triggering mode, the ICE450 compares the input trigger frequency to the programmed frequency on the Remote Box. If they do not match, an interlock condition occurs.
IF3 00000100	Capacitor not discharged	The flashlamp capacitor did not completely discharge after the flashlamp turned off. **CAUTION:** This is due to a fault in the charging system and may be hazardous.	You should not attempt to repair this problem. Contact Quantel Customer Service for repair.	The system controller monitors the voltage on the PFN capacitor. The system displays this interlock if there is an unsafe residual voltage remaining on the PFN capacitor.
IF3 00000010	simmer disabled time out delay expired	The simmer timeout has expired.	You should not attempt to repair this problem. Contact Quantel Customer Service for repair.	You should not attempt to repair this problem. Contact Quantel Customer Service for repair.

NOTE: To clear an interlock message, press the “Cursor Up” or “Cursor Down” button on the Remote Box.

Interlock Value	ICE Front Panel Message	Possible Cause	Solution/Suggestion	Description
IQS 10000000	Q-S disabled	This interlock does not prevent the laser from firing. It prevents Q-Switch activation before the safety timeout expires.	Contact Quantel Customer Service for repair.	This interlock is not used. If this value appears, contact Quantel Customer Service for repair.
IQS 01000000	Q-S disabled coolant temperature under limit	This interlock does not prevent the laser from firing. It prevents Q-Switch activation when the coolant is below the minimum operating temperature.	Allow the coolant to warm up. Contact Quantel Customer Service to inquire about increasing the minimum Q-Switch operating temperature.	To protect optics and ensure reliable laser performance, the coolant temperature must meet a required minimum or Q-Switch operation is locked out. This interlock monitors the coolant temperature using a sensor located in the coolant reservoir.
IQS 00010000	Shutter Closed	Shutter is Closed	Open Shutter	The interlock reports the current state of the shutter.
IQS 00001000 **IQS 00000100** **IQS 00000010** **IQS 00000001**	Q-S disabled iQS_4 Q-S disabled iQS_3 Q-S disabled iQS_2 Q-S disabled iQS_1		Contact Quantel Customer Service.	These interlocks are not used. If they occur, they indicate a problem.

4.0 Serial Communications Troubleshooting

The ICE450 has an important safety feature that may prevent serial communication during use of the Remote Box. Pressing any button on the Remote Box disables the serial port communications. To verify that this feature has not disabled serial communications, use the Remote Box System Info menu and ensure the Serial link item is set to ON. Once it is set to ON, do not press any Remote Box buttons as this would automatically disable serial communications again.

Problem	Possible Cause	Solution/Suggestion
RS-232 port does not operate: no communications.	Serial port disabled	For safety reasons, the serial port is disabled when any button is pressed on the Remote Box. In the “system” menu, turn serial port ON. See **Serial Interface on page 36**.
	Baud rate incorrect	See **Serial Interface on page 36** for correct baud rate setting.
	Serial cable problem	Verify that the cable connection to the correct COM port is secure. Verify that the cable is wired correctly. • Pins 2, 3, and 5 must be used. • Pins 2, 3, and 5 should connect directly to the corresponding pin 2, 3, or 5 at the opposite end of the cable. **Example:** Pin 2 from the ICE450 connector is Transmit, so it must connect to the pin 2 on the computer’s DB-9 connector, which is typically Receive. Pin 3 from the ICE450 connector is Receive, so it must connect to the pin 3 on the computer’s DB-9 connector, which is typically Transmit. Pin 5 is signal ground.

5.0 Diagnosing Problems

Problem	Possible Cause	Solution/Suggestion
No System Power	No power connected	Check the simple things first—make sure the power cord is plugged into the outlet and making connection to the back of the ICE. Verify that the circuit breaker is allowing power to the outlet.
	Mains Power switch is OFF	Verify that AC Mains power is ON by checking the Key Switch.
	Key Switch is OFF	Turn the Key Switch on the front of the ICE450 to the ON "|" position.
	System fuses	Check both fuses located on the ICE450 back panel. If necessary, replace the fuses. See **Replacing the ICE450 Fuses on page 80**. **WARNING:** Disconnect the power cord prior to servicing fuses!
No Laser Output	System Fault condition	If the Fault indicator is illuminated flashing a fault exists. A fault locks out use of the laser system until it is corrected. Enter the STATUS command using a computer connected to your laser system RS-232 port to determine the system status. Refer to **Status Commands on page 42** and to **Resolving Interlock Fault Conditions on page 85** to determine the issue.
	Cables not connected	With the Key Switch OFF and the system unplugged, check all electrical connections between the Laser Head and the ICE450. Make sure all connections are secure. If any of the cables are not installed properly, the system will not function. Turn off the system power before connecting or disconnecting any cables.
	Shutter is closed	Verify the Remote Box Menu option for Shutter is set to ON (open) and the Emissions Warning LED on the Laser Head is illuminated.
	Energy Level setting	Refer to the **Data Summary Sheet** that shipped with your system. Make sure the input energy is not set below the lasing threshold. Correct if necessary.
	Q-Switch not enabled	Verify that the Q-Switch is enabled and properly functioning. Use the Remote Box to determine the system status.
	Q-Switch setup not correct	Verify that the Q-Switch is enabled and that Q-Switch "fire-every" is set up properly. The Q-Switch LED should be illuminated and the Fire LED should be flashing at the Q-Switch PRF.
	Time-out is set to maximum	User value for time sim., time fire, or time QS available from the Remote Box System menu may be set to a large value.

Problem	Possible Cause	Solution/Suggestion
Energy is Low	Flashlamp degradation	These changes are normal over time and after shot accumulation (>50 million). The pump energy can be increased to compensate for lamp degradation. However, excessive input energy (voltage) to the lamp must be avoided since pre-lasing and optics damage may result. If significant lamp degradation is suspected, follow the instructions for **Flashlamp Replacement on page 81**.
	Coolant degradation	Operating the laser system with contaminated coolant can adversely affect energy. Inspect the coolant. The coolant should be very clear and free from contaminants. There should be no large particulate or organic contaminants in the coolant. Black particulate is a sign of pump wear. Green or brown color is a sign of organic substances growing in the cooling system. If contaminated coolant is suspected, the cooling system must be purged and properly cleaned prior to operating the laser. Please consult Quantel for instructions on how to clean your cooling system if you suspect organically contaminated coolant. See **Replacing the DI Cartridge on page 79** for information on coolant properties.
	Incorrect Q-Switch delay	The Q-Switch delay value is system dependent. Your system shipped with a Data Summary Sheet specifying the correct Q-Switch delay for your system. The Q-Switch delay is set to a value in µs with respect to the flashlamp firing (for example: 135µs). Using an oscilloscope, connect channel 1 to the Lamp Sync BNC and channel 2 to the Q-Switch Sync BNC. Trigger the oscilloscope channel 1. Verify that the delay from the rising edge of the Lamp Sync to the rising edge of the Q-Switch Sync is approximately the value for your system (for example: 135µs). If the Q-Switch delay is longer than the value listed for your system on the Data Summary Sheet, the laser output will be attenuated.
	Misaligned	If beam quality has degraded, it may suggest an alignment problem. Contact Quantel for details.
Flashlamp Trigger Delay Bypass command does not eliminate 500 µsec delay	Trigger settings are incorrectly configured	Flashlamp Trigger Delay Bypass is only valid when both the flashlamp and Q-Switch triggers are configured for External Synch (E and QE respectively)
	Bypass was set to 1 (ON) during fire mode (A)	The BYPASS command only takes effect when transitioning from Stop to Fire. To resolve the issue, press the Flashlamp Stop button on the Remote box to stop firing the laser, or send the command “S” via the RS232 interface. Verify that BYPASS is set to 1 (ON) to bypass the flashlamp trigger delay. Restart firing to activate the flashlamp trigger delay bypass feature.

Problem	Possible Cause	Solution/Suggestion
Flashlamp Does Not Fire	Flashlamp is not enabled.	Verify that both the Flashlamp “ready” light and the Flashlamp “start” light on the Remote Box are illuminated.
	Flashlamp is not in Internal Mode.	Verify that Internal sync is selected in the Remote Box Flashlamp menu.
	An interlock exists, indicating a safety problem.	Make sure the “interlock” light on the Remote Box is steadily on, but is not blinking.
	Flashlamp is broken.	After pressing the “Flashlamp Ready” button on the Remote Box, if the “ready” light does not light, and is there a no visible flashlamp flash, the flashlamp may need to be replaced. See the instructions for flashlamp replacement.
	External Flashlamp Trigger input does not cause flashlamp to fire.	• Flashlamp is not enabled. Verify that both the “flashlamp ready” light and the “flashlamp start” light on the Remote Box are illuminated. • External trigger signal does not meet the specified requirements as shown in **External Trigger Signal Requirements on page 53**.
	Simmer problem	If the flashlamp does not flash, it may be an indication that the lamp will not simmer or is difficult to simmer. Check to see that the simmer indicator is illuminated when high voltage is enabled. If it is not, either ionized or contaminated coolant, or a degraded flashlamp may be the cause. Coolant resistivity must be within the range for proper operation. See **Replacing the DI Cartridge on page 79** for information on coolant properties. If coolant resistivity is less than the recommended value, replace the coolant. If the lamp still does not simmer, follow the procedure for **Flashlamp Replacement on page 81**.
	PRF Setting is Incorrect	The PRF setting may be set for external mode and the external trigger is either not connected or is not adequate to drive the 50Ω input. Set the PRF setting for internal PRF control.
	Charger Latch-up	If the ICE makes a squealing or hissing sound when the high voltage is enabled, and the simmer LED is illuminated but the flashlamp does not flash, disable the high voltage immediately. **WARNING:** A component inside the ICE may have failed and the high voltage charger is attempting to charge into a short circuit. If the ICE is operated in this mode for longer than a few seconds, additional electronics damage may occur.

Problem	Possible Cause	Solution/Suggestion
Q-Switching: External Q-Switch Trigger input does not cause Q-Switch to fire.	Q-Switch is not enabled.	Verify that both the “Q-Switch start” LED and the “flashlamp start” LED indicators on the Remote Box are illuminated.
	External trigger signal does not meet the specified requirements.	The signal generator may not be set up to drive the ICE450 50Ω input. Refer to the **External Trigger Signal Requirements on page 53**.
Frequency setting only adjusts within a ±10% range	You have purchased a GRM Laser Head	For GRM Laser Heads, the frequency is set at the factory. It can only be adjusted to ± 10% of the set value. See your system’s **Data Summary Sheet** for more information.
No Simmer No Interlocks	Faulty laser I/O cable	• Verify laser I/O cable connectors are fully inserted and the screws securing them are tightened. • Visually inspect the high-current contacts on both ends of the laser I/O cable for carbon film or pits caused by poor connector insertion and arcing.
ICE450 does not trigger in External mode	Incorrect signal generator settings	Refer to the **External Trigger Signal Requirements on page 53**.
Poor signal output from Sync BNCs (Lamp out & Q-Sw out)	Incorrect termination	Output signals must be 50Ω terminated for optimal pulse shape and faster edges.
Coolant leak	DI Cartridge installation	Verify that the DI cartridge is correctly in place and its fittings are fully inserted.
	Laser Head o-rings	Inspect o-rings on coolant line connectors at Laser Head for damage and replace if necessary
ICE450 does not operate in horizontal position.	Incorrect side is down	Verify that the ICE450 is oriented with the coolant fill port lower than the vent port. Verify that the coolant level is OK and fill if necessary.
Remote Box display “locks up” during start-up (after Key switch is turned on)	A terminal emulator program (such as Hyperterminal) has a port to the processor open, interfering with the processor initialization	Disconnect the RS-232 cable from the ICE450 and try again to start the system.
System will not start when cold	Coolant viscosity causes a pump and flow meter issue	At temperatures colder than -10/-15°C (approximately) when the system power OFF so there was no coolant circulation, the system may not be able to start. To resolve this problem, put the system into Drain mode and let the coolant circulate until it has warmed up.

WARRANTY

We at Quantel are proud of our specialty laser systems. Our manufacturing and quality control processes emphasize consistency, stability, ruggedness, reliability and performance. We strive to make reliable laser systems and to provide superior customer support.

Should there be a problem with operation or failure of any kind, please have your **serial numbers** ready and then call:

Quantel Service Center France
33-1-6929-1700 (International)

Quantel toll-free customer service hotline
1-800-914-8216 (inside the U.S. & Canada)

We will do our best to get your system fully operational as quickly as possible.

Feedback

We welcome your feedback regarding your use, the performance of the laser system and these manuals. Product improvements and refinements come about from your input as we strive to continually improve our product reliability, performance and customer satisfaction.

International customers, please call our service center in France at 33-1-6929-1700. Within the United States and Canada, call our toll free number: 1-800-914-8216.

You can also visit us online at:
www.quantel-laser.com.

Warranty

(a) Quantel USA warrants the lasers it manufactures and produces to be free from defects in materials and workmanship for twelve (12) months following the date of shipment provided that all operating instructions are properly followed. 213nm optical components are warranted for 90 days following the date of shipment. Flashlamps are warranted for 50 million shots or one year, whichever comes first. Consumables (filters, coolant) are excluded. This warranty is limited to the original purchaser of the laser and is not transferable.

During the 12 months warranty period, we will repair or replace, at our option, any defective products or parts at no additional charge, provided that the product is returned, shipping prepaid, to Quantel USA, 601 Haggerty Lane, Suite C, Bozeman, MT 59715. All replaced parts and products become the property of Quantel USA.

(b) This warranty is the only warranty made by QUANTEL USA with respect to the goods delivered hereunder and no representative or person is authorized to bind QUANTEL USA for any obligations or liabilities beyond this warranty in connection with the sale of QUANTEL USA's goods.

(c) Remedies are available only if QUANTEL USA is notified in writing by Buyer promptly upon discovery of any defects and in any event within the warranty period for the individual goods, whereby Seller's examination of such goods discloses to QUANTEL USA's satisfaction that such defects actually exist and the goods have not been (i) repaired, worked on or altered by persons not authorized by QUANTEL USA so as, in QUANTEL USA's sole judgment to effect the stability, reliability or proper operation of such goods; (ii) subject to misuse, negligence, abuse or accident; or (iii) connected, installed, used or adjusted otherwise than in accordance with the instructions furnished by QUANTEL USA or normal usage.

(d) All goods that Buyer considers defective shall be returned, freight and insurance prepaid, to QUANTEL USA's office, as designated on the face hereof. QUANTEL USA shall not be liable for additional transportation costs arising from the goods having to be shipped to a location remote from the original one. Buyer shall obtain return authorization from QUANTEL USA before returning any goods. QUANTEL USA shall not bear responsibility for damage or loss to goods not properly prepared for transportation.

(e) If it is found QUANTEL USA's goods have been returned without cause and are still serviceable, Buyer will be notified and the goods returned at Buyer's expense, freight collect. In addition, a charge for testing and examination and/or for reimbursement of shipment costs paid by QUANTEL USA under subsection (d) above, may, at QUANTEL USA's sole discretion, be made on goods so returned which such charges shall also be payable by the Buyer.

(f) The foregoing warranty is exclusive and in lieu of all other warranties whether written, oral or implied, including any warranty of merchantability or fitness for a particular purpose, and shall be the Buyer's sole remedy and QUANTEL USA's sole liability on contract or warrant or otherwise for the product.

(g) This warranty shall not apply in the event that the original device identification markings have been removed, defaced or altered, or if any parts have been substituted or modified without the express consent of QUANTEL USA.

(h) This warranty will not apply if the customer's general account at QUANTEL USA is delinquent in whole or in part.

QUANTEL USA's liability under, for breach of, or arising out of this agreement and/or sale will be limited to repair or replacement of any defective goods or a refund of the purchase price of the goods, at QUANTEL USA's sole discretion. In no event will QUANTEL USA be liable for costs of procurement of substituted goods by buyer, nor will QUANTEL USA be liable for any special, consequential, incidental or other damages (including without limitation loss of profit) whether or not QUANTEL USA has been advised of the possibility of such loss, however caused, whether for breach or repudiation of contract, breach of warranty, negligence or otherwise.

CUSTOMER SERVICE

Quantel USA takes pride in our specialty laser systems. Our manufacturing and quality control processes emphasize consistency, stability, ruggedness, reliability, and performance. We strive to make our laser systems even more reliable and to provide superior customer support.

Should there be problems with operation or failure of any kind, please call the Quantel USA customer service hotline toll-free at 1-800-914-8216. We will do our best to get your system operational as quickly as possible.

Returning a System for Repair

Use the following steps when returning a system for repair:

1. Contact customer service for a Return Material Authorization (RMA) form. International customers, please call our service center in France at 33-1-6969-1700. Within the United States and Canada, call our toll free number: 1-800-914-8216. The system part number and serial number are required on the RMA form. To find where the part and serial numbers are located, see **Part/Serial Numbers on page 7**.
2. Return the completed RMA form to the Quantel Service Center. You may also email the completed the completed RMA form to CustomerService@quantelusa.com.
3. Customer Service will issue a Return Material Authorization Number (RMA#) for the return of your product.
4. Ensure that all coolant is properly removed from the system. See **Draining the ICE450 on page 75**, **Draining a Rack ICE450 on page 77**.
5. Carefully pack the product in the original or equivalent packing material. The Customer is responsible to ensure that the product is appropriately packaged. Products damaged due to inadequate packaging are not covered by Quantel's warranty.
6. For US and Canadian customers, use prepaid shipping to send the system to the following address (International customers, please contact the service center in France to determine the appropriate shipping address):

   ATTN RMA#_____
   Quantel USA, Inc.
   601 Haggerty Lane
   Bozeman, MT 59715-2001
   Phone: 1-800-914-8216

Shipping Charges

For warranty repairs Quantel will return your system using prepaid freight.

For non-warranty repairs Quantel will do one of the following:

- Return the product and invoice the customer for the shipping costs.
- Provide information for the customer to arrange their own shipping.
- Accept a shipping account number to pay for the shipment.

For International shipments of both warranty and non-warranty products the Customer is responsible for all duties, broker fees and freight charges that may arise.

CERTIFICATES

CE Certificate of Conformance

By affixing the CE marking, Quantel assures that the ICE450 meets all the essential requirements of all applicable European Union (EU) directives required for market placement in the European Economic Area (EEA).

Declaration of Conformity

Conforming to standards according to ISO/IEC Guide 22 and EN 45014. See the Certificate of Conformance for Electromagnetic Compatibility (EMC), electrical and laser safety standards, and requirements applicable to the CE certification mark of the ICE450.

CE

Big Sky Laser

Applicant: Big Sky Laser Technologies, Inc.
601 Haggerty Lane, Suite C, Bozeman, Montana 59715
Tel: 406-586-0131 Fax: 406-586-2924

DECLARATION OF CONFORMITY
According to ISO/IEC Guide 22 and EN 45014

We, EMC Compliance Management Group declare under our sole responsibility that the product:

Product Description	:	Integrated Cooler and Electronics (ICE) Power Supply with Two Pulsed ND: YAG Laser Heads
Model Name	:	BriO PIV
Test Report Number	:	BI-0509-4879-CE
Date of Testing	:	September 19th, 2005 to January 4th, 2006
Manufactured by	:	Big Sky Laser Technologies, Inc.
Manufacturer's Address	:	601 Haggerty Lane, Suite C, Bozeman, Montana 59715

The product herewith conforms to the following Council Directives:
The EMC Directive 89/336/EEC and The Low Voltage Directive 73/23/EEC

This Declaration of Conformity is based upon compliance of the product with the harmonised Standards:

EN 61326 04: 1997 + A1 06: 1998 + A2: 2001 (Emissions)
EN55011:1998 + A1:1999, CISPR 11:2003 Edition 4.1:2004, Class A Radiated and Conducted Emissions.
EN 61326 04: 1997 + A1 06: 1998 + A2: 2001 (Immunity)
IEC 61000-4-2 Edition 1.2 (2001), Electrostatic Discharge Immunity Test.
IEC 61000-4-3:2002, Radiated, Radio-Frequency Electromagnetic Field Immunity Test.
IEC 61000-4-4:2004, Electrical Fast Transient/Burst Immunity Test.
IEC 61000-4-5 Edition 1.1:2001, Surge Immunity Test.
IEC 61000-4-6 Edition 2.0 (2003), Immunity to Conducted Disturbances Test.
IEC 61000-4-8 Edition 1.1 (2001), Power Frequency Magnetic Field Immunity Test.
IEC 61000-4-11:2004, Voltage Dips and Short Interruptions Immunity Test.
EN 61010-1 and IEC 61010-1 - Safety requirements for electrical equipment for measurement, control, and laboratory use Part 1: General requirements

Responsible Party:

Manufacturer: Big Sky Laser Technologies, Inc.

Signature:

Responsible Person: Jeremie L. Waller

Title: Electrical Engineer

Date: 2006, March 20

Issued by Test Laboratory:

ECMG
Worldwide Certification Solutions
EMC Compliance Management Group
670 National Ave., Mountain View, CA 94043
650-968-0900(Tel) 650-968-6647(Fax)
www.ecmg-global.com

NVLAP

CE

This is the result of tests that were carried out from the submitted product sample(s) in conformity with the specification of the respective standards. The certification holder has the right to affix the CE-Mark for EMC on the product complying with the inspection sample.

Signed by:
Name: Tony Wang
Title: QC Manager
Date of Issue: 2006, March 16

ECMG ACCREDITED

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Certificate No. CE2019

Quantel USA
601 Haggerty Lane, Suite C
Bozeman, MT 59715 (USA)
Phone: 406-586-0131
www.quantel-laser.com

Certificate of Compliance

Date of Issue: 2015-02-19

Quantel USA hereby declares that testing has been completed and reports generated for;

Product: Class 4 Laser System

Model: CFR 200/300/400

That this product has been assessed and found to comply against the following Standards:

IEC 60825-1: 2007-03 Safety of laser products

Attestation by: Kim Bares
Director of Engineering (Quantel USA)

Signature

2015-02-19
Date

Bay Area Compliance Lab Corp.
1274 Anvilwood Ave., Sunnyvale, CA 94089 (USA)
Phone: (408) 732-9162, Fax: (408) 732-9164
www.baclcorp.com

ATTESTATION OF CONFORMITY

Date of Issue: 2008-05-01 Attestation Number: R0804231

Bay Area Compliance Laboratories Corp. (BACL) hereby declares that testing has been completed and reports have been generated for;

Product: Solid State Laser System

Model Tested: 17559020/Rev1 & 19008300-1621-1/Rev1

Applicant: Quantel USA
601 Haggerty Lane, suite C
Bozeman, MT 59715, USA

And, in accordance with the following Applicable Directives;

Directive 2004/108/EC: Electromagnetic Compatibility (EMC)

That this product has been assessed against the following Applicable Standards;

EMC: EN 55011: 1998 + A1: 1999 + A2: 2002 Class A
EN 61326-1: 2006

Application of the CE Mark is permitted only after all applicable requirements are met in accordance with the European Union Rules, including the manufacturer's issuance of a "Declaration of Conformity." Additional guidelines can be found at http://ec.europa.eu/enterprise/rtte/guide7.htm. This attestation is specific to the standard(s) stated above and compliance with additional standards and/or directives may be required.

Attestation by: John Chan

Signature

2008-05-01
Date

C1012-A

DECLARATION OF SIMILARITY

April 13, 2009

To:
Bay Area Compliance Laboratories Corp.
1274 Anvilwood Ave.
Sunnyvale, CA 94089
Phone: 408-732-9162, Fax: 408-732-9164
http://www.baclcorp.com

Dear Sir or Madam:

We, Quantel USA hereby declare that product: *Class IV Solid State Laser System,* model(s): *ICE^{450} Rack with Ultra 20/50/100, Brilliant or Brio Laser Heads* are electrically identical with the same electromagnetic emissions and electromagnetic compatibility characteristics as model: *ICE^{450} Rack with CFR 200/300/400 Laser Head* tested by BACL, the results of which are featured in BACL project: *R0804231.*

A description of the differences between the tested model and those that are declared similar are as follows:

ICE^{450} Rack with Brio Laser Head: includes PFN components; C=45µF & L=30µH
17559000: Standard configuration, includes heater assembly & remote control box
17559000-10: emergency stop switch replaces remote control box
ICE^{450} Rack with Brilliant Laser Head: includes PFN components; C=64µF & L=42µH
17559010: Standard configuration, includes heater assembly & remote control box
17559010-10: emergency stop switch replaces remote control box
ICE^{450} Rack with CFR 200/300/400 Laser Head: includes PFN components; C=52µF & L=55µH
**** 17559020: Standard configuration, includes heater assembly & remote control box*
17559020-01: no coolant heater assembly
17559020-10: emergency stop switch replaces remote control box
17559020-11: no coolant heater assembly & e-stop switch replaces remote control box
ICE^{450} Rack with Ultra 20/50/100 Laser Head: includes PFN components; C=20µF & L=80µH
17559030: Standard configuration, includes heater assembly & remote control box
17559030-01: no coolant heater assembly
17559030-10: emergency stop switch replaces remote control box
17559030-11: no coolant heater assembly & e-stop switch replaces remote control box

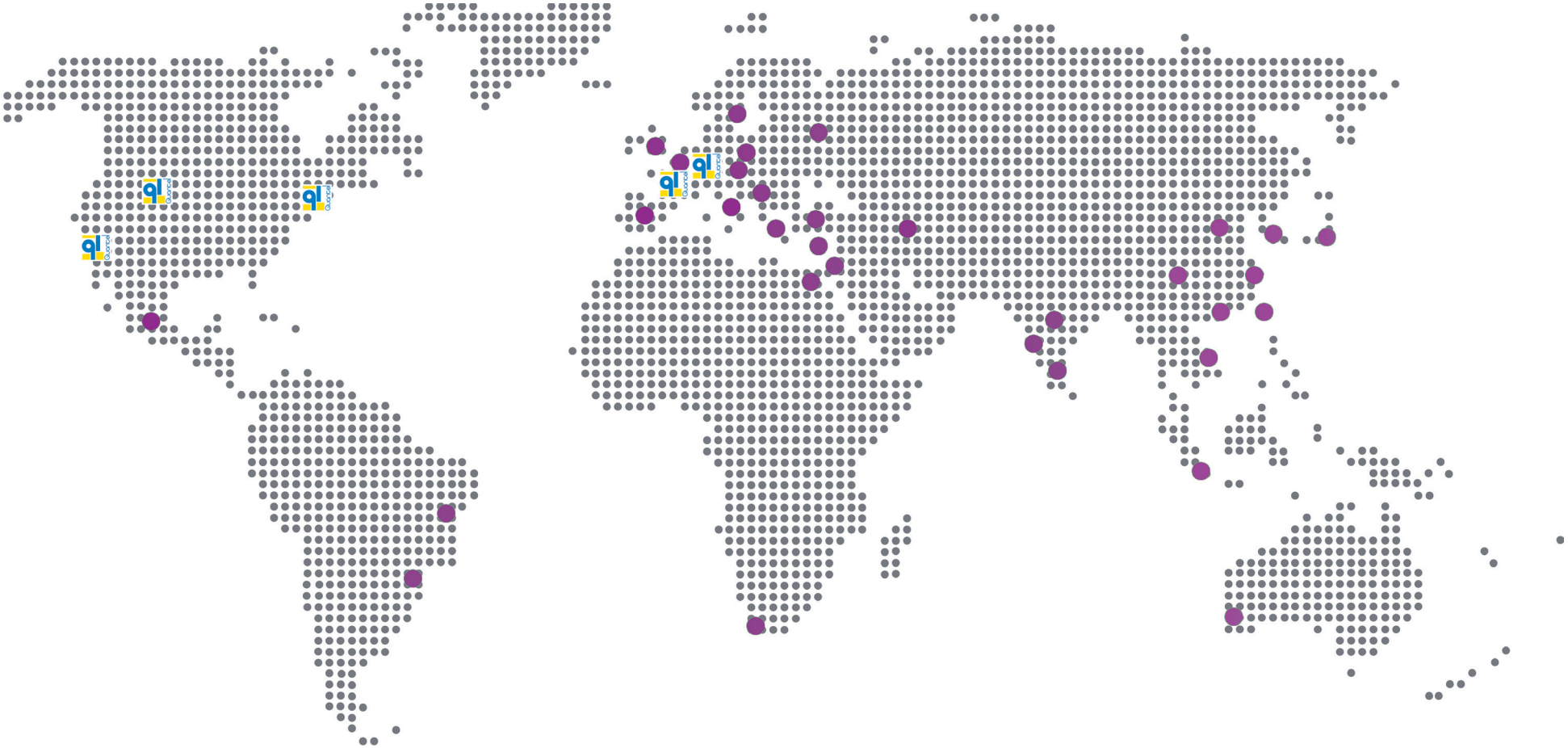
**** Indicates test configuration tested by BACL*

Please contact me should there be need for any additional clarification or information.

Best Regards,

Jeremie L Waller, Electrical Engineer
Quantel USA (Big Sky Laser Technologies)
601 Haggerty Lane
Bozeman, MT 59715 USA

BACL-NF0028-A



www.quantel-laser.com