ALP-AECL-355

Airborne Elastic Cloud Lidar

Installation and User Manual
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## Revision History

<table>
<thead>
<tr>
<th>Version Number</th>
<th>Revision Date</th>
<th>Description</th>
<th>Serial Numbers</th>
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<tr>
<td>1</td>
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<td>SN001-SN002</td>
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Symbols Used in This Document

This symbol is intended to alert the operator to the presence of potentially dangerous voltages associated with the instrument that may constitute a risk of electrical shock.

This symbol is intended to alert the operator to the presence of important operating and/or maintenance instructions.

This symbol is intended to alert the operator to the danger of exposure to hazardous visible and invisible laser radiation.
Preface

This manual contains user information for the APL-AECL-355 airborne cloud lidar.

READ THIS MANUAL CAREFULLY BEFORE OPERATING THE LIDAR FOR THE FIRST TIME. SPECIAL ATTENTION MUST BE GIVEN TO THE MATERIAL CONTAINED IN SECTION 1: LASER SAFETY ON PAGE 1, THAT DESCRIBES THE SPECIFICATIONS FOR THE LASER AND THE SAFETY FEATURES BUILT INTO THE LIDAR

CAUTION – USE OF CONTROLS OR ADJUSTMENTS OR PERFORMANCE OF PROCEDURES OTHER THAN THOSE SPECIFIED HEREIN MAY RESULT IN HAZARDOUS RADIATION EXPOSURE

PLEASE NOTE: THIS IS A CLASS 4 LASER PRODUCT DURING ALL PROCEDURES OF OPERATION AND IT EMITS INVISIBLE RADIATION. AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION.

FOR QUESTIONS, PROBLEMS OR SERVICE PLEASE CONTACT:

ALPENGLOW INSTRUMENTS, 1938 HARNEY, LARAMIE, WY 82072

It is the policy of Alpenglow Instruments to strictly comply with U.S. export control laws. Export and re-export of laser products manufactured by Alpenglow Instruments are subject to U.S. Export Administration Regulations, administered by the Department of Commerce.
Laser Safety

PLEASE NOTE: THIS IS A CLASS 4 LASER PRODUCT DURING ALL PROCEDURES OF OPERATION AND IT EMITS INVISIBLE RADIATION. AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION.

PLEASE NOTE: THIS PRODUCT EMITS INVISIBLE RADIATION – AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION.
Introduction

The Alpenglow ALP-AECL Airborne Cloud Lidar system has been designed to provide protection to the operator in the event of a single component failure, provided that the instrument has been configured and operated properly as described in the Installation and User Manual. All instrument users must read, understand and follow the safety warnings and operating instructions contained in this manual.

Alpenglow Instruments is unable to guarantee laser user safety in the event of two independent component failures. It is therefore of critical importance that the equipment not be operated if there is any evidence of hazard, component failure, improper installation or significant damage. Single component failure is not hazardous, but may result in reduced or non-existent protection in the event of a second failure. Routine inspection of the instrument for evidence of potential safety hazards is critical.

If there is any evidence of unsafe instrument operation, instrument damage, or if any safety related part is missing, turn the laser off, disconnect the input power and contact Alpenglow Instruments immediately. Do not restore power to the instrument or attempt to initiate repairs unless specifically directed to do so by a qualified Alpenglow representative.

Optical Safety

Some of the unique properties of laser light pose safety hazards not associated with light from conventional sources. The safe use of lasers requires that all laser users and instrument operators, as well as those who will be in the near proximity to the laser based instrument are aware of the dangers involved. Continued safe use of this instrument depends on the user being familiar with the instrument and the properties of coherent, intense beams of light.

Laser beams can ignite volatile substances such as alcohol, gasoline, ether and other solvents, as well as potentially damage light sensitive elements in video cameras, photomultipliers and photodiodes.
Safety Advisories

Reflected beams may also cause damage. Users of this instrument are advised to read and follow the precautions listed below.

1. Observe all safety precautions in the User Manual.
2. Exercise extreme caution when using solvents in the area surrounding or in direct proximity to the laser output aperture.
3. Limit access to the instrument to qualified users who are familiar with laser safety practices and who are aware of the dangers involved.
4. Never look directly into the laser light source or at scattered laser light from any surface. Never sight down the beam into the source.
5. Maintain experimental or maintenance setups at low heights to prevent inadvertent beam-eye encounter during operation.

6. As a precaution against accidental exposure to the output laser beam or reflections from it, those using this instrument in a non-aircraft operating mode must wear safety glasses with a minimum Optical Density (OD) of 2.4 as detailed in the Protective Eyewear section below. This is not necessary during aircraft operations since there is no exposure to the laser aperture during normal flight operations.

7. Do not point laser or allow laser light to be directed or reflected toward other people or reflective objects.

8. Avoid direct exposure to the laser light emitted from the laser aperture on the instrument body. The intensity of the beam can easily burn personnel and ignite clothing.

Laser safety glasses can present a hazard as well as a benefit; while they protect the eye from potentially damaging exposure, they block light at the laser wavelengths preventing the operator from seeing the beam. Use extreme caution even when using safety glasses.
9. If the instrument is removed from the aircraft for test or maintenance, it should be used only in an enclosed and properly signed and secured room. Laser light remains collimated over long distances and presents a hazard if not confined.

10. Warning signs must be posted in the area that may be exposed to the laser beam. This includes but is not limited to hangar and tarmac areas during instrument test.

11. Advise all personnel using the instrument of these precautions. When this instrument is operated on the ground it is good practice to limit access to the area and insure that the exit aperture window area is monitored or isolated with restricted access.

12. This product should be operated under the supervision of a properly trained Laser Safety Officer (LSO) and in the terms of ANSI Z136.1 and Z136.7

**Nominal Ocular Hazard Distance (NOHD)**

The NOHD is the distance along the axis of the unobstructed beam from the laser beyond which the irradiance or radiant exposure is not expected to exceed the appropriate ocular Maximum Permissible Exposure (MPE). The MPE for the AECL355 was calculated using three methods as per ANSI Z136.1 - 2014. Although airborne operation would justify use of the single pulse MPE, the fact that the AECL may be used on the ground indicates that the more conservative use of the intrabeam 100 second exposure from ANSI Z136.1 – 2014 Table 2 is appropriate as shown.

**Single Pulse MPE (Rule 1):** $\text{MPE}_{sp} = 0.56t^{0.25}$  
(10$^9$ to 10 sec exposure ANSI Z136.1-2014 Table 5a)  

where: $t =$ pulse width = 6ns  

Thermal $\text{MPE}_{sp} = 4.93 \text{ mJ}/(\text{cm}^2)$

**Average Power MPE (Rule 2):** $\text{MPE}_{ap} = 0.56t^{0.25}$  
(10$^9$ to 10 sec exposure ANSI Z136.1-2014 Table 5a)  

where: $t =$ exposure time = 100 seconds (ANSI Z136.1-2014 Table 2)  

Thermal $\text{MPE}_{ap} = 1.77 \text{ J}/(\text{cm}^2)$

Assume 100 seconds exposure @20Hz PRF = 2000 Pulses

Thermal $\text{MPE}_{ap}/\text{PULSE} = 0.88 \text{ mJ}/\text{cm}^2$

The Photochemical MPE is 1.0 J/cm$^2$ (10 to 30000 sec exposure ANSI Z136.1-2014 Table 5a)

The resultant per pulse MPE based on photochemical effects is:

Photochemical $\text{MPE}/\text{PULSE} = 1.0\text{J}/\text{cm}^2/2000 = .5\text{mJ}/\text{cm}^2$
Multi-pulse Correction (Rule 3): Rule 3 is generally not applicable to lasers with output in the 180nm to 400nm range. In addition, the source is not extended and the pulse is less than \( t_{\text{min}} \) in length, therefore \( C_p = 1 \) so there is no multi-pulse correction.

The Average Power, photochemical MPE is the lowest MPE and is therefore used in the calculation of the NOHD.

From Z136.1 – 2014:

\[
r_{\text{NOHD}} = \frac{1}{\varphi} \left[ \left( \frac{4\Phi}{\pi \text{MPE}} \right) - a^2 \right]^{\frac{1}{2}} = 134 \text{ meters}
\]

where:

\( \varphi = \) Beam Divergence = \( 0.4 \times 10^{-3} \) radians
\( \Phi = \) Beam Energy = \( 0.012 \) Joules/Pulse
\( \text{MPE} = \) Maximum Permissible Exposure = \( 0.005 \) Joules/cm\(^2\)
\( a = \) Initial beam diameter = \( 0.9 \) cm

**Protective Eyewear Information**

The minimum Optical Density (OD) recommended for protective eyewear is calculated as:

\[
D_\lambda = \log \left( \frac{H}{\text{MPE}} \right)
\]

where:

\( H = \) Radiant Exposure calculated over the limiting aperture
\( \text{MPE} = \) Maximum Permissible Exposure as above.

This is calculated using the following parameters:

Wavelength = 355nm
Energy/Pulse = 12mJ
Pulse width = 6ns
Pulse repetition rate = 20Hz
\( A_L = \) limiting aperture (from Z136.1 – 2014 Table 8a) = 3.5mm

\[
D_\lambda = 0.012 / (\pi * (A_L / 2)^3) / 0.005 = 2.4
\]

This is the minimum OD required for eye protection. Use of eyewear with an OD of 4 is recommended due to availability and enhanced safety.
ALP-AECL-355 Safety Labels

General Information
The Alpenglow ALP-AECL-355 airborne elastic cloud lidar has a number of built-in safety features intended to protect the user from exposure to hazardous laser exposure. Before proceeding, please carefully read the following safety summary:

IMPORTANT INFORMATION

The above information, along with other safety labels are affixed to the outside of the ALP-AECL-355 instrument. It is critical that all information available on these labels is strictly adhered to. An image of each label is reproduced below with explanatory text. The Label_x designator is used in Figure 1 through Figure 3 which directly follow the explanatory table.

These labels are installed at the factory and should not be removed by the user. If for any reason a label is removed or damaged, please contact Alpenglow Instruments for a replacement.
### Label Identification

<table>
<thead>
<tr>
<th>Label</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Label_A:</strong> Hazard Warning Symbol</td>
<td>This symbol is intended to alert the operator to the danger of exposure to hazardous visible and invisible laser radiation.</td>
</tr>
<tr>
<td><img src="image" alt="Hazard Warning Symbol" /></td>
<td></td>
</tr>
<tr>
<td><strong>Label_B:</strong> Explanatory Label</td>
<td>This label shows the laser class and the specific characteristics of the laser.</td>
</tr>
<tr>
<td><img src="image" alt="Explanatory Label" /></td>
<td></td>
</tr>
<tr>
<td><strong>Label_C:</strong> Laser Aperture</td>
<td>This label is used to identify an aperture of the laser that is intended to emit Class 4 laser radiation. The label will designate all possible apertures, and in some instances will not indicate an active aperture. Close examination of the AECL configuration should be made with the laser off to determine the active apertures. Contact Alpenglow Instruments if there are any questions or doubts regarding active aperture designation.</td>
</tr>
<tr>
<td><img src="image" alt="Laser Aperture" /></td>
<td></td>
</tr>
<tr>
<td><strong>Label_D:</strong> Non-Interlocked Housing</td>
<td>This label is used to designate panels which, if removed, could expose the user to dangerous Class 4 laser radiation. Panels with this label are not to be removed by untrained operators, and should only be removed for service by trained technical personnel.</td>
</tr>
<tr>
<td><img src="image" alt="Non-Interlocked Housing" /></td>
<td></td>
</tr>
<tr>
<td><strong>Label_E:</strong> Certification Statement</td>
<td>This label indicates product compliance with applicable FDA regulations and is to be applied after certification.</td>
</tr>
<tr>
<td><img src="image" alt="Certification Statement" /></td>
<td></td>
</tr>
<tr>
<td><strong>Label_F:</strong> Manufacturer Information</td>
<td>This label is used to list appropriate manufacturer information.</td>
</tr>
<tr>
<td><img src="image" alt="Manufacturer Information" /></td>
<td></td>
</tr>
</tbody>
</table>
Safety Label Locations

Figure 1: Lidar Head Safety Labels – View 1

Figure 2: Lidar Head Safety Labels – View 2
Figure 3: Internal Safety Labels

Label D: Non-Interlocked Housing (Internal)
SETUP

**Caution:** Do not power up the instrument before thoroughly reading the installation and operation instructions, including those in this manual and those in the included Quantel Ultra User Manual.

**Unpacking**

The instrument is shipped in 2 custom crates. Please use these crates for transport, shipping and storage of the AECL-355.

Crate 1 contains the AECL-355 Lidar Instrument Head and AECL-355 Data Acquisition System.

Crate 2 contains the AECL-355 Laser Power supply and accessories.

Please refer to the appropriate packing list to insure that all parts are present. This list can also be used as the basis for a checklist used in the instrument deployment.

**Instrument Interconnect Diagram**

The block diagram shown in Figure 4 illustrates the basic components of the lidar instrument including the instrument head, the laser power supply and the data acquisition system. This section contains a brief description of each major component with emphasis on information necessary to correctly connect and install the instrument. Details regarding each subsection including operation are given in the subsequent sections titled FUNCTION and OPERATION and in the included Quantel Ultra User Manual, the ALP-AECL 355 System Acquisition and Control Software Reference Manual and the ALP-AECL 355 Data Display Manual.

![Figure 4: System Block Diagram](image)
Lidar Head

There are no user serviceable parts in the lidar head. Panels may only be removed by service personnel. Exposure to hazardous laser light, both visible and invisible is possible if panels are removed.

The lidar head is shown below in Figure 5 and is comprised of the Quantel Ultra 50 laser, the transmitter section, the receiver telescope, the aft optics module, a signal conditioning section and a beam bender.

![Figure 5: Lidar Head](image)

Quantel Ultra 50 Laser
The connections to the laser include a power and control cable and two coolant hoses. Details regarding laser connection, coolant fill/drain procedures and operation are contained in the included Quantel Ultra User Manual. A summary of the connections is given in the ICE450 Power Supply Section below.
Pay particular attention to the laser fill and drain procedures. The lidar must not be powered up prior reading and following the fill instructions. The system should not be stored or shipped without carefully following the drain procedures detailed in the Quantel Ultra User Manual. Failure to follow these instructions may result in permanent damage to the laser head and power supply.

Transmitter Section

This section is shown schematically in Figure 6 and contains the laser, a beam expander, the polarization waveplate, a motorized adjustable mirror to adjust the lidar overlap alignment, and folding mirrors for compact design and to direct the beam out of the lidar head.

Figure 6: Lidar Transmitter Section

Adjustment of the alignment mirror is to be done by factory trained personnel only. While this adjustment does not pose an eye safety issue, poor alignment will affect data quality, lidar range and signal to noise ratios on all channels.
The receiver telescope and aft optics are used to collect the returned light from the laser output pulse and convert the light to an electrical signal that will be digitized in the data acquisition system. A basic diagram of these components is shown in Figure 7. The aspheric lens is used to focus the incoming light into the beam forming optics section. This is followed by the aft optics section which splits the beam into its polarized components, filters it and conditions it for detection by the PMT’s. The PMT signal is conditioned and isolated prior to connection to the data acquisition system.
This entire section has no user serviceable parts and the cover plates should not be removed except by factory trained personnel.

**Figure 7: Telescope, Aft Optics and Electronics Interface**

**Lidar Head Power** The lidar head uses 28VDC (< 3 amp). This is converted internally into an isolated 24VDC supply used to power the PMT’s and a 12VDC supply used to power the laser reference measurement and the motorized alignment mirror. In addition, there are high voltage and high current connections that are used to power the laser itself.
The 28VDC is connected to the head via a 2 pin Bendix connector.
The laser requirements are met by the ICE450 laser power supply discussed in the next section.
Lidar Head Electronics  The lidar head electronics consist of a power distribution card that produces an isolated 24VDC supply as well as a 12VDC supply. It also provides the power interface to the PMT assemblies, the power indicator LED interface and the power distribution to the motorized mirror and the laser power reference module. This system is not user serviceable. Please contact Alpenglow Instruments for questions and service.

The lidar head also contains four (4) PMT modules that consist of a high gain PMT, PMT bias circuitry and an isolated trans-impedance circuit used to interface to the data acquisition system.
ICE450 Laser Power Supply and Chiller

The ICE 450 Laser Power Supply and Chiller is supplied by Quantel USA. Detailed operation of this component is contained in the Quantel Ultra User Manual supplied with this unit. This section will outline the connections between the ICE450, the Lidar Head and the Data Acquisition System.

**ICE450 Basic Connections**

The basic connections of the ICE450 are shown in Figure 9. Please note that the laser is mounted in the lidar head as shown in Figure 5. Details of the connections and the system operation are given in the operations section below, as well as the Quantel Ultra User Manual.

Figure 9: ICE450 Connections
Front Panel Connections
The front panel of the ICE450 is shown in Figure 10. The AECL355 uses the Key Switch, the Remote Control Head, the Q-Switch Trigger Output and the External Interlock connections.

Figure 10: ICE450 Front Panel Connections

Key Switch: The Key Switch is located on the front panel of the ICE450 as shown in Figure 10. The Key Switch should be set to the OFF position and the key removed when the AECL355 system is left unattended.

Remote Control Head: The Remote Control Head is connected via a multi pin connector to the mating socket on the front face of the ICE450 Power Supply. Failure to connect, or a momentary disconnect of this subsystem will result in a laser interlock condition and will require remedy of the error and a full laser restart including manual activation of the flashlamp and the Q-switch controls. Operation of the Remote Control Head is summarized in the Functions and Operations Sections below and detailed in the Quantel Ultra User Manual included in this shipment.

Q-Switch Trigger Output: The Q-Switch Output is used to trigger the acquisition system at the start of a laser pulse. It should be connected to the data acquisition system using the supplied cable that is terminated with an SMA and a BNC connector.
External Interlock In: This interlock is not used in the AECL355 Lidar, but may be connected by the user to facilitate remote laser shutdown by system operators. When not used the BNC connector should be terminated using the supplied shorting connector. Please contact Alpenglow Instruments for assistance in connecting an external interlock circuit.

Rear Panel Connections

The ICE450 Rear Panel connections are shown in Figure 11. The AECL355 system uses the AC Mains, the Coolant, and the External I/O connections.

AC Power: The AC mains power is a standard IEC 60320 power connector at 100-240 VAC, 50/60Hz, 850 VA. Fuses shown disconnect the ICE450 in the event of an electrical fault. Connect the AC Mains power cable from the ICE450 back panel to an appropriate grounded power outlet capable of supplying 100-240 VAC, 850VA, 50/60 Hz, Power Factor Corrected. Check the
ICE450 back panel to ensure that the system is connected to the proper voltage prior to powering the system.

**Coolant Lines:** The coolant lines are color coded for easy connection to both the ICE450 power supply and the lidar head. Directions for filling, draining and periodic maintenance of this system is detailed in the Quantel Ultra User Manual included with this shipment. Note that the deionization cartridge is located on the Blue (cold) coolant line and that the flow arrow must face away from the ICE450.

⚠️ Proper filling and draining procedures are critical to the operation of the system. Extensive damage can occur if directions are not followed explicitly.

**Laser I/O Connection:** The connection between the laser and the ICE450 supplies the control signals as well as the high voltage and high current supply lines. Ensure that the connectors are fully inserted and that the locking collars and screw locks are fully engaged.

**Filling the ICE450:** **Caution:** Do not operate the system until it has been filled. Refer to the detailed instructions in the Quantel Ultra User Manual Section 4.0.
Data Acquisition System Connections
The data acquisition system utilizes a Trenton 2005 custom ruggedized chassis, a single board computer running the Windows Operating System, a butterfly PCIe backplane and a GAGE Razor high speed digitizer card. The system also includes a dual USB3.0 port expansion accessible from the front panel and dual network expansion card used to communicate with the laser power meter and the alignment mirror controller that are embedded in the lidar head. This system can operate with a standard USB keyboard/mouse and HDMI/VGA monitor (preferred) or as a headless system connected via remote access software to a centralized CPU.

Lidar Signal Connections: The lidar signals are connected to the Data Acquisition System using double shielded PE-C100-LSZH coaxial cables. These cables are custom low smoke zero halogen cables. The one-time bend radius is 1 inch, and careful treatment of the cable is critical to avoid shield damage. Care should be taken to connect each channel to its corresponding lidar head output. (i.e. Channel 1 to Channel 1). The high density connectors on the digitizer card can be difficult to connect properly. Loose cables will significantly degrade the signal, and cross threading these connectors can damage the digitizing card.

Q-Switch Trigger Input: The Q-switch output from the ICE450 should be connected to the TI (Trigger Input) connector on the digitizer card using the supplied custom cable.

Network Connections: There are two dedicated network connections that are assigned static IP addresses and are used to communicate with the alignment mirror controller in the lidar head and the laser power meter also contained in the lidar head. These connections are shown in Figure 12 below, and the connections should be made using the supplied M12-RJ45 cables. Two general purpose DHCP network connections are available as shown in Figure 12. These can be used for remote desktop type connections and to supply NTP time synchronization.

USB3 Connections: Two USB3 connections are available on the front panel of the data system and can be identified by the standard blue USB connector. These are best used to download data from the system after a flight. Please see the AECL Data Acquisition System manual for details of this operation.

AC Power: Connect the AC Mains power cable from the Data System back panel to an appropriate grounded power outlet capable of supplying 100-240 VAC, 300VA, 50/60 Hz.
FUNCTIONS

Data Acquisition Functions

The AECL355 data acquisition system is based on the Trenton Systems TRC2500 rackmount chassis and a PICMG butterfly backplane. The embedded Single Board Computer is a TSB7053 3.0 GHz quad core processor with 8GB of ram and a 128GB SS hard drive.

The digitizing system is a GAGE Razor 044-400 8 lane, full size PCIe card. The four data channels are sampled at 200MHz (nominal) and have a user scalable input range that is typically selected based on expected reflectivity magnitudes.

Front panel connections on the TRC2500 include the Power switch, The Reset switch and a key lock used to secure the solid state drive into the rack. These controls are shown in Figure 13.

Figure 13: TRC2500 Front Panel Controls
ICE450 Laser Power Supply Functions

The Quantel ICE450 Laser Power supply provides laser power and cooling as well as interface controls, timing controls and safety features that include interlocks and a Key Switch. Details of the operation and features of this supply are contained in the Quantel Ultra User Manual included in this shipment and are summarized below.

ICE450 Front Panel Controls

The ICE450 front panel controls are shown in Figure 14 below.

![ICE450 Front Panel Controls](image)

**Key Switch**

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

OFF: To turn the ICE450 OFF, rotate the Key to the OFF ("O") position. Remove the key to prevent unauthorized access.

**Power ON Indicator**

This indicator illuminates when mains power (100-240 VAC, 50-60 Hz) is connected and the Key Switch is in the ‘ON’ position. The light is amber colored to ensure visibility through safety goggles.

**HV Emission Indicator**

---

Figure 14: ICE450 Front Panel
This indicator illuminates to indicate that laser output is possible. This indicator is amber colored to ensure visibility with laser goggles. Users should observe all proper safety precautions when the emission indicator is illuminated.

Remote Box Connection and Interface
The Remote Control head attaches to the laser control system via this connection. The Remote Head supplies access to operating parameters, settings and controls. It also contains the Emergency Stop button. This control box must be attached to the ICE450 for the laser to operate. Details of operation are contained in the Quantel Ultra User Manual and summarized below in the Operations section.

Auxiliary I/O Connections
The Q switch Trigger Out signal is used to initiate A/D sampling synchronized to the laser output pulse. The External Interlock In signal is used to remotely shut down the laser. This feature is not used in the AECL355 lidar system, but may be added by the user if desired. Please contact Alpenglow Instruments personnel for assistance in implementing this addition.

The Interlock Out signal may be used to activate a warning indicator. It is pulled to ground when the laser is disabled, but sources 15VDC at 150ma when the laser high voltage is enabled. This output is not short circuit protected.

ICE450 Rear Panel Controls

The ICE450 front panel controls are shown in Figure 15 below.
AC Mains Power
Connect the AC Mains power cable from the ICE450 back panel to an appropriate grounded power outlet capable of supplying 100-240 VAC, 850VA, 50/60 Hz, Power Factor Corrected. Check the ICE450 back panel to ensure that the system is connected to the proper voltage prior to powering the system.

Laser I/O Connection
The connection between the laser and the ICE450 supplies the control signals as well as the high voltage and high current supply lines. Ensure that the connectors are fully inserted and that the locking collars and screw locks are fully engaged.

Other connections shown are described in the Quantel Ultra User Manual but are not used in this application.
OPERATION

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

Caution: Wear eye protection. Follow safety precautions as though the system is capable of lasing at any time.

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

Caution: This instrument is not to be used if there is any evidence that the unit is defective, not operating properly or damaged. Please contact Alpenglow Instruments if you have questions as to the operability of the instrument.

ALP-AECL-355 Safety Features

The ALP-AECL-355 elastic cloud lidar is specifically designed to be deployed on an aircraft in either the Nadir (down looking) or zenith (up looking) configuration. It is also expected that it may be operated in a ground based configuration for system checks, service or testing. In any of these scenarios there are two issues that must be carefully considered when working around this instrument:

1. Use EXTREME caution around all labeled laser apertures. This includes high awareness of reflective tools and or environments, other personnel working in the area. Activation of the laser should always be a well thought out procedure. It is strongly encouraged that the user develop a comprehensive checklist that is specific to the conditions and area of deployment. This checklist should include, but not be limited to:
   a. Placarding the area
   b. Restricting access to necessary and trained personnel
   c. Reducing the exposed area using laser curtains, baffles or beam stops
   d. Providing audible and/or visible indications when the laser is active
   e. Always provide one person to activate the Emergency Shutdown switch if necessary. This person should pay attention not only to the persons working on and around the AECL instrument, but also to individuals or circumstances that have not been planned for.

2. Adhere to all warnings regarding interlocked and non-interlocked access to the instrument. There are no user serviceable parts inside the AECL-355 instrument. Panels should not be removed without close interaction and oversight by trained personnel.

Other than the marked laser apertures, there is no exposure to harmful laser radiation when all cover panels are intact.
Quantel Laser Features

The laser used in the AECL-355 is in the ULTRA 50 series of lasers built by Quantel/Big Sky lasers: http://www.quantel-laser.com/products/item/ultra-50-100-mj--134.html

The following information has been extracted from the Quantel Ultra User Guide included with this shipment. This condensed summary of operations is intended to be used for reference and to give the user an overview of laser operations. Refer to the enclosed Quantel Ultra User manual for more detailed information and instructions.

In general, the laser is in one of four states following application of power and appropriate control sequences:

1. **Power on, Ready State:** In this state, the system is ready to Lase. There are no outstanding ‘Interlock” conditions. There is no laser radiation emitted.

2. **Interlock Fault:** This state is entered when any of the interlock conditions fail. Interlocks may fault due to conditions that may damage the laser, or due to conditions that may be unsafe for the operator. Please see the Quantel Ultra User manual for details. This condition is indicated by the Laser On signal turning off, the Interlock LED flashing and the interlock fault being annunciated on the remote Panel as detailed below. Removal of the fault condition NEVER results in the laser turning back on in the active state. The system will always return to the ‘Power On, Ready’ state.

3. **Flashlamp On state:** This state is entered by pressing the Start button in the Flashlamp section. It is indicated by the Flashlamp Start LED flashing, and is exited by an interlock fault or pressing the Stop button.

4. **Laser Active state:** This state is entered from the ‘Power On, Ready’ state by two distinct actions:
   a. Flashlamp Activation
   b. Q-switch activation

   When active, Class 4 radiation is emitted from the instrument aperture(s) and the ‘Start’ LED in the Q-switch section will be flashing as will the Flashlamp LED. Transition from this state occurs if:
   a. The Q-switch Stop button is pressed. Returns to Power On Ready.
   b. The Flashlamp Stop button is pressed. Returns to Power O, Ready.
   c. An Interlock Fault occurs. System moves to the Interlock Fault state.

This series of lasers include the following safety features:

- **Key Switch Power Control.** Power is applied to the laser power supply via a locking Key Switch. The key may be removed only when the system is off, and must be used to activate power to the laser.
- **Remote control head.** The remote control head includes an Emergency Stop control, an annunciator panel, mode selection switches, the Flashlamp Activation control and display and the Q-switch activation control and display. (See the Quantel Ultra User Manual and the Remote Control Head Summary below for details)
  - **Emergency Stop:** This is the large red button on the top of the remote control. Pressing this button turns off the laser immediately (<2 seconds) and places the laser system in an interlock condition. Returning the Emergency Stop button to the active state will put the...
laser system in the laser enabled mode, but the system will not return to the laser on state until the Flashlamp is activated followed by the Q-switch enable.

- **Annunciator Panel**: This panel provides menu access to the laser functions and shows the system status. If any interlock condition is entered, the annunciator will detail what the condition is. The panel also has a ‘Laser On’ indicator which shows that there is power to the laser unit and that there is no interlock failure condition. There is a redundant ‘Interlock’ indicator LED which indicates that there is no interlock condition when illuminated, but when flashing indicates that the system is in the interlock fail state.

- **Mode Selection**: These controls allow the user to select operating modes and navigate through menus.

- **Flashlamp Activation Control and Display**: When enabled, a yellow LED (visible through protective glasses) shows the Flashlamp state. When the ‘START’ button is pressed, this control activates the Flashlamp used to provide initial laser energy. On activation, the yellow LED on the Start switch flashes. It should be noted that when ONLY the Flashlamp indicator is strobing there is no harmful output from the laser apertures. The Flashlamp is turned off using the Stop control.

- **Q-Switch Activation and Control**: The Q-switch may only be activated after the Flashlamp is in the active state. This provides a level of safety redundancy since it takes two, specialized control activations to move from the enabled (non-interlock) state to the laser on state. The Q-switch is disabled by an interlock condition or by pressing the Stop button.

- Remote interlock. This is an externally available pair of inputs which need to be shorted together in order to enable the laser output. When they are connected, the flashlamp circuit is enabled. This will not activate the laser, but until the flashlamp is enabled and activated the laser will not fire. If the interlock pins go to an open circuit state, the system enters the Interlock Fault state as discussed above.

- Power Fail Reset Protection. If the power fails to the laser while in the Laser Active state, and then is restored before the Key Switch is activated, the system will move to the Power On, Ready state. It will therefore take two distinct user actions (flashlamp start followed by Q-switch start) to return to the Laser Active’ state.

**Interlock Summary**

All interlock conditions result in the following actions:

- The laser turns off immediately (<5 sec)
- The amber ‘Interlock’ light begins to flash. This light is normally on.
- The annunciator panel on the Remote Control indicates the interlock type.

When the interlock condition is removed, the system returns to the ‘Ready to Lase’ state. The interlock condition description may be removed from the annunciator panel by pressing the ‘up’ or ‘down’ scroll buttons.

Reactivation of the laser requires two distinct manual operations:

1. **Flashlamp ‘START’**
   Indicated by the flashing ‘START’ indicator in the Flashlamp section.

2. **Q-switch ‘START’**
   Indicated by the flashing amber ‘START’ indicator in the Q-switch section.
## Remote Control Head Summary

The following summary has been extracted from the Quantel ICE450 User Manual. Refer to this included manual for details on options and proper operation of the Quantel Laser and Laser Power Supply.

<table>
<thead>
<tr>
<th>Emergency Stop</th>
<th>Push this button to stop the ICE450. It discharges the laser PPN capacitor in less than 5 seconds. Pull the button out to restart the system.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Indicator</td>
<td>This light shows orange when the main power line is connected and the Key Switch is in the ON position.</td>
</tr>
<tr>
<td>Interlock Indicator</td>
<td>When an interlock condition is detected, the laser system ceases operation and discharges high voltage (in under 5 seconds). A message flashes, indicating the detected interlock. Once the condition is corrected, the Interlock indicator is illuminated, showing that the ICE-450 is fully operational. Refer to Troubleshooting on page 88 for a complete list of the interlocks and suggestions to correct the fault condition causing them. Continuous orange light: Indicates that the Key Switch is ON and no interlock conditions exist. Blinking orange light: Indicates a security safety interlock condition exists.</td>
</tr>
<tr>
<td>Emission Indicator</td>
<td>This light is orange when the flashlamp(s) are operating (flashing or simmer current). It warns the user to observe laser safety precautions.</td>
</tr>
</tbody>
</table>

### Remote Box Functions

- **Flashlamp Stop**: Press this button to stop flashlamp operation.
- **Flashlamp Start**: Press this button to start flashlamp operation.
- **Flashlamp Ready**: Press this button to simmer the flashlamp. 
  **Note**: A flashlamp discharge will occur as part of the simmer initiation process.
- **Q-Switch Single Shot**: Press this button for a single Q-Switch pulse.
- **Q-Switch Start**: Press this button to start Q-Switch operation.
- **Q-Switch Stop**: Press this button to stop Q-Switch operation.
- **LCD Display**: Displays menu selections for various system parameters.
  - **Cursor Up**: Press this button to scroll the cursor up on the display.
  - **Cursor Down**: Press this button to scroll the cursor down on the display.
  - **Increase Value**: Press this button to increase the value of a parameter.
  - **Decrease Value**: Press this button to decrease a value.
  - **Enter Menu**: Press this button to select a new menu on the display.
ALP-AECL355 Operation and Use

The Alpenglow AECL355 cloud lidar is typically used as an airborne lidar system capable of collecting cloud and aerosol data either in the zenith or nadir configuration. With proper safety precautions it can also be used on the ground, either for stationary observations or for conducting maintenance or troubleshooting procedures. Airborne and ground based procedures are nominally the same, with differences in some safety precautions and aircraft operational restrictions.

Ground Based Operations

Ground based operations increase the possibility of longer term exposure to the laser radiation hazards. The Normal Ocular Hazard Distance (NOHD) of 134 meters was calculated based on a 100 second exposure, which is clearly more than sufficient when the instrument is moving at nominal aircraft speeds of 50-100 meters per second. Ground operations require additional precautions as detailed in the Laser Safety section in this manual.

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

**Caution:** Wear eye protection. Follow safety precautions as though the system is capable of lasing at any time.

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

Aircraft Operations

Aircraft operations are normally controlled by national, regional and local regulations that specify laser operational restrictions based on proximity to airports and other sensitive areas. Typical restrictions include specific flight zones that are defined both by altitude and linear proximity to an airport. These zones may include:

- **Laser Free Zone:** Laser must be in the ‘no lase’ state.
- **Critical Flight Zone:** Very low power lasers may be allowed. The AECL355 would not be allowed to lase in these zones.
- **Sensitive Flight Zone:** These areas are usually determined based on approach corridors and other factors that vary by specific flight venue. Instrument users should determine these restrictions prior to deployment.

Important Information:

Ground based operation of the AECL355 lidar when installed on an aircraft in the nadir configuration can damage the sensitive PMT light sensing detectors due to very strong ground reflectivity. This is also a safety consideration since indirect radiation from ground scatter may still present an ocular hazard.

**Activation of the lidar on the ground is not recommended!**

Please contact Alpenglow Instruments personnel for details regarding ground operations.
AECL355 Instrument Startup
The startup procedure for the AECL355 is straightforward and summarized below. For additional information please refer to the Software Section in this manual, or to the more detailed and complete ALP_AECL355_Acquisition_Manual and the ALP_AECL355_Dispaly_Manual included in the documentation package.

It is good practice to develop a comprehensive checklist to be used when initializing and activating complex instrumentation. The summary shown in Table 1 can be used as a starting point, with the user supplying details based on expected flight operations and aircraft/deployment specific information. Refer to the appropriate manual or section for details on each process step.

This checklist is included in the documentation package in WORD© format to facilitate final checklist development.

<table>
<thead>
<tr>
<th>Process</th>
<th>Description</th>
<th>Notes</th>
</tr>
</thead>
</table>
| 110 VAC and 28 VDC On | 110 VAC power for:  
• Data acquisition Chassis  
• Laser Power Supply  
28 VDC power for:  
• PMT modules  
• Alignment mirror control  
• Laser power monitor | Power requirements detailed in Specification Section of this manual. |
| Data Acquisition Chassis (DAC) Power ON | Black momentary rocker switch on front panel | • Boot Operating System  
• Login  
• Start Data Acquisition (DAQ) App  
  o Double click icon OR  
  o Execute ALPAECL355.exe |
| Verify Operating Parameters | Check Hardware and MetaData tabs to verify proper setup | • Check hardware voltage range, desired sample rate and desired sample range.  
• Check disk free space.  
• Check MetaData for data path and file name defaults. |
| ICE450 Laser Power Supply ON | Key Switch on front panel | • Check Remote annunciator for errors or faults |
| Enable data acquisition | Main tab on DAQ display. Click ‘ACQUIRE’ | • System should move to the ‘Waiting for Trigger’ state.  
• Actual trigger depends on connection to the external Trigger In (TI) input on the GAGE digitizer card. |
| Check operational constraints | Insure that all operational restrictions are satisfied prior to laser operations. | • Airborne applications will include altitude and proximity restrictions.  
• Ground based operations may require placards, access restrictions and spotters. |
<table>
<thead>
<tr>
<th>Task</th>
<th>Action</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enable laser operation</td>
<td>On Remote control head press 'Flashlamp Start' followed by 'Q-Switch Start'</td>
<td>• Laser operation will begin following Q-switch activation.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Check DAC display for triggering and proper signal.</td>
</tr>
<tr>
<td><strong>DISABLE LASER OPERATION</strong></td>
<td>Laser Operations may be stopped at any time using the EMERGENCY STOP button on the Remote Control Head</td>
<td>• Press the Emergency Stop button to immediately disable the laser transmission.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Re-enabling the laser requires:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>o Manually pull STOP button out.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>o Re-enable the Laser Flashlamp</td>
</tr>
<tr>
<td></td>
<td></td>
<td>o Re-enable the laser Q-switch.</td>
</tr>
<tr>
<td>Enable Data Recording</td>
<td>Main DAQ tab. Click on 'Data Recording Stopped' button.</td>
<td>• Button will turn GREEN and indicate ‘Data Recording’.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• NOTE: The IDL based real time data display code will not operate properly until the system is recording data.</td>
</tr>
<tr>
<td>Initialize Lidar Display</td>
<td>Double Click Icon OR execute Lidar_Display.sav</td>
<td>• Activation of the Real Time Display requires that the DAQ system is recording data.</td>
</tr>
<tr>
<td>Normal Shutdown Procedure</td>
<td>Use these procedures when acquisition is complete</td>
<td>•</td>
</tr>
<tr>
<td>Disable Laser Transmission</td>
<td>Use Remote Control Head</td>
<td>STOP Q-Switch</td>
</tr>
<tr>
<td></td>
<td></td>
<td>STOP Flashlamp</td>
</tr>
<tr>
<td>Stop Data Recording and</td>
<td>From DAQ MAIN tab</td>
<td>• Click on ‘Data Recording’ button. It should turn RED and display 'Data Recording Stopped'*.</td>
</tr>
<tr>
<td>Acquisition</td>
<td></td>
<td>• Click on the STOP button to stop data acquisition.</td>
</tr>
<tr>
<td>Stop IDL Lidar Display</td>
<td>Click on QUIT in IDL Display Window</td>
<td>•</td>
</tr>
<tr>
<td>Exit DAQ program</td>
<td>From DAQ MAIN tab</td>
<td>• Click on the EXIT button to properly close the DAQ app.</td>
</tr>
<tr>
<td>Shutdown DAC chassis</td>
<td>Standard Windows shutdown</td>
<td>•</td>
</tr>
<tr>
<td>Power down ICE450 Laser</td>
<td>Use Key Switch</td>
<td>Remove Key Switch to prevent unauthorized system power up.</td>
</tr>
<tr>
<td>Power Supply</td>
<td></td>
<td>•</td>
</tr>
<tr>
<td>System Power OFF</td>
<td>110VAC and 28VDC power off</td>
<td>•</td>
</tr>
</tbody>
</table>

Table 1: AECL355 Operations Checklist
SOFTWARE

The software used in the AECL355 Cloud Lidar consists of a Data Acquisition executable (DAQ) and a Data Display executable. Each program has a stand-alone manual that is included with the documentation package. This section is intended to give a brief overview of the software packages as well as enough detail to enable the user to perform basic system operations.

Data Acquisition Software

The data acquisition software operates as a National Instruments LabView executable. It does not require the installation of the LabView development environment.

Special Data Acquisition Notes

There are several important issues with the data acquisition process that impact both data storage and real time data visualization:

- This instrument stores data at a fairly high rate that is ultimately dependent on the chosen sample rate and the desired retrieval distance. The approximate data rate is shown on the HARDWARE CONFIGURATION Tab and the user should insure that there is sufficient disk space available for the anticipated acquisition period. A good practice is to limit the data storage on the data acquisition computer to only those files that have not yet been copied to an archival medium.
- The Data Display code uses the most recent data file for real time display. This means that data recording MUST be enabled prior to initiating the display code. If the system is not recording new data, the display code will revert to the most recent file stored on the disk, and begin displaying data from that file. Problems can be avoided by copying all data to an archive location or a data storage folder after each flight. As noted above, the best solution is to refrain from using the Data Acquisition Computer to store data files other than the real time files.
- Lidar data files are stored in the C:\lidardata folder. This is not optional. Data files should be downloaded from this location following each flight, and the user should clean up this file to insure there is sufficient disk space prior to each usage.
- The USB3 ports on the front face of the data system provide a fast download connection. Attach a USB3 device to one of these ports and drag/drop the relevant files after each flight.
The DAQ software is started by either double clicking the DAQ startup ICON on the desktop:

- or by executing the ALPAECL355.exe software directly.

The DAQ software consists of five tabs, each is presented below in an abbreviated format.

MAIN Display Tab
1. **Menu Bar**

2. **ACQUIRE:** Start acquisition using active configuration (STARTUP or modified by HARDWARE and/or METADATA tabs.

3. **STOP:** Stops current acquisition

4. **DATA RECORDING:** Controls data recording to the path specified in the METADATA dialog.

5. **HARDWARE:** Activates the Hardware Configuration Dialog.

6. **METADATA:** Activates the Instrument Configuration Dialog.

7. **INFORMATION:** Displays the System Status Display.

8. **EXIT:** Used to properly EXIT the data acquisition system.

9. **DISPLAY GRAPH:** Shows current returns from the four analog lidar return channels.
   
   a. **Y-Axis.** Right click to select autoscale or highlight min/max to manually specify.

   b. **X-Axis.** Same as a.

   c. **Clipboard.** Copies current display to system clipboard.

10. **STATUS:** Displays system status – newest message last. Use scroll to view older messages.

11. **PARALLEL HIGH GAIN CHANNEL:** Toggles channel display.

12. **PARALLEL LOW GAIN CHANNEL:** Toggles channel display.

13. **PERPENDICULAR HIGH GAIN CHANNEL:** Toggles channel display.

14. **PERPENDICULAR LOW GAIN CHANNEL:** Toggles channel display.

15. **R² II H CHANNEL DISPLAY**

16. **SERVICE MODE:** Enter SERVICE MODE to control embedded calculations.

17. **UDP STATUS:** Displays current UDP feed status.

18. **SINGLE/10 SAMPLE AVERAGE:** Toggle single profile/10 profile display average.

19. **CURRENT PROFILE START TIME**

20. **CURRENT PROFILE END TIME**

21. **TOTAL NUMBER PROFILES SAMPLED**
HARDWARE Configuration Tab

1 – 4. SELECT VOLTAGE RANGE (On Gage digitizer card)

5. ACQUISITION PARAMETER SELECTION:
   - SAMPLE RATE (RANGE GATE)
   - RETRIEVAL DISTANCE (8000 meters max)
   - TRIGGER LEVEL (Preset to 25% - change only on consultation with ALPENGLOW personnel.
   - TRIGGER SOURCE: Set to external to allow triggering from laser. May be set to auto for troubleshooting.

6. RANGE and DATA RATE: Displays calculated data rate and range gate spacing for selected sample rate and retrieval distance.

7. OK Button: Confirms present selections.

8. REFRESH: Sets all parameters to current system operating conditions.

9. CANCEL: Close window and return without changes
METADATA Configuration Tab

In general, these selections allow the user to identify the experimental venue for the deployment. Of special interest are those parameters used to control the data file format and location:

7. **DATA DIRECTORY SELECTION BOX**: Designate or choose the data directory.

8. **FILE PREFIX LIST BOX**: Select ‘AUTO’ or ‘USER’. All files will contain date/time information.

9. **USER FILE PREFIX**: User specified data file prefix if ‘USER’ is selected in the FILE PREFIX LIST BOX (8).
SYSTEM STATUS Tab

This tab displays the current settings for the data system and the digitizer. No values may be modified from this window.

1. CLIPBOARD BUTTON: Used to save copy of information display window to the system clipboard for documentation and troubleshooting.

2. OK Button: Used to exit the STATUS display.
SERVICE MODE Tab

This tab enables the user to perform functions that can help verify proper system operation. Access is ‘password’ protected to confirm user intentions since changes will affect data display and interpretation. Note that changes made are temporary and do not persist between sessions, nor do changes affect recorded data.

1. **SERVICE MODE ACCESS CODE:** Used to verify user intent. PASS is 1234.
2. **DISPLAY PRE-TRIGGER:** Enables display of pre-trigger values used in baseline determination.
3. **DISABLE SMOOTHING (R>100m):** Disables the moving average filter at ranges > 100m.
4. **REMOVE BASELINE CORRECTION:** Disables the baseline correction calculated from the pre-trigger values. Mainly used for troubleshooting.
5. **SMOOTHING FILTER ½ WIDTH:** Controls the width of the smoothing filter used at ranges > 100m.
6. **R SCALE FACTOR:** Multiplier used to scale $R^2$ display.
7. **OK BUTTON:** Used to confirm changes to operating parameters.
8. **REFRESH:** Used to revert stings to parameters used when the SERVICE MODE is entered.
9. **CANCEL:** Used to cancel changes and return to MAIN window.
Lidar Display and Quick Look Software

The Display and Quick Look software is written in IDL and distributed as an executable file. A free ‘virtual’ IDL machine is available at:

Special Lidar Display Notes

⚠️ There are several important issues with the data acquisition process that impact both data storage and real time data visualization:

- The Data Display code uses the most recent data file for real time display. This means that data recording MUST be enabled prior to initiating the display code. If the system is not recording new data, the display code will not update. Problems can be avoided by copying all data to an archive location or a data storage folder after each flight. As noted above, the best solution is to refrain from using the Data Acquisition Computer to store data files other than the real time files.
The Display code is started by double clicking the Display Code ICON on the Desktop or by executing the Alpenglow_lidar_display.sav software directly.

There are three selectable functions:

1. View Collected Data
2. Real Time Display
3. NetCDF Generation
View Collected Data
To View previously collected data (Quick Look), click ‘Selected Data File’, then select the desired file for viewing.

- The files are large and can take some time to load. Be patient!
- Use sliders to change display range, start and end times.

Change display height to 1 km and click on ‘Nadir’ display option:
Change ‘Start’ and ‘End’ times to highlight a feature:

Real Time Display
Enable Real Time Display by selecting the Real Time Display checkbox. Note that the Data Acquisition System must be recording data in order for new data to be displayed. Control functions for the real time display are equivalent to the ‘View Collected Data’ mode.

Convert to NetCDF
The native .meg file may be converted to a NetCDF file using the ‘Generate NETCDF’ checkbox. Specify a directory, then all .meg (raw) files will be converted to NetCDF format.
SPECIFICATIONS

Instrument Specifications:

THIS IS A CLASS 4 LASER PRODUCT DURING ALL PROCEDURES OF OPERATION AND IT EMITS BOTH VISIBLE AND INVISIBLE RADIATION. AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION.

<table>
<thead>
<tr>
<th>Transmitter</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Laser Wavelength</td>
<td>355 nm YAG</td>
</tr>
<tr>
<td>Pulse Repetition Frequency</td>
<td>20 Hz</td>
</tr>
<tr>
<td>Pulse Width</td>
<td>~ 8 ns</td>
</tr>
<tr>
<td>Pulse Energy</td>
<td>12mJ</td>
</tr>
<tr>
<td>Beam Diameter</td>
<td>0.9 cm</td>
</tr>
<tr>
<td>Beam Divergence</td>
<td>0.4x10^-3 radians</td>
</tr>
<tr>
<td>NOHD</td>
<td>134 meters</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Receiver</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter</td>
<td>~ 100 mm</td>
</tr>
<tr>
<td>Field of View</td>
<td>~1000 urad</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Data System</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Channels</td>
<td>Four: Low and high gain parallel and perpendicular signals</td>
</tr>
<tr>
<td>Detector</td>
<td>PMT</td>
</tr>
<tr>
<td>Range Resolution</td>
<td>1.5m, 3.0m, 6.0m, 12m (programmable)</td>
</tr>
<tr>
<td>Maximum Range</td>
<td>8 km</td>
</tr>
<tr>
<td>Data Acquisition System</td>
<td>High Speed Digitizer, Housekeeping, Display and Recording, Network Interface</td>
</tr>
<tr>
<td>Power (Approximate total for full system)</td>
<td>100-240VAC 14 amps, 28VDC 3 amps</td>
</tr>
</tbody>
</table>

Weight (Approximate. TBD with customer input)

| Instrument:          | ~ 10Kg           |
| Laser Power:         | ~ 12Kg           |
| Data Acquisition:    | ~10Kg            |

<table>
<thead>
<tr>
<th>Size (Approximate. TBD with customer input)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Instrument:</td>
<td>400 x 300 x 135 (H x L x W) mm</td>
</tr>
<tr>
<td>Laser Power:</td>
<td>500x500x90</td>
</tr>
<tr>
<td>Data Acquisition:</td>
<td>90 x 460 x 460 (19’’ rack)</td>
</tr>
</tbody>
</table>

Table 2: AECL355 Specifications
MAINTENANCE

All scheduled maintenance on the AECL355 instrument is performed with the power off except the coolant circulation requirement when the laser is not in use. If long periods (> 1 month) of inactivity are expected it is best to drain the system (See Quantel User Manual). For all other maintenance, the laser power supply should be off, and the Key Switch removed for operator safety.

The following procedures may be performed by the user, but it is highly recommended that the instrument be returned to Alpenglow Instruments for full maintenance once every year. Maintenance plans are available. Please call or email Alpenglow Instruments for details.

Routine Maintenance

Optics:
The transmit and receive mirrors in the beam bender should be inspected on a routine basis for dust and foreign debris contamination. Cleaning using an optical compressed air source (duster) followed by isopropyl alcohol on a lint-free optical cloth is recommended. Visible debris should be removed prior to using the cloth to avoid damaging the optical surfaces.

The optical window used to seal the pressure vessel of the aircraft should be examined not only for debris and deposits, but also for structural integrity. This should be a part of the operational limitations and inspections for the instrument.

Coolant:
Coolant levels in the laser power supply should be checked on a routine basis. Low coolant levels will result in a ‘Low Coolant Level’ laser interlock condition.

All coolant connections should also be checked for evidence of leakage.

Laser Safety

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

The following procedures should be performed as indicated to maintain and insure laser safety:

- Examine all laser safety labels on the instrument and compare to the placement guide in the AECL355 Safety Labels Section in this manual. Replace any missing or damaged label. Labels are available at no charge from Alpenglow Instruments.
- Verify that the emission indicator (identified in the Remote Control Head Summary in this manual) is functional:
  - Power up the ICE450 Laser Power Supply
  - Put on appropriate Laser Protective glasses. (See the Laser Safety section in this manual)
  - Activate the flashlamp (but not the Q switch)
  - Verify that the LASER emission indicator illuminates
  - Deactivate the flashlamp and power down the system.
If the emission indicator does not illuminate please contact Alpenglow Instruments for assistance. This part is NOT user serviceable.

Laser Maintenance
As indicated in the Maintenance section of the Quantel User manual, the following maintenance should be performed on a regular basis:

- Turn Key Switch ON to operate the pump and circulate the coolant for at least 30 minutes every month when the laser is not in use. Note that the flashlamp and the Q-switch are NOT to be enabled during this time.
- Replace de-ionizing cartridge every 6 months and each time the flashlamp is replaced.
- Replace the flashlamp every 50 million shots

Table 3 below summarizes the required and suggested scheduled maintenance.

<table>
<thead>
<tr>
<th>Maintenance Item</th>
<th>Procedure</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lens and Window cleaning</td>
<td>Use compressed air followed by isopropyl alcohol on a lint free optics cloth to maintain optics.</td>
<td>As needed</td>
</tr>
<tr>
<td>Optical Window</td>
<td>Examine for structural integrity</td>
<td>Every install cycle</td>
</tr>
<tr>
<td>Laser Coolant Level</td>
<td>Examine coolant level and all connections</td>
<td>10-20 Operating hours</td>
</tr>
<tr>
<td>Laser Safety Labels</td>
<td>Examine and compare to placement Diagram, replace as necessary</td>
<td>Yearly/as necessary</td>
</tr>
<tr>
<td>Emission Indicator</td>
<td>Check for illumination when flashlamp enabled</td>
<td>Monthly</td>
</tr>
<tr>
<td>Coolant circulation</td>
<td>Energize Laser Power supply to circulate coolant (30 Minutes)</td>
<td>Monthly</td>
</tr>
<tr>
<td>De-ionize cartridge</td>
<td>Replace</td>
<td>6 months and when replacing flashlamp</td>
</tr>
<tr>
<td>Flashlamp</td>
<td>Replace</td>
<td>50 million shots</td>
</tr>
</tbody>
</table>

Table 3: Maintenance Table
TROUBLESHOOTING

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

**Caution:** Wear eye protection. Follow safety precautions as though the system is capable of lasing at any time.

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

There are no user serviceable parts in the lidar head. Panels may only be removed by trained service personnel. Exposure to hazardous laser light, both visible and invisible is possible if panels are removed.

Problems with the AECL355 can be divided into the following groups:

- Optical and Laser and beam alignment problems
- Electronics issues
- Software issues
## Optical, Laser and Beam Alignment Problems

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Problem Identification</th>
<th>Solutions(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Laser</td>
<td>Flashlamp and/or Q-switch not started</td>
<td>Use remote to START</td>
</tr>
<tr>
<td></td>
<td>Interlock condition</td>
<td>Use remote annunciator to ID problem. Refer to the Quantel User Manual for assistance in identifying interlock condition. The laser and the lidar head do not contain user serviceable parts. Please contact Alpenglow Instruments for assistance.</td>
</tr>
<tr>
<td></td>
<td>Flashlamp needs to be replaced</td>
<td>The procedure for flashlamp replacement is outlined in the Quantel User manual. This procedure requires that the lidar head be partially disassembled. Please contact Alpenglow Instruments for assistance.</td>
</tr>
<tr>
<td></td>
<td>Optical component failure</td>
<td>Contact Alpenglow Instruments for assistance</td>
</tr>
<tr>
<td>Weak laser</td>
<td>Internal optical misalignment</td>
<td>Contact Alpenglow Instruments</td>
</tr>
<tr>
<td></td>
<td>Flashlamp needs to be replaced</td>
<td>The procedure for flashlamp replacement is outlined in the Quantel User manual. This procedure requires that the lidar head be partially disassembled. Please contact Alpenglow Instruments for assistance.</td>
</tr>
<tr>
<td>Low signal return</td>
<td>Weak Laser</td>
<td>See above</td>
</tr>
<tr>
<td></td>
<td>Transmit Beam misalignment (Overlap)</td>
<td>May be adjusted by trained service personnel. Please contact Alpenglow Instruments for assistance.</td>
</tr>
<tr>
<td>PMT Problems</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Internal optical component failure or misalignment.</td>
<td></td>
</tr>
<tr>
<td>Poor sensitivity at long (&gt; 2km) range</td>
<td>Transmit Beam misalignment (Overlap)</td>
<td>May be adjusted by trained service personnel. Please contact Alpenglow Instruments for assistance.</td>
</tr>
</tbody>
</table>
Electronics Issues

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Problem Identification</th>
<th>Solutions(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No signal output</td>
<td>No Laser</td>
<td>See above</td>
</tr>
<tr>
<td></td>
<td>No PMT power</td>
<td>Check 28VDC power and Electronics interface fuses</td>
</tr>
<tr>
<td>Noisy signal – one or more channels</td>
<td></td>
<td>• Check SMA connections at Lidar Head and DAQ. These connectors can feel tight but not be making proper connection. Make sure that strain relief is not binding the connector.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Check for cable damage – particularly on shield connections</td>
</tr>
<tr>
<td>Low gain (sensitivity) on one channel</td>
<td>PMT Bias problem</td>
<td>Please contact Alpenglow Instruments for PMT bias check and adjustment.</td>
</tr>
</tbody>
</table>

Software Issues (DAQ)

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Problem Identification</th>
<th>Solutions(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>System will not initialize after clicking on ICON.</td>
<td>ICON link is broken (usually because executable has been moved.</td>
<td>Locate executable and execute directly. Fix ICON if necessary.</td>
</tr>
<tr>
<td>Nothing happens after the ACQUIRE button is pressed.</td>
<td>System is not triggering</td>
<td>• Check that cable is in place from the TI input on the DAQ to the Q-Switch output on the laser power supply.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Check that the Flashlamp and the Q-Switch have been started using the Laser remote.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Check the HARDWARE tab to insure that external triggering is selected and that the trigger level is set to 25%.</td>
</tr>
<tr>
<td>Error on Starting Data Recording</td>
<td>Disk Full</td>
<td>Check free space on system disk. Archive old data files.</td>
</tr>
</tbody>
</table>

Software Issues (Lidar Display)

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Problem Identification</th>
<th>Solutions(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>System will not initialize after clicking on ICON.</td>
<td>ICON link is broken (usually because executable has been moved.</td>
<td>Locate executable (lidar_display.sav) and execute directly. Reset shortcut if desired.</td>
</tr>
<tr>
<td>Real-time display does not update or displays incorrectly.</td>
<td>DAQ is not recording</td>
<td>Start DAQ recording.</td>
</tr>
<tr>
<td>Data not displayed in ‘Playback’ mode.</td>
<td>Data file not found</td>
<td>Check path to data file</td>
</tr>
<tr>
<td>Data not displayed in ‘Playback’ mode.</td>
<td>Large file load time</td>
<td>Data files are large and may take significant load times depending on processor configuration.</td>
</tr>
</tbody>
</table>