MINISYSTEM Laser System
Operating Manual

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Contents

1. Introduction

This manual is a reference designed to familiarize you with the Quantum Composers miniSystem series laser system and is arranged so that you can easily find the information you're looking for. Generally, each topic has its own section and no section assumes that you've read anything else in the manual.

Technical Support

For questions or comments about operating the MINISYSTEM our technical staff can be reached via one of the following methods:

- Phone – 1 (406) 582-0227
- Fax – 1 (406) 582-0237
- Internet - www.quantumcomposers.com

Warranty

The miniSystem has a one-year limited warranty from the date of delivery. This warranty covers defects in materials and workmanship. Quantum Composers will repair or replace any defective unit. Contact us for information on obtaining warranty service.

Package Contents

The box you receive should contain the following:

- miniSystem Laser System Payload
- Desktop Power Supply
- USB Cable
- SMART Controller (Optional)
- User's Manual and Control Software on Disk
- Acceptance Test Results

Contact Quantum Composers 1 (406) 582-0227 if any parts are missing.

2. Safety

This user's manual contains the technical information needed to properly install, operate, and maintain the miniSystem laser system. It provides instructions for setup and installation, operation, service, preventive maintenance, and troubleshooting (fault-isolation). The laser system consists of one major subassembly:

1. The Payload, which consists of a laser, laser optics, and all supporting control circuits.

The laser system is truly "turn-key" and has been shipped fully functional. Only minor adjustments are necessary after installing to operate the system.

Caution labels, in accordance with CDRH and CE requirements, are prominently displayed on the Laser Optical Assembly and Laser Power Supply. The maximum ratings indicated on the system labels are in excess of the normal operating parameters. Please refer to the Data Summary Sheet for specific information pertaining to your system.
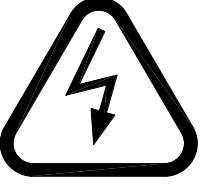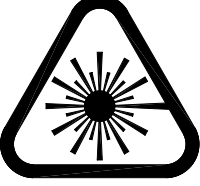
The laser system produces laser radiation, which is hazardous to eyes and skin, can cause burning and fires and can vaporize substances. The safety chapter contains essential information and user guidance about these hazards.

This product complies with safety standards EN61010:1993+A2:1995, EN60825:1994+A11:1996, and CDRH21 CFR 1040.10(d). Do not install substitute parts or perform any unauthorized modification to this product. Return the product to manufacturer for service or repair to ensure that all safety features are maintained.

Do not operate this product beyond its specifications.

SYMBOL	DEFINITION OF SYMBOL
	CAUTION: Calls attention to a procedure, practice, or condition that could cause damage to the product, or cause bodily injury to the user. Refer to accompanying documentation.
	ATTENTION: Ce symbole signale une procédure, une méthode ou une condition qui peut endommager le produit ou blesser l'utilisateur. Se référer à la documentation jointe.
	ACHTUNG!: Beachten Sie Verfahren, Praktiken oder Zustände, die das Produkt beschädigen oder zu Verletzungen fuhren können. Lesen Sie die deigefugte Dokumentation.
	ATTENZIONE: Porre estrema cautela alla procedura, uso o condizioni che potrebbero danneggiare il prodotto o l'utilizzatore. Far riferimento alla documentazione inviata insieme al prodotto.
	ADVERTENCIA: Llamar la atención de un producto, practica, o estado que puede causar daño al producto o puede herir el usario.

	CAUTION: Risk of Electric Shock.
	ATTENTION: Risque d'éléctrocution.
	ACHTUNG!: Gefahr durch Stromschlag.
	ATTENZIONE: Rischio di shock elettrico.
	ADVERTENCIA: Riesgo de choque eléctrico
	CAUTION: Risk of exposure to hazardous laser radiation.
	ATTENTION: Risque d'exposition à un rayonnement laser dangereux.
	ACHTUNG!: Gefahr durch gefährliche Laserstrahlung.
	ATTENZIONE: Rischio di esposizione a pericolose radiazioni laser.
	ADVERTENCIA: Riesgo de exposición a radaciên láser peligrosa.

Laser Safety

VISIBLE AND/OR INVISIBLE LASER RADIATION

 CAUTION: The MINISYSTEM Laser System is a Class 4 OEM laser.   Its output beam is, by definition, a safety and fire hazard. Precautions must be taken to prevent accidental exposure to both direct and reflected beams.

Precautions for Safe Operation of Class 4 OEM Lasers:

- Keep the protective covers on the Laser Head as much as possible. Do not operate the laser with the covers removed for any reason.

- Avoid looking at the laser output beam.

- Do not wear reflective jewelry while using the laser, as it might cause inadvertent hazardous reflections.

- Use protective eyewear at all times. Consult the ANSI, ACGIH, or OSHA standards listed at the end of this section for guidance on goggles and safety matters.

- Operate the laser at the lowest possible beam intensity, given the requirements of the intended application.

- Increase the beam diameter wherever possible to reduce beam intensity and thus reduce the hazard.

- Avoid blocking the laser beam with any part of the body.

- Use an IR detector or energy detector to verify that the laser beam is off before working in front of the laser.

- Establish a controlled access area for laser operation. Limit access to those trained in the principles of laser safety.

- Maintain a high ambient light level in the laser operation area so the eye pupil remains constricted, thus reducing the possibility of hazardous exposure.

- Post prominent warning signs near the laser operation area.

- Provide enclosures for the beam path whenever possible.

- Set up an energy absorber to capture the laser beam, preventing unnecessary reflections or scattering.

CAUTION: Use of controls, adjustments or performance of procedures other than those specified in this User's Manual may result in hazardous radiation exposure.

- Follow the instructions within this manual carefully to ensure the safe operation of your laser. At all times during laser operation, maintenance, or servicing, avoid unnecessary exposure to laser or collateral radiation that exceeds the accessible emission limits listed in "Performance Standards for Laser Products," United States Code of Federal Regulations, 21 CFR 1040.10(d). This information is also available in EN60825-1:1994, Section 8.2, titled "Measurements of Laser Radiation for Determining Classification."

- Preventative Maintenance for Safety

- Preventative maintenance is required to ensure the laser remains in compliance with Center for Devices and Radiological Health (CDRH) Regulations and European Norm (EN) requirements. This laser product complies with Title 21 of the United States Code of Federal Regulations, Chapter 1, Subchapter J, Parts 1040.10, as applicable, and with EN60825-1:1994, Part 1 for a Class 4 laser, as applicable. To maintain compliance, verify the operation of all features listed below, either annually or whenever the product has been subjected to adverse environmental conditions, which may have affected these features and functions.

- Verify that removing the remote interlock connector prevents laser operation. This connector is located on the rear panel of the Laser Power Supply.

Verify that an 8 second time delay exists between turning on the main power and the start of laser firing. It must give enough warning to allow action to be taken to avoid exposure to laser radiation.

Safety Issues

Normal use of test equipment presents a certain amount of danger due to electrical shock because it may be necessary for testing to be performed where voltage is exposed.

An electrical shock causing 10 milliamps of current to pass through the heart will stop most human heartbeats. Voltage as low as 35 VDC or 35 V_{RMS} AC should be considered dangerous and hazardous, as it can produce a lethal current under certain conditions. Higher voltages pose an even greater threat because such voltage can easily produce a lethal current. Your normal work habits should include all accepted practices that will prevent contact with exposed high voltage and steer current away from your heart in case of accidental contact with a high voltage. You will significantly reduce the risk factor if you know and observe the following safety precautions:

- If possible, familiarize yourself with the equipment being tested and the location of its high-voltage points. However, remember that high voltage may appear at unexpected points in defective equipment.

- Do not expose high voltage needlessly. Remove housing and covers only when necessary. Turn off equipment while making test connections in high- voltage circuits. Discharge high-voltage capacitors after shutting down power.

- When testing AC powered equipment, remember that AC line voltage is usually present on power input circuits, such as the on-off switch, fuses, power transformer, etc.

- Use an insulated floor material or a large, insulated floor mat to stand on, and an insulated work surface on which to place equipment. Make certain such surfaces are not damp or wet.

- Use the time-proven "one hand in the pocket" technique while handling an instrument probe. Be particularly careful to avoid contact with metal objects that could provide a good ground return path.

Never work alone. Someone should always be nearby to render aid if necessary. Training in CPR first aid is highly recommended.

Electrical Safety

CAUTION: Both the Laser Optics Assembly and Laser Power Supply contain electrical circuits operating at lethal voltage and current levels. Always unplug the system Mains connection and wait at least one (1) minute to allow capacitors to discharge before servicing any part of the laser system.

Consult with the manufacturer if repair of the laser electronics is required. Only those trained in high voltage, high current electronics, and who understand the laser circuitry, should be allowed to service and repair the laser electronics. If any such action is required, it is recommended that you contact the manufacturer for details.

Sources of Laser Safety Standards
"Safe Use of Lasers" (Z136.1)
     American National Standards Institute (ANSI)
     11th West 42nd Street
     New York, NY 10036 USA
     Phone: (212) 642-4900

"A Guide for Control of Laser Hazards"
     American Conference of Governmental and Industrial Hygienists (ACGIH)
     6500 Glenway Avenue, Bldg. D-7
     Cincinnati, OH 45211 USA
     Phone: (513) 661-7881

Occupational Safety and Health Administration
U.S. Department of Labor
200 Constitution Avenue N.W.
Washington, DC 20210 USA
Phone: (202) 523-8148

"Safety of Laser Products" (EN60825-1:1994)
Global Engineering Documents
15 Iverness Way East
Englewood, CO 80112-5704 USA
Phone: (303) 792-2181

Safety Labels and Locations

The following figures show the safety labels, model number, serial number and origination labels, and their locations on the miniSystem 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 the manufacturer for a replacement.
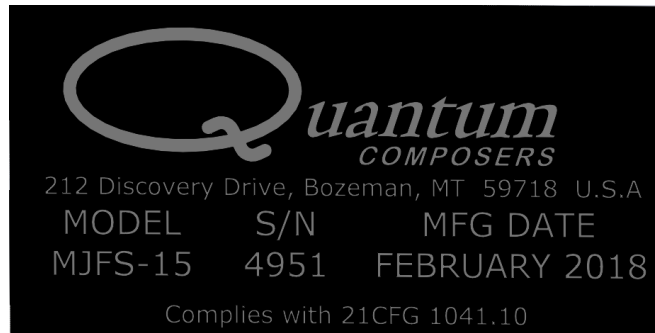
Figure 1 Certification & ID Label

Figure 2 Laser Wavelengths Label

Figure 3 Laser Aperture
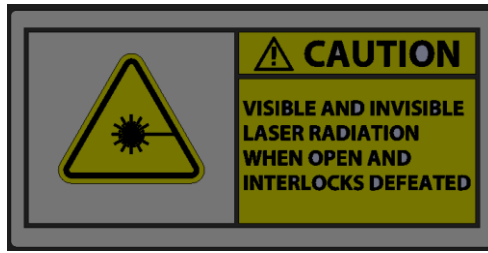
Figure 4 Cover Exposure Label
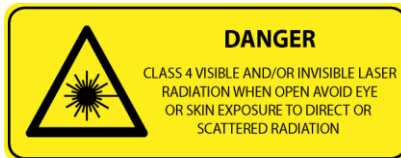
Figure 5 Non-Interlocked Cover Label

Figure 6 Model, Serial, and Origination Label

Figure 7 MINISYSTEM Safety Labels Front

Figure 8 MINISYSTEM Safety Labels Back

3. System Overview

MINISYSTEM Block Diagram

Figure 9 shows the laser system block diagram, which consists of the Jewel Laser, the laser optic modules, and the System Power Supply.
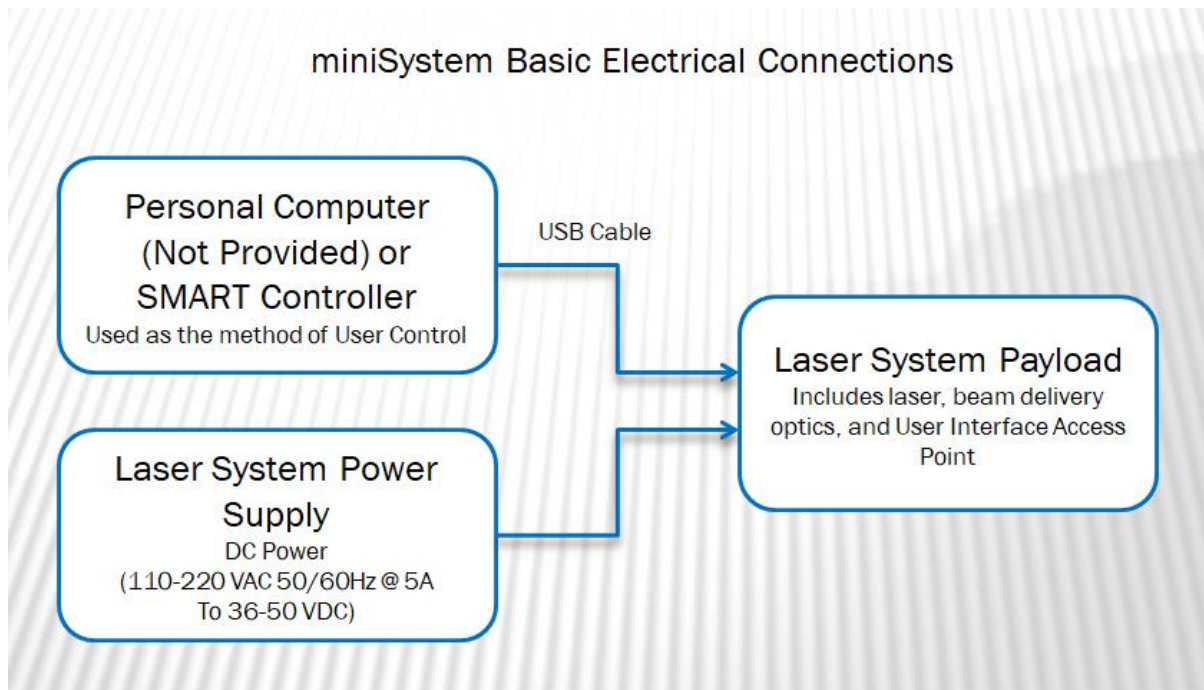

Figure 9 System Block Diagram

Laser System Power Supply
The portable power supply contains an AC/DC converter to supply the needed voltage for the miniSystem system from one AC supply. The main source can be 100-240 VAC and 50-60 Hz.

MECHANICAL DRAWING

units: mm
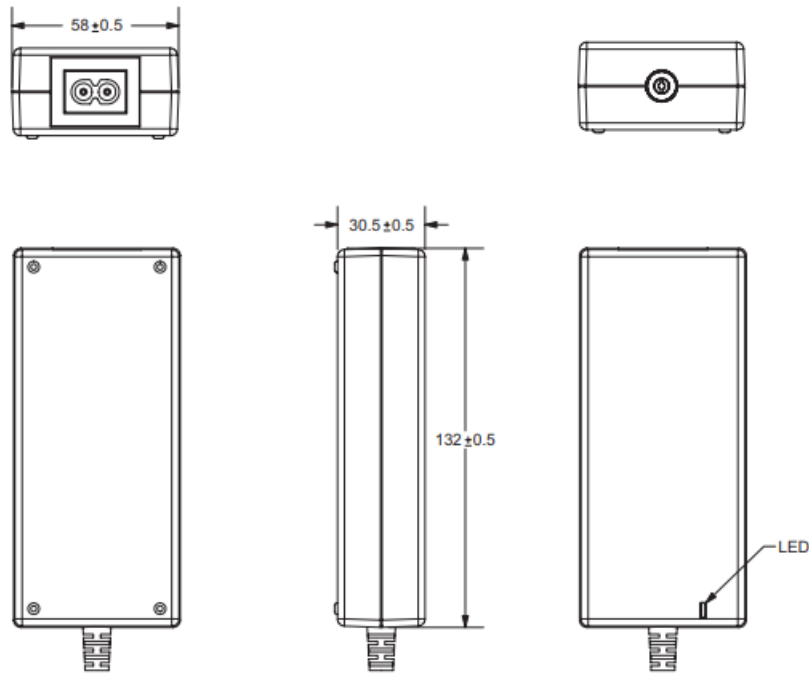
Figure 10 Power Supply

Description of Payload
The miniSystem payload contains multi-wavelength laser optics assemblies for beam control, the miniJewel laser head, a beam combining assembly, and the payload system controller. The laser head includes a 1064nm laser with an attached nonlinear module which converts the 1064nm (IR) laser output to 532nm (GRN), 355nm (UV), or 266nm (DUV). The laser features a ruggedized sealed housing designed for ease of maintenance and reliable operation. The laser beam control optics modify the output of the laser head providing wavelength selection, energy control, beam sizing, and beam shaping. The payload also contains a Laser System Control (LSC) card, which provides an interface to the user and control of all the motorized optic modules contained within the payload. This box also contains the input ports for USB communications from a user supplied computer or SMART controller, an external trigger, an external interlock, and sync out signal.

Description of the miniJewel Laser
The miniJewel is a conductively cooled 1064 nm diode pump laser with 8 mJ of nominal output power. The miniJewel is a self-contained laser housing the diode driver.

Laser Optic Assemblies

The available laser optical assemblies (Figure 11) are explained below.
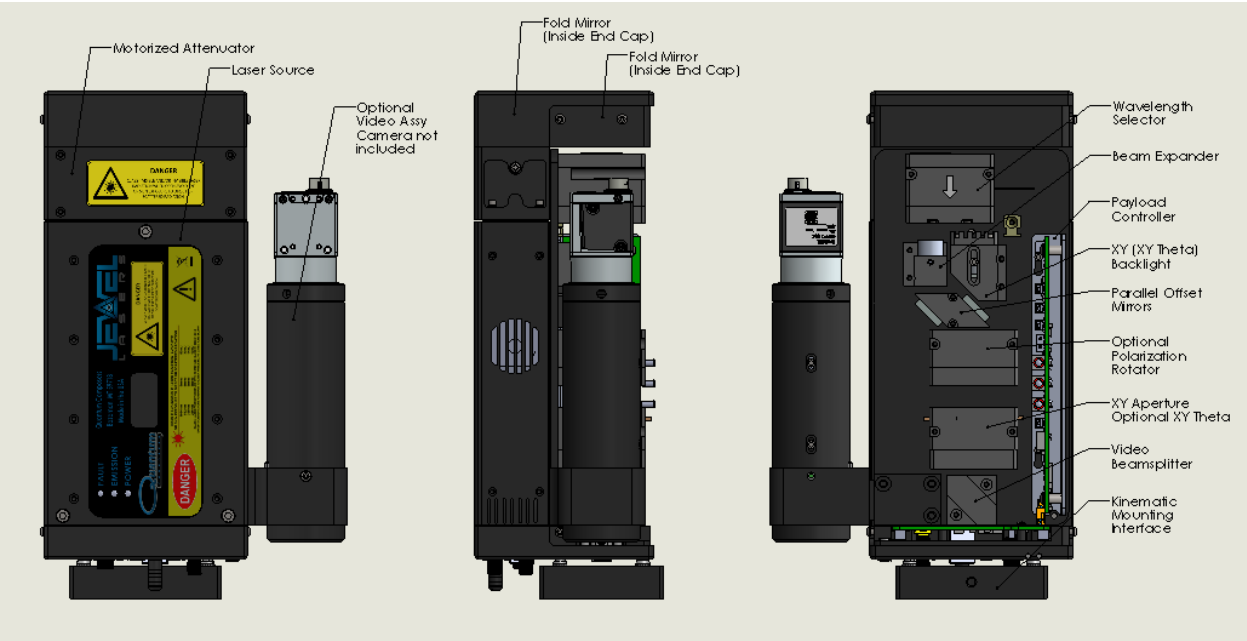
Figure 11 Laser Optical Assembly

1. The resonator is a diode pumped laser with an output wavelength of 1064 nm and nonlinear module to perform harmonic generation to produce a few key wavelengths. Resonator mirrors are hard-mounted to the machined resonator bench, which results in an extremely stiff, rugged resonator which is much less sensitive to misalignment then standard laser resonators. The output of the laser enters the integral nonlinear module. Harmonic generation is performed using non-linear crystal(s). The crystal temperature is tightly regulated by mounting them inside a temperature controlled oven assembly. The laser head has a nonlinear optic (NLO) crystal mounted inside a nonlinear module. The output is collinear, with all wavelengths exiting the same aperture.

2. The next component in the beam path is the attenuator. The attenuator is used to control the amount of energy exiting the payload. The attenuator is designed with a waveplate/polarizer to provide motorized attenuation of the laser beams from 0-100% of the full energy at the given wavelength. The attenuator utilizes high precision encoders to provide closed-loop motor control.

3. The laser beam leaves the laser and is reflected off of the Fold Mirror to the Wavelength Selector. The Wavelength Selector contains filters to separate the beam into discrete wavelengths and allow the selection of High or Low energy modes.

4. The beam expander follows the wavelength selector. The beam expander enlarges the laser beam for the proper illumination of the XY Theta aperture.

5. The laser beam is then offset by the parallel mirror assembly so that it is nominally centered on the XY (or XY Theta) Aperture.

6. The next component in the beam path is the optional Polarization Rotator. This module can rotate the output polarization of the system ± 90 degrees from a vertical or horizontal input polarization.

7. The laser beam then illuminates the optional XY Theta aperture. The XY Theta aperture forms a rectangular shape and each axis is independently controlled. The rectangular shape can be rotated ±45 degrees from horizontal.
8. The Aperture Backlight shines through the 2nd mirror of the Parallel Mirror assembly to illuminate the XY Aperture. When mounted in a system with the appropriate video optics, the aperture can easily be viewed indicate where the laser cuts will occur.

9. The Beam Splitter assembly separates the visual wavelengths from the laser beam path for viewing with a machine vision camera.

10. The optional Camera Port allows a machine vision camera to be utilized for viewing of the laser process. The Camera Port is a **C-mount** (1.00"-32 thread).

4. Installation

Unpacking the Laser System

The laser system has been carefully packaged for shipment. If the container arrives damaged in any way, please contact the shipper's agent to be present for the unpacking. Inspect each unit as it is unpacked, looking for dents, scratches, or other damage. If damage is evident, immediately file a claim against the carrier and notify the manufacturer.

It is recommended that the shipping container be kept for possible further shipping purposes, should the unit require repair or maintenance services. If a damage claim has been filed, the container will be needed to prove shipping damage.

The laser system is a turnkey system, designed so that a field service engineer is not required to get the system up and operating properly. The system has undergone extensive testing to verify its conformance to the specifications prior to delivery.

Before operating the laser however, it is important to fully understand its main features and controls.

CAUTION: Do not power up the system before thoroughly reading the system description. Use of the controls or adjustments, or performance of procedures other than those specified in this user's manual my result in hazardous radiation exposure, laser system damage or result in voiding the warranty. Please refrain from connection the main power until you make sure the power switch is in the OFF position.

System Inventory

The miniSystem Laser system consists of the following items. Verify that all listed items are present in the shipping container. If there are any shortages or discrepancies, contact Quantum Composers immediately.

- miniSystem Laser System Payload
- Desktop Power Supply
- USB Cable
- SMART Controller (Optional)
- User's Manual and Control Software on Disk
- Acceptance Test Results

System Installation

⚠️ **CAUTION: When utilizing the Remote Interlock capability, use an isolated contact closure such as a relay to avoid generating undesirable ground loops.**

⚠️ **CAUTION: Ensure that the system is connected to the proper Mains voltage. The voltage rating is marked on the Laser System Power Supply. Operating the system at the incorrect voltage may result in damage to the unit.**

⚡ **CAUTION: Ensure that the Mains power outlet that the Laser System Power Supply connects to is properly grounded. Poor ground quality could result in exposure to electrical shock.**

Payload Setup

1. Remove payload from packaging and lift onto microscope or VMU. Secure payload with 2 set screws in kinematic interface.
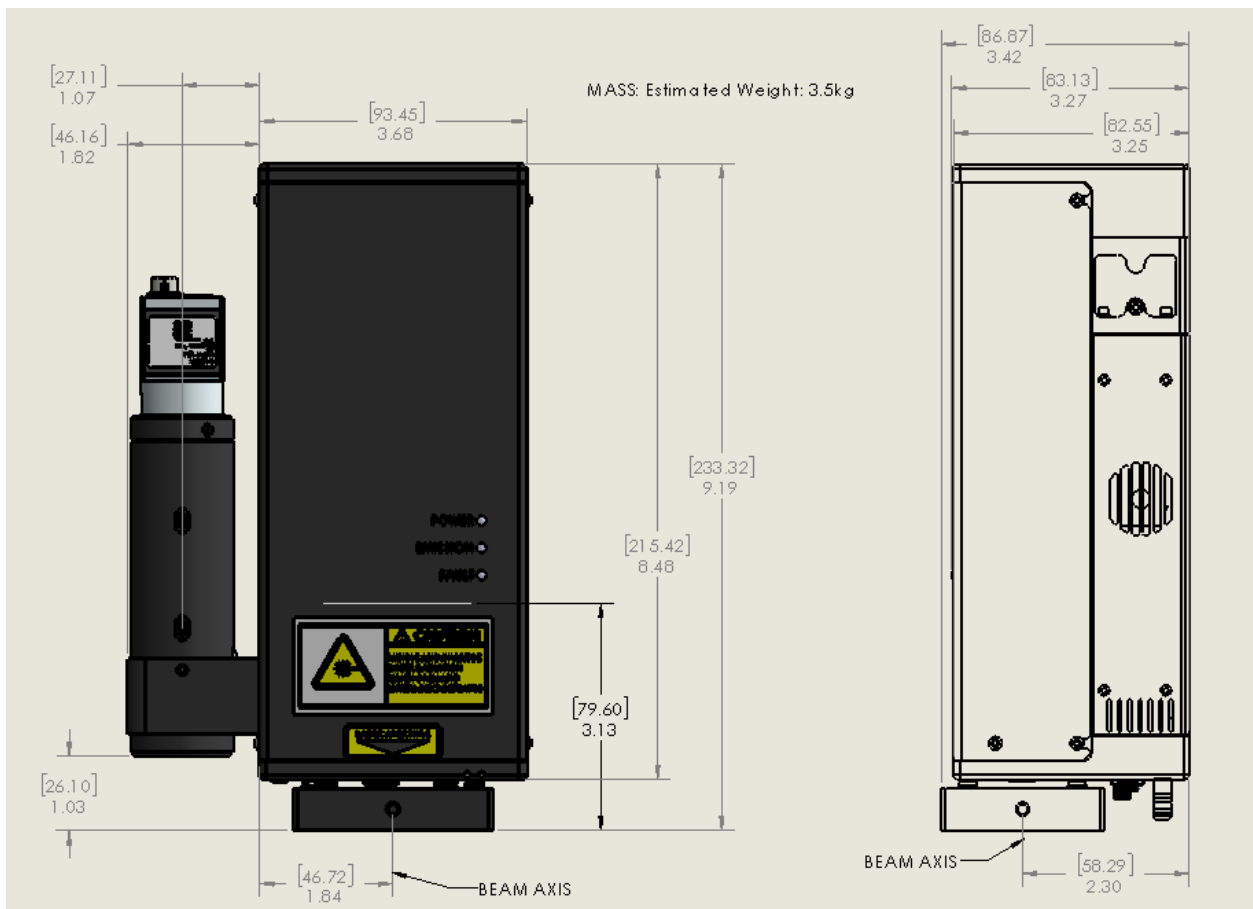

Figure 12 Mechanical Interface

Laser System Setup

1. Attach USB cable to laser system payload and connect the opposite end to a computer or optional SMART controller. The connections are specific so that connectors cannot be miss-matched.
2. Connect the power barrel connector to the laser system payload.
3. Plug in the AC power to the desktop power supply to a suitable 100-240 VAC supply using the provided plug. Plug in smart controller power cable if applicable.

Figure 13 Laser System Connections

Optional System Connections

The Laser System has optional connections that can be used if desired see Figure 13 Laser System Connections.

1. Remote Interlock. The remote interlock can be connected to any normally closed switch such as a door or access panel. If not used, the shorting jumper must be connected. When opened, the system will indicate an interlock fault and stop firing the laser.
2. Sync. The sync connection is an output that can indicate various system states depending on the state of the sync output settings (see command set). The signal present on this connector will be 5V max amplitude. The output can indicate the laser diode pulse state, or emission state.
3. Trig. This is an optional input that can be customized based on application needs. An optional footswitch can be connected to the TRIG input to control laser output. Please contact the factory for your needs if externally triggering or gating the system is required.
4. Optional Board Mount Camera micro-USB. This is an optional output that is only available with an internal board mount camera. Please contact the factory for your needs if an internal board mount camera is required.

System Indicators

The system has multiple visual indicators that show the state of the system. The Laser Payload has Emission, Fault and Power indicators on either side of the system. The Emission indicator will be active when the laser is enabled and able to be actively fired. The Fault indicator will be active whenever a fault has occurred.

Authorized operation

CDRH regulations mandate the use of a key control or password to allow operation of the laser system (1040.10(f)(4)). The miniSystem size prevents the implementation of a standard key operation so a password method has been implemented. When using the Quantum Composers LSxxx application or the SMART controller, the user will be prompted to enter either the master or user password before allowing the laser to be enabled and fired. Once the correct password has been entered, the user no longer has to re-enter the correct password as long as the system remains on and the application software has not been closed. The master password and the default user password are as follows:

Master: 40668

User: 12345

The user password can be changed as long as the Master password has been entered first. This allows controlled access to the laser. Please refer to the device command listing for commands to either enter the passwords or change the User password.

Initial Power On

Power-On Checklist
  ☐ Verify cable connections are correct.

Turn on system power.
  1. The laser harmonic crystal(s) will warm up to the set temperature. This takes approximately 10 minutes.
  2. The attenuator will independently home upon power up.
  3. The XY and optional Theta aperture will home upon power up.
  4. The wavelength selector will home on power up.
  5. The optional output polarizer will home on power up.
The system will be ready to operate after approximately 5 minutes. Best laser performance will require another 5 minutes of warm-up time.

5. Laser Operation

The laser system has undergone extensive testing to verify its conformance to the specifications prior to delivery.

Once the laser system has been set up as outlined in the previous chapter, it is ready to operate. Turn ON the Laser Power Supply. After approximately 5 minutes, the laser system is initialized and ready for operator control.

NOTE: Laser harmonic crystals must warm up. This can take 10 minutes before stable output energy can be realized.

Operation Guidelines

⚠ **CAUTION: Below is a list of guidelines, which apply to all Quantum Composers' laser systems. These guidelines should be followed whenever possible to avoid laser damage.**

- Operate the laser in a dust-free environment and keep the Laser Optics Assembly covered when not in use. This protects the output aperture against dust and particulate.

- The Laser Optics Assembly is sealed with careful attention to use of low outgassing materials. Silicone and similar sealing, bonding or insulating materials should not be used in close proximity to the Laser Optics Assembly 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 promote damage to optical components in the Laser Head. For example, an uncoated convex lens or a glass disk calorimeter will reflect about 4% of the incident energy. While the reflection may seem harmless, it can perturb the resonator operation to the extent that the near field beam intensity profile is degraded and may promote optical damage. In some cases, even anti-reflection coated glass optics can reflect enough energy to promote damage to 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.**

6. System Operation

The system can be controlled by multiple methods, using provided software application, using the SMART controller, or direct communication by using discrete commands.

SMART Controller

The SMART controller is a standalone remote box that allows manual control of the system. This method is usually preferred when the system is used on a microscope and used for manual repairs. The SMART controller is connected to the miniSystem via a standard USB cable. Please refer to the SMART Controller Manual for more information on its operation.

miniSystem Software Application

A software communication application has been included on the System Disc that can operate and set all the functions of the miniSystem laser system. This communication application communicates with the miniSystem via a USB cable.

Getting Started

- Attach a USB cable from the USB port of the computer to the USB port on the Laser System Payload.

- Start the LSxxx software.

- The miniSystem application startup screen will be displayed as shown in Figure 14. This application has been designed as a graphical user interface for ease of use. There is a Command Terminal section that can be used as well in order to manually send and receive commands to the laser system. This area allows the user to enter a command and press Send or Enter key. The large area shows the command that was sent and the response. The large area also shows the commands and responses from controls in other portion of the Graphical User Interface (GUI).

- The software allows you to run the basic functions of the laser system. From this screen the user can pick laser wavelength, energy level, firing mode, frequency, adjust aperture size, and set the slit backlight illumination level.

- The software also provides a system status indicator for the major interlocks and faults.
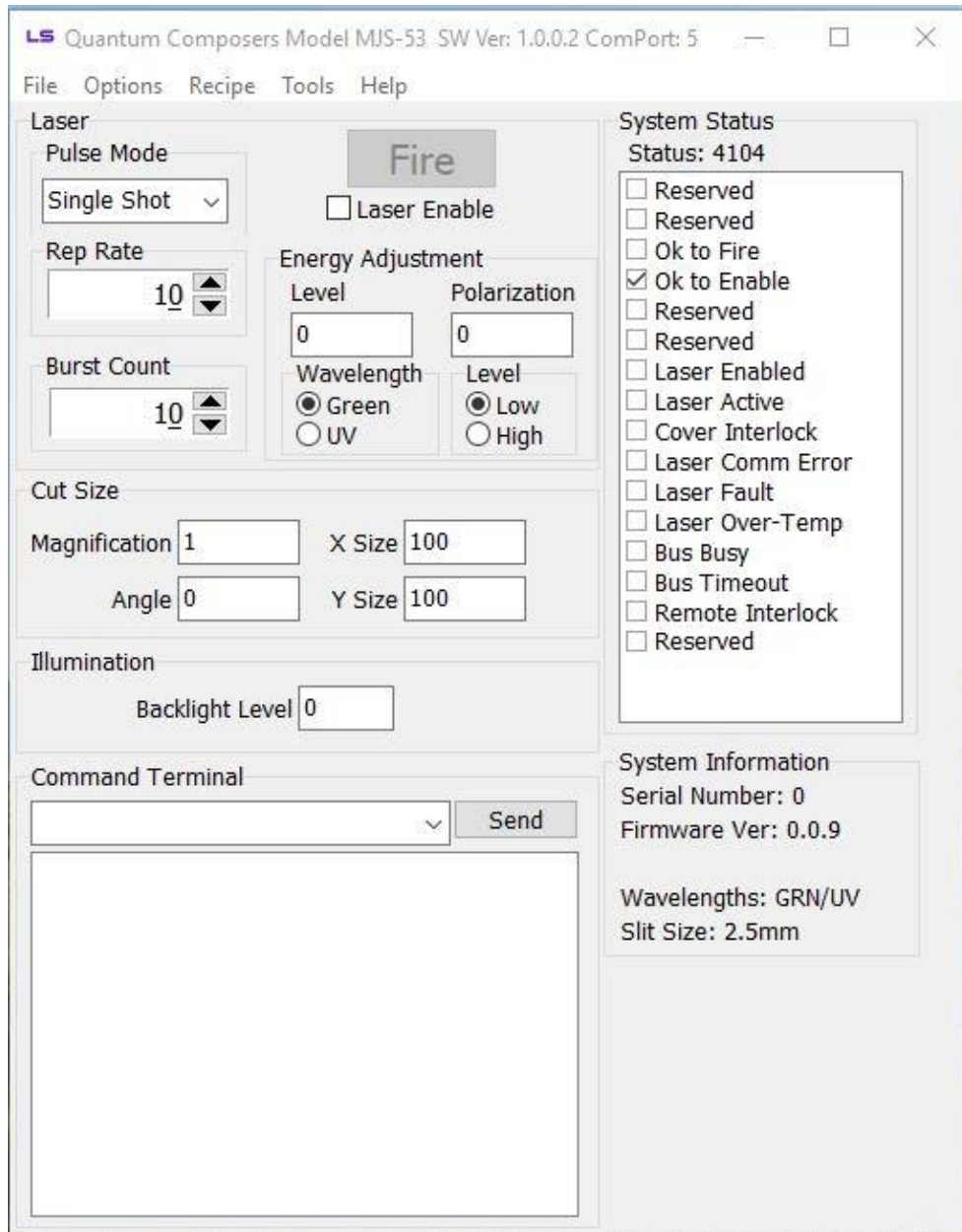
Figure 14 LS6xx Software Application Opening Screen

Laser Control
1. Pulse Mode – Options are continuous, single shot or burst.
    a. Continuous mode – The laser will fire continuously from the time the Fire button is pressed until the Stop button is pressed. The pulses per second are controlled with the Rep Rate parameter.
    b. Single Shot – The laser will output 1 single laser pulse when the Fire button is pressed.
    c. Burst mode - The laser will output the number of laser pulses specified by the Burst Count parameter. The laser will stop firing at the end of the burst.
2. Fire button – Selecting the fire button will start laser output. NOTE: the laser must be enabled before the Fire button becomes active.
3. Energy Adjustment – Range for each wavelength is 0 to 1000 (0 to 100.0%).
4. Wavelength Adjustment – Choose one of the two available wavelengths to be used.
5. Power Level Adjustment – Options are High and Low power.

a. High Power – The laser energy will range from 0 to the value set with the calibration command. (See ECS in the command section).
b. Low Power – The laser energy will range from 0 to 25% of the value set with the calibration command. (See ECS in the command section).

Cut Size

The cut size value is measured at the sample. Example: a 2500µm aperture opening with a 50x microscope objective has a cut size of 50.00µm.

1. Magnification – specified magnification of microscope objective being used.
2. X-size & Y-size – value corresponds to image size which is determined by the aperture size (range 0 to max size) divided by the microscope objective magnification. The max size of the aperture is specified at time of order. The system ID? query will tell you what size slit is installed on the system.
3. Angle – Values are ± range of 0 to 450 (45.0 degrees). Positive values rotate the aperture positive, Negative values rotate the aperture negative. A "-" must be entered for the aperture to rotate in the negative direction.

Objective Magnification	Max Size for 2.5mm Slit (mm)	Max Size for 4mm Slit (mm)
1x	2500	4000
2x	1250	2000
5x	500	800
10x	250	400
20x	125	200
50x	50	80
100x	25	40
200x	12.5	20

Illumination

The MINISYSTEM is configured with an illuminator used to show the XY-Theta aperture.

1. Backlight Level – values are 0 to 1000 (0 to 100.0%).

7. USB Communications

Personal Computer to Laser System Communication

The MINISYSTEM has a standard USB port. All menu settings can be set and retrieved over the computer interface using a simple command language. The command set is structured to be consistent with the Standard Commands for Programmable Instruments (SCPI). Although due to the high number of special features found in the miniSystem, many of the commands are not included in the specification. Sending commands faster than 50 ms may cause the unit to not respond properly. It is advised to wait until a response from the previous command is received before sending the next command.

USB Interface Overview

The USB port is located on the bottom of the MINISYSTEM laser payload and uses a USB-B type connector with the following pinout (as viewed from the back of the unit):

Pin Number	Name	Description
1	+5 VDC	Vbus
2	D-	Data -
3	D+	Data +
4	Ground	Power Return

Device Command Format

All commands use ASCII characters and are composed of the following fields:

<Prefix><Address>< Delimiter ><Command String>[Parameters]<Terminator>

Field	Description
Prefix	Single semicolon character ";", must precede all commands. All devices will reset their command input buffer when the prefix is received.
Address	2 ASCII characters. Each device has a unique address which is programmed into its firmware. See the table below for a list of addresses.
Delimiter	Single colon character ":", must follow device address.
Command String	Commands are specific to each device -- see the following sections for the commands that each device supports.
Parameters	(optional field) Some commands may not require a parameter. For Query commands immediately follow the command string with the question mark character "?". For non-query commands immediately follow the command string with a single space character " " followed by the parameter. Multiple commands are separated by commas.
Terminator	ASCII carriage return character (0Dh). The receiving device does not process any commands until the terminator is received.

Device Address

Address   Device
LC   Laser Controller

Command Types
There are two types of commands -- those that set a value or initiate an action (control commands), and those that request information (query commands). Each device must respond in the proper manner to each type of command.

Control Commands
A device must always parse a control command and return a response immediately.
- If the command is a recognized command and the parameter is valid, then the device returns an "OK<CR>".
- If the command is not recognized, then the device responds with a "?1<CR>".
- If the command is recognized, but the parameter value is missing or invalid, then the device responds with a "?4" or "?5".
- If a control command is received while the device is in the midst of executing a previous command, and the commands are mutually exclusive (cannot be executed in parallel), then the previous command is aborted and the new one executed. It is up to the host controller (the PC) to poll the device and make sure the previous command has finished, if that is needed.

Query Commands
Query commands return a value to the PC as soon as the command is parsed and executed. The value returned will depend on the command. The response is always terminated with a "<CR><LF>". If a query command is not recognized by the device, then a "?1" is returned.

Error Codes
?1   Command not recognized.
?2   Missing command keyword. If command requires keyword.
?3   Invalid command keyword. If command requires keyword.
?4   Missing parameter.
?5   Invalid parameter.
?6   Query only, command needs a question mark.
?7   Invalid query, command does not have a query function.
?8   Command unavailable in current system state.
?9   Module timeout error

Laser Controller Example
Below is an example of commands and queries. A <CR> indicates the carriage return value appended. The system will initialize itself on power up. There is no need to home any motors or stages. The system will power up with the last saved recipe (if saved). See the SR and LR commands.

Example Recipe:

Laser Mode: Burst of 10, Rate of 10Hz.
Wavelength: 266nm
Energy Level: High mode at 50%.
Cut Size: 1um x 1um, 45 degree rotation with 10x objective.
Output polarization: 0 degrees.
Backlight Illumination: On at 20%.

Command Sequence:

Command to send:	;LC:EN 1<CR>
Response:	OK<CR>
Description:	This will enable the laser. This only needs to be done once unless a fault disables it or a laser disable is sent.

Command to send:	;LC:PM 2<CR>
Response:	OK<CR>
Description	This sets the laser pulse mode to burst.

Command to send:	;LC:BC 10<CR>
Response:	OK<CR>
Description:	Sets the laser burst count to 10.

Command to send:	;LC:RR 10<CR>
Response:	OK<CR>
Description:	Sets the laser rep rate to 10Hz

Command to send:	;LC:SW 4<CR>
Response:	OK<CR>
Description:	Sets the active wavelength to DUV (266nm).

Command to send:	;LC:ED 4,1,500<CR>
Response:	OK<CR>
Description:	Sets the wavelength to DUV (266nm), the level to high mode and the percentage to 50%.

Command to send:	;LC:SP 10,1000,1000<CR>
Response:	OK<CR>
Description:	Sets the slit opening to 1um x 1um with a 10x objective.

Command to send:	;LC:SA 450<CR>
Response:	OK<CR>
Description:	Sets the slit angle to 45 degrees.

Command to send:	;LC:IL 1,200<CR>
Response:	OK<CR>
Description:	Sets the backlight illumination to 20% on.

The system is now ready to fire the laser:

Command to send:	;LC:FL 2<CR>
Response:	OK<CR>
Description:	Starts the laser firing the burst sequence. Once the burst is finished another FL 2 command can be sent to fire another burst.

To monitor system status, use the SS command:

Query to send:	;LC:SS?<CR>
Response:	72<CR>
Description	Means ok to enable, laser is enabled and ready to fire.

If it is desired to save this recipe for a recall later on, use the following command:

Command to send:	;LC:SR 1<CR>
Response:	OK<CR>
Description:	Saves the current system settings to storage location #1. There are up to 6 locations to store various recipes.

To recall a saved recipe, use the following command:

     Command to send: ;LC:LR 2<CR>
     Response: OK<CR>
     Description: Loads the configurations settings from storage location #2.

Once a recipe is recalled, the only commands that need to be sent are the enable laser (EN) and the fire laser (FL). It is recommended to utilize the recipe storage and recall commands to quickly load new parameters into the system that have been pre-configured.

To minimize the number of setup commands that have to be sent each time when parameters need to change quickly, the laser setup (LS) command can be used. This command combines many of the commonly changed parameters. If the objective magnification stays the same, then this command can be used.

     Command to send: ;LC:LS 4,1,500,0,1000,1000<CR>
     Response: OK<CR>
     Description: Sets wavelength to DUV, level to high, energy to 50%,
                                 polarization to 0 degrees, and slit to 1mm x 1mm.

<u>Various System Status Checks</u>

To check to see if the laser is ready to be enabled, only one bit (bit position 3) of the system status needs to be checked. This bit is the Ready to Enable bit. When this bit is set, then the laser can be issued an enable command. If it is not set, then check to see if any fault is detected.

To check to see if the laser is ready to fire, only the Ready To Fire bit (bit position 2) needs to be checked. When this bit is set, it is ok to send the fire laser command. If it is not set, then check to see if the laser is enabled or if any other fault is detected.

To monitor the status of any motor movement in the system, only the Bus Busy (or motor moving) bit (bit position 12) needs to be checked. This bit will be set whenever any motor on the system is in motion. This could be due to a homing sequence on startup or a commanded movement is still in process.

General System Commands

Command	Description
DONE?	Done Firing. This query will send back a "done" response once the laser is finished firing. An example situation would be waiting for a burst to finish. Once the burst is done, the "done" response will be sent back. If the system is not ready to fire then a response of "?8" will be returned.
EC # EC?	Echo. Parameter = 0=echo characters off (Default: 0), 1=echo characters on. EC? returns echo state.
HA	Home All. Homes all motors on the system. Once homing is complete motors will move to the last set position.
HR	Home Reset. Homes all motors on the system. Once homing is complete motors will move to the power on default positions.
ID?	System ID. QC, model #, serial # (5 digits), FW Version# (x.x.x), Wavelengths, Slit Size. Example: QC,MJS-xx,00101,1.2.0,IR/GRN,2.5mm). Query only
LR # LR?	Load Recipe. Sets up laser according to requested recipe settings. Parameter = Recipe number (0=factory default, 1-6 User Recipes).
PW # PW?	Password. This command is used to enter either the user or master password and allow enabling and firing the laser. A query will return the unlocked state of the laser. 1 = unlocked, 0 = locked. See the Authorized Operation section for the codes.
RDY?	Ready to Fire. This query will send back a "rdy" response once the system is ready to fire. If motors are in motion, then the "rdy" response will not come back until they are done moving. Any command or query send while waiting for a ready response will abort the ready response process. If they system is in a state where the user must intervene to make the system ready (interlock, fault, etc) then an error (?8) will be sent back right away.
SR # SR?	Store Recipe. Store current settings. Parameter = Recipe number (1-6 User Recipes). A query returns the current active recipe.
SS?	System Status – Query Only. Returns the current system state. Value is a 16 bit decimal value with each bit position corresponding to a system state.

15	14	13	12	11	10	9	8
Reserved	Remote Intlk	Bus Timeout	Module Active	Laser Over Temp	Laser Fault	Laser Comm Error	Cover Interlock

7	6	5	4	3	2	1	0
Laser Active	Laser Enabled	Reserved	Reserved	Ready to Enable	Ready to Fire	Reserved	Reserved

Command	Description
ST	Stop. This is a global stop to the system. The laser will be disabled, the motors will all be stopped.

UP # UP?	User Password. This command can be used to query or change the user password to allow enabling and firing of the laser. The Master code must be entered prior to using this command. See the PW command.
VN?	Version Number – Query Only. Returns the current LSC version number in the format of major.minor.release. Ex: 1.3.6

Laser Operation Commands

BC # BC?	Burst Count. Sets the number of laser shots to be fired when firing mode is set to burst. Parameters are from 1-1000. Default is 10. A query will return the currently set burst count.
BL #,# BL:PE? BL:SE?	Blend (if installed). First parameter is blend percentage of Primary to Total energy output amount (Primary/Total). Second parameter is the overall energy density. Range is 0-1000 for both. A query returns both the blend percentage and the energy density. Command only functional on blend systems.
ED #,#,### ED?	Set Energy Density. Parameters: First parameter selects wavelength. Range is 1 to 4 where 1 = IR, 2 = GRN, 3 = UV, 4 = DUV. Second parameter selects High (1) or Low (0). High mode gives 100% of full scale and Low mode is 25% of full scale. Third parameter is Energy Density (0 – 1000). Where 1000 equals the wavelength/mode specific maximum output. ED? returns current energy density setting. The format of the query is #,#,####. If the system is a blend type, then the parameters are as follows: First parameter selects the blend percentage. Second parameter selects energy mode. Third parameter selects energy density.
EM # EM?	Energy Mode. Sets the type of energy mode on systems that support different energy modes. 0 = Normal mode, 1 = High mode, 2 = Weld mode. If the system does not support High or Weld mode, only Normal mode can be set.
EN # EN?	Enable. This will enable or disable the laser. The laser must first be enabled before firing. 0 = Disabled, 1 = Enabled. (Default: 0). A query returns the current enable state.
ET # ET?	External Trigger. Sets the external trigger mode. 0 = Off, 1 = On, 2 = Footswitch/Gate
FL # FL?	Fire Laser. Starts the laser pulsing. 0 = Stop Firing Laser, place laser in idle state, shutter will be closed. 1 = Fire laser,. 2 = Fire laser, shutter is open. A query returns the current firing state.

LS #,#,###,###,###,### LS?	Laser Setup. This is a combined command to adjust multiple system parameters at once instead of issuing multiple commands. First Parameter = Select wavelength (1 = IR, 2 = GRN, 3 = UV, 4 = DUV), Second Parameter = Selects High (1) or Low (0) mode, Third Parameter = Set Energy Density (0 – 1000), Fourth Parameter = Set polarization angle (-900 to +900), Fifth Parameter = Set Slit X-axis (0.00 to 2500 microns, depends on magnification), Sixth Parameter = Set Slit Y-axis (0.00 to 2500 microns, depends on magnification), LS? returns current settings.
PA # PA?	Polarization Angle. Sets the angle of the laser output polarization. Units are 10*degrees. Values range from -900 to 900 for +/-90 degrees, where 0 is vertical. Default is 0.
PM # PM?	Mode. Sets the laser firing mode, 0 = continuous, 1 = single shot, 2 = burst. (Default: 0). A query returns the currently set mode.
RR ## RR?	Repetition Rate. This sets the rate at which the laser will fire at. Values are from 1-50 Hz. A query will return the current rate.
SC?	Shot Count. Queries the laser accumulated shot count.
SW # SW?	Select Wavelength. Selects the wavelength to control. Range is 1 to 4 where 1 = IR, 2 = GRN, 3 = UV, 4 = DUV. A query returns the current wavelength being controlled. NOTE: The system will only have two available wavelengths.
SY # SY?	Sync Output Mode. 0 = Off, 1 = LD Pulse, 2 = Emission
UC 0 UC?	User Count. This is a user re-settable shot counter. It is a saved count and can be cleared by issuing a 0 parameter following the command.

Slit Commands

SA # SA?	Slit Rotation. Sets the current slit rotation angle. Range is from +45 to -45 degrees. A plus or minus is required to determine angle. (Default: 0). Parameter = degrees*10 (+450 to -450). A query returns the current rotation angle.
SP #,##.##,##.## SP?	Slit Position. First Parameter is Magnification. Sets the current slit X and Y blade position. Values are from 0.00 to 2500 microns for both axes depending on magnification. Actual allowed range depends on the objective magnification. Slit range is 0 to 2.5mm, thus the image size range is 0 to 2500/magnification. A query returns the current cut size.

Illuminator Commands

IL #,####	Illuminator level. First parameter is the illuminator channel. 0 = Coax(if installed), 1 = Slit backlight. The second parameter is the intensity level 0 to 1000. Status returns level for both illuminators.

Calibration Commands

ECS #,# ECS?	Energy Calibration Setup. Sets up the system for energy calibration. First parameter is the wavelength; second parameter is high/low energy mode. Output energy will automatically be set to 50%.
ECM # ECM?	Energy Calibration Maximum. Parameter is the measured energy when the output energy is set to 50% level using the ECS command. NOTE: This will be measured at high energy mode only, and will be done for each wavelength available on the system.
ECF #,# ECF?	Energy Calibration Full scale. Sets the desired full scale energy output for the selected wavelength at high level output. First parameter is wavelength; second parameter is the desired high level full scale energy. The low value will automatically be scaled to 25% of the high setting. A query returns both the high and low values for the current wavelength. High, Low.
ECR	Energy Calibration Reset. Resets values to defaults for all wavelengths.

8. Maintenance

The miniSystem Laser System is designed to be maintenance free and should provide many hours of operation before any maintenance is required. In the event that the system is not performing to specification, please contact the factory for service.

9. Trouble-Shooting

The miniSystem control electronics are 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 electrical and optical damage.

No Laser Output
Check Fault and Interlock Conditions: Query status information using commands listed in the command set. Refer to status to determine if a fault or interlock conditions exists.

Check Cables: With the main power OFF and unplugged, check all electrical connections between the Laser Optics Assembly and the Laser Power Supply. Make sure all connections are secured. If any of the cables are not installed properly, the system will not function.

Check Energy Setting: Check to see that the Maximum energy (ECM) setting is not set lower than the Full Scale energy (ECF). Correct if necessary.

Energy is Low
Laser is not warmed up: Be sure to allow the laser to properly warm up a minimum of 10 minutes before operation.

Attenuator is set too low: Verify that the attenuator is set to a percentage that lets sufficient energy through the system.

Filter wheel is in low mode. Verify that the high/low mode is set to a high mode unless a low energy range is desired.

System miss-alignment: The beam path through the system may be misaligned. Contact manufacturer for more details.

Resonator Misaligned: If beam quality has degraded, it may suggest that the resonator needs realignment. Contact manufacturer for more details.

Contact the manufacturer for any repair actions necessary beyond those described in this manual. Attempts to adjust, repair or replace any portion of the laser system may cause additional problems and void the warranty.

10. Specifications

miniSystem Laser Specifications	Specification	Notes
miniJewel Laser		Sealed, conductively cooled resonator integrated with drive and control electronics.
Wavelength	Two wavelengths (1064/532, 532/355, or 532/266)	Beam selection and energy control using filter wheel and dual wavelength attenuator.
Rep Rate	1-30 Hz 30-50Hz Limited*	
Energy per Pulse (Typical)		
1064 nm	≥ 4mJ (1064nm only) ≥ 1.25mJ (dual wavelength)	Energy is specified at the output of the MINISYSTEM system and does not include losses from customer supplied optics. If required energy specification can be increased.
532 nm	≥ 1.25 mJ	
355 nm	≥ 0.4 mJ	
266 nm	≥ 0.4 mJ	
Pulse Width		
1064 nm	6.0 +/-2.0 ns	Full width half maximum
532 nm	6.0 +/-2.0 ns	
355 nm	5.0 +/-2.0 ns	
266 nm	5.0 +/-2.0 ns	
Pulse to Pulse Stability		**full aperture 50% 25% 10%**
1064 nm	≤4% ≤8% ≤10% ≤12%	RMS pulse-to-pulse stability for 98% of pulses after warm-up, with a 100 shot sample window
532 nm	≤5% ≤10% ≤15% ≤25%	
355 nm	≤7% ≤12% ≤20% ≤28%	
266 nm	≤7% ≤12% ≤20% ≤28%	
Diode Lifetime		> 500,000,000 pulses

Attenuator	Specification	Notes
Attenuation Range	0 to 100%	Attenuator is calibrated and linearized to provide the specified energy.
Accuracy	±0.5%	
Resolution	0.20%	
Tact Time	≤ 1.0 s	Full range of travel.
Initialization	≤ 6.0 s	From power-up.

* Long term drift may exceed specifications. Contact factory for details.

X-Y Slit	Specification	Notes
Range	0 to 2.5 mm	0 to 50 µm with 50x objective
Accuracy	±(25 um + 0.01 * size)	
Resolution	25 um	0.5 µm with 50x objective
Tact Time	≤ 1.0 s	Full range of travel.
Initialization	≤ 6.0 s	From power-up.

Theta Slit	Specification	Notes
Rotation Range	-45 to +45 degrees	
Accuracy	± 1.0 degree	
Resolution	0.5 degrees	
Tact Time	≤ 1.0 s	Full range of travel.
Initialization	≤ 6.0 s	From power-up.

Filter Wheel	Specification	Notes
Positions	5	
Tact Time	≤ 1.0 s	Full range of travel.
Initialization	≤ 6.0 s	From power-up.

Waveplate Rotator	Specification	Notes
Rotation Range	-45 to +45 degrees	Rotates polarization ± 90 degrees
Accuracy	±1.0 degree	
Resolution	0.5 degrees	
Tact Time	≤ 1.0 s	Full range of travel.
Initialization	≤ 6.0 s	From power-up.

System	Specification	Notes
Size		
Payload	140 mm x 87 mm x 233 mm	With optional video port
Power Supply	132 mm x 58 mm x 31 mm	
Weight		
Payload	3.5 kg	
Power Supply	≤ 0.5 kg	
Operating Voltage	100 - 240 VAC, 50/60 Hz	Direct DC input range is 36-50VDC
Operating Power	< 50 Watts	
Computer Interface		
Standard	USB	

11. Customer Service

Warranty

The manufacturer warrants the lasers it produces to be free from defects in materials and workmanship for one year following the date of shipment. Laser optics are warranted for 90 days following the date of shipment provided that operating instructions are properly followed. This warranty is limited to the original purchaser of the laser and is not transferable.

During the one year 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 Quantum Composers. All replaced parts and products become the property of the manufacturer.

This warranty does NOT extend to any lasers which have been damaged as a result of accident, misuse, abuse (such as use of incorrect input voltages, improper or insufficient ventilation, failure to follow the operating instructions provided by the manufacturer, or other contingencies beyond our control), or as a result of service or modification by anyone other than the manufacturer.

Feedback

We welcome your feedback in regard to the use and performance of our laser system. Product improvements and refinements come about from these contacts; continually improve our product reliability, performance and customer satisfaction.