



Technical Reference

**Resonetics RapidX 250
CompexPro System**

**Model Serial Number:
5250**

*D09071-01, Rev. A
September 2011*

RESONETICS

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Part I

System Overview

1. Introduction

Thank you for your purchase of the Resonetics RapidX 250 Laser System. It has a wide variety of industrial applications including micromachining, marking, and wire stripping as well as various medical applications. The laser source for the system is a Coherent COMPexPRO[®] 110.

As delivered, the Resonetics RapidX 250 Laser System is a Class I laser product. This means the system does not permit access to dangerous electromagnetic radiation levels during laser operation. Any changes to the enclosure or operation of safety interlocks may invalidate the system classification. See Section 2 for safety details.

1.1 Overview

Procedures for system operation are simple and can be operated by an individual with minimal technical ability. The operator loads material onto the stage assembly, through the access window. After loading, the operator uses software from the system computer to set laser parameters and initiate laser processing. When processing is complete, the system returns to its load position and the operator opens the access window for unloading.

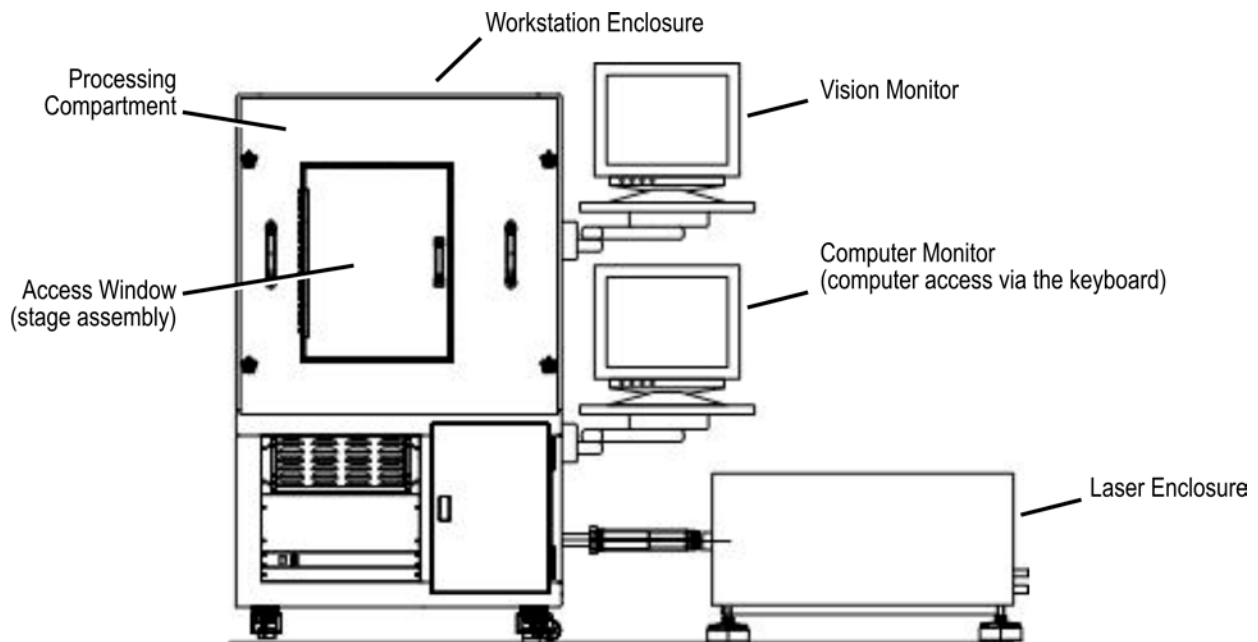


Figure 1-1. Resonetics RapidX 250 Laser System (Front View)

1.2 Scope of This Manual

This manual describes safety, system features, basic startup and shutdown procedures, and maintenance for the Resonetics RapidX 130-L Parylene Laser Ablation System. The manual is divided into five parts:

Part I: System Overview

provides information about safety and basic system operation.

- Section 1, *Introduction*
- Section 2, *Safety*
- Section 3, *Basic System Operation*

Part II: Equipment Reference

describes the theory of operation and provides detailed information about the equipment.

- Section 4, *Theory of Operation*
- Section 5, *Equipment Description*

Part III: Software Reference

provides detailed information about the system software.

- Section 6, *A3200 Software*
- Section 7, *BobCAD Operation*

Part IV: Engineering, Maintenance, and Service Procedures

provides procedures for recipe setup, maintenance, troubleshooting, and service.

- Section 8, *Maintenance*
- Section 9, *Service*

Appendices

provide additional information.

- Appendix A, *Spare Parts List*
- Appendix B, *Layouts and Schematics*

1.3 Audience and Support

The reader is assumed to have a reasonable working knowledge of electrical components and the Windows® XP operating system. You can obtain technical support for the Resonetics RapidX 250 Laser System by contacting Resonetics at 603-886-6772.

1.4 Additional References

This manual describes overall system features, step-by-step operating procedures, and maintenance for the Resonetics RapidX 250 Laser System. There is no attempt to duplicate information already supplied by component technical references which accompany this manual:

- [*RapidX 250 Series Workstation with CompexPro Series Excimer Laser Pre-Installation Guide*](#) (Resonetics, LLC), Document #D05098-09 (Rev. D), assists in preparing a facility for the installation of a Resonetics laser workstation.
- [*Electromechanical Positioning Systems: 404/406XR Series Product Manual*](#) (Parker Hannifin Corporation), P/N 100-5320-01 (Revision 6), describes specifications, mounting procedures, and maintenance of the 406XR electromechanical position system.

- [*COMPexPro® \(RoHS\) Site Preparation*](#) (Coherent Laser Group), P/N 126587 (AA), assists in preparing a facility for the installation of a COMPexPro® laser.
- [*COMPexPro® \(RoHS\) User Manual*](#) (Coherent Laser Group), P/N D125737 (AE), familiarizes the user with the COMPexPro® excimer laser device and its designated use. The manual contains important information on how to install, operate, and service the laser device safely, properly, and most efficiently.
- [*OEM750 Drive OEM750X Drive/Indexer User Guide*](#) (Parker Hannifin Corporation), P/N 88-016109-01 (B), describes the installation, tuning and specifications, and troubleshooting for the OEM750 drive, which is optimized to operate size 23 and 34 two-phase permanent magnet hybrid step motors.
- [*Hitachi KP-D20A/B Camera Datasheet*](#) (Hitachi Kokusai Electric Inc.), P/N DV-E392, lists the color camera features, specifications, supplied equipment, optional accessories, and mechanical drawing.
- [*Hitachi KP-D20A/B CCD Color Camera Operation Manual*](#) (Hitachi Kokusai Electric Inc.) describes the operating considerations, components, and operating features of the camera.
- [*Zoom 6000 High Mag Zoom Lens Brochure*](#) (Navitar Inc.) provides information about the Zoom 6000 lens assembly, including features, dimensions, and performance information.
- [*S-Series Chillers \(Recirculating, Air-Cooled\) Datasheet*](#) (Lydall Industrial Thermal Solutions Inc.), describes the chiller installation, operation, options, and troubleshooting.
- [*Affinity® S-Series Chillers User Manual*](#) (Lydall Industrial Thermal Solutions Inc.), P/N D70000 Rev. A, provides a list of system features, available options, performance characteristics, and performance charts.
- [*BobCAD-CAM V21 Operators Manual*](#) (BobCAD-CAM), provides function descriptions, explanations, and special examples on how to use the BobCAD-CAM software.

Notes



2. Safety

There are four potential hazards from an excimer laser system:

- Laser hazards, which involve the laser beam.
- Mechanical hazards, which involve any moving parts.
- Electrical hazards, which involve primarily low to medium voltages.
- Material hazards, which involve the laser gases.

The Resonetics RapidX 250 Laser System has been designed with these potential hazards in mind so that health risks are minimized. Please read this safety section carefully and adhere to all cautions and safety instructions. In addition, review all safety information provided in the [COMPexPro® \(RoHS\) User Manual](#) and [Affinity® S-Series Chillers User Manual](#) (for the chiller option).

2.1 Overview of the Class I Laser Safe Enclosure

The laser beam is fully enclosed from the laser all the way to the work piece. From the laser to the final image lens, the laser beam is contained in a beam enclosure. An access door is interlocked with the beam stop. The interlock circuit ensures that this shield is in place during normal system operation. The beam stop closes automatically when the interlock circuit is opened. During normal operation, the operator has no access to the laser beam. A service override key (also called an interlock bypass key) can be used to bypass the interlock circuit for maintenance and service purposes.

Details about safety features such as the beam stop, interlocks, access door, and service key are provided in this remainder of this section.

WARNING

This Class I system is designed to prevent access to laser radiation during normal use.

**DO NOT attempt to bypass any of the interlocks
or any other safety feature described in this section.**

The system incorporates a Class IV laser.

**ONLY a qualified service technician should work with the system interlocks bypassed
and should have access to the laser beam radiations.**

**Class IV levels of laser radiation are considered to be an acute hazard to the skin
and eyes from direct or scattered radiation.**

Always use proper protective eyewear when working with the laser.

**DIRECT OR INDIRECT LASER RADIATION
CAN CAUSE SEVERE SKIN AND EYE DAMAGE.**

2.2 Laser Safety Precautions

The Resonetics RapidX 250 Laser System uses a Coherent COMPexPro[®] 110 excimer laser as the light source for machine processing. The laser generates short, high intensity pulses of ultraviolet (UV) light at wavelengths that are hazardous to the eye. Certain levels of UV light also can be harmful to the skin. The hazard potential for these wavelengths is particularly high because UV light is invisible.

2.2.1 Federal Regulations

All manufacturers of laser equipment are required by United States federal law to design and certify their products in compliance with the U.S. Code of Federal Regulations (CFR), Parts 1040.10 and 1040.11. The regulations are based on the Radiation Control Health and Safety Act of 1968 and describe laser safety issues such as enclosure design, interlocks, inspection requirements, operation and maintenance procedures, labeling, and record keeping. The Center for Devices and Radiological Health (CDRH) branch of the Food and Drug Administration (FDA) has jurisdiction over these matters in the U.S.

Federal U.S. statutes distinguish between three types of employees with access to laser products:

- Operators—Laser systems are designed to provide the most protection to operators because they are often production line workers who may be least familiar with technical aspects of laser operation. Furthermore, operators spend the most time with the laser during routine processing operations.
- Maintenance Personnel—Maintenance personnel include the technicians who keep the system running properly, performing tasks such as programming, beam focusing, and preventive maintenance. Service personnel have the most training on laser safety. They perform corrective maintenance on laser systems.
- Service Personnel—Service personnel are the only qualified technicians permitted to override the Resonetics RapidX 250 Laser System interlocks (using the service override key on the beam stop control box, described in Section 5.4.4, page 5-26). Service personnel are expected to employ all laser precautions during service access to the laser beam.



Figure 2-1. Beam Stop Control Box

Federal regulatory classifications are established by the FDA on the basis of the radiation levels expected from the laser and the limited access design of the workstation enclosure. For example, the Coherent COMPexPro[®] 110 excimer laser by itself poses considerable hazard to personnel and has its own laser classification of Class IV. Class IV levels of laser radiation are considered to be an acute hazard to the skin and eyes from direct or scattered radiation.

The Resonetics RapidX 250 Laser System is eligible for the Class I classification because the specific safety design meets the maximum access standards allowed by Table 1 of U.S. Federal Register 21 CFR parts 1000 and 1040. The hardware components that are part of this overall safety design include the workstation enclosure and access doors, beam stop control box, light seal doors, interlock switches, workstation indicator lights, and beam stop. The presence of each of these safety features contributes to the overall Class I laser classification of the Resonetics RapidX 250 Laser System. The removal or disabling of any one feature may negate that classification.

The Class I Resonetics RapidX 250 Laser System is designed to prevent access to laser radiation during normal use. Do not attempt to override any of the interlocks or other safety features.

2.2.2 Ocular Hazards

Laser emissions in the far-UV region of the electromagnetic spectrum present a hazard to the cornea of the eye. Too much exposure to this radiation causes a “welder’s flash” to the cornea that can last several days, depending on the severity. Far-UV radiation emission direct from the laser beam, or even the specular radiation reflecting off a flat surface, may be enough to cause eye injury if exposure is prolonged. Since UV light is invisible to the naked eye, routine protective measures are necessary to prevent needless exposure.

The U.S. Occupational Safety and Health Administration requires that employees with occupations requiring exposure to laser beams are furnished with suitable laser safety goggles for the specific wavelength concerned. Your Class I Resonetics RapidX 250 Laser System does not present a hazard during normal operations; however, a safety policy concerning eye protection should be established by your company. Resonetics recommends the use of safety equipment meeting ANSI standards Z87.1 and Z136.1 for maintenance personnel working with excimer lasers.

2.3 Safety Features

The Resonetics RapidX 250 Laser System includes several safety features described in this section.

2.3.1 Electrical Safety Precautions

High voltages are present in the Coherent COMPexPro[®] 110 excimer laser head. Voltages up to 48 VDC are readily accessible at connectors and cable plugs throughout the workstation. Single-phase, 208 VAC, 15 A power is present up to the laser power supplies.

These voltages all can be lethal. Circuit boards and connectors should not be disconnected while power is available. Prior to servicing the Resonetics RapidX 250 Laser System, all electrical power should be removed by powering down the system (see Section 3.3, on page 3-2.) Always execute the high voltage grounding procedure in the [COMPexPro[®] \(RoHS\) User Manual](#) prior to working near the high voltage components inside the laser head. This action must be taken even if the laser has not been operated for a long period of time.

2.3.2 Mechanical Safety Precautions

All compartments, except the process enclosure and laser compartment, are optically isolated from laser radiation. All electrical access panels require the use of tools for entry.

Mechanical safety hazards include the presence of moving parts within the process enclosure, specifically table motion. Hazard exists in the form of bodily harm potential to hands or arms placed in the processing compartment during table motion. There is also a possibility of damage to motors if tools or other solid materials become lodged between moving surfaces.

2.3.3 Materials Safety Precautions

The helium gas used in this system is completely inert and poses no toxicity threat. However, large amounts of inert gas released into a small, poorly ventilated room might pose a danger of suffocation by replacing oxygen in the atmosphere. Your Resonetics RapidX 250 Laser System should be installed in a well-ventilated area and all gas cylinders must be transported and stored as described below.

The halogen gas fluorine used in the system is corrosive and toxic, but its concentration has been diluted in the premix gas cylinder. Special care should be taken when handling compressed gases in general, but the handling of fluorine mixture requires extra care.

WARNING

The fluorine gas used in this system is highly toxic and poses a toxicity threat. It must be handled with great care and any contact or exposure should be strictly avoided.

Gas handling components have been designed to ensure safe delivery of gases to the laser and to prevent system contamination during cylinder exchanges. The following rules for the safe handling of compressed gases should be observed in order to prevent accidents:

- When moving gas cylinders, always use a hand truck. Cylinders should never be rolled, dragged, or placed on their sides.
- Secure the gas cylinders properly at all times and replace the protective cap over the cylinder valve when not in use.
- Keep the gas cylinder valves closed except when filling or running the laser.
- Never open any gas cylinder into the room atmosphere.
- When connecting a new cylinder to the gas handling subsystem, thoroughly leak-check the connection prior to placing the manifold in service.
- Always make sure the primary valve is securely closed when storing a gas cylinder. The safety plug uses left-hand threads.
- When removing a gas cylinder from service, always leak-check the primary valve and its safety plug prior to installing the safety cap.
- Keep the gas cabinet door closed and locked when access is not required.

In the event of a large gas leak, the primary valve to the premix or other gas cylinders should be shut. Shut down the system and direct other nearby employees to vacate the area. Make sure all ventilation subsystems are operating and call appropriate safety personnel.

2.3.4 Processing and Maintenance Precautions

There are no processing or maintenance operations that require human access to the laser beam. All enclosure access doors (including the beam delivery access doors and processing compartment access window door) must be shut for normal laser processing. Any attempt to access the interior during operation will shut down the system automatically. The following safety precautions apply to routine processing operations and system maintenance:

- The service override key must remain off (the red SERVICE OVERRIDE indicator is *not lit*). See Figure 2-1 and Section 5.4.4, page 5-26.
- Interlock switches must be in operating condition and never defeated for any purpose.
- Never touch any lenses or optical components without proper gloves. Dirty optics can scatter the laser beam in a manner or direction not intended by the beam delivery subsystem design, posing a hazard to the next service person. Furthermore, dirty optics will degrade the performance of the laser system.
- Some maintenance tasks that require access to the interior of the workstation must be performed with system power off. In this case, the system power switch (located on the front lower left of the workstation, see Figure 2-2) must be in the OFF position. In addition, follow the safety precautions listed above.

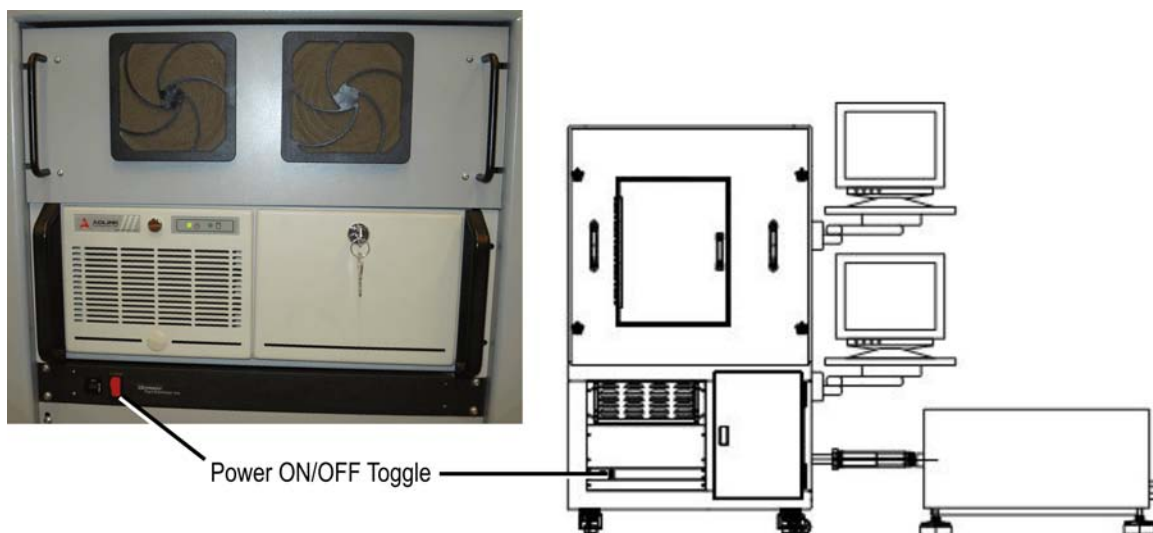


Figure 2-2. Power OFF / ON Toggle Switch

2.4 Service Precautions

It may be necessary for a service person to have access to the beam to perform tasks such as optical alignment of the beam delivery subsystem. This access can be accommodated through the use of the service override key, which is located on the beam stop control box and labeled as SERVICE OVERRIDE (see Figure 2-1). When the interlock override key is in service, the red SERVICE OVERRIDE indicator is *lit*. In this case, all interlocks (except those on the laser specifically) are overridden, thus permitting beam stop operation independent of enclosure access doors.

Service access with an exposed Class IV beam is an inherently dangerous condition for the service person and anyone in the vicinity. The wavelength of the excimer laser presents an additional hazard insofar as the UV beam is invisible to the naked eye. Only service people specifically trained to work on the Resonetics RapidX 250 Laser System should use the service override key. The following precautions must be observed:

- Be sure access to the processing enclosure in service mode is absolutely necessary before using the service override key.

- Only the authorized service person may be in the vicinity while the machine is in service mode. It is the service person's responsibility to determine if assistance is required. All service assistants must be informed of the potential ocular hazard and trained to provide the assistance required.
- The preferable location for service in service mode is inside a room where access by nonessential personnel is limited. Any door leading into the room must have a sign posted conspicuously on the outside, warning people that exposed laser light may be present and that protective eye wear is required. For installations where the system cannot be moved into a separate room, light curtains must be set up to contain fully any specularly reflected beam. If the factory floor has mezzanines, the curtains must be arranged to protect people in those areas while in service mode. The same warning sign must be posted conspicuously at the entrance to the service area.
- Protective eye wear must be worn at all times by service personnel and any assistants. Policies regarding eye protection must be established by the factory according to local safety statutes.
- Rings, watches, and other jewelry must be removed prior to placing hands or arms into the interior of the processing enclosure.
- NEVER look into the laser beam. Use caution to ensure the beam is not present before undertaking any inspection procedure that may require close examination of the beam delivery subsystem. One effective method for detecting the laser beam is to insert (using gloves) a piece of thermal paper into the beam path. The thermal paper will discolor quickly if the UV beam is present. Another technique is to place a carbon block into the beam path. The carbon will fluoresce a white emission if UV light is present.
- Do not expose your skin to the beam or any specularly reflected portion of the beam. Wear long sleeve clothing and cloth gloves for the best protection.
- Do not place hand tools or any other objects down inside the enclosure. Use a mobile cart for temporary tool placement.

2.5 Interlocks

During normal operation, the laser beam is confined to the laser bay and the processing compartment of the workstation enclosure. Access to these areas is not required during laser operations. Therefore, both compartments are sealed optically and interlocked to prevent human access.

2.5.1 Interlock Locations and Operation

The access panels on the process cabinet are interlocked such that the beam stop closes automatically if any door or window is opened during laser operations. Interlocks are installed as shown on Figure 2-3.

All interlock switches are normally closed during laser operations. When the interlock override key is in service, the red SERVICE OVERRIDE indicator is *lit*. In this case, all interlocks (except those on the laser specifically) are overridden, thus permitting beam stop operation independent of enclosure access doors.

Exterior portions of the beam delivery subsystem that are not interlocked require the use of a tool to gain access, and only trained service personnel are allowed to access these while the laser is operating. Prior to each operation shift, the system should be inspected to ensure that all

protective housing components are in place. If any protective housing component is found to be displaced or missing, it must be replaced before normal machine operation is initiated.

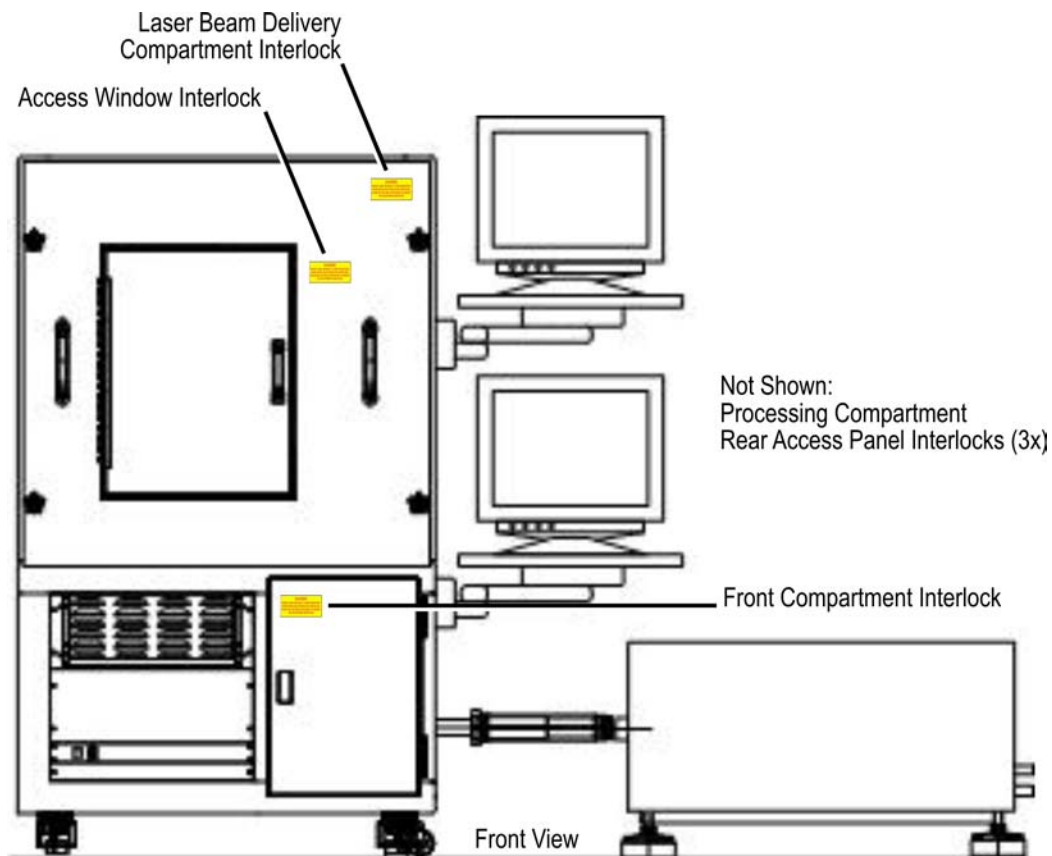


Figure 2-3. Locations of Interlocks

2.5.2 Key Switch Control

There is one key switch control, located on the beam stop control box. It is the service override key, which prevents inadvertent or unauthorized starting of the laser. The key should be to switch to service mode only for service by authorized service personnel. When the interlock override key is in service, the red SERVICE OVERRIDE indicator is *lit*. The key cannot be removed in this position.

See Figure 2-1 on page 2-2 for the location of the service override key and indicator (SERVICE OVERRIDE).

2.6 Safety Mechanisms

The Resonetics RapidX 250 Laser System includes several safety mechanisms, as described in this section.

2.6.1 Manual Reset

The term *manual reset* is used by the FDA to refer to the design provision of a Class I laser product that prevents automatic restart of laser emission in the event of inadvertent system de-energize. The operator must restart the system using normal startup procedures (see Section 3-2, *Startup Procedure*, page 3-2) in the event of a power loss.

2.6.2 Beam Stop

The system has one beam stop located on the right side of the workstation at the entrance of the beam delivery system, as shown in Figure 2-4.

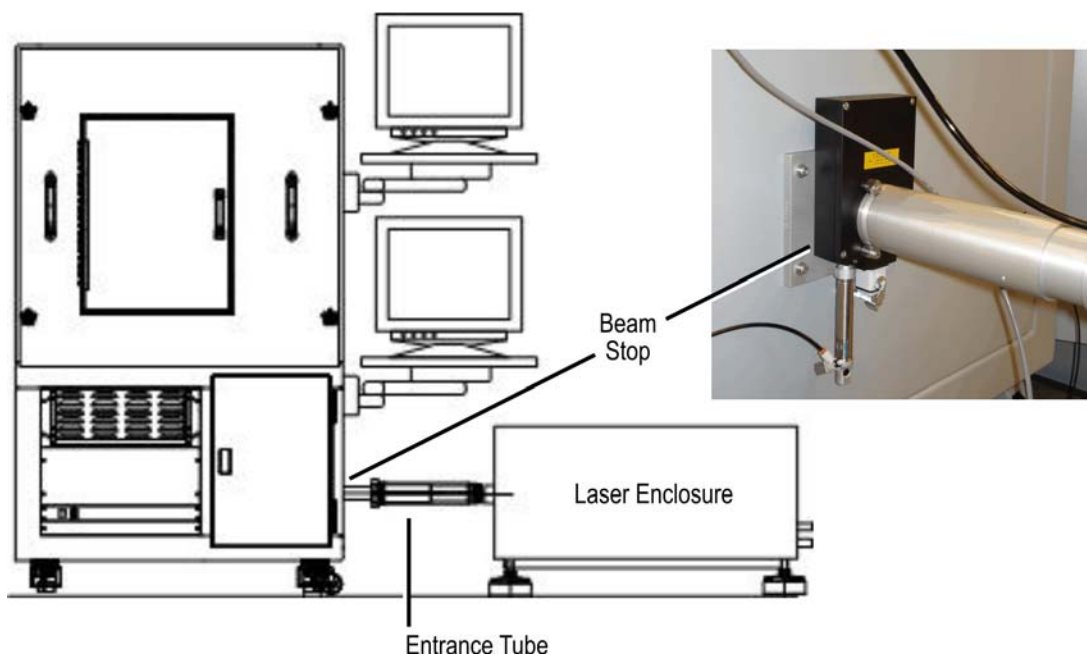


Figure 2-4. Beam Stop Location

The beam stop opens to allow the laser beam to travel into the processing cabinet. When closed, the laser head beam stop prevents the main laser beam from exiting the laser cabinet. The beam stop can be toggled open or closed by an external switch (labeled BEAM STOP OPEN) on the beam stop control box. The beam stop is open when the green BEAM STOP OPEN indicator is lit. Refer to Figure 2-1 on page 2-2 for the location of the beam stop control switch and indicator.

In addition to the external switch (labeled BEAM STOP OPEN) on the beam stop control box, the beam stop can be opened or closed using the laser control keypad (described in Section 5.2.5, page 5-10, or the [COMPexPro® \(RoHS\) User Manual](#)).

If an unsafe condition exists (for example, the access door is open), the beam stop will shut automatically as long as the condition persists.

FOR SERVICE ONLY: When the system is in service mode (*SERVICE OVERRIDE* indicator is *lit*), the beam stop can be opened simultaneously with any access door or window on the processing cabinet.

2.6.3 Labeling

Specially worded laser safety labels are placed on exterior locations around the Resonetics RapidX 250 Laser System. They are intended to warn personnel of the potential laser radiation hazards. These labels are required by federal law and must remain affixed at all times. The system should be inspected periodically for their presence. The exact wording and locations of the labels are shown in Figures 2-5 through 2-8.

Refer to the [COMPexPro® \(RoHS\) User Manual](#) for descriptions of labeling on the Coherent COMPexPro® 110 laser. If you are using the Affinity® chiller option, refer to the [Affinity® S-Series Chillers User Manual](#) for descriptions of labeling.

RESONETICS
MICROMACHINING TECHNOLOGY
4 Bud Way, Building 21, Nashua, New Hampshire 03063
Telephone: (603) 886-6772 FAX (603) 886-3655

MODEL NO: RAPIDX 250 LASER SYSTEM

SERIAL NO: 5250
MANUFACTURED: JULY 2011
IN NASHUA, N.H. U.S.A

120 VAC 1 PHASE 15 A 60 Hz
3 PRONG CONFIGURATION WITH GROUND

This product complies with CDRH performance radiation standards
For Class I Laser System. Excimer Laser, 193 and 248nm, 40W max

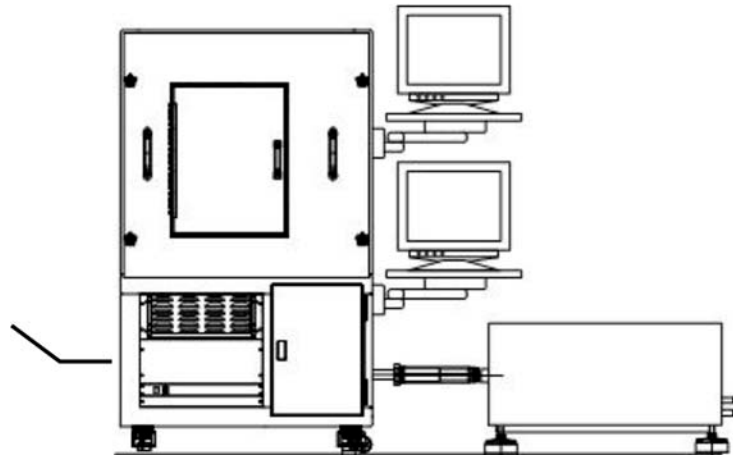


Figure 2-5. System Identifier Label

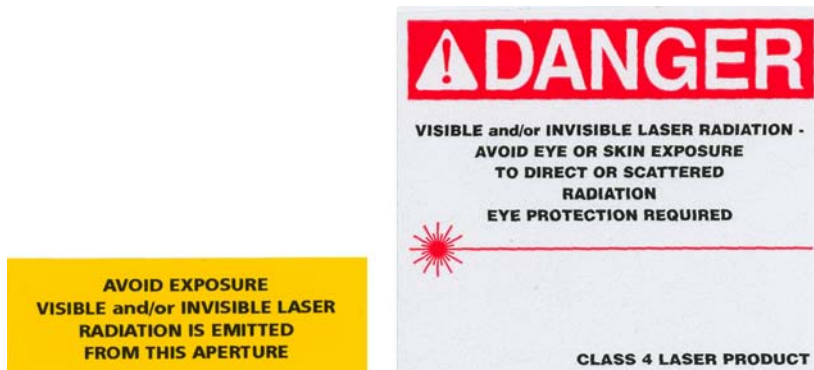


Figure 2-6. Aperture (Avoid Exposure) Label and Class IV Laser (DANGER) Label

Resonetics RapidX 250 CompexPro System

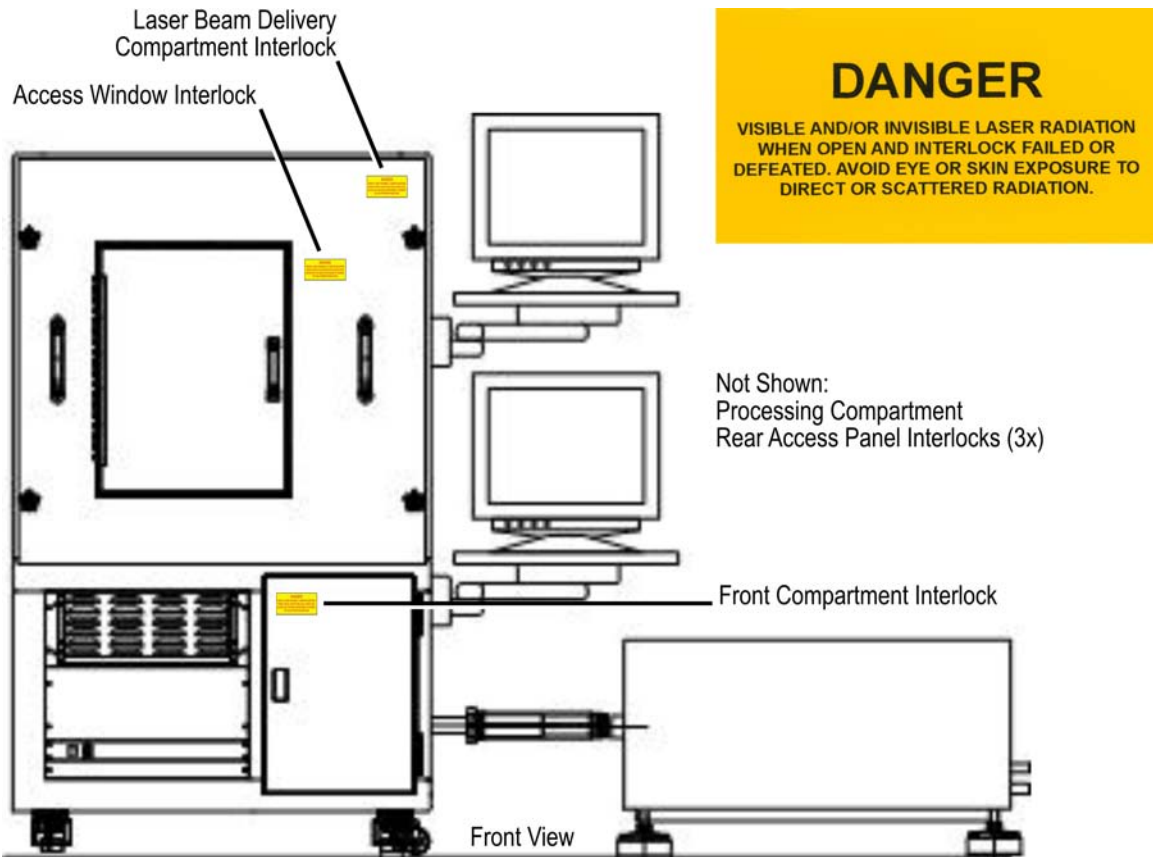


Figure 2-7. Interlock Labels



Figure 2-8. High Voltage Label

Notes

3. Basic System Operation

An excimer laser is a specific type of molecular gas laser that produces high intensity light in the ultraviolet (UV) range of the electromagnetic spectrum. The UV light source is a Coherent COMPexPro® 110 excimer laser, which is configured to operate with KrF (krypton-fluoride) at 248 nm or with ArF (argon-fluoride) at 193 nm.

To switch from a wavelength of 248 nm (standard configuration) to 193 nm, both the resonator mirrors and the beam delivery system (BDS) turning mirrors must be replaced. Beam-forming and projection lenses in the BDS are compatible with both wavelengths. Operation of the RapidX 250 Laser System at 193 nm is possible with a 193 nm conversion kit.

For reference, features of the Resonetics RapidX 250 Laser System are outlined in Figure 3-1. Each feature is described in Section 5.

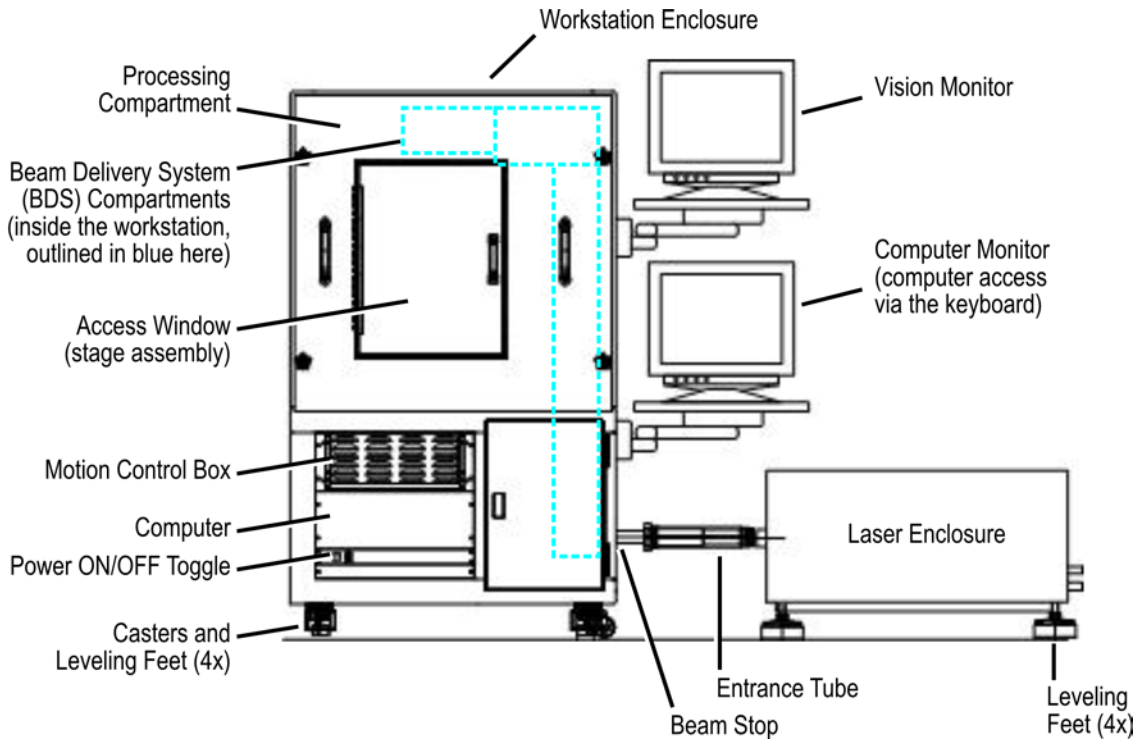


Figure 3-1. System Overview (Front View)

The remainder of this section describes the operation procedures for the Resonetics RapidX 250 Laser System. Operating procedures are carried out by the operator who starts the system, loads the machine, runs process programs, and shuts down the system when processing is complete. Operating procedures do not require access to the laser beam.

3.1 Startup Procedure

This procedure starts the Resonetics RapidX 250 Laser System and should be used from a cold start. The procedure brings the system up to the point where it is ready to process a work piece.

If startup is following actuation of an interlock, the original cause of the abnormality should be corrected first. Refer to the section of the [COMPexPro® \(RoHS\) User Manual](#) regarding laser device startup.

Initial Conditions

- All power is off.
- All access panels and doors are closed.
- The laser main breaker is off.
- The laser key switch is off.
- The BEAM STOP OPEN switch is OFF (the green indicator is *not lit*).
- The SERVICE OVERRIDE switch is in the OFF position (the red indicator is *not lit*) and the key is removed.
- Cooling water and process gas are available to the machine.
- Excimer laser gases are off.
- N₂ purge gas, compressed air supply, electrical services, process gas, and the exhaust system are on.

System Startup Procedure

1. If you have the water chiller option, refer to the [Affinity® S-Series Chillers User Manual](#).
 - a. Inspect the unit inside and out to be sure that there are no fluid leaks. Do not attempt to operate the unit unless the system appears secure and dry.
 - b. All cable connections must be in place and secure. Ensure that the proper power (voltage, breaker, and phase) is applied.
 - c. Turn the ON/OFF switch on the rear panel to the OFF position.

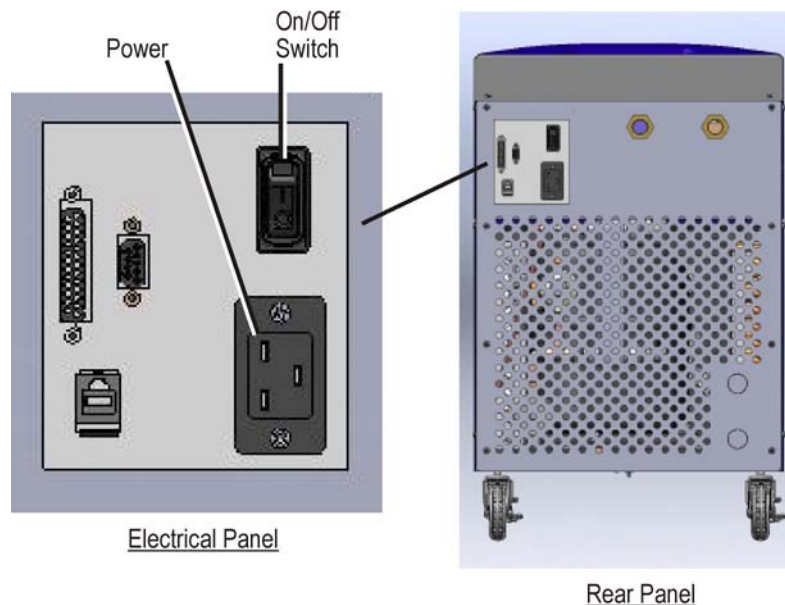


Figure 3-2. Chiller (option) ON/OFF Switch

- d. Fill the reservoir with coolant.
- e. Close the Main Breaker. Turn the ON/OFF switch to the ON position. No warning or alarm lights should be lit.
- f. If necessary, jog the pump by pressing the Power button for 2-3 seconds. The Power button is located on the user interface panel on the front of the chiller. This step may need to be repeated several times. If there is difficulty priming the pump, refer to “Priming the Pump and Connecting the Coolant Loop” in the [Affinity® S-Series Chillers User Manual](#).

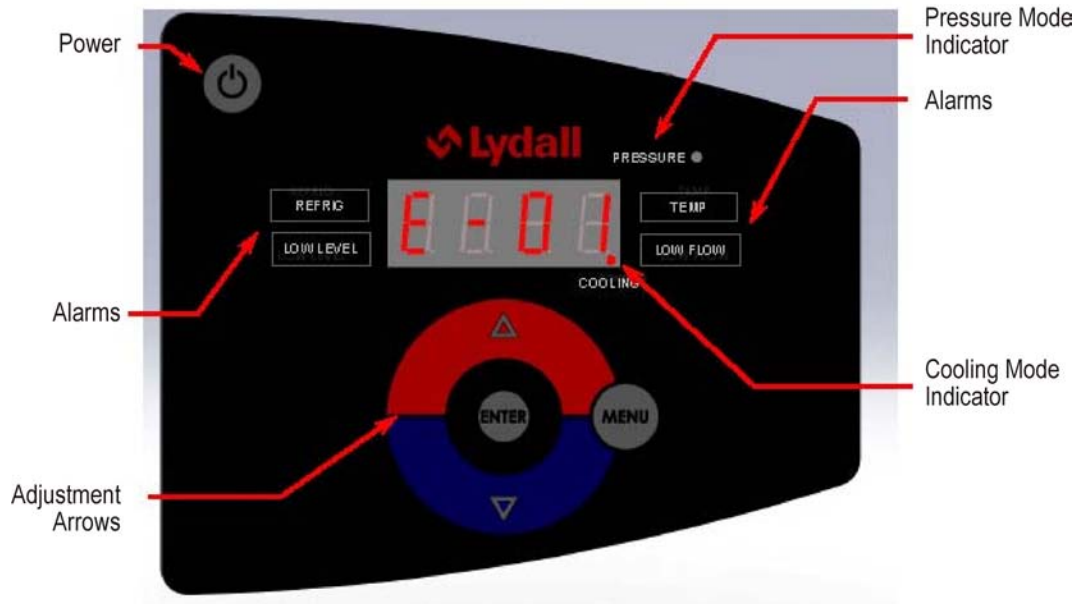


Figure 3-3. Chiller (option) User Interface Panel

- g. Once the pump is primed ensure the reservoir cap in place and secured.
 - h. Push the Power button on the user interface panel. The unit should begin operation.
2. Make sure the air exhaust is operating properly. Your facility exhaust system should remain running continuously.
 3. Check for the presence of parts or materials in the process enclosure, especially anything that would impair the full travel of the positioning system.
 4. Toggle the power switch to the ON position (see Figure 3-4). It is located at the bottom left of the workstation (below the computer). This will energize the main control computer, motion box, camera, camera illuminator, and fans.
 5. Turn on the excimer gases. Consult the [COMPexPro® \(RoHS\) User Manual](#) for the types of gases to use and procedures to replace gas cylinders.

Table 3-1. Excimer Gases

Gas Connection	Gas Type	Pressure
Halogen	F ₂ /Ne mixture	4.3 bar
Rare	Ar or Kr	4.3 bar
Buffer	Ne	4.3 bar
Inert	He	4.3 bar

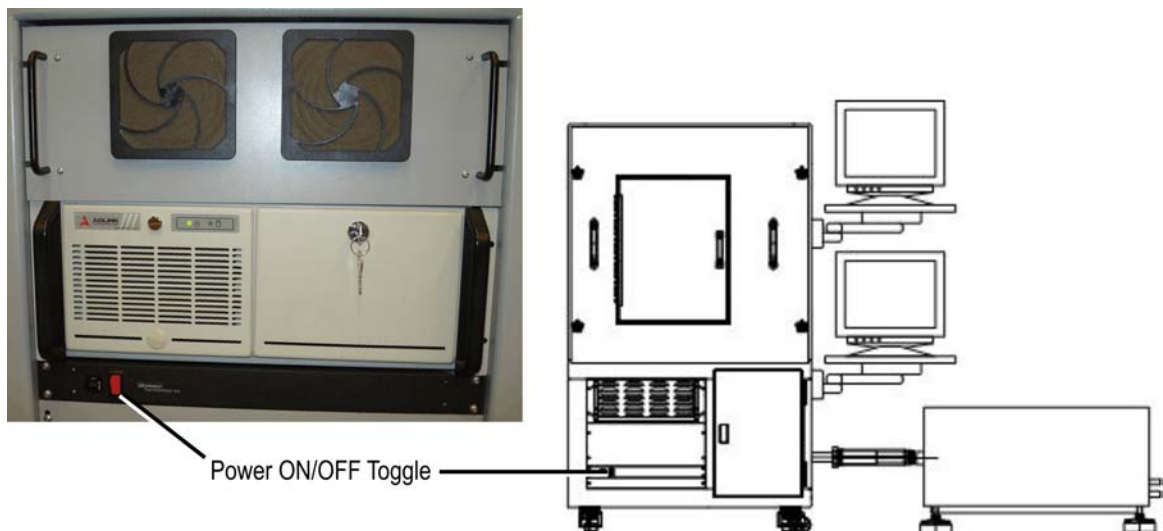


Figure 3-4. Workstation Power Toggle Switch

6. Begin to turn on the laser by setting the mains switch to ON (see Figure 3-5). The green POWER ON light indicates line voltage is applied to the laser. The laser cannot be started, however, until the control voltage is activated through the key switch.

Insert the key into the key switch and set to “I” to activate the control voltage. The control voltage is required for the control modules in the laser device (e.g. local control board). The CONTROL SUPPLY 24V DC light indicates that the control voltage has been activated. When the indicator lights, the control modules in the laser device are ready to operate. See the [COMPexPro® \(RoHS\) User Manual](#) for details.

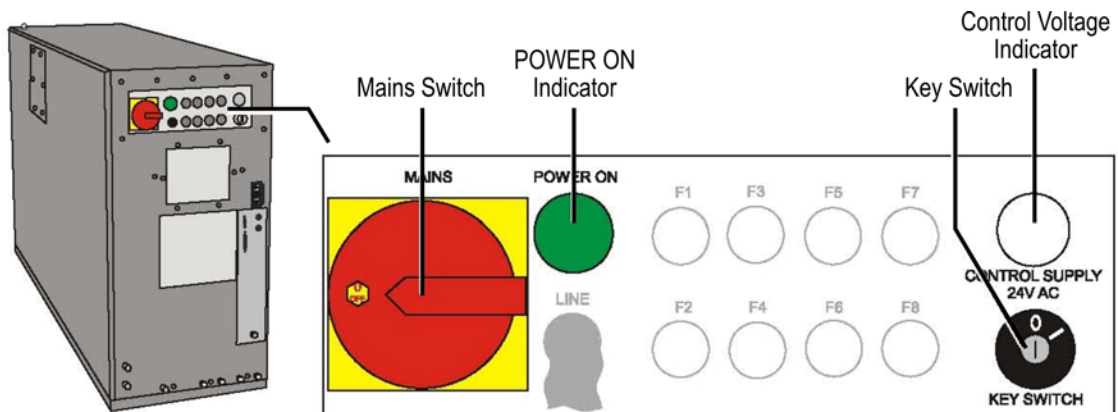


Figure 3-5. COMPexPro® 110 Laser Control Panel

The laser is operated from the laser control keypad (see Section 5.2.5, page 5-10), as detailed in the [COMPexPro® \(RoHS\) User Manual](#).



Figure 3-6. Handheld Keypad

Note: Be sure the beam stop is closed so the beam does not enter the workstation. The beam stop control indicator (green) is *not lit*.

Note: It is very important to operate the laser at or close to its specified parameters. The laser should always operate with the high voltage within its limited specified range. If the high voltage is too low, the discharge is unstable and the output becomes unstable (large variations of energy pulse-to-pulse). If the high voltage is too high, its electrodes will wear rapidly or the laser may misfire. Refer to the [COMPexPro[®] \(RoHS\) User Manual](#) for the proper high voltage operating values. Do not attempt to operate outside of this range. If you need to lower the energy, it is more advisable to use attenuator(s) in the beam path than lowering the high voltage. If you need higher energy, use higher demagnification to increase energy density on target. Do not increase high voltage or laser energy settings as this would result in shorter gas life and shorten thyatron and electrodes life.

7. Press the TRIGGER INT/EXT button to select the laser pulse triggering mode. Use the cursor keys to select INT for internal triggering. Press the ENTER button.
8. Press the Mode button to select the running mode. Use the cursor keys to select EGY NGR for energy constant mode without partial gas replacements. Press the ENTER button.
9. Press the REPRATE button. Enter 20 for the pulse repetition rate. Press the ENTER button.
10. Press the EGY button. Enter 120. Press the ENTER button.
11. Press the RUN STOP button to start the laser. The laser stabilization takes 5-10 minutes.
12. After laser stabilization, repeat Step 9 changing the repetition rate to 100.
13. Repeat Steps 10 and 11.
14. Check the display on the keypad. The HV should be approximately 24 kV and the Energy should be 120 mJ.
15. Stop the laser by pressing the RUN STOP button.
16. Press the TRIGGER INT/EXT button. Select EXT for external triggering. Press the ENTER button.
17. The laser is in standby mode waiting for firing pulses from the motion controller.

- Turn the beam stop control switch (on the beam stop control box) to the ON position. The green indicator should be *lit*.


3.2 Processing Procedure Overview

The following procedure is a basic guideline of how to get started with the A3200 software used to process a work piece. Refer to Section 6 for software details.

Initial Conditions

- The system is energized and the computer has booted.
- The process enclosure access window is open. All other doors are closed.
- The service override switch is in the OFF position and the key is removed.
- The beam stop control switch is in the OPEN position.
- The laser is in External trigger mode and Run mode.

Processing Procedure

- On the Windows® desktop, double-click the A3200 CNC Operator Interface:  The A3200 CNC Operator Interface window is displayed, as shown below. (A3200 software is described in Section 6.)

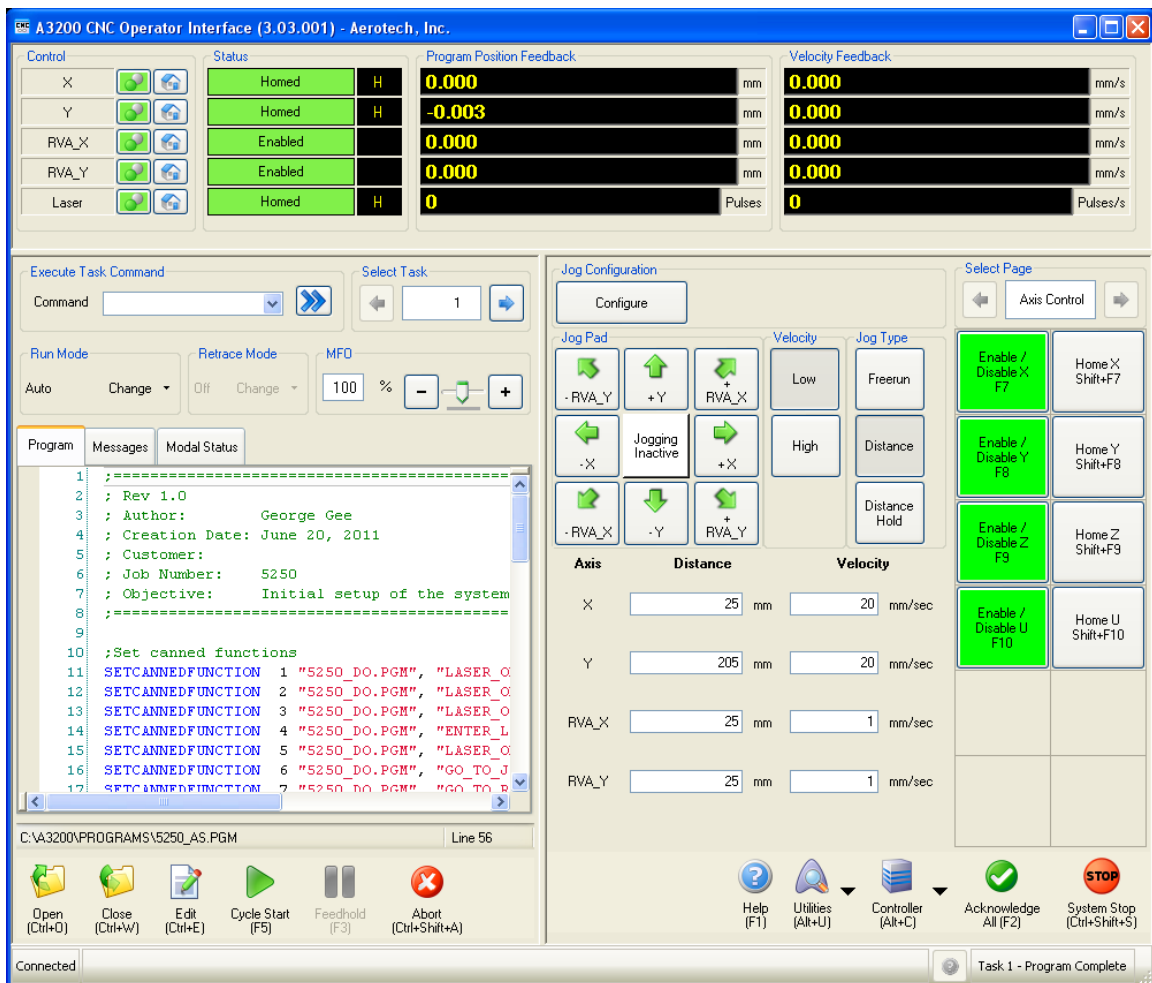


Figure 3-7. A3200 CNC Operator Interface

When A3200 software starts, a setup program runs automatically. It sets up the laser and motion stages. The A3200 CNC Operation Interface will list information as the system initializes.

2. After the initialization, you can open a file for processing. Click the Open button (bottom left of the window) or press Ctrl+O.
3. Select a file for a program to run.
4. Click the Cycle Start button (bottom left of the window) or press F5 to run the program.

Note: Verify proper laser operation occasionally by monitoring the high voltage. In ENERGY CONSTANT mode, the laser automatically increases high voltage to maintain constant pulse energy, compensating for slow gas depletion. When the high voltage approaches the maximum permissible value, a halogen injection or new gas fill is required. Refer to the [COMPexPro® \(RoHS\) User Manual](#) for information about maintaining high voltage and delivering halogen injections to the laser cavity.

Note: You should not have more than one A3200 program open at the same time.

3.3 System Shutdown

This procedure should be used to shut down the Resonetics RapidX 250 Laser System for the day when all processing is complete.

Initial Condition

- The system is ON.

System Shutdown Procedure

1. Turn off the computer using the standard Windows® shutdown procedure:
 - a. Exit the A3200 software.
 - b. From Windows® desktop Start menu (lower left corner of the screen), select the Turn Off Computer option. The computer will shut down.
2. On the laser, set the key switch to “O” to disable the control voltage power. Set the mains switch to OFF to disconnect the laser device from the mains power supply.
3. Toggle the power switch to the OFF position (located on the front lower left of the workstation).
4. If you are using the chiller option, place the ON/OFF/SET switch in the OFF position.
At this point, the system is powered OFF.
5. (Recommended) Turn off all the excimer gases. This is good safety practice. It also ensures that you check all the bottle levels on a regular basis.
6. (Optional) Turn purge gas supply off on both the workstation and laser. Leaving the N₂ purge pressure on all the time may be beneficial to keep the optics clean, but it will consume N₂.

Notes



Part II

Equipment Reference



4. Theory of Operation

The remainder of this section describes the theory of system operation. (Hardware components are described in detail in Section 5.)

Most laser micromachining systems are one of two major types: direct-write systems or projection systems.

Direct-Write Systems

A direct-write system focuses an entire laser beam, often after some manipulation (expansion, profile modification, etc.), to a generally small spot on the surface of the work piece. Relative motion of the beam and the work piece (scanning) is achieved by moving the beam (such as using movable deflecting mirrors in galvanometer scanners) and/or moving the work piece. The profile of the beam on the work piece in these systems is usually round or nearly round, with more or less bell-shaped distribution of intensity across it. The micromachining process is substantially sequential, moving the beam from point-to-point in a desired trajectory so that a “trench” of a desired shape is produced. Depth of machining can be controlled by the intensity of the beam or by the duration of the time the beam is programmed to dwell at each location.

Projection Systems

In a projection system, the laser beam, often after some manipulation (such as expanding or contracting its size and making its intensity distribution uniform), is used to illuminate a binary mask, which is then re-imaged (by a projection or imaging lens) onto the work piece surface, usually with reduction in size (de-magnification). *Binary mask* in this context means an optical aperture with alternating transparent (with full or maximized transmission) and non-transparent (with no or very little transmission) regions, so that the light is admitted through transparent ones and then delivered to the work piece. Illuminating light striking the non-transparent regions is either reflected or absorbed by the mask. In this approach, complicated patterns can be projected simultaneously on the work piece, so the machining process can be parallel—when entire pattern is produced at the same time. Step-and-repeat (move the work piece and repeat exposure) will then allow creation of multiple identical patterns on the work piece.

Alternatively, a mask with a single (or multiple) round or rectangular transparent opening(s) can be used and the work piece moved in a programmed trajectory. In this case, single (or multiple parallel) “trenches” are produced as in the direct-write system. The projection system in this case enjoys a benefit of uniform intensity distribution across the mask opening(s) and thus across the beam spot on the work piece surface. This makes it possible to create “trenches” of rectangular depth profile.

With appropriate equipment, this projection approach also allows for the use of mask patterns larger in size than the available beam. In this case, the mask is continuously moved across the beam so that various sections of the pattern on the mask are illuminated. The work piece is simultaneously moved in a corresponding trajectory (taking into account reversal of the image and reduction of it in size by the projection lens) so that the entire pattern of the mask is reproduced on the work piece.

4.1 Theory of Operation

The motion and laser control subsystem is the heart of the RapidX 250 Laser System. This subsystem consists of the motors and drivers that move the X-Y positioning table (and any additional optional stages) and the computer hardware that controls the motion. Operating commands that control the motion subsystem and laser firing parameters are entered on an industrial PC.

4.1.1 Excimer Laser

An excimer laser is a specific type of molecular gas laser that produces high intensity light in the ultraviolet (UV) range of the electromagnetic spectrum. The primary component of the excimer laser is the laser head, which is the aluminum structure that is visible when the exterior cabinet panels are removed. The actual laser light is generated within the laser resonator cavity, which is a portion of the laser head. A special mixture of gases forms the *laser medium* and is held inside the laser head. These gases are re-circulated at high speed across the heat exchanger, the particle filter, and the electrodes by the gas circulation blower.

The most plentiful ingredient in the gas mixture is neon. Neon is referred to as the *buffer gas*. Small concentrations of fluorine (halogen) and rare gas (argon) are mixed with the buffer gas to form the laser medium. When a high voltage is applied across the laser electrodes, an electrical discharge is created which changes the physical state of the laser gas mixture. The process by which the gas returns to its normal state from this excited state results in high intensity light emission.

On each of the two ends of the laser resonator cavity with fine adjustable mounts are the resonator mirrors. Resonator mirrors are two finely polished and dielectrically coated mirrors that reflect light back and forth within the gas medium. The combination of these mirrors and the discharge electrodes forms an optical cavity that directs light emission into the form of a laser light pulse. The rear resonator mirror is highly reflective, while the front one is quite transmissive and only slightly reflective. The light exits the laser through the front mirror, after which it is directed and transformed to a useable form by the *beam delivery subsystem* (BDS).

4.1.2 Laser Machining Process

Due to its high pulse energy and short wavelength, UV excimer laser light can be used to process materials in ways other types of lasers cannot. Target materials exposed to the excimer laser beam are immediately vaporized. This vaporization process occurs quickly, in roughly 100 nanoseconds. The gaseous remains of the vaporized material expand very rapidly, carrying with it the heat generated during the process. The ablation process results in little or no heat affected zone in the vicinity of beam impact on the work piece surface. Consequently, excimer laser machining produces a clean edge cut that cannot be duplicated by other lasers. Excimer laser micromachining is sometimes called a “heatless” process.

The other factor making UV light desirable for materials processing is its *short wavelength*. In the RapidX 250 Laser System, features can be imaged with UV light to resolutions on the order of one micron. Since the absorption depth of UV light is very small (about one tenth of a micron), the layer of material affected by the beam is very thin. One laser pulse will vaporize one layer of material a fraction of micron deep.

4.1.3 Projection Imaging

In the RapidX 250 Laser System, the laser beam is manipulated by an optical BDS, whose first element is a horizontal beam tube directing the beam from the laser cabinet into the processing cabinet. The length of the beam path inside the workstation determines the minimum and maximum attainable imaging demagnification parameters. One video display monitor is included for work piece alignment and for observing the machining process in progress.

The projection lens creates an image of the mask on the work piece surface. The workstation comes with three projection lenses to choose from, depending on the demagnification required. See Table 5-2 (page 5-5) for available operating parameters. If your system is accompanied by an argon-fluoride conversion kit, the projection lenses will be dual-coated for both ArF and KrF operation.

A manually adjusted iris is provided at the entrance to the projection lens mount. The purpose of the iris is to limit the cone of the light admitted to the imaging lens thus affecting characteristics of the image.

The machining quality of the laser beam depends on the pulse rate, table feed rate, and power density delivered to the applications site. The BDS directs and shapes the laser beam thereby controlling the beam pattern and power density at the work piece as shown in Figure 4-1. Both these parameters depend on:

- How the beam is shaped with the mask and
- How the mask pattern is imaged on the processed material.

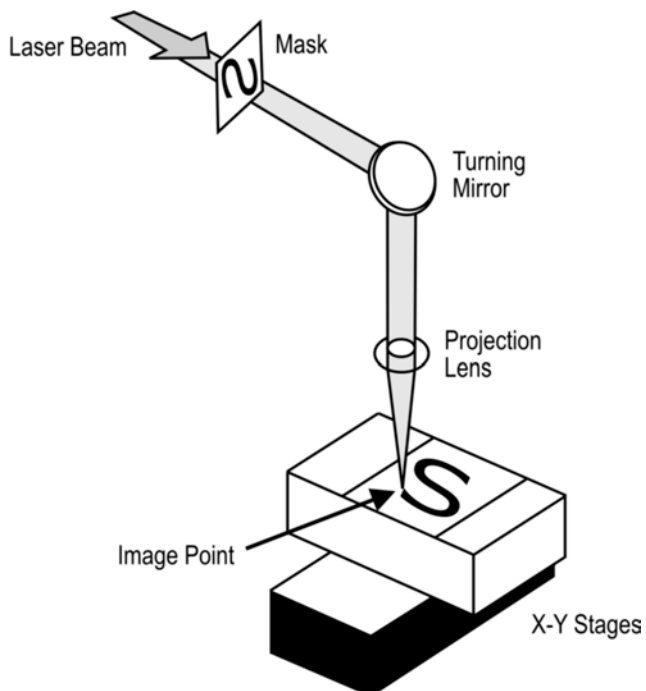


Figure 4-1. Image Point Machining with a Laser Beam

The basic features of mask imaging are illustrated in Figure 4-2, where **OD** is the object distance, **ID** is the image distance and **FL** is the focal length of the imaging lens. h_o is the object and h_i is the image size.

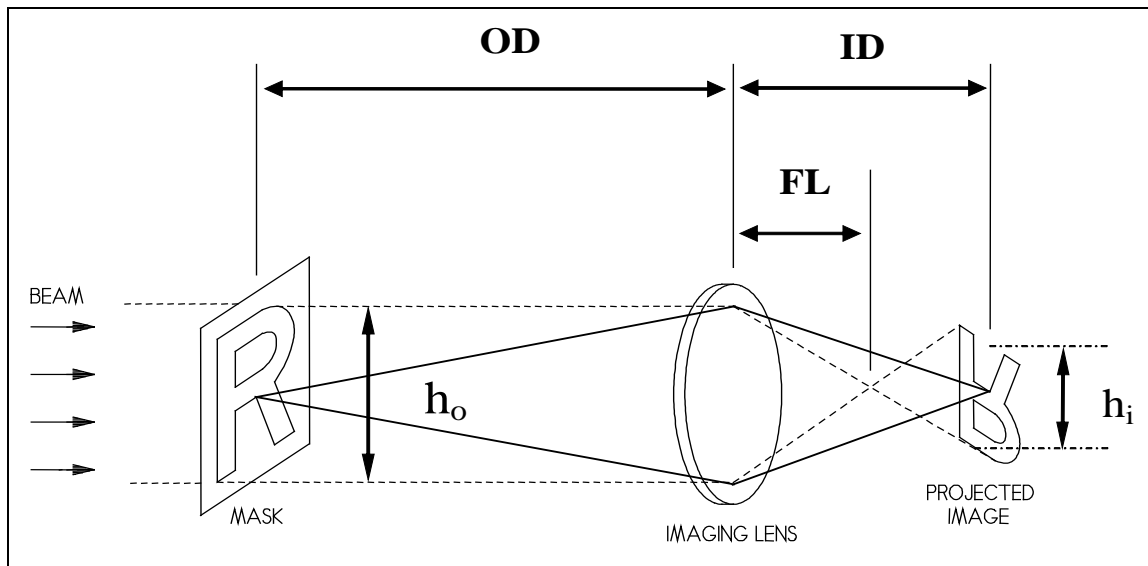


Figure 4-2. Mask Imaging

The relationship between the parameters in Figure 4-2 can be approximated by the thin lens equation:

$$\frac{1}{FL} = \frac{1}{OD} + \frac{1}{ID}$$

When manipulating the figures in this equation, be sure to convert the parameters to the same units of measurement. The term *magnification* in optics normally is used to describe the ratio of the image size to the size of the object, implying that the image size h_i is greater than the size of the object h_o . Here we have a case of *demagnification*, where the image size is smaller than the object, or mask. Consequently, the relationship of demagnification to the setup parameters of Figure 4-2 is:

$$d = h_o / h_i = \frac{OD}{ID}$$

where d is the demagnification. Since, if losses are neglected, the same amount of energy is present at the image plane as at the mask plane, it should be obvious that a desirable byproduct of near-field imaging is increased energy density. The effects of the beam compression component of near-field imaging can be approximated by:

$$p_i = p_o d^2$$

where p_i and p_o represent the image (sample) and object (mask) pulse energy densities or fluences.

Adjustment to the height of the projection lens above the work piece provides a means of focusing the image (setting ID distance) while positioning of the mask holder allows the setup of a proper object (mask) to lens distance OD.

5. Equipment Description

The Resonetics RapidX 250 Laser System consists of these major subsystems:

- **Workstation enclosure.** The workstation enclosure is a frame that contains (as described below) beam delivery and motion subsystems as well as exhaust connections, gas connections, and electrical distribution. The frame structure has interlocks for safety. See Section 5.1 (page 5-2) for a description of the enclosure subsystem (including facility requirements).
- **Coherent COMPexPro[®] 110 excimer laser enclosure.** See Section 5.2 (page 5-5) for a description of the laser subsystem and optional accessories. There may be an optional water chiller subsystem (as described in Section 5.2.10, page 5-12).
- **Beam delivery subsystem (BDS).** The BDS includes all components that steer and shape the laser beam from the point where it leaves the laser cabinet to the incident point on the work piece. In addition, the BDS illuminates process operations and displays video of operations on the camera view monitor. Section 5.3 (page 5-15) describes each BDS component.
- **Motion and laser control subsystem.** This subsystem consists of the motors and drivers that move the XY positioning table as well as a computer that controls the motion and laser firing parameters. The computer also communicates to the machine vision software. See Section 5.4 (page 5-24) for a description of each motion and laser control component.
- **Exhaust, gas, and electrical subsystems.** The workstation enclosure includes exhaust connections, gas connections, and electrical distribution. See Section 5.5 (page 5-27).

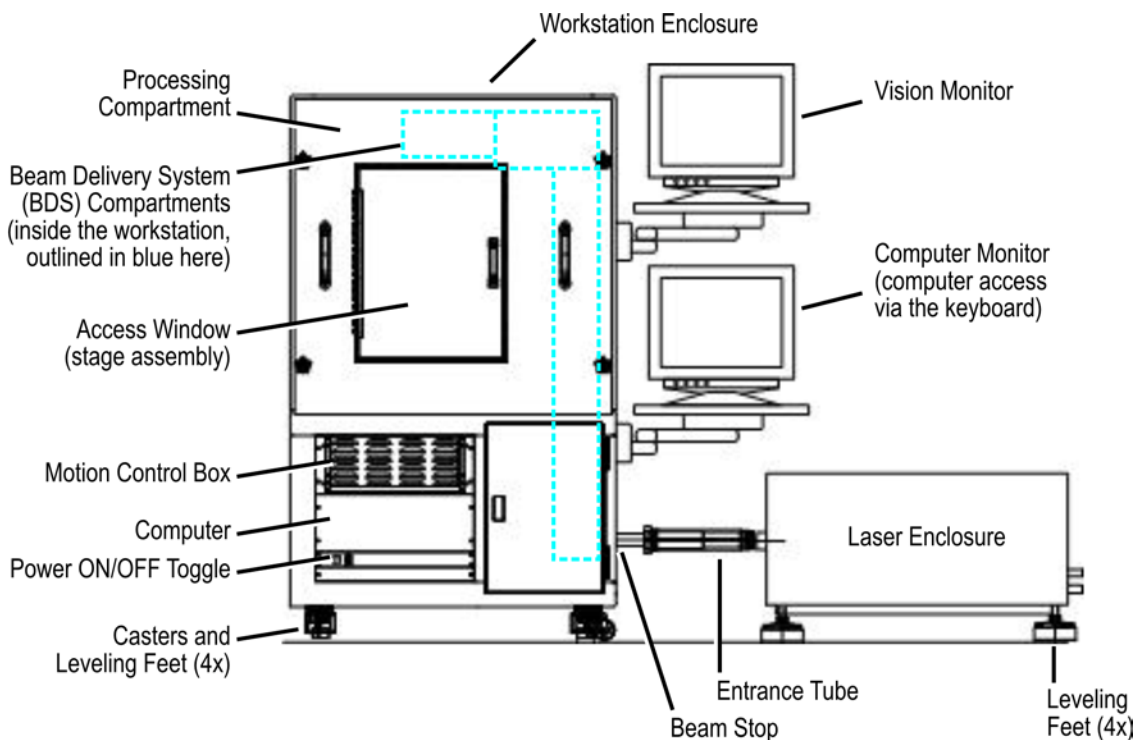


Figure 5-1. System Overview (Front View)

This section begins with an overall description of the equipment followed by information about each subsystem.

5.1 Workstation Enclosure

The process enclosure is a steel structure with two access doors (rear door and lift-top door) and a front loading window. The beam delivery system (BDS) and processing compartments are interlocked with the laser beam stop for safety purposes, so that personnel access to the laser beam is not possible.

5.1.1 Facility Requirements

The following are specifications and layouts of the Resonetics RapidX 250 Laser System.

Table 5-1. Workstation Specifications

Dimensions	Workstation	Width: 40" (100 cm) Height: 66" (167 cm) Depth: 37" (95 cm)
	Laser	Length: 175 cm (69") Width: 86 cm (34") Height: 58 cm (23")
	Chiller (optional)	Length: 67.4 cm (26.5") Width: 41.7 cm (16.4") Height: 68.0 cm (26.8")
Weight	Workstation	500 lbs (250 kg)
	Laser	275 kg (505 lb)
	Chiller (optional)	82 kg (180 lb) dry
Facility Support	Nitrogen Purge	2-10 scfm (0.15-0.3 m ³ /min) (for 193 nm operation only) ¼" (6 mm) OD tubing on the left side
	Process Gas Assists	70 PSI (5-6 bars) max., flow as required ¼" (6 mm) OD tubing on the left side
	Compressed Air	70 PSI (5-6 bars), flow 5 scfm (0.15 m ³ /min) Dry, oil free ¼" (6 mm) OD tubing on the left side
Electrical Requirements	Workstation	115 VAC, 60 Hz, 1 phase 15 A service Flying lead 3-wire cable
	Laser	115 VAC ±10%, 50/60 Hz, 1 phase 3 wires (hot, neutral, and ground) 25 A service
	Chiller (optional)	208VAC, 2 phases and ground, 20 A max., 60 Hz
Exhaust Requirements	Workstation	Flow: 100-200 scfm (170-340 m ³ /hour) Flange: 3" (75 mm) diameter (on the right side) Head Load: < 1 kW
	Laser	Flow: 120 scfm (200 m ³ /hour) Flange: 6" (150 mm) diameter (on the right side) Head Load: < 1 kW

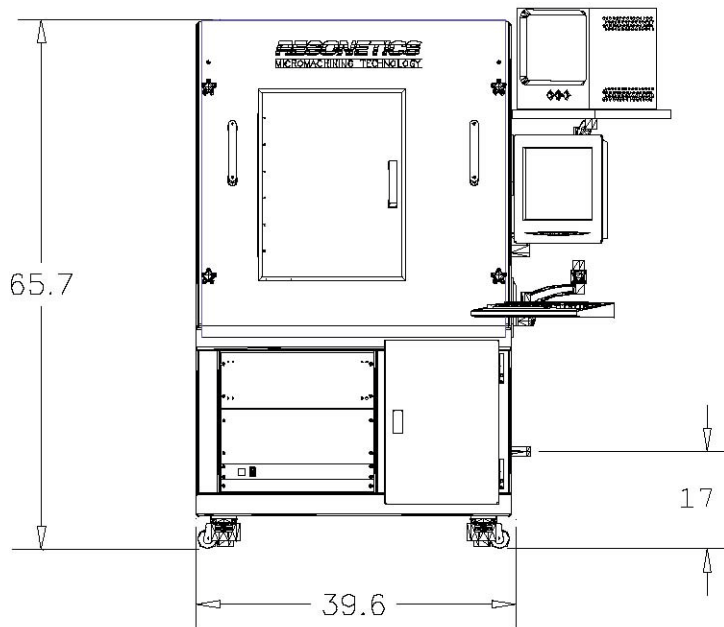


Figure 5-2. Front View of the Resonetics RapidX 250 Laser System (dimensions in inches)

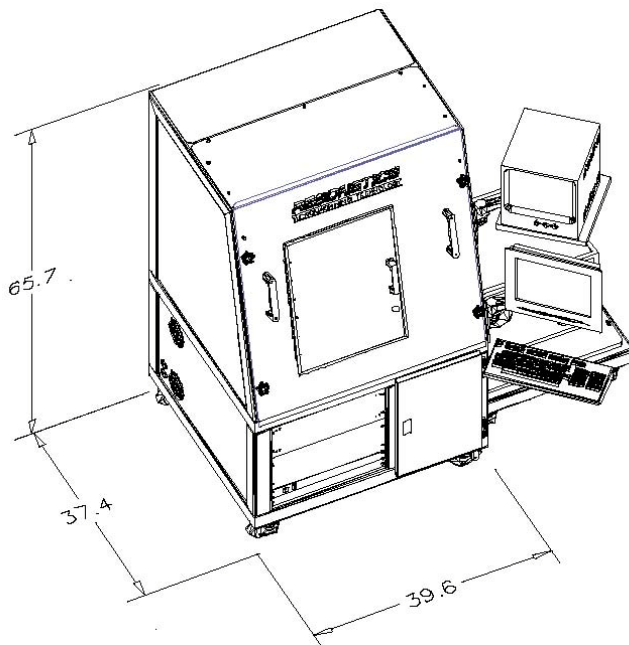


Figure 5-3. Isometric View (dimensions in inches)

5.1.2 Bulkhead Connection Panel

Refer to the [RapidX 250 Series Workstation with CompexPro Series Excimer Laser Pre-Installation Guide](#) for additional information.

5.1.3 Casters and Leveling Feet

The workstation is supplied with four casters to move it into place (see Figure 5-4). When the system is installed, the workstation should be lifted off the casters.

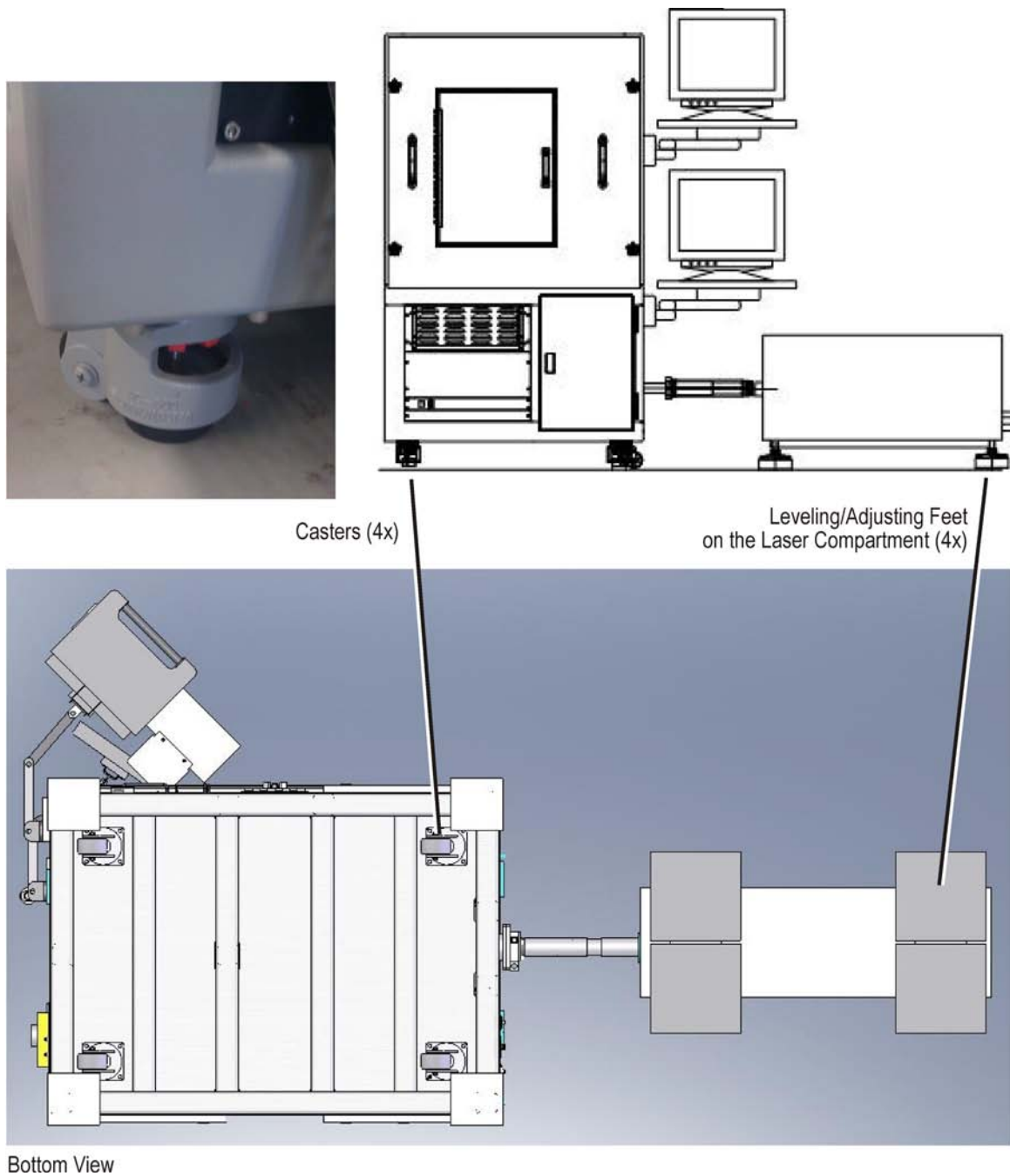


Figure 5-4. System Casters and Feet

5.2 Laser and Optional Accessories

The laser subsystem components include the laser head, high voltage power supply, main control assembly, gas handling module, and energy monitor. The vacuum pump is installed outside the laser and connected to the gas manifold via a halogen gas filter. All cabling, gas connections, and cooling water piping enter the laser cabinet through the back panel.

A list of laser performance parameters is provided in Table 5-2. For facility requirements (environmental, physical, and electrical), refer to Section 5.1.1 on page 5-2. A more complete list and detailed description of the Coherent COMPexPro[®] 110 excimer laser subsystem is contained in the [COMPexPro[®] \(RoHS\) User Manual](#).

Table 5-2. COMPexPro[®] 110 Laser Subsystem Parameters

Laser Specifications	ArF	KrF		
Wavelength	193 nm	248 nm		
Maximum output power	12 W	30 W		
Maximum pulse energy at 100 Hz	120 mJ	300 mJ		
Typical operating pulse energy	96 mJ	240 mJ		
Repetition rate	100 Hz	100 Hz		
Pulse duration	20 ns	20 ns		
Beam dimensions (V x H), FWHM	24 mm x 5 mm	24 mm x 7 mm		
Typical usable beam	16.0 mm x 3.4 mm	16.0 mm x 4.7 mm		
Projection Lenses	ArF (193 nm)		KrF (248 nm)	
	Min Demag	Max Demag	Min Demag	Max Demag
FL = 155 mm	5x .6 J/cm ²	15x 5.4 J/cm ²	5x 1.5 J/cm ²	15x 13 J/cm ²
FL = 75 mm	15x 5.4 J/cm ²	25x 15 J/cm ²	15x 13 J/cm ²	25x 37 J/cm ²
FL = 50 mm	25x 15 J/cm ²	35x 30 J/cm ²	25x 37 J/cm ²	35x 70 J/cm ²

5.2.1 Laser Head Cabinet

As mentioned previously, the laser head is the large centrally mounted aluminum structure inside the laser head assembly. It is a pressurized housing that contains the laser resonator cavity and the laser vessel. The laser resonator cavity is a small portion of the laser head where the laser light is actually formed. It consists of the resonator optics, the pre-ionization gaps, and a pair of high voltage electrodes that run along the entire length of the chamber. The pre-ionization gaps produce the required electron density in the gas medium between the electrodes just before high voltage is applied for each laser pulse. When high voltage finally is applied, the electric discharge pumps the gas molecules to their excited state and a laser pulse results.

Typically, a higher voltage across the electrodes produces a larger pulse energy and, in order to maintain constant laser power, the high voltage must be increased gradually as the laser gas degrades. The largest portion of the laser head is the laser vessel that serves as a reservoir of laser gas required in support of the lasing process. This reserve of fresh laser gas is blown continuously through the laser resonator cavity across the electrodes by a gas circulation blower. The blower is actually a squirrel cage fan that is magnetically coupled to the external motor at the back end of

the laser head. The lasing medium must be circulated at a high turnover rate because the gas molecules must relax following each laser pulse. If the blower is not operating properly, the laser will sputter and multiple pulsations will not be possible. An electrostatic dust precipitator for scrubbing the gas clean is located inside the laser vessel.



Figure 5-5. COMPexPro[®] 110 Laser Head Cabinet

Other components associated directly with the laser head include the main control assembly, high voltage power supply, energy monitor, and pulsed power module. The high voltage power supply uses a switching mode to produce pulsed voltage to the thyatron. The thyatron is simply an electronic switch that opens and shuts in response to a control trigger and is capable of switching a high current at high repetition rates. When triggered, the thyatron closes, applying the charge held by the storage capacitor across the bank of peaking capacitors and gas discharge cavity.

Most excimer laser subsystem failures can be traced back to components in the high voltage power supply or discharge cavity because of the high currents involved. If the laser will not fire, even though high voltage is applied, the heater and reservoir voltage adjustments on the thyatron are the most likely culprits. These voltages, typically 6-7 VAC, heat the gas in the thyatron by thermal emission. As the thyatron ages, heater and reservoir voltages must be increased slightly to achieve proper switching. If the laser tends to fire prematurely when no trigger is present, try lowering heater and reservoir voltages slightly. The procedure for making thyatron adjustments is provided in the [COMPexPro[®] \(RoHS\) User Manual](#).

5.2.2 Gas Handling

The gases normally used for ArF applications in excimer lasers include argon, fluorine, neon, and helium. The gases normally used for KrF applications in excimer lasers include krypton, fluorine, and neon.

The appropriate mixture of these gases will provide the greatest laser energy output at the specified wavelength. Argon and krypton are sometimes called *rare gases* while fluorine is often called the *halogen gas* and neon is the *buffer gas* in excimer laser applications. These gases are mixed automatically during a new gas fill at the ratio listed in Table 5-3.

The gas fill in an excimer laser will age during usage until the entire cavity gas charge needs to be replaced. During this aging process, the laser beam will expand horizontally and vertically, thereby reducing the energy density of the beam. The reason for this aging process is that fluorine byproducts from the gas discharge infiltrate the resonator cavity and plate out on the interior surfaces of the laser cavity. Overall laser energy can be maintained to a point by raising the high voltage set point. But, once the high voltage limits of the power supply are reached, a gas replenishment is required. Either the gas fill must be replaced completely, or a halogen injection can be administered. A halogen injection constitutes a spurt of fluorine, usually 20-40 mbar, introduced into the cavity that can extend the life of the gas up to several hours of laser operation.

A complete refill of the laser cavity gas is called an *Auto Fill*. A new gas fill, or Auto Fill, is administered automatically by an operator using the handheld keypad (see Figure 5-8 in Section 5.2.5, page 5-10).

Table 5-3. Standard Gas Ratios for ArF (193 nm) and KrF (248 nm)

These mixtures are for a standard recipe. Your laser recipe may vary slightly. The exact recipe for your laser is programmed and can be viewed on the handheld keypad (Section 3.3.5, page 3-15).				
Gas Mixture (Wavelength)	Gas	Pressure (%)	Gas Connection	Total Pressure (mbar)
ArF (193 nm)	Fluorine mix (F ₂ /He)	0.17/3.16	Halogen	3000
	Argon (Ar)	5.33	Rare	
	Neon (Ne)	78.00	Buffer	
	Helium (He)	13.33	Inert	
KrF (248 nm)	Fluorine mix (F ₂ /He)	0.12/2.30	Halogen	3300
	Krypton (Kr)	3.03	Rare	
	Neon (Ne)	94.55	Buffer	
Laser gas suppliers normally stock fluorine in a standard mixture of 5% fluorine and the balance in helium or neon as shown above. When administering a new gas fill to the COMPexPRO® 110 laser cavity manually, for example, the partial pressures for halogen and rare gasses should be delivered first, and the neon added last to a total pressure of 3000 mbar.				

Immediately after system delivery or following a laser refurbishment, a new fill may last approximately one day of laser operation using ArF or may last a week or so of laser operation using KrF. After a number of new gas fills, laser output energy will become insufficient for machining purposes due to fluorine residue on the front and rear optics. In this case, cleaning the resonator optics will restore laser energy to its original output. As the laser shots accrue over time, however, the lifetime of a gas fill will decrease until neither laser fill nor optics cleaning is effective in restoring laser power. At this point a complete cavity refurbishment is required.

(Refer to Section 8.1.1, page 8-2, for information on initiating a new gas fill.)

The laser can be configured to receive gas from separate gas cylinders or a premix cylinder. The partial pressures required for separate cylinder gas delivery are listed in Table 5-3. A new gas fill from a premix source is easier to administer than as described above; however, there are several drawbacks. First, the premix cylinders are a more expensive means of gas delivery. Second, gas cylinder replacement using a pre mixture is more frequent and the presence of fluorine dictates special handling each time a cylinder is replaced. Your workstation configuration may include a gas cabinet. If so, the gas cabinet may be piped for delivering halogen injections automatically when operating in the Halogen Injection laser mode. The purpose of the gas cabinet is to isolate toxic gases in the event of leakage and exhaust them outside the facility.

Great care must be exercised at all times when handling gas cylinders, but especially during cylinder exchange procedures, to make sure that air from the factory environment does not enter and contaminate the interior of the laser. Equal care must be employed when handling fluorine because of its toxic nature. The use of all laser gases should be carefully monitored to control costs and ensure optimum laser operation.

When new, the cylinder gas pressure is at its maximum. As the gas is gradually consumed, the primary gas cylinder pressure will gradually decrease. A gas cylinder should be replaced when its primary pressure becomes too low to support a new fill. Table 5-4 shows the recommended replacement primary pressure for each laser gas cylinder. Outgassing of contaminants may occur,

especially for fluorine, from the interior walls of a gas cylinder when its primary pressure becomes too low and the cylinder is inactive for an extended period of time.

Table 5-4. Excimer Laser Gas Specifications

Do not commence a new fill if the neon or premix cylinder cannot sustain the complete fill volume—change the gas cylinder first.

Gas	Contents	CGA Fittings	Threads	Full Pressure (typ)	Regulator Setting	Replace Cylinder at Primary Pressure
Rare (ArF)	Argon 99.995%	CGA 580	Standard	~150 bar (2100 psig)	4.3 bar (60 psig)	14 bar (200 psig)
Rare (KrF)	Krypton 99.997%	CGA 580	Standard	~70 bar (1000 psig)	4.3 bar (60 psig)	14 bar (200 psig)
Halogen	Fluorine 5% He balance	CGA 679 (lead gasket)	Reverse	~70 bar (1000 psig)	4.3 bar (60 psig)	14 bar (200 psig)
Buffer	Neon 99.996%	CGA 580	Standard	~150 bar (2100 psig)	4.3 bar (60 psig)	14 bar (200 psig)
Inert	Helium 99.999%	CGA 580	Standard	~170 bar (2500 psig)	4.3 bar (60 psig)	14 bar (200 psig)
Premix	Kr/F ₂ /Ne	CGA 679	Reverse	~150 bar (2100 psig)	4.3 bar (60 psig)	14 bar (200 psig)

Gas pressures regarding excimer lasers are measured in millibar (mbar) or pounds per square inch (psi). One thousand millibar of absolute pressure equals one bar which is defined as atmospheric pressure at sea level. Typical gas cylinder regulator gauges are graduated in terms of gauge pressure (psig) whereas the COMPexPro[®] 110 handheld keypad (described in Section 5.2.5, page 5-10) displays pressure in *mbar absolute*.

A gas cylinder must have adequate pressure to introduce additional gas into the pressurized vessel. During a new gas fill, the laser reservoir will be pressurized to approximately 3000 mbar absolute. The gas regulator should be set to approximately 4.3 bar. You should observe the typical drop in gas cylinder pressure for a laser fill on your system and apply this value in determining when a gas cylinder should be replaced. The pressure set points listed in Table 5-4 are provided as guidelines until more compatible set points can be determined.

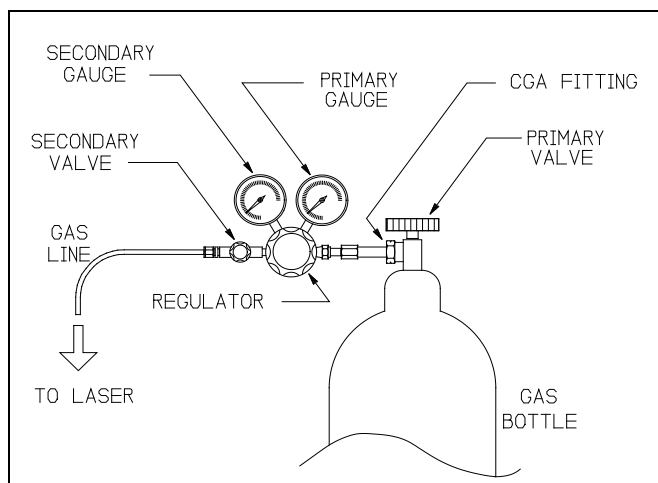


Figure 5-6. Gas Cylinder and Regulator

Gas cylinders are equipped with a *primary valve* and a Compressed Gas Association (CGA) fitting that is the connection point to the workstation. Fittings for non-toxic gases use standard threads, while oxidizing and toxic gas (such as fluorine) fittings must employ reverse (left-handed) threads. The appropriate gas connection for fluorine cylinders is a CGA 679 fitting. Since a gas pre-mixture contains fluorine, the regulator and cylinder connection for a premix configuration is CGA 679 and the gas piping is stainless steel. The neon and helium cylinders require a CGA 580 fitting.

When installed in the system, all cylinders are connected to a *pressure regulator* that regulates the gas delivery pressure to the laser. Most regulators are equipped with two pressure gauges: a *primary gauge* that indicates the pressure of the cylinder and a *secondary gauge* that indicates the delivery pressure to the laser as established by the regulator. Many regulators also have a *secondary valve* that is used to shut off the laser from the regulator. Good engineering practice dictates that the premix gas cylinder should be shut off at the primary valve after administering a new gas fill. All regulators are included in the optional gas cabinet (see Section 5.2.3).

Gas cylinders with a CGA 679 fitting are accompanied by new lead gaskets to replace the existing gasket in the CGA fitting. A new lead gasket should be installed each time the fitting is hooked up.

5.2.3 Gas Cabinet (Option)

Your workstation configuration may include a gas cabinet. The purpose of the gas cabinet is to isolate toxic gases in the event of leakage and exhaust them to outside the facility. An exhaust connection is provided on the gas cabinet (an 8" flange is located at the top of the cabinet).



Figure 5-7. Gas Cabinet and Gas Panel

5.2.4 Laser Internal Energy Monitor

Laser beam output for excimer lasers generally is evaluated in terms of pulse energy rather than power. Power measurements are more meaningful for high repetition rates or continuous wave emissions. The COMPexPro[®] 110 energy monitor is located inside the laser cabinet and displays on the handheld keypad (described in Section 5.2.5). The energy detector monitors laser energy from the energy reflected off a beam splitter that extracts a small portion of the laser emission. The energy monitor displays the laser energy averaged over a one-second period, so readings at low pulse rates may fluctuate.

5.2.5 Handheld Keypad

Laser energy and gas parameters are monitored and controlled from the handheld keypad. Laser engineers and operators should become familiar with the menus and parameter entries for the handheld keypad. Refer to the [COMPexPro[®] \(RoHS\) User Manual](#) for a complete description.



Figure 5-8. Handheld Keypad

The laser can operate in four modes that can be controlled using the handheld keypad. Refer to the [COMPexPro[®] \(RoHS\) User Manual](#), Section 3.5.2, for a complete description of each mode. In summary:

- Energy (EGY) mode without gas action (no gas replacement, NGR)
This is the constant energy mode of operation where the operator enters the required laser energy output and the energy monitor automatically adjusts high voltage to maintain the energy. If the process application for your machine requires only a few seconds of laser operation, the Energy mode may not be suitable for controlling laser energy during this application. The laser energy may fluctuate excessively in Energy mode.
- Energy (EGY) mode with gas action (partial gas replacement, PGR)
This is similar to the previous mode except that the system performs an automatic injection of halogen gas when the HV increases above a certain threshold value. This action increases the lasing efficiency, thus reducing the HV required to achieve the requested energy. EGY PGR mode can be used to increase the life of the gas. However, during the automatic gas injection, the laser energy may fluctuate, which may not be desirable in the middle of a sensitive process.

- High Voltage (HV) mode without gas action (no gas replacement, NGR)

This is a method of manual energy control that can be satisfactory for short applications; however, a certain degree of operator attention is required when operating in this mode. The user controls laser energy in this mode through manual adjustments to laser high voltage. A gradual increase in high voltage with time is required to compensate for gas aging. When high voltage reaches the point where adjustments can no longer return laser energy to the required output, a manually administered halogen injection or gas fill is required.

- High Voltage (HV) mode with gas action (partial gas replacement, PGR)

This is similar to the previous mode except that the system performs an automatic injection of halogen gas when the decreases below a certain threshold value. This action increases the lasing efficiency, thus increasing the energy output. HV PGR mode can be used to increase the life of the gas. However, during the automatic gas injection, the laser energy may fluctuate, which may not be desirable in the middle of a sensitive process.

Use of the High Voltage mode requires the attention of an operator to occasionally monitor laser energy and make the appropriate high voltage adjustments. The operator is encouraged to test the application with each of the modes of operation before selecting the optimal production mode.

The COMPexPro[®] 110 laser has two trigger modes:

- Internal—The internal laser trigger function can be used to warm up the laser or during various maintenance operations.
- External—In external trigger mode, the laser fires when it sees a trigger pulse on the BNC laser trigger input connection located on the right side panel (0-5 V TTL signal).

A complete description of each mode is provided in the [COMPexPro[®] \(RoHS\) User Manual](#).

5.2.6 High Voltage Power Supply

The high voltage power supply generates the high voltage necessary to charge the storage and peaking capacitors in the COMPexPro[®] 110 pulsed power module. The power supply is of a switched type because of the high voltage and instantaneous currents required. Although the power supply is fairly reliable, failures that do occur will be obvious, usually invoking an error message on the laser control keypad (described in Section 5.2.5, page 5-10). If components inside the power supply module fail, the entire power supply module should be sent back to the manufacturer for repair.

At high repetition rate, the high voltage can be set in the range of 22-26 kV. If laser pulse rate is limited under 10 Hz, the COMPexPro[®] 110 may be operated at high voltages even greater than the maximum of 26 kV. This capability may be useful for applications that require only a few pulses at high energy.

5.2.7 Exhaust Flange

A 6" (150 mm) diameter exhaust flange is located on the right side panel of the laser, as shown in Figure 5-9. The exhaust flange has a flow rate of 200 m³/hour (120 scfm) and a maximum heat transfer of 1 kW.

5.2.8 Water Connections

The laser requires approximately 2-3 l/min of water coolant with a maximum heat load of 1.5 kW. The laser head requires water coolant hoses, ½” (12 mm) inner diameter (ID), which are connected via two barb fittings located on the right side of the laser, as shown in Figure 5-9.



Figure 5-9. Water Connections on the Laser

5.2.9 Vacuum Pump

The COMPexPro[®] 110 vacuum pump is installed outside the laser head cabinet. The purpose of the pump is to evacuate the laser cavity during gas fills or other maintenance. The pump takes suction from the gas manifold through a halogen filter. The filter removes fluorine from the gas exhaust before it reaches the pump and is discharged to the atmosphere. The fluorine scrubber should be replaced approximately every 50 gas fills or whenever laser pump-down time becomes excessive. Spent canisters should be neutralized in baking soda and disposed of according to local environmental statutes.

The vacuum pump is turned on and off via the laser control keypad.

5.2.10 Water Chiller (Option)

The Resonetics RapidX 250 Laser System can be provided with a Affinity[®] S-Series air-cooled chiller, as shown in Figure 5-10.

The water chiller specifications are summarized in Table 5-5. For facility requirements (environmental, physical, and electrical), refer to Section 5.1.1 on page 5-2. Reference the [Affinity[®] S-Series Chillers User Manual](#) for chiller operation and maintenance procedures.

Always use clean filtered (10 micron) water such as spring or distilled water. Do NOT use de-ionized water. Do NOT use any chemicals or antifreeze in the water. To prevent algae water, a small amount of glycol can be used (<5%).



Figure 5-10. Water Chiller

It is recommended to keep the water temperature constant to within $\pm 1^{\circ}\text{C}$ for best stability performance of the laser. Water temperature always should be above dew point to prevent condensation to occur on the laser optics. It is best to keep the water temperature slightly above ambient temperature.

Table 5-5. Water Chiller Specifications

Parameter	Chiller Specifications	Laser Requirements
Pump Capacity	3.5 gpm (13.2 lpm) @ 40 psi (2.8 bar)	0.5 gpm (2 lpm)
Cooling Capacity @ 60 Hz	20°C (68°F) Ambient: 20°C (68°F)	10°C to 30°C
Inlet Water Pressure	40 psig (2.8 bar)	28-56 psig (2-4 bar)
Nominal Heat Removal	2 kW	< 1.5 kW

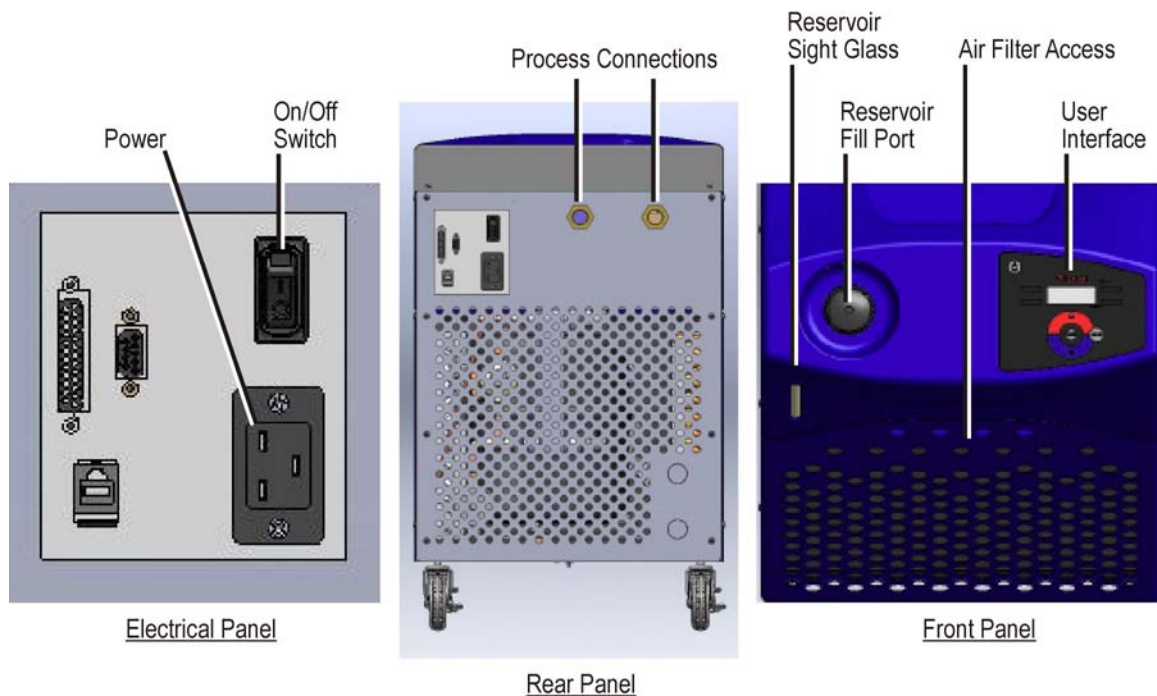


Figure 5-11. Water Chiller Features

Air Filter

An air filter is located on the front of the optional chiller. The filter is used to remove particles in the water. To protect the pump and the laser, routinely inspect the filter to be sure it is clean and attached properly.

Overview of Operation

The optional chiller is equipped with a user interface that combines all control and alarm functions on one panel (Figure 5-12). The multi-function display panel is used to show current process temperature, set value, cooling mode, and any error codes and memory parameters. Temperature, low flow, low level, and refrigeration alarms each have a dedicated backlit LED.

While the chiller is on, the default value shown in the display is the process value. To view the set point value, momentarily press either the up (red) or down (blue) Adjustment Arrow. To change

Resonetics RapidX 250 CompexPro System

the set point, hold down either the up or down Adjustment Arrow until you reach the desired set point and then press ENTER.

A Cooling Mode Indicator light is provided in the lower right hand corner of the user interface display window. This light will come on while the chiller is actively cooling. It is normal for this light to switch on/off when the chiller has satisfied the set point or heat load.

Use the MENU button to access the parameter submenus for changing parameters. Hold down the MENU button for 5 seconds to access the parameter menus. Press ENTER to go to a parameter. Press MENU to move “back” until you are out of the parameter menus.

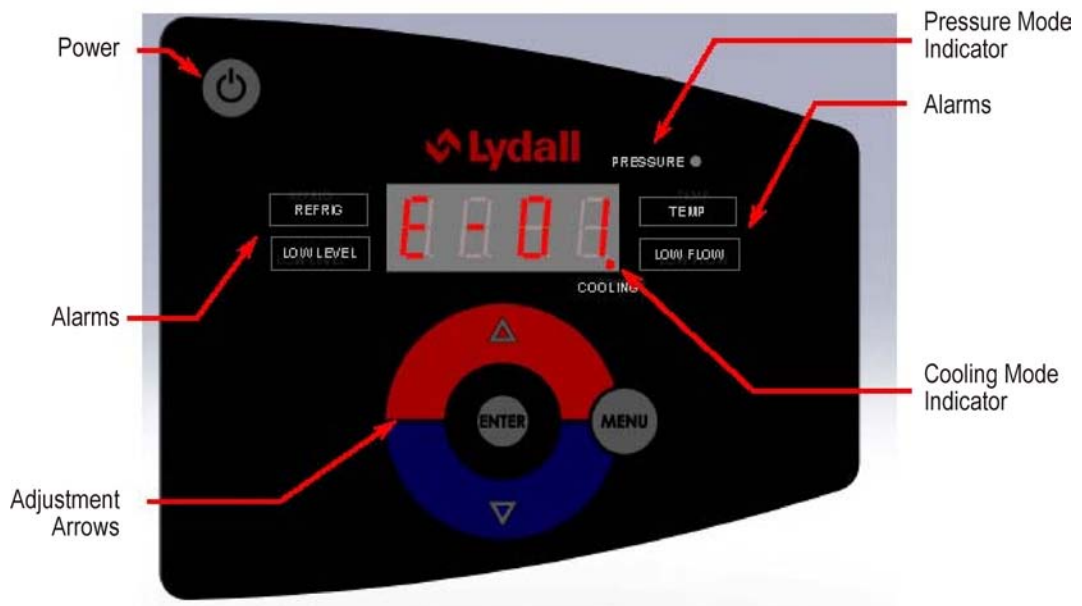


Figure 5-12. Chiller (option) User Interface Panel

5.3 Beam Delivery Subsystem (BDS)

The beam delivery subsystem (BDS) includes all components that steer and shape the laser beam from the point where it leaves the laser cabinet to the incident point on the top surface of the work piece (the target). In addition, the BDS illuminates process operations and displays video of operations on the camera view (vision) monitor.

On exiting the laser, the beam passes through the pneumatic beam stop into the purged BDS and arrives at turning mirror M1 which directs it vertically up through a mask holder*, attenuator (optional)*, and rectangular variable aperture (RVA)*. The beam then passes to turning mirror M2 where it travels horizontally to M3 and is re-directed vertically down through the projection lens assembly to the work piece mounted on the stage. A beam-trimming iris aperture is installed above the projection lens.

* The mask holder, attenuator, and RVA can be positioned anywhere along the beam path rails.

The BDS can be purged (from the beam stop to the projection lens) and the ambient air can be replaced with nitrogen, thus reducing absorption of radiation and preventing ozone generation.

The configuration of the BDS is illustrated in Figures 5-13 and 5-14.

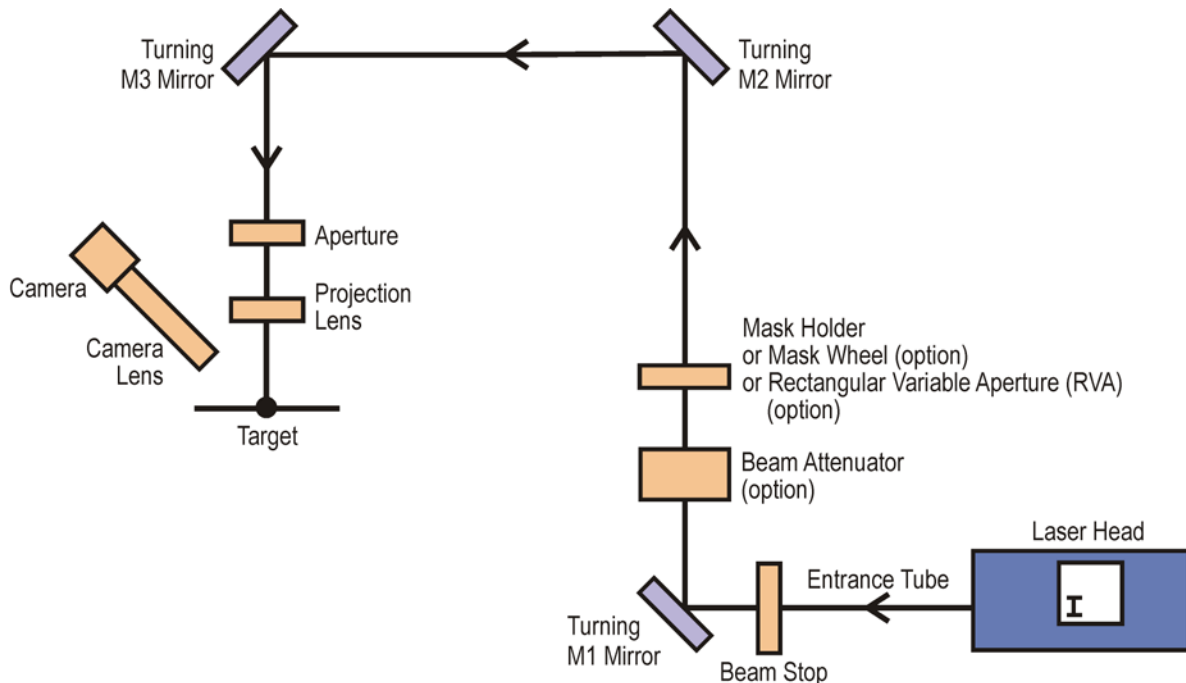


Figure 5-13. Block Diagram of the Beam Delivery Subsystem

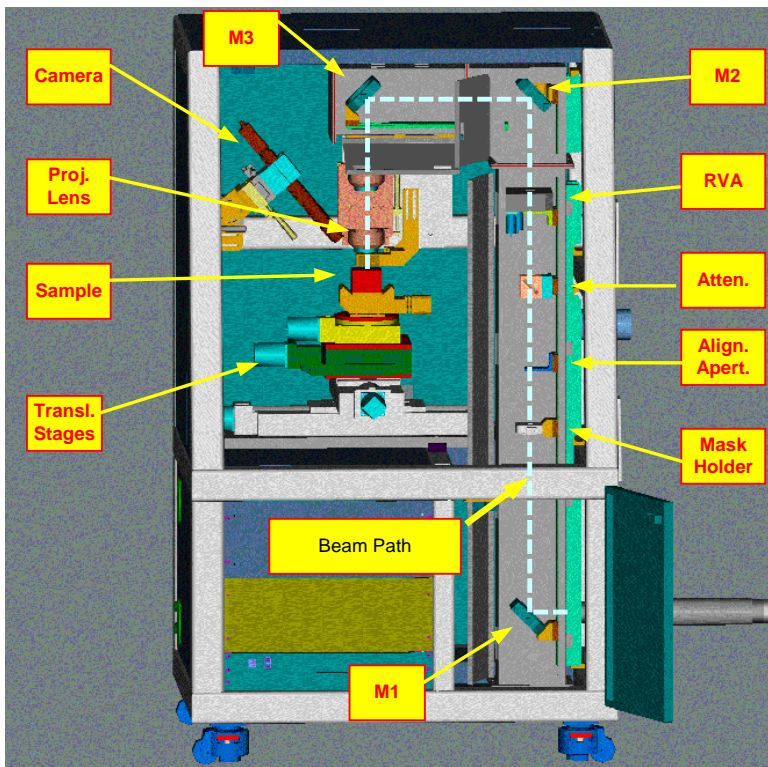


Figure 5-14. Overview of the Beam Delivery Subsystem Components

Components downstream of the laser include:

- Beam Stop Assembly (Section, page 5-17)
- Periscope Compartment (Section 5.3.2, page 5-18)
- Projection Assembly (Section 5.3.3, page 5-20)
- Camera Assembly (Section 5.3.4, page 5-21)
- Process Gas, Nitrogen Purge, and Compressed Air Vacuum (Section 5.3.5, page 5-23)

5.3.1 Beam Stop Assembly

The BDS supports the Class I regulatory categorization by providing a pneumatic laser beam stop as an operator safety measure. The laser beam is enclosed during normal processing operations and no operator access is possible. The beam stop assembly is mounted on the right side of the workstation at the end of the entrance tube that connects the laser to the workstation (see also Figures 5-13 and 5-14).

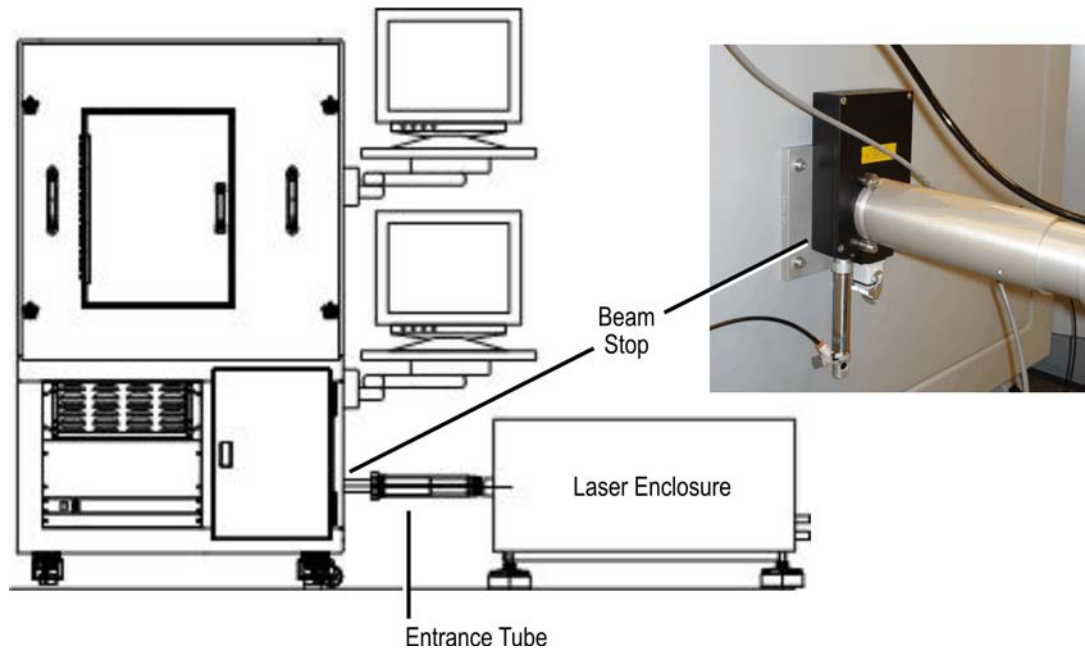


Figure 5-15. Beam Stop Assembly and Entrance Tube

In the closed position, the laser beam is prevented from entering the processing compartment and is absorbed by the energy dissipater. Normally, operations of the laser are controlled by the host computer.

If any safety interlock is actuated, the beam stop automatically closes.

The beam stop only operates manually with the beam stop control switch on the beam stop control box (see Figure 2-1 on page 2-2). The service interlock bypass key on the beam stop control box permits bypassing the beam stop interlock for service operations. If this switch is in the OFF position, the beam stop can be manually opened only if all interlocks are closed. In SERVICE mode (the switch is ON), the beam stop can be manually opened regardless of the interlock status. The beam stop assembly is spring-loaded to close on a loss of electrical power.

5.3.2 Periscope Compartment

The periscope compartment houses two turning mirrors (M1 and M2), single mask holder, rectangular variable aperture (RVA), beam attenuator, and drop-down mirror (M3).

Mirrors (M1, M2, and M3)

Each 2” mirror mount provides two degrees of rotational adjustment about the mirror center as well as translational adjustment relative to the optical bench. Once aligned, there should be no reason to make further alignment adjustments to the mirrors. All mirrors are kinematically mounted for precise angular alignment.

Mirrors are constructed of silicon. Components in the BDS are specifically constructed for 193 nm or 248 nm wavelengths and should not be replaced haphazardly. The mirrors require cleaning on a regular basis (refer to Section 8.3.1, page 8-6).



Turning Mirror M1



Turning Mirror M2



Drop-Down Mirror M3

Figure 5-16. Mirrors

Single Mask Holder and Mask Wheel (option)

The Resonetics RapidX 250 Laser System is a projection system in which the laser beam is used to illuminate a mask. Standard with the system is a stationary single mask holder (see Figure 5-17), which is designed to accommodate standard pin-referenced masks (typically, made of thin stainless steel foil). The holder is mounted on a sliding dovetail, so it can be mounted anywhere along the rail depending on the desired demagnification.

Note: In order to use the mask wheel option, you must ensure that the proper software parameters are set, as described in Section 6.4, page 6-8.

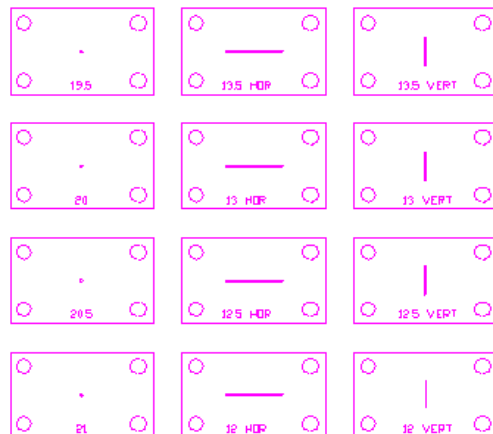


Figure 5-17. Single Mask Holder and Mask Set

Rectangular Variable Aperture, RVA (option)

The rectangular variable aperture or RVA (see Figure 5-18) allows for symmetric aperturing of the beam with the use of two sets of mutually-orthogonal blades. The aperture sizes range from 0 to 12 mm via a manual micrometer adjustment. The maximum aperture size is 12 mm x 12 mm. The RVA is mounted on a sliding dovetail, so it can be mounted anywhere along the rail.

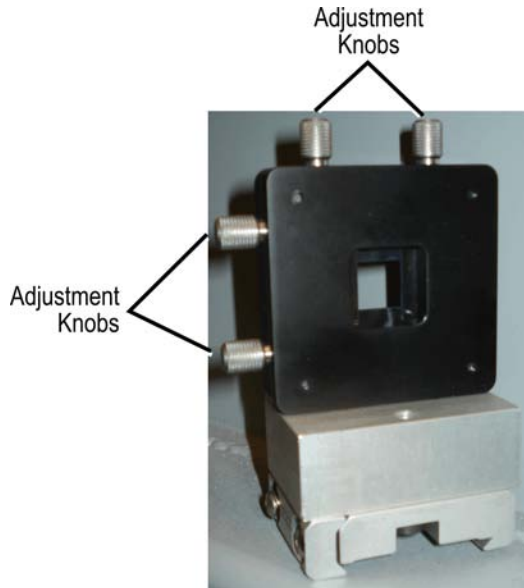


Figure 5-18. Rectangular Variable Aperture (RVA)

Note: In order to use the RVA option, you must ensure that the proper software parameters are set, as described in Section 6.4, page 6-8.

Beam Attenuator (option)

The attenuator block is designed to accept an attenuator plate (40 mm x 40 mm x 1.5 mm thick). The attenuator is a fused silica window with a nominal reflectance of 50% when mounted at 45° to the incoming beam. The attenuator block is equipped with a sliding dovetail, so it can be mounted anywhere along the rail.



Figure 5-19. Attenuator Assembly

5.3.3 Projection Assembly

The projection assembly is a long working distance focusing lens assembly with an effective focal length of 50 mm, 75 mm, or 155 mm, depending on the projection lens that is used (see Table 5-6). The assembly produces a demagnified image of the mask aperture onto the target work piece.

The projection assembly consists of a tube, aperture, spacer, projection lens, and optics focus. The laser beam enters the tube from the drop down mirror M3. When using the optics focus, the lower tube slides up/down along the upper tube for the adjustment. The aperture is used for beam-trimming by sliding the aperture lever right/left.

The projection lens requires cleaning on a regular basis (refer to Section 8.3.1, page 8-6).

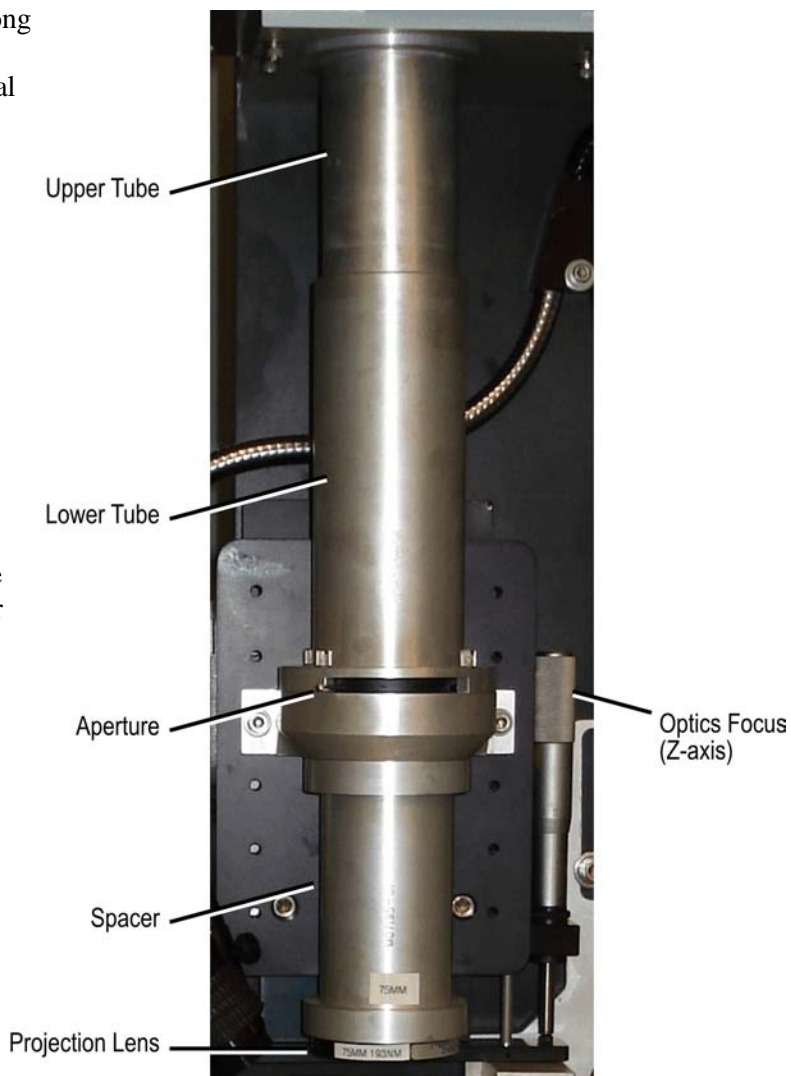


Figure 5-20. Projection Assembly

Six projection lenses are provided with three focal lengths for the 193 nm and 248 nm wavelengths. Three spacers are provided (based on focal length). Refer to Table 5-6.

Table 5-6. Projection Lenses

Lens	Demagnification	Focal Length	Wavelength	Spacer
Double	5X-15X	155 mm	193 nm	155 mm
Double	5X-15X	155 mm	248 nm	
Doublet	15X-25X	75 mm	193 nm	75 mm
Doublet	15X-25X	75 mm	248 nm	
Triplet	22X-35X	50 mm	193 nm	50 mm
Triplet	22X-35X	50 mm	248 nm	

5.3.4 Camera Assembly

The camera (work piece vision system) enables you to align the work piece to the location of the mask projection so that micromachining can occur in precise reference to the work piece features. This also enables you to observe the laser machining process in progress. Vision system components (see Figures 5-21, 5-22, and 5-23) include:

- ½” color CCD camera (Hitachi Denshi, Model KP-D20BN)
- Lens assembly (Navitar, Model Zoom 6000, 6.5X, with 12 mm fine focus)
- Crosshair generator (Techni-Quip, Model T-Q/DCG-100)
- 19” flat-screen color vision monitor (Viewsonic, Model NX1932W)
- Illuminators—one illuminator (Capra Optical, Model FOI-150/F) and two gooseneck illuminators (Capra Optical, Model QHI-85)

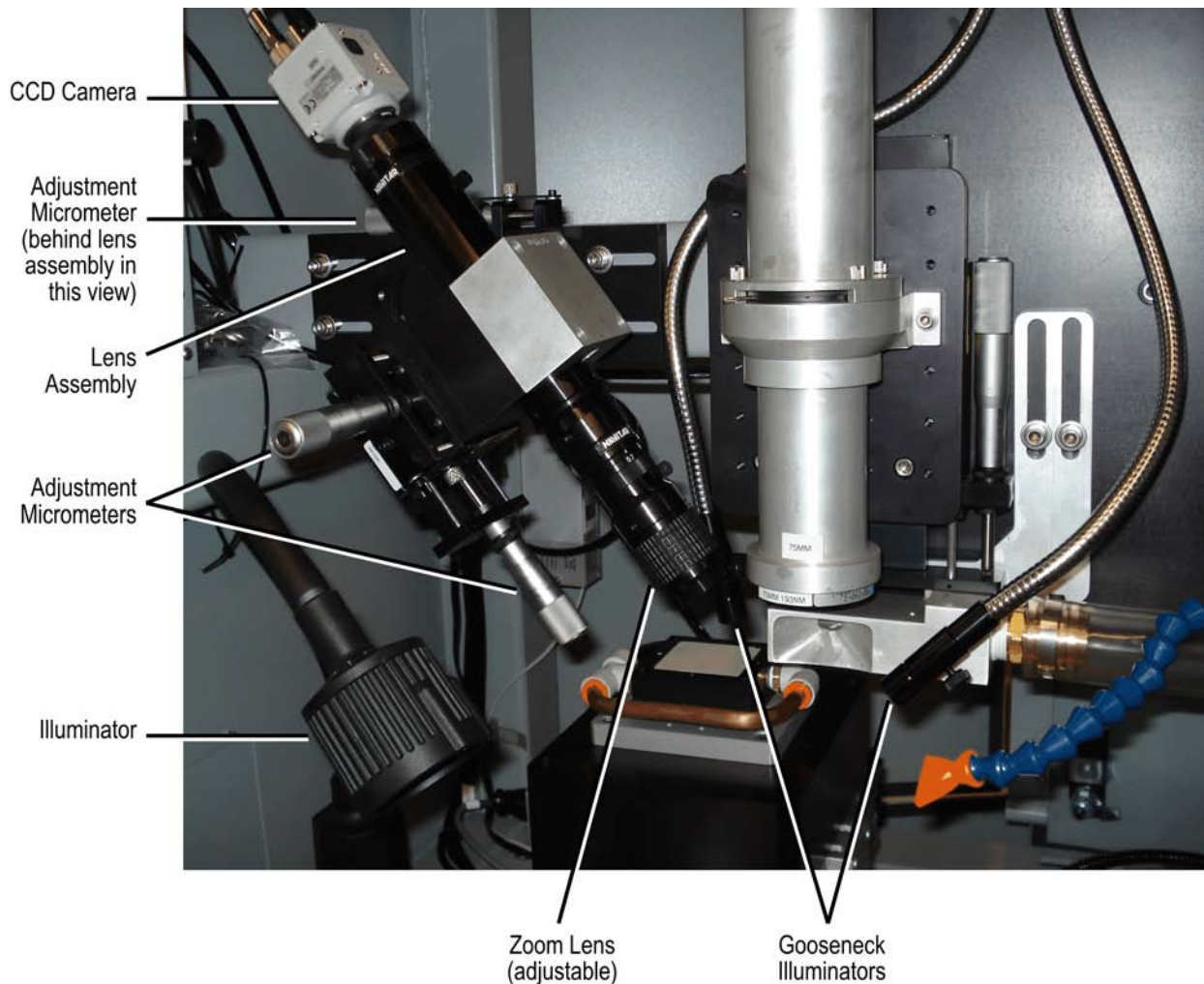


Figure 5-21. Camera Assembly

Resonetics RapidX 250 CompexPro System

The system is designed for optical magnification range on the camera chip of 1.4X to 9.0X, providing for diagonal field of view on target of 5.71 mm to 0.89 mm. With a 19" monitor, this corresponds to an overall magnification range of 33.6X to 216X. Because of the off-axis observation, there is a parallax distortion of the image (i.e., a round feature on the work piece will be displayed as an ellipse).

The camera lens objective has a fine focus adjustment ring and a zoom ring. A coarse focus can be achieved by moving the entire lens and camera mount left and right using the micrometer-driven translation stage.

Illumination is furnished by a 150 W incandescent lamp. The illuminator is toggled on/off with a switch at its base (where is it anchored to the workstation in the processing compartment). In addition, two gooseneck illuminators are provided for spot lighting. They are controlled with a unit located in the rear of the processing compartment. In addition to an on/off setting, you can control illumination intensity.

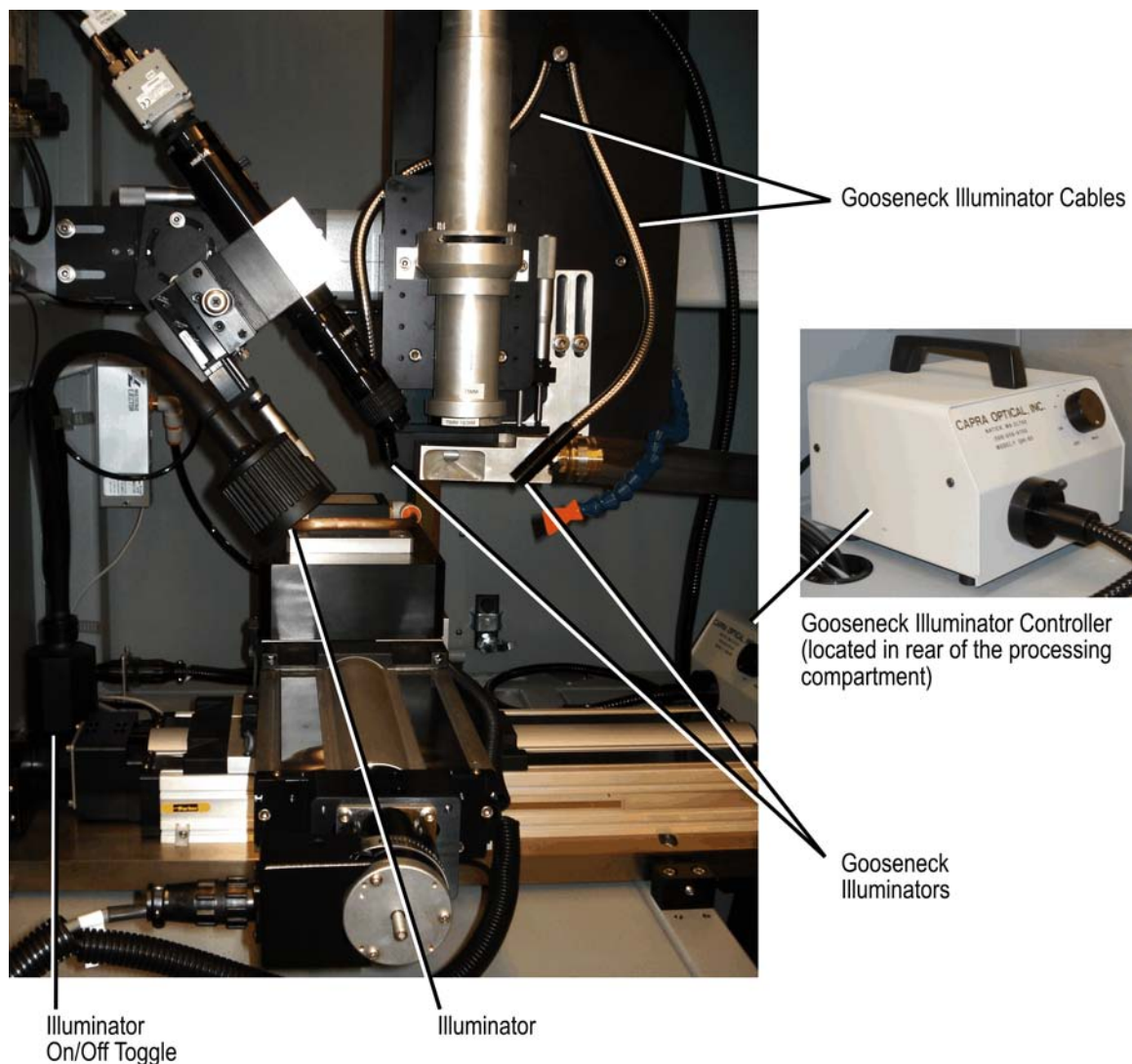


Figure 5-22. Illuminators

The crosshair generator provides the crosshair lines displayed on the vision monitor. In addition to a power toggle on the generator (see Figure 5-23), switches are provided to set the line style (solid, dashed, or none) and display matte level (black to white).

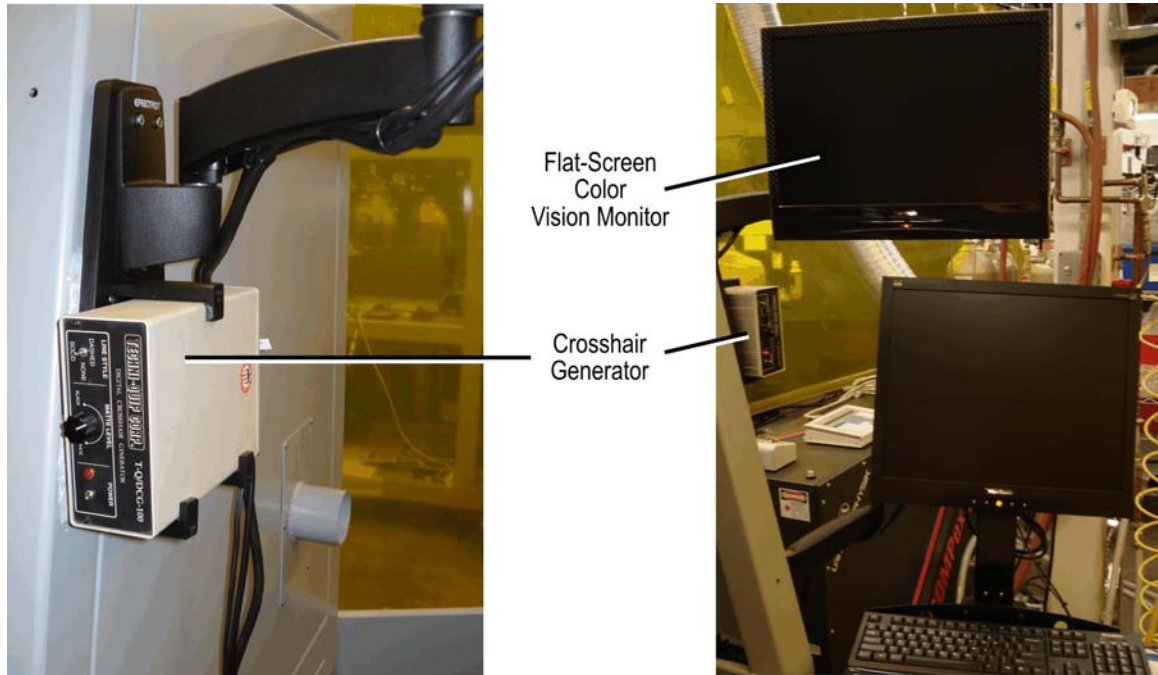


Figure 5-23. Crosshair Generator and Vision Monitor

5.3.5 Process Gas, Nitrogen Purge, and Compressed Air Vacuum

Process gas, which is introduced close to the work piece, is used to attain a cleaner (enhanced) cut during the lasing process. Refer to Section 5.5.2, page 5-28, for details.

Compressed air drives a Venturi pump for debris exhaust. Refer to Section 5.5.5, page 5-31, for details.

Nitrogen purge is available to the entrance tube and BDS compartments. The purpose of the nitrogen purge is to rid the atmosphere in the beam path of oxygen that is quite absorptive at the wavelength of 193 nm and is converted into ozone under this illumination. A steady source of nitrogen purge will displace most of the oxygen within the processing compartment and facilitate the removal of the ozone produced during processing. A stainless steel compartment encloses the beam path to help contain the nitrogen gas during 193 nm laser operation. Refer to Section 5.5.3, page 5-28, for details.

Note: The presence of oxygen has no affect on the 248 nm laser beam.

5.4 Motion and Laser Control Subsystem

This subsystem includes X and Y staging and motion control, laser triggering, and a computer interface.

The Resonetics software is integrated into the laser workstation so that simultaneous laser operation and table motion can be achieved in a controlled manner. The motion control system maintains strict control over all laser firing during the lasing process and stage motion to a high degree of accuracy.

5.4.1 Stage Assemblies

The X and Y stages are Parker Daedal assemblies with 200 mm x 200 mm travel, $\pm 2 \mu\text{m}$ repeatability and $\pm 1 \mu\text{m}$ resolution. Refer to the [Electromechanical Positioning Systems: 404/406XR Series Product Manual](#) for details.

As described in the next sections, stepper motors drive each axis for motion control. Home and full travel limit switches are mounted on the side of each stage. The stages are factory mounted orthogonal to each other. **Do not separate the stages for any reason.**

The stage assembly includes a porous ceramic vacuum chuck (50 mm x 50 mm). Compressed air drives a SMC pressure switch (ZL Multistage Ejector) for the vacuum chuck control. Refer to Section 5.5.4, page 5-30, for details.

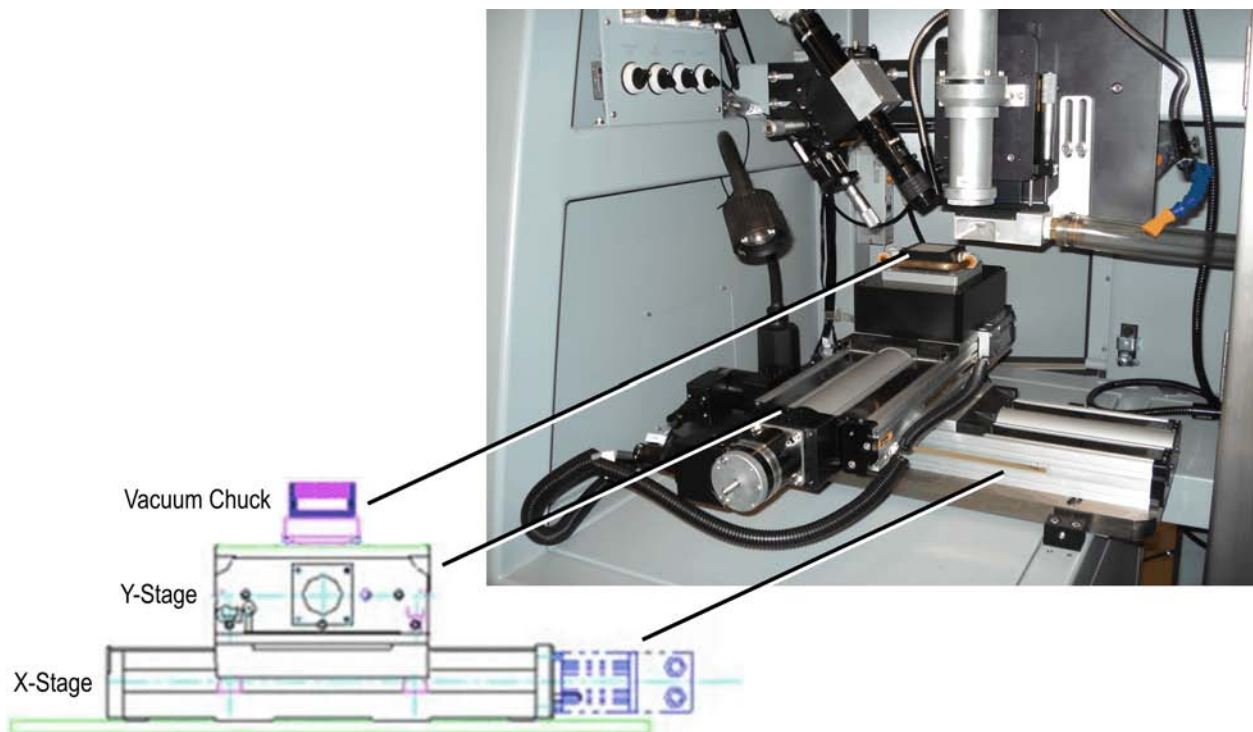


Figure 5-24. Stage Assembly

5.4.2 Motion Control and Laser Triggering

The motion control box is installed directly above the computer. It houses the four Compumotor OEM750 bipolar stepper motor drivers, an OEM300 power supply, two Nstep controller boxes, and a laser firing card.

The X-Y stage assembly maximum stage velocity is 5 cm/s with 50,000 steps per revolution. See the [OEM750 Drive OEM750X Drive/Indexer User Guide](#) for procedures to tune Compumotor stepper motor drivers. The stepper motors are wired in series configuration.

The laser axis from the Nstep #2 motion controller is fed directly to the laser gating card. This circuit board has been specially designed to convert the TTL output to a laser trigger signal. The firing card jumpers are already configured for the laser and should not be changed. The laser firing pulse is enabled with one I/O bit (bit #16, laser axis).

5.4.3 Computer Control

The system is controlled by a host computer. It is an industrial PC with:

- 19" flat-screen monitor
- Keyboard and trackball mouse

The computer runs under the Windows[®] XP Professional operating system, and is mounted in an industrial 4U rack located on the front left side of the workstation enclosure.

The computer is equipped with a firewire card to communicate with two Nstep controllers. Each Nstep controller controls up to four axes of motion. The Nstep controllers are daisy chained with fire wire cable. Nstep #1 controls stage assembly (X and Y) motion and Nstep #2 controls laser firing.

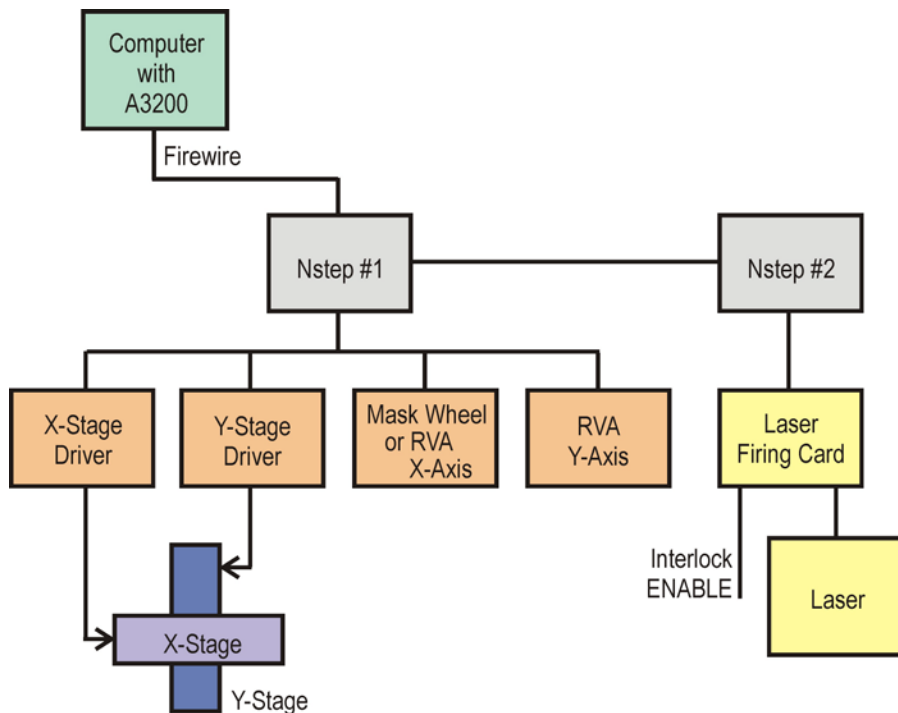


Figure 5-25. Block Diagram of the Resonetics RapidX 250 Laser System

The axes of motion are labeled in the Resonetics software configuration file RPC.INI as:

- X to control X-stage motion
- Y to control Y-stage motion
- Laser to fire the laser
- RVA_X or MaskWheel to control the RVA or mask wheel option
- RVA_Y or None

To change the configuration, you must use the A3200 Configuration Manager, as described in Section 6.4, page 6-8.

Outputs for each controller axis consist of step and direction pulses. These outputs are routed to the Compumotor stepper motor drivers. Pulses to fire the laser are generated using an axis control output and are fed through a gating card and a laser trigger card before being sent to the laser.

5.4.4 Beam Stop Control Box

The beam stop control box can be located anywhere within the processing area of the workstation.

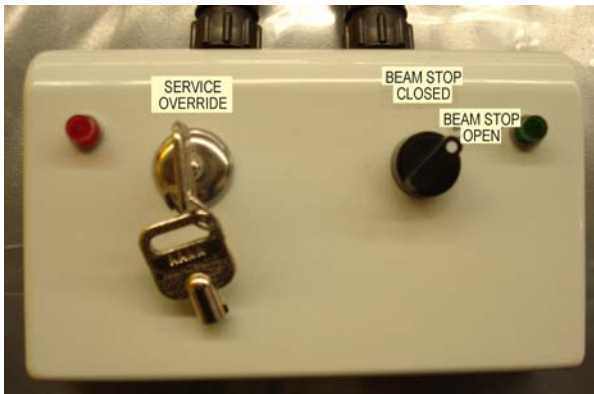


Figure 5-26. Beam Stop Control Box

Beam stop control box switches and indicators are listed in Table 5-7.

Table 5-7. Beam Stop Control Box Switches and Indicators

Switch	Function
SERVICE OVERRIDE Key	Overrides door interlocks and the window access interlock
BEAM STOP OPEN Switch	Opens and closes the laser beam stop
Indicator	Function
SYSTEM INTERLOCKED (red)	Indicates interlocks are closed
BEAM STOP OPEN (green)	Indicates the laser beam stop is open

5.4.5 Electric Power Distribution

The system has single-phase, 208 VAC, 15 A, 60 Hz electric power. The power toggle switch located on the front left of the enclosure controls the main power that feeds the entire system and is rated at 15 A.

The Coherent COMPexPro[®] 110 laser requires single-phase, 115 VAC, 60 Hz 25 A electric power for operation.

5.5 Gas Handling and Exhaust

5.5.1 Gas and Pneumatic Panels

Factory-supplied process air/gas can be delivered to the work piece area via a flexible hose with a flare nozzle. It is connected to a 1/4" bulkhead fitting on the left side of the system. An adjustable flow meter (0-100 scfm) is installed in-line.

A debris control nozzle is provided for removal of process products. Vacuum for it is created by a Vaccon high-flow vacuum generator (using factory-supplied compressed air) and is controlled by a manual 2-position pneumatics valve. Exhaust outlet of the vacuum generator is connected to a 3" bulkhead panel (on the right side system cover) ready for connection to a factory exhaust system.

Inlets for process air/gas (air supply for the vacuum generator and for beam delivery system nitrogen purge) are located at the bottom of the left side workstation panel.

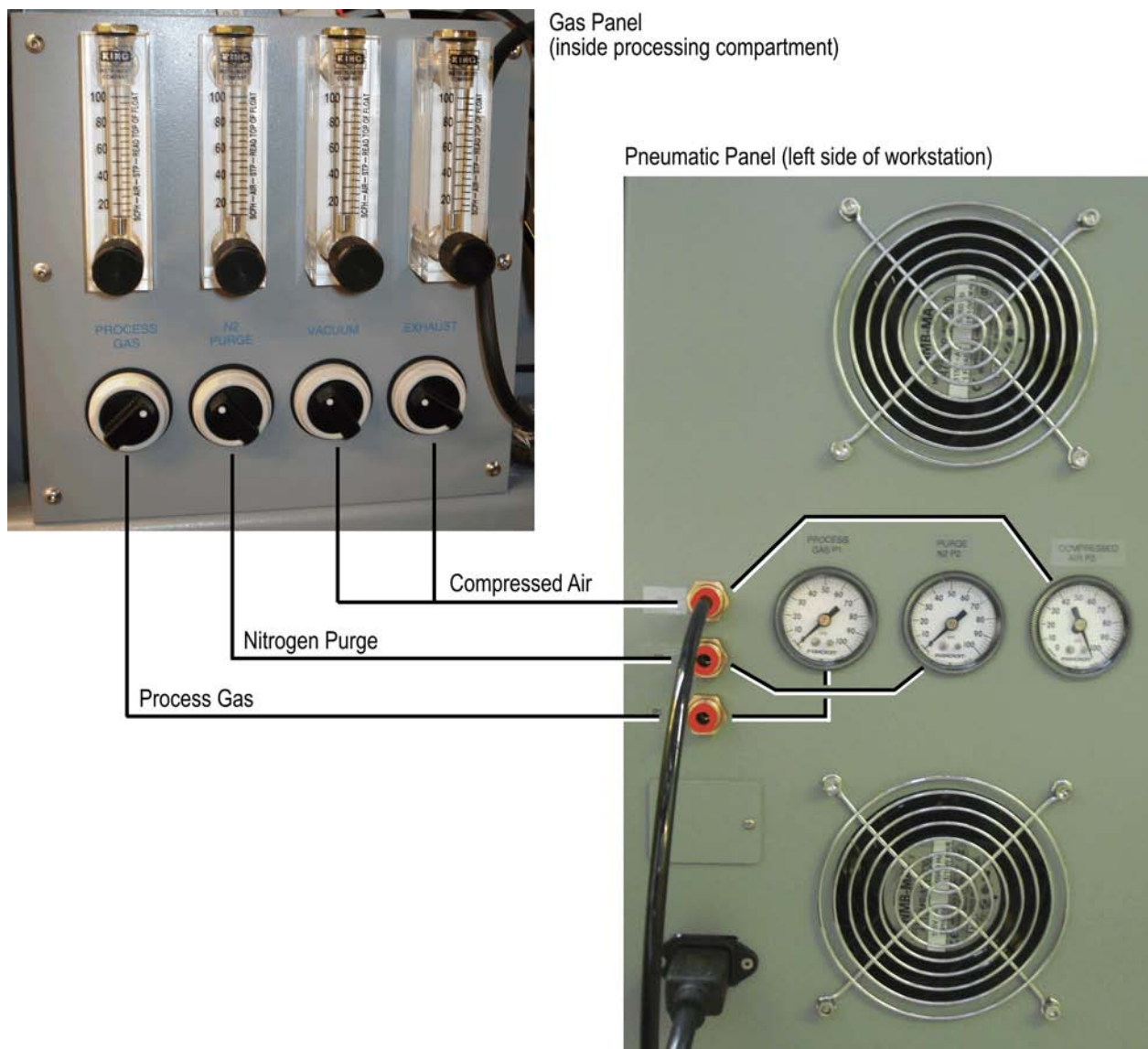


Figure 5-27. Gas and Pneumatic Panels

5.5.2 Process Gas

Process gas, which is introduced close to the work piece, is used to attain a cleaner (enhanced) cut during the lasing process. The process gas enters the workstation enclosure through a ¼” tube fitting at the bulkhead connection panel on the left side of the workstation. An on/off switch and regulator are positioned inside the processing compartment (to the left of the staging). The process gas regulator should be adjusted as experience dictates.

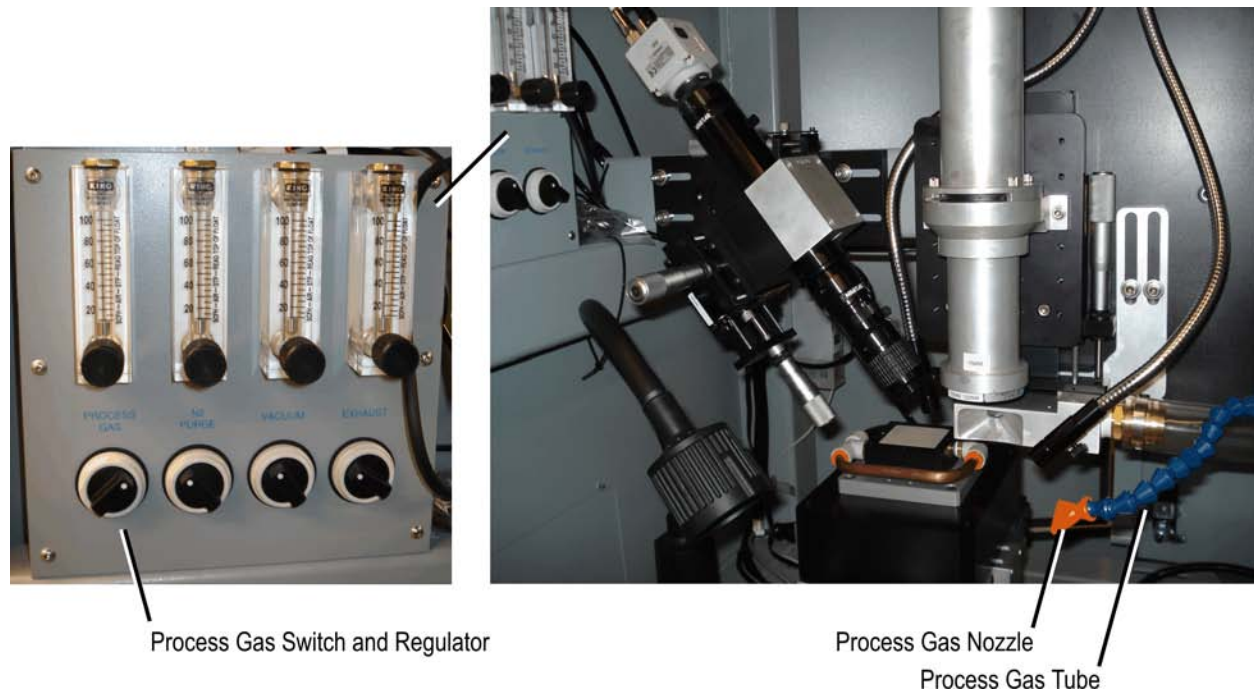


Figure 5-28. Process Gas

5.5.3 Optics Purge for Optional 193 nm Laser Operation

Nitrogen purge is available to the entrance tube and BDS compartments (see Figure 5-29). The purpose of the nitrogen purge is to rid the atmosphere in the beam path of oxygen that is quite absorptive at the wavelength of 193 nm and is converted into ozone under this illumination. A steady source of nitrogen purge will displace most of the oxygen within the processing compartment and facilitate the removal of the ozone produced during processing. A stainless steel compartment encloses the beam path to help contain the nitrogen gas during 193 nm laser operation.

The nitrogen connector to the workstation is located on the left side of the workstation. An on/off switch and regulator are positioned inside the processing compartment (to the left of the staging).

Note: The presence of oxygen has no affect on the 248 nm laser beam.

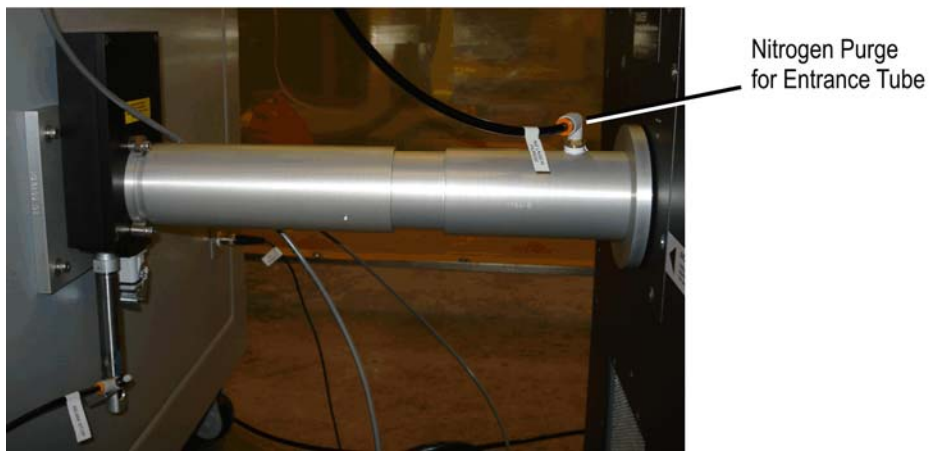
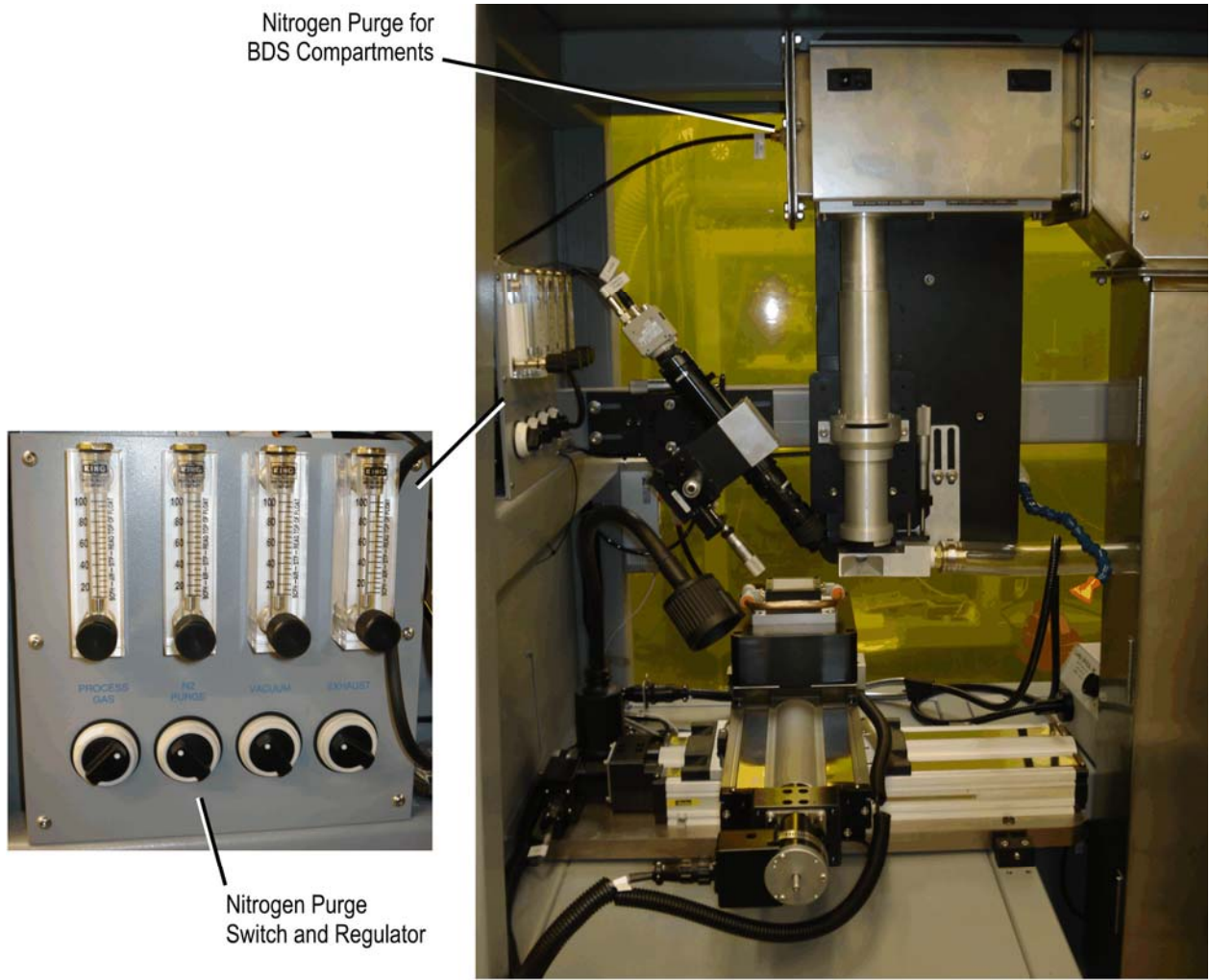


Figure 5-29. Nitrogen Purge

5.5.4 Vacuum Chuck

Compressed air enters the workstation enclosure through a ¼” tube fitting at the bulkhead connection panel on the left side of the workstation. An on/off switch and regulator are positioned inside the processing compartment (to the left of the staging).

Compressed air drives a Venturi pump (ZL Multistage Ejector SMC Pressure Switch) for the vacuum chuck. Air flows to the vacuum chuck via the ports, as shown in Figure 5-30.

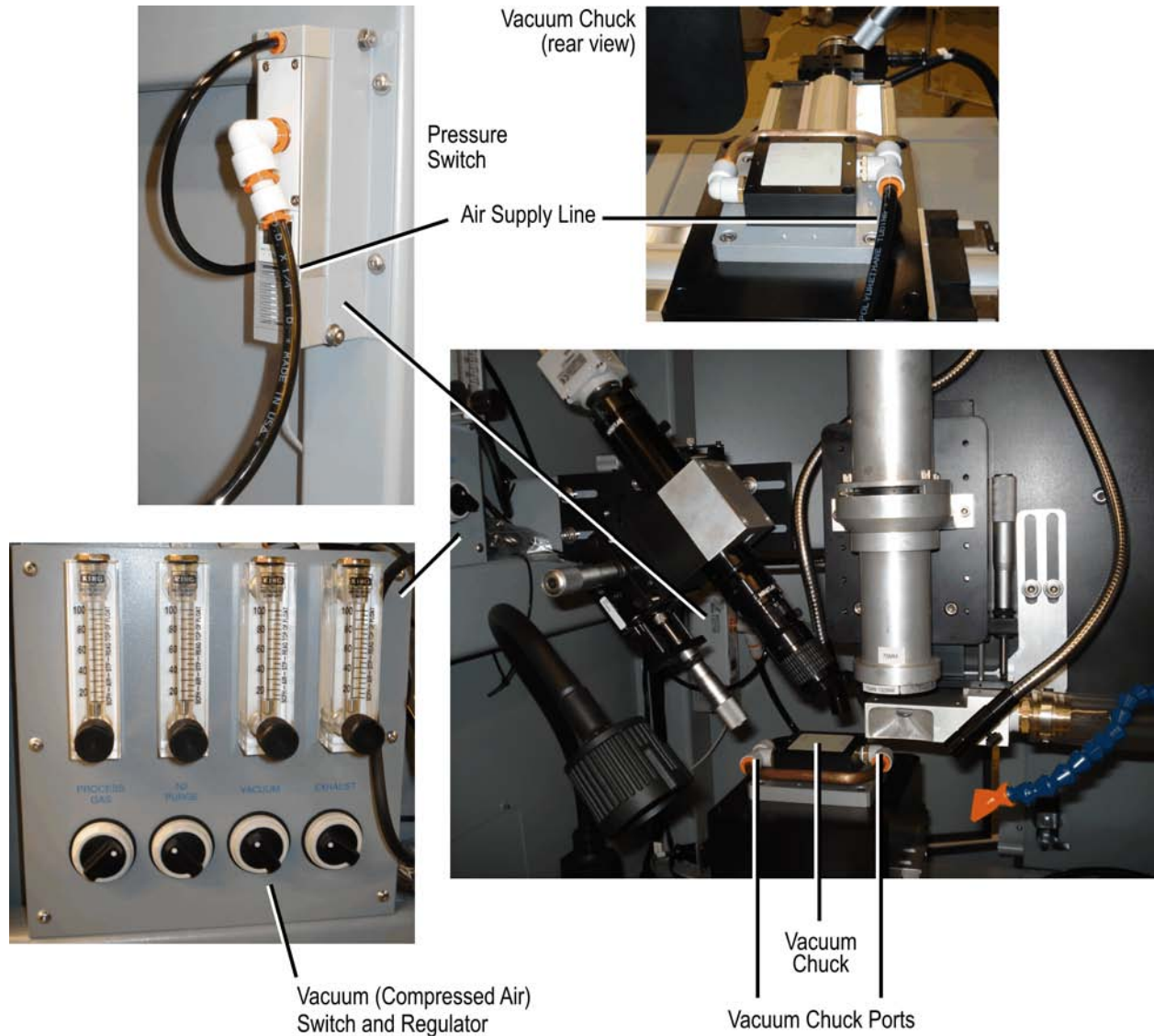


Figure 5-30. Compressed Air for the Vacuum Chuck

5.5.5 Debris Vacuum

Compressed air also drives a Venturi pump (Vaccon Vacuum Products, Model DF5-3) for debris exhaust. In addition, a needle valve controls flow of air to the Venturi vacuum pump that pulls vacuum through the debris exhaust above the stage assembly.

Compressed air enters the workstation enclosure through a 1/4" tube fitting at the bulkhead connection panel on the left side of the workstation. An on/off switch and regulator are positioned inside the processing compartment (to the left of the staging).

Debris is exhausted on the right side of the workstation enclosure. The exhaust pipe must be connected to an exhaust blower via a 3" diameter flange.

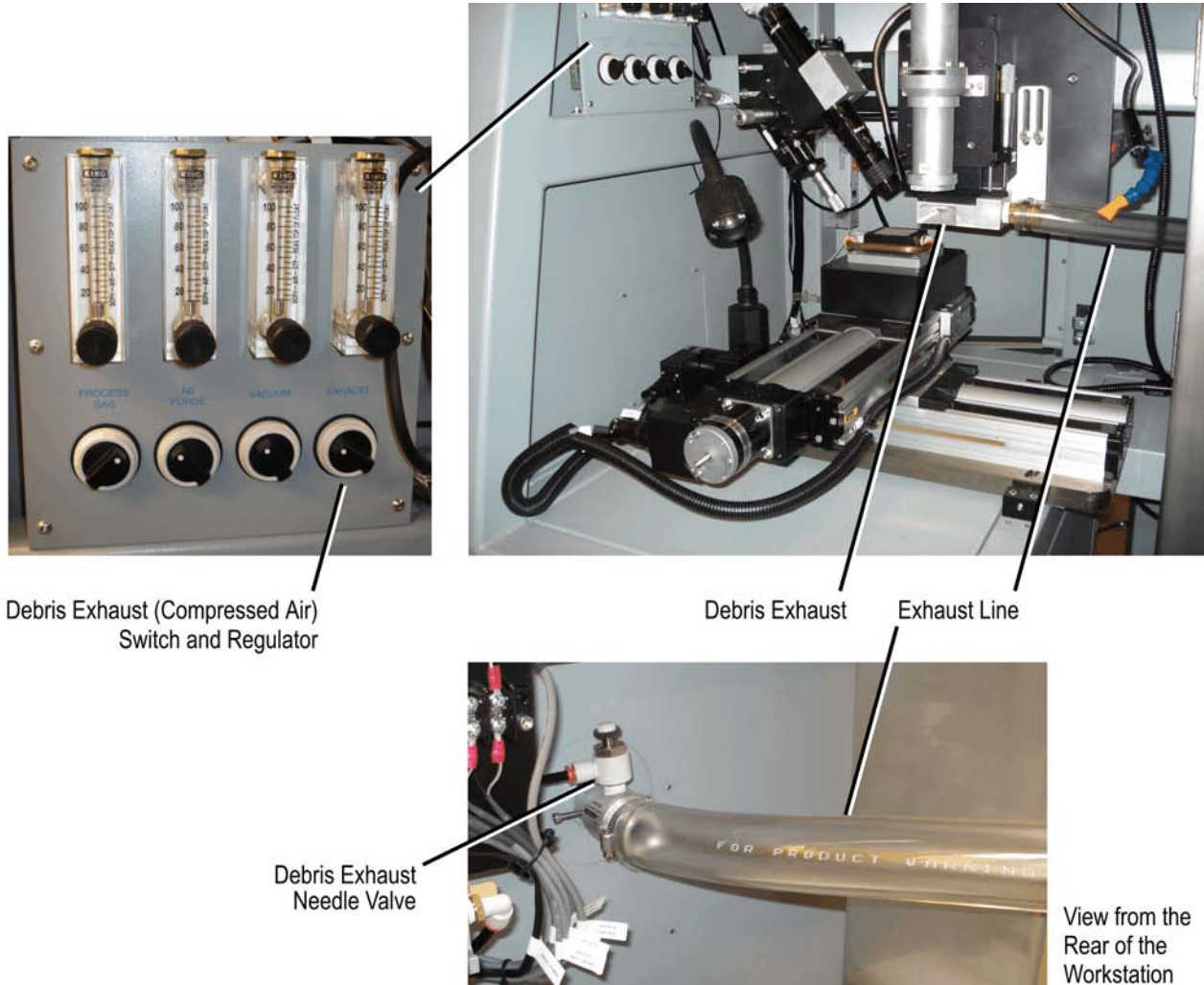


Figure 5-31. Compressed Air for Debris Exhaust

Notes

A dark blue vertical bar on the left side of the page. It features a bright white diagonal line starting from the top left and ending at a glowing point. From this point, a series of white dots extends horizontally and vertically, forming a cross-like shape. There are also some lens flare effects around the glowing point.

Part III

Software Reference

6. A3200 Software

Although primarily used for setup, the A3200 software provides an alternative graphical way to use the Resonetics RapidX 250 Laser System. A3200 supports the configuration, programming, and customization needed for setup, service, and maintenance. This section provides an overview of the A3200 software. Refer to the [A3200 Help](#) for details about all features.

A3200 software consists of three components, each accessed with an icon on your desktop:



A3200 CNC Operator Interface (Section 6.1) is used to run programs, manipulate the stages, jog axes, view status, and operate the Resonetics RapidX 250 Laser System.



A3200 Motion Composer (Section 6.2, page 6-4) is used by engineers and technicians to develop programs, jog axes, and view status. Use it to perform command basic motion, inspect diagnostic information, and perform basic configuration.



A3200 Configuration Manager (Section 6.3, page 6-7) is used to edit parameters, set the active parameter file, and change system settings for program automation. This program should be used only by trained engineers or technicians. Change in the system parameters will affect system performance.

Note: Do not open more than one component at a time.

6.1 A3200 CNC Operator Interface

The A3200 CNC Operator Interface window is a starting point from which you can access several features (see Figures 6-1 and 6-2), such as:

Feature	Description
Enable/Disable	Enable or disable a specific stage. The status is then displayed in the Stage Status box.
Home Stage	Home a specific stage. If the stage is homed, the letter H appears in the box to the right of the Stage Status.
Program Position Feedback	Review the stage position.
Velocity Feedback	Review the average velocity feedback.

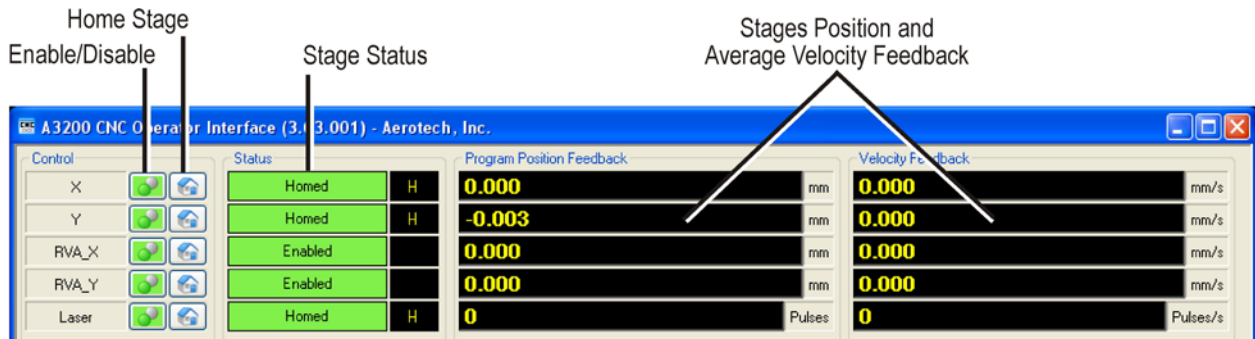


Figure 6-1. A3200 CNC Operator Interface (top section)

Resonetics RapidX 250 CompexPro System

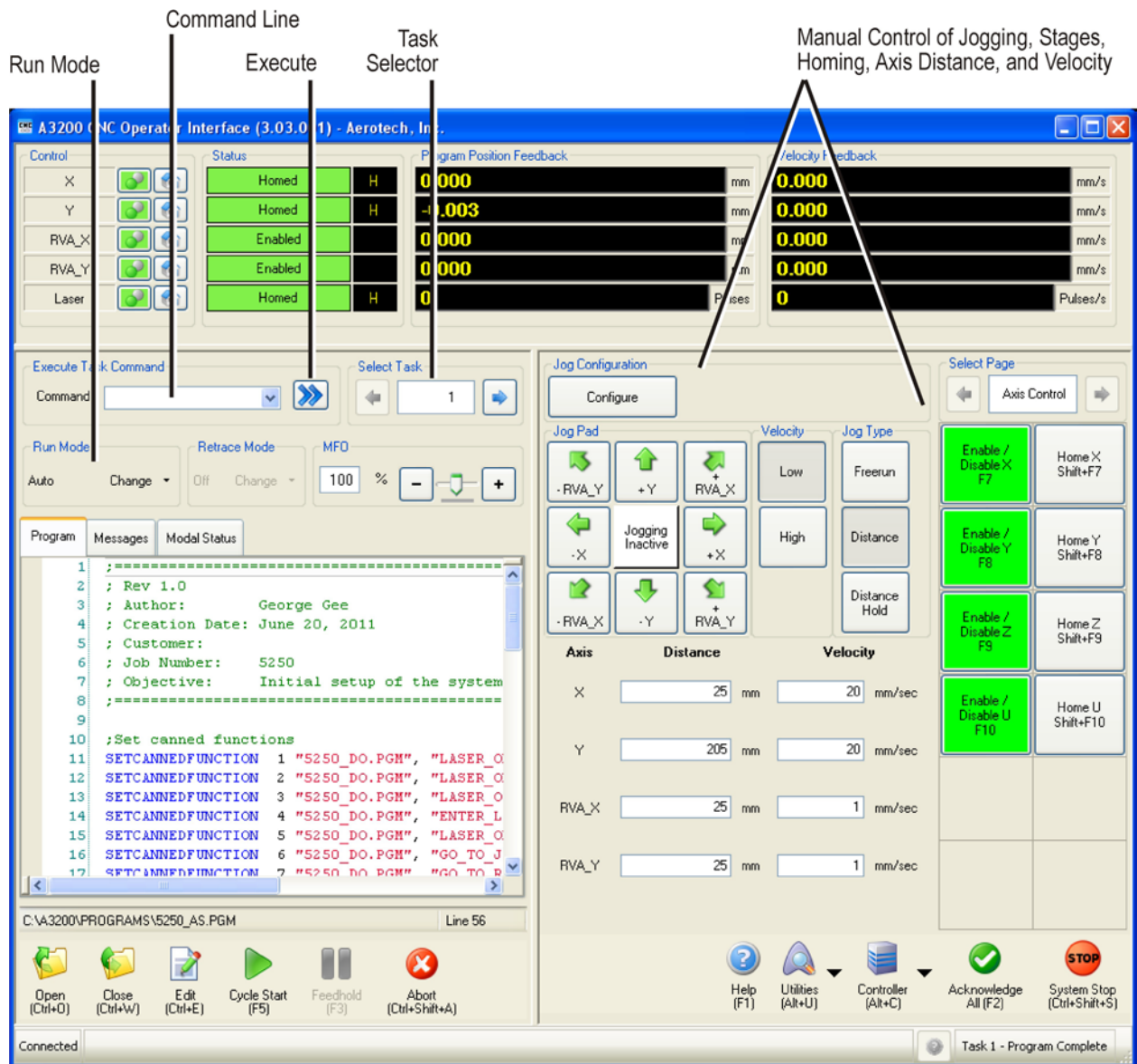


Figure 6-2. A3200 CNC Operator Interface

Feature	Description
Command Line	Enter a command in the Command Line box and then click the Execute button to execute it. This enables you to enter a single command manually and execute it, such as for debugging.
Execute	
Task Selector	Choose a task by number.
Run Mode	Run a program automatically (Auto) or one line at a time (Step Over or Step Into).
Jogging Control	Jog an axis manually a specific speed or distance. You also can indicate the jog direction (positive or negative).

There are three tabs above a display area on the left of the A3200 CNC Operator Interface window:

Display	Description
Program	Displays the program as it is executed.
Messages	Indicates any messages associated with the program execution (such as error messages).
Modal Status	Shows the status of motion at that moment.

Buttons at the bottom of the A3200 CNC Operator Interface window are used to:

Button	Description
Open, Close, and Edit	Select and modify PGM programs.
Cycle Start	Start the program.
Feedhold	Temporarily suspend processing after the current move is completed. Click this button again to resume laser processing.
Abort	Stop execution of the program. Click this button again to reset/reload the program when it is not running.
Help	Launch the A3200 Help system.
Utilities	Set preferences, access the tool table, review feedback of the stages in graphical form (digital scope), launch the A3200 Configuration Manager, launch the A3200 Motion Composer, and review the status of the A3200 (I/O, faults on a stage, etc.).
Controller	Disconnect/reconnect the controller, and get a running status of the controller.
Acknowledge	Indicate that you acknowledge a fault condition occurred and proceed with the program. If an error occurs, processing stops and an error message displays. You should proceed as follows: <ol style="list-style-type: none"> 1. Determine the cause and correct the error. 2. Click the Acknowledge button. 3. Click the Cycle Start button to restart the program. 4. Remove the product from the tooling assembly and reload new product material.
System Stop	Stop all processing.

6.2 A3200 Motion Composer

A3200 Motion Composer is used by engineers and technicians to develop programs, jog axes, and view status. Use it to perform command basic motion, inspect diagnostic information, and perform basic configuration. The A3200 Motion Composer window includes several features (see Figures 6-3 and 6-4), such as:

Feature	Description
Acknowledge All	Acknowledge all controller actions.
Abort Controller	Abort the controller.
Reset Controller	Reset the controller.
Connect Controller	Connect the controller.
Disconnect Controller	Disconnect the controller.
Reset Controller	Reset the controller.
Build	Build a program.
Load	Load a program.
Run	Start the program.
Pause	Temporarily suspend processing after the current move is completed. Click this button again to resume laser processing.
Stop	Stop execution of the program. Click this button again to reset/reload the program when it is not running.
Stop All	Stop all processing.
Step Over	Step over the next line in the program.
Step Into	Step into the next line in the program.

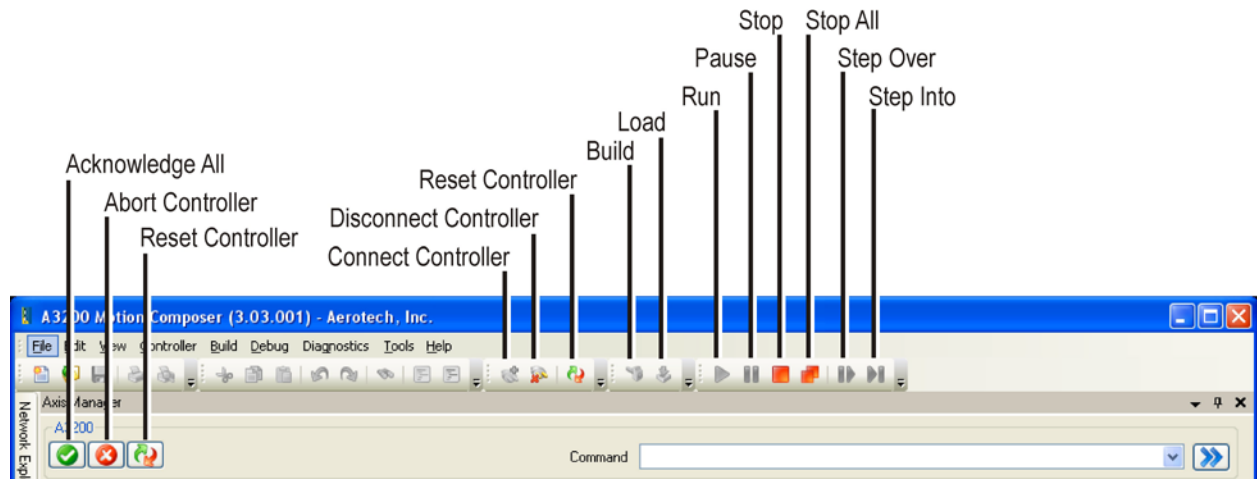


Figure 6-3. A3200 Motion Composer (top section)

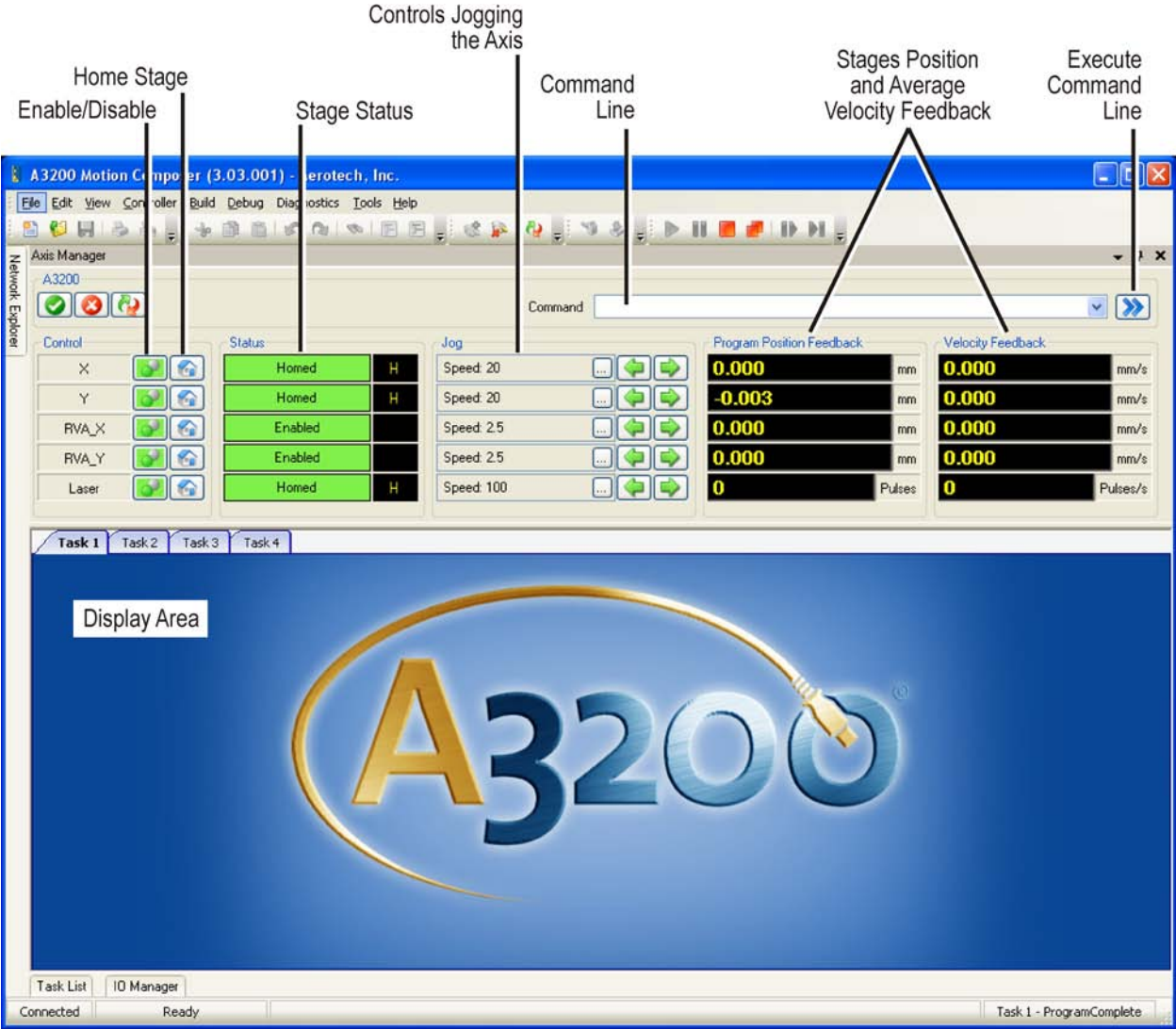


Figure 6-4. A3200 Motion Composer

Feature	Description
Command Line	Enter a command in the Command Line box and then click the Execute button to execute it. This enables you to enter a single command manually and execute it, such as for debugging.
Execute	
Enable/Disable	Enable or disable a specific stage. The status is then displayed in the Stage Status box.
Home Stage	Home a specific stage. If the stage is homed, the letter H appears in the box to the right of the Stage Status.
Jog	Controls jog of the axis. You can access jog settings (...) or use the arrow keys to adjust the jog speed.
Program Position Feedback	Review the stage position.
Velocity Feedback	Review the average velocity feedback.

Buttons at the bottom of the A3200 Motion Composer window are used to:

Button	Description
Task List	Display the information associated with the selected task (including tasks, status, and error messages).
IO Manager	Display I/O information, as described in Section 6.2.1, below.

6.2.1 IO Manager

You can access the I/O manager by clicking the IO Manager button at the bottom left of the A3200 Motion Composer window. Inputs and outputs are displayed under the Tasks display, as shown in Figure 6-5. Note that laser bit #16 must be ON for the laser to fire.

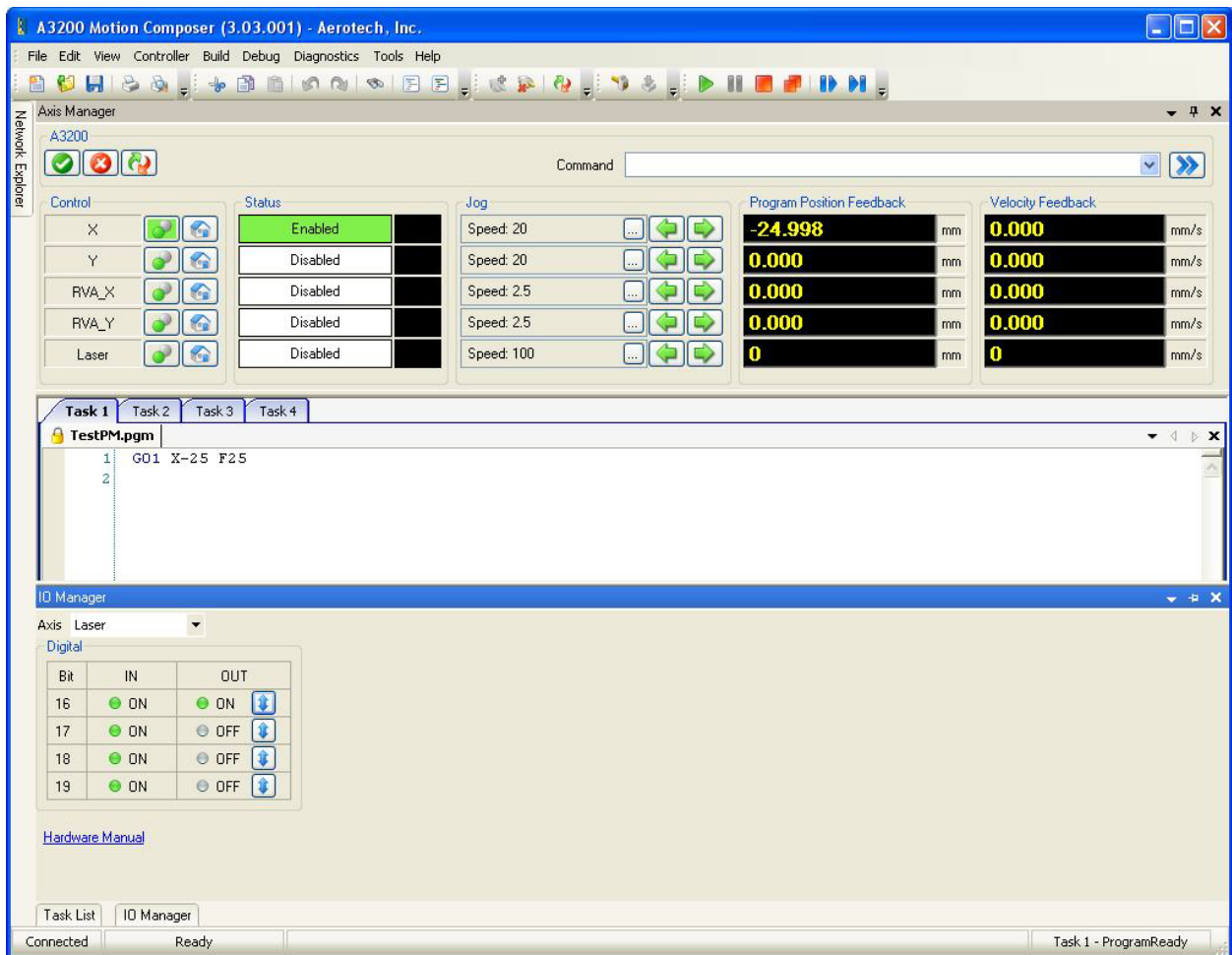


Figure 6-5. I/O Manager

6.3 A3200 Configuration Manager

The A3200 Configuration Manager is used to edit parameters, set the active parameter file, and change system settings for program automation. For example, the file information is displayed here for the rectangular variable aperture (RVA) parameter file:

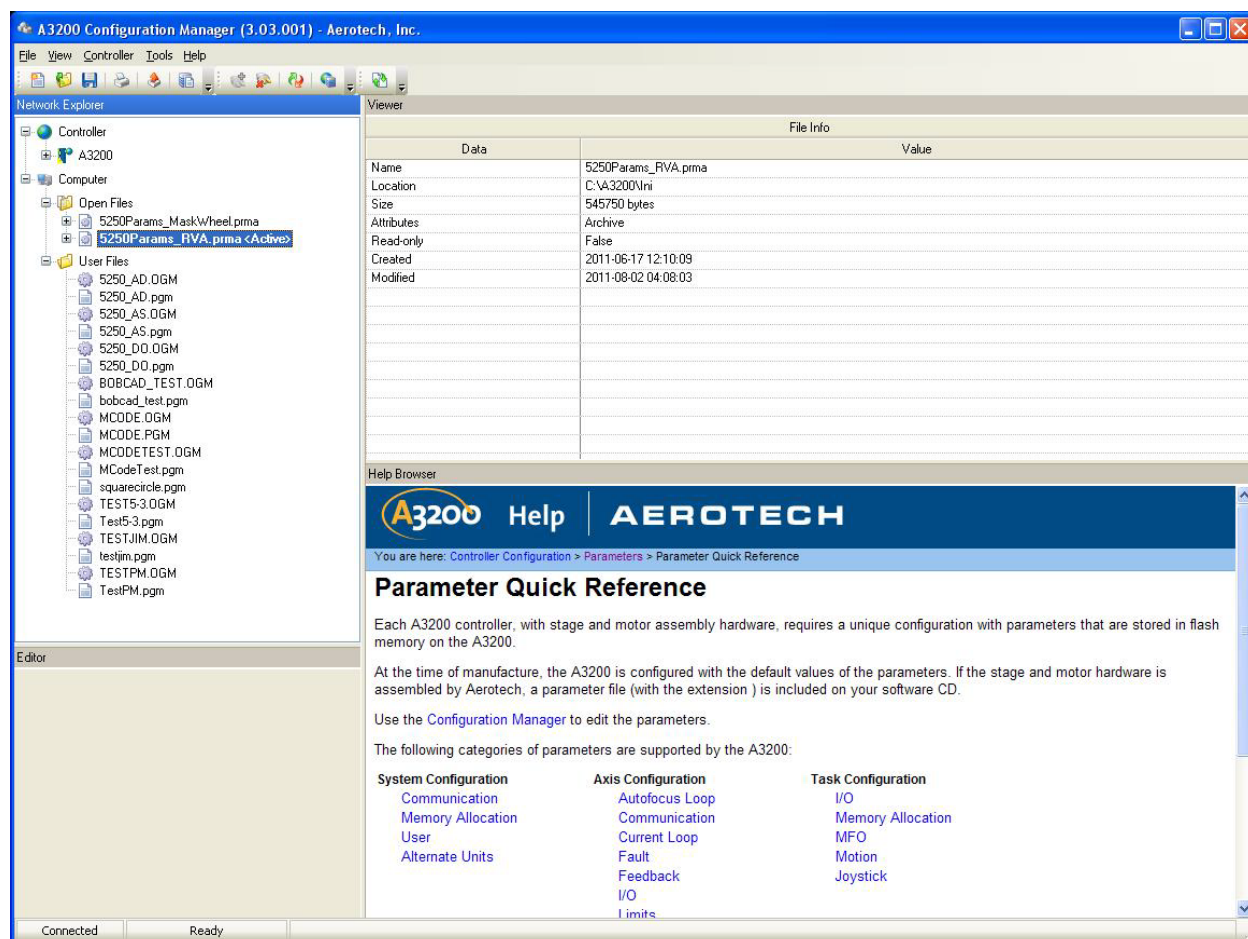


Figure 6-6. A3200 Configuration Manager

Several user files are available with the Resonetics RapidX 250 Laser System. Refer to Section 6.7, page 6-14.

6.4 Changing to the Rectangular Variable Aperture (RVA) or Mask Wheel Option

The system automatically activates the correct axis depending on which parameter file is selected. Complete the following procedure to change to the RVA or mask wheel option:

1. Close the A3200 Motion Composer or A3200 CNC Operator Interface if either is open.
2. Open the A3200 Configuration Manager.
3. Open the File menu and select the Open Parameter File option.
4. Navigate to the location of the parameter files, which is C:\A3200\Ini
Select the parameter file for the option to which you want to change:

RVA parameter file: 5250Params_RVA.prma

Mask wheel parameter file: 5250Params_MaskWheel.prma

Then click Open.

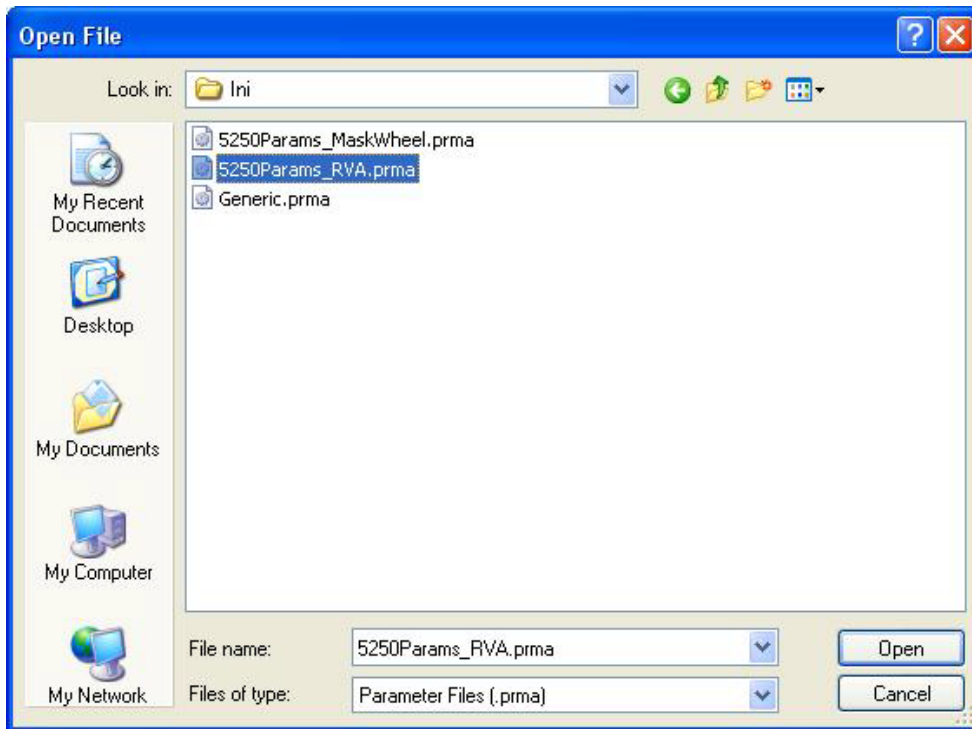


Figure 6-7. Opening a Parameter File

5. The file you selected will appear in the file listing on the A3200 Confirmation Manager window. Right click on the file name to open a drop down menu. Select the Use As Active Parameters option, as shown in Figure 6-8.

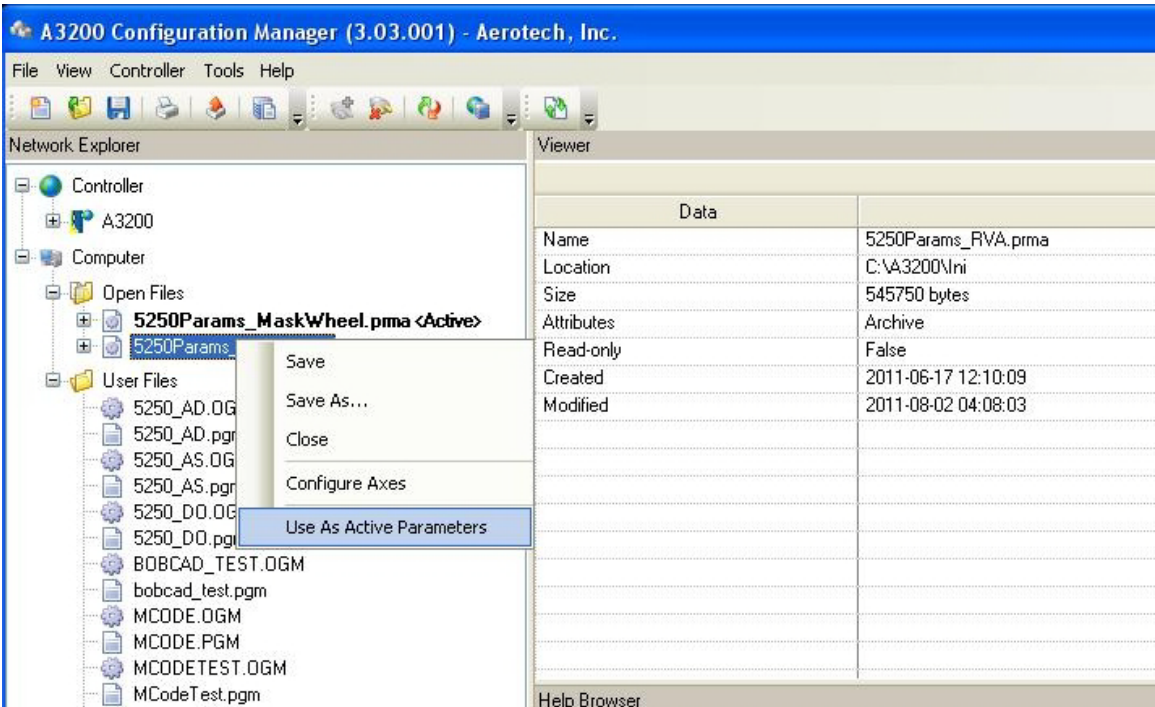


Figure 6-8. Choosing to Use the Active Parameters

<Active> is displayed to the right of the active parameter file, as shown in Figure 6-9.

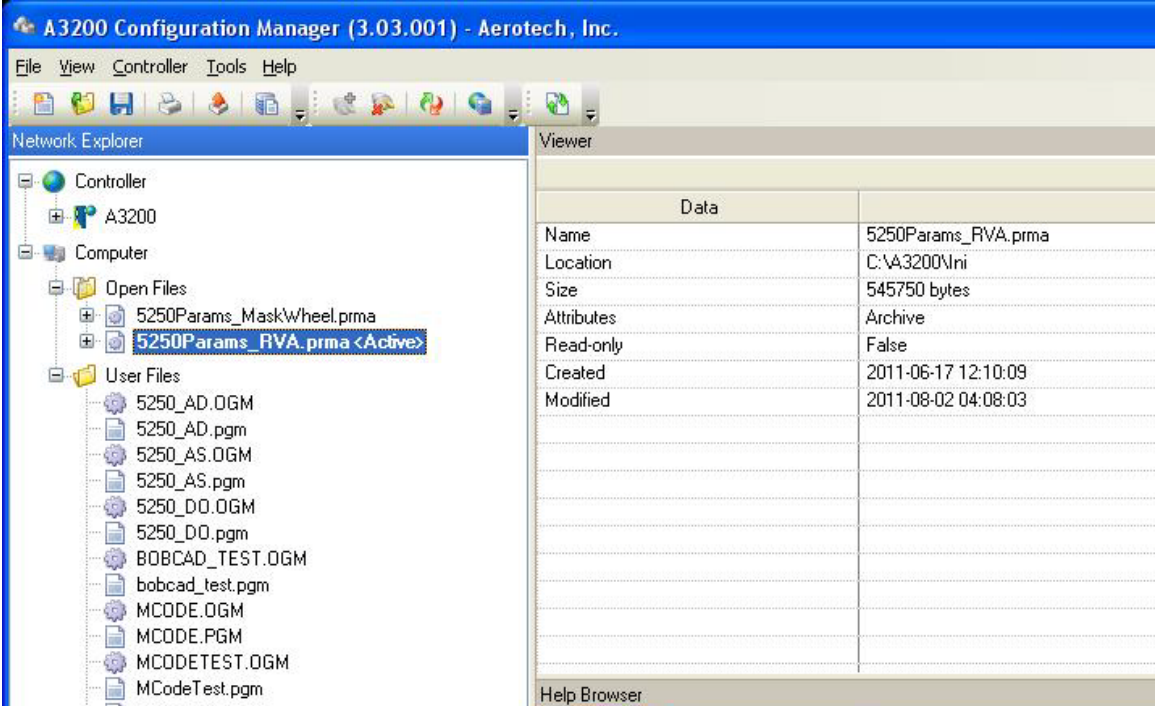


Figure 6-9. Active RVA Parameter File

- 6. At this point, you can close the A3200 Configuration Manager.
- When you open the A3200 Motion Composer, check the displayed axis:

Resonetics RapidX 250 CompexPro System

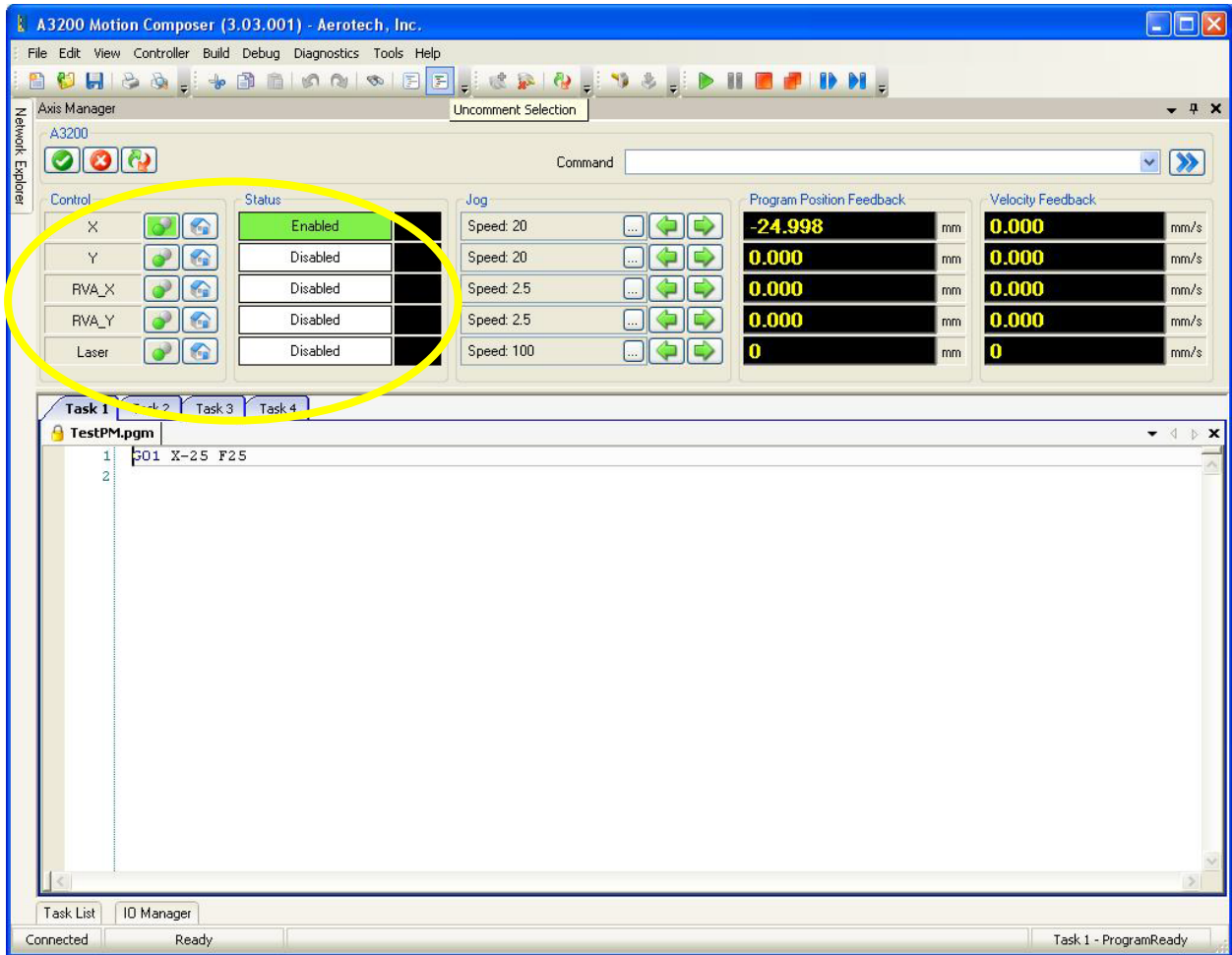


Figure 6-10. A3200 Motion Composer with the RVA Option

If you open the A3200 CNC Operator Interface, you will notice that the status for the option is displayed:

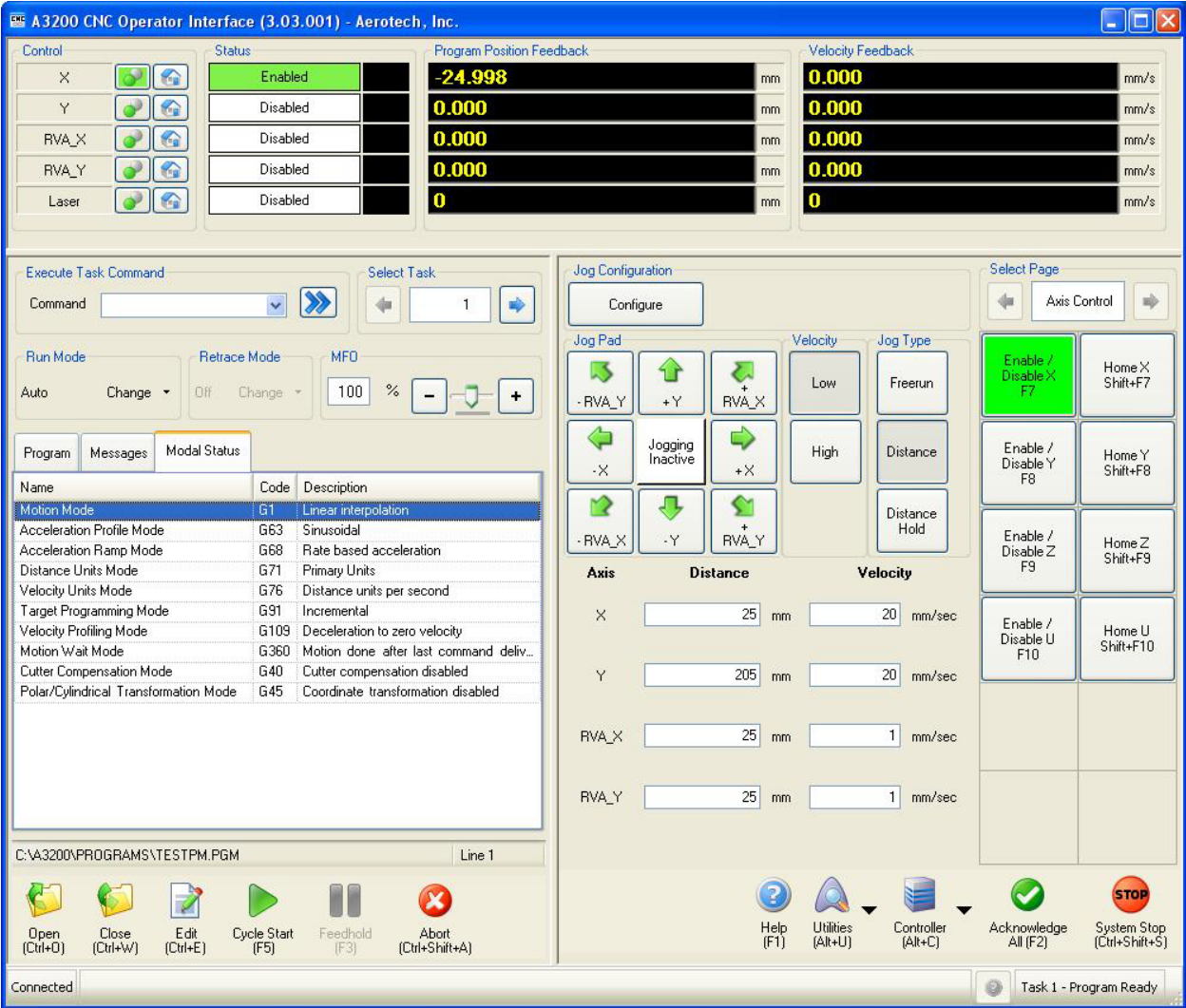


Figure 6-11. A3200 CNC Operator Interface with the RVA Option and Status Display

6.5 Programming: Motion Commands

The A3200 controller and software is used for all motion, I/O, and pulse generation. You can easily configure all the motion parameters for the axes. A3200 software supports all the configuration, programming, and customization needed.

6.5.1 Motion Commands

Table 6-1 provides a list of most commonly used A3200 commands for programming. For a detailed explanation and the complete list of commands, consult the [A3200 Help](#).

Table 6-1. Motion Commands (G-Code and Extended Command Counterpart)

G-Code	Extended	Description
G0	RAPID	Fast move
G1	LINEAR	Line (synchronized contoured motion)
G2	CW	Circle, arc (synchronized contoured motion) – clockwise
G3	CCW	Circle, arc (synchronized contoured motion) – counterclockwise
G4	DWELL	Point – wait at location for specified time in seconds
G108	VELOCITY ON	Constant velocity contour start
G109	VELOCITY OFF	Constant velocity contour end
G90	ABSOLUTE	Use absolute coordinates
G70	ENGLISH	Inches as units
G76	SECONDS	Seconds as units
G92		Define position
G82		Restore position
G84		Part rotation
	ENABLE X Y	Enable axes
	F	Set the linear feed rate (only affects G1, G2, and G3)
	M2	End of program
	M30	End program and restart at the first line

Basic A3200 programming for points, lines, and circles (arcs) is accomplished with G0 through G3. Laser firing is accomplished in two ways:

- Static (firing a number pulses or continuously), as described below.
- Motion (firing while moving along a line or arc), as described in Examples 2 and 3 (page 6-13).

Static Firing

Static firing is done either based on a number of pulses or continuous. To fire 50 pulses, enter:

G1 Laser 50 F 100 ; Set the axis as Laser, the number of pulses as 50, and the repetition rate
; (F) as 100.

To fire continuously, enter:

FREERUN Laser 100 ; Laser is the axis and 100 is a repetition rate.

: ; Enter additional commands.

ABORT Laser ; Stop FREERUN of the laser.

6.5.2 Extended Commands

In order to simplify the programming of the laser subsystem, Resonetics has prepared a set of custom defined M-codes that can be used to program the laser operation. These M-codes are automatically loaded when the A3200 is started and the codes are stored in the file A3200/Programs/MCode.pgm (described on page 6-14). The custom M-codes use a set of global variables, outlined below.

Table 6-2. Custom M-Codes

M-Code	Description
M504	Turn laser continuously ON at fixed repetition rate and pulse width
M505	Fire a fixed number of pulses at constant repetition rate and pulse width
M506	Turn the laser OFF

Table 6-3. Custom Global Variables

Variable	Description
\$GLOB3	Number of pulses
\$GLOB4	Repetition rate

Example 1: Drilling with Fixed Pulse Number

```
$GLOB3 = 100           ; Set number of pulses to 100
M505                   ; Fire the laser 100 pulses and wait for firing to complete
```

Example 2: Cutting at Fixed Repetition Rate

```
ABSOLUTE ENGLISH
$GLOB4=100           ; Set the repetition rate to 100
F10                  ; Set the linear velocity to 10 mm/sec
G92 X0 Y0           ; Define current position as X=0, Y=0
VELOCITY ON         ; Start constant velocity contour
M504                 ; Start firing the laser
G1 X5 Y0            ; Move to X=5, Y=0
G1 X6 Y3            ; Move to X=6, Y=3
G1 X5 Y6            ; Move to X=5, Y=6
M506                 ; Turn laser OFF
VELOCITY OFF        ; Finish constant velocity contour
G82                  ; Restore coordinates
```

Example 3: Cutting at Fixed Pulse Spacing

```
RELATIVE ENGLISH
G1 X1 Y0.5 Laser 50 F0.2 ; Move the stage in a linear motion 1 inch in X and 0.5 inches in Y
                          ; at a velocity (F) of 0.2 inch/second and fire 50 pulses at the same
                          ; time. The 50 pulses are fired uniformly along the diagonal path
                          ; defined by the vector (X=1, Y=0.5).
:                          ; Enter additional commands.
M506                       ; Turn off the laser.
```

6.6 Utility and Parameter Files

The following utility and parameter files are used with the Resonetics RapidX 250 Laser System.

Table 6-4. Utility and Parameter Files

Button	Description
5250_AS.pgm	Startup routine used for initial set up of the laser and stages. It performs initialization, sets stage and cassette offsets, and opens additional utility files. It is executed automatically when the A3200 software is first started. This file handles the use of parameters for the rectangular variable aperture (RVA) or mask wheel option. The system automatically activates the correct axis depending on which parameter file is selected (see Section 6.4).
5250_DO.pgm	Automatically downloaded when the A3200 software is started. This program contains all selection code in a canned function, including setting all parameters after a parameter file is selected, such that this code may be called both on startup and from the application program.
MCODE.pgm	Human readable aliases for global variables used for all tasks. See Section 6.5, page 6-12.
*.prma	Parameter file. You can choose to activate one of the following parameter files, depending on your hardware: Rectangular variable aperture (RVA): 5250Params_RVA.prma Mask wheel: 5250Params_MaskWheel.prma The procedure used to select and active a parameter file is provided in Section 6.4, below.

6.6.1 Utility Programs

Utility programs (PGM files) are listed in the following subsections.

- [5250_AS.pgm](#) to set up the laser and stages (see below)
- [5250_DO.pgm](#) to implement various M-codes (page 6-16)
- [MCode.pgm](#) to define M-codes (page 6-16)

You can access each by selecting a linked file name.

Set Up the Laser and Stages

The [5250_AS.pgm](#) script is a startup routine used for initial set up of the laser and stages. It is executed automatically when the A3200 software is first started.

1. Set the canned functions for later use.
2. Enable the X, Y, MaskWheel (or RVA_X, RVA_Y), and Laser axes.
 Note that the MaskWheel or RVA is detected automatically in the parameter file and used in the 5250_AS.pgm file, as appropriate.
3. Home the X, Y, MaskWheel (or RVA_X, RVA_Y), and Laser axes.
4. Set the default values for:
 - Pulse period
 - Pulse width
 - Duty cycle
 - Number of pulses
 - Repetition rate
 - Pulse spacing

The following is a sample of the 5250_AS.pgm file.

```

;=====
; Rev 1.0
; Author:      George Gee
; Creation Date: June 20, 2011
; Customer:
; Job Number:  5250
; Objective:   Initial setup of the system.
;=====
DVAR $result

;Set canned functions
SETCANNEDFUNCTION 1 "5250_DO.PGM", "LASER_ON_CONTINUOUS" ; M504
SETCANNEDFUNCTION 2 "5250_DO.PGM", "LASER_ON_POINT"      ; M505
SETCANNEDFUNCTION 3 "5250_DO.PGM", "LASER_OFF"           ; M506
SETCANNEDFUNCTION 4 "5250_DO.PGM", "ENTER_LASER_PARAMS" ; M507

METRIC
SECONDS
;PORT X DIRECTION 0 OUTPUT

;Enable X, Y, and Z axes
WAIT MODE INPOS
ENABLE X Y
HOME X Y
$strtask[0] = READCONFIGSTRING PARAMETERFILE
$result = STRFIND($strtask[0],"RVA",0)
IF($result >= 0)THEN
    $strglob[1] = "RVA_X"
    $strglob[2] = "RVA_Y"
    ENABLE %%$strglob[1]%
    ENABLE %%$strglob[2]%
    HOME %%$strglob[1]%
    HOME %%$strglob[2]%
ELSE
    $strglob[1] = "MaskWheel"
    ENABLE %%$strglob[1]%
    HOME %%$strglob[1]%
ENDIF
ENABLE Laser
HOME Laser
ABSOLUTE

;-----
; "Public" Laser Parameters
;-----
resonPulseWidth = 50 ;Pulse Width in microseconds
resonDutyCycle = 0 ;Duty Cycle in % (0 - 60)
resonNumPulses = 1 ;Num Pulses
resonRepRate = 100 ;Rep Rate in Hz (Standard units is Hz)
resonPulseSpacing = 0.002 ;Pulse Spacing
resonPulsePeriod = 1 / resonRepRate * 1000000 ;Pulse Period in microseconds

;Radians to degrees = 360 / (2*PI)
$GLOB21 = 57.29578
$GLOB5 = 0

LaserEnable ;$DO[16].Laser=1 Enable the laser
;Message can't not be generated by BobCAD
$STRGLOB0 = "Program has completed, press Run to Continue or Stop to quit."

M2
;=====
;Change History:
; George Gee 06-20-2011: rev. 1.0 - Initial release
;=====

```


Implement Various M-Codes

The [5250_DO.pgm](#) script is automatically downloaded when the A3200 window is opened. This program contains a series of utility subroutines that are used in the process programs. There are subroutine sections: canned functions and standard functions. The canned functions give function to the various buttons in the A3200 software and allow the operator to use M-codes to replace FARCALL commands with a simpler M-code.

The canned function subroutines are:

Subroutine LASER_ON_CONTINUOUS

1. Make sure the values being used are within specifications.
2. Put the Laser axis into FREERUN

Subroutine LASER_ON_POINT

1. Make sure the values being used are within specifications.
2. Put the Laser axis into FREERUN.
3. Wait for the calculated amount of time.
4. Stop firing pulses.

Subroutine LASER_OFF

Stop firing pulses.

Subroutine ENTER_LASER_PARAMS

1. Make sure the values being used are within specifications.
2. Ask the operator for the desired repetition rate.
3. Ask the operator for the desired number of pulses.

The standard function subroutines are:

Subroutine LogStartupError

Open the error log and begin to record errors (message, date, and time).

The following is a sample of the 5250_DO.pgm file.

```

;=====
; Rev 1.0
; Author:      George Gee
; Creation Date: June 20, 2011
; Customer:
; Job Number:  5250
; Objective:
;=====
#DEFINE LogMessage $STRGLOB3

DVAR $Response
DVAR $TempX, $TempY
DVAR $PulsePeriod, $PulseWidth
DVAR $PowerSum, $Index, $AvePower
DVAR $DwellTime
DVAR $Angle
M2
;-----
;M504
;-----
DFS LASER_ON_CONTINUOUS
;Make sure we have the defaults when running before setting the parameters
; CALL CHECK_GLOBALS
;FB1On condition
$GLOB5 = 1
;Set units to seconds (same as the programs will)

```

(Continued on the next page.)


```

SECONDS
FREERUN Laser $GLOB4
ENDDFS

;-----
;M505
;-----
DFS LASER_ON_POINT
;Make sure we have the defaults when running before setting the parameters
;CALL CHECK_GLOBALS
;MSGDISPLAY 1, "{#D #D #D #F}" "Firing ", $GLOB3, " times, Pulse Period is ", $GLOB0,
" us, Pulse Width is ", $GLOB1, " us, total time is ", $GLOB0 * $GLOB3 * 0.000001, "
sec"
;Set units to seconds (same as the programs will)
SECONDS
;FB1On condition
$GLOB5 = 1
FREERUN Laser $GLOB4
DWELL ($GLOB0 * $GLOB3)/1000000
ABORT Laser
;FB1On condition
$GLOB5 = 0
;MSGDISPLAY 1, "Finished firing pulses"
ENDDFS

;-----
;M506
;-----
DFS LASER_OFF
;FB1On condition
$GLOB5 = 0
ABORT Laser
ENDDFS

;-----
;M507
;-----
DFS ENTER_LASER_PARAMS
;Make sure we have the defaults when running before setting the parameters
;CALL CHECK_GLOBALS
;Prompt user for Rep Rate and Number of Pulses
$GLOB4 = MSGINPUT DF_MSGBOX_OKONLY "Laser Parameters;Please Enter Rep Rate (1 - 300
Hz);" $GLOB4
; $GLOB2 = MSGINPUT DF_MSGBOX_OKONLY "Laser Parameters;Please Enter Duty Cycle (0 - 60
%);" $GLOB2
$GLOB3 = MSGINPUT DF_MSGBOX_OKONLY "Laser Parameters;Enter Number of Pulses (1 -
100000);" $GLOB3
;Clamp inputs if necessary
IF ($GLOB4 < 1) THEN
    $GLOB4 = 1
ENDIF
IF ($GLOB4 > 300) THEN
    $GLOB4 = 300
ENDIF
;IF ($GLOB2 < 0) THEN
;    $GLOB2 = 0
;ENDIF
;IF ($GLOB2 > 60) THEN
;    $GLOB2 = 60
;ENDIF
IF ($GLOB3 < 1) THEN
    $GLOB3 = 1
ENDIF
IF ($GLOB3 > 100000) THEN
    $GLOB3 = 100000
ENDIF
;Compute Pulse Period in us out of entered Rep Rate
$GLOB0 = 1 / $GLOB4 * 1000000
;Compute Pulse Width in us out of Pulse Period and Duty Cycle
; $GLOB1 = $GLOB0 * $GLOB2 / 100

```

(Continued on the next page.)

```

$GLOB1 = 50 ;Hard code to 50 usec per specs.
ENDDFS

;-----
; END OF CANNED FUNCTIONS
;-----

;-----
--
;Error log. LogMessage($STRTASK6) contains the text of error. Date and time stamp.
;-----
--
DFS LogStartupError
    FILEWRITE resonErrorLogName, "#DT #TS " LogMessage
ENDDFS

;=====
;Change History:

; George Gee 06-20-2011: rev. 1.0 - Initial release

;=====

```

Define M-Codes

The [MCode.pgm](#) script defines default M-code syntax for all of the inputs and outputs on the axes of the NMotion SMC controller. This file does not define any new functionality; instead, it provides M-code syntax to access I/O, which is more familiar to some users and is axis name independent.

For example, this file allows the following syntax to be used:

M3005

rather than:

\$D0.axis1.5=1 ; axis1 is the name of the first axis

Table 6-5. M-Code Summary

M-Codes	Description
M1000-1153	Read the inputs
M2000-2153	Read the state of the outputs
M3000-3153	Set the state of the outputs
M4000-4153	Clear the state of the outputs
M5000-5153	Specify the state of the outputs

Syntax for use of the M1xxx and M2xxx series of M codes is:

\$var = M1xxx

All other syntax is simply:

Mxxxx

Refer to Section 6.5.2, page 6-13, for a list of custom defined M-codes that can be used to program the laser operation. Refer also to the [A3200 Help](#) (see *Programming Commands, I/O, M-Code I/O*) for the number and type of inputs and outputs available.

WARNING: You may change the MCode.pgm file at will, but it is cautioned that M-codes below M500 are reserved for special use and defining these will override their

definitions. For example, the RS-272 standard defines M2 to be “program stop” and if you redefine M2 in the MCode.pgm file, the new definition will override the use of M2 as a program stop.

The following is a sample of the Mcode.pgm file.

```

;-----
;Resonetics custom M-codes
; (Note: M501, M502, M503, M510 are defined locally in BobCAD generated programs)
;-----
#DEFINE M504 EXECCANNEDFUNCTION 1, 0 ;Laser On continuously - fixed rep rate
#DEFINE M505 EXECCANNEDFUNCTION 2, 0 ;Fire laser burst
#DEFINE M506 EXECCANNEDFUNCTION 3, 0 ;Laser Off
#DEFINE M507 EXECCANNEDFUNCTION 4, 0 ;Enter Laser Parameters

;-----
;Resonetics Global Variables being used.
;-----
;$GLOB0-$GLOB22 used by BobCAD Script to create a cutting program.
;$STRGLOB0 used by BobCAD Script for messages.
#DEFINE resonPulsePeriod $GLOB0 ;Pulse Period in microseconds
#DEFINE resonPulseWidth $GLOB1 ;Pulse Width in microseconds
#DEFINE resonDutyCycle $GLOB2 ;Duty Cycle in % (0 - 60)
#DEFINE resonNumPulses $GLOB3 ;Num Pulses
#DEFINE resonRepRate $GLOB4 ;Rep Rate in kHz
#DEFINE resonPulseSpacing $GLOB6 ;Pulse Spacing

#DEFINE resonLaserCamOffsetX $GLOB9 ;Offset between camera and laser center in X
#DEFINE resonLaserCamOffsetY $GLOB10 ;Offset between camera and laser center in Y

#DEFINE resonExternalsDllHandle $GLOB23
#DEFINE resonMaskOffset $GLOB24 ;Mask Offset
#DEFINE resonPwrMtrX $GLOB25 ;X Location of Power Meter
#DEFINE resonPwrMtrY $GLOB26 ;Y Location of Power Meter
#DEFINE resonPwrMtrZ $GLOB27 ;Theta Location of Power Meter
#DEFINE resonPwrMtrConv $GLOB28 ;Conversion of Power Meter Reading
#DEFINE resonPwrMtrOffset $GLOB29 ;Offset of the Power Meter (raw)
#DEFINE resonMotionDrillDwell $GLOB29 ;Time to wait before lasing (seconds)

#DEFINE resonExternalsDllName $STRGLOB1
#DEFINE resonErrorLogName $STRGLOB2
#DEFINE LogMessage $STRGLOB3

;-----
;Defined I/O bits
;-----
#DEFINE LaserEnable $DO[16].Laser=1
#DEFINE LaserDisable $DO[16].Laser=0
;-----
;Task Variables being used.
;-----

```

Notes

7. BobCAD Operation

See the [BobCAD-CAM V21 Operators Manual](#) for a complete description of BobCAD software.

7.1.1 Importing a Drawing and Generating G-code

Using the BobCAD V21 software package, you can import a CAD drawing in multiple formats (such as DXF or DWG) and generate G-code compatible with the A3200 motion controller.

BobCAD software typically has two windows (see Figure 7-1). The window on the left is the CAD window. This is a full CAD package to draw 2D or 3D drawings. For this system, only 2D drawings will be considered. The right window is the CAM window. This is where the CAM-generated code is written. You can edit the CAM code manually as well in this window.

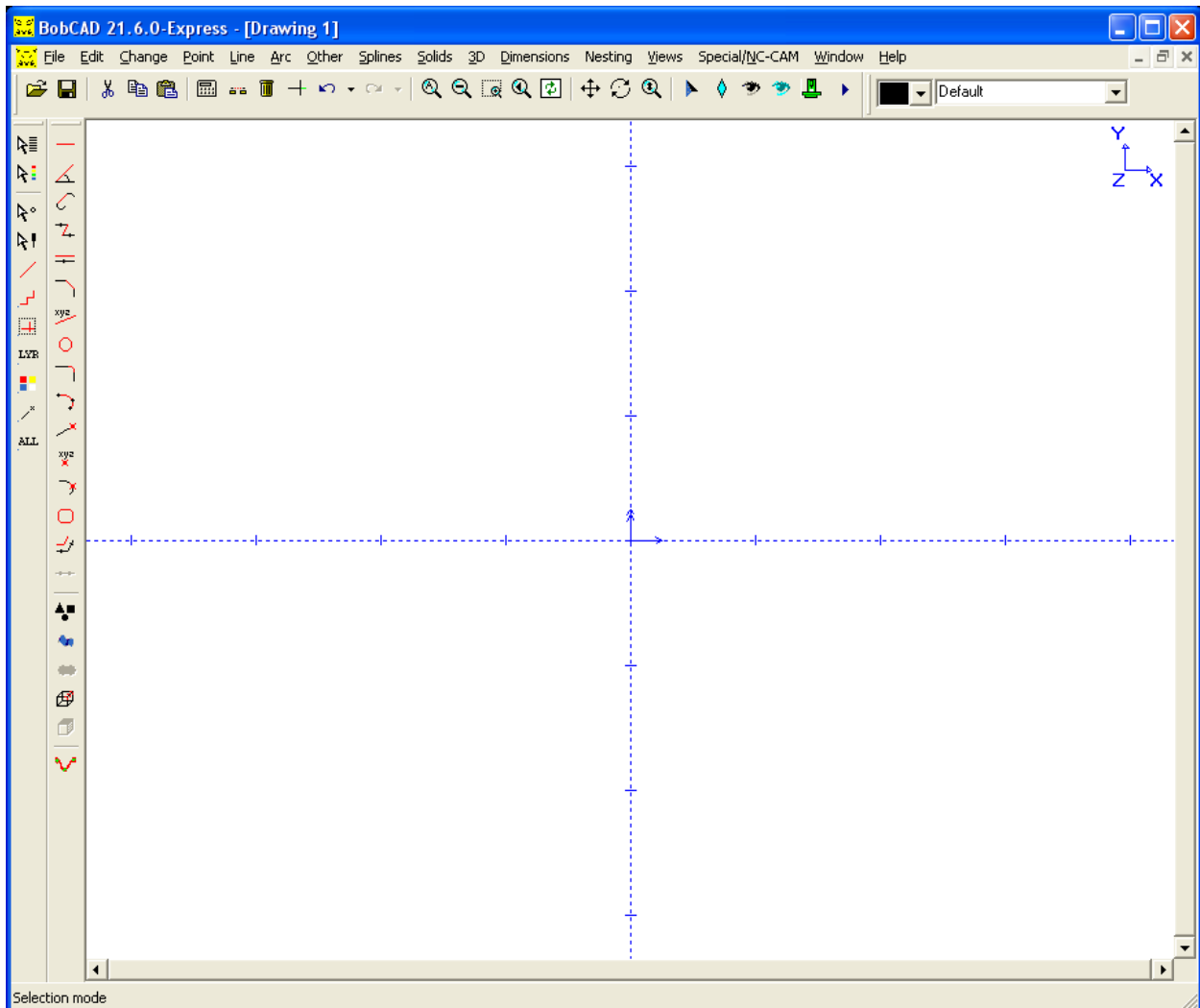


Figure 7-1. BobCAD Window

7.1.2 Opening BobCAD



Select the BobCAD icon on the desktop:

The window shown in Figure 7-2 is displayed. Select the Restore Last File option to restore the previously loaded drawing. Otherwise, select Remove File.

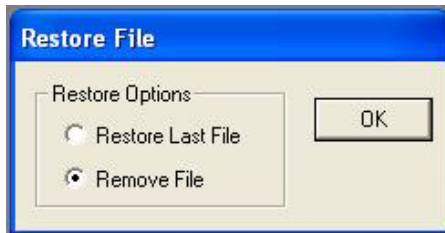


Figure 7-2. Restore File Window

If a file was not previously loaded, this window does not appear. Open a new drawing using the File menu and Open option. Your selected drawing will appear in the CAD window.

7.1.3 Organizing the Drawing Cuts

Make sure all the lines that are present in the drawing need to be cut with the laser. If extra lines are present, remove or blank out these lines. The points will be ignored until the drill cycle is performed (refer to the Drill Cycle option described on page 7-5).

The next step is to review the cut order and to make sure that the open or closed contours are cut in the proper directions. For this purpose, select all the cut features (use the right mouse button or the Edit menu). The cut lines change to red with an arrow in the center, which indicates the direction of the cut. If the lines are cut in the incorrect direction, select the line on the back side of the arrow to reverse the arrow direction.

You can also do this automatically with the Cleanup & Optimize option the Change menu and Reorganize submenu. Normally, the Clean & Optimize routine is executed automatically with the Resonetics script.

7.1.4 Execute the Resonetics Excimer Router Script

The simplest way to generate the full CNC code that can be interpreted with the A3200 motion controller is to use the “Resonetics Excimer Router.bas” script within BobCAD. The script is saved in:

C:\Program Files\BobCAD-CAM\BobCAD\CAM V21\Scripts\Resonetics Excimer Router.bas

Note: This script performs general conversion of the drawings for XY axes, but does not address any other axis such as the mask wheel or RVA.

Select the Script function either with the button on the bottom of the toolbar or from the Special/NC-CAM menu. The window shown in Figure 7-3 appears. Select the “Resonetics Excimer Router” script.

Note: When executing the “Resonetics Excimer Router.bas” script, always ensure that the CAM window is CLOSED. If a CAM window is open, close it first. The script will automatically open a CAM window. If a CAM window is already opened, no script can be written.

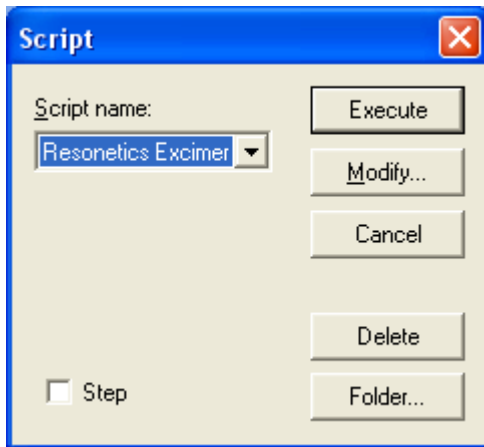


Figure 7-3. Script Selection Menu

Select the Execute button. The script will first prompt for the type of lasing: Fixed Rep Rate or Fixed Spacing (Figure 7-4).

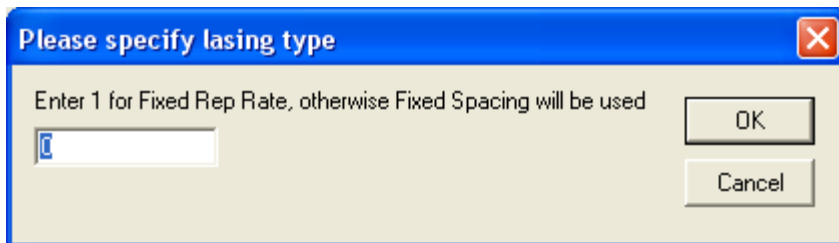


Figure 7-4. Lasing Type Menu

If you select the Fixed Spacing option, the system will ask for the specific laser parameters shown in Figure 7-5. If you select the Fixed Rep Rate option, the Pulse Spacing field will change to Rep Rate.

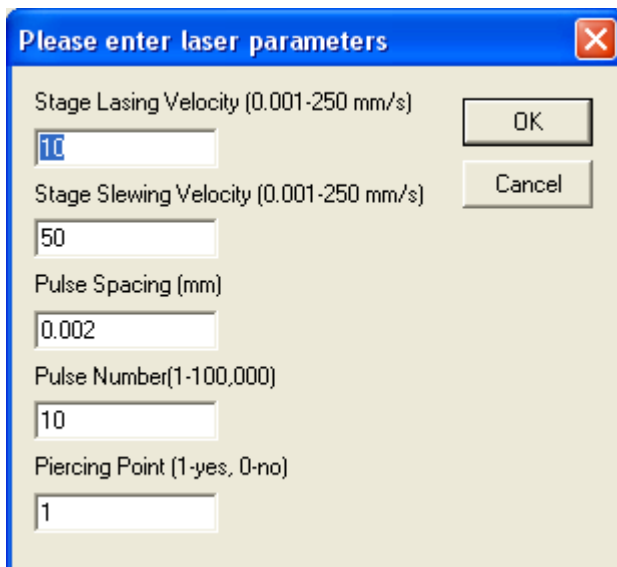


Figure 7-5. Laser Parameters Menu, Fixed Spacing Option

You must enter the following laser parameters in the Laser Parameter window.

Table 7-1. Laser Parameters

Parameter	Description
Stage Lasing Velocity	Sets the A3200 variable \$RES_CUT_SPEED_INCH_PER_SEC, which is used in the F command (feedrate specifier G-code) in the generated G-code. You can modify this variable manually later at the top of the G-code.
Stage Slewing Velocity	Sets the A3200 variable \$RES_SLEW_SPEED_INCH_PER_SEC, which sets the X,Y axis parameter RapidFeedRate and the F command for fast moves without lasing in the generated G-code. You can modify this variable manually later at the top of the G-code.
Rep Rate	Used to compute Pulse Period, Max Laser Power, and Pulse Width for Fixed Rep Rate mode.
Piercing Point	Fires a fixed number of pulses at the beginning of a contour to pierce through the material before cutting. This is sometimes necessary. On some material, if you start moving the stages without piercing first through the material, the cut will not go through. The number of pulses during piercing is defined by the Pulse Number parameter.

After selecting OK, the BobCAD CAM window opens and some G-code is generated in a window such as the one shown in Figure 7-6. The G-code generated is the header block of code and the M-code for cutting the lines.

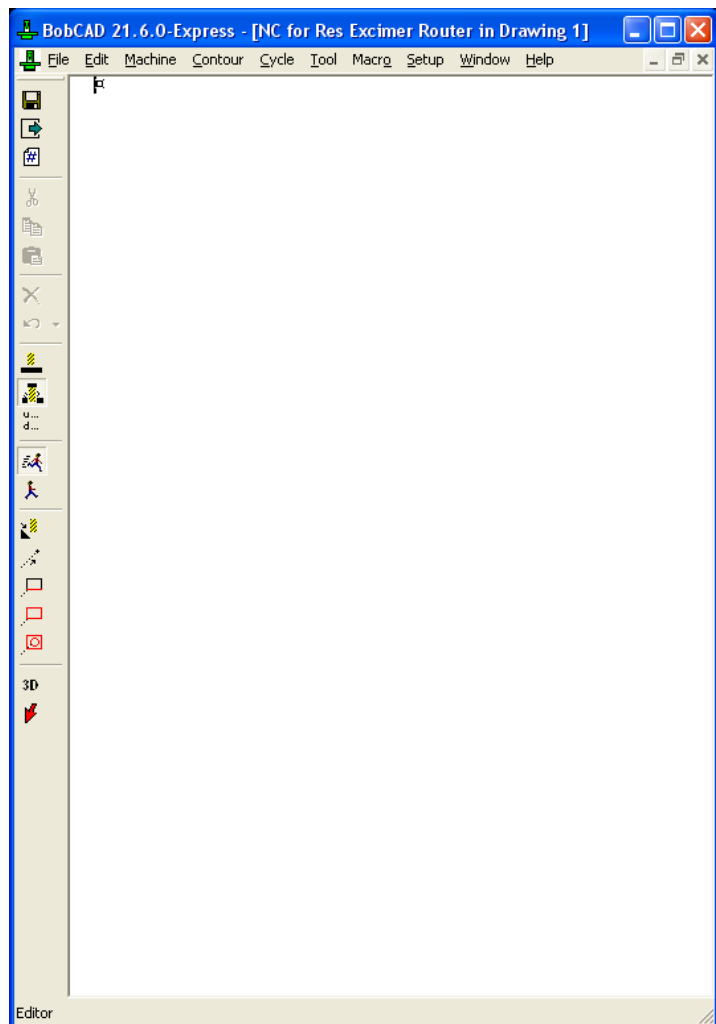


Figure 7-6. NC Screen

A Drill Cycle option window appears (see Figure 7-7). If you select 0 (no drill points), BobCAD completes the NC code with a trailer block of code. You just have to save the CAM file in the folder (for example, A3200\Programs) as a text file.

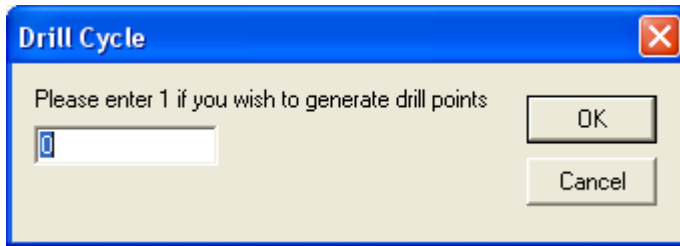


Figure 7-7. Drill Cycle Option

If you select 1 (drill points), then the trailer block of code is first written in the CAM window. The Execute Cycle window opens (see Figure 7-8) asking which cycle to use. Select the Resonetics Drill Cycle option and select OK. The system then generates a drill cycle subroutine appended at the end of the G-code program.

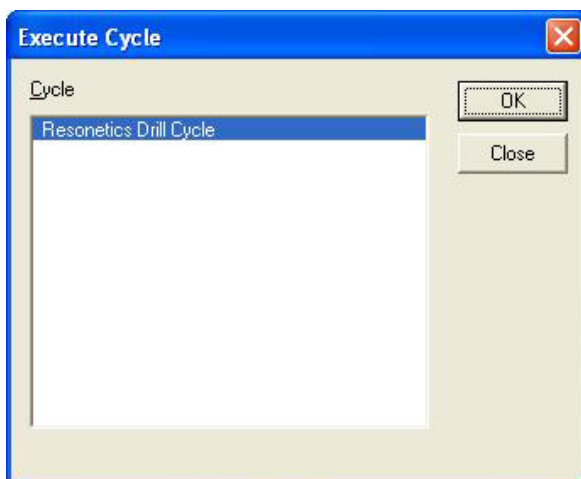


Figure 7-8. Drill Cycle Selection Menu

The Resonetics Excimer Router script is now completed. You can edit the G-code in the CAM window. By moving the cursor up and down in the CAM window, you can see the position of the laser in the CAD window corresponding to the line in the G-code. A red arrow indicates the current position of the laser for that line in the G-code. This is very useful to simulate line-by-line what the G-code will draw on the part.

7.1.5 Resonetics Post-Processor and Macros

The Resonetics RapidX 250 Laser System post-processor automatically generates the G-code based on all the features on the CAD drawing. For example, to cut a single line:

```
M510 G01 X0.0634 Y0.0437 ; Rapid stage move to position
M501 ; Laser on for contoured move
G01 X-0.0429 ; Cut in X
M503 ; Laser off and end of contoured move
```

The CAM window and the Resonetics post-processor can be manually opened with the Insert NC option on the Special/NC-CAM menu in the BobCAD CAD window.

The window shown in Figure 7-9 opens. Select the Resonetics Excimer Router configuration. Select OK and the CAM window opens on the right of the screen.

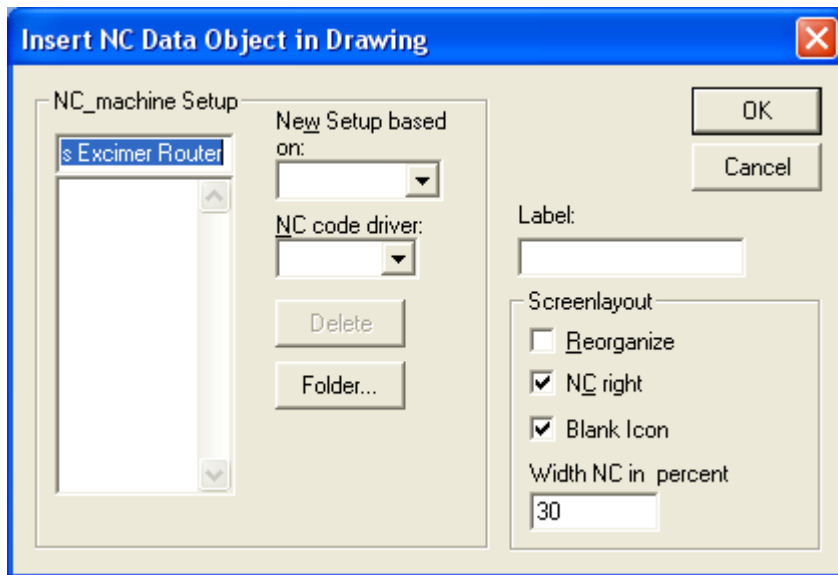


Figure 7-9. Post-Processor Selection Window

In the CAM window, you can edit the script or write the script line-by-line with the help of BobCAD.

There are five prepared macros.

Table 7-2. Macros

Macro	Description
Program Start	This macro writes the header block of the G-code. Default laser parameters are entered at the top of the code and can be edited manually. After executing this macro, you can write a machine cycle with the CUT SINGLE, CUT ALL, or CUT AUTO commands in the MACHINE menu of the CAM window. After the cut cycle, you must insert the trailer block of G-code with the PROGRAM END macro.
Program End Fixed Rep. Rate	This macro only writes the trailer block of G-code with the Fixed Repetition Rate option (no drill cycle is enabled with this macro).
Program End Fixed Spacing	This macro only writes the trailer block of G-code with the Fixed Spacing laser cutting option and with no drill cycle (cutting only).
Program Drill Cycle	This macro writes the program (header and trailer) for a drill cycle. Default laser parameters are written at the top of the code and can be edited manually. After executing this macro, you can select a DRILL CYCLE from the MACHINE menu in the CAM window. The drill cycle should be appended at the end of the G-code as a subroutine.
Resonetics Full Script	This macro executes the full Resonetics Excimer Router script.

You can easily modify the post-processor and the macros. However, modification should only be done by users familiar with both BobCAD and the A3200 controller. Any modifications to the post-processor may adversely affect the behavior of the system when running the G-code generated with this post-processor.

7.1.6 Example of G-Code Generation

Open a drawing from BobCAD with the File menu, Open option.

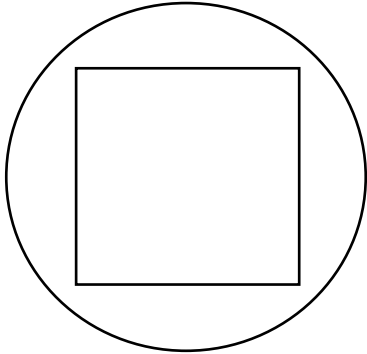


Figure 7-10. Sample Drawing

Execute the “Resonetics Excimer Router” script from the Special/NC-CAM menu or by selecting the SCRIPT icon in the toolbar. A series of windows opens to define some options (fixed rep rate or fixed spacing, laser parameters, drill point options). At the end, the CAM window opens on the right of the CAD drawing with the content of the NC code. For example:

```

;This program was generated in BobCAD with Resonetics Excimer Router.bas script

;Declare variables
DVAR $RES_PULSE_PERIOD_US
DVAR $RES_PULSE_WIDTH_US
DVAR $RES_PULSE_NUMBER
DVAR $RES_PULSE_SPACING_MM
DVAR $RES_CUT_SPEED_MM_PER_SEC
DVAR $RES_SLEW_SPEED_MM_PER_SEC

;-----
;Any laser parameter or stage velocity changes may be performed below between dashed lines
;-----
$RES_PULSE_PERIOD_US = 200
$RES_PULSE_WIDTH_US = 50
$RES_PULSE_NUMBER = 10
$RES_PULSE_SPACING_MM = 0.002
$RES_CUT_SPEED_MM_PER_SEC = 10
$RES_SLEW_SPEED_MM_PER_SEC = 50
$GLOB9 = 0 ;Camera to Laser Offset X
$GLOB10 = 0 ;Camera to Laser Offset Y
;-----

;Define custom M-codes
#define M501 CALL CONSTANT_VELOCITY_CUT_START
#define M502 CALL DRILL_POINT
#define M503 CALL CONSTANT_VELOCITY_CUT_END
#define M510 F$RES_SLEW_SPEED_MM_PER_SEC

;System initialization
MSGCLEAR -1
ABSOLUTE
METRIC
SECONDS
ENABLE X Y
;Assign X, Y axis parameters for G0 (RAPID) movements
DefaultSpeed.X = $RES_SLEW_SPEED_MM_PER_SEC
DefaultSpeed.Y = $RES_SLEW_SPEED_MM_PER_SEC

;Zero stage to apply relative laser offset
G92 X0 Y0

```

Resonetics RapidX 250 CompexPro System

```
;Move stage from camera to laser
G0 X$GLOB9 Y$GLOB10

;Zero stage for laser origin
G92 X0 Y0

;Enable software deskew with the angular difference set above
G84 X Y F$GLOB20

;Assign globals for custom M-codes to control laser in both this program and manually
CALL SET_LASER_PARAMS P$RES_PULSE_PERIOD_US I$RES_PULSE_WIDTH_US E$RES_PULSE_NUMBER
CALL SET_LASER_PARAMS S$RES_PULSE_SPACING_MM

LOOKAHEAD FAST ;Enable multiblock look aheads to fast.
;-----
;Below between dashed lines is the G-code for cutting
;-----
G00 X1.250 Y-1.250
M504
G01 X-1.250 Y-1.250
G01 X-1.250 Y1.250
G01 X1.250 Y1.250
G01 X1.250 Y-1.250
M506
G00 X2.000 Y0.000
M504
G02 X2.000 Y0.000 I-2.000 J0.000
M506
;-----

;Execute drilling
CALL DRILL_CYCLE

;Reset axes' direction
G84 X Y

;Return to camera origin, unzero stage
G0 X-$GLOB9 Y-$GLOB10
G82

;Post Program Completed message
MSGBOX DF_MSGBOX_OKONLY, $STRGLOB0

LOOKAHEAD NORMAL ;Return multiblock look aheads to normal.
;Restart program
M30

;Subroutines
DFS CONSTANT_VELOCITY_CUT_START
CALL DRILL_POINT
F$RES_CUT_SPEED_MM_PER_SEC
VELOCITY ON
M504
ENDDFS

DFS CONSTANT_VELOCITY_CUT_END
M506
VELOCITY OFF
ENDDFS

DFS DRILL_POINT
M505
ENDDFS

DFS SET_LASER_PARAMS
IF ($P.DEFINED) THEN
$GLOB0 = $P
ENDIF
IF ($I.DEFINED) THEN
$GLOB1 = $I
ENDIF
IF ($E.DEFINED) THEN
```

```

$GLOB3 = $E
ENDIF
IF ($S.DEFINED) THEN
$GLOB6 = $$S
ENDIF
ENDDFS

DFS DRILL_CYCLE
G00 X1.000 Y-0.500
CALL DRILL_POINT
G00 X0.500 Y-1.000
CALL DRILL_POINT
G00 X1.000 Y0.500
CALL DRILL_POINT
G00 X0.500 Y1.000
CALL DRILL_POINT
G00 X-0.500 Y1.000
CALL DRILL_POINT
G00 X-1.000 Y0.500
CALL DRILL_POINT
G00 X-1.000 Y-0.500
CALL DRILL_POINT
G00 X-0.500 Y-1.000
CALL DRILL_POINT
G00 X0.000 Y0.000
CALL DRILL_POINT
ENDDFS

```

Once the NC code is generated, you must manually save the code in the folder “C:\A3200\Programs” so the code can be opened and used within the A3200 software.

Open the File menu and select the Save As a Copy option (see Figure 7-11). Select a file name, open the “A3200\Program” folder, and save the NC code.

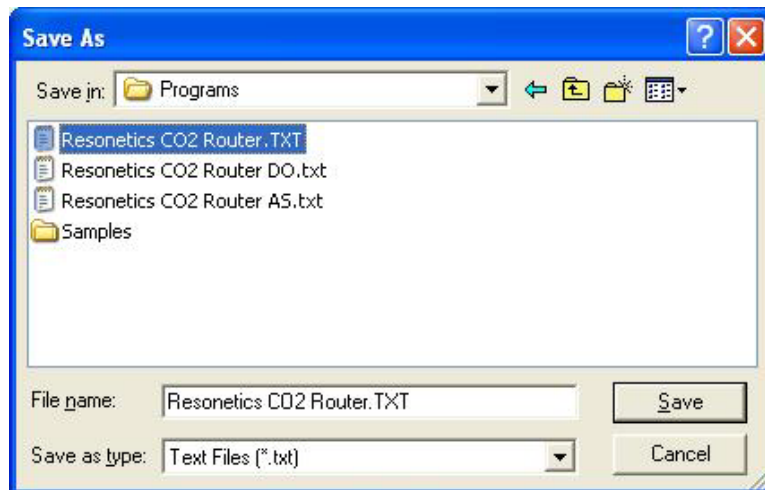


Figure 7-11. Save As File Window

Now the NC code is ready to be executed in A3200 software environment.

Notes



Part IV

Engineering, Maintenance, and Service Procedures



8. Maintenance

The maintenance procedures described in this section can be performed by anyone knowledgeable of system operation. Access to the laser beam is not required.

Procedures for maintaining the laser (including changing the gas cylinders) are described in the [*COMPexPro® \(RoHS\) User Manual*](#).

You should keep a Resonetics Excimer Laser Ablation System maintenance notebook for recording all data pertinent to laser operation. Possible entries might include dates and total pulse counts for new gas fills, routine and corrective maintenance, beam profiles, fluence measurements, etc. Certain notebook entries should be made in the laser notebook after every new gas fill. These entries should include the shot count and date when the fill is administered. Upon completion of each fill, the laser should be pulsed at a standard repetition rate and high voltage (100 pulses/sec and 22 kV). Laser energy and a beam profile should be taken at this point and entered in the notebook for future reference.

CAUTION

Always use proper protective eyewear when working with the laser beam when the laser interlock is defeated.

Restrict access to the system when the interlocks are defeated for service purposes.

Refer to Section 2, *Safety*, in this manual.

ONLY a qualified service technician should work with the system interlocks overridden and should have access to the laser beam radiations.

**DIRECT OR INDIRECT LASER RADIATION
CAN CAUSE SEVERE SKIN AND EYE DAMAGE.**

Periodicity of preventive maintenance depends on machine usage. These maintenance schedules assume an average laser usage of 40 hours a week.

The [*COMPexPro® \(RoHS\) User Manual*](#) (Section 7) lists preventative maintenance for the laser.

Cleanliness of the optical components is critical for proper performance of the system (as described in Section 8.3.1). UV mirror and lenses will normally degrade over time with usage. Regularly check and clean all optics for proper performance (reflectivity for mirror and transmission for lenses).

Table 8-1. Preventative Maintenance Schedule for the Workstation

Period	Maintenance Tasks	Reference in this Manual
Weekly	Clean the process enclosure using a dry cloth or one lightly dampened with alcohol. Vacuum all inside surfaces.	Self-explanatory
	Initiate a new gas fill.	Section 8.1.1
	Check the chiller water level and cleanliness.	Section 8.1.2
Monthly	Replace the water filter.	Section 8.2.1
	Clean or replace the air filters in front of the motion control box and on the computer. Clean more frequently, as required, based on the environment.	Section 8.2.2
	Check laser fluence and record the results.	Section 8.2.3
Quarterly	Clean the beam delivery optics. The lens and mirrors in the beam path will require cleaning.	Section 8.3.1
Annual	Vacuum the insides of the motion control box and the computer compartment.	Self-explanatory
	Perform a grid test to test the stage calibration.	Section 8.4.1

8.1 Weekly Maintenance

8.1.1 Initiate a New Gas Fill

If the laser gas is older than 5 days or more than 10 million shots have been executed, you must initiate a new gas fill. (Note that these are general numbers for a new laser. As the resonator optics become dirty and as the laser head ages, these values will diminish.) For more information, refer to the [COMPexPro® \(RoHS\) User Manual](#).

Keep a log book to record date, shot count, calibrated energy, and bottle pressures.

1. Open all required gas cylinders. Check that the minimum pressure in the cylinder is satisfied and that the regulating pressure is correct.
2. Press MENU SEL on the COMPexPro® handheld keypad.
3. Use the ARROW key to scroll to the either SINGLE GAS if you are using single gas cylinders or PREMIX if you are using one premix cylinder and He for flushing.
4. Press ENTER several times until the menu clears.



5. Press NEW FILL on the COMPexPro® handheld keypad.
6. Press ENTER to select the gas fill.
7. Press EXE and the system will automatically start the vacuum pump, vacuum the vessel, and then fill it with the appropriate gas recipe.

8. Calibrate the laser energy meter. This procedure requires an external power meter and requires access to the laser beam. Wear protective eyewear rated for UV during this procedure.
 - a. Remove the laser tube connecting the laser to the workstation (tool required).
 - b. Insert the external power meter at the output of the laser.
 - c. Set the laser to run at HV Constant mode with Internal trigger:

193 nm		
Low Limit:	22 kV	
High Limit:	26 kV	> 10 Hz
	30 kV	< 10 Hz

248 nm		
Low Limit:	19 kV	
High Limit:	26 kV	> 10 Hz
	30 kV	< 10 Hz

- d. Press the EGY CAL button.
- e. Press ENTER.
- f. Press EXE. The laser will start up.
- g. Read the power from the power meter.
Multiply wattage by 10 to convert to milliJoules (mJ).
- h. Enter the mJ reading.
- i. Press ENTER to accept the calibration.
- j. Place the beam tube back in place.

8.1.2 Check the Chiller Water (if the chiller option is used)

Maintenance of the chiller water involves two procedures: checking the water level and checking the water cleanliness.

Check the Chiller Water Level

DO NOT RUN THE PUMP DRY. If the pump does not establish prime, the pump shaft seal may overheat and be damaged. If the water level is low, use spring water to refill to the proper level.

Note: Do not use any chemicals in the chiller water. DO NOT use de-ionized water.

Refer to the [Affinity® S-Series Chillers User Manual](#) for instructions on how to verify that the water level inside the closed cycle chiller is sufficient. Water should be above the level sensor in the reservoir.

If the water level cannot be maintained, check for leaks.

Check Chiller Water Cleanliness

During the water level check, do a qualitative inspection of the cleanliness and purity of the water.

If the water appears to be cloudy or shows signs of corrosion or calcium build up, replace the water. In addition, verify that the replacement water is spring water and not normal tap water.

8.2 Monthly Maintenance

8.2.1 Replace the Chiller Water Filter (if the chiller option is used)

A disposable particle filter is located on the back of the chiller behind the water flow control valve and gauge. The filter is used to remove particles in the water. It is easily removed and replaced. To protect the pump and the laser, inspect the filter to be sure it is clean and attached properly.

8.2.2 Clean or Replace Air Filters

Initial Conditions

- Power to the system is OFF.
- The laser beam stop control switch is OFF.

Procedure

Clean or replace the air filters in front of the motion control box and in front of the computer box. The filters snap into place.



Figure 8-1. Air Filters

8.2.3 Measure Laser Fluence Using an External Energy Probe

This procedure is used to measure fluence after an application is set up. Record the fluence measurement so that the same laser parameters can be achieved on future setups.

Fluence measurements are an indicator of the energy density of the laser beam at the target surface and can be used to troubleshoot poor machining conditions. The measurement must be taken downstream of the projection lens assembly so that diffraction losses are not included in the calculations.

An energy probe calibrated to ultraviolet frequencies can be purchased from Resonetics. The probe must be hooked up to a display device, typically a specialized energy meter display.

Recommended Energy Meter

- Coherent/Molelectron model 550-MUV and display model FieldMAXII Top
- Thermal paper

Initial Conditions

- The system is ON and has been operating for at least several minutes
- The beam delivery unit (BDU) is aligned

Procedure to Measure Laser Fluence Using an External Energy Probe**CAUTION**

Always use proper protective eyewear when working with the laser beam when the laser interlock is defeated.

Restrict access to the system when the interlocks are defeated for service purposes.

Refer to Section 2, *Safety*, in this manual.

ONLY a qualified service technician should work with the system interlocks bypassed and should have access to the laser beam radiations.

**DIRECT OR INDIRECT LASER RADIATION
CAN CAUSE SEVERE SKIN AND EYE DAMAGE.**

1. Put the system in service mode—turn the SERVICE interlock bypass key (on the beam stop control box) to the ON position.
2. Open the beam stop. To do so, turn the key in the beam stop control switch (on the beam stop control box) to the ON position.
3. Program the laser to pulse continuously at 10 pps.

CAUTION

**DO NOT POSITION THE ENERGY PROBE NEAR THE BEAM FOCAL POINT OR
THE PROBE MAY BE DAMAGED**

4. Open the work piece loading access window.
5. Insert the energy probe in the beam path just where it exits the projection lens barrel. Hold the probe steady and measure the detector voltage on an oscilloscope or other electronic display. Toggle the laser off and close the beam stop. The energy is typically displayed in Joules or the power is displayed in Watts:

$$\text{Power (Watts)} = \text{Energy (Joules)} \times \text{Reprate (Hz)}$$
6. Place a thin piece of UV-sensitive material, such as Kapton tape, on the target surface. Fire several laser pulses.
7. Remove the UV-sensitive material (Kapton tape) and measure the dimensions of the image under a microscope. Determine the area within the image in square centimeters using the outside dimensions.
8. Calculate the fluence by dividing the laser energy in Joules by the area.

$$\text{Fluence (J/cm}^2\text{)} = \text{Energy (J)} / \text{Area (cm}^2\text{)}$$

9. Obtain a beam profile on a blank card or, preferably, a piece of thermal fax paper just after the beam stop.
10. Turn the SERVICE interlock bypass key (on the beam stop control box) to the OFF position (to exit service mode). Remove the key.
11. File the beam profile and record the fluence in your Resonetics RapidX 250 Laser System maintenance/service notebook for future reference.

8.3 Quarterly Maintenance

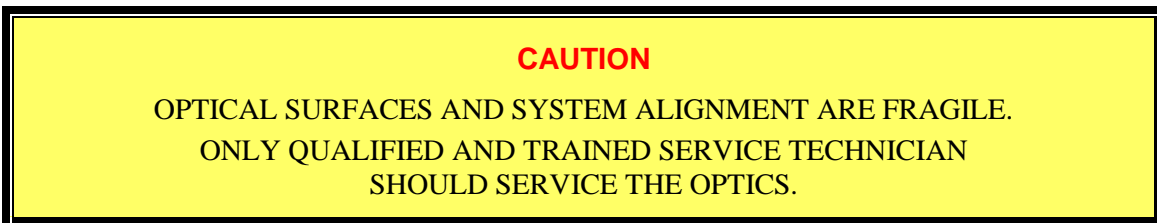
8.3.1 Clean the Beam Delivery Subsystem (BDS) Optics

This procedure should be conducted approximately every three months or when optics are suspected to need cleaning or replacement. The lens and the mirrors in the beam path will require cleaning.

Initial Condition

- The system is OFF

Procedure to Clean the BDS Optics



1. Remove the enclosure covers.
2. If an optics surface is not easily accessible, it will need to be removed from its holder to allow its surface to be cleaned.

Note: Always wear clean room, powder-free, latex gloves to remove optics.

3. With an air bulb or clean dust free air duster, blow away all dust and debris from the optical surface of the lens or mirror.
4. Dampen a lint-free lens tissue with HPGL-grade filtered methanol. Gently wipe the surface with the damp lens tissue. Do not rub hard. Drag the tissue across the surface just fast enough so the liquid evaporates behind the tissue. This should leave no streaks. Use a cotton lint-free swab on hard-to-reach optics.

Note: Avoid using isopropyl alcohol or acetone because they may leave streaks on the optics.

Do not attempt to polish the optics surface. The lenses are AR coated and this coating would be damaged by polishing action.

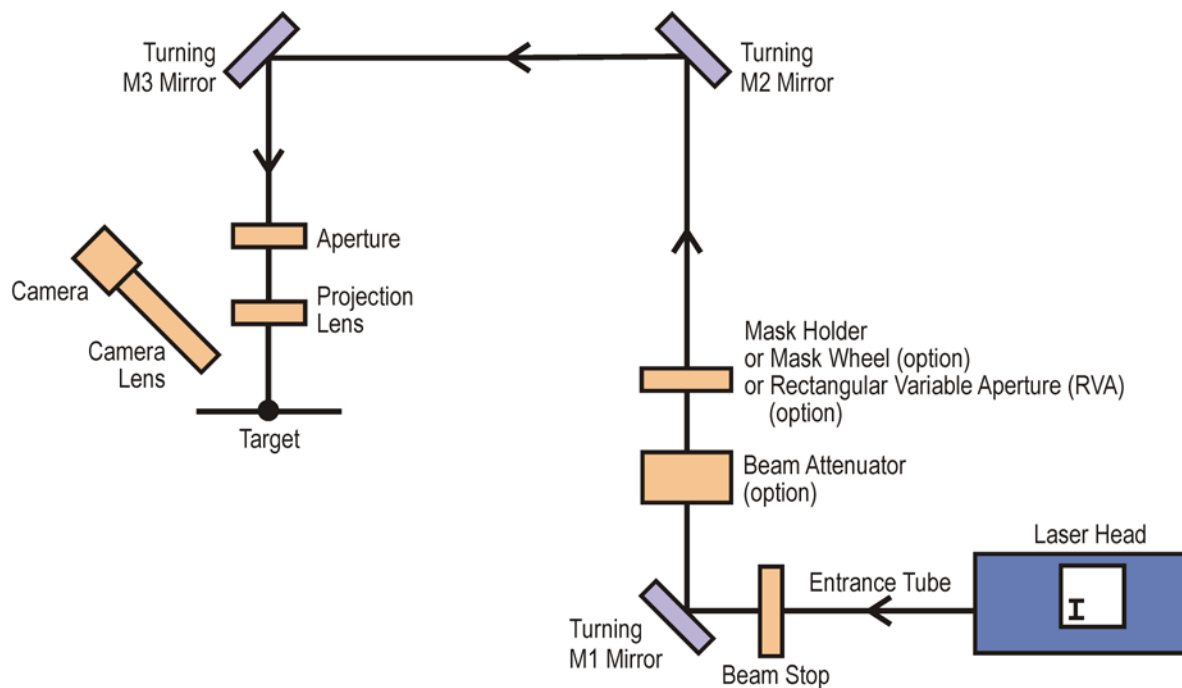


Figure 8-2. Beam Delivery Subsystem Assembly

5. Examine the lens or mirror carefully. If the color of the surface has changed or appears to be abraded, the lens or mirror should be replaced or returned for rework.
6. Reinstall the lens or mirror in its holder.
7. After all optics have been cleaned, check the beam alignment (see Section 9.1, page 9-1). Reinstall the covers and purge tubes.
8. Check the laser fluence after cleaning. See Section 8.2.3, page 8-4.

8.4 Annual Maintenance

8.4.1 Test the Stage Calibration with a Grid Test

Test the stage calibration on an annual basis. This can be performed by writing a test grid pattern on a sample such as an acrylic sheet. Using a calibrated measurement microscope, measure the grid pattern generated with the laser.

The test can be performed in two ways:

- Put four marks at the corners of a glass slide. Using a calibrated measurement microscope, measure the distances of the grid pattern marks generated with the laser.

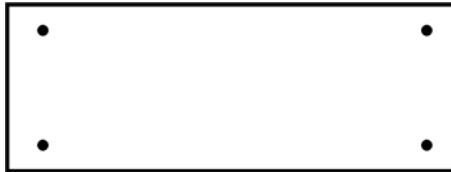


Figure 8-3. Microscope Slide with Marks to Measure

- Another method is to place a calibrated glass slide (or equivalent) on the stage and check it with on the vision monitor. Jog the stage to check its accuracy with respect to the calibrated scale.

Note: For accurate measurements, the scale must run true with respect to the stage. Make sure the scale is also de-skewed so it runs parallel to one or the other stage axis.

If you detect a significant error in one or the other axis calibration, adjust the corresponding calibration parameters. Calculate the ratio of the actual X distance to the intended. Do the same for the Y distance.

Notes



9. Service

The service procedures may require work with the interlocks bypassed and access to the laser beam radiations. The procedures described in this section should be performed **ONLY** by a qualified service technician.

All procedures for servicing the laser (including changing the gas cylinders) are described in the [COMPexPro® \(RoHS\) User Manual](#) and are not repeated in this manual.

CAUTION

Always use proper protective eyewear when working with the laser beam when the laser interlock is defeated.

Restrict access to the system when the interlocks are defeated for service purposes. Refer to Section 2, *Safety*, in this manual.

DIRECT OR INDIRECT LASER RADIATION CAN CAUSE SEVERE SKIN AND EYE DAMAGE.

9.1 Beam Delivery Subsystem (BDS) Path Alignment

The BDS path alignment should be accomplished after replacement of BDS optics or when the beam is suspected to be misaligned. Once the path is established, there should be no reason to repeat the entire alignment.

The BDS path alignment involves several procedures (see Figure 9-1). Accomplishment of any single step is based on the successful performance of the previous procedure. The performance of one procedure, however, does not necessarily require re-performance of all other procedures.

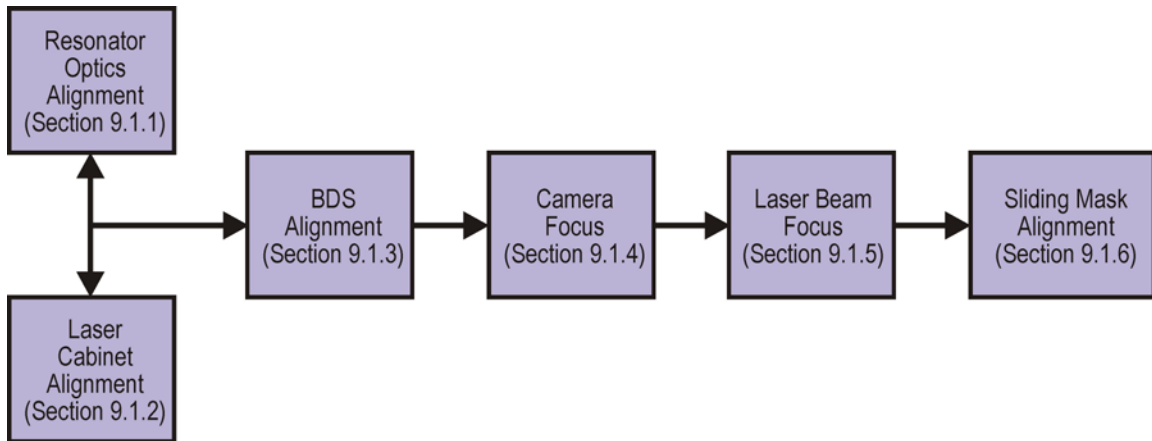


Figure 9-1. Logical Sequence of Alignment Procedures on the Excimer System

Resonetics RapidX 250 CompexPro System

The block diagram above describes the basic sequence in aligning the laser workstation. Accomplishment of any single step is based on the successful performance of the previous procedure. The laser beam cannot be focused before the camera, for example, because camera adjustments may change the length of the image distance. The performance of one procedure in the diagram above, however, does not necessarily require the re-performance of all follow-on steps.

The laser beam path is shown in Figure 9-2. Three beam alignment tools are provided for positioning the laser beam at the proper locations. These tools are placed into the beam path during this procedure and removed when the alignment is accomplished.

The easiest technique for locating the invisible excimer laser beam is to place a white piece of paper in its path. A business card is ideal for this purpose; or, thermal paper can be used. The ultraviolet light will cause the paper to fluoresce, eventually producing a beam profile image on the card.

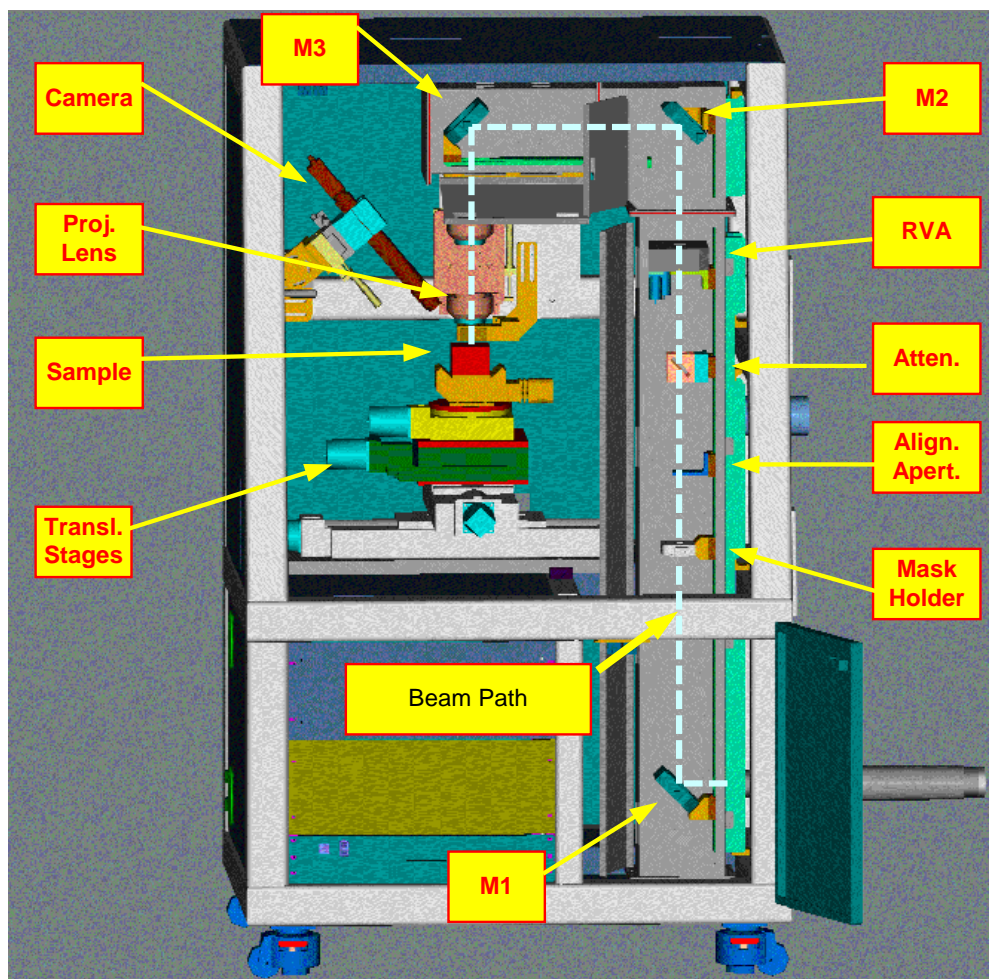


Figure 9-2. Beam Delivery Subsystem Assembly

9.1.1 Resonator Optics Alignment Procedure

The resonator optics requires alignment only after being cleaned or replaced. If the BDS is not already aligned, the appropriate procedure described in the [COMPexPro® \(RoHS\) User Manual](#) should be performed in its entirety. There are several methods of alignment, all of which require some insight and ingenuity. A diode laser alignment fixture, available through Coherent, is an ideal option.

Initial Conditions

- BDS is already aligned
- System is ON

Tools and Materials Required

- Safety glasses
- Blank business cards
- COMPexPro® optic aperture plugs (to be used with a diode aligner only)

Procedure to Align the Resonator Optics

DANGER

Always use proper protective eyewear and other protective gear when working with the laser beam when the laser interlock is defeated.

Do not expose eye or skin to laser radiation when operating with panels open and interlocks defeated.

Refer to Section 2, *Safety*, in this manual.

Restrict access to the system when the interlocks are defeated for service purposes. ONLY a qualified service technician should work with the system interlocks bypassed and should have access to the laser beam radiations.

**DIRECT OR INDIRECT LASER RADIATION
CAN CAUSE SEVERE SKIN AND EYE DAMAGE.**

1. Refer to the [COMPexPro® \(RoHS\) User Manual](#) for optics alignment information.
2. Remove the beam entrance tube.
3. Program the excimer laser to pulse continuously at approximately 30 Hz.
4. Make minor adjustments to the front optic to maximize laser energy, at the same time observing the beam location and profile just in front of M1. If anything more than minor adjustment is required, it may be necessary to make further adjustments to the laser position.
5. When optic adjustments are complete, turn off the laser and reinstall the entrance beam tube.
6. Calibrate the laser energy detector using the procedure described in the [COMPexPro® \(RoHS\) User Manual](#) (Section 7.9.1).
7. Close the beam stop. To do so, turn the key in the beam stop control switch to the OFF position.

8. Program the laser to fire continuously at pulse rate 100 Hz and high voltage set point 24 kV. Toggle on the laser and note the energy display on the remote control unit. Record this energy reading in the workstation notebook and compare it to previous recorded values.
9. Obtain a profile of the beam cross-section with a blank business card. Archive the beam profile in the notebook for future reference.
10. If either pulse energy or the beam profile checks are unsatisfactory, the laser must be realigned with one of the procedures in the [COMPexPro® \(RoHS\) User Manual](#).

9.1.2 Laser Cabinet Alignment Procedure

The laser cabinet must be aligned if the laser beam is not centered on the M1 entrance mirror. The beam can be lifted or lowered by adjusting the four setscrews on the foot plates. (The two foot plates extend from one side of the laser cabinet to the other and there are two setscrews on each side of each plate.)

The laser beam can be shifted in and out by loosening the locking screws and using the two in/out adjusters (one on either side of the plate).

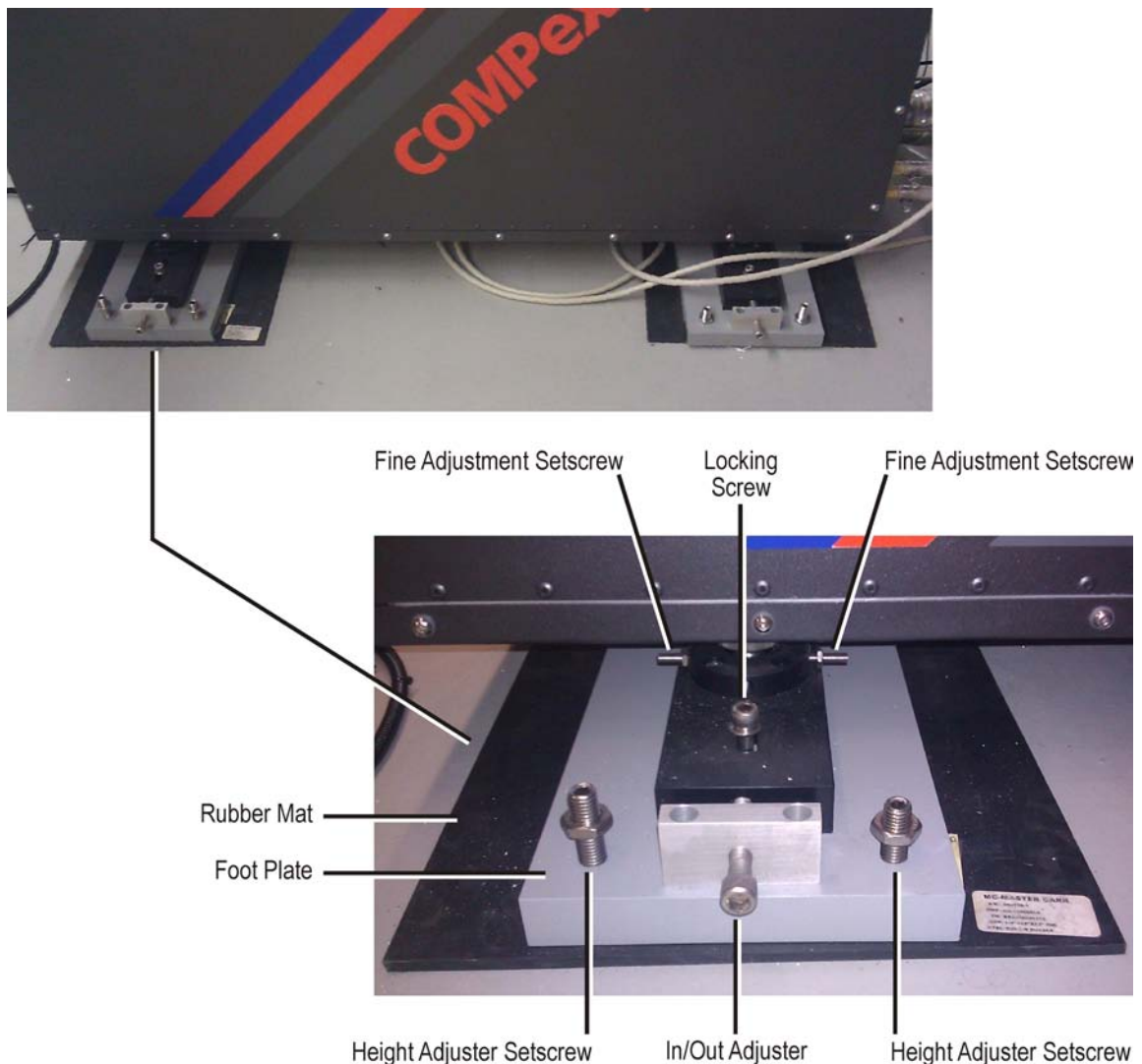


Figure 9-3. Foot Plates and Adjusters

9.1.3 Beam Delivery Subsystem (BDS) Alignment Procedure

DANGER

Always use proper protective eyewear and other protective gear when working with the laser beam when the laser interlock is defeated.

Do not expose eye or skin to laser radiation when operating with panels open and interlocks defeated.

Refer to Section 2, *Safety*, in this manual.

Restrict access to the system when the interlocks are defeated for service purposes.

ONLY a qualified service technician should work with the system interlocks bypassed and should have access to the laser beam radiations.

**DIRECT OR INDIRECT LASER RADIATION
CAN CAUSE SEVERE SKIN AND EYE DAMAGE.**

Optics Cleaning Notes

- Do not expose skin or other body tissues to the beam.
- Avoid contaminating mirror surfaces with finger oils. Wear clean room, powder-free, latex gloves.
- Wipe a surface in a manner that does not cause scratches from wiping the particulate contamination on the surface. Use clean dry air or nitrogen blow-off before employing wipes. Use each wipe for one drag only. Discard used wipes.
- If a surface does become contaminated, clean it with analytical-grade methanol and a clean lint-free tissue.

Tools and Materials Required

- Safety glasses and other safety equipment
- Blank business cards

Procedure to Align the BDS

1. Open the purged compartments.
2. Remove the projection lens.
3. Remove the mask wheel, RVA, and/or mask holder.
4. Remove the attenuator.
5. Fire the laser at 5 Hz.
6. Use a business card in the laser beam path to locate the laser beam position in adjustment steps starting below.

Adjust Laser to Center the Beam in the Chamber

7. Place A1 at the beam stop end of the laser entrance tube. Refer to Figures 9-4 and 9-5.
8. Adjust the laser to align the beam with mirror M1 so that the beam is centered into the chamber.



Figure 9-4. Alignment Aperture A1

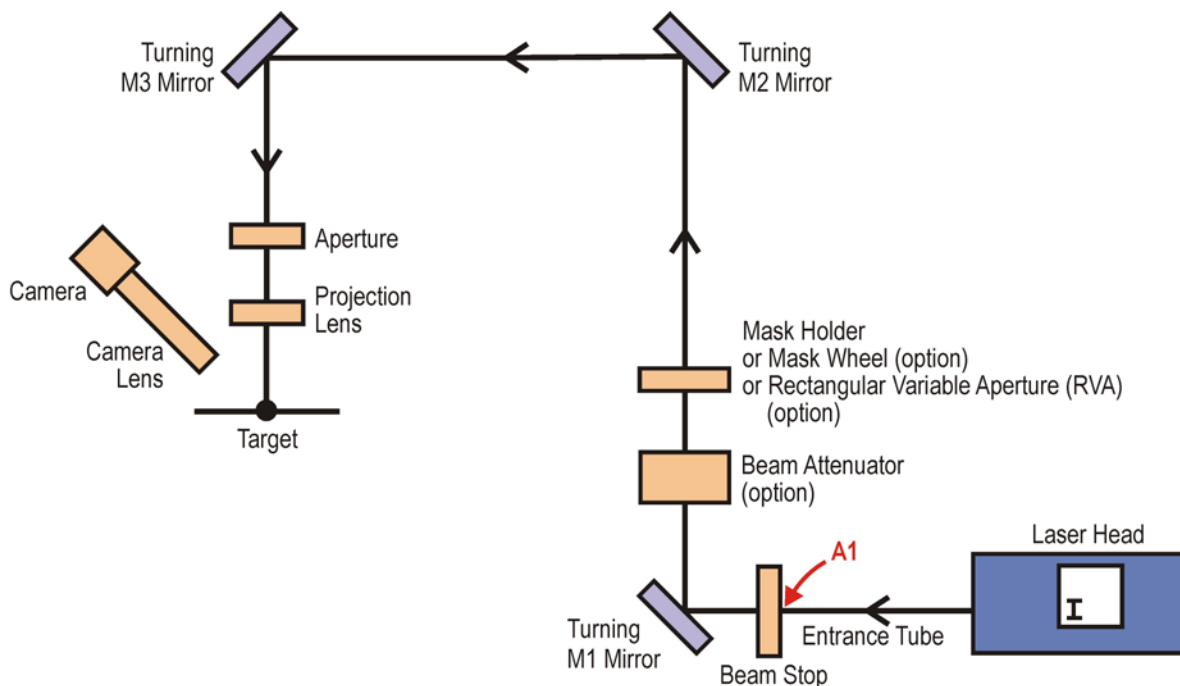


Figure 9-5. Laser Alignment

Adjust M1

9. Install the alignment aperture A2 before/close to M2. Refer to Figures 9-6 and 9-8.
10. Adjust turning mirror M1 up and down along the rail to center the laser beam on M1.
11. Adjust the adjustment knobs on M1 to let the laser beam pass through A2.
12. Install another A2 close to M1.
13. Adjust M1 up and down along the rail to let the laser beam pass through both A2 apertures.
14. Adjust M1 (adjustment knobs) to let the laser beam pass through both A2 apertures. Refer to Figure 9-7.
15. Repeat this alignment procedure (Steps 9 through 15) for M1, as necessary.

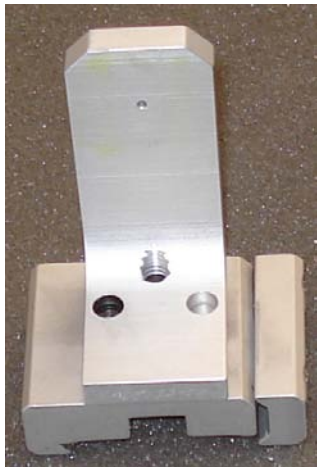


Figure 9-6. Alignment Aperture A2

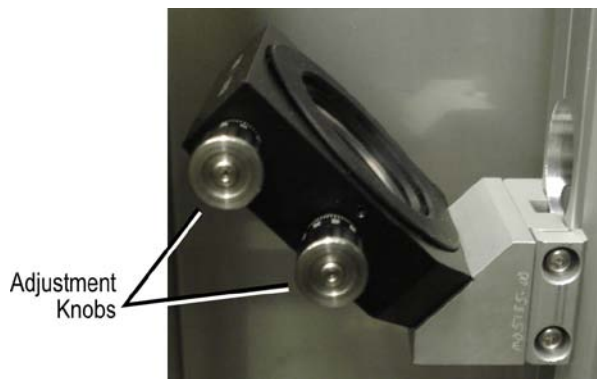


Figure 9-7. Mirror Adjustment Knobs

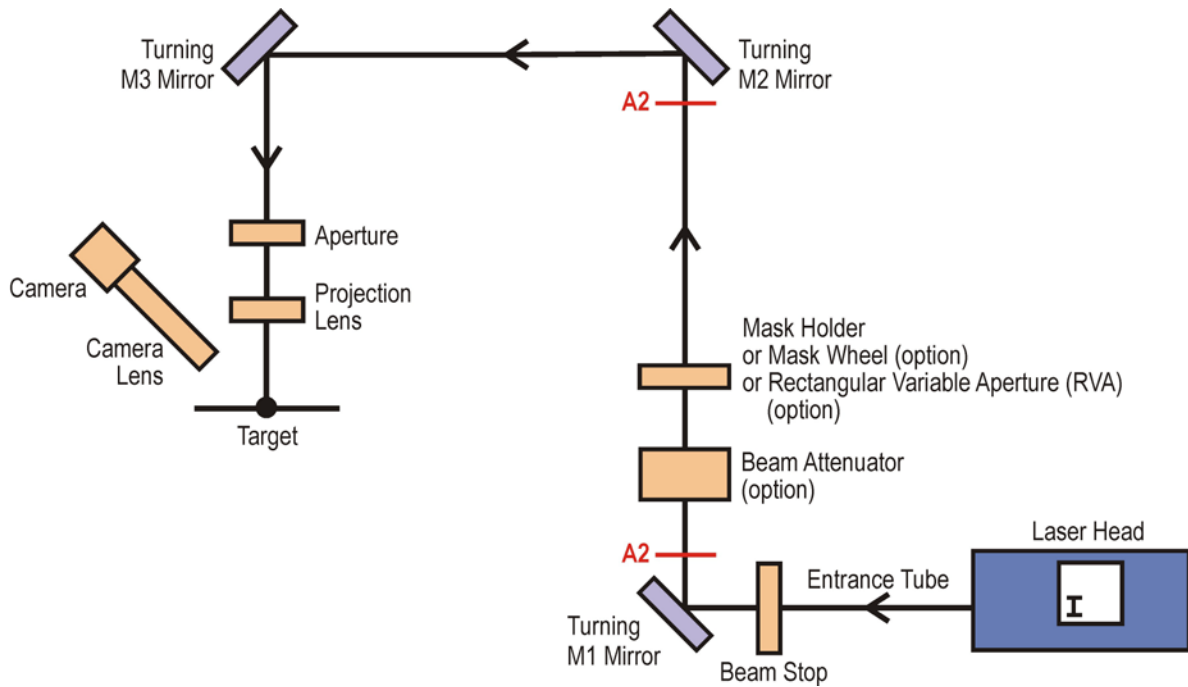


Figure 9-8. Mirror M1 Alignment

Adjust M2

16. Install A2 before/close to M3. See Figure 9-9.
17. Adjust M2 up and down along the rail to let the laser beam pass through A2.
18. Install another A2 after/close to M2.
19. Adjust M2 (adjustment knobs) to let the laser beam pass through both A2 apertures.
20. Reinstall the field lens and attenuators. Reinstall A2 after the field lens. Then, repeat Steps 9 through 19 to align M1 and M2. Only a small adjustment should be necessary.

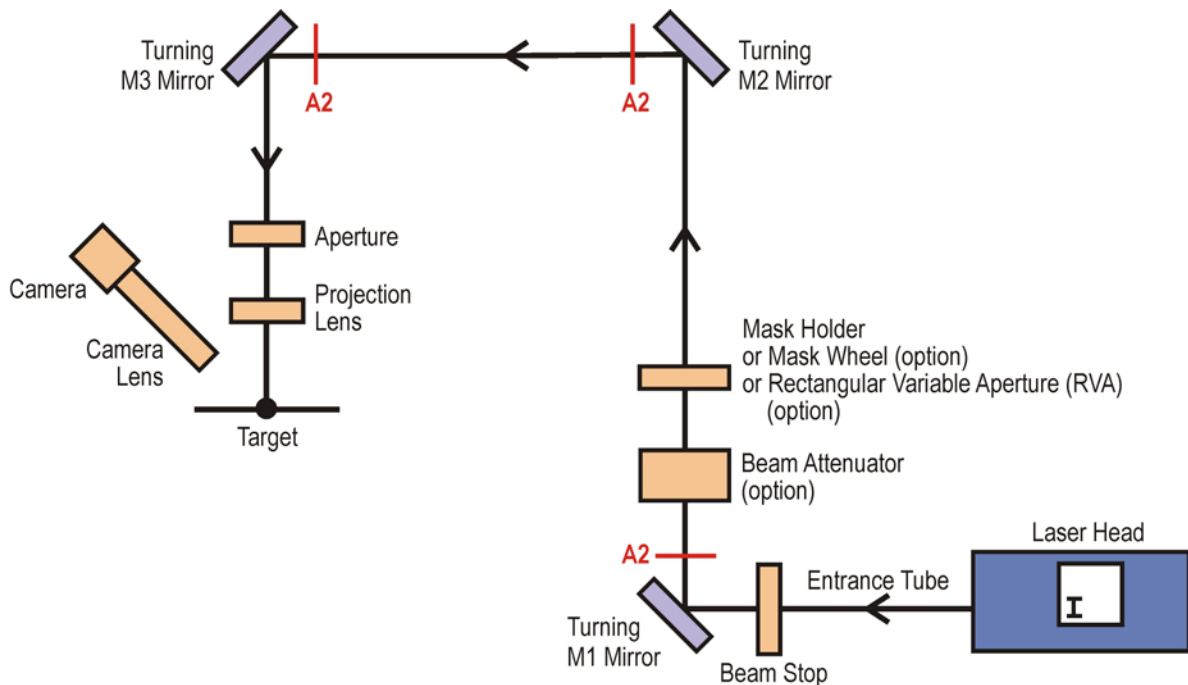


Figure 9-9. Mirror M2 Alignment

Adjust M3

21. Place A3 after M3 in the top of the projection lens assembly upper tube. Refer to Figures 9-10 and 9-11.
22. Adjust M3 along the rail to let the laser beam pass through A3.
23. Adjust M3 (adjustment knobs) so that the beam is centered on A3.
24. Carefully screw A4 into the flange where the projection lens mounts (replacing the spacer and lens). Refer to Figures 9-10 and 9-11.
25. Adjust M3 (adjustment knobs) so the beam is centered on A4 and passes cleanly through both the top and bottom pinholes. This ensures the beam is centered and perpendicular to the final lens.
26. Replace the projection lens.



Alignment Aperture A3



Alignment Aperture A4

Figure 9-10. Alignment Apertures A3 and A4

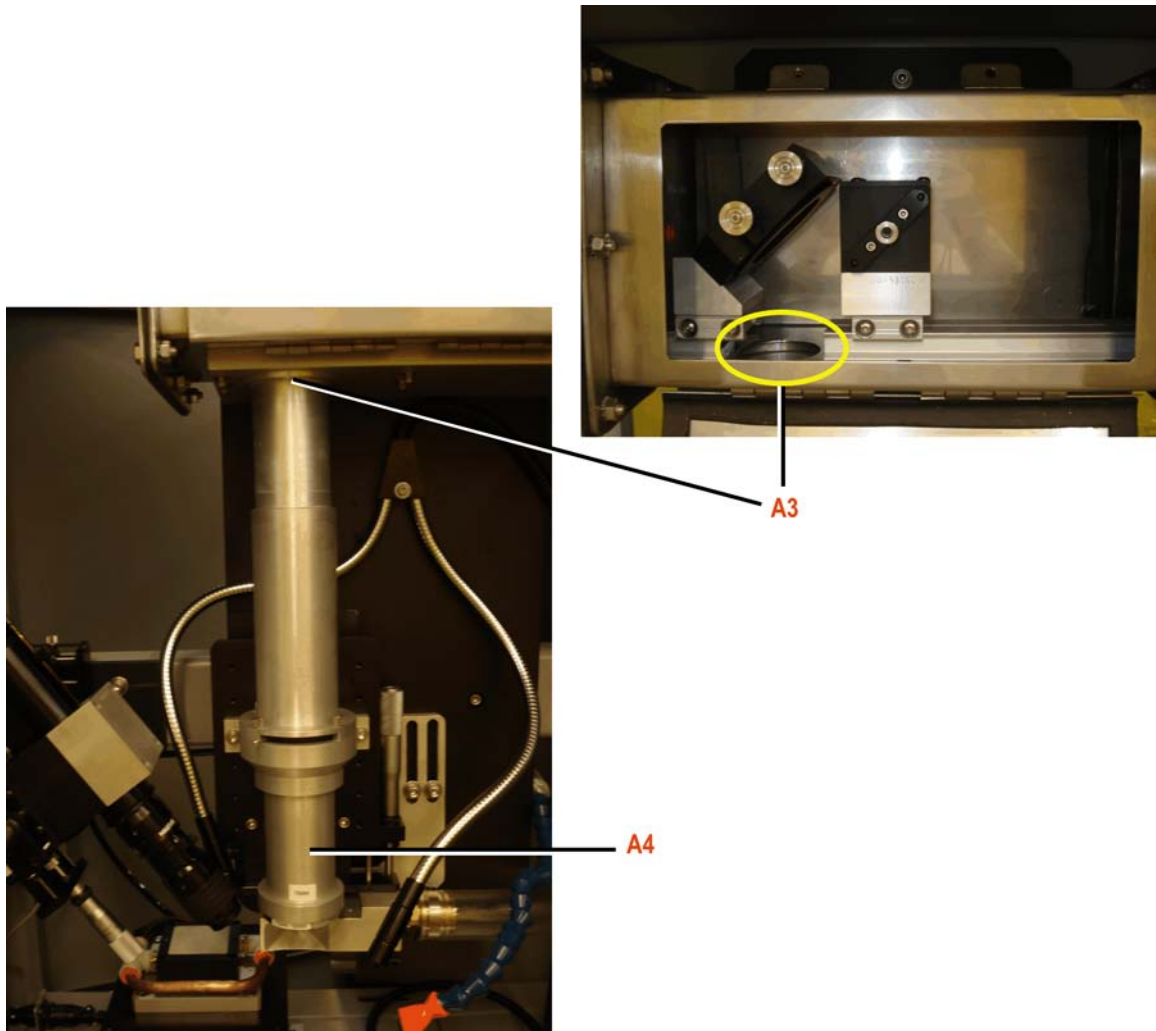


Figure 9-11. Mirror M3 Alignment

9.1.4 Camera Alignment and Focus Procedure

Camera alignment should be checked on a routine basis, usually at the beginning of each work day, to ensure the laser beam is centered on the vision monitor. This procedure has three primary goals:

- Adjust the camera to an angle that limits the effects of parallax since the camera assembly has an off-axis configuration.
- Maintain a constant camera focus on the laser spot as you zoom through the demagnification range.
- Adjust the camera so that the crosshair on the vision monitor is aligned with the center of the laser spot.

Note: The camera alignment and focus procedure is an iterative process. In addition, it may be necessary to combine this process with the laser beam focus procedure (Section 9.1.5).

Initial Conditions

- Laser is ON
- Mask is aligned and permanently position in the laser beam

Procedure to Align and Focus the Camera

1. Check that the beam stop is closed.
2. Examine the mounting assembly and check that the camera points toward the sample location.
3. Adjust the camera fine focus mechanism (see Figure 9-12) so it is positioned midway between its upper and lower extents of travel. Make sure sufficient light from the illuminator is plated on the target surface.
4. Place a blank card on the target surface. Close the loading door and program the laser to pulse continuously at approximately 5 pulses/second.
5. Open the beam stop and toggle the laser on until a spot is visible on the card.
6. Toggle the laser off and close the beam stop.
7. The Navitar zoom system is designed to stay in focus when adjusted from one magnification to another. This is referred to as *parfocality*. The steps below describe how to adjust the components to ensure that the focus remains constant throughout the zoom range.
 - a. Position the fine focus mechanism at the middle point of travel.
 - b. Adjust the magnification to its highest setting.
 - c. Adjust focus by either moving the entire optical system using the adjustment micrometer noted in Figure 9-12 or using the fine focus provided on the lens. Adjust until you have a sharp image.
 - d. Adjust the magnification to its lowest setting. At this point, DO NOT re-adjust using the fine focus or the micrometer.
 - e. Adjust the back focus of the lens. This is done by adjusting the glass in the adapter tube. The adapter tube has a locking screw and an adjustment screw. Release the locking screw and then use the adjustment screw to bring the image into focus.
 - f. Lock the back focus adjustment.

At this point, the lens should produce sharp images from low to high magnification.

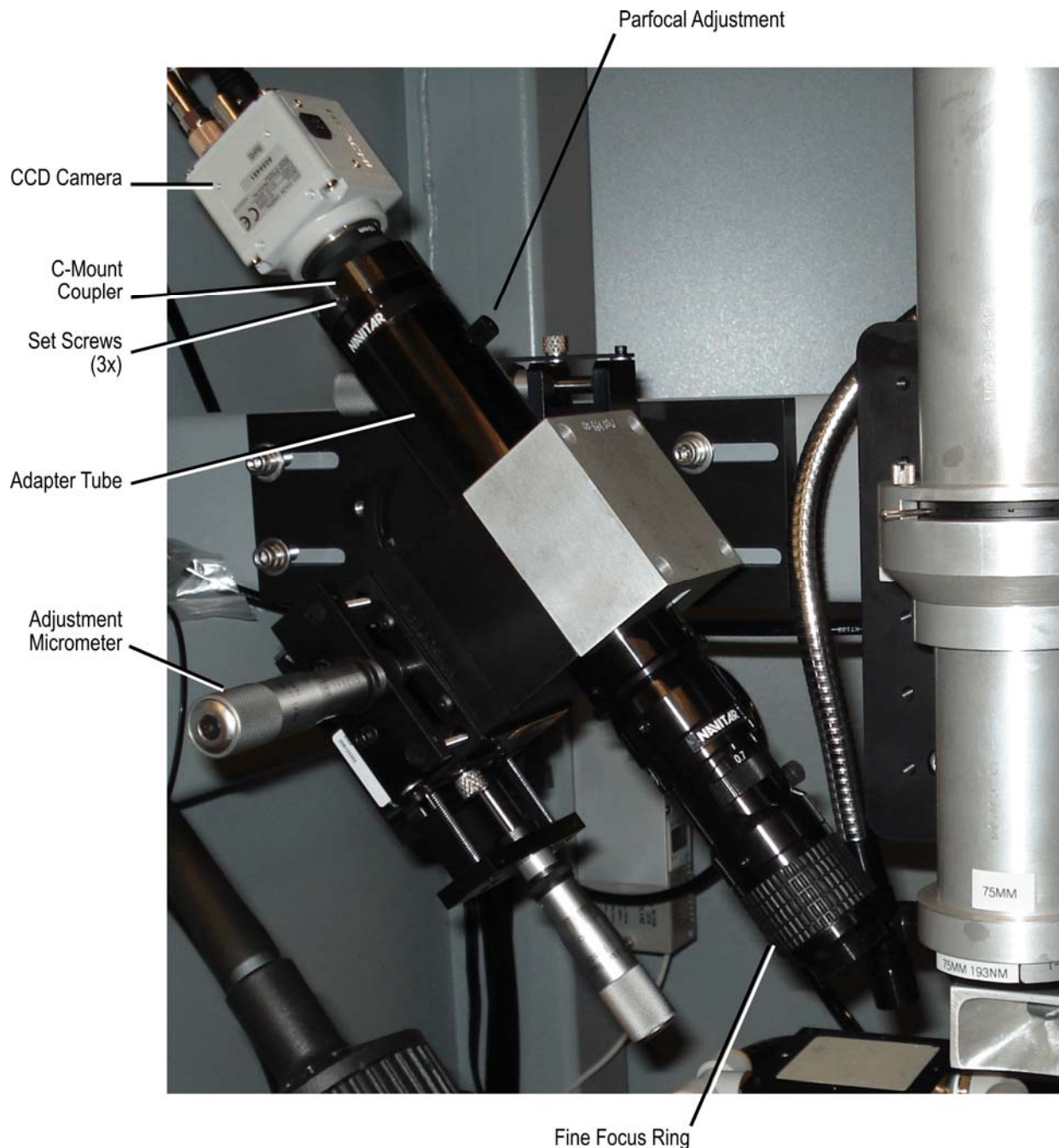


Figure 9-12. Camera Alignment and Focus

8. Check to be sure the zoom is boresighted (the image does not move laterally during zooming). Due to camera and lens tolerances, it is not possible to bolt components together and have perfect alignment. The C-mount coupler has clearance that permits positioning the camera over the optical zoom center. Remember that, with a 12X zoom system, any centration error at low magnification will be 12 times larger at high magnification.

The Navitar zoom system is designed to zoom on center. Adjust the position of the CCD camera with respect to the optical axis of the lens:

- a. Choose a target that has many small features.
- b. Mark the center point of your monitor.
- c. Change the zoom from low to high magnification many times and locate a reference that does not shift laterally as you zoom.
- d. Adjust to the lowest magnification setting.
- e. Adjust the three setscrews on the C-mount coupler to bring that reference point to the center (crosshair) of your vision monitor. (Use three hex wrenches at the same time to make this adjustment: 8-32 x 0.125).

The system should now stay on center when the magnification is adjusted.

9. Focus the laser beam, as described in Section 9.1.5. Remember that the camera alignment/focus and laser beam focus procedures are iterative.

9.1.5 Laser Beam Focus Procedure

The laser beam is properly focused when the image on the target surface is clear. The image plane of the 155 mm projection lens assembly is located beyond the focal point at a position approximately 160 mm from the end of the projection lens barrel. Adjusting the projection lens assembly micrometer shifts the image plane up or down. It may be helpful to use a focus test mask while accomplishing this procedure. A focus test mask is a mask designed specifically for focusing the BDS. If used, the design should be small enough to fit in the beam. It should include straight lines.

This procedure can be used during application setup or any time that beam focus is suspect. You should complete the *Camera Alignment and Focus Procedure* (Section 9.1.4, page 9-10) before attempting to focus the laser beam.

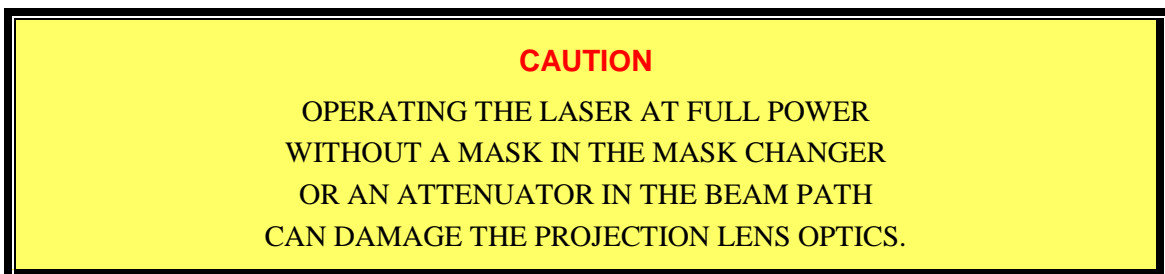
Initial Conditions

- Beam path is ALIGNED
- Camera is ALIGNED and FOCUSED
- System is ON

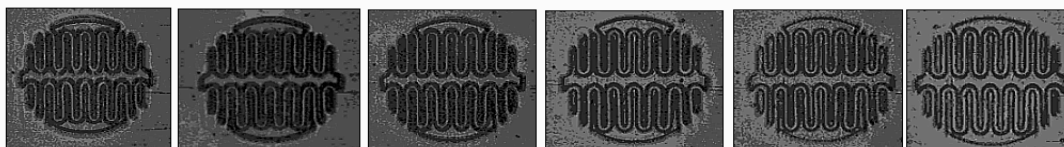
Tools and Materials Required

- Face shield
- Blank business cards
- Kapton sheet material or tape

Procedure to Focus the Laser Beam



1. Put the system in service mode—turn the SERVICE interlock bypass key to the ON position.
2. Turn the key in the beam stop control switch to the ON position.
3. Open the access covers to expose the BDS.
4. Program the laser to fire continuously at approximately 5 Hz. Toggle the laser on and off again.
5. Position the focus test mask in a mask holder.
6. If the projection lens assembly is already close to its focused position, only small adjustments may be required. Otherwise, adjust the micrometer so the total distance between the final lens in the projection lens assembly and the target surface is as appropriate for a given lens and the selected demagnification.



The figure above is a microscopic image of a focus test mask on Kapton tape during beam focusing. The image at the far right is in focus.

7. Place a piece of UV-sensitive material or Kapton tape at the target surface. Fire the laser a single pulse. Remove the material and examine the image under a microscope. When properly focused, the image should be sharp and clear. Repeat this step, each time fine adjusting the micrometer until the image is focused.

(Alternatively, a series of one-pulse exposures can be produced on the sample next to each other using the Jog Menu to shift the sample between the exposures. Position of the projection lens also will have to be changed by a constant step (~ 0.25 mm) between exposures. After microscope review of the series, select the most focused image, shift the lens back to the corresponding position, and repeat the series with the smaller lens shift step, thus converging to the best focus to within ~ 0.025 mm.)

8. Close the door and turn off the laser.
9. Turn the beam stop control switch to the OFF position. Proceed to the mask alignment procedure, if required.

9.1.6 Mask Alignment Procedure

Materials Required

- Small mask
- Kapton sheet material or a glass slide

Procedure to Align the Mask

1. Remove the mask (RVA or mask holder).
2. Mount alignment aperture A1 (see Figure 9-6) on the rail in place of the mask at the desired location.
3. Focus and image the A1 pinhole onto the media (Kapton or a glass slide).
4. Remove A1 and reinstall the mask.
If using an RVA, make a small rectangle.
If using a single mask holder, use the smallest mask.
5. Image the mask.
6. Examine the images. If they do not overlap each other, adjust the mounting block.

9.2 Switching From One Operational Wavelength to the Other

Use this procedure to switch the RapidX wavelength from 193 nm (ArF) or 248 nm (KrF) operation, or from 248 nm to 193 nm.

You will find that the laser beam at 193 nm carries less energy than at 248 nm. The ablation rate, however, may be increased or decreased, depending on the absorption characteristics of the material under process. The argon-fluoride wavelength usually is best for machining Teflon, Nylon, or glass materials. An argon-fluoride gas fill will not last as long as KrF. One method of increasing the gas lifetime of the argon-fluoride gas fill is to use a gas processor to remove contaminants in the gas before they plate out on the laser cavity surfaces. Reasonably high on-target fluence can be achieved by using the nitrogen purge capability available with the beam delivery system. The purpose of the nitrogen purge is to remove the ozone that accumulates in the beam path within the processing compartment.

The rear resonator optic should be installed with the reflective coating on the outside of the cavity in order to shield it from the corrosive effects of fluorine. When installing a turning mirror, make sure the reflective coating faces the source. The coated side of any optic can be identified by the > mark on the edge of the optic that points toward the coating.

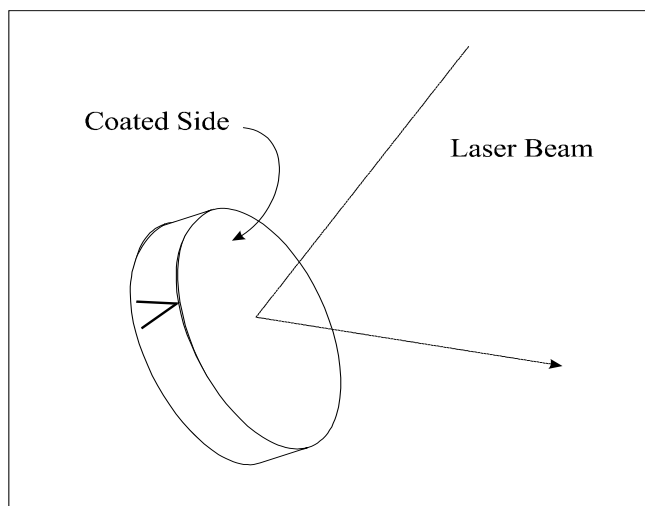


Figure 9-13. The “>” Mark Always Points to the Coated Side of the Optic

Initial Conditions

- System ON

Switching Operational Wavelength Procedure

1. The following step (Step 2) assumes that both the argon and krypton cylinders are T'd together. If not, replace the rare gas cylinder or the premix cylinder before continuing, using the appropriate procedure in the [COMPexPro® \(RoHS\) User Manual](#). If you changed the rare gas cylinder and completed all procedure steps, skip to Step 3 below.

Note: You should use a lock out, tag out system to prevent cross contamination of gases and wasted gas.

2. Complete the following to ensure all of the original rare gas is out of the lines:
 - a. Close the rare gas cylinders, leaving the regulator line valves open.
 - b. Open the Helium regulator line valve and the Helium cylinder. Set the regulator line pressure to 60 psi.
 - c. Press FLUSH LINE on the COMPexPro® handheld keypad.
Press the right ARROW until RARE gas is displayed.
Press ENTER to select RARE.
Press EXE to flush the rare gas lines.

Repeat the line flushing until the rare gas line pressure reading on the regulators is 0 psig.
This will ensure that a minimum amount of rare gas is left in the gas line.
 - d. Be sure the Helium cylinder is still open.
To purge with Helium, press PURGE LINE.
Use the ARROW key to scroll to RARE gas.
Press ENTER to select RARE.
Press EXE to purge the rare gas lines with Helium.

This will insure that all residual rare gas is removed from the rare gas lines.
Repeat this step two times.
 - e. Press FLUSH LINE again.
Press the ARROW key until RARE gas is displayed.
Press ENTER to select RARE.
Press EXE to flush the rare gas lines.

This will remove residual Helium from the rare gas lines.
 - f. Finally, open the desired rare gas cylinder.
Set the line pressure regulator to 60 psi.
Press FLUSH LINE again.
Press the ARROW key until RARE gas is displayed.
Press ENTER to select RARE.
Press EXE to flush the rare gas lines with the desired rare gas.

This will ensure the desired rare gas is properly filling the rare gas lines and that no residual original rare gas is present.
3. Select the wavelength:
 - a. Press MENU SEL on the COMPexPro® handheld keypad.
 - b. Use the ARROW key to scroll to the appropriate wavelength (193, 248, etc.).

- c. Press ENTER several times until the menu clears. For example (for 248 nm, KrF):



- 4. Open cylinders and fill the lines:
 - a. Open all required gas cylinders.
 - Note:** Only one rare gas cylinder should be opened at a time. Never open both at once.
 - b. Press NEW FILL.
 - c. Press ENTER to select the gas fill.
 - d. Press EXE and the system will automatically start the vacuum pump, vacuum the vessel, and then fill it with the appropriate gas recipe.

Repeat this step two times.

- 5. Replace each of the turning mirrors in the BDS with the appropriate mirrors provided in the argon-fluoride conversion kit.
- 6. Check the alignment of the resonator optics and realign, if necessary, using the appropriate procedure in the [COMPexPro® \(RoHS\) User Manual](#).
- 7. Calibrate the laser energy meter. This procedure requires an external power meter and requires access to the laser beam. Wear protective eyewear rated for UV during this procedure.
 - a. Remove the laser tube connecting the laser to the workstation (tool required).
 - b. Insert the external power meter at the output of the laser.
 - c. Set the laser to run at HV Constant mode with Internal trigger:

193 nm		
Low Limit:	22 kV	
High Limit:	26 kV	> 10 Hz
	30 kV	< 10 Hz

248 nm		
Low Limit:	19 kV	
High Limit:	26 kV	> 10 Hz
	30 kV	< 10 Hz

- d. Press the EGY CAL button.
 - e. Press ENTER.
 - f. Press EXE. The laser will start up.
 - g. Read the power from the power meter. Multiply wattage by 10 to convert to milliJoules (mJ).
 - h. Enter the mJ reading.
 - i. Press ENTER to accept the calibration.
 - j. Place the beam tube back in place.
- 8. Operate the laser at a standard energy setting and pulse rate. Record wavelength changeover and the high voltage and laser energy output in the system notebook.
- 9. Check the BDS alignment using the *Beam Delivery Subsystem (BDS) Alignment Procedure* described in Section 9.1.3, page 9-5.

10. Connect the nitrogen purge tubing to the BDS connection. Adjust the regulator setting to approximately 2 psig and allow the chamber to fill with nitrogen. You can experiment with the regulator setting over a period of time until your machining results are optimum.

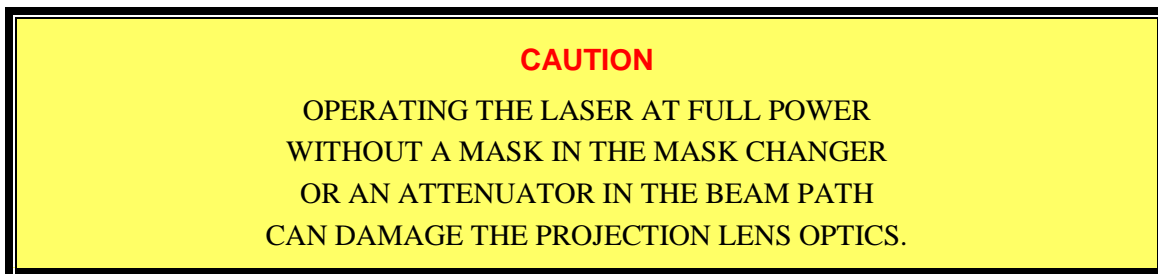
9.3 Troubleshooting and Corrective Service

This section is intended to assist in isolating problems that may occur with specific components of the Resonetics RapidX 250 Laser System. This information is provided to allow the possibility of quick onsite and in-house maintenance and repair. Refer also to Appendix A.1.1.1B for electrical schematics.

It is strongly advised that you review the *Terms of Warranty* before performing maintenance.

Failures most likely to occur in the Resonetics RapidX 250 Laser System are categorized as motion control or laser related. Motion control related problems might be manifested by the failure of an axis to slew from the Jog Menu or during program execution. Possible laser related problems include reduced laser output power, insufficient fluence at the processing site, or no laser pulse at all.

9.3.1 Poor Image Quality



The ability to isolate and remedy the cause of a poor image on the target surface can be achieved only through experience. There are only three factors that influence image quality on the machine: focus, beam uniformity, and iris adjustment. There are, however, many obstacles and pitfalls the technician must overcome to master control over these three factors. Once the BDS is aligned and focused (as described in Section 9.1.3, beginning on page 9-3), the only justification for repeating the alignment and focusing procedures is the replacement of one or more critical optical components. The following procedure can be used to isolate the cause of a poor image at the image plane.

1. Open the door to gain access to the BDS. Insert the attenuator optic in the filter mount.
2. Check that the part is held completely stationary by the tooling during lasing.
3. Using the blank business card technique, check the uniformity of the beam cross-section as the beam enters the processing cabinet. If the beam exhibits hotspots or is not uniform, the difficulty is inside the laser cabinet.
4. Check the uniformity of the beam cross-section just before turning mirror M1. An example of a good quality beam cross-section is provided in Figure 9-14.



Figure 9-14 Typical Raw Beam Profile of COMPexPro® Laser

5. If the beam cross-sections are acceptable, use the blank card technique to verify that the mask cutout fits into the beam cross-section and is centered on the beam. If not, either the mask is incorrectly positioned or the beam alignment between mirrors M1 and M2 has been disturbed.
6. Check each of the turning mirrors for smudges or damage.
7. Check that the beam entering the projection lens assembly is centered. Hold a blank card just beyond the lens and pulse the laser slowly at 1 Hz. The centroid of the masked beam should appear in the center of the aperture stop.

9.3.2 Motion Control Axis Will Not Respond

The failure of an axis to respond to motion commands is usually the result of a loose electrical connection. When checking connections to circuit boards, it is best to de-energize the system first. If a motion control failure occurs, check other features on the software including the remaining motion control axes.

If the software appears to be working and more than one axis is affected, complete the following steps:

1. Check that the position display window on the A3200 window indicates the axes are enabled. Also check that a display cell is not depressed, indicating the workstation “thinks” the axis is executing a move.
3. Check the encoder cable connection at the motion drive box.
4. Open the cover to the motion drive box and inspect the motor drivers for any abnormalities. Check that only the green indicator is illuminated on each of the drivers condition LEDs.

If an axis moves independent of commands, the most likely cause is a broken connection to the encoders. The encoder cabling is susceptible to strain at the staging if the cable becomes pinched during motion. Check that the cable is secure and that the cable is not under stress.

Contact Resonetics if the problem cannot be determined and resolved.

9.3.3 Laser Failures

Procedures for troubleshooting the excimer laser are found in the [COMPexPro® \(RoHS\) User Manual](#). If the laser fails during operation, a failure message displays on the laser handheld keypad. If the system fails to start up, an interlock message displays. If the laser will not fire and no warning or interlock message is offered, attempt to fire the laser in internal mode:

Using the COMPexPro® handheld keypad, select the trigger mode as internal.

If the laser fires internally but not externally, perform these troubleshooting steps:

1. Check the trigger cables leading from the motion drive box to the laser cabinet.
2. The BNC connector at the laser end can be plugged into an oscilloscope and checked for a trigger signal. The 5-volt pulse train should meet the specification listed in the [COMPexPro® \(RoHS\) User Manual](#).

If there is no trigger signal, the Resonetics firing card mounted in the motion drive box may have failed. Contact Resonetics for assistance.

9.3.4 Low Output Power

DANGER

Always use proper protective eyewear and other protective gear when working with the laser beam when the laser interlock is defeated.

Do not expose eye or skin to laser radiation when operating with panels open and interlocks defeated.

Refer to Section 2, *Safety*, in this manual.

Restrict access to the system when the interlocks are defeated for service purposes. ONLY a qualified service technician should work with the system interlocks bypassed and should have access to the laser beam radiations.

**DIRECT OR INDIRECT LASER RADIATION
CAN CAUSE SEVERE SKIN AND EYE DAMAGE.**

Low output power can be manifested by low energy indication on the laser handheld keypad, low fluence at the image plane, or a poor beam profile at the laser cabinet aperture. Check the spatial distribution of the beam cross-section using a blank card or, preferably, a piece of thermal fax paper. This may require access to the beam and should be accomplished by a qualified and laser trained service technician familiar with all the safety issues required while working with lasers.

Low energy output or a poor beam profile can be caused by one of the following conditions:

Bad gas fill.	Replace the gas fill in the laser using the procedure in the COMPexPro® (RoHS) User Manual . This action is not lengthy and typically solves a majority of the laser energy problems.
Misaligned laser cavity optics.	Align the beam vertically and horizontally using the alignment procedures described in this section.
Contaminated optics.	Clean and inspect the rear and front tube windows, as well as the rear and front resonator optics, using the Resonator Optics Maintenance section of the COMPexPro® (RoHS) User Manual . It may be necessary to replace damaged optics.
Damaged beam splitter.	Refer to the COMPexPro® (RoHS) User Manual for beam splitter replacement procedures.

Notes



Appendices



A. Spare Parts List

The following is a table of spare parts applicable to the Resonetics RapidX 250 Laser System.

Type	Qty	Description	Part Number
BDS Optics	1	Lens, double, UV, 5X-15X, 155 mm FL, AR 248 nm	P001780-2
	1	Lens, doublet, UV, 15X-25X, 75 mm FL, AR 248 nm	P001740-1
	1	Lens, triplet, 50 mm FL, AR 248 nm, with Protective Window	P002265-1
	3	Mirror, 2" Dia., Hr 45 Deg., 248 nm, 0.375" thick	P002695-1
	1	Lens, double, UV, 5X-15X, 155 mm FL, AR 193 nm	P001780-1
	1	Lens, doublet, UV, 15X-25X, 75 mm FL, AR 193 nm	P001740-2
	1	Lens, triplet, 50 mm FL, AR 193 nm, with Protective Window	P002265-2
	3	Mirror, 2" Dia., Hr 45 Deg., 193 nm, 0.375" thick	P001741
	1	Window, 2" dia. x	P003333-2
Laser	1	Rear cavity mirror, Dielectric coated, 248 nm	P001416
	1	Rear cavity mirror, Dielectric coated, 193 nm	P001415-1
	1	Output coupler, 248 nm and 193 nm	P001411
	1	Beamsplitter, 248 nm and 193 nm	P001455
	1	Halogen filter, CompexPro	P001517
	1	Thyrotron, CompexPro	P005121
Consumables	2	(for optional chiller) Replacement cartridge, water filter, 5 µm, sediment filter, 4 ⁷ / ₈ " height	P004328
	2	Halogen illuminator bulb, DDL, 150 W	P003061
	1	Methanol, HPLC grade	
	1	Clean room wipes	
	1	Lens tissues	
	1	Cotton swabs	

Notes



B. Layouts and Schematics

This appendix provides links to mechanical layouts and electrical schematics associated with the Resonetics RapidX 250 Laser System. You can access layout and schematic drawings by selecting the linked title.

Mechanical Layouts

The mechanical layout associated with the Resonetics RapidX 250 Laser System is listed below. You can access it by selecting the linked title.

- [Resonetics RapidX 250 Laser System Dimensions](#)
- [Resonetics RapidX 250 Laser System Dimensions—Front View](#)
- [Resonetics RapidX 250 Laser System Dimensions—Isometric View](#)

In addition, refer to the system specifications and drawings in Section 5.1.1, *Facility Requirements*, on page 5-2.

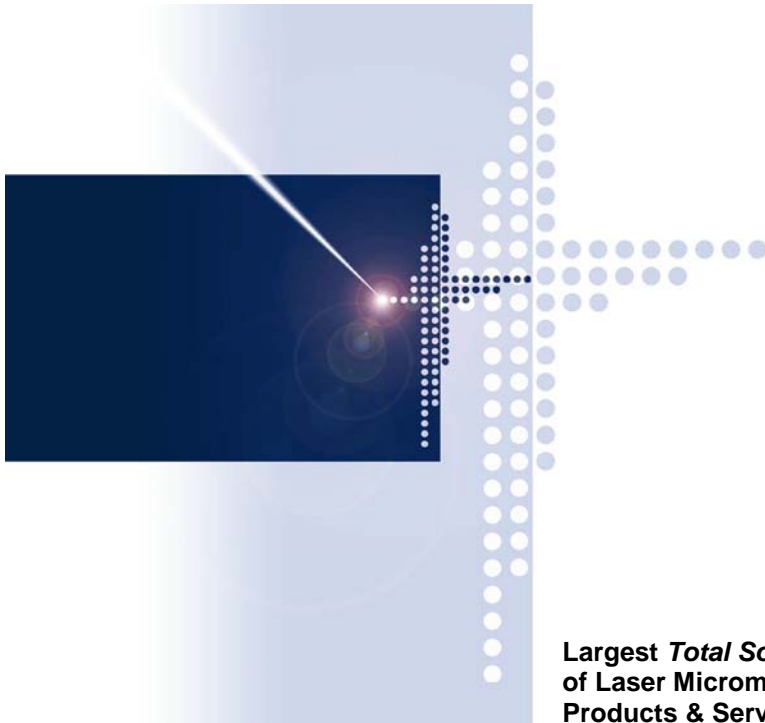
Electrical Schematics

Electrical schematics associated with the Resonetics RapidX 250 Laser System are listed below. You can access each by selecting a linked title.

Table B-1. Resonetics Schematics

Number	Title
E-04979-05	System Diagram
E-05088-10	Motion Drive Box and Stage Wiring

Notes



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