ICE 450 Power Supply

User's Manual

August 2006

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CHAPTER 1

The ICE 450 Power Supply

Introduction

The ICE 450 Integrated Cooler and Electronics Unit houses all of the necessary items to operate a variety of Laser Heads. Fundamentally, the ICE 450 electronics supply the high current pulse to the flashlamp located in the Laser Head. It also supplies critical timing signals to the Laser Head. Since lasers are inherently inefficient, the ICE 450 contains a water-to-air heat exchanger to remove the unwanted heat from the Laser Head.

The ICE 450 contains the following functional components:

- AC Power Factor Correction (PFC)
- CE Compliant Line Filtering Electronics
- The Flashlamp Pulse Forming Network (PFN)
- The Capacitor Charging Supply
- Power Distribution Electronics
- Microprocessor Based System Controller
- System Input/Output (I/O) Electronics
- Coolant Circulation Pump
- Coolant De-Ionization Cartridge
- Water-to-Air Heat Exchanger and Cooling Fans
- Coolant Heater

Features of the ICE 450:

- CE Compliant
- RoHS Compliant
- Power Factor Correction
- Thermally Stabilized Coolant
- Compact Power Electronics and Cooling Unit
- A Disconnecting Umbilical
- Air-Cooling
- Controlled Through RS232 (or RS485) or USB
- BNC Synchronization and External Triggering on the Front or Back Panel
- Backlit Coolant Chamber
- Water Level and Filling/Purging on the Front Panel
- Vertical (desktop) or Horizontal (19” rack) Mounting
- Rugged Aluminum External Housing
- Easy to Carry with Convenient Handle

CHAPTER 2

Safety Precautions

Safety Labels

The Laser Head and the ICE 450 come equipped with safety labels. Do not remove these labels, as they are factory-installed according to safety guidelines. Please contact Big Sky Laser Technologies, Inc. for replacements if removal, obscurity, or damage to any label(s) has occurred.

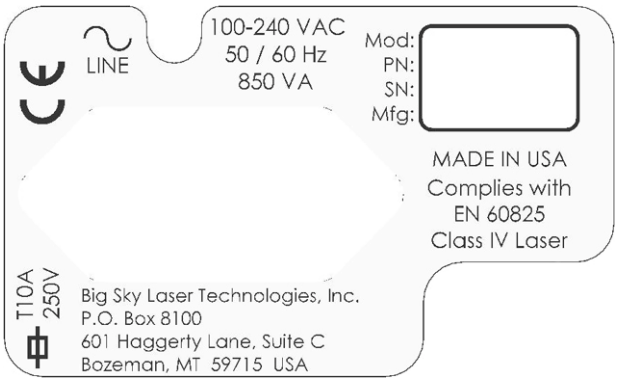


Figure 2-1: The ICE 450 Power Supply Label

DANGER HIGH VOLTAGE

Both the Laser Head and Power Supply Unit contain electrical circuits operating at lethal voltage and current levels. Always unplug and wait at least one minute to allow capacitors to bleed down before servicing any part of the laser system.

Consult with the Big Sky Laser Technologies Customer Service Department before servicing the laser. Only those trained in high voltage, high current electronics, and who understand the laser circuitry should service and repair the Power Supply Unit.

This manual includes the warning symbols below. Also, be aware of these warning symbols on our equipment. These symbols alert the user of important instructions that, if not followed, could result in serious injury.

WARNING - HIGH VOLTAGE: Electric shocks and burns from capacitor discharge or power circuits could lead to serious injury or even death.

WARNING – DANGER: Other serious precautions other than those mentioned above.

CHAPTER 3

Installation

Inventory

The Power Supply consists of the following items:

1. The ICE 450 Power Supply
2. Remote Control Unit
3. 2 Keys
4. Coolant Fill Kit

Verify that these items are all included in the shipping container. If there are any discrepancies, contact Big Sky Laser Technologies Customer Service immediately.

Filling and Draining the Power Supply

Before shipping the laser from Big Sky Laser Technologies, the coolant is drained from the coolant tank. To prepare the cooling group for use, the customer must fill the coolant tank with about 1.5 L of distilled water or BSLT approved coolant. Please follow the steps below:

1. Fill the bottle with coolant. Attach the coolant fill/drain connectors. The fill/drain fitting is attached to the fill bottle. The fitting with the hose connected to it attaches to the upper vent fitting. Loosen the cap on the fill bottle and add coolant until it drains from the vent fitting.
2. Turn the key switch to the ON ("I") position. The pump will turn on automatically after the system is on and coolant will begin filling the umbilical coolant lines. When the coolant level falls below the depression in the front of the reservoir, the pump will shut off and the illuminating lights in the reservoir will blink. Continue to add coolant until the umbilical coolant lines are full and the coolant level visible in the reservoir is above the depression. Disconnect the fill bottle and vent tube and, if using water as a coolant, empty all remaining coolant from the fill bottle. When the coolant is above the minimum level, the reservoir backlights will remain on continuously.
3. To remove the coolant from the reservoir, connect the vent tube to the vent fitting, and then connect the empty bottle to the fill/drain fitting. Loosen the cap on the bottle and lower the bottle below the ICE 450 as far as it can go. Lowering the bottle will cause the coolant to drain from the system. This is adequate to remove most of the coolant from the system, but is not sufficient to prepare the ICE 450 for shipment when freezing conditions are present if water is the primary coolant used. See Step 4 for instructions on how to ship the unit in freezing conditions.
4. For a water-cooled (as compared to an ethylene glycol/water solution) system that is being prepared for shipment, it is necessary to remove **ALL** water from the system, as there are places within the ICE 450 where water will become trapped, and irreversible damage may occur to the internal components when the water freezes. Disconnect the

umbilical coolant lines from the ICE 450 and drain the water from the reservoir (follow the steps described in Step 3). Then, disconnect the umbilical coolant lines from the Laser Head and reconnect the red fitting to the ICE 450. Remove the vent fitting from the front of the reservoir and gently (do not use air pressure greater than 0.35 bar [5 psi]) blow air into the corresponding red fitting at the Laser Head end of the umbilical coolant lines. Continue to blow air until no more water is visible through the drain tube into the bottom of the bottle. Then disconnect the red fitting from the ICE 450, connect the blue fitting, and repeat this process. Next, disconnect the blue fitting. Finally, reconnect the vent tube to the vent fitting on the reservoir, and tip the ICE 450 forward to cause the water to run to the front. Following this detailed procedure will drain all the water from the system, and prevent freezing damage during shipment.

Note: When turned ON ("I"), the ICE 450 will briefly make a "buzzing" sound. This noise is normal. The A/C front-end electronics are current-limiting the inrush current during power-up, which causes the "buzzing".

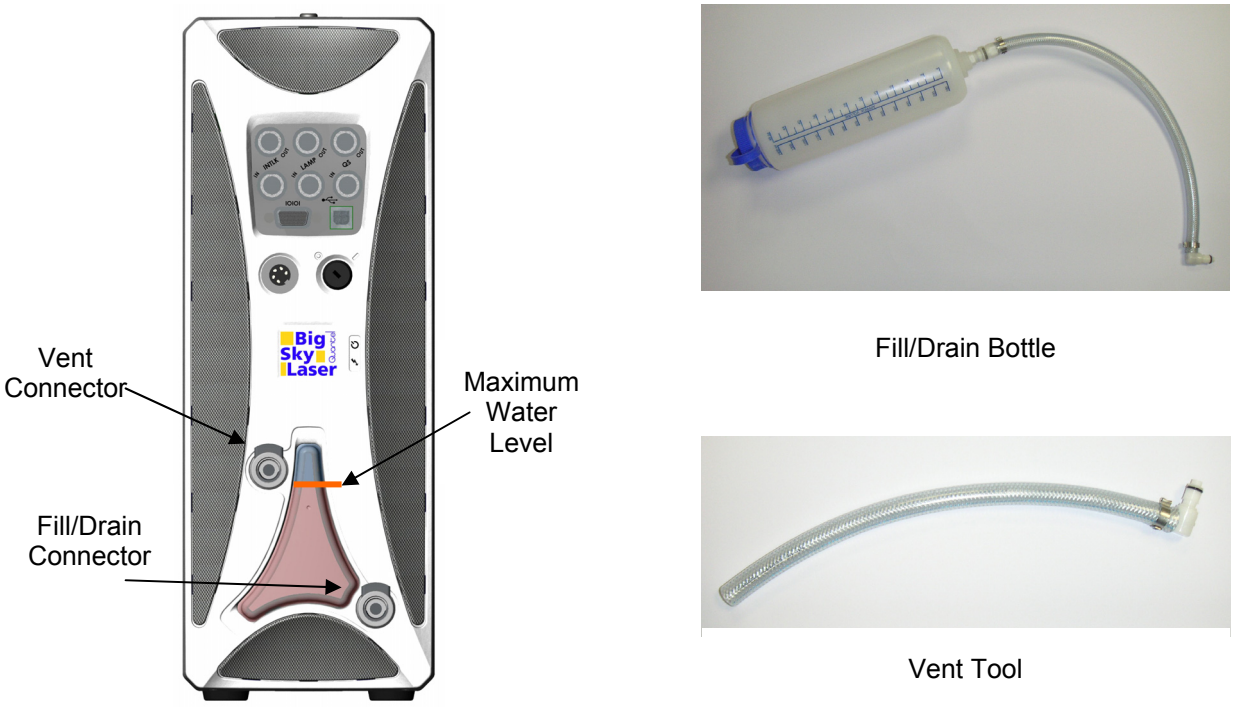


Figure 3-1: Fill/Drain Part Locations

CHAPTER 4

Operation

Cooling Group Unit Description

The Cooling Group Unit (CGU) is an independent unit located inside the ICE 450. It cools the flashlamps and the rod with a closed loop of de-ionized coolant. This temperature-regulated coolant also provides thermal stabilization of the oscillator's structure.

A liquid-to-air stainless steel exchanger cools the de-mineralized coolant.

A thermostatic electronic circuit, which regulates the fan's speed and consequently the airflow rate through the exchanger, causes thermal stabilization of the coolant. The temperature stabilization is within ± 1 °C. The ambient air temperature can range from 18 °C to 28°C with no effect on laser operation.

In the closed loop, to maintain the coolant resistivity (> 1MOhm/cm), a pick-off shunt deviates part of the coolant from the heat exchanger into a de-ionization cartridge. The de-ionized coolant comes back directly into the tank. The CGU has coolant level, flow, and heat-sensing switches to interlock with the Power Supply Unit to prevent damage to the Laser Head in the event of a cooling system failure.

The CGU requires 1.5L (0.4 US gal.) for use. For the maintenance of the CGU, please see Chapter 6.

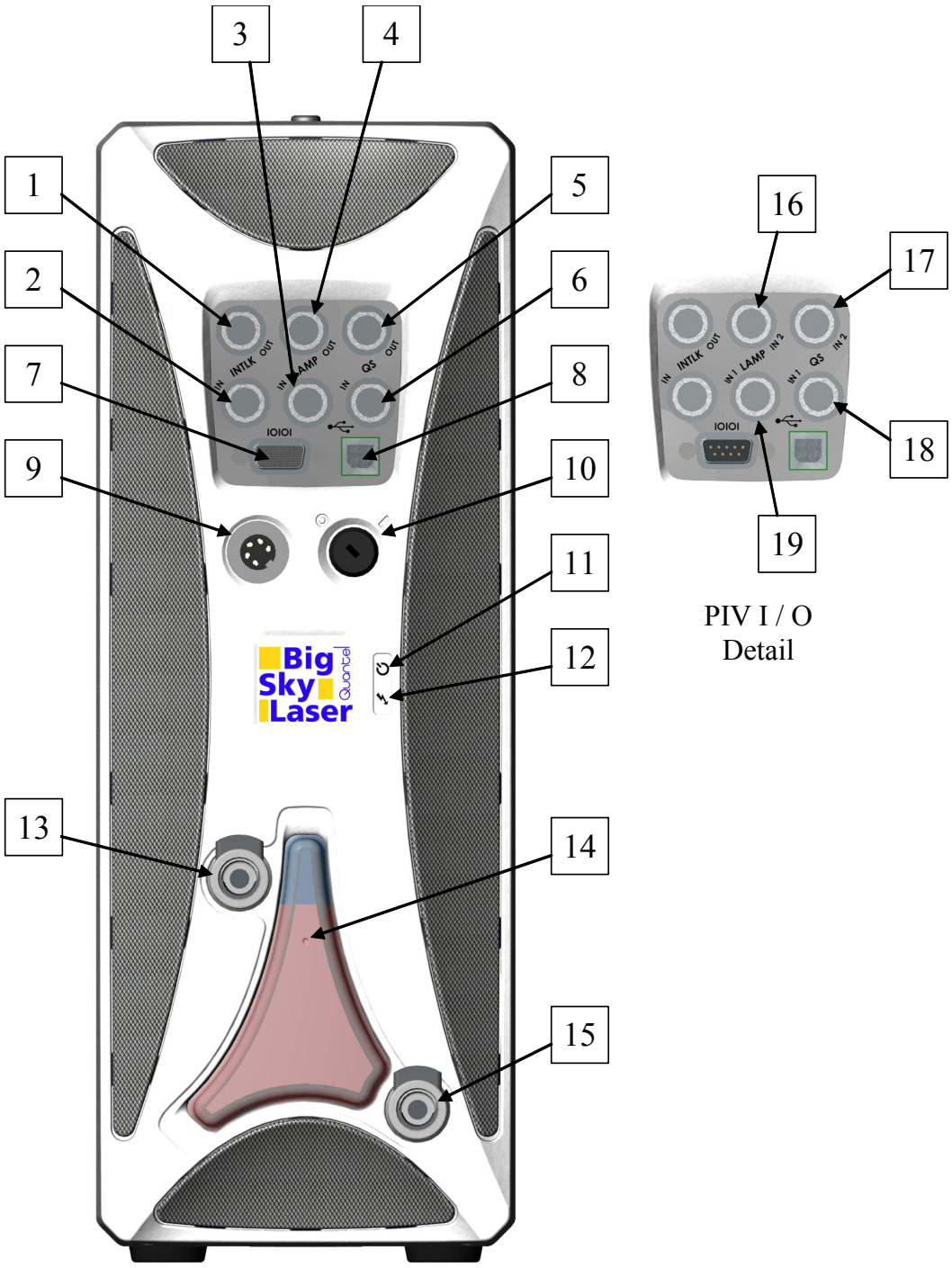


Figure 4-1: Front Panel Description

Rear and Front Panel Description

1. **Interlock Out**: This BNC Connector allows the user to connect to an external laser warning indicator. Output is low (pulled to ground) when the laser is disabled. When enabling the laser high voltage, output goes to +15 VDC and is capable of providing up to 150mA. **CAUTION: This output is not short circuit protected.**
2. **Interlock In**: This BNC Connector allows the user to interface to an external safety shutdown switch. The user must short this connector to allow the laser to operate. If detection of an open circuit occurs, the laser Power Supply high voltage is disabled and the PFN capacitor discharges in less than 5 seconds. If the employment of multiple safety switches occurs, it is important that they connect in series. Install the attached BNC shorting cap on this connector if this function is unnecessary.
3. **Lamp In**: This BNC Connector provides external synchronization of the flashlamp fire order when selection of the External Flashlamp Trigger Mode occurs via the Remote Box or serial interface. The trigger source must be capable of supplying a pulse with the following characteristics:
    - Amplitude: +5VNOM into 50 ohms.
    - Pulse-width: 10µs to 100µs as described on Figure 4-2.

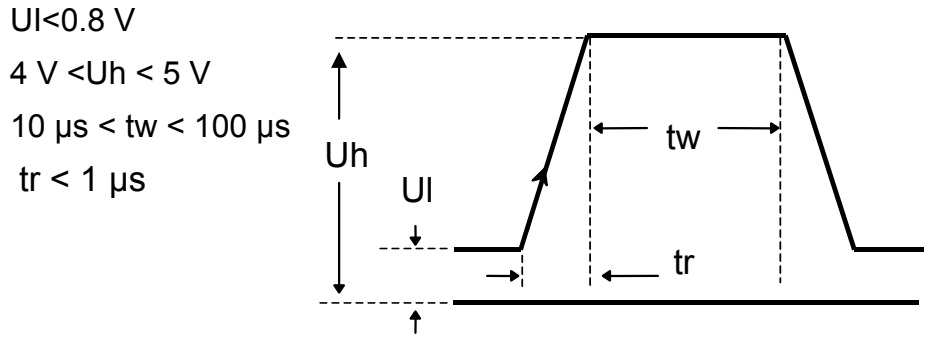


Figure 4-2: Characteristics of the Input Signal for Flashlamp Synchronization

4. **Lamp Out**: This BNC Connector allows synchronization to the laser flashlamp trigger signal. This order corresponds to the rising edge of a positive TTL signal (5V, 20 mA max, 50 µS duration).

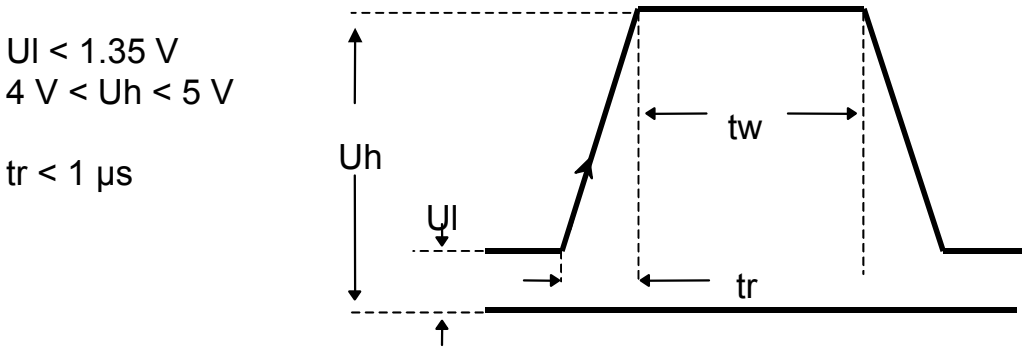


Figure 4-3: Characteristics of the Input Signal for Q-Switch Synchronization

5. **Q-Switch Out**: This BNC Connector allows synchronization to the laser Q-Switch trigger signal. This order corresponds to the rising edge of a positive TTL signal (5V, 20 mA max, 10 µS duration).
6. **Q-Switch In**: This BNC Connector provides external synchronization of the Q-Switch trigger when selection of External Q-Switch Trigger Mode occurs via the Remote Box or serial interface. The trigger source must be capable of supplying a pulse with the following characteristics:
    - Amplitude of +5VNOM into 50 ohms and a Pulse-width of 10µs to 100µs. See Figure 4-3 for descriptions of all the features.
    - The minimum Q-Switch trigger delay must be 150 +/- 1 µsec with respect to the flashlamp trigger (as measured on the Lamp Out Connector).
    - Triggering the Q-Switch with a shorter delay may result in double pulsing of the laser that will damage the optics.
    - Triggering the Q-Switch with a longer delay will attenuate the laser output.
7. **Computer Serial Port Interface (RS-232)**: This is the DE-9S. This D-Sub Connector allows laser system operation by remote computer control via the standard RS-232 interface. Chapter 5 describes the port configuration and command set. To disable computer control, toggle one of the Remote Box buttons.
8. **Computer Serial Port Interface (USB)**: A USB Connector allows laser system operation by remote computer control via the standard USB interface. Chapter 5 describes the port configuration and command set. To disable computer control toggle one of the Remote Box buttons.
9. **Remote Box Interface (RB)**: (DIN Connector) All operating parameters and settings for laser control can be accessed when the Remote Box is connected to the laser Power Supply.
10. **Power Key Switch**: To turn the laser Power Supply ON, rotate the key to the (“I”) position. With the key switch in the (“I”) ON position, the laser system is ready for use. The key is not removable in the ("I") position. To turn the laser Power Supply OFF, rotate the key to the ("O") position. Remove the key to keep unauthorized personnel from operating the laser.

11. **Power ON Indicator**: The indicator illuminates when the key switch is ON ("I") and the Main plugs into 85 – 264VAC 50/60 Hz. The indicator is amber-colored to ensure visibility through laser goggles.

12. **Laser ON Indicator**: When high voltage is charging in the capacitor, the indicator illuminates. The indicator is amber-colored to ensure visibility through laser goggles. When this indicator is illuminated, the user must observe laser safety precautions.

13. **Reservoir Vent Port**: The vent port allows pressure equalization in the Cooling System when coolant is added or drained. Refer to the "Fill and Drain" instructions in Chapter 3 of this manual.

14. **Minimum Coolant Level Indicator**: The circular depression on the front of the coolant reservoir indicates the recommended minimum coolant level when mounting the system horizontally or standing it vertically. The reservoir is backlit with dual color LED's for improved coolant level visibility. If the coolant drops below the minimum level, the level interlock trips to inhibit laser operation, and the reservoir backlight flashes to notify the user to add coolant.

15. **Reservoir Fill/Drain Port**: This port is where coolant is added or drained.

16. **PIV Lamp #2 In**: This BNC Connector provides external synchronization of the flashlamp fire order for the second Laser Head of a PIV laser pair when selection of "External Flashlamp Trigger Mode" occurs via the Remote Box or serial interface. The trigger source must be capable of supplying a pulse with the following characteristics:

    - Amplitude: +5VNOM into 50 ohms
    - Pulse-width: 10µs to 100µs as described in Figure 4-5.

17. **Q-Switch #2 In**: This BNC Connector provides external synchronization of the Q-Switch trigger for the second Laser Head of a PIV laser pair when selection of "External Q-Switch Trigger Mode" occurs via the Remote Box or serial interface. The trigger source must be capable of supplying a pulse with the following characteristics:

    - Amplitude: +5VNOM into 50 ohms
    - Pulse-width: 10µs to 100µs. It is important that the Q-Switch trigger delay is 150 µS +/- 1 µsec with respect to the flashlamp #2 trigger.
    - Triggering the Q-Switch with a shorter delay may result in double pulsing of the laser.
    - Triggering the Q-Switch with a longer delay will attenuate the laser output.

18. **Q-Switch #1 In**: This BNC Connector provides external synchronization of the Q-Switch trigger for the first Laser Head of a PIV laser pair when selection of "External Q-Switch Trigger Mode" occurs via the Remote Box or serial interface. All other characteristics are identical to Q-Switch #2 In.

19. **PIV Lamp #1 In**: This BNC Connector provides external synchronization of the flashlamp fire order for the first Laser Head of a PIV laser pair when selection of "External Flashlamp Trigger Mode" occurs via the Remote Box or serial interface. All other characteristics are identical to PIV Lamp #2 In.

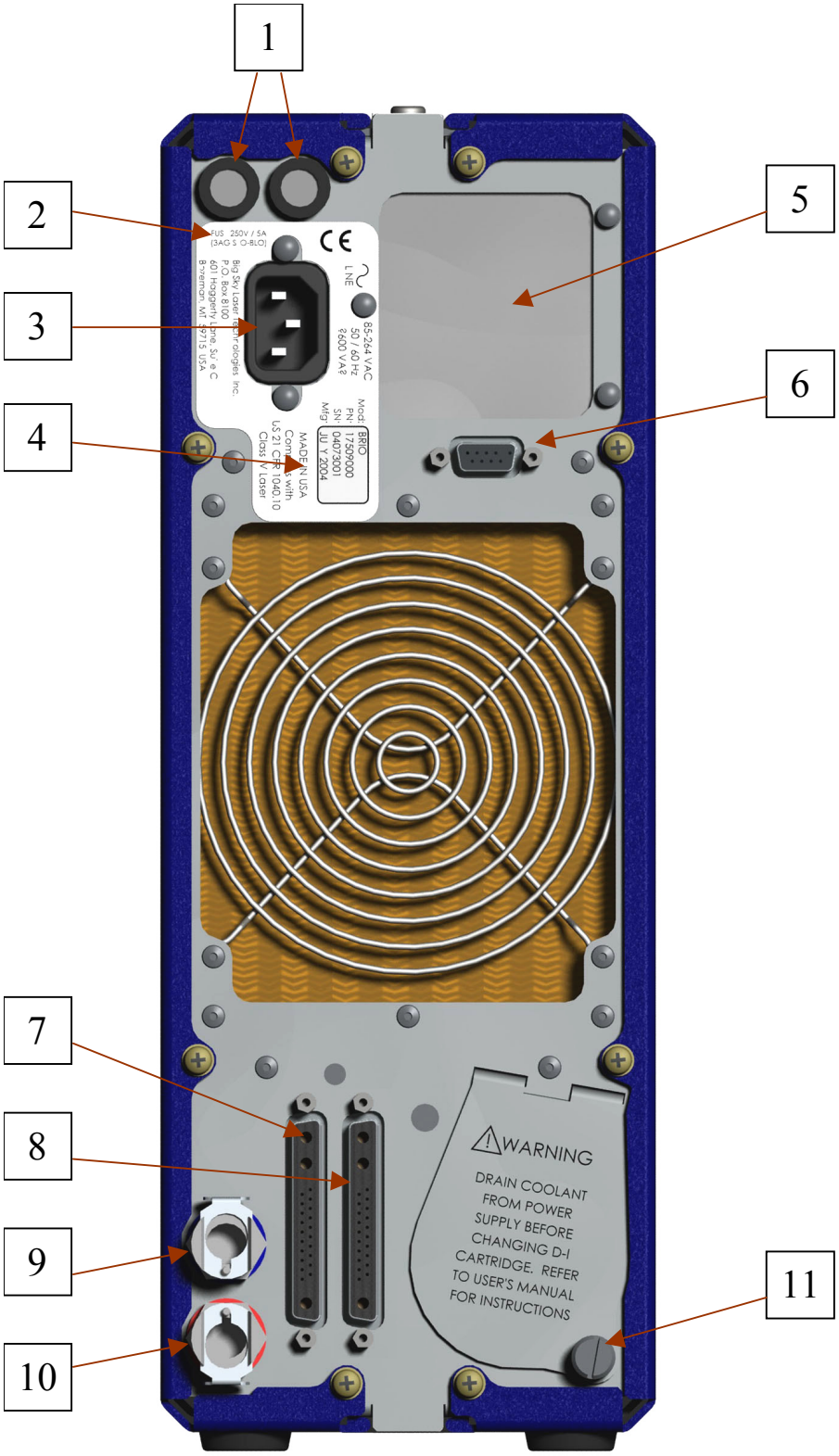


Figure 4-4: Rear Panel Description

1. **AC Mains Power Fuses**: System AC power fuses disconnect the ICE 450 from the AC Mains in the event of an electrical fault inside the cabinet. The Power Supply operates on universal input power as defined in item #3 below. Because of this, fusing both AC lines ensures safe operation.
2. **Fuse Specification**: The type of replacement fuse is located on the label next to the fuse holders. Use only the specified fuse type and rating. Failure to do so could result in equipment damage or personal injury.
3. **AC Mains Power Line Input**: Industry standard IEC 60320-power inlet provided for the AC Mains power input. The AC input rating is 85-264 VAC, 50/60 Hz, at 0.5KVA.
4. **Identification Label**: This label indicates Model Number, Part Number, Serial Number, and Date of Manufacturing.
5. **Auxiliary I/O Connection Port Placement**: System Interlock (In/Out), Lamp Sync (In/Out), Q-Switch Sync (In/Out), RS-232 Port, and USB Port connectors may be factory-installed on the back panel as a user option.
6. **PIV Interface**: The DA-15S-HD, D-Sub Connector provides serial communications between the Master and Slave ICE 450's in a Dual-ICE 450 PIV system (not installed on single PIV ICE 450).
7. **External I/O #1**: The CBD25W3F, D-Sub, Mixed Contact Connector is the electrical interface between the ICE 450 and the Laser Head. Since this connector carries high voltage and high current, it is important to fully insert the mating connector into the Laser Head umbilical and fullly engage the screw locks prior to laser operation must occur.
8. **External I/O #2**: The Dual PIV ICE 450 has two external I/O connectors. Each connector matches the corresponding Laser Head. There is not a second connector installed on a standard ICE 450.
9. **Coolant OUT Port**: Connect the Laser Head umbilical cooling line identified with the BLUE band to this coolant port to provide coolant to the Laser Head.
10. **Coolant RETURN Port**: Connect the Laser Head umbilical cooling line identified with the RED band to this coolant port to provide the coolant return from the Laser Head.
11. **D-I Cartridge Cover**: Provides access to the coolant D-I Cartridge. It is important to drain the coolant prior to changing the D-I Cartridge. See Chapter 3 for instructions on draining the coolant, replacing the cartridge, and filling the system with new coolant.

Remote Box Control

The functions on the Remote Control Box (RB) provide:

- Flashlamp firing in single shot or automatic.
- Choice between internal or external synchronization of the flashlamp.
- Flashlamp voltage.
- Flashlamp shot counter and user shot counter.
- Choice between internal or external synchronization of the Q-Switch.
- Activation or inhibition of the Q-Switch in single shot, automatic, and burst mode.
- Q-Switch shot counter and user shot counter.
- Output energy modification by adjustment of the delay between flashlamp and Q-Switch firing.

Once the key in the front face of the ICE 450 is ON ("I"), control of laser operation begins via the Remote Control Box (RB). Figure 4-5 shows this RB and the functions available from it.

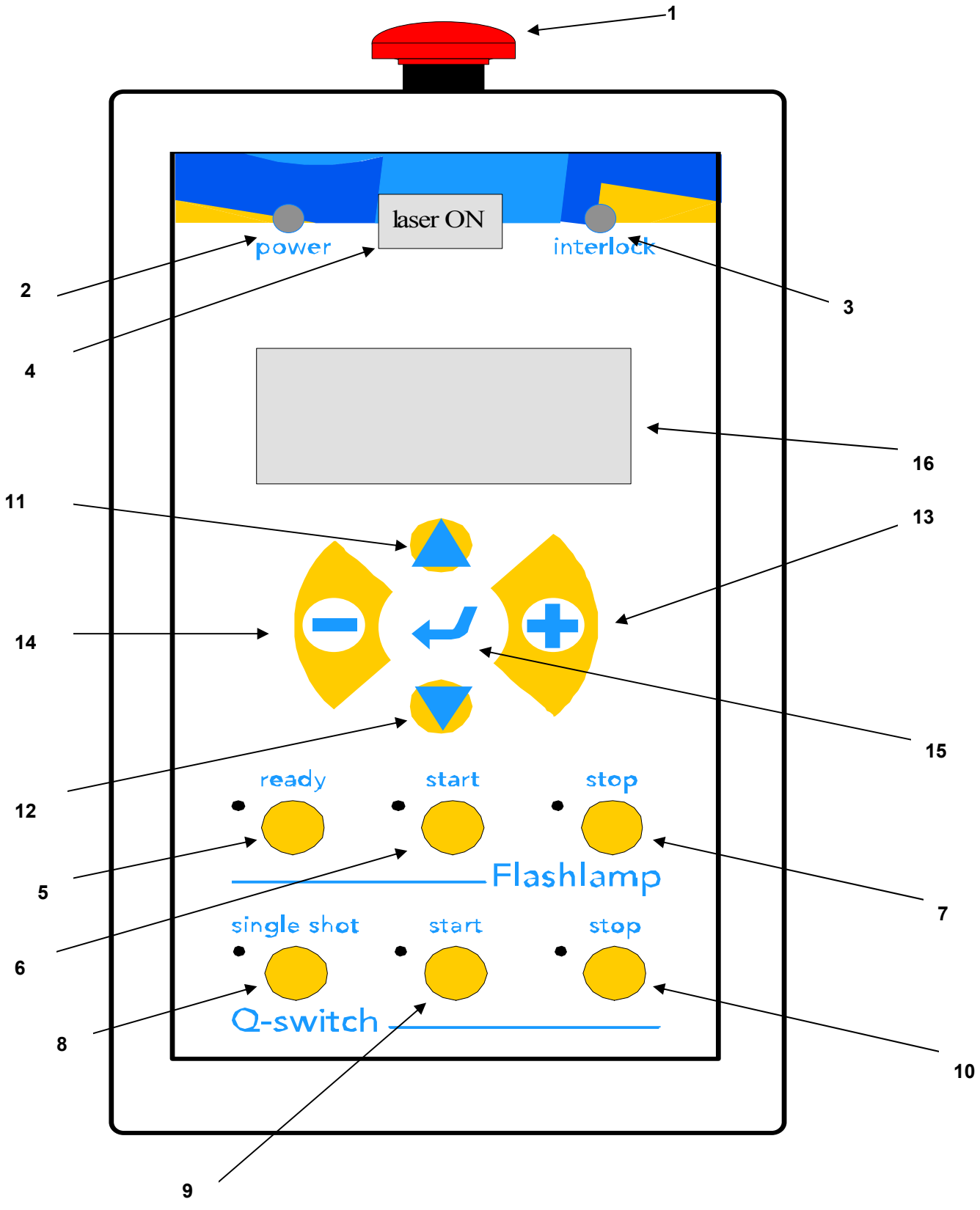


Figure 4-5: Remote Control Box

The RB connects to the front panel of the ICE 450 front panel through a three-meter flexible DIN connector **(9)** of Figure 4-1.

1. **EMERGENCY STOP**: Pushing this button stops the ICE 450, and the capacitor banks ground in less than 5 seconds. Pull the button out before restarting the system.
2. **POWER**: This light is orange when the main power line is connected and the key switch is in the ON ("I") position.
3. **INTERLOCK**: This light is orange continuously when the key switch is in the ON ("I") position and all securities are completed. The ICE 450 stops when detection of a security malfunction occurs, the capacitor banks ground in less than 5 seconds, and the orange indicator flashes. A message displays on the screen (16) indicating the interlock detected. If the malfunction is corrected, the indicator lights up again and the ICE 450 becomes operative. The following safety interlocks may detect a malfunction:
    - Coolant Flow or Level Discharge Button
    - Emergency Stop Push-Button: see (1) on figure 4-5
    - Cover Switch
    - Head Temperature
    - External Safety Interlock
    - Temperature Too Low
4. **LASER ON:** This light is orange when the flashlamps are operating (flashing or simmer current). It warns the user to observe laser safety precautions.
5. **FLASHLAMP READY**: This button has two functions:
    1. After turning the key (10) of Figure 4-1 on the front panel, and when the laser temperature has reached the preset value, pushing this button will fire a single discharge in the flashlamp and starts the simmer current. The ready indicator will illuminate.
    2. If the ready indicator is lit, pushing this button will fire a single discharge in the flashlamp (manual operation).
6. **FLASHLAMP START**: When the laser temperature has reached the preset value, push this button to fire the flashlamp automatically (its indicator lights up). The charge and fire orders are internally generated.
7. **FLASHLAMP STOP**: Push this button to stop the automatic firing or the simmer current of the flashlamp. The small indicator to the left of the button will illuminate. When the beam shutter light warning illuminates and the flashlamp is operating, pushing the following buttons will be followed by laser pulse emission.
8. **Q-SWITCH SINGLE SHOT**: When the laser temperature has reached the preset value, and the Q-Switch start indicator is not flashing, pushing this button allows single pulse operation.
9. **Q-SWITCH START**: This button allows the operation of the Q-Switch in Automatic Mode, whatever the Q-Switch triggering source may be (external or internal). When the laser temperature has reached the preset value, after pushing this button, its

indicator and the emission indicator LED **(12)** of Figure 4-1 will flash until you stop the Q-Switch.

10. **Q-SWITCH STOP**: Push this button to stop the automatic firing of the Q-Switch operation.

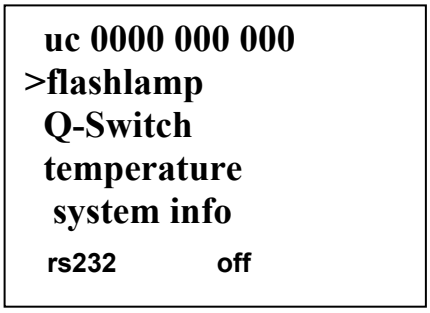
11.-16. **Screen Display and Buttons to Select and Validate Laser Operating Parameters:**

- Internal or external synchronization of the flashlamp
- Flashlamp voltage
- User shot counter and counter time
- Internal or external synchronization of the Q-Switch
- Activation or inhibition of the Q-Switch in single shot, automatic, scan and burst mode
- Delay of the output synchronization signal with respect to opening of the Q-Switch
- Delay between flashlamp and Q-Switch firing

The main menu displayed on the screen is:

BIG SKY LASER TECHNOLOGIES
Name of Laser
Date of Software

Press **ENTER (15)** to display the main menu**:**



Toggle the buttons **(11)** or **(12)** to move down or up the arrow **(>)**, to select the desired submenu.

To go through a submenu, press **ENTER (15)**.

To select a parameter or an operating condition, point the arrow **(>)** on it.

To modify a numeric value, toggle the buttons **(13)** & **(14)** for slow change or depress and hold them for faster change.

To switch a non-numeric operating condition, toggle the buttons **(13)** & **(14)**.

Operating Conditions

RS232 **on** or **off**: The **off** position inhibits any modification of the laser parameters coming through the RS232 serial port, while reading the status is not affected.

Synchro **internal** or **external**: The operating condition can be switched from internal synchronization to the external one for the flashlamps or the Q-Switch.

Q-Switch mode **auto scan or burst**: Select this mode with buttons **(13)** & **(14)** and press ENTER to access the mode modification.

When the **auto** mode is validated, the Q-Switch operates continually, and the user can choose the repetition rate For F/n (n is an integer).

The **scan** mode is used when the user would like to repeat the Q-Switch sequence several times. See the description of scan mode in the example below:

- "nb of scan" 12 → the sequence is repeated 12 times
- "Active pulse" 06 → firing is authorized for 06 shots
- "Passive pulse" 12 → firing stops for 12 shots,
- *For continuous mode operation, replace 12 with 99.*

If the scan mode is activated, another menu is displayed and the operating condition can be modified. To validate any modification in the Q-Switch mode, the Q-Switch must be stopped and restarted.

The **burst** mode is used when the user would like to have a simple sequence of X (X is an integer) shots once.

Adjustable Parameters

FLASHLAMP VOLTAGE xxxxV: The user can adjust the pump energy in the flashlamps if required. To avoid free-running operation in the laser, the high voltage variation has a limited range.

FI-QS DELAY xxx µs: The user can adjust the time delay between the flashlamp and the Q-Switch fire order and the output energy of the laser will decrease as this delay moves away from the optimal value. The optimal value is set during laser optimization at Big Sky Laser Technologies.

Q-Switch Repetition Rate

When the flashlamp is stopped, all set modifications will be loaded in the system memory. This stored configuration is automatically set when the laser is turned ON ("I").

To access the operating conditions and adjustable parameters, Figure 4-6 presents a schematic diagram of the different menus provided by the Remote Box. To follow the → from one menu to another, press the ENTER button.

The Remote Box is also used to display an error message when one of the safety devices interlock is defeated.

Details on the error messages and solutions are presented in Chapter 5.

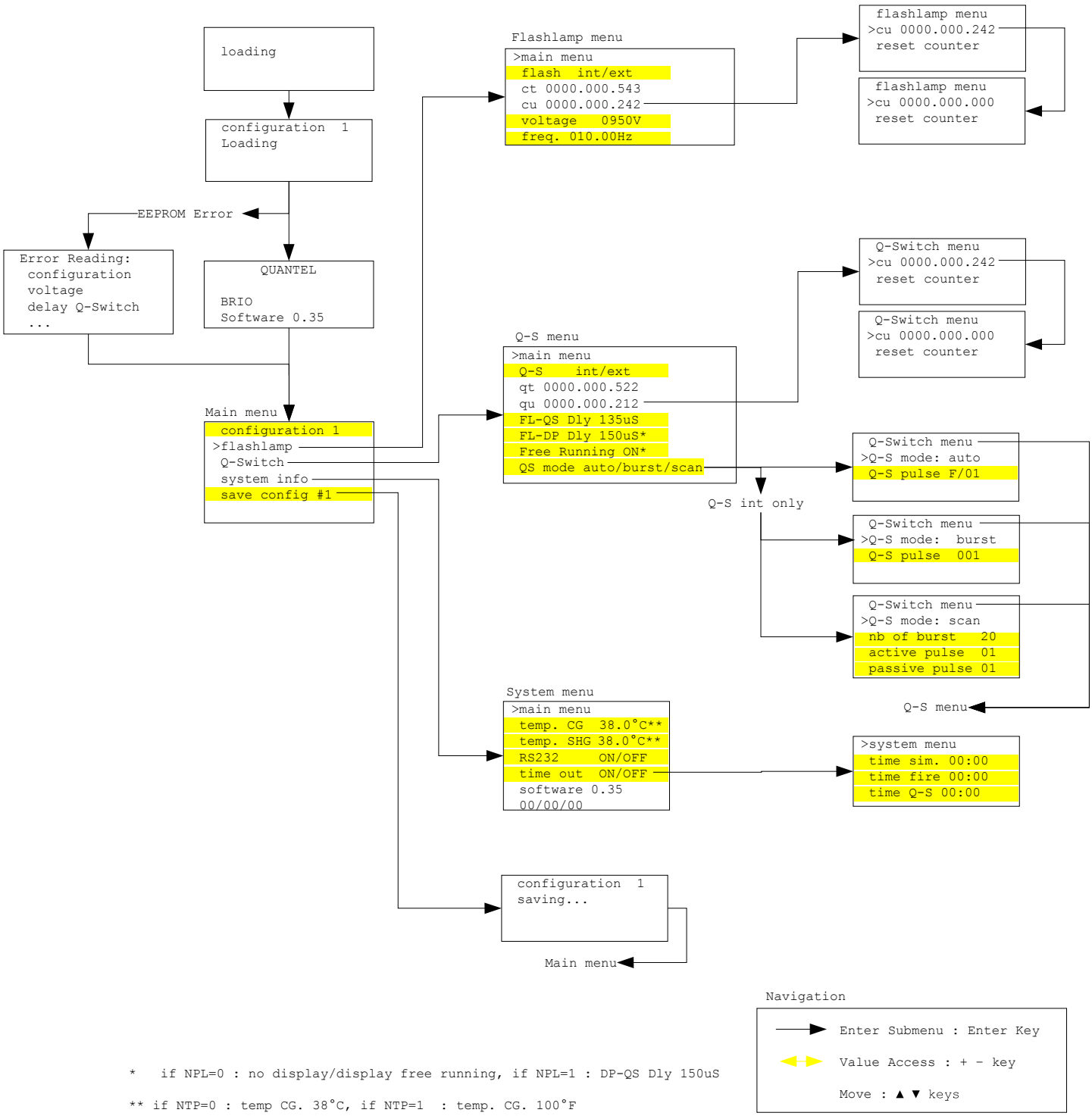


Figure 4-6: Schematic Diagram of the Menus on the Remote Box

Modes of Operation

ICE 450 lasers provide three modes of operation (Manual, Automatic, and External) for Nd:YAG rod pumping (flashlamp pulses), and three modes (Single shot, Automatic and External) for Q-Switching (laser emission).

To select the modes of operation use the Remote Control Box (RB). Select the operating modes for the flashlamp with the **ready** and **start** buttons, and screen display (**internal** or **external**). For the Q-Switch operating modes, select the **single shot** and **start** buttons, as well as the screen display (**internal** or **external**).

Manual Mode

After turning the key of the laser's Power Supply to ON ("I"), press the **ready** button on the (RB) to initiate the Simmer current in the flashlamp and ensure that the **LASER ON** indicator is lit. When the Simmer indicator is lit up, a single flashlamp shot occurs by pressing the **ready** button.

Use Manual Mode to check the normal operation of the Power Supply and flashlamp. **DO NOT** perform Laser emission under this mode, unless a special configuration is on the laser. Figure 4-7 describes Manual Mode.

Please follow the standard safety precautions of this manual, even when using Manual Mode. During laser operation, everyone present in the laser room must wear safety goggles appropriate for the specific output wavelengths.

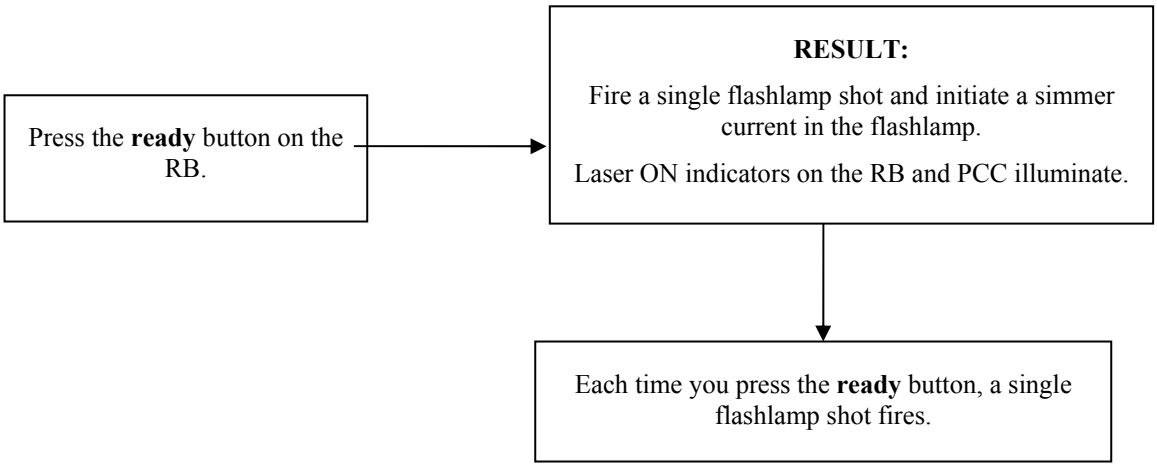


Figure 4-7: Manual Mode

Manual Mode (Internal & Start)

In the internal (**Int**) synchronization mode, the controller board, at a rate determined by an internal clock, automatically generates the “fire” command of the flashlamp. The Q-Switch activates with a fixed delay (factory set or user delay set on the RB) after the beginning of the "fire" order. Figure 4-8 describes Automatic Mode.

This is the most common mode of operation at the factory-set repetition rate for the ICE 450 Nd:YAG laser. For 8 seconds after flashlamp activation, the Q-Switch stops to avoid transient thermal effects in the Nd:YAG rod.

For the Gaussian Resonator (GRM), the internal repetition rate is factory-set and can only be changed by a Big Sky Laser Technologies personnel, or a Big Sky Laser Technologies qualified representative.

The customer, using the Remote Box, can change the repetition rate. In this case, the specifications (energy, divergence, and beam profile) are only available at the factory repetition rate.

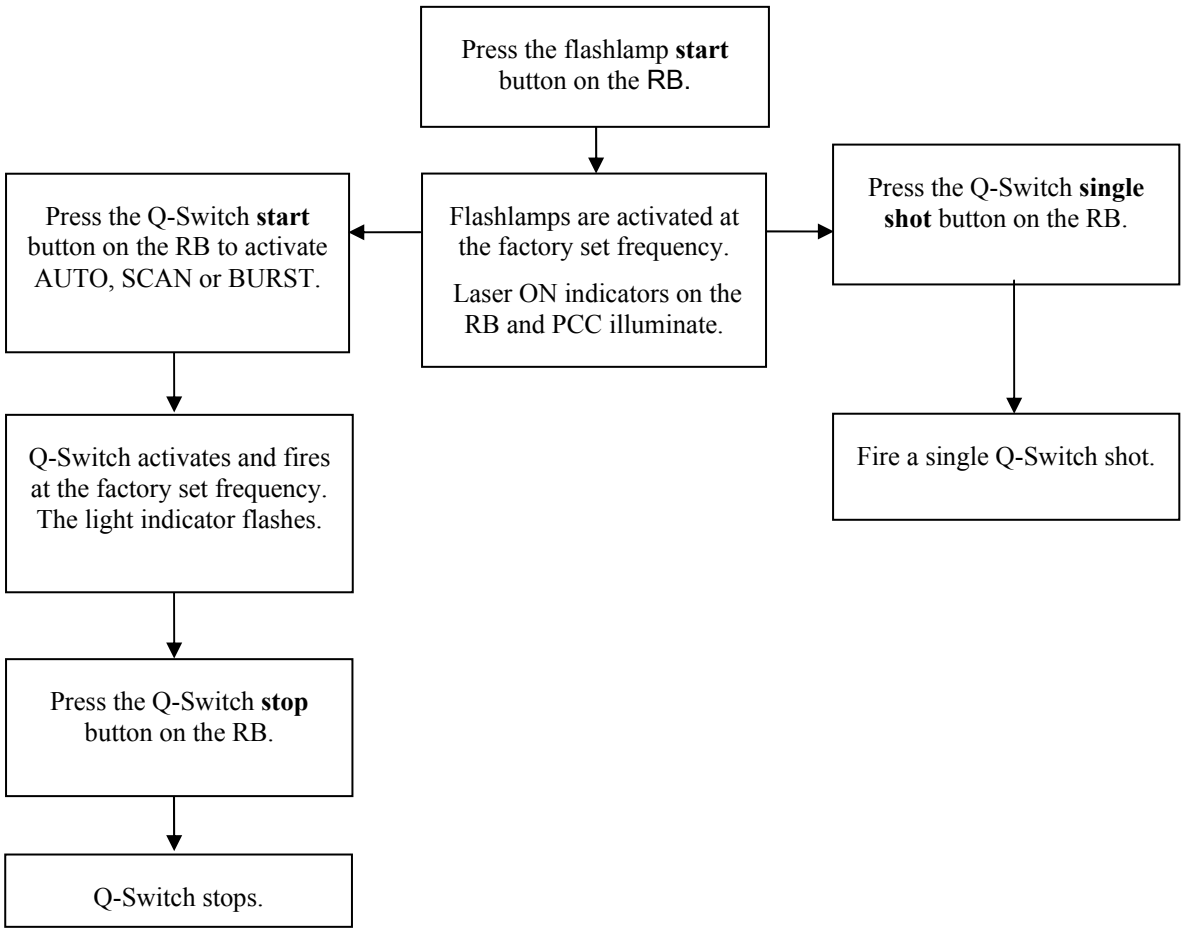


Figure 4-8: Automatic Mode

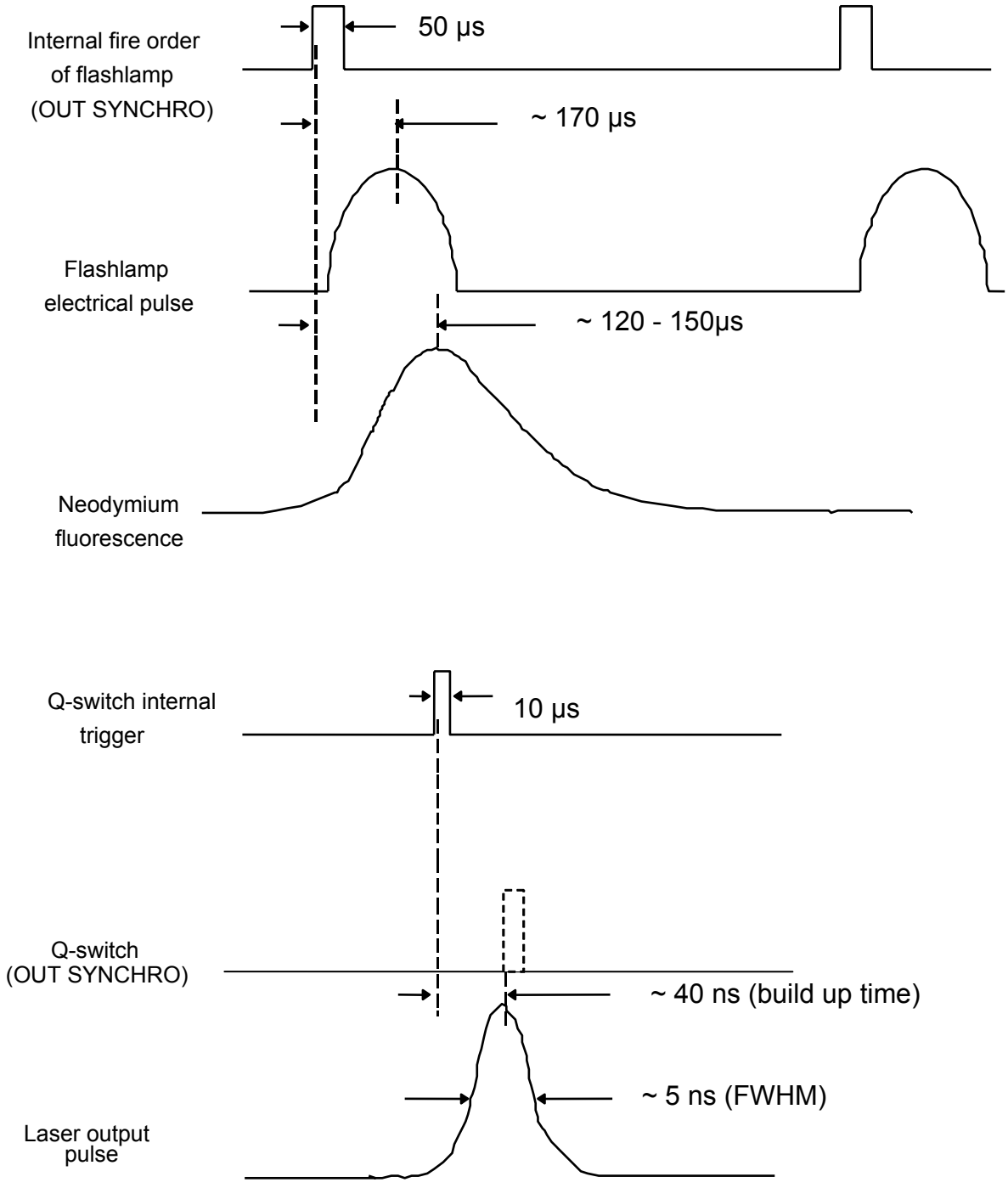


Figure 4-9: Automatic Mode – Timing Diagram

Decreasing the Output Energy

Operation at a decreased energy level is used when starting an experimental setup, testing equipment, etc. The RB provides easy access to this function, with the variable Flashlamp / Q-Switch delay. Increasing the flashlamp / Q-Switch delay above the optimum value will result in a lower energy output pulse, as well as longer pulse-width, thereby reducing the risk of damage to optics or detectors, while slightly modifying the laser's beam characteristics.

Big Sky Laser Technologies advises against decreasing the high voltage of the flashlamps to reduce the output energy. Decreasing the high voltage of the flashlamps 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, proceed as follows:

1. On the RB, select Q-Switch from the Main menu.
2. Press Enter.
3. Select Flashlamp / Q-Switch delay (fl-QS Dly) from the Q-Switch menu.
4. Toggle the **-** and **+** buttons on the RB to adjust the output energy to the desired value.
5. Press Enter.

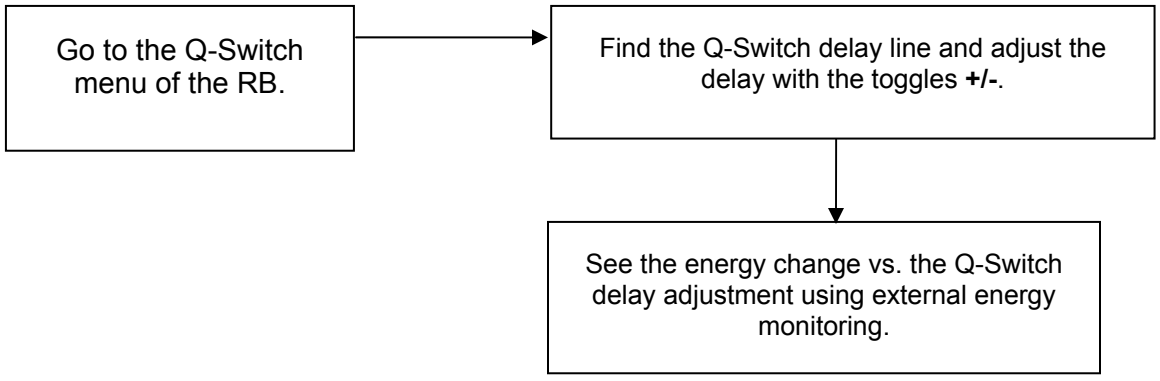


Figure 4-10: Decreasing the Energy

External Modes (EXT)

Big Sky Laser Technologies configures the laser at the optimal repetition rate specified by the customer.

For a GRM laser in External Mode, the repetition rate has to be equal to the initial setting (with an allowance of ± 5%).

For Stable resonators in External Mode, the repetition rate can be variable to the maximum (factory setting specified by the costumer). However, the specifications are only available at the initial setting.

NOTE: Rising edges are active edges (for low jitter operation, the rise time must be as short as possible: < 1µs).

To maintain a short rise time and minimal jitter, the input Q-Switch is not opto-coupled. <u>Do not apply voltages greater than 5V</u>.

For flashlamp and Q-Switch synchronization, the user must send signals as indicated in Figures 4-2 and 4-3. The delay between flashlamp and Q-Switch synchronization signals may range from 135µs to 500µs. In order to optimize laser operation (maximum energy), this delay must be measured and adjusted.

Described in the next section are the different ways that the user can utilize the External Mode according to the synchronization specifications of the user's experimental setup.

Flashlamp in External Mode and Q-Switch *in Internal Mode*

The electrical pulses in the flashlamp synchronize to an external clock. The Q-Switch is internally triggered (factory set delay after the beginning of each electrical pulse or user delay set on the RB). In this mode, the accuracy of optical pulse synchronization with an external event is about 10µs. Figure 4-11 describes this mode.

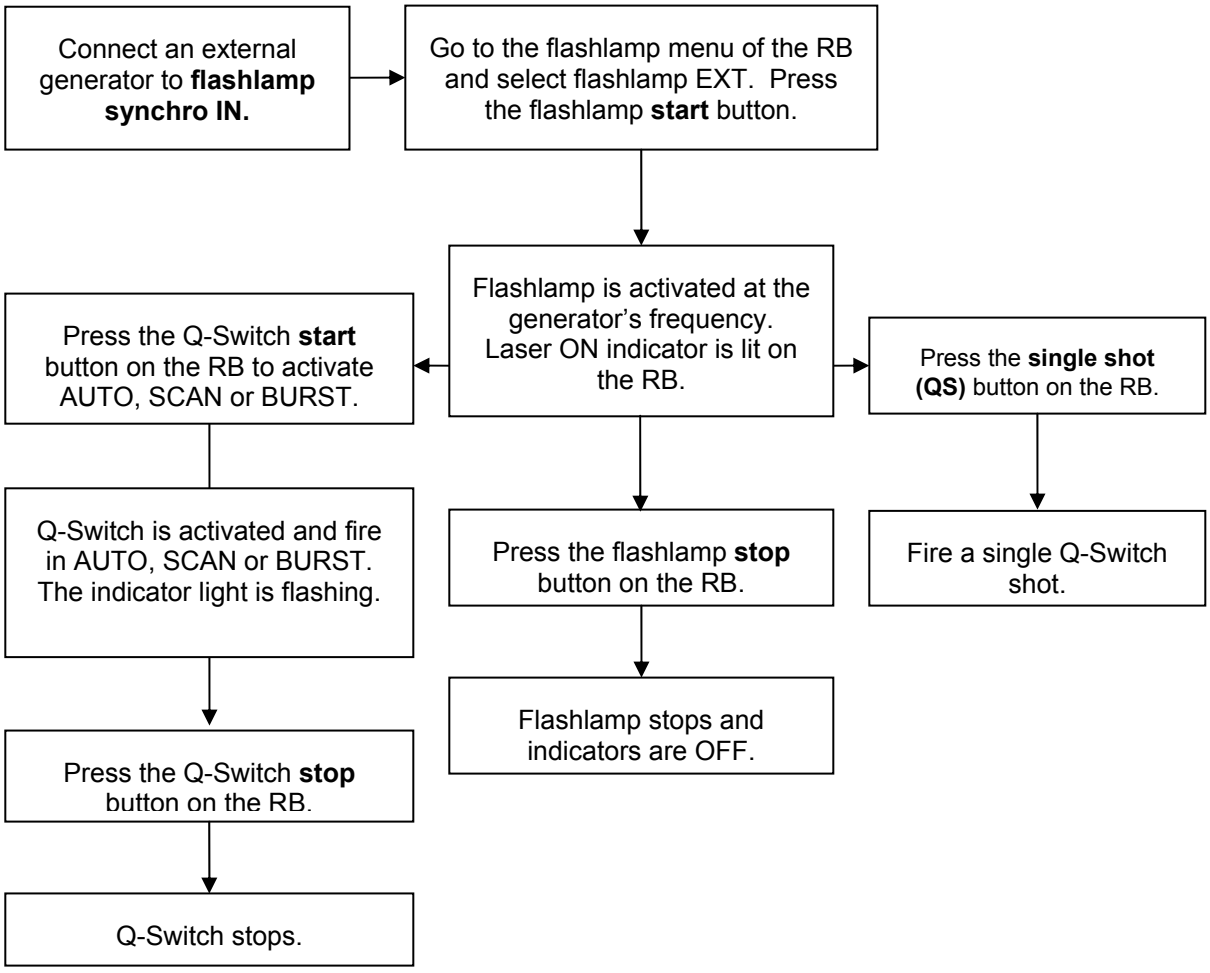


Figure 4-11: Flashlamp in the External Mode and Q-Switch in Internal Mode

Flashlamp in Internal Mode and Q-Switch *in External Mode*

In this mode of operation, the user must delay the flashlamp fire order (available on the flashlamp BNC SYNCHRO **OUT** with its own generator) and then connect the delayed signal to the Q-Switch BNC SYNCHRO **IN** connector. Fixed for each different laser, the time delay between the input signal and the Pockels trigger range from 600ns to 700ns from one laser to another. In this case, the jitter of the delay generator, with a minimum value of ±0.5ns limits the jitter between the optical pulse and the fire order. The user must be aware that a delay different from the factory set value will induce a decrease of the output energy. To activate this choice you should press the start button on the RB as described in Figure 4-12 or CC"CRLF" if you are using the serial port RS232.

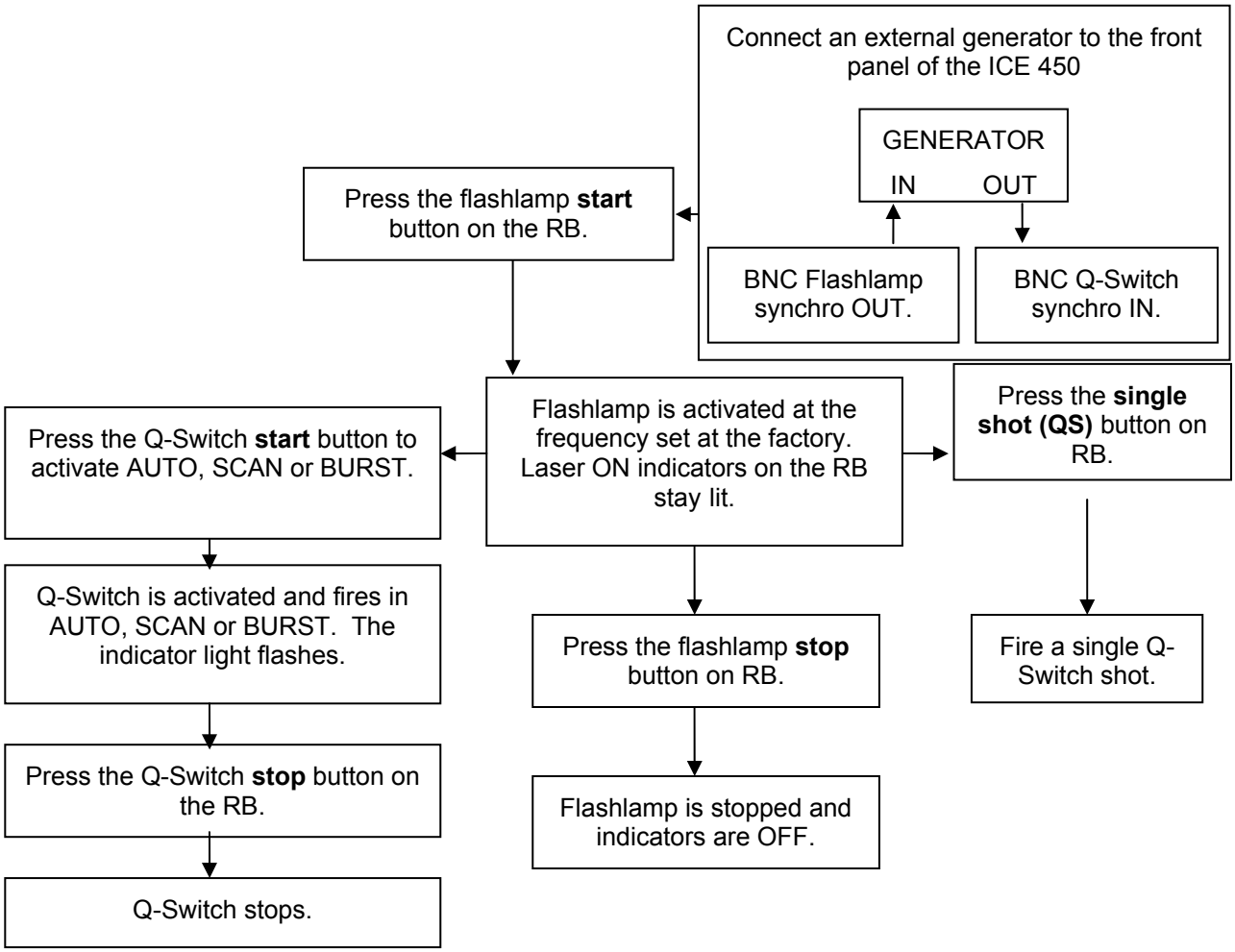


Figure 4-12: Flashlamp in the Internal Mode and Q-Switch in External Mode

Flashlamp and Q-Switch *in External Mode*

Use this mode when the laser emission has to synchronize with the user's experimental set-up with an accuracy of a few nanoseconds to about 10µs (depending on the jitter of the delay generator).

As in the Automatic Mode of operation, the Q-Switch stops for 8 seconds after the activation of the flashlamp to avoid transient thermal effects in the Nd:YAG rod. Figure 4-13 describes this mode.

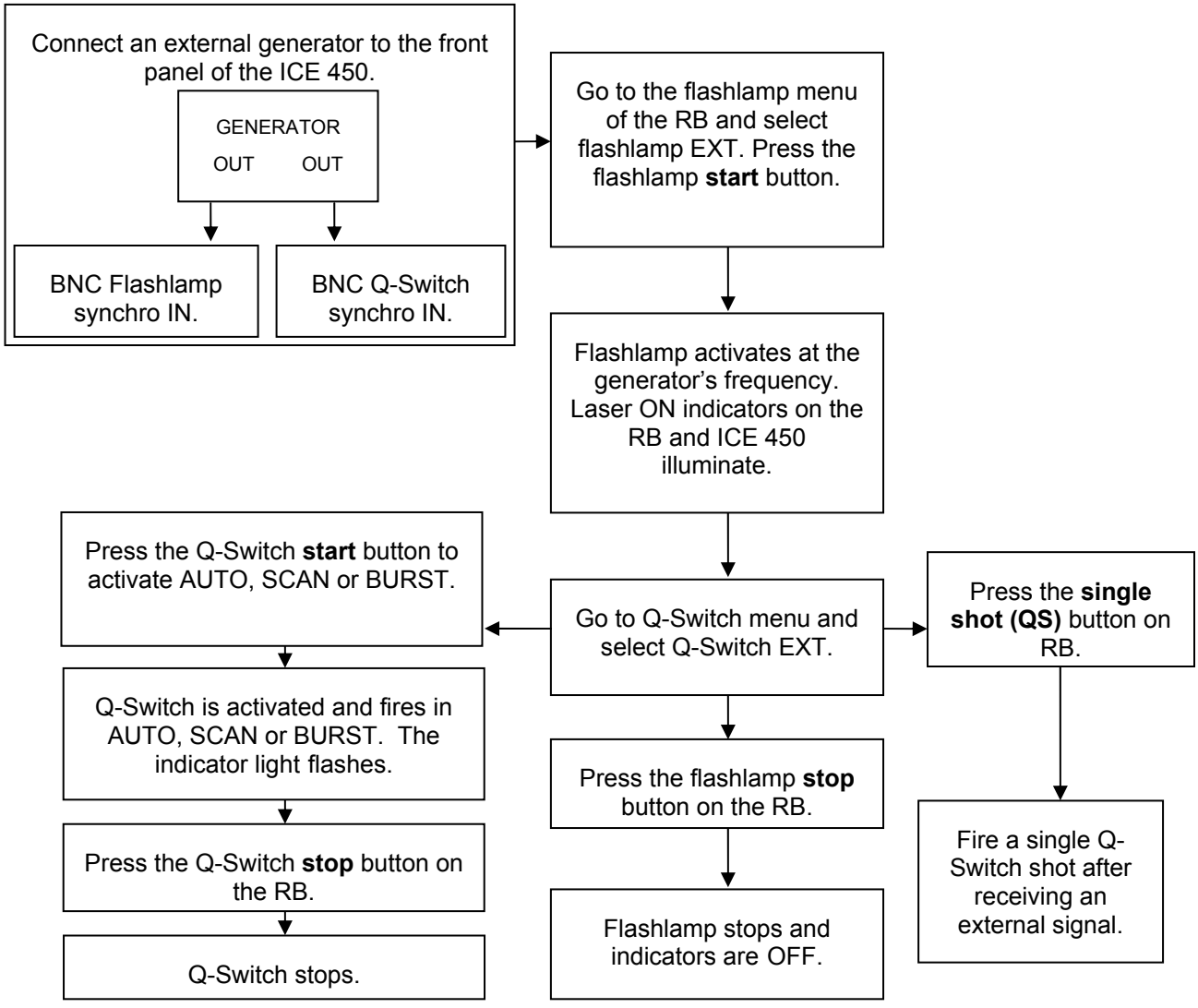


Figure 4-13: Flashlamp and Q-Switch in External Mode

Daily Start-Up and Shutdown Procedures

To start the laser system follow the instructions below:

1. Turn the control key on the front panel of the ICE 450 to the ("I") ON position. The "**power**" and the "**interlock**" indicators on the RB must light up. If not, check for defaults on the RB screen - see Chapter 4.

2. Wait 10-15 min until the water temperature reaches the preset value for flashlamp operation.

3. Press the **ready** button. Its LED indicator and the LASER ON indicators on the RB and on the front panel of the ICE 450 must light up.

4. Select the configuration or the following:

    - Select the operation mode: **internal** or **external** using display on RB.
    - In **External Mode**, follow the procedures of the "Modes of Operation" section. Press 1 to configure, connect the I/O cables to the laser inputs, and follow the procedure below.
    - In **Internal Mode**, follow the procedure below.

5. Press the **start** button of the flashlamp. Its indicator must illuminate, and the flashlamp fires at a fixed frequency. In External Mode, the flashlamp will flash when the user applies an external signal.

6. Open the laser's beam shutter. Its warning LED will illuminate.

7. Wait about 8 seconds before the Q-Switch control electronics enable normal operation of the laser. You may have to wait several minutes if the water temperature of the laser is below the preset value for Q-Switching operation.

The next steps allow the laser to operate and the laser beam to emit from the output aperture.

1. Press the **start** button to activate the Q-Switch, and its light indicator flashes. In External Mode, the Q-Switch will fire when the user applies the external signal.

2. If Harmonic Generation crystals are used, a warm-up time of 20 minutes from start-up is necessary before phase matching adjustment if needed.

3. To stop laser emission press the **stop** buttons on the Q-Switch and the flashlamp on the Remote Box. Their LED indicators should turn off.

4. Rotate the manual shutter to the closed position

Daily Shutdown Procedure

To stop the laser emission press the **stop** buttons of the Q-Switch and flashlamp on the RB, their LED indicators must turn off.

1. Close the beam shutter of the laser, its warning LED turns off.

2. Turn the control key on the front panel of the Power Supply to the OFF ("O") position.

Normal Operation

General Set-Up and Functions

Do not attempt to modify the pumping power by increasing the charging voltage on the Remote Control Box of the Power Supply. This voltage has been factory set for optimal laser performance.

Adjust the charging voltage if the flashlamp efficiency decreases. Contact Big Sky Laser Technologies Customer Service Department to be certain of the default's origin.

After the start-up procedure is complete, control of laser output occurs via the Remote Control Box (RB) or through the RS 232 port if activated.

Continuous Emission at the Factory-Set Rate

To obtain continuous emission of laser pulses press the Q-Switch and Flashlamp **start** buttons. Their indicator lights and the warning LED of the beam shutter of the laser will flash.

To disable the laser emission, press the **stop** button of the Q-Switch. Its indicator light and the warning LED of the laser's beam shutter will stop flashing.

Single Pulse Emission

To obtain a single pulse emission from the laser press the **single shot** button. Its indicator light will flash one time.

Use this mode to perform alignment of the experimental set-up.

Burst Mode Emission

Use this mode through the RS 232 port or with the Remote Box. With this mode, it is possible to emit a precise sequence of pulses. It allows Q-Switch firing for a fixed number of shots. See Chapter 4 for the RS 232 instruction lines, or proceed as described in Figure 4-16 with the Remote Box.

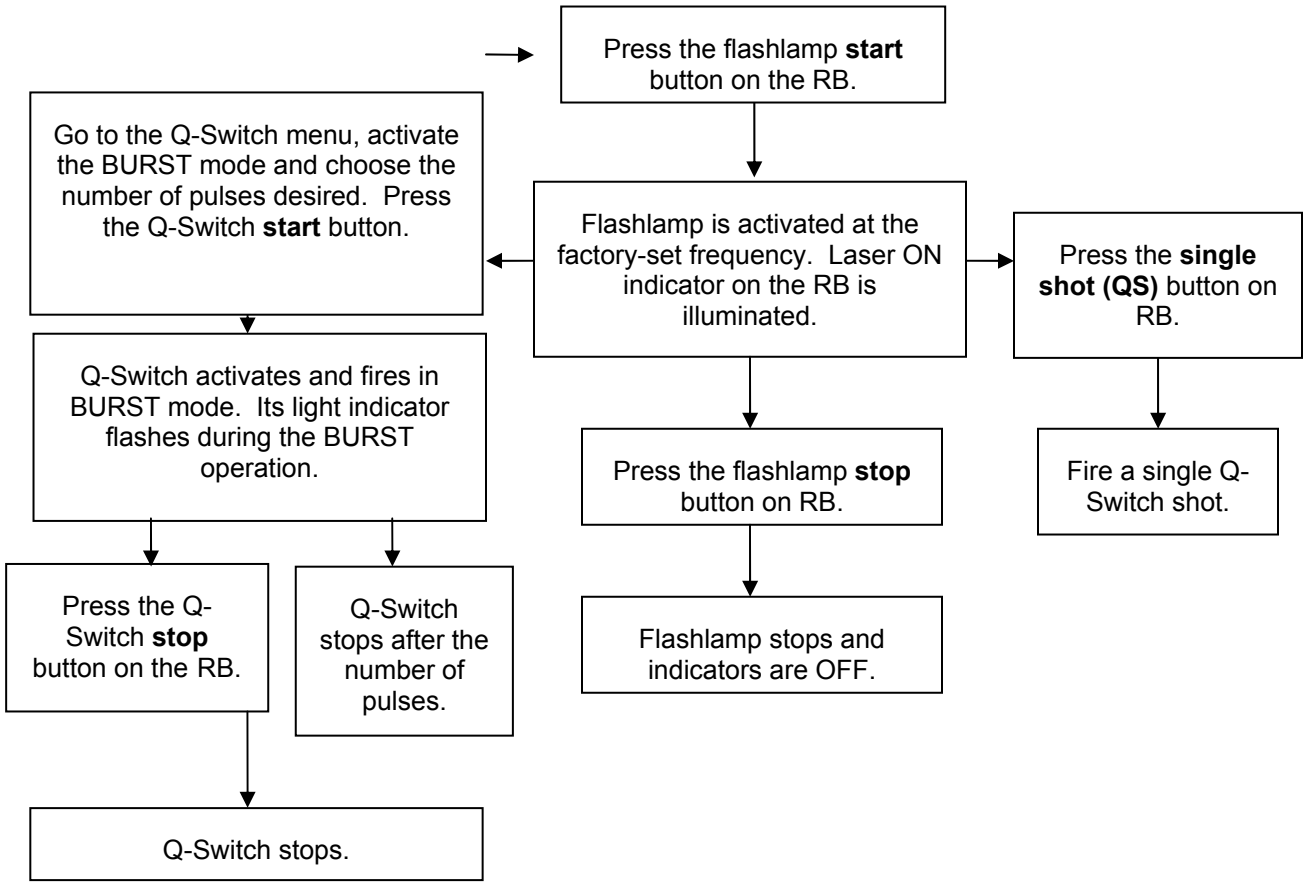


Figure 4-14: BURST Mode Description

Scan Mode Emission

Use the **scan** mode when the user would like to repeat the Q-Switch sequence several times. A description of the scan mode in the example follows:

- "nb of scan" 10 → The sequence is repeated 10 times.
- "Active pulse" 06 → Firing is authorized for 06 shots.
- "Passive pulse" 12 → Firing stops for 12 shots, for continuous mode operation, replace in "nb of scan" 10 by 99.

If activation of the scan mode occurs, another menu displays in which the user can modify the operating condition. Stop and re-start the Q-Switch firing to validate any modification in the Q-Switch mode.

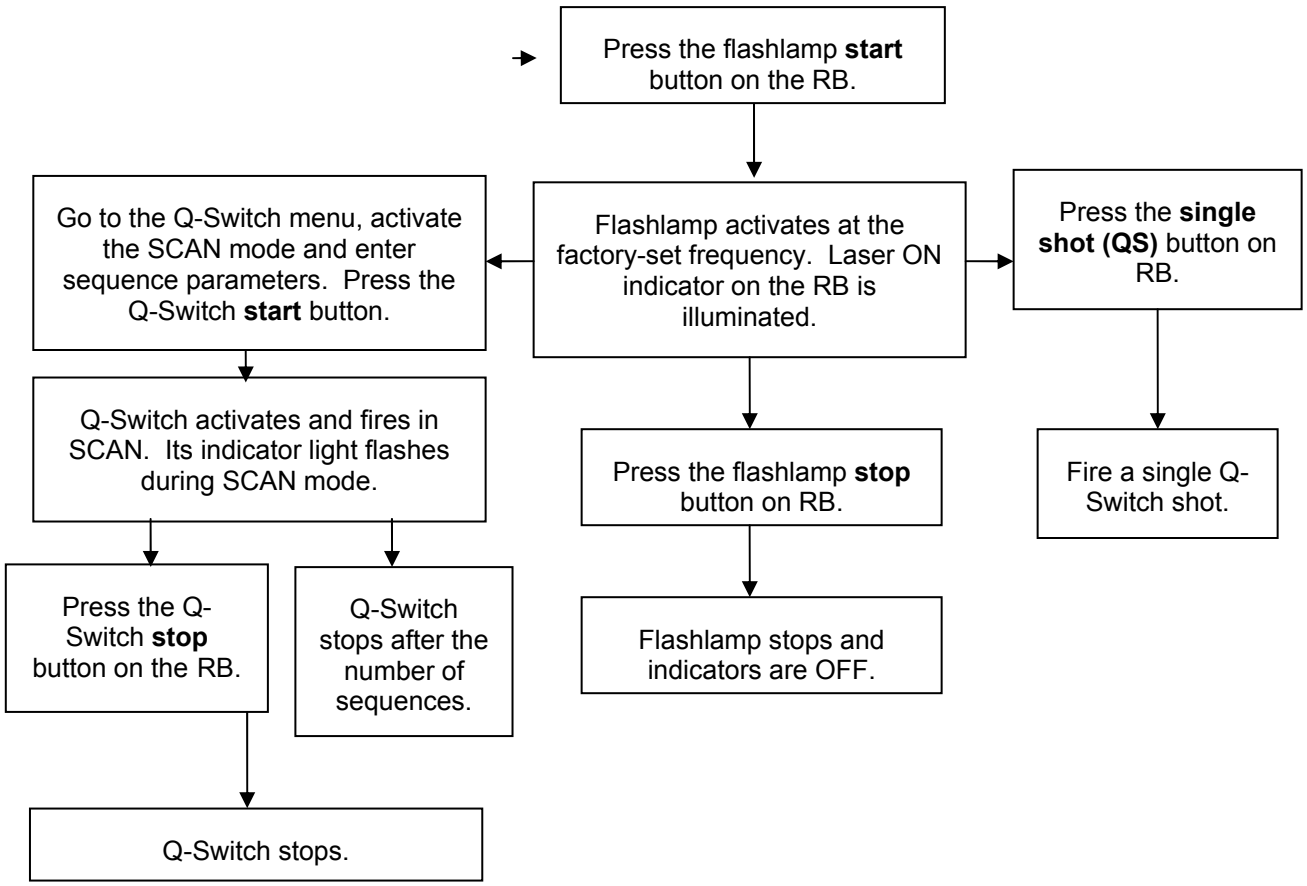


Figure 4-15: SCAN Mode Description

Harmonic Generation (HG)

If the purchase of Harmonic Generators occurs after the laser system purchase, it is necessary to activate the correct Harmonic Generation Module option on the Remote Control Box. To select the option choose the "**system info**" submenu, move to the harmonic generation section, and toggle buttons **(+)** and **(-)** to activate.

The following choices are available:

Option HG: Off / On

Off →No HG regulation available

On →The regulation for HGM is switched on and the temperature feedback from the SHG displays on the Remote Box.

Boost 4w: Off / On

Off →No 4w boost available

On →The temperature of the FoHG module boosts when the Q-Switch is off to compensate the beam energy, allowing faster 4ω stabilization.

CHAPTER 5

The ICE 450 Serial Protocol and Command Set

Serial Protocol Specifications

Protocol Description

The serial interface to the ICE 450 is RS-232, running at 9600 baud, 8 data bits, no parity, 1 stop bit, and no flow control. On board the controller is an optional RS-485 to RS-232 converter, and an optional USB to RS-232 converter.

The serial interface is on at power-up. The user can disable or re-enable the serial interface from one of the remote box menus.

The user sends commands from the command set, followed by a CR ('\r', 0x0D) and LF ('\n', 0x0A), in that order. In general, to query a value, the user sends just the command with no extra characters. The firmware responds by sending a CR, an LF, a 15-character string consisting of some informative information, an ASCII-formatted representation of the requested value followed, and as many spaces as required to make the string 15 characters.

If the user sends a command that the ICE 450 does not recognize, the ICE 450 will respond with the string "cmd not found".

Each command has a unique response structure. The "Command Set" section of this document attempts to clarify each response.

To set a value, the user must send the command name, followed immediately (no space) by the new value for the setting, then CR, then LF. The firmware will respond with the new value if it is valid, or with the old value if the new value is invalid.

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

PIV Operation

In a PIV system, the Master unit is the only unit connected to the serial link. Commands intended for the slave unit must proceed the two-character sequence "@2".

Use of Terminal Emulator

To ease the user's task, the protocol allows backspaces. These erase the last-sent character. To improve readability when using HyperTerminal (for example), enable the "Backspace sends ctrl-H, space, ctrl-H" setting.

Flashlamp Command Set

Fire, Internal Sync "A"

Write-only command to put the flashlamp into "internal" sync mode and to start flashing. The response to this command is the state string (see the description in the "ST" command section). If the flashlamp is able to start flashing, the response will be "fire auto." If not, the response will indicate the state.

	Command	Response
Write	A	state string
Example	A	fire auto

Fire, External Sync "E"

Write-only command to put 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.

	Command	Response
Write	E	state string
Example	E	fire ext

Simmer "M"

Write-only command to put 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.

	Command	Response
Write	M	state string
Example	M	simmer

Stop Flash "S"

Write-only command to stop the flashlamp from flashing and turn off the simmer. The response to this command is the state string, and it should be "standby".

	Command	Response
Write	S	state string
Example	S	standby

Flashlamp Voltage "V"

If the Power Supply configuration allows voltage settings, this command reads or sets the voltage applied to the flashlamp capacitor. This voltage sets the energy of each flashlamp pulse. The average voltage "VMO" command and the voltage window "VWIN" command specify the allowable range of voltage settings : "VMO" – "VWIN" to "VMO" + "VWIN".

	Command	Response
Read	V	voltage nnnnV where "nnnn" is the present voltage setting
Example	V	Voltage 0780V
Write	Vnnnn where nnnn is the new voltage setting	voltage nnnnV where nnnn is the new voltage if valid or the old voltage if invalid.
Example	V650	Voltage 0650V

Flashlamp Average Voltage "VMO"

Command to read or set the "midpoint" voltage. The allowable range of voltage settings ("V") is from "VMO" – "VWIN" to "VMO" + "VWIN".

	Command	Response
Read	VMO	voltage mnnnnV where "nnnn" is the present average voltage setting
Example	VMO	voltage m0780V
Write	VMOnnnn where nnnn is the new voltage setting	voltage mnnnnV where nnnn is the new avg. voltage if valid or the old one if invalid.
Example	VMO650	voltage m0650V

Flashlamp Energy "EJ"

If the Power Supply has been configured to allow energy settings (using the "FSM" factory command), this command reads or sets the flashlamp energy. The energy is the electrical energy stored in the flashlamp capacitor, calculated as ½CV².

	Command	Response
Read	EJ	energy xx.yy J where "xx.yy" is the energy in Joules
Example	EJ	energy 06.77 J, indicating the flashlamp energy is 6.77 Joules
Write	EJ nnnnn where nnnnn is the new energy setting in **tenths of Joules.**	energy xxxx J where "xxxx" is the energy in tenths of Joules
Example	EJ 600	energy 06.00 J, indicating the energy setting is now 06.00 Joules.

Flashlamp Energy and Power "POW"

Command to read the flashlamp energy and power. The flashlamp energy is the energy stored in the capacitor, calculated as ½CV². The flashlamp power is the energy multiplied by the flashlamp frequency.

	Command	Response
Read	POW	FL nnnW/xx.yyJ, where nnn is the power in Watts and xx.yy is the energy in Joules.
Example	POW	FL 124W/06.23J

Flashlamp Frequency "D"

Command to read or set 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.

	Command	Response
Read	D	freq xxx.yyHz where "xxx.yy" is the present frequency setting **in Hertz.**
Example	D	freq 021.00Hz
Write	Dnnnnn where nnnnn is the new frequency setting in **tenths of Hertz.**	freq xxx.yyHz where "xxx.yy" is the present frequency setting
Example	D2200	freq 022.00Hz

Maximum Flash Frequency "DMX"

Command to read or set the maximum flashlamp firing frequency. The flashlamp frequency setting must be less than this setting. Acceptable values are from 0 to 9999 (99.99 Hz).

	Command	Response
Read	DMX	fr. M xxx.yyHz where "xxx.yy" is the present max frequency setting **in Hertz.**
Example	DMX	fr. M 030.00Hz
Write	DMXnnnnn where nnnnn is the new max frequency setting in **tenths of Hertz.**	fr. M xxx.yyHz where "xxx.yy" is the present max frequency setting
Example	DMX3100	fr. M 031.00Hz

Minimum Flash Frequency "DMN"

Command to read or set the minimum flashlamp firing frequency. The flashlamp frequency setting must be more than this setting. Acceptable values are from 0 to the maximum frequency setting.

Note: When setting this value, first be sure to set the frequency ("D" command) above the minimum setting.

	Command	Response
Read	DMN	fr. m xxx.yyHz where "xxx.yy" is the present min frequency setting **in Hertz.**
Example	DMN	fr. m 00.10Hz
Write	DMNnnnnn where nnnnn is the new min frequency setting in **tenths of Hertz.**	fr. m xxx.yyHz where "xxx.yy" is the present min frequency setting
Example	DMN20	fr. m 000.20Hz

Flashlamp Count "F"

Command to read the total number of flashlamp firings since shipment from the factory.

	Command	Response
Read	F	ct LPnnnnnnnnnn, where nnnnnnnnnn is the count.
Example	F	ct LP0000012345

User Flashlamp Count "UF"

This is the command to read the number of flashlamp firings since the resetting of the count. With every flashlamp replacement, the flashlamp count must be reset.

	Command	Response
Read	UF	cu LPnnnnnnnnnn, where nnnnnnnnnn is the count.
Example	UF	cu LP0000012345

Reset User Flashlamp Count "UF0"

Command to reset the number of flashlamp firings. When replacing the flashlamp, this command will display.

	Command	Response
Read	UF0	cu LP0000000000
Example	UF0	cu LP0000000000

Q-Switch Command Set

Fire Q-Switch "CC"

Write-only command to start Q-Switching. The response to this command is the state string.

	Command	Response
Write	CC	state string
Example	CC	fire auto qs

Fire Q-Switch Single Shot "OP"

Write-only command to fire a single Q-Switch. The response to this command is the state string.

	Command	Response
Write	OP	state string
Example	OP	fire auto qs

Stop Q-Switch "CS"

Write-only command to disable the Q-Switch. The response to this command is the state string.

	Command	Response
Write	CS	state string
Example	CS	fire auto

Q-Switch Delay "W"

Command to read or write 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. The max-delay command ("WMX") sets the maximum allowable delay and the min-delay command ("WMN") sets the minimum allowable delay.

	Command	Response
Read	W	delay nnn uS, where nnn is the Q-Switch delay in microseconds
Example	W	delay 123 uS
Write	Wnnn,	delay nnn uS, where nnn is the Q-Switch delay in microseconds
Example	W144	delay 144 uS

Minimum Q-Switch Delay "WMN"

Command to read or write the minimum Q-Switch delay, in microseconds. The range of acceptable values for WMN is 1 to 120.

	Command	Response
Read	WMN	dly QS m nnn where "nnn" is the minimum delay
Example	WMN	dly QS m 050 indicating a minimum allowable delay of 50 µsec.
Write	WMNnnn, where "nnn" is the new setting.	dly QS m nnn
Example	WMN55	dly QS m 055

Maximum Q-Switch Delay "WMX"

Command to read or write the maximum Q-Switch delay, in microseconds. The range of acceptable values for WMx is 1 to 500. Before writing this setting, set the Q-Switch delay to a low number.

	Command	Response
Read	WMX	dly QS M nnn where "nnn" is the maximum delay
Example	WMX	dly QS M 400 indicating a maximum allowable delay of 400 µsec.
Write	WMXnnn, where "nnn" is the new setting.	dly QS M nnn
Example	WMX425	dly QS M 425

Q-Switch Internal Sync "QI"

Write-only command to put the Q-Switch into Internal sync mode.

	Command	Response
Write	QI	QS sync: INT
Example	QI	QS sync: INT

Q-Switch External Sync "QE"

Write-only command to put the Q-Switch into External sync mode.

	Command	Response
Write	QE	QS sync: EXT
Example	QE	QS sync: EXT

Q-Switch Sync "QSSYNC"

Read-only command to read the Q-Switch sync mode.

	Command	Response
Read	QSSYNC	QS sync: aaa, where "aaa" is either "INT" or "EXT"
Example	QSSYNC	QS sync: EXT

Q-Switch Mode "QSM"

Command to read or write the Q-Switch operating mode. The operating mode is one of the following:

- "auto": The Q-Switch runs at every flashlamp pulse.
- "burst": The Q-Switch runs for only a specified number of flashlamp pulses.
- "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.
- "freerun": The Q-Switch runs on every flashlamp pulse, and the Q-Switch delay is 0.

The mode parameter for this command is encoded, with "1" meaning "auto," "2" meaning "burst", "3" meaning "scan", and "4" meaning "freerun."

	Command	Response
Read	QSM	QS mode : n, where "n" is "1", "2", "3", or "4".
Example	QSM	QS mode : 1, indicating the mode is "auto."
Write	QSMn, where "n" is the mode code.	QS mode : n
Example	QSM3	QS mode : 3, indicating "scan" mode.

Q-Switch Free-Run "QFM"

Command to read or write the Q-Switch free-run setting. This command is another method for setting the Q-Switch mode to free-running. In this mode, Q-Switches occur on every flashlamp pulse, and the Q-Switch delay is 0.

	Command	Response
Read	QFM	free running n where "n" is "0" if the Q-Switch mode is not FreeRun, and "1" if it is.
Example	QFM	free running 0 indicating that the Q-Switch mode is not FreeRun.
Write	QFMn, where "n" is "1" or "0".	free running n
Example	QFM1	free running 1 indicating the Q-Switch mode is FreeRun.

Q-Switch Auto Ratio "QSF"

Command to read or write 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. 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.

	Command	Response
Read	QSF	QS rep-rate F/nn, where "nn" is rate setting
Example	QSF	QS rep-rate F/04, indicating that the flashlamp will fire three times without a Q-Switch, then fire with a Q-Switch.
Write	QSFnn, where "nn" is the new ratio.	QS rep-rate F/nn
Example	QSF3	QS rep-rate F/03

Q-Switch Burst Count "QSP"

Command to read or write 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.

	Command	Response
Read	QSP	burst QS nnn where "nnn" is the burst count
Example	QSP	burst QS 020 indicating that the Q-Switch will fire 20 times after start-up.
Write	QSPnnn, where "nnn" is the new count.	burst QS nnn
Example	QSP100	burst QS 100

Q-Switch Scan Parameters "Q"

One "scan" consists of a number of active pulses followed by a number of passive pulses. This is the command to read or write the Scan parameters. In Scan mode with Internal Q-Switch sync selected, there are a number of active pulses followed by a number of passive pulses. Active pulses are flashlamp pulses that have an associated Q-Switch pulse. Passive flashlamp pulses have no Q-Switch pulse. Scan mode has a Total Scans parameter. After this number of cycles comprised of active pulses and passive pulses, the Q-Switch is disabled. If the Total Scans parameter is 99 Q-Switching is not disabled. The maximum value for all these settings is 99.

The format to write this set of values is not straightforward. 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.

	Command	Response
Read	Q	Q pp aa tt where “pp” is the passive count, ”aa” is the active count, and “tt” is the total count.
Example	Q	Q 11 22 33 indicating the Scan parameters are: 11 passive pulses, 22 active, with a total of 33 scans.
Write	Qppaatt, where “pp” is the passive count, ”aa” is the active count, and “tt” is the total count.	Q aa pp tt
Example	Q051099	Q 05 10 99, indicating 5 passive pulses and 10 active pulses in a scan, repeating forever (total scans=99).

Q-Switch Double Pulse “NPL”

Command to read or write the setting for the double-pulse setting. With this setting enabled, two Q-Switch pulses generate instead of one. A number of microseconds specified by the “WD” command separates the pulses.

	Command	Response
Read	NPL	option PULSE: n, where “n” is “0” if the double-pulse option is disabled, and “1” if it is enabled.
Example	NPL	option PULSE: 1 indicating that the double-pulse option is enabled.
Write	NPLn, where “n” is “0” to disable double pulsing, and “1” to enable it.	option PULSE: n
Example	NPL1	option PULSE: 1

Q-Switch Double-Pulse Delay "WD"

Command to set or read the spacing between the initial Q-Switch pulse and the second one. The parameter for this command is in microseconds, and the range is 70 to 250. The first Q-Switch pulse will occur at the delay specified by the "w" command. The rising edge of the second one will occur "WD" microseconds after the rising edge of the first.

	Command	Response
Read	WD	QS1-QS2 nnn uS where "nnn" is the present double-pulse delay
Example	WD	QS1-QS2 100 uS indicating the rising edges of the two pulses are separated by 100 microseconds
Write	WDnnn where nnnn is the new delay setting	QS1-QS2 nnn uS where nnn is the new delay.
Example	WD115	QS1-QS2 115 uS

Q-Switch Auto Run "QOF"

Command to read or write the "Q-Switch At Run" setting. With this setting enabled, Q-Switching will start immediately after the flashlamp has been running for its eight second timeout after start-up. If this setting is disabled, Q-Switching will not commence until explicitly commanded to do so using the "CC" or "OP" commands.

	Command	Response
Read	QOF	QS at run n where “n” is “0” if the Q-Switch At Run feature is disabled, and “1” if it is enabled.
Example	QOF	QS at run 0 indicating the Q-Switch At Run feature is disabled: Q-Switching will only commence when commanded.
Write	QOFn where n is the setting.	QS at run n
Example	QOF1	QS at run 1, indicating that Q-Switches will automatically start when the eight-second flashlamp timeout has expired.

Q-Switch *Ramp Count* *“QSR”*

Command to read or write the Q-Switch ramp count. In all Q-Switch modes except free-run, the Q-Switch delay ramps down from an initial value to the final value (set by the “W” command), if this value is not zero. The initial Q-Switch delay will ramp down by the step size in microseconds (set by the “QSS” command), for this number of steps. So, if the final Q-Switch delay is represented by “W”, the step size is represented by “qss”, and the ramp count is represented by “qsr”, the initial Q-Switch delay is given by “W” + (qsr * qss). Each time the Q-Switch pulses, the ramp count is decremented until the Q-Switch delay is “W”.

The range for the ramp count is 0 to 99. If the count is 0, no ramping occurs: the Q-Switch delay is always the value specified by the “w” command.

	Command	Response
Read	QSR	QS ramp : nn, where “nn” is the ramp count.
Example	QSR	QS ramp : 50 indicating that the Q-Switch delay will decrement 50 times before it is the final value.
Write	QSRnn, where “nn” is the new ramp count.	QS ramp : nn
Example	QSR40	QS ramp : 40

Q-Switch *Ramp Step Size* *"QSS"*

Command to read or write the Q-Switch ramp size, in microseconds. See the remarks for the QSR command. The range for the step size is 1 to 99.

	Command	Response
Read	QSS	QS step : nn uS, where "nn" is the step size.
Example	QSS	QS step : 5 indicating that the Q-Switch delay will decrement by 5 microseconds after each Q-Switch pulse.
Write	QSSnn, where "nn" is the new step size.	QS step : nn
Example	QSS10	QS step : 10

Status Commands

State *"ST"*

Read only. The response to this command is the "state string." It contains easy-to-read instructions that tell the reader about the basic state of the laser. It can include the following:

- "**standby**": This is the state string when the laser is not firing and not simmering.
- "**simmer**": This the state string that is returned when the laser is only simmering.
- "**fire auto**": Then the flashlamp is firing in internal sync mode.
- "**fire ext**": 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 also be added. So, 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**"

Here are some other example of state strings:
"**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: The "enter" key on most keyboards sends CR-LF. This will also cause the firmware to respond with the state string.

Status Word *"WOR"*

Read-only. This command is included in the ICE 450 for compatibility with the Brilliant Power Supply. It provides a set of codes that infer the state of the laser. The response is:

I *a* F *b* S *c* Q *d,*
Where "***a***" is "**0**" if there are no interlocks, and "**1**" if there are.

"***b***" is one of the following:
"**0**" means the flashlamp is in internal sync mode and is not running.
"**2**" means the flashlamp is in internal sync mode and is running.
"**4**" means the flashlamp is in external sync mode and is not running.
"**6**" means the flashlamp is in external sync mode and is running.

"***c***" is "**1**" if simmer is established, "**0**" if not.

"***d***" is one of the following:
"**0**" means the Q-Switch is in internal sync and is off.
"**1**" means the Q-Switch is in internal sync and is in single mode.
"**2**" means the Q-Switch is in internal sync and is running.
"**4**" means the Q-Switch is in external sync and is off.
"**6**" means the Q-Switch is in external sync and is running.

For example, if WOR returns the string I 0 F 2 S 1 Q 6, 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).

Interlock Byte 1 *"IF1"*

Read-only. Response:
IF1 ab cd ef gh, where the bits of interlock byte 1 are as follows:

a: "1" if e-stop button pressed. 0 if not.

b: "1" if bnc interlock open

c: "1" if Laser Head thermostat open

d: "1" if Laser Head housing switch open

e: "1" if Power Supply housing switch open

f: "1" if internal bus error

g: "1" if external bus error

h: "1" if flashlamp timeout

Example: IF1 00 01 00 00: Laser Head housing switch is open.

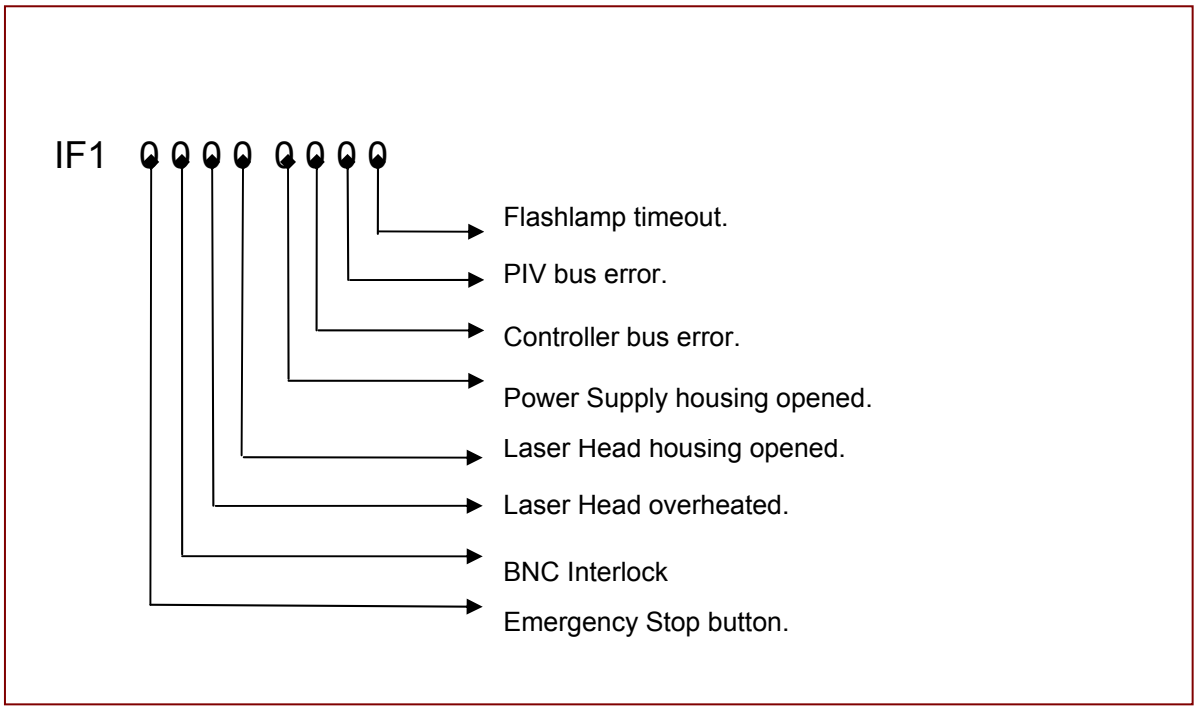


Figure 5-1: IF1 Status Bits

Interlock Byte 2 *"IF2"*

Read-only. Response:
IF2 ab cd ef gh, where the bits of interlock byte 2 are as follows:

a: "1" if heater thermostat open.

b: "1" if charger temperature over maximum temperature setting

c: "1" if coolant temperature under minimum temperature setting

d: "1" if coolant temperature over maximum temperature setting

e: "1" if coolant level low

f: "1" if coolant flow low

g: "1" if charger, coolant, or harmonic generator temperature below minimum

h: "1" if flashlamp power setting too high

Example: IF2 00 00 01 00: coolant flow is low.

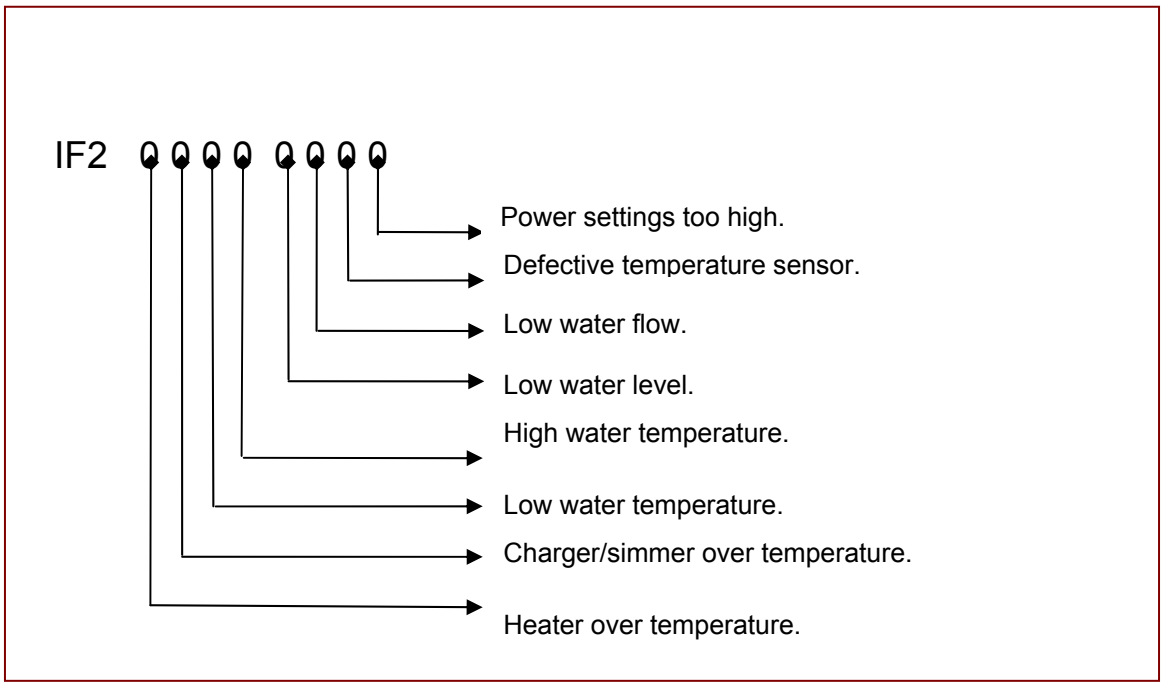


Figure 5-2: IF2 Status Bits

Interlock Byte 3 *"IF3"*

Read-only. Response:
IF3 ab cd ef gh, where the bits of interlock byte 3 are as follows:

a: "1" if no end of charge (PSU charge error).

b: "1" if voltage over setting

c: "1" if no simmer sense

d: "1" if external flash signal frequency too low

e: "1" if external flash signal frequency too high

f: "1" if capacitor discharge problem

g: "1" if simmer timeout

h: "1" if PIV slave indicates master unit has interlock

Example: IF3 00 10 00 00: no simmer sense.

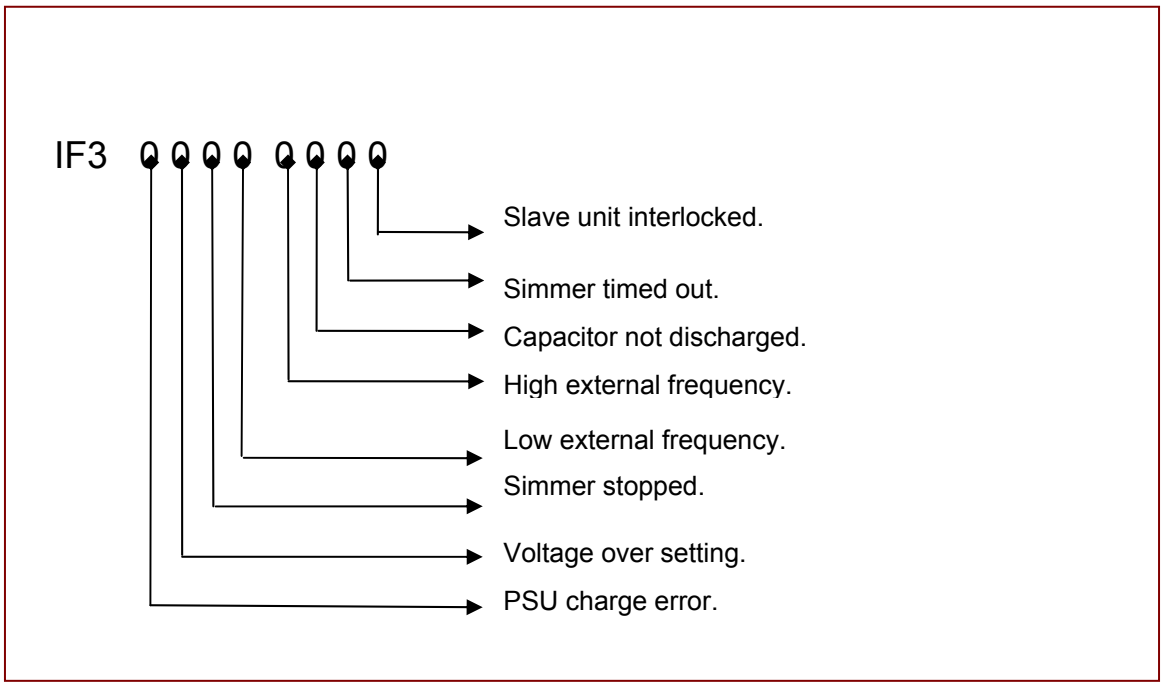


Figure 5-3: IF3 Status Bits

Q-Switch *Interlock Byte* *"IQ"*

Read-only. Response:
IQS ab cd ef gh, where the bits of Q-Switch interlock byte are as follows:

a: "1" if in the 8-second forced delay after flashlamp starts

b: "1" if coolant temperature is too low

c: "1" if Q-Switch timeout

d: "1" if shutter is closed

e: "0"

f: "0"

g: "0"

h: "0"

Example: IQS 01 00 00 00: coolant temperature is low.

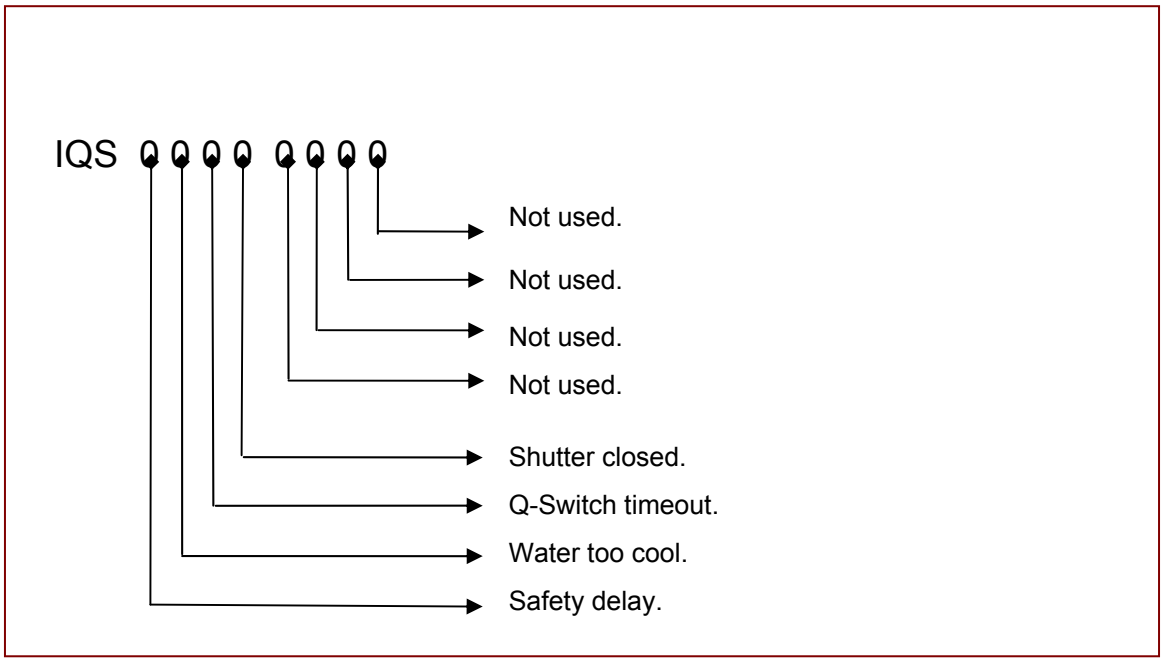


Figure 5-4: IQS Status Bits

First Interlock *"IF"*

Read only query of the interlock that caused a laser shutdown. The response is the response from either IF1, IF2, IF3, or IQ depending on which one caused a shutdown. In the case of multiple causes, priority is from IF1 down to IQ.

Temperature Commands

Cooling Group Temperature "CGT"

Read-only command to read the temperature of the coolant in degrees Celsius.

	Command	Response
Read	CGT	temp. CG nn d where "nn" is the temperature of the coolant.
Example	CGT	temp. CG 45 d indicating the coolant temperature is 45 °C

Harmonic Generator Temperature "HGT"

Read-only command to read the temperature of the harmonic generator in degrees Celsius.

	Command	Response
Read	HGT	temp. SHG nn d where "nn" is the temperature of the harmonic generator.
Example	HGT	temp. SHG 75 d indicating the harmonic generator temperature is 75 °C

Charger/Simmer Temperature "CST"

Read-only command to read the temperature of the charger/simmer controller in degrees Celsius.

	Command	Response
Read	CST	temp. CS nn d where "nn" is the temperature of the charger/simmer.
Example	CST	temp. CS 55 d indicating the charger/simmer temperature is 55 °C

All Three Temperatures "T3"

Command to read 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.

	Command	Response
Read	T3	T3 xxx yyy zzz where: "xxx" is the CG T in °C/10, "yyy" is the SHG T in °C/10, and "zzz" is the CS T in °C/10.
Example	T3	T3 372 553 771 indicating the coolant temp (CGT) is 37.2 °C, the SHG temp is 55.3 °C, and the CS temp is 77.1 °C.

Pump Control "PUMP"

Command to turn on or off the coolant pump. When reading, responds with the on/off state of the pump.

	Command	Response
Read	PUMP	pump : sss where "sss" is "on" or "off."
Example	PUMP	pump : on indicating the pump is on
Write	PUMPn, where "n" is the new setting:1 for on, 0 for off.	pump : sss
Example	PUMP0	pump : off

Pump Mode *"PMOD"*

Command to put the coolant pump in normal or fill mode. When reading, responds with the pump mode.

	Command	Response
Read	PMOD	pmod: sss where "sss" is "normal" or "fill."
Example	PMOD	pmod: normal indicating the pump is in normal mode
Write	PMODn, where n is the new setting: 0 for normal and 1 for fill.	pmod: sss
Example	PMOD1	pmod: fill

Coolant Level *"LEV"*

Command to read the coolant level status.

	Command	Response
Read	LEV	level: sss where "low" or "ok."
Example	LEV	level: low indicating the coolant level is low.
Example	LEV	level: ok indicating the coolant level is OK.

Coolant Flow Rate "FLOW"

Command to read the coolant flow rate in liters per minute (lpm).

	Command	Response
Read	FLOW	FLOW m.nnn lpm where "mm.nnn" is the flowrate.
Example	FLOW	FLOW 2.450 indicating the flow rate is 2.45 lpm.

Configuration Commands

Configuration "CFG"

Command to read the configuration number or to select a new configuration.

	Command	Response
Read	CFG	configuration n where "n" is the current configuration
Example	CFG	configuration 1
Write	CFGn, where "n" is the new configuration.	configuration n this will recall configuration "n" from the eeprom.
Example	CFG2	configuration 2

Save Configuration "SAV"

Command to save the present settings into eeprom at the configuration number specified. The configuration number can be between 1 and 4.

	Command	Response
Write	SAVn, where "n" is the configuration number.	Save config. n this will save the current settings as configuration "n".
Example	SAV2	configuration 2

Timeout Commands

The timeout feature, when enabled, causes the firmware to shut off the laser after a user-specified time has elapsed. The timeout can occur either when the simmer has been on for some time, the flashlamp has been on, or the Q-Switch.

Timeout Status "L"

Command to read or write the enabled/disabled status of the timeout feature.

	Command	Response
Read	L	time out n where "n" is "0" if timeouts are disabled, "1" if they are enabled.
Example	L	time out 0 indicating timeouts are disabled.
Write	Ln where "n" is "0" or "1".	time out n
Example	L1	time out 1

Simmer Timeout Duration "CLS"

Command to read or write the duration of the simmer timeout. The timeout value reads in "minutes:seconds" format, but it must be written as seconds. The range of acceptable values for the timeout is 0 to 5999.

	Command	Response
Read	CLS	con SIM = xx:yy where xx:yy is the simmer timeout in "minutes:seconds" format.
Example	CLS	con SIM = 20:30 indicating the simmer will time out in 20 minutes and 30 seconds.
Write	CLSnnnn where "nnnn" is the number of seconds corresponding to the timeout.	con SIM = xx:yy where xx:yy is the new timeout in "minutes:second" format.
Example	CLS1000	con SIM = 16:40 (1000 seconds is 16 minutes 40 seconds)

Simmer Timeout Count "LS"

Command to read the time left until the simmer times out.

	Command	Response
Read	LS	cpt SIM = xx.yy where xx:yy is the remaining time in "minutes:seconds" format.
Example	LS	cpt SIM = 16:10 indicating there is 16 minutes 10 seconds until the simmer times out.

Flashlamp Timeout Duration "CLC"

Command to read or write the duration of the flashlamp timeout. The timeout value is read in "minutes:seconds" format, but it must be written as seconds. The range of acceptable values for the timeout is 0 to 5999.

	Command	Response
Read	CLC	con LF = xx:yy, where xx:yy is the flashlamp timeout in "minutes:seconds" format.
Example	CLC	con LF = 10:30 indicating the flashlamp will time out in 10 minutes and 30 seconds.
Write	CLCnnnn where "nnnn" is the number of seconds corresponding to the timeout.	con LF = xx:yy where xx:yy is the new timeout in "minutes:second" format.
Example	CLC1800	con LF = 30:00 (1800 seconds is 30 minutes)

Flashlamp Timeout Count "LC"

Command to read the time left until the simmer times out.

	Command	Response
Read	LC	cpt LF = xx.yy where xx:yy is the remaining time in "minutes:seconds" format.
Example	LC	cpt LF = 15:20 indicating 15 minutes 20 seconds until the flashlamp times out.

Q-Switch *Timeout Duration* *"CLQ"*

Command to read or write the duration of the Q-Switch timeout. The timeout value is read in "minutes:seconds" format, but it must be written as seconds. The range of acceptable values for the timeout is 0 to 5999.

	Command	Response
Read	CLQ	con QS = xx:yy, where xx:yy is the Q-Switch timeout in "minutes:seconds" format.
Example	CLQ	con QS = 9:30 indicating the Q-Switch will time out in 9 minutes and 30 seconds.
Write	CLQnnnn where "nnnn" is the number of seconds corresponding to the timeout.	con QS = xx:yy where xx:yy is the new timeout in "minutes:second" format.
Example	CLQ720	con QS = 12:00 (720 seconds is 12 minutes)

Q-Switch *Timeout Count* *"LQ"*

Command to read the time left until the simmer times out.

	Command	Response
Read	LQ	cpt QS = xx.yy where xx:yy is the remaining time in "minutes:seconds" format.
Example	LQ	cpt QS = 11:23 indicating 11 minutes 23 seconds until the Q-Switch times out.

Uptime *"T"*

Command to read the time since the most recent power-up.

	Command	Response
Read	T	ct time xxxx.yy where xxxx:yy is the up-time in "minutes:seconds" format.
Example	T	ct time 0424:24 indicating the Power Supply has been running for 424 minutes 24 seconds.

Elapsed Time *"ET"*

This command displays the total powered-on time since shipment of the unit from the factory.

	Command	Response
Read	ET	ET xxxx.yy where xxxx:yy is the total elapsed time in "minutes:seconds" format.
Example	ET	ET 14565:15 indicating the Power Supply has run for 14565 minutes 15 seconds since first shipped.

Miscellaneous Commands

Shutter Control *"SHC"*

Command to open or close the shutter. This command is only valid for the CFR head. The response to a read is the previously entered setting, NOT feedback about the shutter.

	Command	Response
Read	SHC	shc: sss, where sss is either OPEN or CLOSE
Example	SHC	shc: OPEN, indicating shutter has been commanded to open.
Write	SHC n, where n is 0 to close the shutter, and 1 to open it.	shc sss where sss is either OPEN or CLOSE
Example	SHC 0	shc: CLOSE

Shutter Feedback "SHFB"

Command to read the shutter position. This command is only valid for the ICE 450 and Brilliant heads.

	Command	Response
Read	SHFB	shutter: sss, where sss is either OPEN or CLOSED
Example	SHFB	shutter: OPEN, indicating shutter is open.

Firmware Version "X"

Command to read the firmware version.

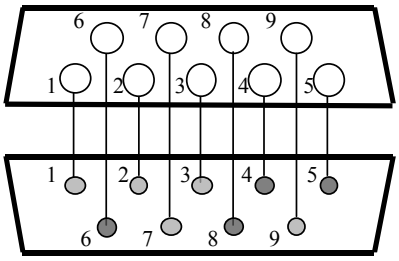
	Command	Response
Read	X	ICE 450 x.yy where "x.yy" is the version number.
Example	X	ICE 450 2.21

Serial Connector Pin Out

The host computer has to incorporate an RS 232 command format and the cable to the ICE 450 should not exceed 20 m. See the description of the standard wiring diagram in Figure 5-5. All wires must be present.

Cable wiring scheme of RS 232 interface

To computer :
9-pin female
connector



To laser :
9-pin male
connector

Computer Pin	Signal Name
1	DCD (not used)
2	RX (Receive data)
3	TX (Transmit data)
4	DTR (not used)
5	GND
6	DSR (not used)
7	RTS (not used)
8	CTS (not used)
9	RI (not used)

Figure 5-5: Cable Wiring Scheme of RS 232 Interface

Chapter 6

Maintenance

Deionizing Cartridge Maintenance

The ICE 450 systems require a minimum of Service. However, monthly checking ensures proper operation.

The deionization cartridge and the deionized water must be changed every six months. Please follow this procedure to change the deionized water:

Before proceeding switch the Power Supply OFF and unplug the AC power cord.

1. Orient the ICE 450 so that the rear of the unit is visible.

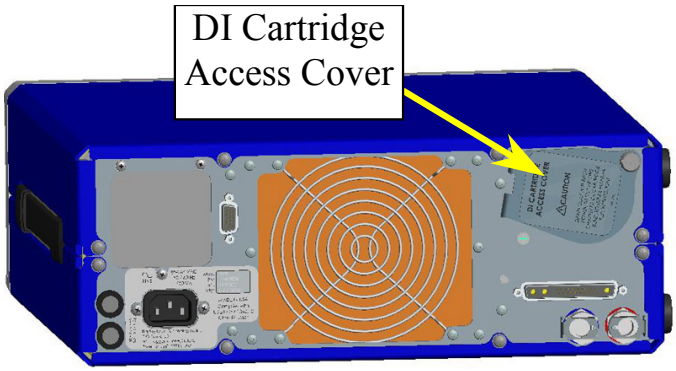


Figure 6-1: Location of the DI Cartridge Access Cover

2. As indicated on the DI cartridge access cover (Figure 6-1), it is necessary to drain the coolant from the ICE 450. Follow the procedure described below:

   - To remove the coolant from the reservoir, connect the vent tube to the vent fitting, and then connect the empty bottle to the fill/drain fitting. Loosen the cap on the bottle and lower the bottle below the ICE 450 as far as it can go. This will cause the coolant to drain from the system. This is adequate to remove most of the coolant from the system, but is not sufficient to prepare the ICE 450 for de-ionized cartridge exchange.

   - It is necessary to drain ALL water from the system. Disconnect the umbilical coolant lines from the ICE 450 and drain the water from the Laser Head (follow the steps described in Chapter 3). Then disconnect the umbilical coolant lines from the Laser Head and reconnect the red fitting to the ICE 450. Remove the vent fitting

from the front of the reservoir and gently (do not use air pressure greater than 0.35 bar [5 psi]) blow air into the corresponding red fitting at the Laser Head end of the umbilical coolant lines. Continue to blow air until no more water is visible flowing through the drain tube into the bottom of the bottle. Next, disconnect the red fitting from the ICE 450, connect the blue fitting, and repeat this process. Disconnect the blue fitting. Finally, reconnect the vent tube to the vent fitting on the reservoir, and tip the ICE 450 forward to cause the water to run to the front.

3. Loosen the screw holding the DI cartridge access cover in place. The cover swings open 90 degrees. After opening the cover 90 degrees, remove it from the back of the ICE 450 by pulling it away from the rear of the unit.

4. Grasp the end of the latch as indicated in Figure 6-2. Pull the latch to open it. It should open about 80 degrees before stopping.

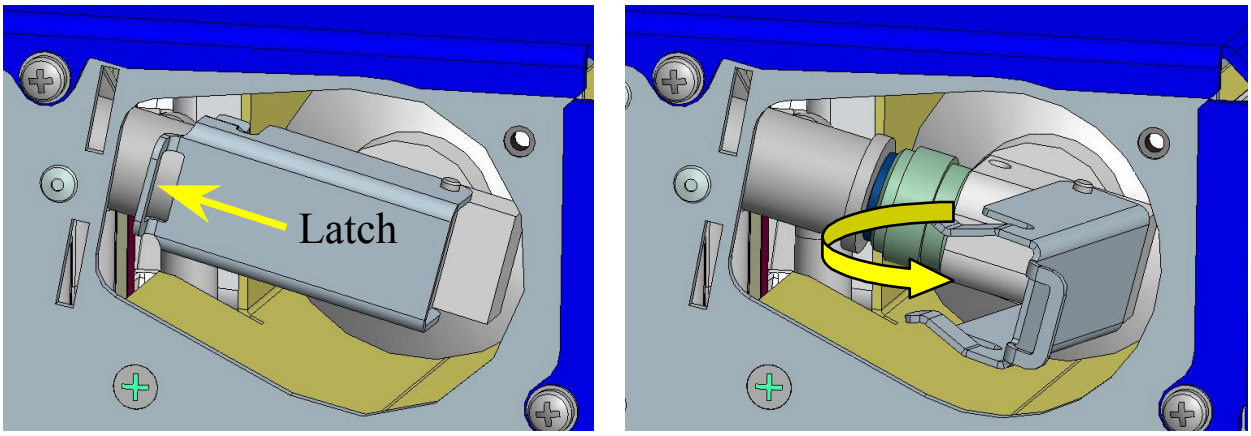


Figure 6-2: Latch Opening Procedure

5. Continue pressing on the lever and it will cause the DI cartridge connecting tube to release from the mating fitting. It is only necessary to move the DI cartridge about 6mm (¼") to be completely free of the mating connector. See Figure 6-3 for component positions.

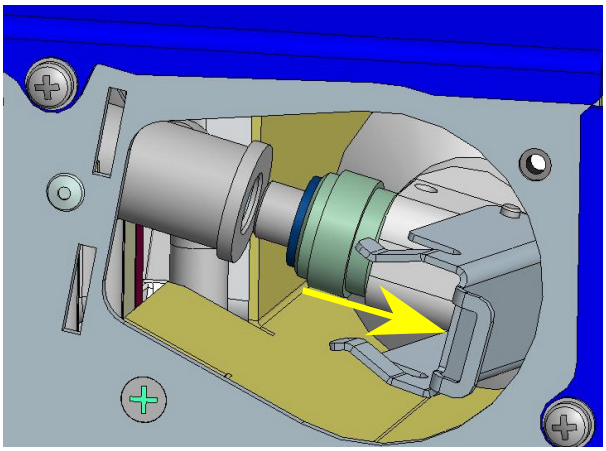


Figure 6-3: D-I Cartridge Free of Mating Connector

6. Pull on the latch to extract the DI cartridge assembly through the opening in the back of the ICE 450, as shown in Figure 6-4.

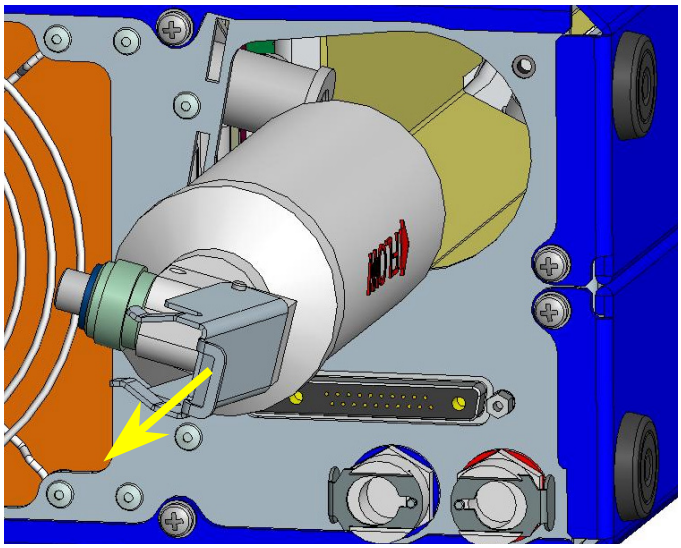


Figure 6-4: D-I Cartridge Extraction

7. Orient the extracted DI cartridge assembly, and the new DI cartridge, as indicated in Figure 6-5. Note the direction of the FLOW arrow on the side of the cartridges. Unscrew the tube adapter fitting from the old cartridge and wrap the fitting threads with 3-4 turns of Teflon pipe-sealing tape. Thread the tube adapter fitting completely into the output (note FLOW arrow) end of the replacement DI cartridge, until the nut stops against the DI plastic body.

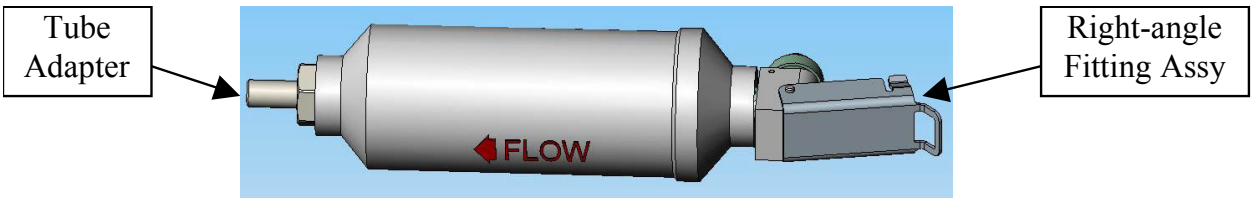


Figure 6-5: Tube Adapter and Right-Angle Fitting Assembly Locations

8. Unscrew the right-angle fitting assembly from the old cartridge and wrap the fitting threads with 3-4 turns of Teflon pipe-sealing tape. Thread the right angle fitting assembly completely into the open end of the new DI cartridge.

9. Insert the new DI cartridge assembly into the back of the Power Supply. The tube adapter fitting will engage another fitting deep inside the Power Supply, and may require a little force to insert. It is sometimes useful to rotate the cartridge slightly while pushing. After insertion, it should appear as shown in Figure 6-6.

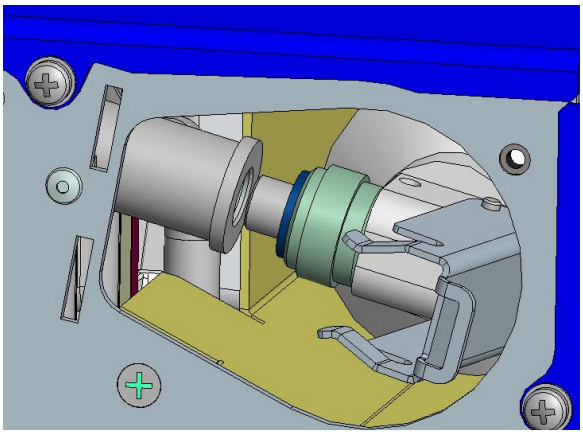


Figure 6-6: Re-Insertion of the D-I Cartridge

10. Pull the cartridge back out slightly with the latch until the metal tube in the right-angle fitting lines up with the internal mating fitting in the ICE 450. Use the latch to push the metal tube into the internal mating fitting, as shown in Figure 6-7.

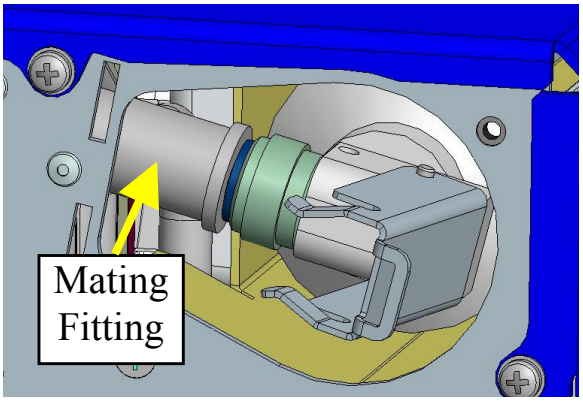


Figure 6-7: Insertion into the Internal Mating Fitting

11. While holding the two fittings together as described in Figure 6-7, push the latch into position, so that the metal tabs latch over the internal mating fitting, as shown in Figure 6-6-8.

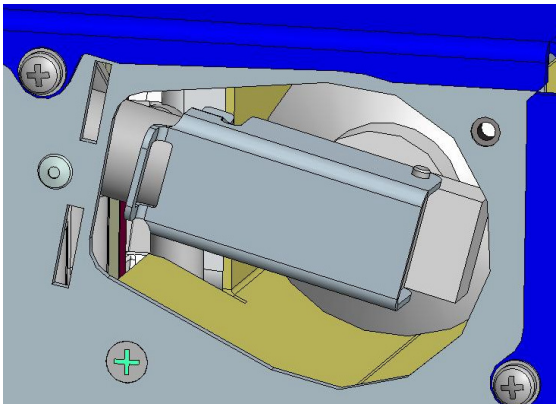


Figure 6-8: D-I Cartridge Complete Assembly

12. Replace the access cover over the DI cartridge assembly.

13. Re-fill the Power Supply with distilled water following the fill procedure described below:

    a) Fill the bottle with fresh coolant. Attach coolant fill/drain connectors. The fill bottle connects to the fill/drain fitting and the fitting with a hose attaches to the upper vent fitting. Loosen the cap on the fill bottle, raise the bottle, and wait until coolant drains from the vent fitting.

    b) Turn the key switch ON ("I"). The pump will turn on automatically after power-up, and begin filling the umbilical coolant lines. When the coolant level falls below the depression in the middle front of the reservoir, the pump will shut off and the reservoir lights will begin blinking. Continue to add coolant until the umbilical coolant lines are full and the coolant level visible in the reservoir is above the depression. Disconnect the fill bottle and vent tube, and if using water as a coolant, empty all remaining coolant from the fill bottle. When the coolant is above the minimum level, the reservoir lights will remain on continuously.

Chapter 7

Troubleshooting

Troubleshooting of the laser falls into two distinct categories: optics and electronics.

The electronics troubleshooting can be done by the user when the problem is created by a security system (external safety interlock, beam shutter interlock, HV head security) or a connection deficiency. The following will help the customer fix the problem, or simply identify the problem before calling Big Sky Laser Technologies Customer Service.

The problem of output energy decay can easily be fixed by the user if they are related to Harmonic Generation crystals phase matching tuning or flashlamp efficiency. If an optical component is damaged, its replacement and realignment require repair by Big Sky Laser Technologies Customer Service.

If a failure occurs, at start-up or during operation, the best way to detect the failure is to shut the laser OFF (“O”) and to follow the troubleshooting diagnostics indicated in the following paragraphs.

Electronics Troubleshooting

WARNING – DANGER: No user serviceable parts inside. Only qualified Big Sky Laser Technologies personnel may service the unit.

WARNING – DANGER: Disconnect power cord prior to servicing fuses.

Note: *To make the interlock message disappear, press the up or down button.*

ICE 450 Power Supply Interlocks

Displayed and Received Value	Displayed Message	Cause. Recommended action. If that doesn't work.
IF1: 10000000	emergency stop button pushed	Big red button on remote box pushed in. Pull it out. It is possible that there is a broken wire in the remote box. Contact Customer Service.
IF1: 01000000	BNC Intlk in on ICE 450 front panel	BNC connector not shorted. Short it. The BNC connector circuit may be faulty. Contact Customer Service.
IF1: 00100000	thermal sensor on Laser Head	Thermostat in Laser Head closed. Allow head to cool down. It is possible that there is a shorted wire in head cable. Contact Customer Service.
IF1: 00010000	Laser Head housing opened	Removal of the Laser Head cover has occurred. Replace cover. It is possible that there is a shorted wire in head cable. Contact Customer Service.
IF1: 00001000	Power Supply housing opened	Removal of the side panel on ICE 450 has occurred. Replace side panel. The switches may be faulty. Contact Customer Service.
IF1: 00000100	controller bus error	Major problem in the controller system. Contact Customer Service.
IF1: 00000010	controller PIV bus error	Communications problem with PIV slave. Ensure the attachment of the slave powered-up cable. The PIV interconnect cable may be faulty. Contact Customer Service.
IF1: 00000001	flashlamp disabled time out delay expired	Timeout expired. This is normal. Either disable timeouts or change flashlamp timeout to 00:00.

		It is possible that there is a firmware defect. Contact Customer Service.

Displayed and Received Bit	Displayed Message	Cause. Recommended action. If that doesn't work.
IF2: 10000000	heater over temp.	Coolant heater is too hot. Turn off the ICE 450 and let it cool down. The heater thermostat or circuit may be faulty. Contact Customer Service.
IF2: 01000000	charger/simmer over temp.	Charger/simmer is too hot. Turn off the ICE 450 and let it cool down. The thermistor circuit may have failed. Contact Customer Service.
IF2: 00100000	low water temperature	Coolant is too cool for proper operation. Give coolant time to warm up. The heater may have failed. Contact Customer Service.
IF2: 00010000	high water temperature	Coolant is too warm for proper operation. Turn off the ICE 450 and allow it to cool down. The fans may have failed. Contact Customer Service.
IF2: 00001000	low water level ICE 450 cooling	Not enough coolant in the system. Add coolant. Follow instructions in manual. The level switch may be faulty. Contact Customer Service.
IF2: 00000100	low water flow	Coolant not flowing properly. Check for obstructions in coolant lines. The pump may be faulty or there may be obstructions in the internal lines. Contact Customer Service.
IF2: 00000010	defective temp. sensor	A thermistor is broken or running too cold. Ensure all temperatures are above 18°C. A thermistor circuit may be faulty. Contact Customer Service.
IF2: 00000001	power too high.	Voltage or frequency settings are too high. Reduce V or F until power < 450 W.

		It is possible that there is a firmware defect. Contact Customer Service.

Displayed and received bit	Displayed message	Cause. Recommended action. If that doesn't work.
IF3: 10000000	PSU charge error	Power Supply Unit not fully charged. Reduce pulse repetition rate (frequency). It is possible that there is a charger malfunction. Contact Customer Service.
IF3: 01000000	voltage over setting	PSU charged too high. **This is a safety problem.** Contact Customer Service. The charger may be malfunctioning. Contact Customer Service.
IF3: 00100000	simmer stop	Simmer failed to establish, or disengaged. Re-attempt to establish simmer. It is possible that there are faulty head connections. Contact Customer Service.
IF3: 00010000	low frequency	External trigger input frequency is less than 80% of the set point frequency. Increase external input frequency, decrease set point frequency, disable GRM option, or turn off check-freq. It is possible that there is a firmware defect. Contact Customer Service.
IF3: 00001000	high frequency	External trigger input frequency is more than 120% of the set point frequency. Decrease external input frequency, increase set point frequency, disable GRM option, or turn off check-freq. It is possible that there is a firmware defect. Contact Customer Service.
IF3: 00000100	Capacitor not discharged	Flashlamp capacitor is not discharged when flashlamp is disabled. **This is a safety problem.** Contact Customer Service. Capacitor discharge circuit may be faulty. Contact Customer Service.

IF3: 00000010	simmer disabled time out delay expired	Normal operation: timeouts enabled and simmer timed out. Either disable timeouts or set simmer timeout to 00:00. It is possible that there is a firmware defect. Contact Customer Service.
IF3: 00000001	Other unit (master if slave and slave if master) interlocked tertiary	"Other" unit in PIV system has an interlock. Determine and remove other units interlock. It is possible that there is a faulty PIV interface cable. Contact Customer Service.

Displayed and received bit	Displayed message	Cause. Recommended action. If that doesn't work.
IQS: 10000000	Q-S disabled Please wait for 8 seconds	There is a built-in safety delay between the start of flashlamp operation and the start of Q-Switch operation. Wait until safety delay expires. If the safety delay does not expire, there is a possible firmware defect. Contact Customer Service.
IQS: 01000000	Q-S disabled water temperature under limit	Coolant is cooler than minimum Q-Switch operating temperature setting. Allow coolant to warm up. The thermistor may be faulty. Contact Customer Service.
IQS: 00100000	Q-S disabled time out delay expired	Normal operation: timeouts enabled and Q-Switch timed out. Either disable timeouts or set Q-Switch timeout to 00:00. It is possible that there is a firmware defect. Contact Customer Service.
IQS: 00010000	Q-S disabled Please open beam shutter on optical head	Shutter is closed and Q-Switch will not operate. Open the shutter. The shutter sensor may be faulty. Contact Customer Service.
IQS: 00001000	Q-S disabled iQS_4	This interlock is not used and it indicates a problem in the system controller. Contact Customer Service.

		Possible firmware defect.
IQS: 00000100	Q-S disabled iQS_5	This interlock is not used and it indicates a problem in the system controller. Contact Customer Service. Possible firmware defect.
IQS: 00000010	Q-S disabled iQS_6	This interlock is not used and it indicates a problem in the system controller. Contact Customer Service. Possible firmware defect.
IQS: 00000001	Q-S disabled iQS_7	This interlock is not used and it indicates a problem in the system controller. Contact Customer Service. Possible firmware defect.

Indicators of the Remote Box

Check the indicators to see if the laser is operating normally. After pushing the **ready** button **(5)** of Figure 4-5, and the **ready** indicator does not light up, check the following points:

a) Verify that the **interlock** LED is lit.
b) Repeat the start-up procedure by switching off the key and verify the **ready** LED lights up when the key is turned ON.
c) If the LED does not light up when the key is turned ON, the LED is out, the simmer current may start. Push the **start** button of the flashlamp and observe the flashlamp operation.
d) If the LED is not out, repeat start-up procedure 3 times. If the LED is still off push the **start** button of the flashlamp and observe the flashlamp operation. If the LED is still off shut down the laser and follow the procedure for flashlamp replacement. The flashlamp may be broken.

After pushing the start buttons, if those indicators light up but there is no Flashlamp or laser output, check the RB to verify that the internal mode is activated. In External Mode, check if the input signals parameters are as specified in Chapter 4 under “Modes of Operation”.

Technical Assistance Contact Information

If any of the interlocks continue to cause problems, please contact:

BIG SKY LASER TECHNOLOGIES CUSTOMER SERVICE

Phone: 1-800-914-8216

Fax : (406) 522-2007

e-mail : CustomerService@bigskylaser.com