Princeton Instruments

VersArray® System

VersArray®
PRINCETON INSTRUMENTS

4411-0093
Version 1.C
February 5, 2003

Roper Scientific, Inc.
3660 Quakerbridge Rd
Trenton, NJ 08619
TEL: 609-587-9797
FAX: 609-587-1970

Printed in the United States of America.

Table of Contents

Figures

Tables

This page intentionally left blank.

Chapter 1
Introduction

VersArray® Family of Cameras

The VersArray CCD cameras are high-performance digital systems designed for demanding low-light applications. The line incorporates a wide selection of full-frame, front- or back-illuminated, scientific-grade CCDs, a choice of thermoelectric or cryogenic cooling, and low-noise electronics to provide high sensitivity and high dynamic range. Permanent coatings are available to extend the range of the cameras into the UV while maintaining high quantum efficiency. The VersArray cameras are therefore ideal for a wide variety of demanding applications, including high-throughput screening, streak tube readout, gel documentation, astronomy, pressure-sensitive paint imaging, and semiconductor failure analysis.

Complete Camera Control

The operation of the VersArray camera is regulated by the camera controller. This electronics box contains the circuitry required to accept input from the host computer and software and convert it to appropriate control signals for the camera. These signals include extensive capabilities for synchronizing the operation of the VersArray system with the rest of your experiment. Because all the sensitive electronic circuits are enclosed in the EM-shielded controller, the system is able to deliver the lowest noise performance, even in a less-than-optimal environment. The controller unit also collects the analog signal returned by the camera, digitizes it, and sends it to the computer. Power supplies for the camera, along with temperature-regulation circuits, are also contained in the controller.

The controller allows you to specify read rate, on-chip binning parameters (m x n), and regions of interest — all under software control. For instance, if your experiment requires rapid image acquisition, then the CCD's on-chip binning can be set to increase frame rates. For the utmost in versatility, the VersArray controller can be configured with a dual-speed digitizer that provides fast imaging rates and low-noise readout modes.

System Components

Standard Components

A VersArray system consists of the camera, an ST-133A controller, the appropriate interface hardware for your computer system, and this user manual. Note that an internal shutter is standard with the thermoelectric and cryogenic (LN-cooled) cameras.

Figure 1. Standard Components

Optional System Components

Optional items include the WinView/32 application software, mounting adapters, coolant circulators, and dual digitization capability.

Application Software

The VersArray camera can be operated by using WinView/32, Roper Scientific's 32-bit Windows® software package designed specifically for high-end imaging or by using other commercially available image processing packages. WinView/32 provides comprehensive image capture and display functions, so you can perform data acquisition without having to rely on third-party software. The package also facilitates snap-ins to permit easy customization of any function or sequence. Using the built-in macro record function, you can also create and edit your own macros to automate a variety of operations. WinView takes full advantage of the versatility of the VersArray camera and even enhances it by making integration of the detection system into larger experiments or instruments an easy, straightforward endeavor.

Note: WinView/32 (version 2.5+) supports Programmable Virtual Camera Access Method (PVCAM®), a library of functions that can be used to control and acquire data. Image processing must be provided via custom code or by extensions to other commercially available image processing packages.

About this Manual

Manual Organization

This manual provides the user with all the information needed to install a VersArray camera and place it in operation. Topics covered include detailed description of the cameras in the VersArray family, installation, microscopy applications, cleaning, specifications and more.

Chapter 1**, **Introduction provides an overview of the VersArray cameras.

Chapter 2, Installation Overview cross-references system setup actions with the relevant manuals and/or manual pages. It also contains system layout diagrams.

Chapter 3, System Setup provides detailed directions for setting up the camera for imaging, spectroscopic, or microscopy applications and presents over-exposure protection considerations.

Chapter 4**, **Operation discusses a number of topics, including cooling and effects of high humidity and includes a step-by-step procedure for verifying system operation.

Chapter 5, Timing Modes discusses the basic Controller timing modes and related topics, including Synchronous vs. Asynchronous, Free Run, External Sync, and Continuous Cleans.

Chapter 6, Exposure and Readout discusses Exposure and Readout, together with many peripheral topics, including shuttered and unshuttered exposure, saturation, dark charge, and binning.

Chapter 7, System Component Descriptions provides information about the camera, controller, interface card, cables and application software.

Chapter 8, TTL Control provides information about how to use the TTL connector on the rear of the controller.

Chapter 9, Troubleshooting provides courses of action to take if you should have problems with your system.

Appendix A, Specifications includes camera and controller specifications.

Appendix B, Outline Drawings includes outline drawings of C-mount, F-mount, and fiber-optic coupled cameras.

Appendix C, LN Autofill System discusses how to set up and operate the optional Autofill system for side-looking and down-looking LN-cooled cameras.

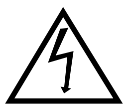
Appendix D, Spectrometer Adapters provides mounting instructions for the spectrometer adapters available for VersArray LN and NTE cameras.

Declarations of Conformity contains the Declarations of Conformity for VersArray systems (LN-, NTE-, and TEA-cooled).

Warranty & Service provides the Roper Scientific warranty and customer support contact information.

Safety Related Symbols Used in this Manual

Caution! The use of this symbol on equipment indicates that one or more nearby items should not be operated without first consulting the manual. The same symbol appears in the manual adjacent to the text that discusses the hardware item(s) in question.



Warning! Risk of electric shock! The use of this symbol on equipment indicates that one or more nearby items pose an electric shock hazard and should be regarded as potentially dangerous. This same symbol appears in the manual adjacent to the text that discusses the hardware item(s) in question.

Grounding and Safety

The ST-133A is of Class I category as defined in IEC Publication 348 (Safety Requirements for Electronic Measuring Apparatus). It is designed for indoor operation only. Before turning on the controller, the ground prong of the powercord plug must be properly connected to the ground connector of the wall outlet. The wall outlet must have a third prong, or must be properly connected to an adapter that complies with these safety requirements.

WARNING!

If the equipment is damaged, the protective grounding could be disconnected. Do ***not*** use damaged equipment until its safety has been verified by authorized personnel. Disconnecting the protective earth terminal, inside or outside the apparatus, or any tampering with its operation is also prohibited.

Inspect the supplied powercord. If it is not compatible with the power socket, replace the cord with one that has suitable connectors on both ends.

WARNING!

Replacement powercords or power plugs must have the same polarity as that of the original ones to avoid hazard due to electrical shock.

Precautions

To prevent permanently damaging the system, please observe the following precautions:

- Always switch off and unplug the ST-133A Controller before changing your system configuration in any way.
- The CCD array is very sensitive to static electricity. Touching the CCD can destroy it. Operations requiring contact with the device can only be performed at the factory.
- If you are using high-voltage equipment (such as an arc lamp) with your camera system, be sure to turn the controller power ON LAST and turn the controller power OFF FIRST.
- Use caution when triggering high-current switching devices (such as an arc lamp) near your system. The CCD can be permanently damaged by transient voltage spikes. If electrically noisy devices are present, an isolated, conditioned power line or dedicated isolation transformer is highly recommended.
- Never connect or disconnect any cable while the system is powered on. Reconnecting a charged cable may damage the CCD.
- Never prevent the free flow of air through the equipment by blocking the air vents.
- Never operate a liquid-assisted or liquid-cooled-only VersArray camera with coolant at a temperature below that specified for it.

UV Effect on Scintillator

Caution If you have a camera with a UV scintillator (lumogen) coated CCD, protect it from unnecessary exposure to UV radiation. This radiation slowly bleaches the scintillator, reducing sensitivity.

Cleaning

WARNING! Turn off all power to the equipment and secure all covers before cleaning the units. Otherwise, damage to the equipment or injury to you could occur.

Controller and Camera

Although there is no periodic maintenance that *must* be performed on a VersArray camera, users are advised to wipe it down with a clean damp cloth from time to time. This operation should only be done on the external surfaces and with all covers secured. In dampening the cloth, use clean water only. No soap, solvents or abrasives should be used. Not only are they not required, but they could damage the finish of the surfaces on which they are used.

Optical Surfaces

Optical surfaces may need to be cleaned due to the accumulation of atmospheric dust. We advise that the *drag-wipe* technique be used. This involves dipping a clean cellulose lens tissue into clean anhydrous methanol, and then dragging the dampened tissue over the optical surface to be cleaned. Do not allow any other material to touch the optical surfaces.

CRYOTIGER Compressor

Refer to the maintenance and cleaning instructions in the CRYOTIGER compressor manual.

Repairs

Save the original packing materials. Because the VersArray camera system contains no user-serviceable parts, repairs must be done by Roper Scientific. Should your system need repair, contact Roper Scientific technical support for instructions (telephone, e-mail, and address information are provided on page 160 of this manual).

Use the original packing materials whenever shipping the system or system components.

Chapter 2
Installation Overview

The list and diagrams below briefly describe the sequence of actions required to hookup your system and prepare to gather data. Refer to the indicated references for more detailed information.

Action	Reference
1. If the system components have not already been unpacked, unpack them and inspect their carton(s) and the system components for in-transit damage.	Chapter 3 System Setup, page 22
2. Verify that all system components have been received.	Chapter 3 System Setup, page 22
3. If the components show no signs of damage, verify that the appropriate voltage settings have been selected for the Controller.	Chapter 3 System Setup, page 25
4. If the application software is not already installed in the host computer, install it.	Chapter 3 System Setup, page 26 & Software manual
5. If the appropriate interface card is not already installed in the host computer, install it.	Chapter 3 System Setup, page 26
6. Depending on application, attach lens to camera, mount camera to spectrometer, or mount camera to a microscope	Chapter 3 System Setup, page 27, page 29, or page 34
7. With the Controller power turned OFF, connect the Detector-Controller cable to the appropriate connector on the rear of the **Controller** and the other end to the appropriate connector on the rear of the **Camera**. Adjust the slide latches so the cable connections are locked.	Chapter 3 System Setup, page 38
8. With the Controller and computer power turned OFF, connect the TAXI® cable to the Controller and the interface card in the host computer. Then tighten down the locking hardware.	Chapter 3 System Setup, page 38
9. With the Controller power turned OFF, connect the Controller power cable to the rear of the controller and to the power source.	Chapter 3 System Setup, page 38
10. If the system is cooled by coolant circulation, make the tubing connections between the coolant circulator or CRYOTIGER and the camera. If the system is LN-cooled, ***DO NOT FILL DEWAR YET.***	Coolant Circulator, page 41 CRYOTIGER, page 44
11. Turn the Controller **ON**.	
12. Turn on the computer and begin running the application software.	Software manual
13. Enter the hardware setup information or load the defaults from the controller.	Software manual

Action	Reference
14. Set the target array temperature.	Chapter 4 Operation, page 55
15. If the system is LN-cooled, fill the Dewar.	Chapter 4 Operation, page 49
16. When the system reaches temperature lock, wait an additional 20 minutes and then begin acquiring data in focus mode.	Chapter 4 Operation, page 59 or page 62
17. Adjust the focus for the best image or spectral lines. If you are using WinSpec/32, you may want to use the Focus Helper function for this purpose.	Chapter 4 Operation, page 59 or page 62

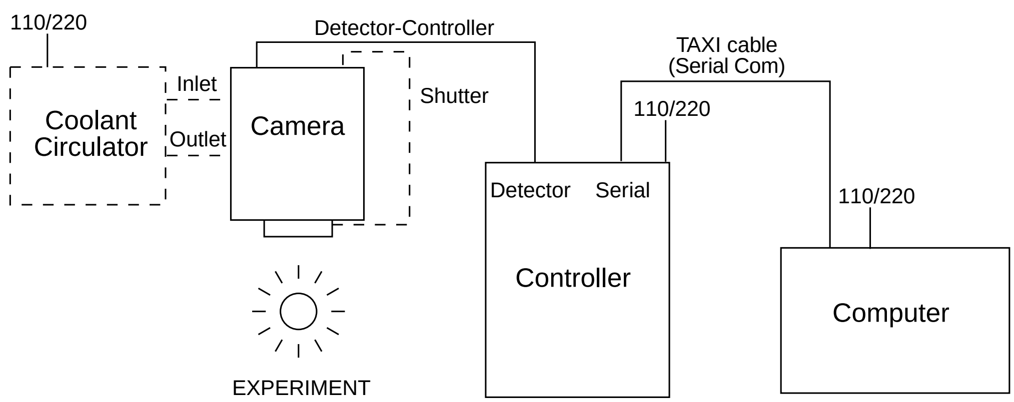


Figure 2. Imaging System Diagram: TE-cooled Camera

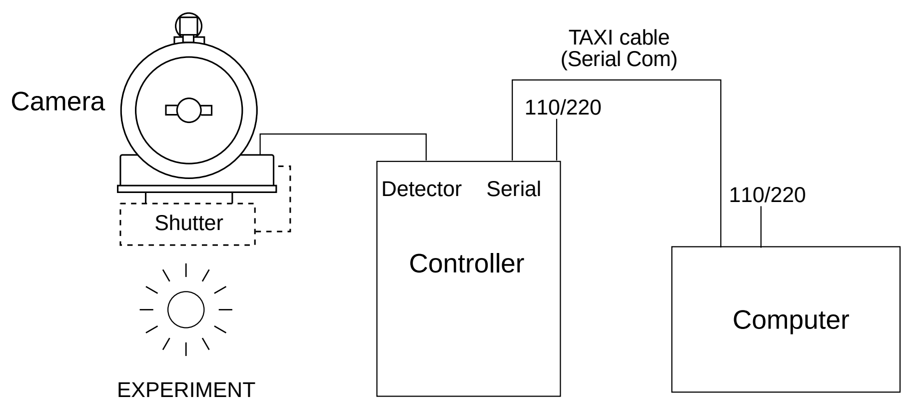


Figure 3. Imaging System Diagram: LN-cooled Camera

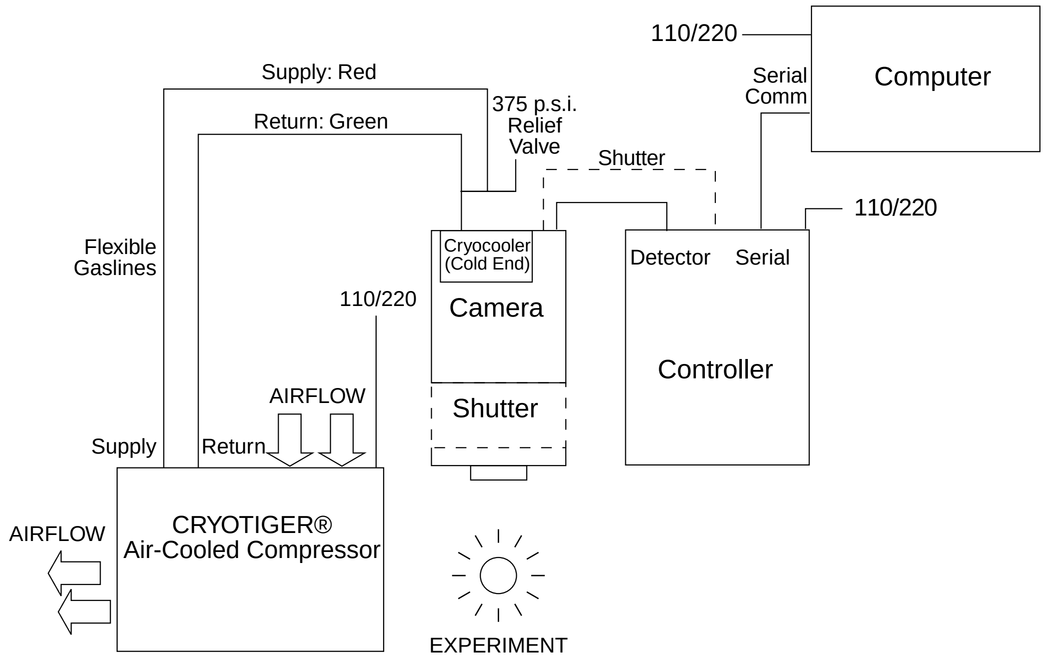


Figure 4. Imaging System Diagram: CRYOTIGER-Cooled Camera

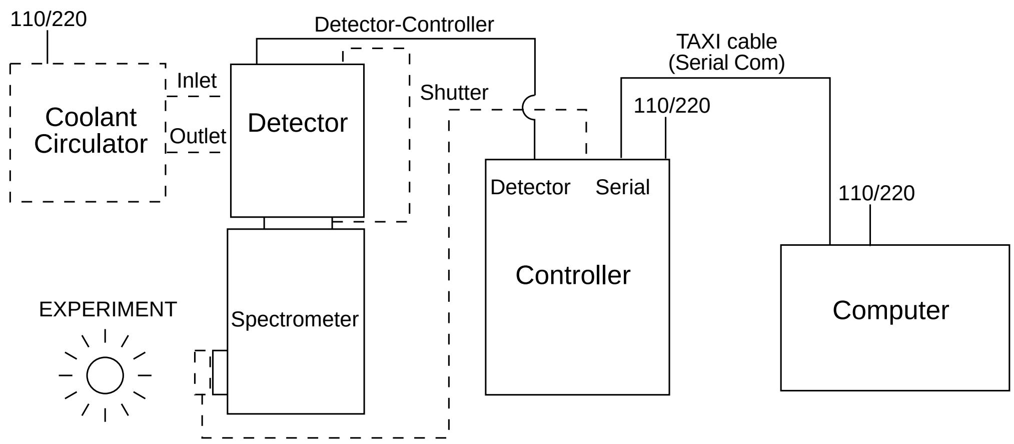


Figure 5. Spectroscopy System Diagram: TE-cooled Camera

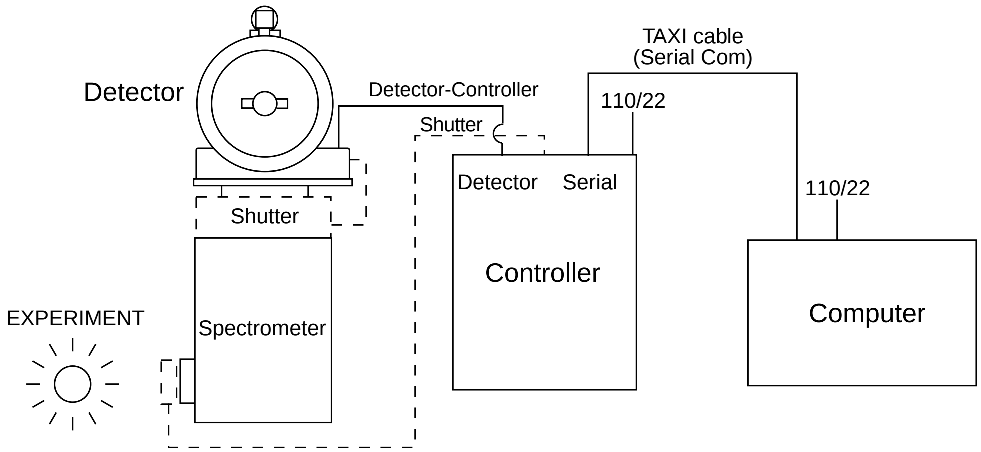


Figure 6. Spectroscopy System Diagram: LN-cooled Camera

Chapter 3

System Setup

To minimize risk to users or to system equipment, turn the system **OFF** before any cables are connected or disconnected.

Introduction

A VersArray camera system consists of four hardware components:

- Interface hardware
- Controller
- Camera head (air-assisted, liquid-assisted, or liquid-only thermoelectric; LN; or CRYOTIGER cooling)
- Cables

A VersArray system with a liquid-cooled camera head also requires a coolant circulator. A VersArray$_{CT}$ system includes a CRYOTIGER cooling system. All of the components and cables required for your configuration should be included with your shipment. Your VersArray system has been specially configured and calibrated to match the camera and readout rate options specified at the time of purchase. The CCD and coating you ordered has been installed in your camera head.

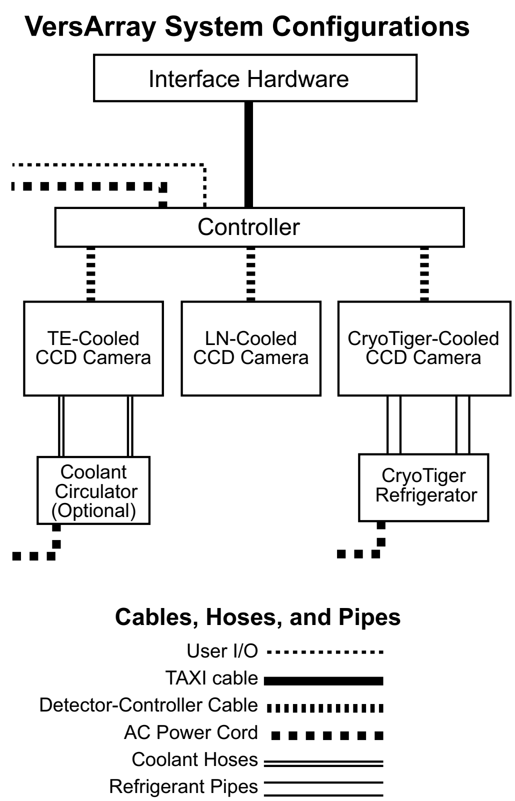


Figure 7. System Configurations

Keep all the original packing materials so you can safely ship the VersArray system to another location or return it for service if necessary. If you have any difficulty with any step of the instructions, call Roper Scientific Customer Service. For Contact Information, refer to page 160.

Hardware installation may consist of:

- Installing an interface card.
- Attaching a lens to a C- or F-mount adapter.
- Connecting the camera to the controller.

- Selecting the appropriate power for an internal shutter.
- Connecting the camera to an external shutter, if one is required.
- Mounting the camera to a spectrometer or to a microscope.
- Connecting the camera to a coolant supply or a CRYOTIGER refrigeration system.

Software installation depends on the application software you will be using to run the system. Refer to the manual supplied with the software for information about installing and setting it up.

Unpacking the System

During the unpacking, check the system components for possible signs of shipping damage. If there are any, notify Roper Scientific and file a claim with the carrier. If damage is not apparent but camera or controller specifications cannot be achieved, internal damage may have occurred in shipment. Please save the original packing materials so you can safely ship the camera system to another location or return it to Roper Scientific for repairs if necessary.

Checking the Equipment and Parts Inventory

Confirm that you have all of the equipment and parts required to set up the VersArray system. A complete system consists of:

- **Camera** (TE air-assisted, liquid-assisted, or liquid-cooled only; LN-cooled; or CRYOTIGER-cooled).
- **Controller:** ST-133A.
- **Detector-Controller cable:** DB25 to DB25 cable. Standard length is 10 ft (6050-0321). Also available in 6’, 15’, 20’, and 30’ lengths.
- **Controller-Computer (TAXI) cable**: DB9 to DB9 cable. Standard length is 25 ft (6050-0148-CE). Lengths up to 165 ft (50 m) are available.
- **Interface Card:** High-Speed PCI Interface board
- **Computer:** Can be purchased from Roper Scientific or provided by user.
- **VersArray User Manual**
- **WinView/32 CD-ROM** (optional)
- **System Dependent Interface Components:**

    Caron Chilled Coolant Circulator and Tubing/Fittings Kit

    CRYOTIGER Compressor

System Requirements

Environmental Requirements

Storage temperature: ≤55°C
Operating environment temperature: 5ºC to +30ºC; for TE-cooled Detectors, the environment temperature range over which system specifications can be guaranteed is +18ºC to +23ºC
Relative humidity ≤50%; non-condensing

Notes:

1. When using LN, periodic wiping of the Dewar vent ports may be required to prevent frost accumulation from interfering with venting. In a spectroscopy setup with an LN-cooled camera, high humidity conditions may require continuous flushing of the spectrometer's exit port with nitrogen.
2. For TE-cooled cameras, the shutter enclosure may have a quartz window that allows the shutter to be back-filled with dry nitrogen. This further reduces the possibility of condensation on the window of the camera. The shutter window, if present, can be seen whenever the lens is removed.
3. For TE-cooled cameras, the cooling performance may degrade if the room temperature is above +23°C.
4. CRYOTIGER® Compressor: Refer to the CRYOTIGER manual for gas pressures and environmental considerations.

Ventilation

Detector: Allow at least one inch clearance for side and rear air vents. Where the detector is inside an enclosure, < 30 cfm air circulation and heat dissipation of 100W is required for TE air-cooled detectors.

ST-133A: There is an internal fan located at the right side of the rear panel behind an exhaust opening. Its purpose is simply to cool the controller electronics. This fan runs continuously whenever the controller is powered. Air enters the unit through ventilation openings on the side panels, flows past the warm electronic components as it rises, and is drawn out the rear of the controller by the fan. It is important that there be an adequate airflow for proper functioning. As long as both the controller's intake ventilation openings and the fan exhaust opening aren't obstructed, the controller will remain quite cool.

Caution

	Fuse Rating	
Line Voltage	**Left**	**Right**
100 - 120 ~	0.75A - T (S.B.)	2.50A - T (SB)
220 - 240 ~	0.30A - T (SB)	1.25A - T (SB)

Table 1. ST-133A Line Voltage and Fuse Requirements

The plug on the line cord supplied with the system should be compatible with the line-voltage outlets in common use in the region to which the system is shipped. If the line cord plug is incompatible, a compatible plug should be installed, taking care to maintain the proper polarity to protect the equipment and assure user safety.

Coolant

WARNING!

COOLANT IS HARMFUL IF SWALLOWED.
KEEP OUT OF REACH OF CHILDREN.

VersArray cameras with liquid-assisted cooling or liquid-only cooling require circulating coolant (50:50 mixture of ethylene glycol and water) for proper operation. The recommended flow rate and fluid pressure are: 2 liters/minute at 25 psig (maximum).

Power

Detector: The VersArray camera receives its power from the controller, which in turn plugs into a source of AC power.

ST-133A: The controller can operate from any one of four different nominal line voltages: 100, 120, 220, or 240 V AC. The power consumption averages 300 Watts and the line frequency can range from 47 to 63 Hz.

Host Computer Requirements

Note: The following information is only intended to give an approximate indication of the computer requirements. Please contact the factory to determine your specific needs.

PC System

The host computer for your VersArray system must have the following:

- AT-compatible computer with 80486 (or higher) processor (50MHz or faster), Pentium or better recommended.
- Windows® 95 (or higher) or Windows NT® (version 4.0 or higher) operating system.
- High speed PCI serial card or at least one unused PCI card slot. Computers purchased from Roper Scientific are shipped with card installed.
- Minimum of 32 Mbyte of RAM for CCDs up to 1.4 million pixels. Collecting multiple images or spectra at full frame or high speed may require 128 Mbytes or more of RAM.
- CD-ROM drive
- Hard disk with a minimum of 80 Mbytes available. A complete installation of the program files takes about 6 Mbytes and the remainder is required for data storage, depending on the number and size of images or spectra collected. Disk level compression programs are not recommended.
- Super VGA monitor and graphics card supporting at least 256 colors with at least 1 Mbyte of memory. Memory requirement is dependent on desired display resolution.
- Two-button Microsoft compatible serial mouse or Logitech three-button serial/bus mouse.

Verifying Voltage Settings

ST-133A

The Power Module on the rear of the Controller contains the voltage selector drum, fuses and the powercord connector. The appropriate voltage setting is set at the factory and can be seen on the back of the power module.

Each setting actually defines a range and the setting that is closest to the actual line voltage should have been selected. The fuse and power requirements are printed on the panel above the power module. The correct fuses for the country where the ST-133A is to be shipped are installed at the factory.

To Check the Controller's Voltage Setting:

1. Look at the lower righthand corner on the rear of the Controller. The current voltage setting (100, 120, 220, or 240 VAC) is displayed on the Power Module.
2. If the setting is correct, continue with the installation. If it is not correct, follow the instructions on page 93 for changing the voltage setting and fuses.

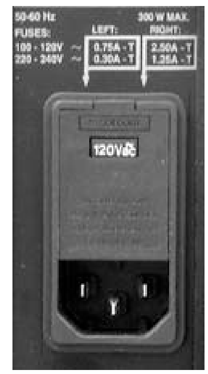


Figure 8. Controller Power Module

CRYOTIGER Compressor

The voltage selector for the CRYOTIGER compressor is located at the lower lefthand corner of the rear panel.

To Check the Compressor's Voltage Setting:

1. Look at the lower lefthand corner on the rear of the compressor. The current voltage setting (100, 120, 220, or 240 VAC) is displayed on the Power Module.
2. If the setting is correct, continue with the installation. If is not correct, follow the instructions in the CRYOTIGER Compressor Operating manual (supplied with the compressor) for changing the setting and fuses.

Installing the Application Software

Installation is performed via the WinView/32 or WinSpec/32 installation process, which should be done before the interface card is installed in the host computer. On the **Select Components** dialog box (see Figure 9), click on the button appropriate for the interface card. For a PCI card, select the **AUTO PCI** component to install the required PCI card driver and the most commonly installed program files. If you do not want to install the PCI driver or would like to choose among the available program files, select the **Custom** component. If the interface card was installed at the factory, the appropriate driver was installed at that time.

Figure 9. WinView Installation: Interface Card Driver Selection

Note: WinView/32 and WinSpec/32 (versions 2.6.0 and higher) do not support the ISA interface.

Installing the Interface Card

If the computer is purchased from Roper Scientific, it will be shipped with the Serial Buffer card already installed. PCI Interface boards are standard.

Note: The PCI card can be installed and operated in any Macintosh having a PCI bus, allowing the ST-133 or ST-133A to be controlled from the Macintosh via IPLab™ software and the PI Extension.

Caution

If using WinView/32 software, either **High Speed PCI** or **PCI(Timer)** can be the selected Interface type. This selection is accessed on the **Hardware Setup|Interface** tab page. **High Speed PCI** allows data transfer to be interrupt-driven and gives the highest performance in some situations. **PCI(Timer)** allows data transfer to be controlled by a polling timer. This selection is recommended when there are multiple devices sharing the same interrupt.

To Install a PCI Serial Buffer Card:

1. Review the documentation for your computer and PCI card before continuing with this installation.
2. To avoid risk of dangerous electrical shock and damage to the computer, verify that the computer power is OFF.
3. Remove the computer cover and verify that there is an available PCI slot.
4. Install the PCI card in the slot.
5. Make sure that the card is firmly seated and secure it.

6. Replace and secure the computer cover and turn on the computer only. If an error occurs at bootup, either the PCI card was not installed properly or there is an address or interrupt conflict. Go to *"Error Occurs at Computer Powerup"*, page 97, for instructions.

Note: The PCI card has no user-changeable jumpers or switches.

Installing the PCI Card Driver

Administrator privileges are required under Windows NT, 2000, and XP to install software and hardware.

The following information assumes that you have already installed the WinView/32 or WinSpec/32 software. After you have secured the PCI card in the computer and replaced the cover, turn the computer on. At bootup, Windows will try to install the new hardware. If it cannot locate the driver, you will be prompted to enter the directory path, either by keyboard entry or by using the browse function.

If you selected **AUTO PCI** during the application software installation, WinView/32 or WinSpec/32 automatically put the required INF file into the Windows/INF directory and put the PCI card driver file in the Windows/System32/ Drivers directory.

Windows Version	PCI INF Filename Located in "Windows"/INF directory*	PCI Device Driver Name Located in "Windows"/System32/Drivers directory
Windows 2000 and XP	rspi.inf (in WINNT/INF, for example)	rspipci.sys (in WINNT/System32/Drivers, for example)
Windows NT	N/A	pi_pci.sys
Windows 95, 98, and ME	pii.inf	pivxdpci.vxd

* The INF directory may be hidden.

Table 2. PCI Driver Files

Attaching Lenses to C- and F-Mount Adapters

Caution

Overexposure protection: Cameras that are exposed to room light or other continuous light sources will quickly become saturated. Set the lens to the smallest aperture (highest f-number) and cover the lens with a lens cap to prevent overexposure.

Attaching to a C-Mount Adapter

Standard TE-cooled cameras and some TE-cooled cameras with the "microscope nose" can be ordered with an integral C-mount adapter. C-mount lenses simply screw into the front of these cameras. Tighten the lens by hand only.

Connecting to a microscope is discussed in "Mounting a TE-Cooled VersArray Camera to a Microscope" on page 34. If you cannot use the adapter you received, contact the factory for technical support or replacement. *See page 160 for Information on accessing the Roper Scientific Technical Support Dept.*

Note: C-mount cameras are shipped with a dust cover lens installed. Although this lens is capable of providing surprisingly good images, its throughput is low and the image quality is not as good as can be obtained with a high-quality camera lens. Users should replace the dust-cover lens with their own high-quality laboratory lens before making measurements.

Attaching to an F-Mount Adapter

Cameras for use in imaging systems (cameras) are shipped with the lens mount already attached. Standard Princeton Instruments™ lens mounts use the Nikon bayonet format, as shown in Figure 10 and Figure 11. This can be converted to most other formats by using commercially available adapters. If your optical system cannot be converted to this format, contact the factory. *Other mounts may be available. Consult the factory for specific information relating to your needs*. *See page 160 for Information on accessing the Roper Scientific Technical Support Dept.*

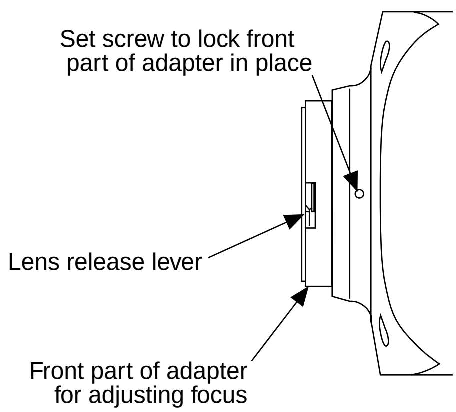


Figure 10. F-Mount Adapter 1 for TE-Cooled Cameras

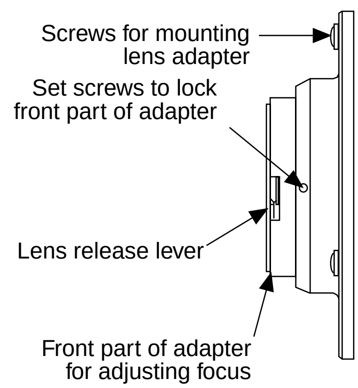


Figure 11. F-Mount Adapter 2 for TE-, LN-, and CRYOTIGER-Cooled Cameras

To Mount the Lens on the Camera:

1. Locate the large indicator dot on the side of the lens.
2. Note the corresponding dot on the front side of the adapter.
3. Line up the dots and slide the lens into the adapter.
4. Turn the lens counterclockwise until a click is heard. The lens is now locked in place.
5. In addition to the focusing ring of the lens, there is provision for focusing the adapter itself. That adjustment is secured by setscrews on the side of the adapter's adjustment ring. Directions for focusing the lens *and* the adapter are provided on page 56.

To Remove the Lens:

1. Locate the lens release lever at the front of the lens mount.
2. Press the lever toward the camera housing and simultaneously rotate the lens clockwise.
3. Then pull the lens straight out.

Although microscopes more commonly are used with a C-mount adapter, operation with a camera having an F-mount adapter may also be possible. See "Mounting a TE-Cooled VersArray Camera to a Microscope" on page 34, *Microscopy Applications* and the adapter literature for further directions.

WARNING! The standard LN-cooled side-looking camera or an end-looking LN-cooled camera must never be tilted more than 30° from vertical unless the “all-directional” Dewar option has been purchased. If mounting the camera to your system means that you will tilt the Dewar more than 30°, you may have the wrong type of Dewar. Contact the factory.

Mounting to a Spectrometer

The camera must be properly mounted to the spectrometer to take advantage of all the available grouping features. Additional precautions must also be taken to prevent overexposure of the camera.

LN Cameras: At the time of purchase, both the Dewar and the adapter were selected for your specific application.

WARNING! A Dewar must never be tilted more than 30° from vertical, unless the “all-directional” Dewar option has been purchased. For this reason, a side-looking camera and an end-looking camera are available for mounting to vertical and horizontal image planes, respectively. If mounting the Dewar to your system requires you to exceed the 30° limit, you may have the wrong type of Dewar. Contact the factory.

The distance to the focal plane from the front of the mechanical assembly depends on the specific configuration. Refer to "Focal Distance" on page 103 for more information.

Array Orientation

For square format CCDs (for example, 512 × 512, 1340 × 1300, or 2048 × 2048) you may orient the CCD to achieve binning along either direction of the CCD.

- Binning along columns (parallel mode) provides maximum scan rate and lowest noise.
- Binning along the rows (perpendicular mode) minimizes crosstalk and is therefore better for multi-spectral applications. The drawback to this method is that scanning is slower and noise may increase somewhat.

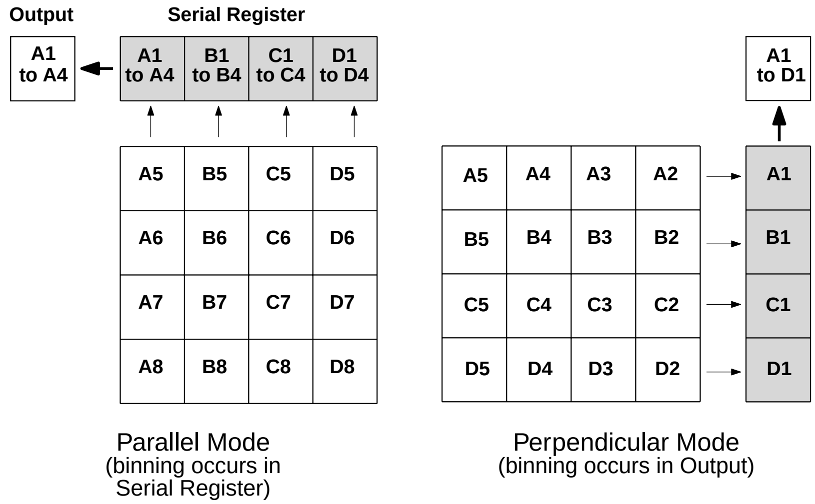


Figure 12. Binning and Array Orientation

Note: Users of TE-cooled cameras can easily switch between these orientations by rotating the camera 90° and changing the binning parameters in the application software.

Deep Focal Plane

Spectrometers with a focal plane 25 mm or more beyond the exit interface are called deep focal plane spectrographs. With these spectrographs, the shutter housing (if one has been installed) remains connected to the camera. Such spectrometers include all Acton models, the ISA HR320, ISA HR640, Chromex 250IS, and most instruments that are 1 meter or longer. (If you are not sure of the depth of the exit focal plane, contact the spectrometer manufacturer.)

Adapters for these spectrographs are generally in two pieces, as shown in Figure 13. The generic assembly directions that follow can be used as a general guide. However, contact the factory if you need detailed instructions for your specific adapter.

Mounting Directions

1. Bolt Flange 2 to the camera using the screws provided. In the case of a camera with mounted shutter, place Flange 2 over the shutter housing and bolt the adapter to the shutter using the screws provided.
2. Next, loosen the setscrews (3) on Flange 1. If Flange 1 is an integral part of the spectrograph or is already installed, skip Step 3.
3. Mount Flange 1 to the spectrograph.
4. Slide Flange 2 into Flange 1.

Do not tighten the setscrews until focusing and alignment are achieved as discussed in Chapter 4, on page 63.

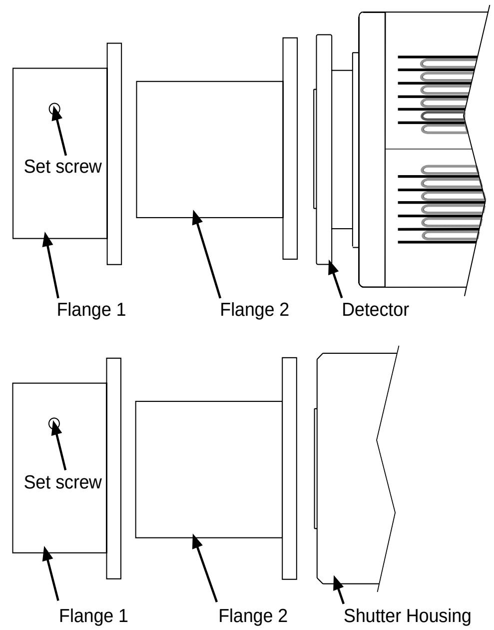


Figure 13. Adapter for Deep Focal Plane Spectrograph

Shallow Focal Plane

For spectrometers with a focal plane distance less than 25 mm beyond the exit interface, the shutter provided can either be mounted on the entrance slit of the spectrometer or operated as a stand-alone shutter. Generally there is not enough room for a camera-mounted shutter.

CCD	**Type of Mount**
EEV (Marconi) 576	Type 1
All other EEV (Marconi)	Type 2
All SITe (Tektronix)	Type 2
PI/PID/RS	Type 1 & 2

Table 3. Shallow Focal Plane Mount Types

The camera mount provided in these cases does not allow focusing via the adapter. Focusing must be accomplished by adjusting the spectrometer. Consult the table above to determine the type of mount for your CCD. The generic assembly directions that follow can be used as a general guide. However, contact the factory if you need detailed instructions for your specific adapter.

For a Type 1 camera:

1. Mount the flange to the camera using the two half-rings and the screws provided. Note that the tapered side of each half-ring faces the adapter. See Figure 14.
2. Next, screw the 10-32 hex screws halfway into three of the six tapped holes in the spectrometer's exit plane.
3. Position the camera so the three hex head screws line up with the openings in the adapter flange.
4. Slide the camera over the screws and rotate into the proper orientation.
5. Leave the camera free to rotate until it is aligned as described in Chapter 4, on page 63.

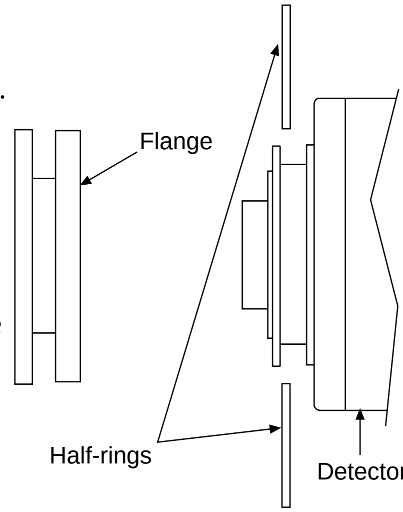


Figure 14. Type 1 Camera Adapter

For a Type 2 camera:

1. Mount the adapter to the spectrometer first.
2. Then insert the front of the camera into the adapter.
3. Thread it into place using the large captive ring nut on the camera. ***DO NOT OVERTIGHTEN THE RING NUT.***

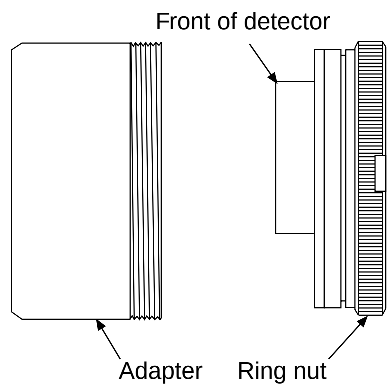


Figure 15. Type 2 Camera Adapter

Entrance Slit Shutter

This shutter can either be mounted on the entrance slit of the spectrometer or used as a stand-alone shutter. Shutters for stand-alone operation have two tapped holes for mounting to a stand: one metric, the other English.

Entrance slit shutter mounts come in two types. The first type is for use with CP-200 and HR-250 Spectrometers, and is shown in Figure 16.

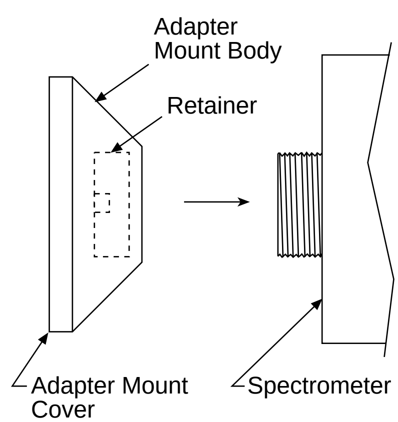


Figure 16. Type 1 Entrance Slit Shutter Mount

Type 1 Shutter Mount Directions

1. Remove the Adapter Mount Cover by removing the four Phillips head screws.
2. Place the Adapter Mount Body over the entrance slit.
3. Mount it by threading the Retainer to the spectrograph.
4. Replace the shutter and the Adapter Mount Cover.

Type 2 Shutter Mount Directions

The second shutter mount type, used with all Acton Research spectrographs, requires no disassembly. Mount it to the spectrograph as shown in Figure 17.

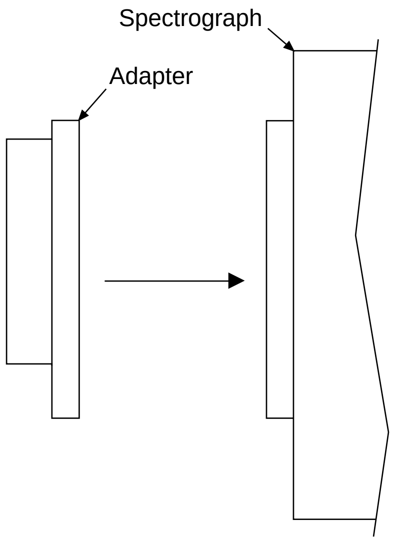


Figure 17. Type 2 Entrance Slit Mount

Shutter Cable Connection

WARNING!

> Dangerous live potentials are present at the Remote **Shutter** power connector. To avoid shock hazard, the Controller power should be OFF when connecting or disconnecting a remote shutter.

1. Verify that the ST-133A controller is turned OFF (or not connected)
2. Connect the shutter cable to the side of the camera.
3. Then connect the other end to either the Shutter Power connector on the camera or to the Shutter Power connector on the ST-133A controller. In the case of TE cameras, the shutter cable should be connected to the Shutter Power connector on the rear panel of the camera or to the Shutter Power connector on the ST-133A Controller. In many systems, cable length considerations will make it more convenient to connect to the Shutter Power connector on the camera.

   Note: Longer cables are available from the factory.

Overexposure Protection

Cameras that are exposed to room light or other continuous light sources will quickly become saturated. This most often occurs when operating without a shutter. If the camera is mounted to a spectrograph, close the entrance slit of the spectrograph completely to reduce the incident light.

Notes:

1. If the CCD is cooled to low temperatures (below -50°C), exposure to ambient light will over-saturate it. This may increase dark charge significantly. If the camera remains saturated after all light sources are removed, you may have to bring the camera back to room temperature to restore dark charge to its original level.
2. Saturation is not harmful to a non-intensified camera.

Mounting a TE-Cooled VersArray Camera to a Microscope

Introduction

This section discusses the setup and optimization of your digital imaging system as applied to microscopy.

Since scientific grade cooled CCD imaging systems are usually employed for low light level microscopy, the major goal is to maximize the light throughput to the camera. In order to do this, the highest Numerical Aperture (NA) objectives of the desired magnification should be used. In addition, you should carefully consider the transmission efficiency of the objective for the excitation and emission wavelengths of the fluorescent probe employed. Another way to maximize the transmission of light is to choose the camera port that uses the fewest optical surfaces in the pathway, since each surface results in a small loss in light throughput. Often the trinocular mount on the upright microscope and the bottom port on the inverted microscope provide the highest light throughput. Check with the manufacturer of your microscope to determine the optimal path for your experiment type.

A rule of thumb employed in live cell fluorescence microscopy is “if you can see the fluorescence by eye, then the illumination intensity is too high”. While this may not be universally applicable, it is a reasonable goal to aim for. In doing this, the properties of the CCD in your camera should also be considered in the design of your experiments. For instance, if you have flexibility in choosing fluorescent probes, then you should take advantage of the higher Quantum Efficiency (QE) of the CCD at longer wavelengths (QE curves can be found on the Princeton Instruments camera data sheets). Another feature to exploit is the high resolution offered by cameras with exceptionally small pixel sizes (data available on the Princeton Instruments camera data sheets). Given that sufficient detail is preserved, you can use 2x2 binning (or higher) to increase the light collected at each “super-pixel” by a factor of 4 (or higher). This will allow the user to reduce exposure times, increasing temporal resolution and reducing photodamage to the living specimen.

Another method to minimize photodamage to biological preparations is to synchronize a shutter on the excitation pathway to the exposure period of the camera. This will limit exposure of the sample to the potentially damaging effects of the excitation light.

Mounting the Camera on the Microscope

The camera is connected to the microscope via a standard type mount coupled to a microscope specific adapter piece. There are two basic camera-mounting designs, the F-mount (standard) and the C-mount (optional). The F-mount uses a tongue and groove type mechanism to connect to the camera while the C-mount employs a standard size thread to make the connection.

F-Mount

For a camera with the F-mount type design, you need two elements to mount the camera on your microscope:

- **A Diagnostic Instruments Relay Lens.** This lens is usually a 1x relay lens that performs no magnification. Alternatively, you may use a 0.6x relay lens to partially demagnify the image and to increase the field of view. There is also a 2x relay lens available for additional magnification.
- **A Microscope-specific Diagnostic Instruments Bottom Clamp.** Table 4 shows which bottom clamps are routinely used with each of the microscope types. They are illustrated in
- Figure 19. If you feel that you have received the wrong type of clamp, or if you need a clamp for a microscope other than those listed, please contact the factory.

To Mount the Camera:

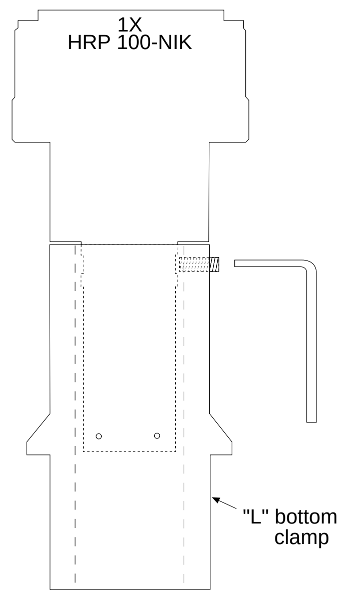


Figure 18. Bottom Lamp Secured to Relay Lens

1. First, pick up the camera and look for the black dot on the front surface.
2. Match this dot with the red dot on the side of the relay lens.
3. Then engage the two surfaces and rotate them until the F-mount is secured as evidenced by a soft clicking sound.
4. Next place the long tube of the relay lens into the bottom clamp for your microscope, securing it to the relay lens with the three set screws at the top of the clamp as shown in Figure 21.
5. This whole assembly can now be placed on the microscope, using the appropriate setscrews on the microscope to secure the bottom clamp to the output port of the microscope.
6. The F-mount is appropriate for any trinocular output port or any side port.
   - When mounting the camera perpendicular to the microscope on the side port, it is ADVISED that you provide some additional support for your camera to reduce the possibility of vibrations or excessive stress on the F-mount nose.
   - Roper Scientific DOES NOT advise using an F-mount to secure the camera to a bottom port of an inverted microscope due to possible failure of the locking mechanism of the F-mount. *Contact the factory for information about a special adapter for operating in this configuration.*

C-Mount

For a camera equipped with a C-mount thread, use the standard C-mount adapter that is supplied by the microscope manufacturer to attach the camera to the microscope.

1. Screw the adapter into the camera.
2. Secure the assembly to the microscope using the standard setscrews on the microscope. The camera can be mounted on the trinocular output port, the side port or the bottom port of the inverted microscope.
3. If you are mounting one of the LARGER cameras in the following orientations, it is ADVISED that you provide additional support for the camera:
   - **Perpendicular to the microscope, on the side port.** Additional support is advised to reduce vibrations or excessive stress on the C-mount nose.
   - **At the bottom port of the inverted microscope.** The C-mount is designed to support the full weight of the camera. However, additional support is advisable since the camera is in a position where it could be deflected by the operator's knee or foot. This kind of lateral force could damage the alignment of the nose and result in sub-optimal imaging conditions.
4. If additional optical elements are required at an output port for image collection, please check with your microscope manual to determine if the chosen output port requires a relay lens.
5. Verify that all optical surfaces are free from dust and fingerprints, since these will appear as blurry regions or spots and hence degrade the image quality.

Microscope Type	Diagnostic Instruments Bottom Clamp Type
Leica DMR	L-clamp
Leitz All types	NLW-clamp
Nikon Optiphot, Diaphot, Eclipse	O-clamp
Olympus BH-2, B-MAX, IMT-2	V-clamp
Zeiss Axioscope, Axioplan, Axioplan 2, Axiophot	Z-clamp
Zeiss Axiovert	ZN-clamp

Table 4. Bottom Clamps for Different Microscopes

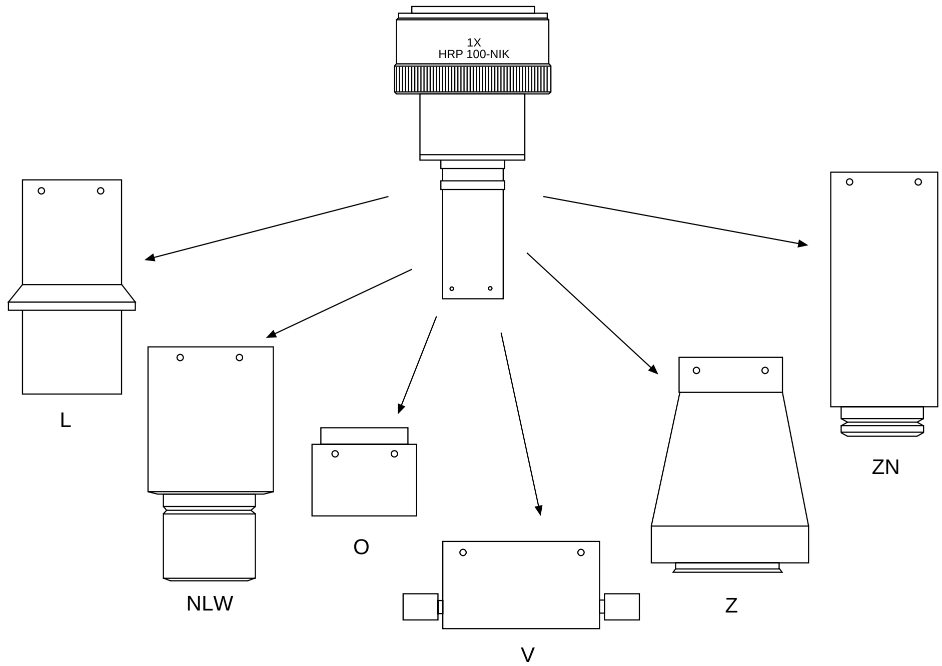


Figure 19. Diagnostic Instruments Bottom Clamps for Different Microscopes

Adjusting the Parfocality of the Camera

After the camera has been mounted, verify that you get a clear, focused, transmitted light image through the eyepiece. Then, divert the light to the camera and lower the illuminating light intensity.

To adjust the parfocality on an F-mount system:

- Begin collecting images with a short exposure time.
- Focus the light on the camera by rotating the ring on the Diagnostic Instruments relay lens without touching the main focusing knobs on the microscope.

To adjust the parfocality on a C-mount system:

On a C-mount system, the camera should be very close to parfocal, although some C-mounts will be adjustable using setscrews on the microscope to secure the adapter slightly higher or lower in position.

To focus a Camera with an F-mount Lens Adapter:

Focusing is normally done by means a focus adjustment on the relay-lens adapter.

Note: The camera lens mount itself also has a focus adjustment. Although it is unlikely that you would ever need to use this adjustment in operation with a microscope (it is preferable that you use the relay-lens focus adjustment), it could be used if necessary. The procedure for using the adjustment is provided in Chapter 4, pages 56-55.

Caution

Microscope optics have very high transmission efficiencies in the infrared region of the spectrum. Since typical microscope light sources are very good emitters in the infrared, some microscopes are equipped with IR blockers or heat filters to prevent heating of optical elements or the sample. For microscopes that do not have the better IR blockers, the throughput of infrared light to the CCD can be fairly high. In addition, while the eye is unable to see the light, CCD cameras are particularly efficient in detecting infrared wavelengths. As a result, the contaminating infrared light will cause a degradation of the image quality due to a high background signal that will be invisible to the eye. Therefore, it is recommended that you add an IR blocker prior to the camera if you encounter this problem with the microscope.

WARNING!

Before You Start, if your system includes a microscope Xenon or Hg arc lamp, it is CRITICAL to turn off all electronics adjacent to the arc lamp, especially your digital camera system and your computer hardware (monitors included) before turning on the lamp power.

Powering up a microscope Xenon or Hg arc lamp causes a large EMF spike to be produced that can cause damage to electronics that are running in the vicinity of the lamp. We advise that you place a clear warning sign on the power button of your arc lamp reminding all workers to follow this procedure. While Roper Scientific has taken great care to isolate its sensitive circuitry from EMF sources, we cannot guarantee that this protection will be sufficient for all EMF bursts. *Therefore, in order to fully guarantee the performance of your system, you must follow this startup procedure.*

Installing the Controller

The Model ST-133A is a compact, high performance CCD Camera Controller for operation with Princeton Instruments brand* cameras. Designed for high speed and high performance image acquisition, the ST-133A offers data transfer at speeds up to 1 megapixel per second, standard video output for focusing and alignment and a wide selection of A/D converters to meet a variety of different speed and resolution requirements. For more information about the controller, refer to "ST-133A Controller", page 83.

1. Verify that the controller voltage and fuse selections are correct for your location. *See page 25.*
2. Before connecting or disconnecting computer-controller cables, make sure that the computer and the controller are both turned OFF.
3. Install the PCI card in the host computer if it has not already been installed. Refer to page 26.
4. Secure the cable ends of the 9-pin serial **Controller to Computer Interface** cable (typically PN 6050-0148) to the controller at the **Serial Com** connector and to the

* The ST-133A controller must be factory configured for operation with an LN-cooled camera. For this reason, a controller purchased for operation with an LN-cooled camera can only be used with an LN-cooled camera. Similarly, a controller purchased for operation with a TE-cooled camera can ***not*** be used with an LN-cooled camera.

connector on the interface card installed in your computer. Use the screws or the slide-latch locks provided.

5. Secure the ends of the **Camera-Controller cable** to the controller at the **Detector** connector and to the camera at the **Controller** connector. The 25-pin **Camera** connector (type DB25), the cable, and the corresponding connector on the camera are configured so that the cable cannot be installed incorrectly. Note that this cable is secured by a slide-lock mechanism at the end that connects to the controller. The other end will be secured by screws or by a slide-lock as required by the camera. To ensure reliable operation, it is essential that both ends of the cable connector be secured before powering the controller.
6. Always turn the power off at the Controller before connecting or disconnecting a cable that interconnects the camera and controller or serious damage to the CCD may result. **This damage is *NOT* covered by the manufacturer's warranty.**
7. Connect the AC powercord to the controller (and later to the AC power source).
8. Leave the controller OFF at this time. For more information about connectors and other features of the ST-133A Controller, refer to Chapter 7, System Component Descriptions, ST-133A Controller (beginning on page 83) and to Chapter 8, TTL Control.

Attaching/Connecting Shutters

Internal Shutters

WARNING! Disconnecting or connecting the shutter cable to the camera while the controller is on can destroy the shutter or the shutter driver in the controller!

A camera will have an internal shutter if ordered by the user.

- **TE-cooled Cameras:** C-mount cameras use a 25 mm internal shutter that is housed in the main body. F-mount cameras use a 35 mm shutter that is housed in an additional front section of the camera. Cameras with the 35 mm internal shutter must be controlled by an ST-133A Controller with the 70 Volt Option.
- **LN-cooled Cameras:** The 40 mm internal shutter is housed in the nose section of the camera. To accommodate the shutter, a deeper nose housing is used, with a resulting increase in the focal plane distance. The 70 Volt Option is not required by 40 mm shutters.

The only case in which an internal shutter will not be supplied is when an TE-cooled camera is configured for spectroscopic applications.

Note: Electromechanical shutters typically have a lifetime of about a million cycles. Avoid running the shutter unnecessarily. Also avoid using shorter exposure times and higher repetition rates than are required.

Shutter Cable

The **Shutter to Controller** cable connects an external shutter to the **Remote** Lemo connector on the rear of the controller. If the camera is equipped with an internal shutter, then the **Remote** connector should not be used to drive an external (second) shutter. Such a configuration will result in under-powering both shutters and may cause damage to the system. If your application requires both an internal and an external shutter, refer to the controller manual for the setup information.

WARNINGS

1. Dangerous live potentials are present at the **Remote** connector. To avoid shock hazard, always turn the controller power **OFF** before connecting or disconnecting an external shutter cable.
2. Disconnecting or connecting the shutter cable to the controller while the controller power is **ON** can destroy the shutter or the shutter driver in the controller.

35 mm Shutter

As shown in Figure 20, TE cameras having an F-mount nose use a 35 mm opening shutter. This shutter does not completely clear a large array (for example, a 1340×1300 array with ~38 mm diagonal) and the array is not fully illuminated. ***This does not mean that the shutter is too small.*** The F-mount lens actually limits the field size ahead of the 35 mm shutter. *The difficulty is that the F-mount standard itself does not provide sufficient coverage to completely illuminate the large array.*

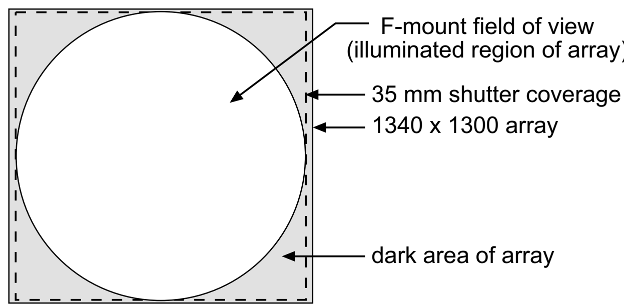


Figure 20. 35 mm Shutter Coverage on 1340×1300 Array for F-mount Design

Note that a camera having the 35 mm shutter can only be used with an ST-133A equipped with the 70 V shutter option. An ST-133A that has the 70 V shutter option can be identified by the **70 V OPT** label on its rear panel as shown in Figure 21.

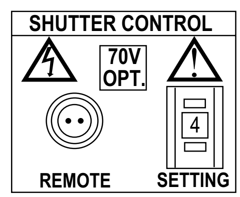


Figure 21. 70 V Shutter Option Label

Shutter Setting Selection

The Shutter Setting dial is correctly set at the factory for the camera's internal shutter if one is present.

1. Verify that the Controller power is OFF.
2. Refer to Table 5 when looking at the rear of the Controller. Verify that the correct shutter setting has been selected for the shutter you are using.
3. If the setting is not correct, press the "-" or the "+" button until the correct setting is displayed in the window.

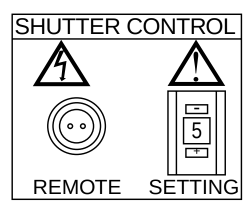


Figure 22. Shutter Setting for Large Internal Shutter (40 mm)

Shutter Setting*	Shutter Type
1	25 mm Roper Scientific supplied External shutter (typically an Entrance slit shutter)
2	25 mm Roper Scientific Internal shutter
4	35 mm Roper Scientific Internal shutter (requires 70 V Shutter option)
5	40 mm Roper Scientific Internal shutter (supplied with LN camera having a 1340 × 1300 or larger CCD)
* Shutter settings 0, 3, and 6-9 are unused and are reserved for future use.	

Table 5. ST-133A Shutter Setting Selection

WARNING!

⚠

An incorrect setting may cause the shutter to malfunction or be damaged. An ST-133A with the 70 V Shutter option cannot be used with a camera having the 25 mm shutter or the 40 mm shutter, even by selecting a different number, because the shutter could be permanently damaged by the high drive voltage and larger stored energy required to drive the 35 mm shutter. Note that the shutter is not covered by the warranty.

Overheating

Larger shutters do not normally exhibit thermal overloading, so they do not require the thermal interlock used by small shutters.

Making the Coolant Circulator-Detector Connections

Caution

1. Do not use any coolant fittings other than those supplied by Roper Scientific. Although standard pipefittings are similar, in most cases they are not the same. Forcing these fittings into the cooling block will permanently damage the threads.
2. VersArray cameras with liquid-assisted cooling or liquid-only cooling require circulating coolant (50:50 mixture of ethylene glycol and water) for proper operation.
3. Take care that the coolant used is pH neutral. Acidic or alkaline coolant can damage the camera fittings and internal cooling block through corrosion. Such damage could be very expensive to repair.
4. Coolant should be no colder than +15°C to prevent condensation at 50% relative humidity. Operating a VersArray detector with coolant at a colder temperature could cause induced condensation in the electronics enclosure and possible catastrophic damage to the detector. ***Damage resulting from this type of operation may void the warranty.***

1. Set up the coolant circulator according to the directions in the user manual for that equipment. Do not apply power to the circulator until directed to do so.
2. Make the hose connections between the circulator and the detector. For best cooling performance, the tubing should be no longer than necessary. Connection directions are provided for two tubing sizes. Follow the directions appropriate to your camera.

a. **1/4" Connections:** Use 1/4", thin-wall plastic tubing. Be sure the tubing is properly secured at both ends. Note that the ports on this camera use a ferrule-less quick-disconnect method of securing the tubing and that both the camera's valve body and the fitting insert include automatic shutoff to prevent coolant leaks when disconnected.

To Secure the Tubing:

For best cooling, connect the inflow and outflow tubing to the ports as indicated in Figure 23.

1) Remove the retaining nuts for the fitting and slide them over the outside of the plastic tubing.
2) Slide the tubing over the barb on the fitting.
3) Slide the retaining nuts to the end of the tubing and tighten them to the threads of the fitting.
4) Insert the fitting into the appropriate valve body (Inlet or Outlet) until you hear a click.
5) Then insert the fitting at the other end of the tubing into the appropriate port on the coolant circulator. You should hear a click, which indicates that the fitting is latched in place.
6) Because of the automatic shutoffs, disconnecting the coolant supply is done by simply depressing the release tabs (Figure 23) and removing the fittings. Reconnecting the supply is done by reinserting each fitting into the appropriate valve body until you hear a click.

b. **3/8" Connections:** Use 3/8" I.D., thick-wall PVC tubing. Hose clamps secure the tubing to the male quick-disconnects.

To Secure the Tubing:

For best cooling, connect the inflow and outflow tubing to the ports as indicated in Figure 23.

1) Insert the male quick-disconnect (on tubing) into the appropriate female quick-disconnect on the camera (Inlet or Outlet) until you hear a click.
2) Then insert the fitting at the other end of the tubing into the appropriate port on the coolant circulator. You should hear a click, which indicates that the fitting is latched in place.
3) Because of the automatic shutoffs, disconnecting the coolant supply is done by simply depressing the release tabs (Figure 23) and removing the fittings. Reconnecting the supply is done by reinserting each fitting into the appropriate valve body until you hear a click.

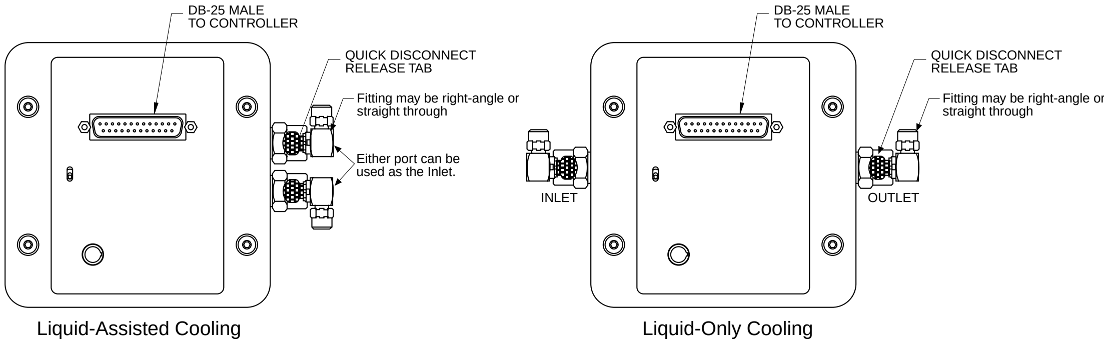


Figure 23. Coolant Ports

Recommended Flow Rate and Fluid Pressure

Flow Rate: 2 liters/minute. Users are advised to install a flow meter to monitor the rate.

Fluid Pressure: 25 psig (maximum).

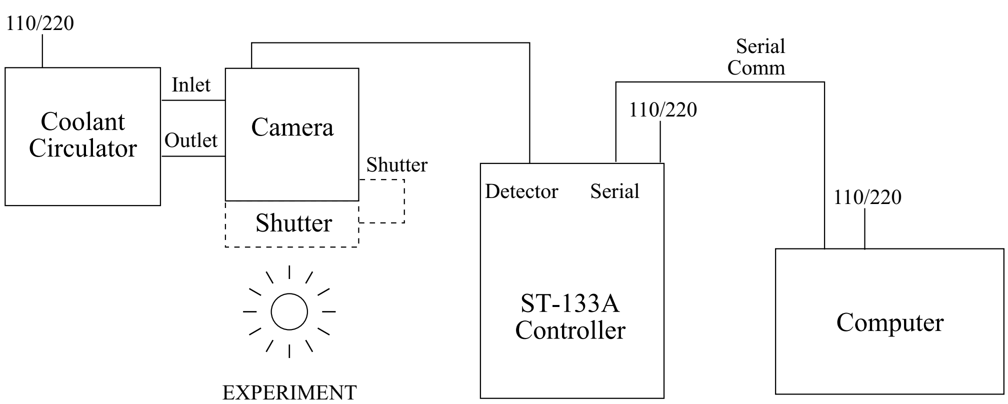


Figure 24. System Diagram: Air-Assist/Liquid-Assist TE Camera with Coolant Circulator

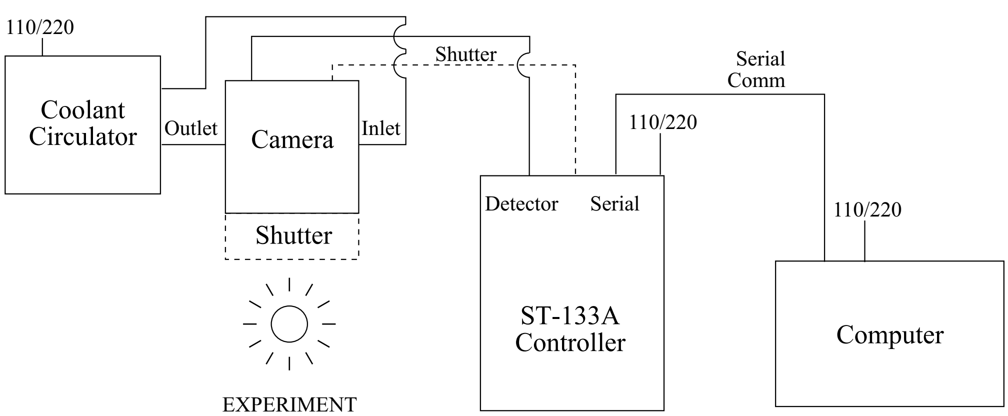


Figure 25. System Diagram: Liquid-Cooled TE Camera with Coolant Circulator

Setting up a CRYOTIGER Compressor

DANGER

FLAMMABLE GAS. AVOID IGNITION SOURCES. Liquid flammable refrigerant collects in the camera's cryocooler during operation. Never disconnect the gas lines or other components until the camera temperature reaches 10-30° C (50-86° F). Over-pressure will occur if the liquid is confined. Cold gas or liquid trapped in the cryocooler can reach high pressures as it warms and vent flammable gas through the camera's pressure relief valve.

FLAMMABLE GAS. AVOID IGNITION SOURCES. Do not heat pressurized gas lines or other gas-charged components. Prevent gas escape when connecting and disconnecting gas lines. Work in a ventilated area.

AVOID GAS LEAKS. Check the condition of the gasket seal on the male half of each gas coupling. Be sure the gasket seal is in place and the sealing surfaces on both the male and female halves are clean before connecting.

DANGER

EXPLOSION HAZARD: A pressure relief valve is provided on the camera to prevent an over-pressure condition if a leak of high-pressure refrigerant occurs within the vacuum vessel in the camera. If the cryocooler is allowed to warm above operating temperature, the active pumping material in the system will release gas to increase the pressure in the vacuum vessel.

TOXIC GAS. The refrigerant is toxic. Carefully follow the initial setup instructions for the pump. These instructions include checking the Tip-N-Tell sensor, checking the pressure gauge, removing shipping bolts, and applying the SUPPLY (red) and RETURN (green) labels to the gas lines.

WARNING!

1. Use two wrenches when connecting or disconnecting a gas line coupling to avoid loosening the bulkhead coupling. Gas pressure can project the coupling with enough force to cause injury.
2. Extreme cold hazard. Do not touch any frosted parts.

Caution

1. Avoid gas leaks. Keep the gas line couplings aligned when making or breaking a coupling connection. Leaks can occur due to the weight of the gas line or due to a sharp bend near the connection.
2. Operating the compressor without a camera connected will reduce the life of the compressor and will void the warranty.
3. To prevent potential overheating and possible damage to the camera:
   - Turn on the compressor before turning on the controller.
   - Turn off the controller before turning off the compressor.

Summary of Initial Setup

Unpack the CRYOTIGER compressor and carefully read the CRYOTIGER operating manual shipped with the unit. Then install the compressor and gas lines according to the procedures in the CRYOTIGER manual. Those procedures take you through all of the steps from unpacking, to positioning the compressor, to installing the gas lines. With regard to the procedure for installing the cryocooler, skip the steps that refer to installing the cryocooler into a vacuum housing (the cryocooler has already been installed into the camera) and follow the remaining steps that refer to making the gas line connections.

Caution

Verify that all couplings are free from dirt and debris. Use two wrenches when connecting/disconnecting gas lines to avoid loosening a bulkhead coupling. When connecting the gas lines to the compressor and the camera, ***TORQUE ALL COUPLINGS TO 14-16 N·m (10-12 lb.ft.)***. Tighten each coupling before continuing to the next one.

Note: A 5/8" and a 3/4" open-end wrenches may be included with the CRYOTIGER system. These wrench sizes are required when installing the gas lines.

The following information summarizes the steps required to unpack and setup the CRYOTIGER compressor and camera. It is only provided to give you an idea of what you will need to do. It is **NOT** a substitute for the setup procedures provided in the CRYOTIGER operating manual shipped with the compressor.

1. Make there are no sources of flame nearby. Compressor gas is flammable.
2. Confirm that the location selected for the compressor has an ambient temperature always within the range of 10-35° C (50-95° F) and has a maximum relative humidity of 80%.
3. Check pressure indicator on back of compressor. The pressure should be 275 psig (within +5/-25 psig tolerance).
4. Using a 10 mm box wrench, remove three (3) shipping bolts from bottom of CRYOTIGER compressor. ***Avoid tilting the compressor more than 30 degrees in order to remove the bolts.***
5. Check the Tip-N-Tell indicator on the shipping container. If the indicator is BLUE, the compressor was tipped beyond allowable limits. This means you must let the compressor sit for a minimum of four (4) hours for the oil to settle.
6. Position the compressor within 10 degrees of level and allow at least 160 mm (6") clearance from the rear and left side of the compressor for unrestricted airflow.
7. Route the gas lines before connecting. Provide gas line supports so the allowable 1.5m (5 feet) unsupported length is not exceeded. Make sure that the minimum bend radius (76 mm/12") will not be exceeded.
8. Apply labels to the gas lines.
9. Remove and store dust caps from the couplings on one end of the Return and Supply gas lines. Check for dust and debris. If dirty, clean with methanol or ethanol and air dry.

10. Using two wrenches (5/8" and 3/4"), connect the gas lines at the compressor end. Red label is for Supply, Green label is for Return. ***Torque couplings to 14-16 N·m (10-12 lb.ft.).*** Refer to Figure 26.

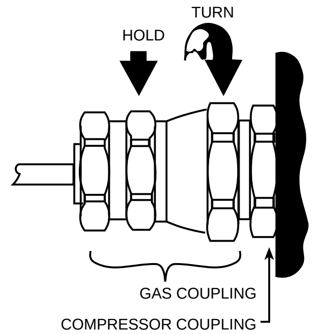


Figure 26. Connect Gas Line to Compressor or Camera

11. Repeat the previous step at the camera. Be sure to match the label colors on the gas lines with those on the camera ports. Figure 27 provides a diagram of a CRYOTIGER-cooled system layout.

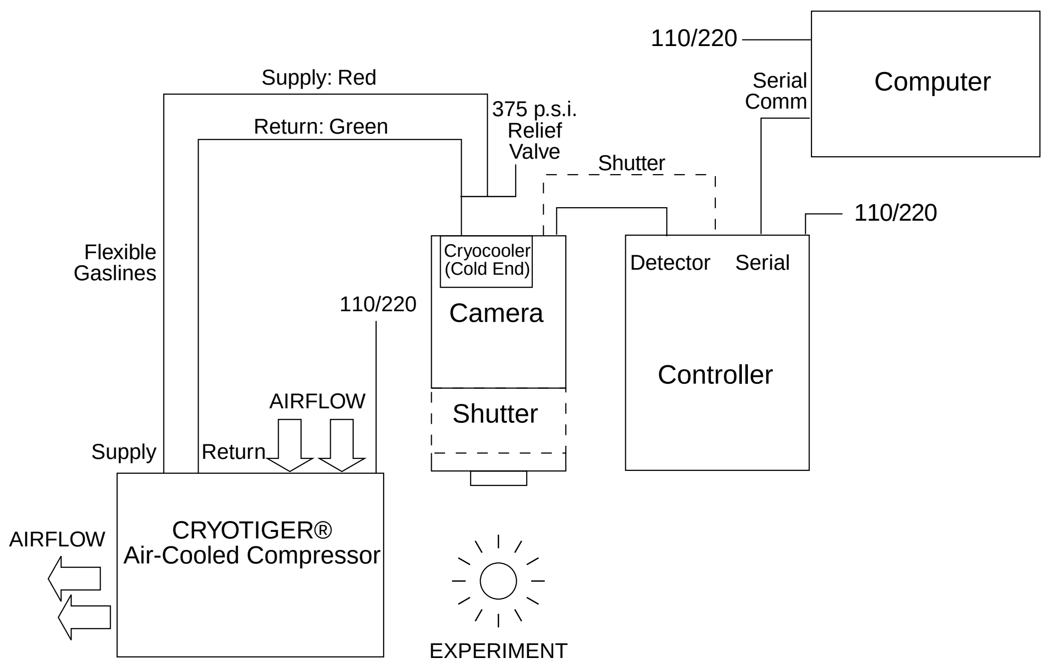


Figure 27. Imaging System Diagram: CRYOTIGER-Cooled Camera

Chapter 4
Operation

Introduction

Dark current is significantly reduced in VersArray camera systems through deep cooling of the CCD arrays. You can choose from either thermoelectric or cryogenic options to best match your application requirements and environment:

- **Thermoelectric (TE) cooling:** Cooling by this method uses a multi-stage Peltier cooler in combination with either air- or coolant-circulation. To prevent condensation and contamination from occurring, cameras cooled this way can either be evacuated or nitrogen backfilled. Cameras under vacuum reach lower temperatures; nitrogen-backfilled cameras are relatively maintenance free. The thermoelectric camera heads feature cost-effective performance, ease of use, and cooling from +20°C to as low as -60°C. Cooling performance depends on whether the array chamber is backfilled or evacuated and whether the TE-cooling is air-assisted, liquid-assisted, or is liquid cooled.

- **Liquid nitrogen (LN) cooling:** Cooling by this method virtually eliminates dark current through the containment of liquid nitrogen in a Dewar reservoir. The use of thermal-radiation shielding and thermal-isolation mounts makes extremely long integration times possible, in excess of 25 hours for a large-capacity Dewar (1.7 liter). VersArray controllers provide stabilized temperature control of LN heads from -70 to -120°C (-70°C to -110°C for large arrays).

- **CRYOTIGER cooling:** Cooling by this method is a custom option for some VersArray camera models. The CRYOTIGER is a self-contained cooling system that provides cryogenic cooling using the Joule-Thomson effect to cool the CCD. The CRYOTIGER gives you liquid-nitrogen-type performance in an easy-to-use, maintenance-free package.

ATTENTION

> With an LN-cooled detector, it is generally good practice to turn on the controller and start at least one data collection while the detector is cooling down, and then to keep the controller in operation for the entire time the Dewar contains liquid nitrogen. This will establish and maintain the “keep cleans” mode of the controller so that, even when the CCD is not actively taking data, it will be continuously cleaning (shifting charge on the array to clear dark charge and cosmic ray artifacts).

Once the VersArray detector has been installed as explained in the preceding chapters, operation of the detector is basically straightforward. In most applications you simply establish optimum performance using the **Focus** mode (in WinView/32 or WinSpec/32, for example), set the target detector temperature, wait until the temperature has stabilized, and then do actual data acquisition in the **Acquire** mode. Additional considerations regarding experiment setup and equipment configuration are addressed in the software manual. Refer to "First Light" section in this chapter for step-by-step procedures for initial data acquisition.

Thermoelectric Cooling

Introduction

As stated before, cameras in the VersArray family can be either thermoelectrically- or cryogenically-cooled. TE cooling is enhanced by providing a fan (air-assist) to remove heat, providing a fan and circulating water/coolant (liquid-assist), or circulating chilled water/coolant (liquid-cooled). Of the three approaches for TE-cooled cameras, liquid-cooled provides the greatest temperature reduction. Cryogenic cooling (as implemented in the LN-cooled cameras and the CRYOTIGER-cooled cameras) provides even deeper cooling. Generally speaking, the lower the array temperature, the better the signal. By cooling the array, dark current contribution to signal is reduced and sensitivity is increased.

TE Air-Assisted

VersArray cameras designed for TE-cooled operation and have three distinct sections to support this type of cooling. The front vacuum enclosure contains the CCD array seated on a cold finger, with an attached thermal sensing diode to monitor its temperature. The cold finger is seated on a multi-stage Peltier thermoelectric cooler, driven by closed-loop proportional-control circuitry. The back enclosure contains the heat exchanger that is cooled by an internal fan. Air is drawn in from the rear most vents on the side of the camera and is exhausted through the front most side vents.

Caution

The VersArray TE-cooled camera requires the ST-133A Controller that has been shipped with it. Do not use the ST-133A Controller with LN- or CRYOTIGER-cooled Princeton Instruments cameras.

Note: Temperature regulation does not reach its ultimate stability for at least 30 minutes after temperature lock is established.

TE Liquid-Assist

TE-cooled cameras with liquid-assisted cooling differ from the air-assist TE-cooled cameras in that they rely on both an internal fan and liquid circulating through the heat exchanger to remove heat. Air is drawn in from the rear most vents on the side of the camera and is exhausted through the front most side vents. The coolant (which enters and exits on the same side of the camera) removes additional heat. Either port can be the inlet or outlet.

WARNINGS

Do not use any coolant fittings other than those supplied by Roper Scientific. Although standard pipe fittings are similar, in most cases they are not the same. Forcing these fittings into the aluminum block will permanently damage the threads.

Take care that the coolant used is pH neutral. Acidic or alkaline coolant can damage the camera fittings and internal cooling block through corrosion. Such damage could be very expensive to repair.

TE Liquid-Cooled

TE-cooled cameras that are liquid-cooled rely only on chilled coolant circulating through the heat exchanger. The coolant flow through this exchanger differs from the flow through the liquid-assisted camera's exchanger in that the coolant ports are on opposite sides of the camera and the inlet and outlet ports are not interchangeable.

LN Cooling

ATTENTION It is generally good practice to turn on the controller and start at least one data collection while the camera is cooling down, and then to keep the controller in operation for the entire time the Dewar contains LN_2. This will establish and maintain the “keep cleans” mode of the controller so that, even when the CCD is not actively taking data, it will be continuously cleaning (shifting charge on the array to clear dark charge and cosmic ray artifacts).

Introduction

LN-cooled cameras use liquid nitrogen to reduce the temperature of the CCD. The liquid nitrogen is stored in a Dewar that is enclosed in a vacuum jacket for minimal external thermal losses. The chip temperature is regulated by closed-loop proportional control circuitry. A thermal sensing diode attached to the cooling block of the camera monitors the chip temperature. The range depends on the CCD device (see Table 6).

CCD Model	Approx. Range
512F	-70°C to -120°C
1300B/F	-70°C to -110°C
2048B/F	-70°C to -110°C

Table 6. Approximate Temperature Range vs. CCD

Caution LN-cooled CCDs, because of their low operating temperatures, must ***always*** be connected to an operating controller. If the controller power is turned off with liquid nitrogen remaining in the Dewar, the CCD will quickly become saturated with charge, which cannot be readily removed without warming the camera to room temperature.

Holding Times

At its lowest operating temperature, Princeton Instrument’s large capacity Dewar (1.7 liters) has a hold time of 25 hours or more in an upright position. However, the hold time will vary depending on the Dewar orientation, array size, and operating temperature.

To maximize the holding time when leaving the camera overnight, in addition to topping off the Dewar, you will want to set the array temperature to its lowest operating temperature (-120° C or -110°C, depending on the array size) via the Detector Temperature panel in the WinView software. *You must leave the controller power on to prevent potential damage due to excessively cold temperatures.* The effect of setting the array temperature to its lowest operating temperature is to reduce the heating of the array and thereby minimize LN evaporation. The following day, reset the camera temperature to the array's operating temperature.

Filling the Dewar

DANGER

1. Even minimal contact with LN can cause severe injury to eyes and skin. Avoid contact with the splashing that will invariably accompany pouring LN into a room temperature Dewar.
2. Always be careful when removing the LN port cap if there is LN present in the Dewar. Pressure due to nitrogen gas can cause the cap to fly out when the retaining nut is loosened, possibly spraying you with liquid LN, which can cause severe injury.

1. After the camera has been properly evacuated, loosen the retaining nut (Figure 28) a few turns, then remove the LN Dewar port cap by pulling it straight out.
2. It is recommended that an LN transfer Dewar with a pouring spout be used to transfer LN from the storage tank to the camera. If you are going to use a funnel, place a thin vent tube into the Dewar through the funnel to reduce splashing due to boiling LN.
3. Pour approximately 100 ml of LN into the Dewar. Stop for 5-10 minutes until you observe a "geyser-like" vapor burst from the Dewar opening. This burst is normal and has to do with reaching a thermal equilibrium between the LN and the Dewar container surfaces.

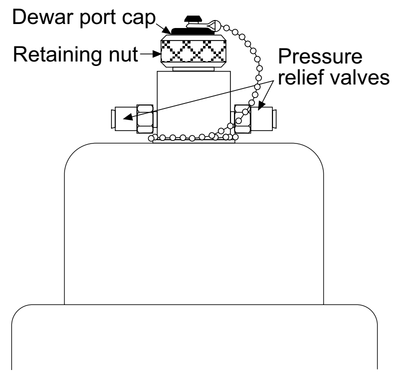


Figure 28. Dewar Ports and Valves

1. Fill up the Dewar (approximately 1.7 liters for standard Dewar or 0.75 liters for an all-directional Dewar). To test the LN level, insert a straight piece of wire (a cryogenic "dip stick") into the Dewar briefly, then remove it. The LN level will be indicated by the condensation on the wire.
2. Once the Dewar has been filled, replace the filler cap and hand-tighten the retaining nut by giving it about 3/4 turn (or more) beyond the point where the nut feels snug.

WARNING!

Ice buildup may occur at the valve ports if the camera is being operated under high humidity conditions. If frost appears on the valves, periodically clean the outside of the valves so that ice does not prevent the valves from venting normally.

3. Once a temperature of -80°C has been achieved, maintain the CCD at that temperature for 2-3 hours, then reset the dial to the desired temperature. This procedure prevents any residual water vapor (if introduced during shipment or through erroneous pumping in your lab, e.g., if your trap is inefficient) from condensing on the CCD window.

   If the Dewar is continuously refilled, this procedure is unnecessary and the dial can be set at the desired temperature without the intermediate -80°C stage.

Note: The pressure relief valves (Figure 28) underneath the protective covering will occasionally emit a plume of N_2 gas and mist. *Continuous* hissing indicates that the vacuum in the Dewar jacket is probably inadequate. In this case, *first remove all LN from the Dewar*, then reconnect the camera to the vacuum pump.

The cooler status indicator will turn from orange to green to indicate that the temperature is thermostated to within ±0.050°C. For an LN-cooled CCD to reach -100°C normally requires 45-55 minutes.

Note: Temperature regulation does not reach its ultimate stability for at least 30 minutes after the green indicator LED has turned on. After this period of time the desired temperature is maintained with great precision.

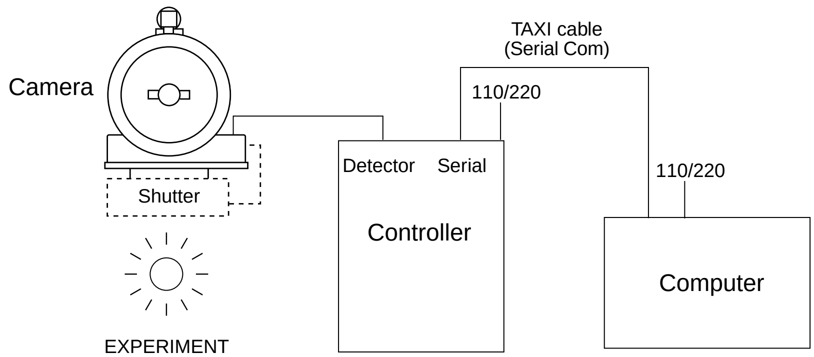


Figure 29. System Diagram: LN-cooled Camera

Dewar Options

<u>All-directional Dewar</u>

Also available is the "all-directional" Dewar. An all-directional Dewar can operate in *any* angular orientation but hold only about approximately 0.75 liters, roughly half as much LN as the side-looking and end-looking Dewars. This reduced capacity translates to half the hold time as well.

Note: There is no simple way to verify whether you have been shipped an all-directional system simply by observing the camera. If you are uncertain, check the shipping paperwork to verify that your Dewar is an all-directional model.

For operation of the all-directional Dewar in a 90° orientation you can refill the Dewar only through a special 90° funnel provided by Roper Scientific. For operation at greater than 90° angles, there is only one refilling choice: the Dewar must be returned to a 0° (upright) orientation for refilling.

CRYOTIGER Cooling

Introduction

CRYOTIGER cooling is achieved by the circulation of a CRYOTIGER proprietary refrigerant through the cryocooler inside the camera. High-pressure refrigerant is supplied from the compressor via the Supply line to the cryocooler. In the cryocooler, the compressed refrigerant expands and cools the cold tip and the array to cryogenic temperatures. (Array temperatures in the region of -90°C to -120° C are achievable.) The low-pressure refrigerant is then returned via the Return line to the compressor where it is compressed, cooled, cleaned, and then supplied to the cryocooler.

One advantage to CRYOTIGER-cooling is that the camera can be mounted in any orientation. However, system components must be arranged so the gas lines are protected from stress and traffic. Minimum bend radius restrictions for flexible gas lines must be followed and gas line supports must be used to ensure that the allowable supported length is not exceeded.

Refer to the CRYOTIGER manual shipped with your system for bend radius and allowable supported length information.

Warnings and Cautions

DANGER

FLAMMABLE GAS. AVOID IGNITION SOURCES. Liquid flammable refrigerant collects in the camera's cryocooler during operation. Never disconnect the gas lines or other components until the camera temperature reaches 10-30° C (50-86° F). Over-pressure will occur if the liquid is confined. Cold gas or liquid trapped in the cryocooler can reach high pressures as it warms and vent flammable gas through the camera's pressure relief valve.

FLAMMABLE GAS. AVOID IGNITION SOURCES. Do not heat pressurized gas lines or other gas-charged components. Prevent gas escape when connecting and disconnecting gas lines. Work in a ventilated area.

AVOID GAS LEAKS. Check the condition of the gasket seal on the male half of each gas coupling. Be sure the gasket seal is in place and the sealing surfaces on both the male and female halves are clean before connecting.

EXPLOSION HAZARD: A pressure relief valve is provided on the camera to prevent an over-pressure condition if a leak of high-pressure refrigerant occurs within the vacuum vessel in the camera. If the cryocooler is allowed to warm above operating temperature, the active pumping material in the system will release gas to increase the pressure in the vacuum vessel.

TOXIC GAS. The refrigerant is toxic. Carefully follow the initial setup instructions for the pump. These instructions include checking the Tip-N-Tell sensor, checking the pressure gauge, removing shipping bolts, and applying the SUPPLY (red) and RETURN (green) labels to the gas lines.

WARNING!

1. Use two wrenches when connecting or disconnecting a gas line coupling to avoid loosening the bulkhead coupling. Gas pressure can project the coupling with enough force to cause injury.
2. Extreme cold hazard. Do not touch any frosted parts.

Caution

1. Avoid gas leaks. Keep the gas line couplings aligned when making or breaking a coupling connection. Leaks can occur due to the weight of the gas line or due to a sharp bend near the connection.
2. Operating the compressor without a camera connected will reduce the life of the compressor and will void the warranty.
3. To prevent potential overheating and possible damage to the camera:
   - Turn on the compressor before turning on the controller.
   - Turn off the controller before turning off the compressor.

Operation and Maintenance

A general startup and operation sequence follows. The ON/OFF sequence for system components is intended to prevent potential overheating and possible damage to the camera.

1. Verify that the gas lines have been connected between the compressor and the camera and that the gas lines are properly supported.
2. Verify that the voltage selector is set to the proper voltage for your location.
3. Connect the compressor's powercord to the rear of the compress and connect the other end to a suitable power receptacle.
4. Switch the compressor's circuit breaker (on the front) to the start position.
5. Verify that the charge pressure is correct by checking the pressure gauge and correct for ambient temperature.
6. Turn on the camera controller.
7. Run the WinView/32 software where you can then set the operating temperature for the camera temperature.
8. Enter the hardware setup information and define the experiment setup. Refer to the software user's manual.
9. Run the experiment and store the data.
10. Turn off the controller.
11. Turn off the compressor.

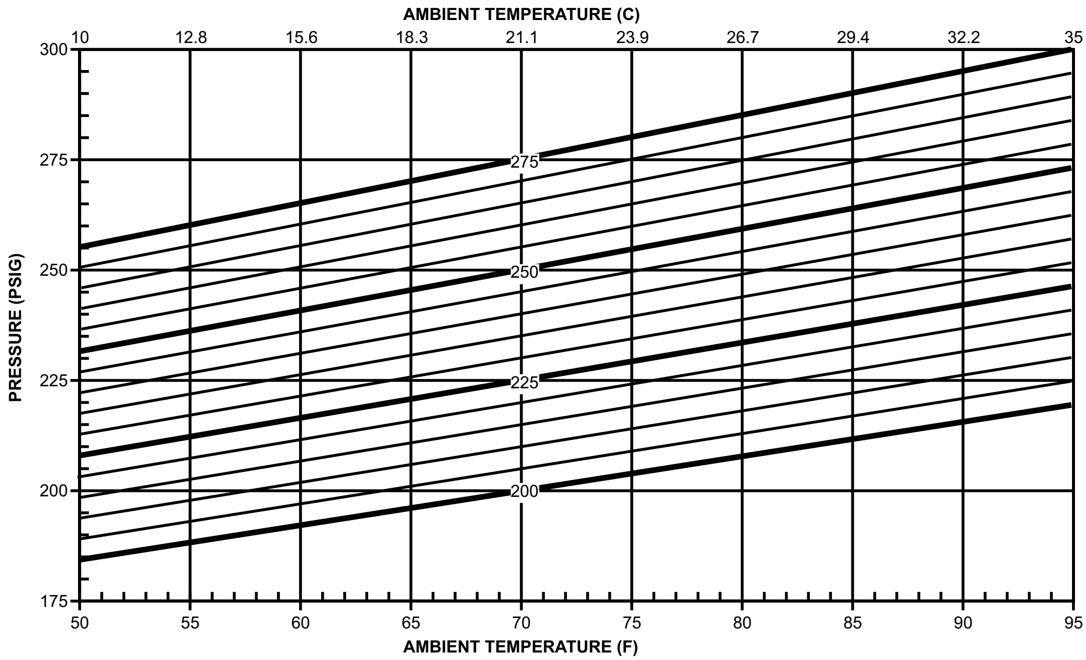


Figure 30. Charge Pressure vs. Ambient Temperature

Refer to the CRYOTIGER Compressor manual and your software manual for further information about operating and maintaining a CRYOTIGER-cooled system.

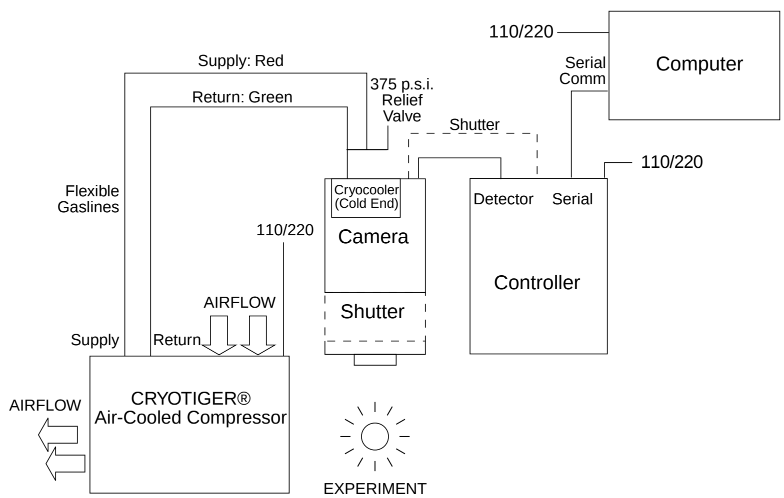


Figure 31. System Diagram: CRYOTIGER-cooled Camera

Setting the Operating Temperature

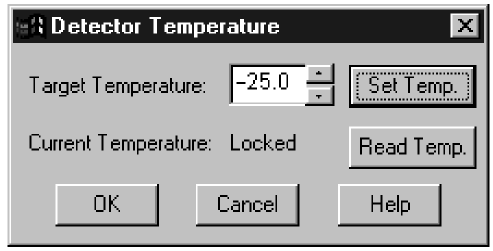


Figure 32. WinView Detector Temperature dialog box

When WinView or WinSpec is the controlling software, temperature control is done via the Camera Temperature dialog box (see Figure 32) accessed from the **Setup** menu. Once the target array temperature has been set, the software controls the camera's cooling circuits to reach set array temperature. On reaching that temperature, the control loop locks to that temperature for stable and reproducible performance. When temperature lock has been reached (temperature within 0.05°C of set value) the green **TEMP LOCK** indicator on the Analog/Control module panel lights and the Camera Temperature dialog box reports that the current temperature is "**Locked**". The on-screen indication allows easy verification of temperature lock in experiments where the computer and controller are widely separated. There is also provision for reading out the actual temperature at the computer so that the progress of the cooldown can be monitored.

The time required to achieve lock can vary over a considerable range, depending on such factors as the camera type, CCD array type, type of cooling, etc. Once lock occurs, it’s okay to begin focusing. However, you should wait an additional twenty minutes before taking quantitative data so that the system has time to achieve optimum thermal stability.

Baseline Signal

With the camera completely blocked, the CCD will collect a dark charge pattern, dependent on the exposure time and camera temperature. The longer the exposure time and the warmer the camera, the larger this background will appear.

Note: Do not be concerned about either the DC level of this background or its shape unless it is very high (i.e., > 1000 counts for LN-cooled or CRYOTIGER-cooled or > 200 counts for TE-cooled). What you see is not noise. It is a fully subtractable readout pattern. Each CCD has its own dark charge pattern, unique to that particular device. Every device has been thoroughly tested to ensure its compliance with Roper Scientific's demanding specifications.

Caution

If you observe a sudden change in the baseline signal you may have excessive humidity in the camera vacuum enclosure. Turn off the controller (if LN-cooled, remove the liquid nitrogen also) and contact the factory.

F-Mount Adapter Focusing Procedure

Note: This procedure sets the focus for the F-mount adapter, not the lens. Once set, it should not need to be disturbed again.

1. The lens should be mounted to the camera as described in Chapter 3.
2. The F-mount adapter is in two sections: the adapter body (into which the lens is mounted) and the adapter adjustment ring that is secured to the front of the camera. Try rotating the adapter body. If it doesn't rotate, you will have to loosen the securing setscrew(s) in the side of the adapter adjustment ring. To change the focus setting, proceed as follows.
   - Loosen the setscrew(s) with a 0.050″ hex key*. Do not remove the screw(s); loosen just enough to allow the adapter body to be adjusted.
   - Set the *lens focus adjustment* to the target distance.

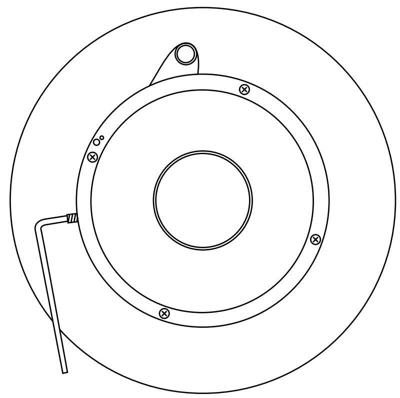


Figure 33. F-mount Adjustment

3. Block off the lens and set it to the smallest possible aperture (largest F-stop number).
4. Mount a suitable target at a known distance in front of the lens. Typically, a photo resolution chart is used. However, even a page of small print will generally serve quite well for this purpose.
5. Verify that all cables and connectors are secured.
6. Turn on the system and start the ***WinView/32*** software.
7. Set the software to the **FreeRun** and **Asynchronous** modes (consult the software manual if you are unfamiliar with these modes). Choose a fast exposure (.1 msec) and begin data collection by selecting **Focus**.
8. Slowly uncover the lens. If the image becomes washed out, recover the lens, choose a shorter exposure, and uncover the lens again. If it is too dark, choose a longer exposure.
9. Double check to be sure the *lens focus* is set to the *target distance* and readjust if necessary.
10. Taking care not to disturb the *lens focus*, rotate the *adapter body* for maximum sharpness in the observed image and tighten the setscrews to secure the adapter body's position.

This completes the procedure for adjusting the *F-mount adapter*. It should not be necessary to disturb the adjustment again. In actual measurements with real subjects, the focusing will be done entirely with the *lens focus adjustment*. Microscope adapters follow a similar procedure except, in this case, the front part of the lens mount should not need adjustment. See Chapter 3 for additional information.

* The screws are #4-40 setscrews. A 0.050″ hex key is required to loosen or tighten them.

Lens Focusing Procedure

Except for the lens mount focus procedure that applies to F-mount lenses as described above, there is no difference between focusing considerations for an F-mount lens and a C-mount lens. Simply use the focusing ring on the lens to produce the sharpest image at full aperture. Then stop the lens down to its sharpest aperture (probably at a mid-range aperture setting) and adjust the Exposure Time for the best possible image as observed at the monitor. In microscopy applications, it will also be necessary to review the discussions in ***Mounting a TE-Cooled VersArray Camera to a Microscope***, page 34.

Field of View

When used for two-dimensional imaging applications, Princeton Instruments CCD cameras closely imitate a standard 35 mm camera. Since the CCD is not the same size as the film plane of a 35 mm camera, the field of view at a given distance is somewhat different.

- D = distance between the object and the CCD
- B = 46.5 mm (Nikon bayonet only), 17.5 for C-mount
- F = focal length of lens
- S = horizontal or vertical dimension of CCD
- O = horizontal or vertical field of view covered at a distance D
- M = magnification

The field of view is:

$$O = S/M, \quad \text{where} \quad M = \frac{FD}{(D - B)^2}$$

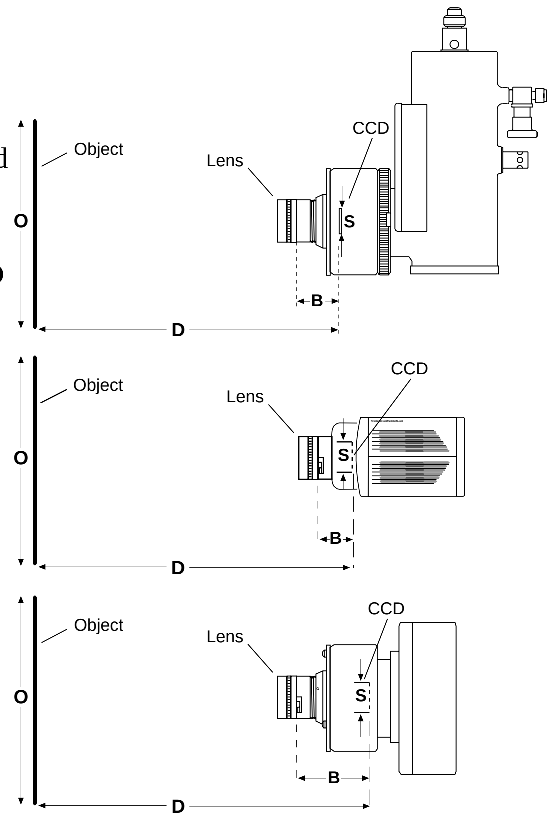


Figure 34. Imaging Field of View

Setting the Camera Gain

Typical choices for gain are 0.5x, 1x, and 2x. The method for changing a camera's analog gain depends on the type of camera.

- Gain for an LN-cooled VersArray camera is via a gain control switch on the side of the electronics enclosure (see switch positions in Figure 35).
- Gain for TE-cooled cameras with a gain switch on the side is selected via that switch.
- Gain for TE-cooled cameras with a gain control switch on the rear panel is set in the application software (for example, on the Experiment Setup tab card in the WinView/32 software). The gain switch setting is overridden by the software selection.

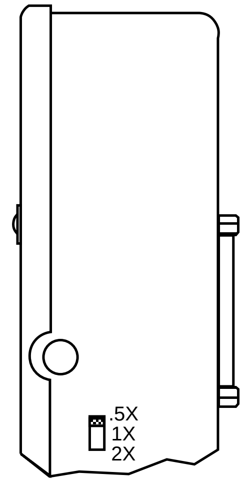


Figure 35. LN-cooled Camera Gain Switch Settings

Note: For some cameras, gain may not be selectable. In those cases, gain settings will not be accessible in the software.

The gain of the camera should generally be set so that the overall noise is ~1 count RMS. In most instances this will occur with the gain setting at 1x. In situations where the A/D range exceeds that of the array, it will generally be better to set the Gain to 2x so that the signal can be spread over as much of the A/D range as possible. Users who consistently measure low-level signals may wish to select 2x, which reduces some sources of noise. Users who measure high-level signals may wish to select .5x to allow digitization of larger signals. This is a particularly important consideration in absorbance measurements. Customized values of gain can be provided. Contact the factory for additional information.

Operation

Once the VersArray camera has been installed and its optics adjusted, camera operation is basically straightforward. In most applications you simply establish optimum performance using the **Focus** mode (WinView/32) and then do actual data acquisition in the **Acquire** mode. Additional considerations regarding experiment setup and equipment configuration are addressed in the software manual. Refer to the appropriate "First Light" section for step-by-step procedures for initial data acquisition for imaging and spectroscopic applications.

First Light (Imaging)

This section provides step-by-step instructions for acquiring an imaging measurement for the first time. The intent of this procedure is to help you gain basic familiarity with the operation of your system and to show that it is functioning properly. Once basic familiarity has been established, then operation with other operating configurations, ones with more complex timing modes, can be performed.

Assumptions

The following procedure assumes that

1. You have already set up your system in accordance with the instructions in Chapter 3.
2. You have read the previous sections of this chapter.
3. You are familiar with the application software.
4. The system is air-cooled, (If your system is designed for liquid-assisted TE-cooled, liquid-cooled TE, LN-cooled operation, or CRYOTIGER, be sure to read ***Thermoelectric Cooling***, ***LN Cooling***, or ***CRYOTIGER Cooling*** section, starting on page 48, before proceeding.)
5. The system is being operated in imaging mode.
6. The target is a sharp image, text, or a drawing that can be used to verify that the camera is "seeing" and can be used to maximize focus.

Warnings

WARNING

Before You Start, if your system includes a microscope Xenon or Hg arc lamp, it is **CRITICAL** to turn off all electronics adjacent to the arc lamp, especially your digital camera system and your computer hardware (monitors included) before turning on the lamp power.

Powering up a microscope Xenon or Hg arc lamp causes a large EMF spike to be produced that can cause damage to electronics that are running in the vicinity of the lamp. We advise that you place a clear warning sign on the power button of your arc lamp reminding all workers to follow this procedure. While Roper Scientific has taken great care to isolate its sensitive circuitry from EMF sources, we cannot guarantee that this protection will be sufficient for all EMF bursts. *Therefore, in order to fully guarantee the performance of your system, you must follow this startup procedure.*

Getting Started

1. Mount a test target in front of the camera.
2. Turn on the controller power.

   Note: A camera overload alarm may sound briefly and then stop. This is normal and is not a cause for concern. However, if the alarm sounds continuously, even with no light entering the camera, something is wrong. Turn off the power and contact the factory for guidance.

3. Turn on the computer power.

4. Start the application software.
5. Start the coolant flow or fill the LN Dewar.
6. Block light from the lens.

Setting the Parameters

Note: The following procedure is based on WinView/32: you will need to modify it if you are using a different application. Basic familiarity with the WinView/32 software is assumed. If this is not the case, you may want to review the software manual or have it available while performing this procedure.

Set the software parameters as follows:

Environment dialog (Setup|Environment): Verify that the DMA Buffer size is 8 Mbytes (min.). Large arrays may require a larger buffer size. If you change the buffer size, you will have to ***reboot the computer*** for this memory allocation to be activated, and then restart WinView.

Controller|Camera tab page (Setup|Hardware): Controller and Detector parameters should be set automatically to the proper values for your system. However, you can click on the **Load Defaults From Controller** button on this tab page to load the default settings.

- **Controller type:** ST-133
- **Controller version:** 3 or higher
- **Camera type:** Select the array installed in your camera.
- **Shutter type:** None, Large, or Remote (system dependent).
- **Readout mode:** Full frame.

Detector Temperature (Setup|Detector Temperature…): -40°C for air-cooled. When the array temperature reaches the set temperature, the green **Temp Lock** LED on the rear of the ST-133A will light and there will be a **locked** indication at the computer monitor. Note that some overshoot may occur. This could cause temperature lock to be briefly lost and then quickly re-established. If you are reading the actual temperature reported by the application software, there may be a small difference between the set and reported temperature when lock is established. This is normal and does not indicate a system malfunction. Once lock is established, the temperature will be stable to within ±0.05°C.

Interface tab page (Setup|Hardware): High Speed PCI (or PCI(Timer))

Cleans and Skips tab page (Setup|Hardware): Default

Experiment Setup Main tab page (Acquisition|Experiment Setup…):

- **Exposure Time:** 100 ms
- **Accumulations & Number of Images:** 1

Experiment Setup ROI tab page (Acquisition|Experiment Setup…): Use this function to define the region of interest (ROI).

- **Imaging Mode:** Selected
- Clicking on **Full** loads the full size of the chip into the edit boxes.

Experiment Setup Timing tab page (Acquisition|Experiment Setup…):

- **Timing Mode:** Free Run
- **Shutter Control:** Normal
- **Safe Mode vs. Full Speed:** Safe (Asynchronous)

Acquiring Data

1. If you are using WinView/32 and the computer monitor for focusing, select **Focus** from the **Acquisition** menu. Successive images will be sent to the monitor as quickly as they are acquired.
2. Adjust the lens aperture, intensity scaling, and focus for the best image as viewed on the computer monitor. Some imaging tips follow:
   - Begin with the lens blocked off and then set the lens at the smallest possible aperture (largest f-stop number).
   - Make sure there is a suitable target in front of the lens. An object with text or graphics works best. If working with a microscope, use any easily viewed specimen.
   - Adjust the intensity scaling and lens aperture until a suitable setting is found. The initial intensity scaling setting of 4096 assures that the image won't be missed altogether but could be dim. Once you've determined that the image is present, select a lower setting for better contrast. Check the brightest regions of the image to determine if the A/D converter is at full-scale. *A 12-bit A/D is at full scale when the brightest parts of the image reach an intensity of 4095.* Adjust the aperture to where it is just slightly smaller (higher f-stop) than the setting where maximum brightness on any part of the image occurs.
   - Set the focus adjustment of the lens for maximum sharpness in the viewed image.
   - In the case of a camera with an F-mount, the camera lens adapter itself also has a focus adjustment. If necessary, this focus can be changed to bring the image into range of the lens focus adjustment. See ***F-Mount Adapter Focusing Procedure***, page 56.
3. After you have focused the camera, you can stop **Focus** mode, continue **Focus** mode, begin **Acquire** mode, or wait for the CCD to reach the operating temperature before going to **Acquire** mode.
4. If the array is cooled by LN, empty the Dewar before turning off the controller. If a coolant circulator, a chiller/circulator, or a CRYOTIGER unit is being used to cool the array, stop the flow before turning off the controller.

   Note: Exposing the CCD to bright light (10× saturation) when cold (<-70°C) will cause the dark current in the exposed pixels to be 3 to 10 times higher than normal for that operating temperature. This effect is due to the formation of temporary traps. The effect can be reversed by allowing the camera to warm up to room temperature.

First Light (Spectroscopy)

The following paragraphs provide step-by-step instructions for placing your spectroscopy system in operation the first time. The intent of this simple procedure is to help you gain basic familiarity with the operation of your system and to show that it is functioning properly. Once basic familiarity has been established, then operation with other operating configurations, ones with more complex timing modes, can be performed. An underlying assumption for the procedure is that the detector is to be operated with a spectrograph such as the Acton SpectraPro™ 300i (SP300i) on which it has been properly installed. A suitable light source, such as a mercury pen-ray lamp, should be mounted in front of the entrance slit of the spectrograph. Any light source with line output can be used. *Standard fluorescent overhead lamps have good calibration lines as well.* If there are no “line” sources available, it is possible to use a broadband source such as tungsten for the alignment. If this is the case, use a wavelength setting of 0.0 nm for alignment purposes.

Assumptions

The following procedure assumes that

1. You have already set up your system in accordance with the instructions in Chapter 3.
2. You have read the previous sections of this chapter.
3. You are familiar with the application software.
4. The system is air-cooled. (If your system is designed for liquid-assisted TE-cooled, liquid-cooled TE, LN-cooled operation, or CRYOTIGER, be sure to read ***Thermoelectric Cooling***, ***LN Cooling***, or ***CRYOTIGER Cooling*** section, starting on page 48, before proceeding.)
5. The system is being operated in spectroscopy mode.
6. An entrance slit shutter is not being controlled by the ST-133A.

Getting Started

1. Set the spectrometer entrance slit width to minimum (10 µm if possible).
2. Turn on the controller power.

   Note: A detector overload alarm may sound briefly and then stop. This is normal and is not a cause for concern. However, if the alarm sounds continuously, even with no light entering the detector, something is wrong. Turn off the power and contact the factory for guidance.

3. Turn on the computer power.
4. Start the application software.
5. Start the coolant flow or fill the LN Dewar.

Setting the Parameters

Note: The following procedure is based on WinSpec/32: you will need to modify it if you are using a different application. Basic familiarity with the WinSpec/32 software is assumed. If this is not the case, you may want to review the software manual or have it available while performing this procedure.

Set the software parameters as follows:

Environment dialog (Setup|Environment): Verify that the DMA Buffer size is 8 Mbytes (min.). Large arrays may require a larger buffer size. If you change the buffer size, you will have to ***reboot the computer*** for this memory allocation to be activated, and then restart WinSpec.

Controller|Camera tab page (Setup|Hardware): Controller and Detector parameters should be set automatically to the proper values for your system. However, you can click on the **Load Defaults From Controller** button on this tab page to load the default settings.

- **Controller type:** ST-133
- **Controller version:** 3 or higher
- **Camera type:** Select the array installed in your detector.
- **Shutter type:** None or Remote.
- **Readout mode:** Full frame.

Detector Temperature (Setup|Detector Temperature…): -40°C for air-cooled. When the array temperature reaches the set temperature, the green **Temp Lock** LED on the rear of the ST-133A will light and there will be a **locked** indication at the computer monitor. Note that some overshoot may occur. This could cause temperature lock to be briefly lost and then quickly re-established. If you are reading the actual temperature reported by the application software, there may be a small difference between the set and reported temperature when lock is established. This is normal and does not indicate a system malfunction. Once lock is established, the temperature will be stable to within ±0.05°C.

Interface tab page (Setup|Hardware): High Speed PCI (or PCI(Timer))

Cleans and Skips tab page (Setup|Hardware): Default

Experiment Setup Main tab page (Acquisition|Experiment Setup…):

- **Exposure Time:** 100 ms
- **Accumulations & Number of Images:** 1

Experiment Setup ROI tab page (Acquisition|Experiment Setup…): Use this function to define the region of interest (ROI).

- **Spectroscopy Mode:** Selected
- Clicking on **Full** loads the full size of the chip into the edit boxes.

Experiment Setup Timing tab page (Acquisition|Experiment Setup…):

- **Timing Mode:** Free Run
- **Shutter Control:** Normal
- **Safe Mode vs. Full Speed:** Safe (Asynchronous)

Focusing

The mounting hardware provides two degrees of freedom, focus and rotation. In this context, focus means to physically move the detector back and forth through the focal plane of the spectrograph. The approach taken is to slowly move the detector in and out of focus and adjust for optimum while watching a live display on the monitor, followed by rotating the detector and again adjusting for optimum. The following procedure, which describes the focusing operation with an Acton 300I spectrograph, can be easily adapted to other spectrographs.

1. Mount a light source such as a mercury pen-ray type in front of the entrance slit of the spectrograph. Any light source with line output can be used. *Standard fluorescent overhead lamps have good calibration lines as well.* If there are no "line" sources available, it is possible to use a broadband source such as tungsten for the alignment. If this is the case, use a wavelength setting of 0.0 nm for alignment purposes.
2. With the spectrograph properly connected to the controller, turn the power on, wait for the spectrograph to initialize. Then set it to 435.8 nm if using a mercury lamp or to 0.0 nm if using a broadband source.

   Hint: Overhead fluorescent lights produce a mercury spectrum. Use a white card tilted at 45 degrees in front of the entrance slit to reflect overhead light into the spectrograph. Select 435.833 as the spectral line.

3. Set the slit to 25 µm. *If necessary, adjust the Exposure Time to maintain optimum (near full-scale) signal intensity.*
4. Slowly move the detector in and out of focus. You should see the spectral line go from broad to narrow and back to broad. Leave the detector set for the narrowest achievable line. You may want to use the **Focus Helper** function (**Process|Focus Helper…**) to determine the narrowest line width: it can automatically locate peaks and generate a report on peak characteristics during live data acquisition (see the WinSpec/32 on-line help for more information).

   Note that the way focusing is accomplished depends on the spectrograph, as follows:

   - **Long focal-length spectrographs such as the Acton 300i:** The mounting adapter includes a tube that slides inside another tube to move the detector in or out as required to achieve optimum focus.
   - **Short focal-length spectrographs:** There is generally a focusing mechanism on the spectrograph itself which, when adjusted, will move the optics as required to achieve proper focus.
   - **No focusing adjustment:** If there is no focusing adjustment, either provided by the spectrograph or by the mounting hardware, then the only recourse will be to adjust the spectrograph's focusing mirror.

5. Next adjust the rotation. You can do this by rotating the detector while watching a live display of the line. The line will go from broad to narrow and back to broad. Leave the detector rotation set for the narrowest achievable line.

   Alternatively, take an image, display the horizontal and vertical cursor bars, and compare the vertical bar to the line shape on the screen. Rotate the detector until the line shape on the screen is parallel with the vertical bar.

   Note: When aligning other accessories, such as fibers, lenses, optical fiber adapters, first align the spectrograph to the slit. Then align the accessory without disturbing the detector position. The procedure is identical to that used to focus the spectrograph (i.e., do the focus and alignment operations while watching a live image).

Chapter 5

Timing Modes

The Princeton Instruments ST-133A Controller has been designed to allow the greatest possible flexibility when synchronizing data collection with an experiment.

The chart below lists the timing mode combinations. Use this chart in combination with the detailed descriptions in this chapter to determine the optimal timing configuration.

Mode	Shutter
Free Run	Normal
External Sync	Normal
External Sync	PreOpen
External Sync with Continuous Cleans	Normal
External Sync with Continuous Cleans	PreOpen

Table 7. Camera Timing Modes

Full Speed or Safe Mode

The WinView/32 Experiment Setup **Timing** tab page allows the user to choose **Full Speed** (Synchronous) or **Safe Mode** (Asynchronous). Figure 36 is a flow chart comparing the two modes. In Full Speed (Synchronous) operation, the ST-133A runs according to the timing of the experiment, with no interruptions from the computer. In Safe Mode operation, the computer processes each frame as it is received. The ST-133A cannot collect the next frame until the previous frame has been completely processed.

Full Speed operation is primarily for collecting "real-time" sequences of experimental data, where timing is critical and events cannot be missed. Once the ST-133A is sent the Start Acquisition command (STARTACQ) by the computer, all frames are collected without further intervention from the computer. The advantage of this timing mode is that timing is controlled completely through hardware. A drawback to this mode is that the computer will only display frames when it is not performing other tasks. Image display has a lower priority, so the image on the screen may lag several images behind. A second drawback is that a data overrun may occur if the number of images collected exceeds the amount of allocated RAM or if the computer cannot keep up with the data rate.

Safe Mode operation is primarily useful for experiment setup, including alignment and focusing, when it is necessary to have the most current image displayed on the screen. It is also useful when data collection must be coordinated with external devices such as external shutters and filter wheels. As seen in Figure 36, in Safe Mode operation, the computer controls when each frame is taken. After each frame is received, the camera sends the Stop Acquisition command to the camera, instructing it to stop acquisition. Once that frame is completely processed and displayed, another Start Acquisition command is sent from the computer to the camera, allowing it to take the next frame. Display is therefore, at most, only one frame behind the actual data collection.

One disadvantage of the Safe (Asynchronous) mode is that events may be missed during the experiment, since the ST-133A is disabled for a short time after each frame.

Standard Timing Modes

The basic ST-133A timing modes are Free Run, External Sync, External Sync with Continuous Cleans, and Internal Sync (available only if the ST-133A has a PTG installed). These timing modes are combined with the Shutter options to provide the widest variety of timing modes for precision experiment synchronization.

The shutter options available include Normal, PreOpen, Disable Opened or Disable Closed. Disable simply means that the shutter will not operate during the experiment. Disable closed is useful for making dark charge measurements, or when no shutter is present in the controller. PreOpen, available in the External Sync and External Sync with Continuous Cleans modes, opens the shutter as soon as the ST-133A is ready to receive an External Sync pulse. This is required if the time between the External Sync pulse and the event is less than a few milliseconds, the time it takes the shutter to open.

The shutter timing is shown in the timing diagrams that follow. Except for Free Run, where the modes of shutter operation are identical, both Normal and PreOpen lines are shown in the timing diagrams and flow chart.

The timing diagrams are labeled indicating the exposure time (t_{exp}), shutter compensation time (t_c), and readout time (t_R). These parameters are discussed in more detail in Chapter 6.

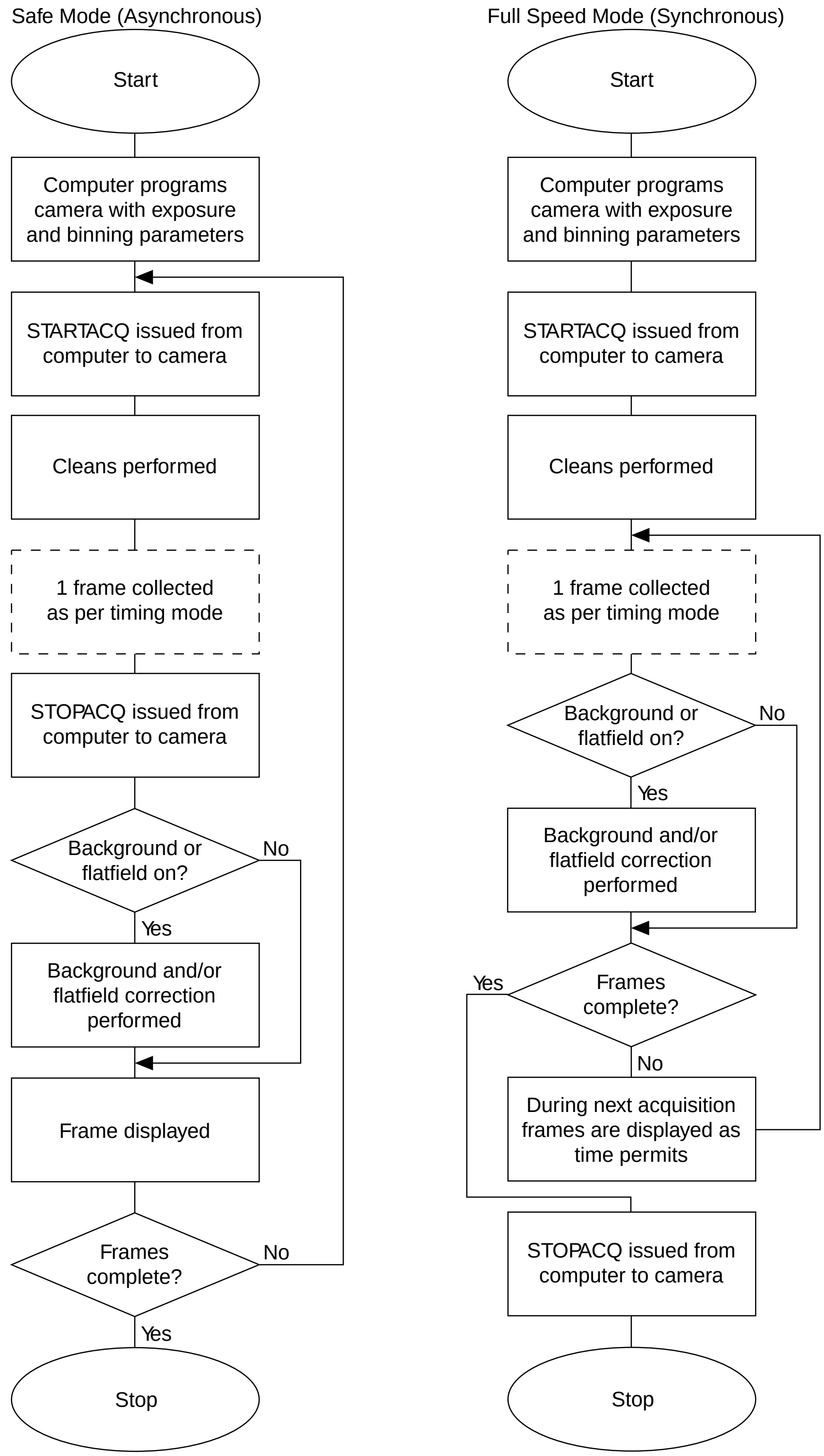


Figure 36. Chart of Safe (async) and Full Speed Mode (sync) Operation

Free Run

In the Free Run mode the controller does not synchronize with the experiment in any way. The shutter opens as soon as the previous readout is complete, and remains open for the exposure time, t_{exp}. Any External Sync signals are ignored. This mode is useful for experiments with a constant light source, such as a CW laser or a DC lamp. Other experiments that can utilize this mode are high repetition studies, where the number of shots that occur during a single shutter cycle is so large that it appears to be continuous illumination.

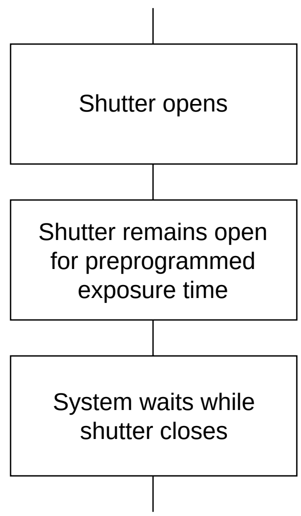


Figure 37. Free Run Timing Chart,
Part of the Chart in Figure 36

Other experimental equipment can be synchronized to the ST-133A controller by using the $\overline{\textbf{SCAN}}$ signal. This TTL output for synchronous operation is shown in Figure 38.

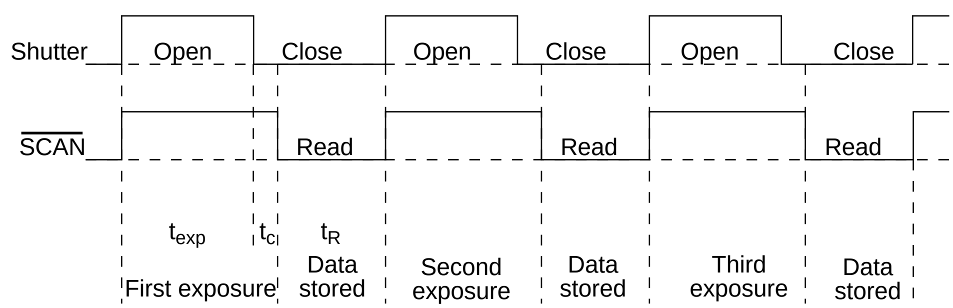


Figure 38. Free Run Timing Diagram

External Sync

In this mode all exposures are synchronized to an external source. As shown in the flow chart, Figure 39, this mode can be used in combination with Normal or PreOpen Shutter operation. In Normal Shutter mode, the controller waits for an External Sync pulse, then opens the shutter for the programmed exposure period. As soon as the exposure is complete, the shutter closes and the CCD array is read out. The shutter requires 5-10 msec to open completely, depending on the model of shutter. (Shutter compensation time is discussed in Chapter 6.)

Since the shutter requires up to 26 msec to fully open, the External Sync pulse provided by the experiment must precede the actual signal by at least that much time. If not, the shutter will not be open for the duration of the entire signal, or the signal may be missed completely.

Also, since the amount of time from initialization of the experiment to the first External Sync pulse is not fixed, an accurate background subtraction may not be possible for the first readout. In multiple-shot experiments this is easily overcome by simply discarding the first frame.

In the PreOpen Shutter mode, on the other hand, shutter operation is only partially synchronized to the experiment. As soon as the controller is ready to collect data, the shutter opens. Upon arrival of the first External Sync pulse at the ST-133A, the shutter remains open for the specified exposure period, closes, and the CCD is read out. As soon as readout is complete, the shutter reopens and waits for the next frame.

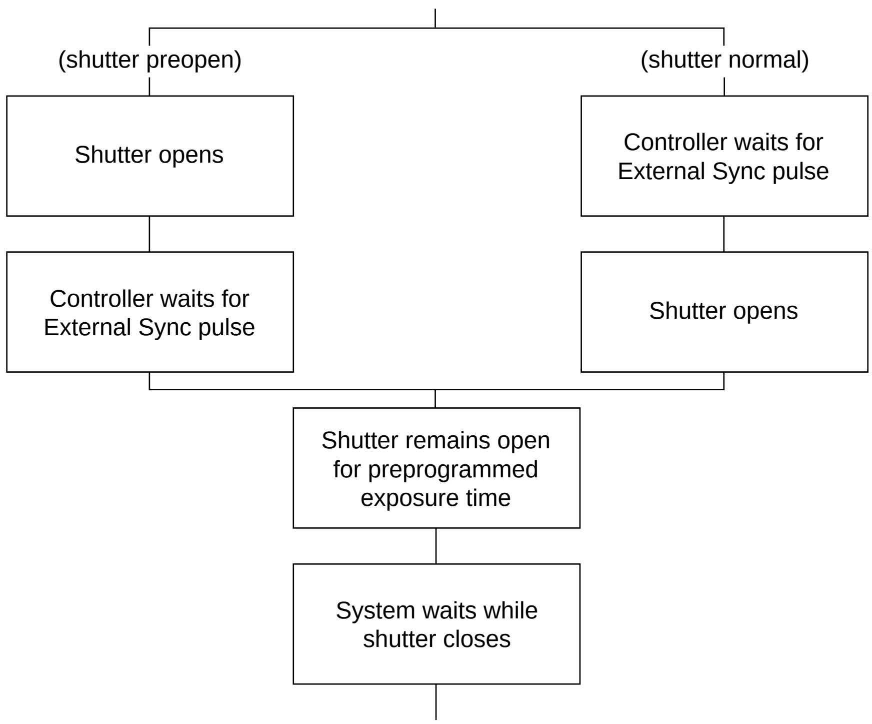


Figure 39. Chart Showing Two External Sync Timing Options

The PreOpen mode is useful in cases where an External Sync pulse cannot be provided 5-26 msec before the actual signal occurs. Its main drawback is that the CCD is exposed to any ambient light while the shutter is open between frames. If this ambient light is constant, and the triggers occur at regular intervals, this background can also be subtracted, providing that it does not saturate the CCD. As with the Normal Shutter mode, accurate background subtraction may not be possible for the first frame.

Also note that, in addition to signal from ambient light, dark charge accumulates during the “wait” time (t_w). Any variation in the external sync frequency also affects the amount of dark charge, even if light is not falling on the CCD during this time.

Note: If EXT SYNC is still active at the end of the readout, the hardware will interpret this as a second sync pulse, and so on.

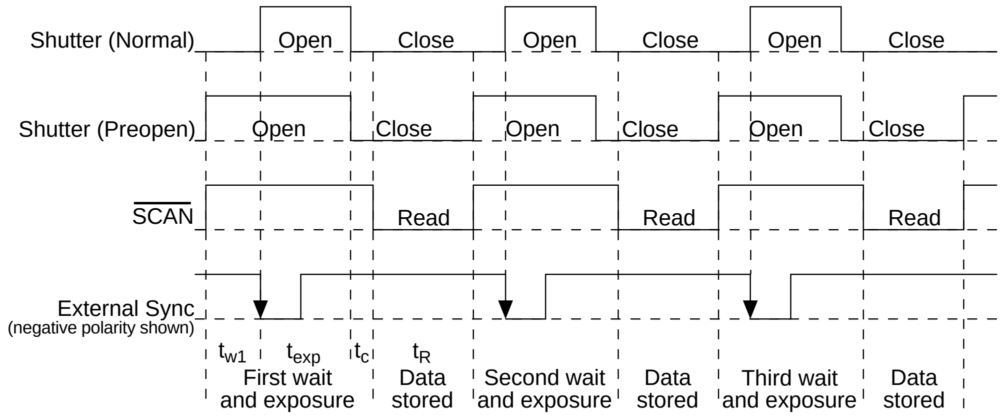


Figure 40. Timing Diagram for External Sync Mode

External Sync with Continuous Cleans Timing

Another timing mode available with the ST-133A camera is called Continuous Cleans. In addition to the standard "cleaning" of the array, which occurs after the controller is enabled, Continuous Cleans will remove any charge from the array until the moment the External Sync pulse is received.

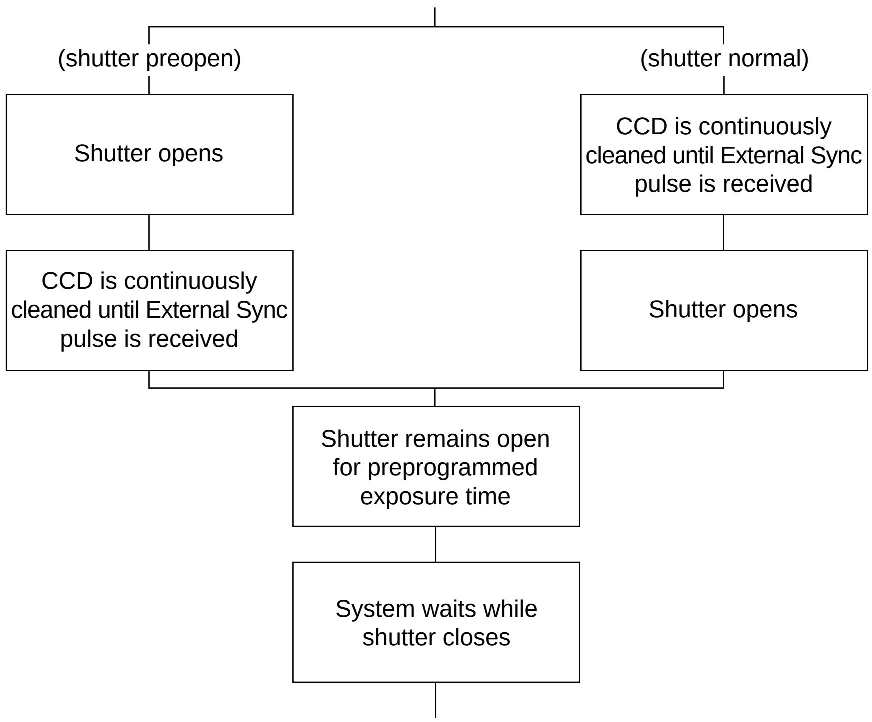


Figure 41. Continuous Cleans Flowchart

Once the External Sync pulse is received, cleaning of the array stops as soon as the current row is shifted, and frame collection begins. With Normal Shutter operation the shutter is opened for the set exposure time. With PreOpen Shutter operation the shutter is open during the continuous cleaning, and once the External Sync pulse is received the shutter remains open for the set exposure time, then closes. If the vertical rows are shifted midway when the External Sync pulse arrives, the pulse is saved until the row shifting is completed, to prevent the CCD from getting "out of step." As expected, the response latency is on the order of one vertical shift time, from 1-30 µsec depending on the array. This latency does not prevent the incoming signal from being detected, since photo generated electrons are still collected over the entire active area. However, if the signal arrival is coincident with the vertical shifting, image smearing of up to one pixel is possible. The amount of smearing is a function of the signal duration compared to the single vertical shift time.

Note: If EXT SYNC is still active at the end of the readout, the hardware will interpret this as a second sync pulse, and so on.

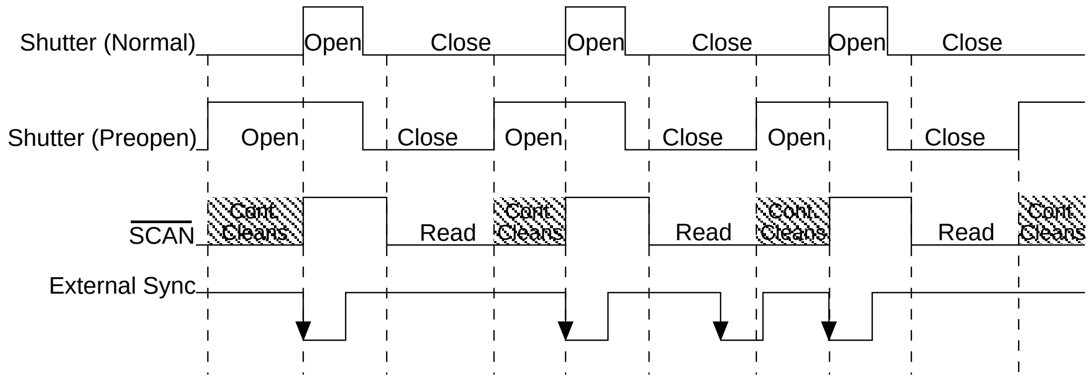


Figure 42. Continuous Cleans Timing Diagram

This page intentionally left blank.

Chapter 6
Exposure and Readout

Introduction

Before each image from the CCD array appears on the computer screen, it must first be read, digitized, and transferred to the computer. Figure 43 is a block diagram of the image-signal path.

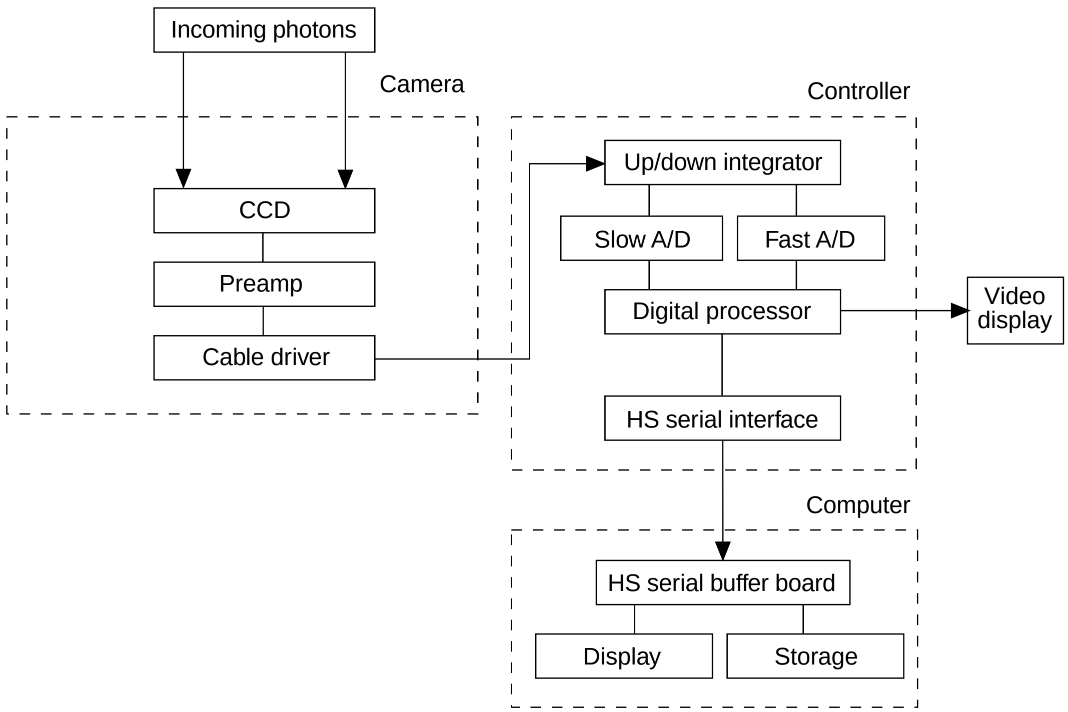


Figure 43. Block Diagram of Light Path in System

The remainder of this chapter describes the exposure, readout, and digitization of the image. Included are descriptions of binning for imaging applications and the specialized ST-133A timing modes.

Exposure

Charge coupled devices can be roughly thought of as a two-dimensional grid of individual photodiodes (called pixels), each connected to its own charge storage “well.” Each pixel senses the intensity of light falling on its collection area, and stores a proportional amount of charge in its associated “well.” Once charge accumulates for the specified exposure time, the pixels are read out serially.

CCD arrays perform three essential functions: photons are transduced to electrons, integrated and stored, and finally read out. CCDs are very compact and rugged.

Unintensified, uncoated CCDs can withstand direct exposure to relatively high light levels, magnetic fields and RF radiation. They are easily cooled and can be precisely thermostated to within a few tens of millidegrees.

Because CCD arrays, like film and other media, are always sensitive to light, light must not be allowed to fall on the array during readout. Unintensified full-frame CCD cameras like the VersArray cameras use a mechanical shutter to prevent light from reaching the CCD during readout. ICCD (intensified) cameras use an image intensifier to gate the light on and off.

The software allows the user to set the length of time the camera is allowed to integrate the incoming light. This is called the exposure time. During each scan, the shutter or intensifier is enabled for the duration of the exposure period, allowing the pixels to register light.

Exposure with a Mechanical Shutter

For some CCD arrays, the ST-133A uses a mechanical shutter to control exposure of the CCD. The diagram in Figure 44 shows how the exposure period is measured. The $\overline{\textbf{SCAN}}$ output provided at the ST-133A Analog/Control panel can be used to monitor the exposure and readout cycle (t_R). This signal is also shown in Figure 44. The value of t_c is shutter type dependent, and will be configured automatically for ST-133A controllers shipped with an internal shutter.

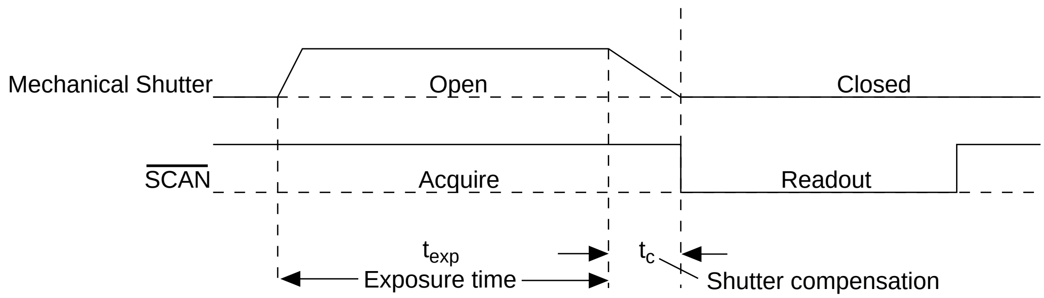


Figure 44. Exposure of the CCD with Shutter Compensation

$\overline{\textbf{SCAN}}$ is low during readout and high during exposure and shutter compensation time.

Since most shutters behave like an iris, the opening and closing of the shutter will cause the center of the CCD to be exposed slightly longer than the edges. It is important to realize this physical limitation, particularly when using short exposures.

Continuous Exposure (No Shuttering)

For full-frame CCDs, the standard VersArray camera is equipped with an integral shutter. However, inasmuch as it is possible to order the camera without a shutter, the following general discussion of unshuttered operation is provided.

Unlike video rate CCD cameras, slow scan scientific cameras require a shutter to prevent “smearing” of features during readout. This is because during readout, charge is moved horizontally or vertically across the surface of the CCD. If light is falling on the CCD during readout then charge will continue to accumulate, blurring the image along one direction only.

For some experimental applications a shutter is not required because no light falls on the CCD during readout. If the light source can be controlled electronically via the $\overline{\textbf{SCAN}}$ or SHUTTER MONITOR output, the CCD can be read out in darkness.

Saturation

When signal levels in some part of the image are very high, charge generated in one pixel may exceed the “well capacity” of the pixel, spilling over into adjacent pixels in a process called “blooming.” In this case a more frequent readout is advisable, with signal averaging to enhance S/N (Signal-to-Noise ratio) accomplished through the software.

For signal levels low enough to be readout-noise limited, longer exposure times, and therefore longer signal accumulation in the CCD, will improve the S/N ratio approximately linearly with the length of exposure time. There is, however, a maximum time limit for on-chip accumulation, determined by either the saturation of the CCD by the signal or the loss of dynamic range due to the buildup of dark charge in the pixels (see below).

Dark Charge

Dark charge (or dark current) is the thermally induced buildup of charge in the CCD over time. The statistical noise associated with this charge is known as dark noise. Dark charge values vary widely from one CCD array to another and are exponentially temperature dependent. At the typical operating temperature of an RTE/CCD camera, for example, dark charge is reduced by a factor of ~2 for every 6º reduction in temperature. In the case of cameras such as the RTE/CCD-768-K and RTE/CCD-1317-K, which have MPP type arrays, the average dark charge is extremely small. However, the dark-charge distribution is such that a significant number of pixels may exhibit a much higher dark charge, limiting the maximum practical exposure. Dark charge effect is more pronounced in the case of cameras having a non-MPP array.

With the light into the camera completely blocked, the CCD will collect a dark charge pattern, dependent on the exposure time and camera temperature. The longer the exposure time and the warmer the camera, the larger and less uniform this background will appear. Thus, to minimize dark-charge effects, you should operate with the lowest CCD temperature possible.

Note: Do not be concerned about either the DC level of this background or its shape unless it is very high, i.e., > 1000 counts with 16 bit A/D or 300 counts with a 12 bit A/D. What you see is not noise. It is a fully subtractable readout pattern. Each CCD has its own dark charge pattern, unique to that particular device. Simply acquire and save a dark charge “background image” under conditions identical to those used to acquire the “actual” image. Subtracting the background image from the actual image will significantly reduce dark-charge effects.

Note: Offset and excess noise problems are more likely to occur if the controller and camera weren’t calibrated and tested as a system at the factory.

Caution If you observe a sudden change in the baseline signal you may have excessive humidity in the vacuum enclosure of the camera. See your detector manual for information on having the detector vacuum repumped.

Array Readout

In this section, a simple 6 × 4 pixel CCD is used to demonstrate how charge is shifted and digitized. As described below, two different types of readout are available. Full frame readout, for full frame CCDs, reads out the entire CCD surface at the same time.

Full Frame

The upper left drawing in Figure 45 represents a CCD after exposure but before the beginning of readout. The capital letters represent different amounts of charge, including both signal and dark charge. This section explains readout at full resolution, where every pixel is digitized separately.

Readout of the CCD begins with the simultaneous shifting of all pixels one column toward the "shift register," in this case the column on the far right. The shift register is a single line of pixels along one side of the CCD, not sensitive to light and used for readout only. Typically the shift register pixels hold twice as much charge as the pixels in the imaging area of the CCD.

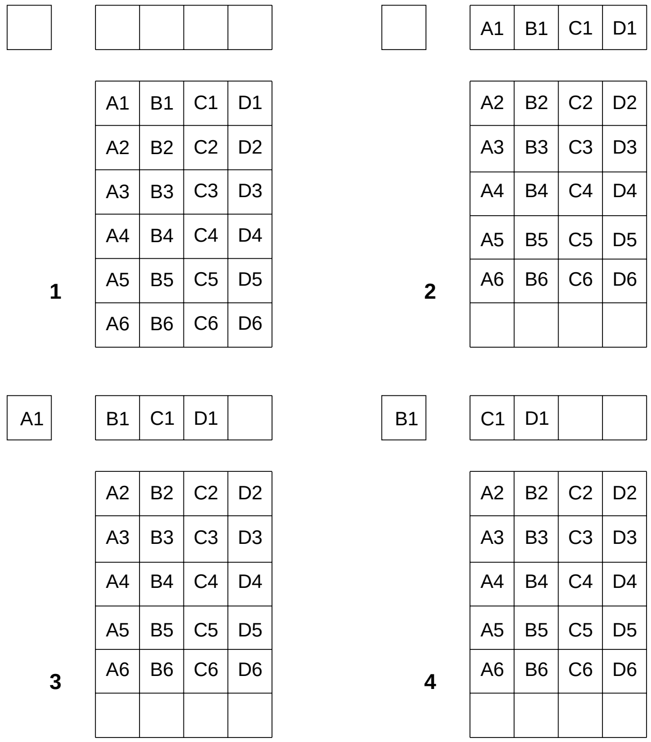


Figure 45. Full Frame at Full Resolution

Readout of the CCD begins with the simultaneous shifting of all pixels one column toward the "shift register," in this case the column on the far right. The shift register is a single line of pixels along one side of the CCD, not sensitive to light and used for readout only. Typically the shift register pixels hold twice as much charge as the pixels in the imaging area of the CCD.

After the first column is moved into the shift register, the charge now in the shift register is shifted toward the output node, located at one end of the shift register. As each value is "emptied" into this node it is digitized. Only after all pixels in the first column are digitized is the second column moved into the shift register. The order of shifting in our example is therefore D6, C6, B6, A6, D5, C5, B5, A5, D4....

After charge is shifted out of each pixel the remaining charge is zero, meaning that the array is immediately ready for the next exposure.

Below are the equations that determine the rate at which the CCD is read out. Tables of values for CCDs supported at the time of the printing of this manual also appear below.

The time needed to take a full frame at full resolution is:

$$t_R + t_{\exp} + t_c \quad (1)$$

where

t_R is the CCD readout time,

t_{exp} is the exposure time, and

t_c is the shutter compensation time.

The readout time is approximately given by:

$$t_R = \left[N_x \bullet N_y \left(t_{sr} + t_v\right)\right] + \left(N_x \bullet t_i\right) \quad (2)$$

where

N_x is the smaller dimension of the CCD

N_y is the larger dimension of the CCD

t_{sr} is the time needed to shift one pixel out of the shift register

t_v is the time needed to digitize a pixel

t_i is the time needed to shift one line into the shift register

A subsection of the CCD can be read out at full resolution, sometimes dramatically increasing the readout rate while retaining the highest resolution in the region of interest (ROI). To approximate the readout rate of an ROI, in Equation 2 substitute the x and y dimensions of the ROI in place of the dimensions of the full CCD. Some overhead time, however, is required to read out and discard the unwanted pixels.

Binning

Binning is the process of adding the data from adjacent pixels together to form a single pixel (sometimes called a super-pixel), and it can be accomplished in either hardware or software. Rectangular groups of pixels of any size may be binned together, subject to some hardware and software limitations.

Hardware Binning

Hardware binning is performed *before* the signal is read out by the preamplifier. For signal levels that are readout noise limited this method improves S/N ratio linearly with the number of pixels grouped together. For signals large enough to render the camera photon shot noise limited, the S/N ratio improvement is roughly proportional to the square-root of the number of pixels binned.

Figure 46 shows an example of 2×2 binning. Each pixel of the image displayed by the software represents 4 pixels of the CCD array. Rectangular bins of any size are possible.

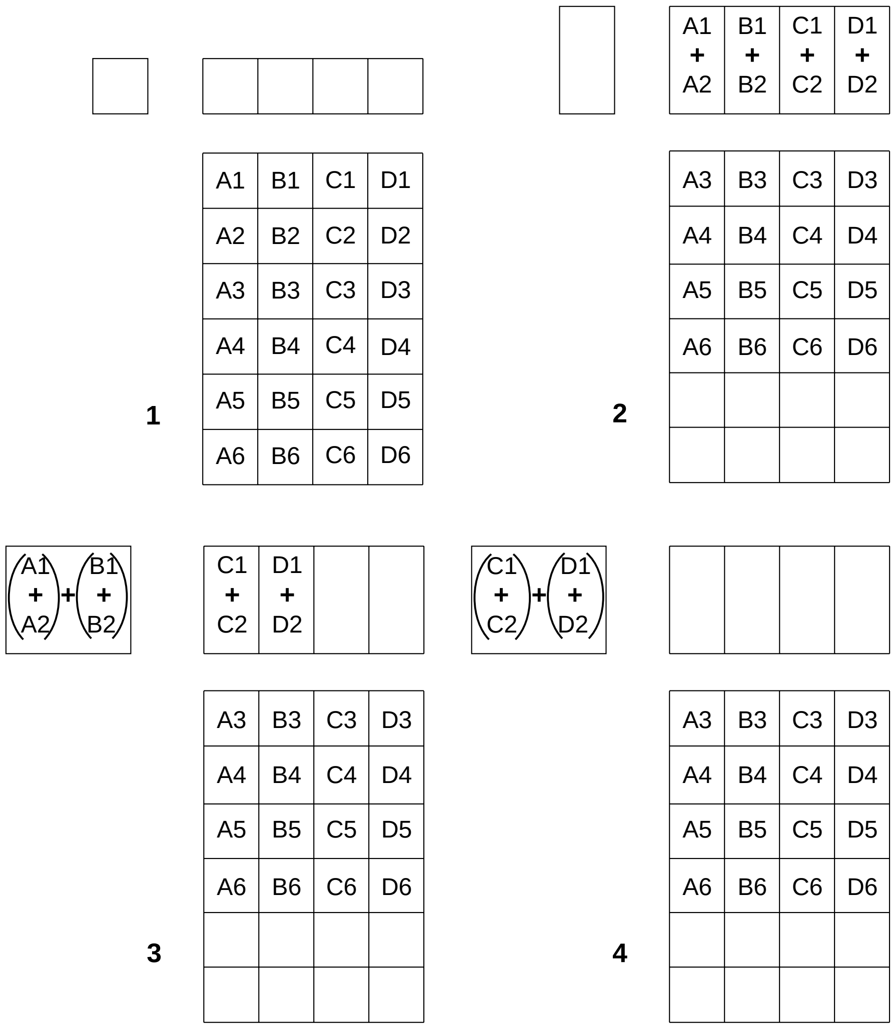


Figure 46. 2 × 2 Binning

Binning also reduces readout time and the burden on computer memory, but at the expense of resolution. Since shift register pixels typically hold only twice as much charge as image pixels, the binning of large sections may result in saturation and “blooming”, or spilling of charge back into the image area.

The readout rate for n × n binning is approximated using a more general version of the full resolution equation. The modified equation is:

$$t_R = \left[N_x \bullet N_y \bullet \left(\frac{t_{sr}}{n} + \frac{t_v}{n^2} \right) \right] + \left(N_x \bullet t_i \right) \qquad (3)$$

Software Binning

One limitation of hardware binning is that the shift register pixels and the output node are typically only 2-3 times the size of imaging pixels. Consequently, if the total charge binned together exceeds the capacity of the shift register or output node, the data will be lost.

This restriction strongly limits the number of pixels that may be binned in cases where there is a small signal superimposed on a large background, such as signals with a large fluorescence. Ideally, one would like to bin many pixels to increase the S/N ratio of the weak peaks but this cannot be done because the fluorescence would quickly saturate the CCD.

The solution is to perform the binning in software. Limited hardware binning may be used when reading out the CCD. Additional binning is accomplished in software, producing a result that represents many more photons than was possible using hardware binning.

Software averaging can improve the S/N ratio by as much as the square-root of the number of scans. Unfortunately, with a high number of scans, i.e., above 100, camera 1/f noise may reduce the actual S/N ratio to slightly below this theoretical value. Also, if the light source used is photon-flicker limited rather than photon shot-noise limited, this theoretical signal improvement cannot be fully realized. Again, background subtraction from the raw data is necessary.

This technique is also useful in high light level experiments, where the camera is again photon shot-noise limited. Summing multiple pixels in software corresponds to collecting more photons, and results in a better S/N ratio in the measurement.

Digitization

During readout, an analog signal representing the charge of each pixel (or binned group of pixels) is digitized. The number of bits per pixel is based on both the hardware and the settings programmed into the camera through the software. One A/D converter is standard with the ST-133A. However, the ST-133A will support two A/D converters with different software-selectable readout rates if the Dual A/D Converters option is ordered.

Dual A/D Converters Option

There is provision in the ST-133A Controller for two complete analog channels optimized for two different A/D conversion rates. Because the readout noise of CCD arrays increases with the readout rate, it is sometimes necessary to trade off readout speed for high dynamic range. For the most common controller configurations, there will be a 1 MHz converter for the fastest possible data collection, and a 100 kHz or 50 kHz converter for use where noise performance is the paramount concern. Switching between the channels is completely under software control for total experiment automation.

This page intentionally left blank.

Chapter 7
System Component Descriptions

VersArray Camera

CCD Array: The VersArray camera system offers both front- and back-illuminated CCDs in a variety of array sizes that allow you to precisely match the sensor to your application. Only scientific-grade devices are used in order to ensure the higher image fidelity, resolution, and acquisition flexibility required for scientific imaging. Roper Scientific has developed exclusive large-area imaging CCDs with unmatched quantum efficiency and low noise to offer the utmost in sensitivity. Large full wells, square pixels, and 100% fill factors provide high dynamic range and excellent spatial resolution. Unichrome (exclusive Roper Scientific technology) and other UV-enhancement coatings can be used to further improve the quantum efficiency of these CCDs in the ultraviolet.

Fiberoptic Configuration: You can custom order a VersArray camera with a fiberoptic bonded to the CCD. These fiberoptic cameras are ideal for lenseless direct imaging of phosphor screens, MCPs, image intensifiers, and other Lambertian sources. Roper Scientific uses a unique, patented process (US patent 5,134,680) to bond the fiber directly to the CCD for maximum resolution and throughput. Imaging fiber bundles are available in a range of demagnifications from 1:1 to 5:1. The input fiberoptic can be as large as 165 mm in diameter. Do not hesitate to contact your Roper Scientific representative for any custom requirement or refer to our VersArray™ models on our website at www.roperscientific.com.

Internal Shutter: For TE- and LN-cooled cameras, the standard internal shutter has a quartz shutter window to protect the shutter mechanism from external dust and humidity. Since each window causes a small signal loss, an optional shutter assembly may be available without the window: added caution must then be used in the handling and storage of the camera. The standard shutter for a TE-cooled camera is the 35 mm shutter (the ST-133A must be equipped with the 70 V shutter option) and for the LN-cooled camera it is the 40 mm shutter.

Shutters are mechanical devices with a finite lifetime, typically of the order of a million cycles, although some individual shutters may last a good deal longer. How long a shutter lasts in terms of experimental time will, of course, be strongly dependent on the operating parameters. High repetition rates and short exposure times will rapidly increase the number of shutter cycles and hasten the time when the shutter will have to be replaced.

Cooling: Dark current is significantly reduced in VersArray camera systems through deep cooling of the CCD arrays. You can choose from either thermoelectric or cryogenic options to best match your application requirements and environment:

- **Thermoelectric cooling:** Cooling by this method uses a four-stage Peltier cooler in combination with either air- or coolant-circulation (liquid assist or liquid only). To prevent condensation and contamination from occurring, cameras cooled this way can either be evacuated or nitrogen backfilled. Cameras under vacuum reach lower temperatures; nitrogen-backfilled cameras are relatively maintenance free. The thermoelectric camera heads feature cost-effective performance, ease of use, and cooling from -40 to -60°C.

- **Liquid Nitrogen cooling:** Cooling by this method virtually eliminates dark current through the containment of liquid nitrogen in a Dewar reservoir. The use of thermal-radiation shielding and thermal-isolation mounts makes extremely long integration times possible, in excess of 25 hours for a large-capacity Dewar. VersArray controllers provide stabilized temperature control of LN heads from -70°C to -120°C (-70°C to -110°C for large arrays).
- **CRYOTIGER cooling:** The CRYOTIGER is a self-contained cooling system that provides cryogenic cooling using the Joule-Thomson effect to cool the CCD. The CRYOTIGER gives you liquid-nitrogen-type performance in an easy-to-use, maintenance-free package. VersArray$_{CT}$ cameras use this method of cooling.

Connectors:

Controller: Power, control signals, and data are transmitted between the ST-133A and the VersArray camera via the 25-pin D connector located on the rear of the detector. The Detector-Controller cable is secured by a slide-lock mechanism. Controller power must be OFF before connecting to or disconnecting from this connector.

Shutter: LEMO connector for driving an internal shutter. Controller power must be OFF before connecting to or disconnecting from this connector.

Fan: (TE only) There may be a fan located inside the camera's back panel. Its purpose is:

- to remove heat from the Peltier device that cools the CCD array and
- to cool the electronics.

An internal Peltier device directly cools the cold finger on which the CCD is mounted. The air drawn into the detector by the internal fan and exhausted through the back panel then removes the heat produced by the Peltier device. The fan is always in operation and air-cooling of both the Peltier and the internal electronics takes place continuously. The fan is designed for low-vibration and does not adversely affect the image. For the fan to function properly, free circulation must be maintained between the rear of the detector and the laboratory atmosphere.

Coolant Ports: Thermoelectrically-cooled cameras are available with liquid-assisted or liquid-only or liquid-cooled only cooling. Two coolant ports are provided on the sides of these cameras. These quick-disconnect ports require 1/4" thin-wall plastic tubing or 3/8" I.D. thick-wall PVC tubing, depending on the VersArray model. Instructions for setting up coolant flow are provided on page 41.

Dewar: LN-cooled cameras are available in both the standard side-on and the end-on configuration. The Dewar for the standard side-on holds 1.7 liters of liquid nitrogen (LN). The Dewar for the end-on camera holds 2.2 liters of liquid nitrogen (LN). These configurations can utilize the optional LN Autofill system (see Appendix C) for refilling the Dewar.

An "all-directional" Dewar is also available from Roper Scientific. This Dewar can operate in *any* angular orientation but holds about half as much LN as the standard Dewar (~0.85 liters). This reduced capacity translates to roughly half the hold time, as well.

Note: There is no simple way to determine if you have been shipped an all-directional system simply by observing the detector. If you are uncertain, check the shipping paperwork to verify that your Dewar is an all-directional model.

ST-133A Controller

Electronics: The ST-133A controller is a compact, high performance CCD Detector Controller for operation with Princeton Instruments brand* detectors. Designed for high speed and high performance image acquisition, the ST-133A offers data transfer at speeds up to 1 megapixel per second, standard video output for focusing and alignment. A variety of A/D converters are available to meet different speed and resolution requirements.

In addition to containing the power supply, the controller contains the analog and digital electronics, scan control and exposure timing hardware, and controller I/O connectors, all mounted on user-accessible plug-in modules. This highly modularized design gives flexibility and allows for convenient servicing.

POWER Switch and Indicator: The power switch, located on the front panel as shown in Figure 47, interrupts both sides of the controller's AC power input. The switch's integral indicator LED lights whenever the ST-133A Controller is powered. Note that, when the power switch is actuated, there may be a few seconds delay before the indicator lights. This is normal and in no way indicative of a malfunction.

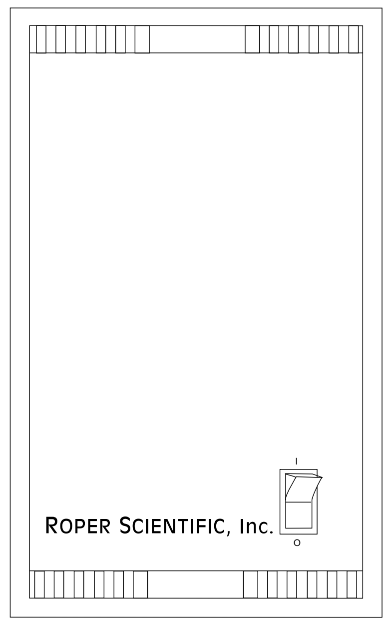


Figure 47. Controller Front Panel

Rear Panel Connectors: There are three controller board slots. Two are occupied by the plug-in cards that provide various controller functions. The third, covered with a blank panel, is reserved for future development. The left-most plug-in card is the Analog/Control module. Adjacent to it is the Interface Control module. Both modules align with top and bottom tracks and mate with a passive backplane via a 64-pin DIN connector. For proper operation, the location of the modules should not be changed. Each board is secured by two screws that also ground each module's front panel. The connectors and functions located on the rear panel are further are described on the following page. Removing and inserting boards is described in Chapter 9, pages 100-101.

WARNING!

To minimize the risk of equipment damage, a module should ***never*** be removed or installed when the system is powered.

---

* The ST-133A controller must be factory configured for operation with an LN detector. For this reason, a controller purchased for operation with an LN detector can only be used with an LN detector. Similarly, a controller purchased for operation with a TE-cooled detector can ***not*** be used with an LN detector.

The **Analog/Control Module**, which should always be located in the left-most slot, provides the following functions.

- Pixel A/D conversion
- CCD scan control
- Exposure control
- Timing and synchronization of readouts
- Temperature control
- Video output control

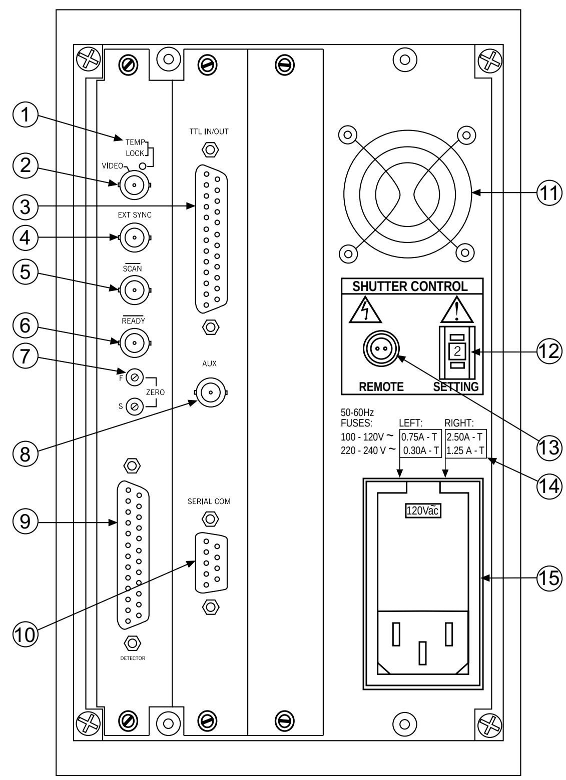
The **Interface Control Module**, which should always be located in the center slot, provides the following functions.

- TTL in/out Programmable Interface
- High speed serial communications control

WARNING! Always turn the power off at the Controller before connecting or disconnecting any cable that interconnects the camera and controller or serious damage to the CCD may result. This damage is ***NOT*** covered by the manufacturer's warranty.

Rear Panel Features:

The descriptions of the rear panel connectors that follow are keyed to the accompanying figure.



#	Feature
1	**Temperature Lock LED:** Indicates that the temperature control loop has locked and that the temperature of the CCD array will be stable to within ± 0.05°C.
2	**Video Output:** Composite video output is provided at this connector. The amplitude is 1 V pk-pk and the source impedance is 75 Ω.
3	**TTL In/Out:** User-programmable interface with eight input bits and eight output bits that can be written to or polled for additional control or functionality. See Chapter 8.
4	**External Sync Input:** TTL input that has a 10 kΩ pullup resistor. Allows data acquisition and readout to be synchronized with external events. Through software, positive or negative (default) triggering can be selected.
5	**$\overline{\text{SCAN}}$ Output:** WinView/32 (ver. 2.4 and higher) software selectable NOTSCAN or SHUTTER MONITOR signal. Default is SHUTTER MONITOR.
10	**Serial COM Connector:** Provides two-way serial communication between the controller and the host computer.
11	**Fan:** Cools the controller electronics. Runs continuously when the controller is turned on.

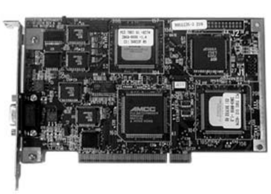
#	Feature	#	Feature
6	**$\overline{\text{READY}}$ Output:** Initially HIGH. Changes state on completion of cleaning cycles before the first exposure.	12	**Shutter Setting Selector:** Sets the shutter hold voltage. Dial is correctly set at the factory for the camera's internal shutter if one is present.
7	**Zero Adjustment:** Control the offset values of the Fast (F) and Slow (S) A/D converters. Preadjusted at factory.	13	**Remote Shutter Connector:** Provides shutter-drive pulses for an external shutter. An ST-133A with the 70 V shutter option is required for a camera with the 35 mm shutter. A 70 V OPT label will be next to the Remote connector when this option is installed.
8	**AUX Output:** Reserved for future use.	14	**Fuse/Voltage Label:** Displays the controller's power and fuse requirements.
9	**Detector Connector:** Transmits control information to the camera and receives data back from the camera via the Detector-Controller cable.	15	**Power Module:** Contains the powercord socket and two fuses.

Cables

Detector-Controller: 1 MHz or 100kHz/1MHz systems. The standard 10' cable (6050-0321) has DB25 connectors with slide-latch locking hardware. This cable interconnects the Detector connector on the rear of the ST-133A with the 25-pin D connector on the back of the VersArray camera. The Detector-Controller cable is also available in 6', 15', 20', and 30' lengths. Note that a longer cable may degrade camera performance.

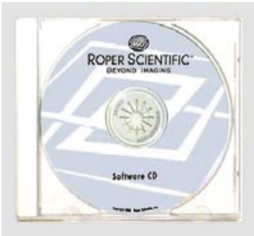
TAXI: The standard 25' cable (6050-0148-CE) has DB9 Male connectors with screw-down locking hardware. The TAXI (Serial communication) cable interconnects the "Serial Com" connector on the rear of the ST-133A and the PCI card installed in the host computer. This cable is also available in 10', 50', 100', and 165' lengths.

Interface Card



PCI Card: The standard interface card plugs-into the host computer's motherboard and provides the serial communication interface between the host computer and the ST-133A. Through WinView/32, the card can be used in either **High Speed PCI** or **PCI(Timer)** mode. **High Speed PCI** allows data transfer to be interrupt-driven and can give higher performance in some situations. **PCI(Timer)** allows data transfer to be controlled by a polling timer.

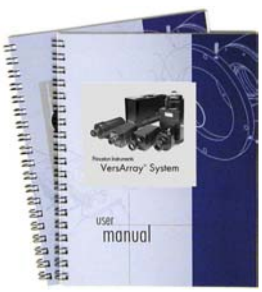
Application Software



The Princeton Instruments WinView/32 software package provides comprehensive image acquisition, display, processing, and archiving functions so you can perform complete data acquisition and analysis without having to rely upon third-party software. WinView/32 provides reliable control over all Roper Scientific cameras, regardless of array format and architecture, via an exclusive universal programming interface (PVCAM®). WinView/32 also features snap-ins and macro record functions to permit easy user customization of any function or sequence.

PVCAM is the standard software interface for cooled CCD cameras from Roper Scientific. It is a library of functions that can be used to control and acquire data from the camera when a custom application is being written. For example, in the case of Windows, PVCAM is a dynamic link library (DLL). Also, it should be understood that PVCAM is solely for camera control and image acquisition, not for image processing. PVCAM places acquired images into a buffer, where they can then be manipulated using either custom written code or by extensions to other commercially available image processing packages.

User Manuals



VersArray System User Manual: This manual describes how to install and use the VersArray system components.

WinView/32 User Manual: This manual describes how to install and use the application program. A PDF version of this manual is provided on the installation CD. Additional information is available in the program's on-line help.

Chapter 8
TTL Control

Introduction

Princeton Instrument's WinView/32 software package incorporates WinX32 Automation, a programming language that can be used to automate performing a variety of data acquisition and data processing functions, including use of the TTL IN/OUT functions. WinX32 Automation can be implemented in programs written in Visual Basic. See the WinX32 documentation for more detailed information.

The TTL lines are made available through the TTL IN/OUT connector on the rear of the ST-133A Controller. This connector provides 8 TTL lines in, 8 TTL lines out and an input control line. Figure 48 illustrates the connector and Table 9 lists the signal/pin assignments.

TTL In

The user controls the 8 TTL Input lines, setting them high (+5 V; TTL 1) or low (0 V; TTL 0). When the lines are read, the combination of highs and lows read defines a decimal number which the computer can use to make a decision and initiate actions as specified in the user's program. If a TTL IN line is low, its numeric value is 0. If a TTL IN line is high, its numeric value is as follows.

TTL IN	Value	TTL IN	Value
1	1	5	16
2	2	6	32
3	4	7	64
4	8	8	128

This coding allows any decimal value from 0 to 255 to be defined. Thus, as many as 256 different sets of conditions can be specified, at the user's discretion, using the TTL IN lines. *Any unused lines will default to TTL high (+5 V).* For example, to define the number three, the user would simply set the lines TTL IN 1 and TTL IN 2 both high (+5 V). It would be necessary to apply TTL low to the remaining six lines because they would otherwise default to TTL high as well.

TTL IN	Value	TTL IN	Value
1	High (1)	5	Low (0)
2	High (2)	6	Low (0)
3	Low (0)	7	Low (0)
4	Low (0)	8	Low (0)

Table 8 illustrates this coding for decimal values 0 through 7. Obviously this table could easily be extended to show the coding for values all the way to 255.

Decimal Equiv.	TTL IN/OUT 8 1= dec 128	TTL IN/OUT 7 1=dec 64	TTL IN/OUT 6 1=dec 32	TTL IN/OUT 5 1=dec 16	TTL IN/OUT 4 1=dec 8	TTL IN/OUT 3 1=dec 4	TTL IN/OUT 2 1=dec 2	TTL IN/OUT 1 1=dec 1
0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	1
2	0	0	0	0	0	0	1	0
3	0	0	0	0	0	0	1	1
4	0	0	0	0	0	1	0	0
5	0	0	0	0	0	1	0	1
6	0	0	0	0	0	1	1	0
7	0	0	0	0	0	1	1	1

Table 8. Bit Values with Decimal Equivalents:
1 = High,
0 = Low

Buffered vs. Latched Inputs

In controlling the TTL IN lines, users also have the choice of two input-line states, *buffered* or *latched*. In the buffered state, the line levels must remain at the intended levels until they are read. With reference to the preceding example, the high level at TTL IN 1 and TTL IN 2 would have to be maintained until the lines are read. In the latched state, the applied levels continue to be available until read, even if they should change at the TTL IN/OUT connector.

This control is accomplished using the EN/CLK TTL input (pin 6). If EN/CLK is open or high, *buffered* operation is established and the levels reported to the macro will be those in effect when the READ is made. With reference to our example, if pin 6 were left unconnected or a TTL high applied, TTL IN 1 and TTL IN 2 would have to be held high until read. If, on the other hand, EN/CLK were made to go low while TTL IN 1 and TTL IN 2 were high, those values would be *latched* for *as long as EN/CLK remained low*. The levels actually present at TTL IN 1 and TTL IN 2 could then change without changing the value that would be read by software.

TTL Out

The state of the TTL OUT lines is set from WinView/32. Typically, a program monitoring the experiment sets one or more of the TTL Outputs. Apparatus external to the ST-133A interrogates the lines and, on detecting the specified logic levels, takes the action appropriate to the detected condition. The coding is the same as for the input lines. There are eight output lines, each of which can be set low (0) or high (1). The combination of states defines a decimal number as previously described for the TTL IN lines.

Pin #	Assignment	Pin #	Assignment
1	IN 1	14	IN 2
2	IN 3	15	IN 4
3	IN 5	16	IN 6
4	IN 7	17	IN 8
5	GND	18	GND
6	EN/CLK	19	Reserved
7	(future use)	20	GND
8	GND	21	OUT 2
9	OUT 1	22	OUT 4
10	OUT 3	23	OUT 6
11	OUT 5	24	OUT 8
12	OUT 7	25	GND
13	Reserved		

TTL IN/OUT

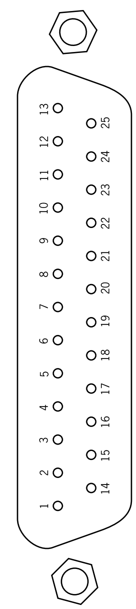


Table 9. TTL In/Out Connector Pinout

TTL Diagnostics Screen

Note that WinView/32 provides a TTL Diagnostics screen (located in WinView/32 under *Hardware Setup - Diagnostics)* that can be used to test and analyze the TTL In/Out lines.

Hardware Interface

A cable will be needed to connect the TTL In/Out connector to the experiment. The design will vary widely according to each user's needs, but a standard 25-pin female type D-subminiature connector will be needed to mate with the TTL In/Out connector at the ST-133A. The hardware at the other end of the cable will depend entirely on the user's requirements. If the individual connections are made using coaxial cable for maximum noise immunity (recommended), the center conductor of the coax should connect to the proper signal pin and the cable shield should connect to the nearest available ground (grounds are conveniently provided at pins 5, 8, 18 and 20). Connector hardware and cables of many different types are widely available and can often be obtained locally, such as at a nearby electronics store. A list of possibly useful items follows. Note that, although the items listed may be appropriate in many situations, they might not meet your specific needs.

- 25-pin female type D-subminiature solder type connector (Radio Shack® part no 276-1548B).
- RG/58U coaxial cable.
- Shielded Metalized hood (Radio Shack part no 276-1536A).
- BNC connector(s) type UG-88 Male BNC connector (Radio Shack part no 278-103).

Example

Suppose you needed to build a cable to monitor the line TTL OUT 1. One approach would be to build a cable assembly as described in the following paragraphs. This procedure could easily be adapted to other situations.

1. Begin with a 25-pin female type D-subminiature solder type connector (Radio Shack part no 276-1548B). This connector has 25 solder points open on the back.
2. Referring to Table 8, note that pin 8 = GND and pin 9 = TTL OUT 1.
3. Using coaxial cable type RG/58U (6 feet length), strip out the end and solder the outer sheath to pin 8 (GND) and the inner line to pin 9 (TTL OUT 1). Then apply shielding to the lines to insulate them.
4. Mount the connector in a Shielded Metalized hood (Radio Shack part no 276-1536A).
5. Build up the cable (you can use electrical tape) to where the strain relief clamp holds.
6. Connect a BNC connector (UG-88 Male BNC connector) to the free end of the cable following the instructions supplied by Radio Shack on the box (Radio Shack part no 278-103).
7. To use this cable, connect the DB-25 to the TTL IN/OUT connector on the back of the ST-133A controller.
8. To check the cable, start WinView/32 and open the TTL Diagnostics screen (located in WinView under *Hardware Setup - Diagnostics*). Click the **Write** radio button. Then click the **Output Line 1** box. Next click the **OK** button to actually set TTL OUT 1 high. Once you set the voltage, it stays until you send a new command.
9. Measure the voltage at the BNC connector with a standard voltmeter (red on the central pin, black on the surrounding shielding). Before clicking **OK** at the TTL Diagnostics screen you should read 0 V. After clicking **OK** you should read +5 V.

Note that adding a second length of coaxial cable and another BNC connector would be straightforward. However, as you increase the number of lines to be monitored, it becomes more convenient to consider using a multiple conductor shielded cable rather than individual coaxial cables.

Chapter 9
Troubleshooting

WARNING! Do not attach or remove any cables while the camera system is powered on.

Introduction

The following issues have corresponding troubleshooting sections in this chapter.

Baseline Signal Suddenly Changes

A change in the baseline signal is normal if the temperature or gain setting has been changed. If this occurs when the temperature or gain setting has not been changed, contact Technical Support.

Camera Stops Working

Problems with the host computer system or software may have side effects that appear to be hardware problems. If you are sure the problem is in the camera system hardware, begin with these simple checks:

- Turn off all AC power.
- Verify that all cables are securely fastened and that all locking screws are in place.
- Check for a burned-out fuse in the Controller power module. For information about changing a fuse, see " Changing the ST-133A's Line Voltage and Fuses” on page 93.
- Correct any apparent problems and turn the system on.
- If you hear 2 clicks separated by 1 second (shutter opening then closing), the shutter is working. Call Roper Scientific Customer Service for further instructions.

If the system still does not respond, contact Roper Scientific Technical Support.

Changing the ST-133A Line Voltage and Fuses

The appropriate voltage setting for your country is set at the factory and can be seen on the power input module. If your voltage source changes, you will need to change the voltage setting and you may need to change the fuse configuration.

WARNING!

Use proper fuse values and types for the controller and camera to be properly protected.

To Change Voltage and Fuse Configuration:

WARNING!

Before opening the power input module, turn the Controller OFF and unplug the line cord.

1. As shown in Figure 49, place the flat side of a flat bladed screwdriver parallel to the rear of the Controller and behind the small tab at the top of the power input module, and twist the screwdriver slowly but firmly to pop the module open.
2. To change the voltage setting, roll the selector drum until the setting that is closest to the actual line voltage is facing outwards.
3. Confirm the fuse ratings by removing the two white fuse holders. To do so, simply insert the flat blade of the screwdriver behind the front tab of each fuse holder and gently pry the assembly out.

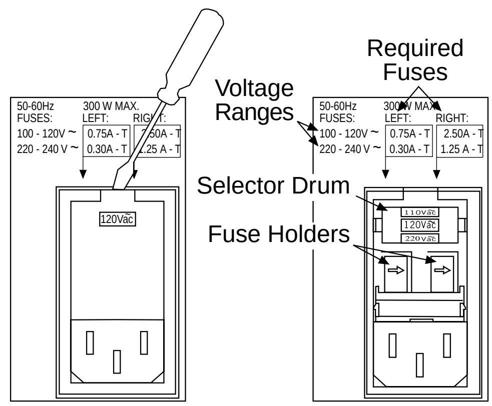


Figure 49. Power Input Module

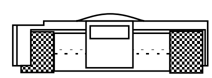


Figure 50. Fuse Holder

4. After inspecting and if necessary, changing the fuses to those required by the selected voltage, reinstall the holders with the arrow facing to the right.
5. Close the power input module and verify that the correct voltage setting is displayed.
6. Verify that the Controller power switch is in the OFF position and then plug the powercord back into the power input module.

Controller Is Not Responding

If this message pops up when you click on **OK** after selecting the "Interface Type" during **Hardware Setup** (under the WinView/32 **Setup** menu), the system has not been able to communicate with the Controller. Check to see if Controller has been turned ON and if the interface card, its driver, and the interface cable have been installed.

- If the Controller is ON, the problem may be with the interface card, its driver, interrupt or address conflicts, or the cable connections.
- If the interface card is not installed, close the application program (WinView/32 or WinSpec/32) and turn the Controller OFF. Follow the interface card installation instructions in provided with your interface card and cable the card to the SERIAL COM port on the rear of the Controller. Then do a "Custom" installation of WinView/32 or WinSpec/32 with the appropriate interface component selected: "PCI Interface" or "ISA Interface", depending on the interface card type. Be sure to deselect the interface component that does not apply to your system.

  Note: WinView/32 and WinSpec/32 (versions 2.6.0 and higher) do not support the ISA interface.
- If the interface card is installed in the computer and is cabled to the SERIAL COM port on the rear of the Controller, close the application program and turn the Controller OFF. Check the cable connections and tighten the locking screws if the connections are loose.
- If the interface card was installed after the application program was installed, close the application program and do a "Custom" installation of WinView/32 or WinSpec/32 with the appropriate interface component selected: "PCI Interface" or "ISA Interface", depending on the interface card type. Be sure to deselect the interface component that does not apply to your system.

  Note: WinView/32 and WinSpec/32 (versions 2.6.0 and higher) do not support the ISA interface.

Cooling Troubleshooting

Temperature Lock Cannot be Achieved or Maintained.

CAUTION

> Operating a VersArray liquid-cooled-only camera with coolant at a temperature colder than specified could cause induced condensation in the electronics enclosure and possible catastrophic damage to the camera. ***Damage resulting from this type of operation may void the warranty.***

Possible causes for not being able to achieve or maintain lock could include:

- Ambient temperature greater than +23°C. This condition primarily affects the TE-cooled cameras (air-assisted, liquid-assisted and liquid-cooled). If ambient is greater than +23°C, you will need to cool the camera environment or raise the set temperature.
- Airflow through the camera is blocked.
- The vacuum has deteriorated and needs to be refreshed.
- The connectors of the cable that interconnects the controller and the camera need to be secured.
- The target array temperature is not appropriate for your particular camera and CCD array.
- For cameras that are liquid-cooled or have liquid-assisted cooling, the coolant flow rate may be insufficient due to a pinched coolant line, blockages, circulator power problem, or pump failure. Check the flow rate and coolant temperature.
- For a TE camera, the camera's internal temperature may be too high, such as might occur if the operating environment is particularly warm or if you are attempting to operate at a temperature colder than the specified limit. TE cameras are equipped with a thermal-protection switch that shuts the cooler circuits down if the internal temperature exceeds a preset limit. Typically, camera operation is restored automatically in about ten minutes. Although the thermo-protection switch will protect the camera, you are nevertheless advised to power down and correct the operating conditions that caused the thermal-overload to occur.

Camera loses Temperature Lock

The internal temperature of the camera is too high. This might occur if the operating environment is particularly warm or if you are trying to operate at a temperature colder than the specified limit. If this happens, an internal thermal overload switch will disable the cooler circuits to protect them. Typically, camera operation is restored in about ten minutes. Although the thermal overload switch will protect the camera, users are advised to power down and correct the operating conditions that caused the thermal overload to occur. *With some versions of the software, the* ***indicated*** *temperature when the camera is in thermal overload (thermal switch is in the cut-out state) is -120° C.*

Gradual Deterioration of Cooling Capability

With time, there may be a gradual deterioration of the camera’s vacuum. This can affect temperature performance such that it may be impossible to achieve temperature lock at the lowest temperatures. In the kind of applications for which cooled CCD cameras are so well suited, it is highly desirable to maintain the system's lowest temperature performance because lower temperatures result in lower thermal noise and better the signal-to-noise ratio.

Vacuum deterioration occurs primarily as a result of material outgassing in the vacuum chamber. Because outgassing normally diminishes with time, the rate of vacuum deterioration in new cameras may be faster than in old ones. For example, a camera that has to be repumped after perhaps a year of operation, may not have to be pumped again for several years. In any case you may notice a gradual deterioration in temperature control performance indicative of vacuum deterioration. If this happens, the camera will have to be repumped. Contact the factory to make arrangements for returning the camera to the support facility nearest to you to have the vacuum restored.

CRYOTIGER Compressor

Problem	Possible Cause	Corrective Action
Compressor does not start when the circuit breaker on the compressor is closed.	No electrical power, defective wiring, motor fault.	Check that the power source is on and the powercord is connected. Contact Roper Scientific.
	Open fuse in the transformer secondary circuit.	Check the fuse. Replace it if blown.
Compressor does not start; no hum.	Wrong or defective wiring; open overload protector	Check the wiring and fuses. Allow the compressor to cool, then restart.
Compressor starts but shuts down some time later.	Compressor is overheated; temperature switch opened; incorrect wiring; motor fault; high equalization pressure; blow fuse.	Restricted airflow. Clean the after-cooler fins and air vents. Allow time for the compressor to cool and the switch to close. Verify that the compressor inlet and outlet air vents are spaced at least 160 mm (6”) from another object. Check the wiring. Check the pressure. Contact Roper Scientific.
		Fan(s) are not running. Check the fan circuit fuses located in the fuse holder part of the voltage selector. Replace the fuse if it is blown.
	Wrong voltage.	Recheck the voltage source. Recheck the voltage selector setting.
	Compressor component is blocked.	Contact Roper Scientific.
Moisture on the cryocooler inlet and outlet manifold or on the upper vacuum enclosure. Otherwise, the cooler performance is normal.	High humidity in the room.	Lower the dew-point temperature or insulate the gas lines.
Moisture on the cryocooler upper vacuum enclosure. Degraded cooler performance.	Heat exchanger thermal short.	Contact Roper Scientific for packing and shipping instructions.

Problem	Possible Cause	Corrective Action
Moisture on the lower vacuum enclosure.	Loss of vacuum.	Pump the vacuum enclosure to < 10^{-4} Torr.
Increased cooldown time; cannot attain desired temperature; lack of capacity.	Low equalization gas pressure.	Contact Roper Scientific.
	Loss of vacuum.	Check for vacuum leaks and repair. Pump to < 10^{-4} Torr.
Temperature cycles in the 250 to 275 K range.	Contamination is freezing in the system.	Contact Roper Scientific.
Temperature is less than 200 K but higher than the normal operating range.	Vacuum leak.	Check the vacuum integrity. Pump the vacuum enclosure to < 10^{-4} Torr.
	Thermal short.	Verify that any attachment to the cold tip does not touch a warm surface.

Error Occurs at Computer Powerup

If an error occurs at boot up, either the Interface is not installed properly or there is an address or interrupt conflict. Turn off the computer, try a new address or interrupt and reinstall the card. Be sure the Interface is firmly mounted in the slot.

Caution Since interrupts and DMA channels cannot be shared, make sure no other boards in your computer use this interrupt or these DMA channels.

Conflicts

One of the many advantages that PCI offers over ISA is that the whole issue of address and interrupt assignments is user transparent and under BIOS control. As a result, users typically do not have to be concerned about jumpers or switches when installing a PCI card. Nothing more should be required than to plug in the card, make the connections, and operate the system. As it turns out, however, in certain situations conflicts may nevertheless occur and user intervention will be required to resolve them.

Typical PCI motherboards have both ISA and PCI slots and will have both PCI and ISA cards installed. In the case of the ISA cards, the I/O address and Interrupt assignments will have been made by the user and the BIOS will not know which addresses and interrupts have been user assigned. When a PCI card is installed, the BIOS checks for available addresses and interrupt levels and automatically assigns them so that there are no *PCI* address or interrupt conflicts. However, because the BIOS doesn't know about the user-assigned ISA I/O address and interrupt level assignments, it is possible that a PCI card will be assigned an address or interrupt that is already assigned to an ISA card. If this happens, improper operation will result. Specifically, the problems could range from erratic operation under specific conditions to complete system failure. If such a conflict occurs, because the user has no control over the PCI address and interrupt assignments, there will be no recourse but to examine the ISA assignments and change them to values that do not conflict. Most (but by no means all) ISA cards make provision for selecting alternative I/O addresses and interrupt levels so that conflicts can be resolved. Software is available to help identify specific conflicts.

The following example may serve to illustrate the problem. Suppose you had a system with an ISA network card, a PCI video card and an ISA sound card. Further suppose that you were then going to install a PCI Serial Buffer card. Before installing the PCI Serial card, the I/O address and interrupt assignments for the installed cards might be as follows.

Slot Type	Status	I/O Address	Interrupt
1 (ISA)	ISA Network Card	200-210	11
2 (PCI)	PCI Video Card	FF00-FFFF	15
3 (ISA)	ISA Sound Card	300-304	9
4 (PCI)	Empty	N/A	N/A

Table 10. I/O Address & Interrupt Assignments before Installing Serial Card

As shown, there are no conflicts, allowing the three peripheral cards to operate properly. If the PCI Serial card were then installed, the BIOS would interrogate the PCI cards and may reassign them new address and interrupt values as follows.

Slot Type	Status	I/O Address(s)	Interrupt
1 (ISA)	ISA Network Card	200-210	11
2 (PCI)	PCI Video Card	FE00-FEFF	11
3 (ISA)	ISA Sound Card	300-304	9
4 (PCI)	Princeton Instruments PCI Serial Card	FF80-FFFF	15

Table 11. I/O Address & Interrupt Assignments after Installing Serial Card

As indicated, there is now an interrupt conflict between the ISA Network Card and the PCI Video card (both cards have been assigned Interrupt 11), causing the computer to no longer function normally. This doesn't mean that the PCI Serial card is defective because the computer stops functioning properly when the Serial card is installed. What it does mean is that there is an interrupt conflict that can be resolved by changing the interrupt level on the conflicting Network card in this example. It is up to the user to consult the documentation for any ISA cards to determine how to make the necessary change.

Note: Changing the order of the PCI cards, that is, plugging them into different slots, could change the address and interrupt assignments and possibly resolve the conflict. However, this would be a trial and error process with no guarantee of success.

Diagnostics Software

Many diagnostics programs, both shareware and commercial, are available to help resolve conflicts. Most often, all that's required is a program that will read and report the address and interrupt assignments for each PCI device in the computer. One such program available from Roper Scientific's Technical Support department is called PCICHECK. When the program is run, it reports the address and interrupt assignments for the first PCI device it finds. Each time the spacebar is pressed, it moves on to the next one and reports the address and interrupt assignments for that one as well. In a few moments this information can be obtained for every PCI device in the computer. Note that, even though there are generally only three PCI slots, the number of PCI devices reported may be larger because some PCI devices may be built onto the motherboard. A good strategy for using the program would be to run it before installing the PCI Serial card. Then run it again after installing the card and note any address or interrupt assignments that may have changed. This will allow you to easily focus on the ones that may be in conflict with address or interrupt assignments on ISA cards. It might be noted that there are many programs, such as the MSD program supplied by Microsoft, that are designed to read and report address and interrupt assignments, including those on ISA cards. Many users have had mixed results at best using these programs.

Operation

There are no operating considerations that are unique to the PCI Serial card. The card can easily accept data as fast as any Princeton Instruments system now available can send it. The incoming data is temporarily stored in the card's memory, and then transferred to the main computer memory when the card gains access to the bus. The PCI bus arbitration scheme assures that, as long as every PCI card conforms to the PCI guidelines, the on-board memory will never overflow.

Unfortunately, there are some PCI peripheral cards that do ***not*** fully conform to the PCI guidelines and that take control of the bus for longer periods than the PCI specification allows. Certain video cards (particularly those that use the S3 video chip) are notorious in this respect. Usually you will be able to recognize when memory overflow occurs because the displayed video will assume a split-screen appearance and/or the message **Hardware Conflict** will be displayed (WinView/32). At the same time, the LED on the upper edge of the PCI Serial card will light.

Users are thus advised not to take any actions that would worsen the possibility of memory overflow occurring when taking data. In that regard, avoid multitasking while taking data. Specific operations to avoid include multitasking (pressing ALT TAB or ALT ESC to start another program), or running a screensaver program.

Excessive Readout Noise

Excessive readout noise with the intensifier off indicates possible moisture accumulation in the CCD. This should be corrected promptly or permanent damage not covered by the Warranty could occur.

Normal camera noise is a function of the gain setting and temperature as well as CCD type, but is typically in the range of 1 ADU rms (6 ADU pk-pk). This is on top of offset that typically is about 40 counts. Moisture accumulation produces a coarser noise with many spikes ≥ 30 ADU. If these types of spikes occur, especially after the camera has been in use for an extended period, turn off the system immediately. Have the unit serviced by Roper Scientific or an authorized service facility of Roper Scientific.

No Images

See "Overexposed or Smeared Images", page 100.

Overexposed or Smeared Images

If the camera has an internal shutter, check to see that the shutter is opening and closing correctly. Possible shutter problems include complete failure, in which the shutter no longer operates at all: the shutter may stick or open (causing overexposed or smeared images) or stick closed (resulting in no images). It may even happen that one leaf of the shutter will break and no longer actuate. High repetition rates and short exposure times will rapidly increase the number of shutter cycles and hasten the time when the shutter will have to be replaced.

Shutter replacement is usually done at the factory. If you find that the shutter on your camera is malfunctioning, contact the factory to arrange for a shutter-replacement repair. ***Shutters are not covered by the warranty***.

Removing/Installing a Module

The ST-133A Controller has three plug-in slots. The Analog/Control module (leftmost slot when the controller is viewed from the rear) and the Interface Control module (middle slot) are always provided. The third slot, however, is always covered with a blank panel unless a PTG module has been installed in an ST-133A Controller.

If a module is ever removed for any reason, internal settings should ***not*** be disturbed. Changing a setting could radically alter the controller's performance. Restoring normal operation again without proper equipment and guidance would be very difficult, and it might be necessary to return the unit to the factory for recalibration.

WARNING! Always turn the Controller OFF before removing or installing a module. If a module is removed or installed when the controller is powered, permanent equipment damage could occur which would not be covered by the warranty.

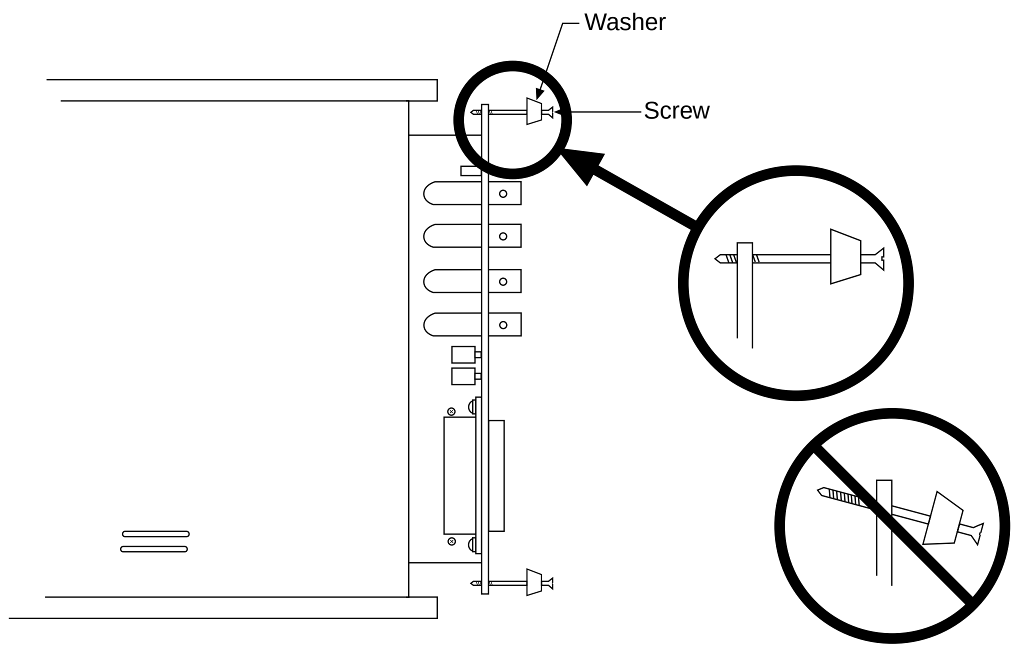


Figure 51. Module Installation

To Remove a Module:

1. Verify that the Controller has been turned OFF.
2. Rotate the two locking screws (one at the top of the module and one at the bottom) counterclockwise until they release from the chassis.
3. Then, grasp the module and pull it straight out.

To Install a Module:

Installing a module is a bit more complex because you first have to be sure the locking screws are aligned correctly. The following procedure is suggested.

1. Rotate the two locking screws counterclockwise until the threads on the screws engage those of the module panel. *See Figure 51.* By doing this, the screws will be perfectly perpendicular to the module panel and will align perfectly when the module is inserted.
2. Insert the module so that the top and bottom edges of the board are riding in the proper guides.
3. Gently but firmly push the module in until the 64-pin DIN connector at the back of the module mates with the corresponding connector on the backplane, leaving the module panel resting against the controller back panel.
4. Rotate the two locking screws clockwise. As the screws are rotated, they will first disengage from the module panel threads, and then begin to engage those of the bracket behind the controller panel.

WARNING! Always turn the Controller OFF before removing or installing a module. If a module is removed or installed when the controller is powered, permanent equipment damage could occur which would not be covered by the warranty.

Shutter Failure

See "Overexposed or Smeared Images", page 100.

Vignetting: LN- or CRYOTIGER-cooled Cameras

All CCD arrays have been tested for uniformity and do not exhibit any unusual vignetting (reduction of response) at the extreme ends of the array. If you do measure such reduction in response across the array, it may be the result of one or more of the following conditions:

- Condensation of water on the edges of the array window has occurred. This should not happen unless the cooling/pumping instructions, previously mentioned, were not followed or if the Dewar has sprung a leak (a rare situation).

The arrays are held with a special mask that has been designed to minimize reflection and stray light. These masks were designed to allow light rays to enter through the Dewar window even at very wide angles ($\geq$ f/1.5). If vignetting is observed, it is possible that your experiment exceeds these angular constraints. Roper Scientific measures the array response with a collimated uniform light source to prevent such false bias results.

This page intentionally left blank.

Appendix A
Specifications

Window

SI-UV fused-silica quartz

CCD Arrays

EEV (Marconi) CCD77-00: 512x512B/F, MPP, 24 x 24µm pixels, TE/LN

EEV (Marconi) CCD36-40: 1340x1300B/F, MPP, 20 x 20µm pixels, TE/LN

EEV (Marconi) CCD36-40: 1340x1300B, MPP, 20 x 20µm pixels, CT (CRYOTIGER)

EEV (Marconi) CCD42-40: 2048x2048B/F, MPP, 13.5 x 13.5µm pixels, TE/LN

Note: The arrays listed are those that were available at the time that the manual was written. Contact Roper Scientific for an updated list of arrays supported by the VersArray.

Mounts

C-mount (standard threaded video mount)

F-mount (standard Nikon® bayonet mount)

Focal Distance

CT:

EEV (Marconi), CCD36-40, Front Surface to Focal Plane (no shutter or adapter):	.450"
EEV (Marconi), CCD36-40, Front of Shutter to Focal Plane:	.890"

LN:

Front of Shutter to Focal Plane:	0.894″

TE:

C-mount, Front Surface to Focal Plane:	.720"
F-mount, Front Surface to Focal Plane:	1.849"
Fiberoptic, Front Surface to Focal Plane:	1.969"

Note: The shutter has a 3.88″ bolt circle.

Shutter

CT: 1.77 in (45 mm) aperture, 30 msec open time, 18 msec close time

LN/TE: 1.59 in (40 mm) aperture, 28 msec open time, 28 msec close time

Camera Head

Connector: Male, D-subminiature 25-pin power/signal connector

Cooling: Thermoelectric (air or liquid coolant); liquid nitrogen; CRYOTIGER proprietary coolant

Temperature Stability: ±0.05°C; closed-loop stabilized-temperature control

Gain: Software-selectable (high, medium, low)

CRYOTIGER-Cooled camera head dimensions:

5.67 in (14.40 cm) width;

16.14 in (41.00 cm) length with shutter, 15.70 in (39.88 cm) without shutter;

7.33 in (18.62 cm) height with shutter; 7.04 in (17.88 cm) without shutter

LN-Cooled camera head dimensions:

6.25 in (15.56 cm) width;

9.24 in (23.47 cm) length;

14.56 in (36.98 cm) height;

9 lb (4.2 kg) weight, with shutter, when empty

TE-Cooled camera head dimensions:

C-Mount	F-Mount
4.63 in (11.76 cm) width;	4.63 in (11.76 cm) width;
7.05 in (17.91 cm) length;	8.18 in (20.78 cm) length;
4.63 in (11.76 cm) width;	4.63 in (11.76 cm) width;
7 lb (3.2 kg) weight	7 lb (3.2 kg) weight

Controller

Dimensions: 5.25 in (13.34 cm) width; 13.63 in (34.62 cm) length; 8.75 in (22.23 cm) height; 13 lb (5.9 kg) weight

Connectors:

VIDEO: 1 V pk-pk from 75 Ω, BNC connector. Either RS-170 (EIA) or CCIR standard video as specified when system was ordered. Requires connection via 75 Ω cable that must be terminated into 75 Ω.

EXT SYNC: TTL input (BNC) to allow data acquisition to be synchronized with external events. Sense can be positive or negative going as set in software. Synchronization and Trigger Modes are discussed in Chapter 5.

$\overline{\text{SCAN}}$: TTL output (BNC) for monitoring camera status. TTL low when array is being read; otherwise high.

$\overline{\text{READY}}$: TTL output (BNC); marks start of *first* exposure. When run is initiated, remains high until completion of cleaning cycles preceding *first* exposure, then goes low and remains low for duration of run.

Detector Interface: female, D-subminiature 25-pin connector for communication and data transfer between the controller and the detector. Provides power to detector.

TTL In/Out: male, D-subminiature 25-pin connector; 8 TTL inputs; 8 TTL outputs

TTL Input: external sync

TTL Output: (ready) frame start; (scan) shutter/readout status

TTL Requirements: Rise time ≤ 40 nsec, Duration ≥ 100 nsec.

AUX BNC connector: Not currently activate. Reserved for future use

Serial Com Interface: female, D-subminiature 9-pin connector for RS232 serial communication

Power Input: 100, 120, 220, 240 V; 47 to 63 Hz. Power to detector is provided through the Detector-Controller cable.

Power Consumption: 300 Watts (average)

CRYOTIGER® Compressor

Dimensions:

17 7/8" (454 mm) wide

14 3/4" (375 mm) high

12 1/4" (311 mm) deep

Weight:

Compressor: 71 pounds (32.2 kg)

Gas Lines (10' length): 2 lb (.9 kg) per gas line

Color Codes:

Gas line couplings on the rear of the compressor and on the cryocooler are labeled SUPPLY (red) and RETURN (green).

Environment:

Location: Protected from the elements.

Ambient Temperature: 50° to 95° F (10° to 30° C).

Clearance: Minimum of 6" (160 mm) clearance from the rear and left side of the compressor for unrestricted flow of cooling air.

Orientation:

Compressor must be mounted base down and level within 10 degrees of horizontal.

Power Input:

100, 120, 220, 240 V; 50 or 60 Hz

Options

A partial listing of options includes: Internal Shutters, C-mount Adapters, F-mount Adapters, and Spectroscopic Mount Adapters. Contact the factory for more information regarding options available for your system.

This page intentionally left blank.

Appendix B

Outline Drawings

NOTE: Dimensions are in inches.

VersArray TE Camera: Air- and Liquid-Assist

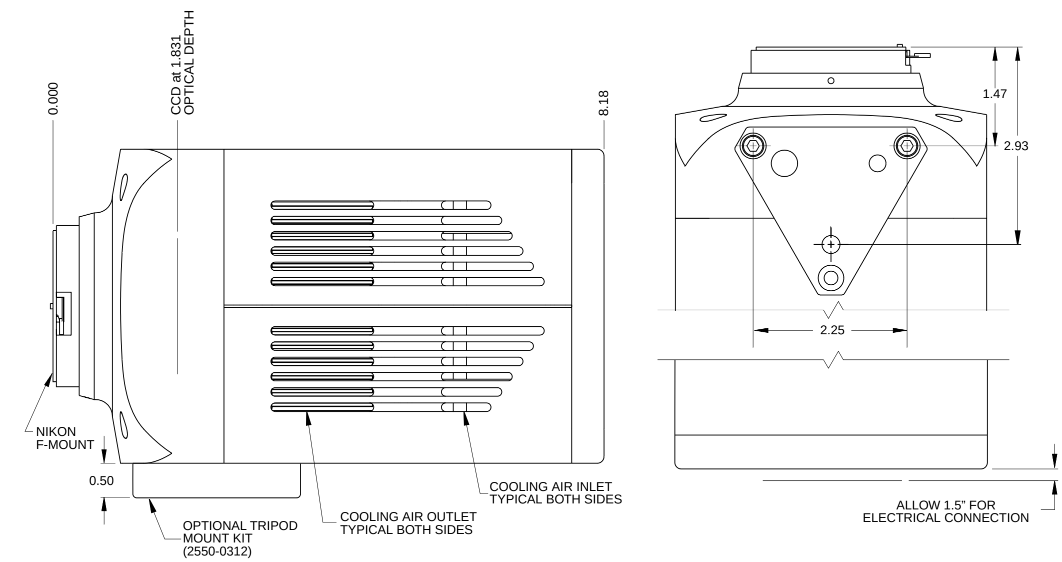


Figure 52. TE F-Mount: Side and Bottom Views

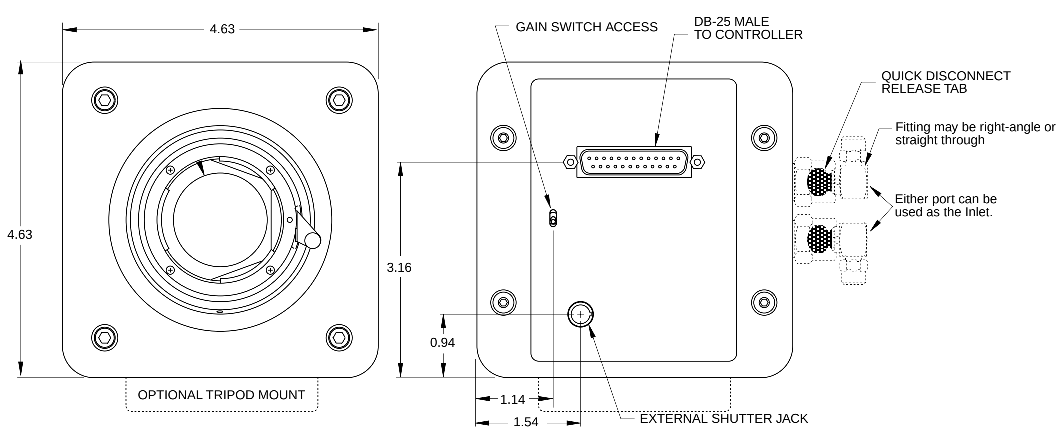


Figure 53. TE F-Mount: Front and Back Views

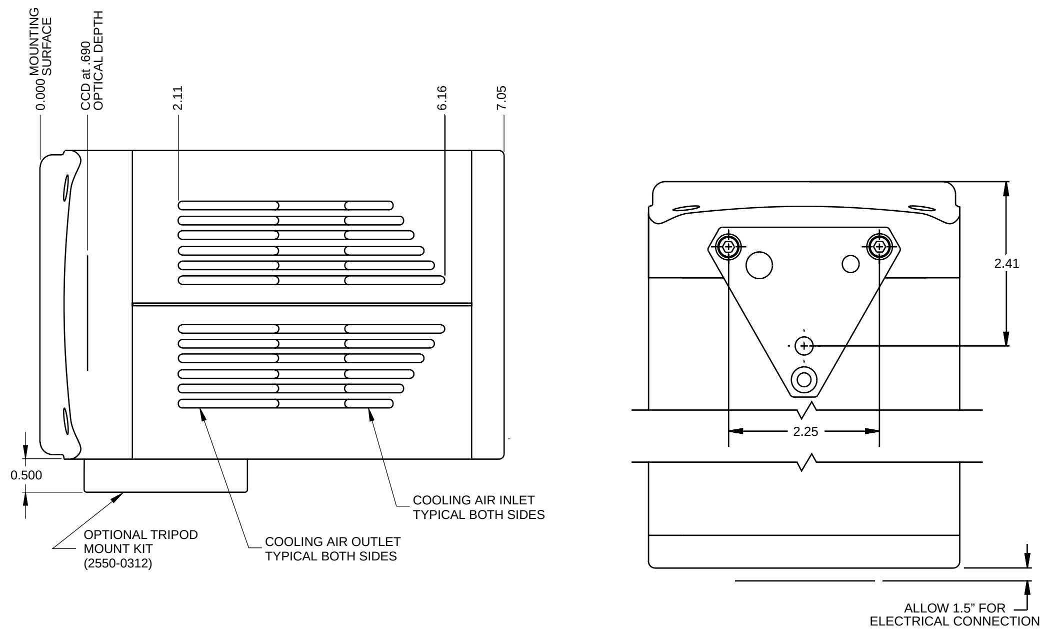


Figure 54. TE C-Mount: Side and Bottom Views

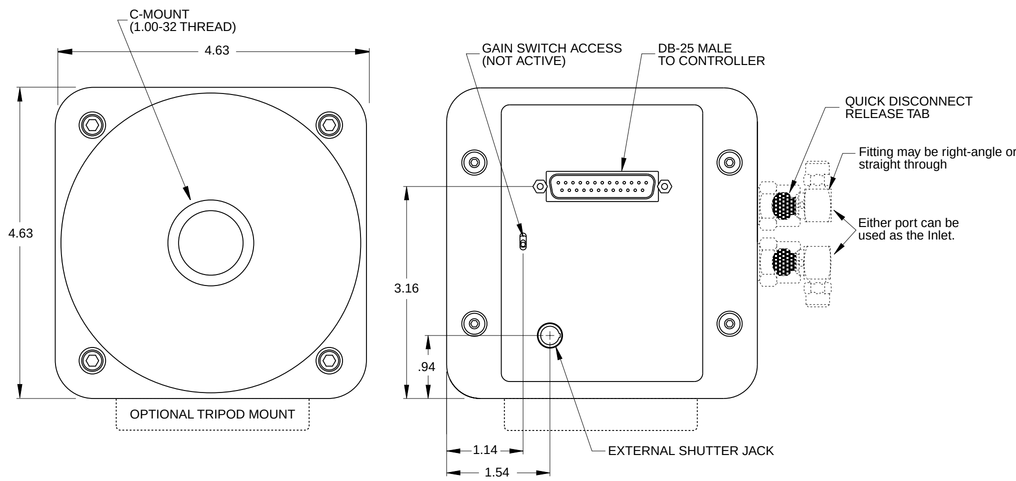


Figure 55. TE C-Mount: Front and Back Views

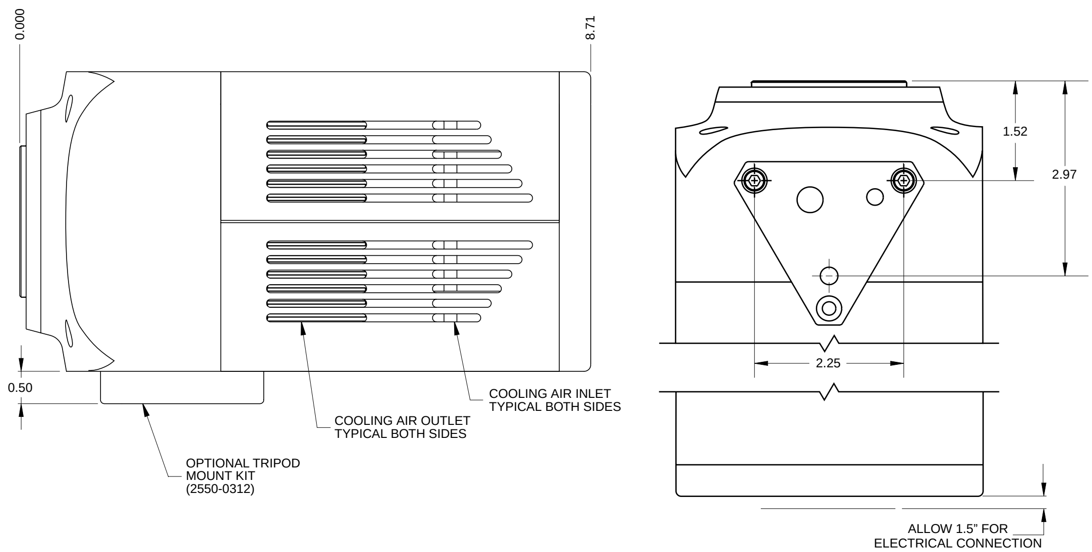


Figure 56. Fiber-Optic Coupled: Side and Bottom Views

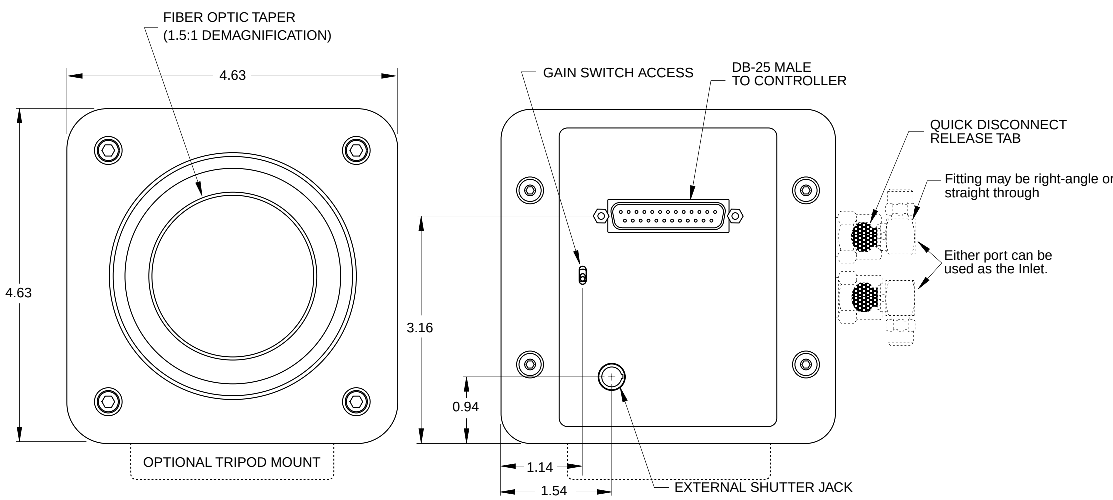


Figure 57. Fiber-Optic Coupled: Front and Back Views

VersArray TE Camera: Liquid-Cooled

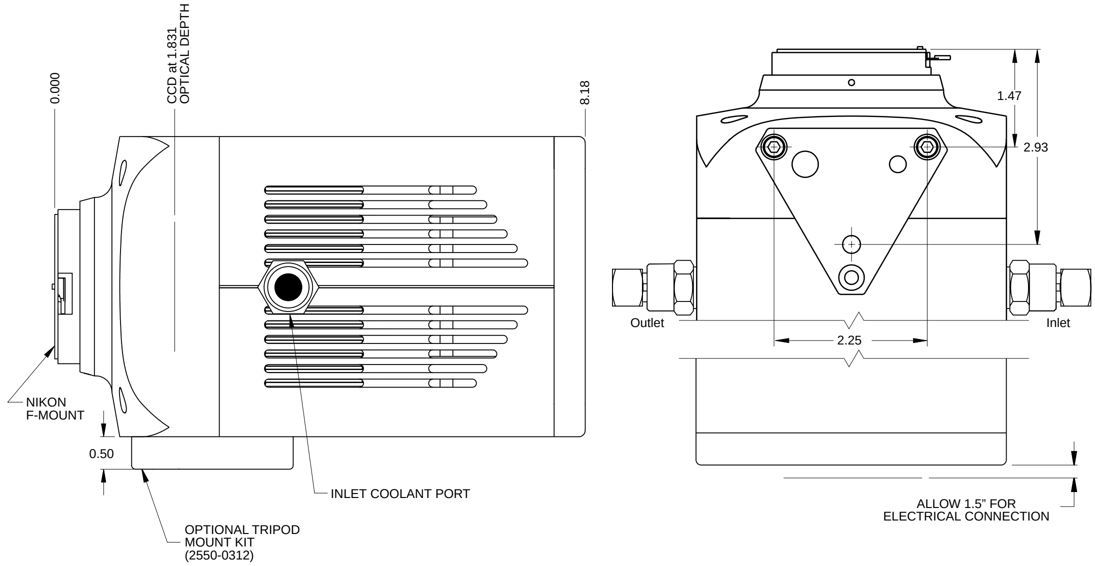


Figure 58. TE F-Mount: Side and Bottom Views

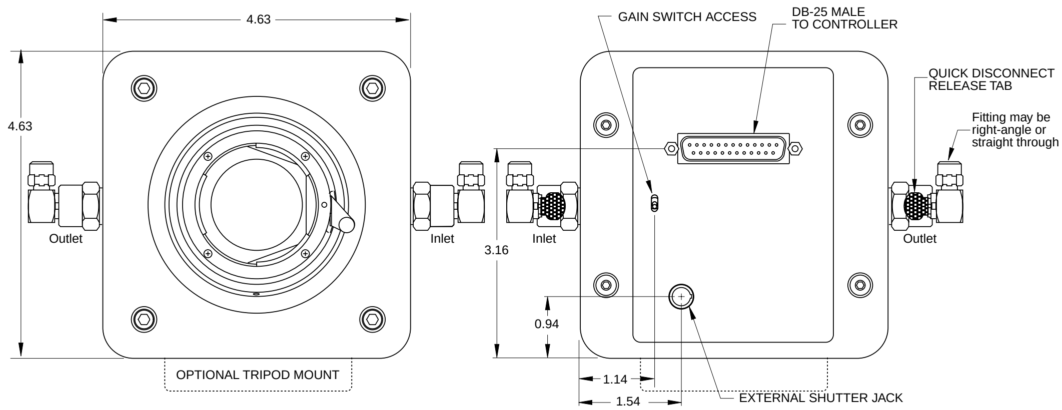


Figure 59. TE F-Mount: Front and Back Views

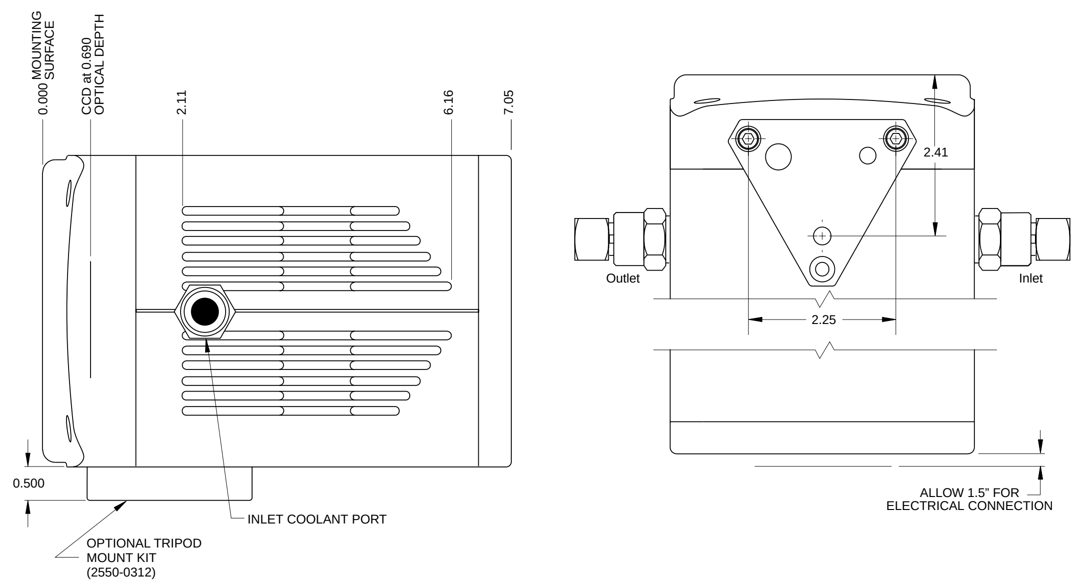


Figure 60. TE C-Mount: Side and Bottom Views

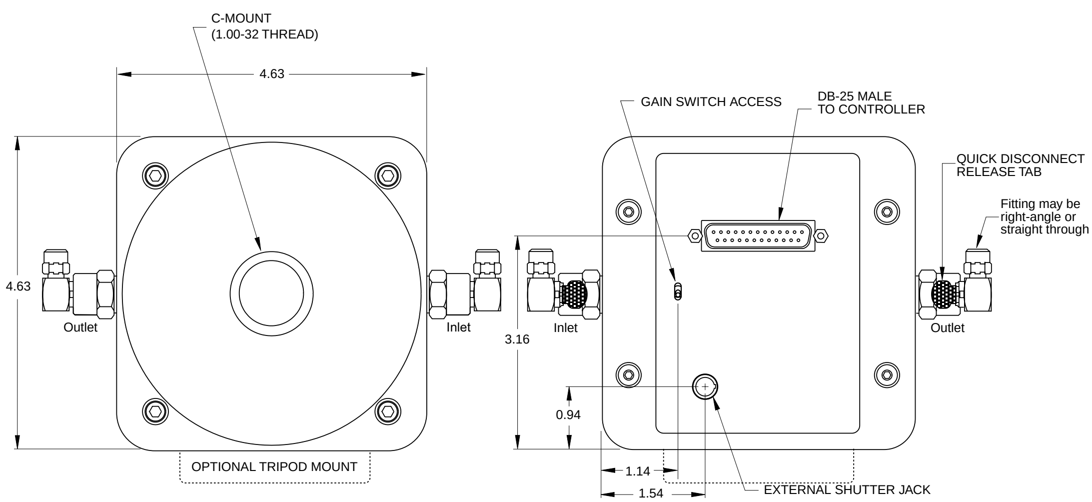


Figure 61. TE C-Mount: Front and Back Views

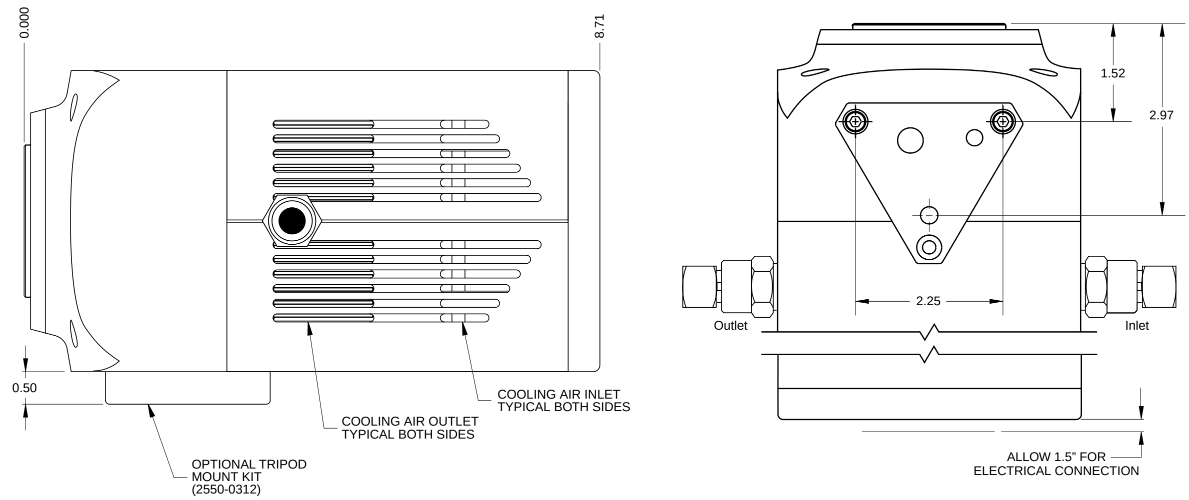


Figure 62. Fiber-Optic Coupled: Side and Bottom Views

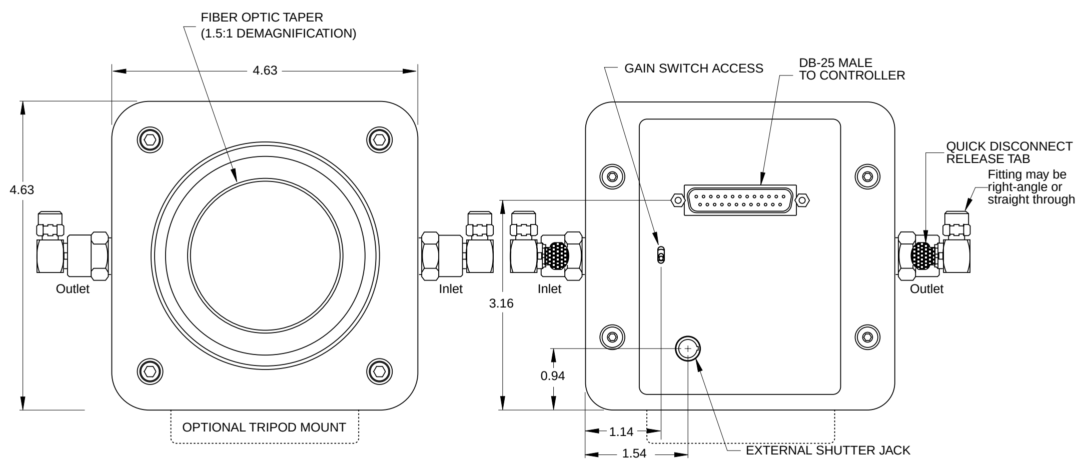


Figure 63. Fiber-Optic Coupled: Front and Back Views

VersArray LN-Cooled Camera

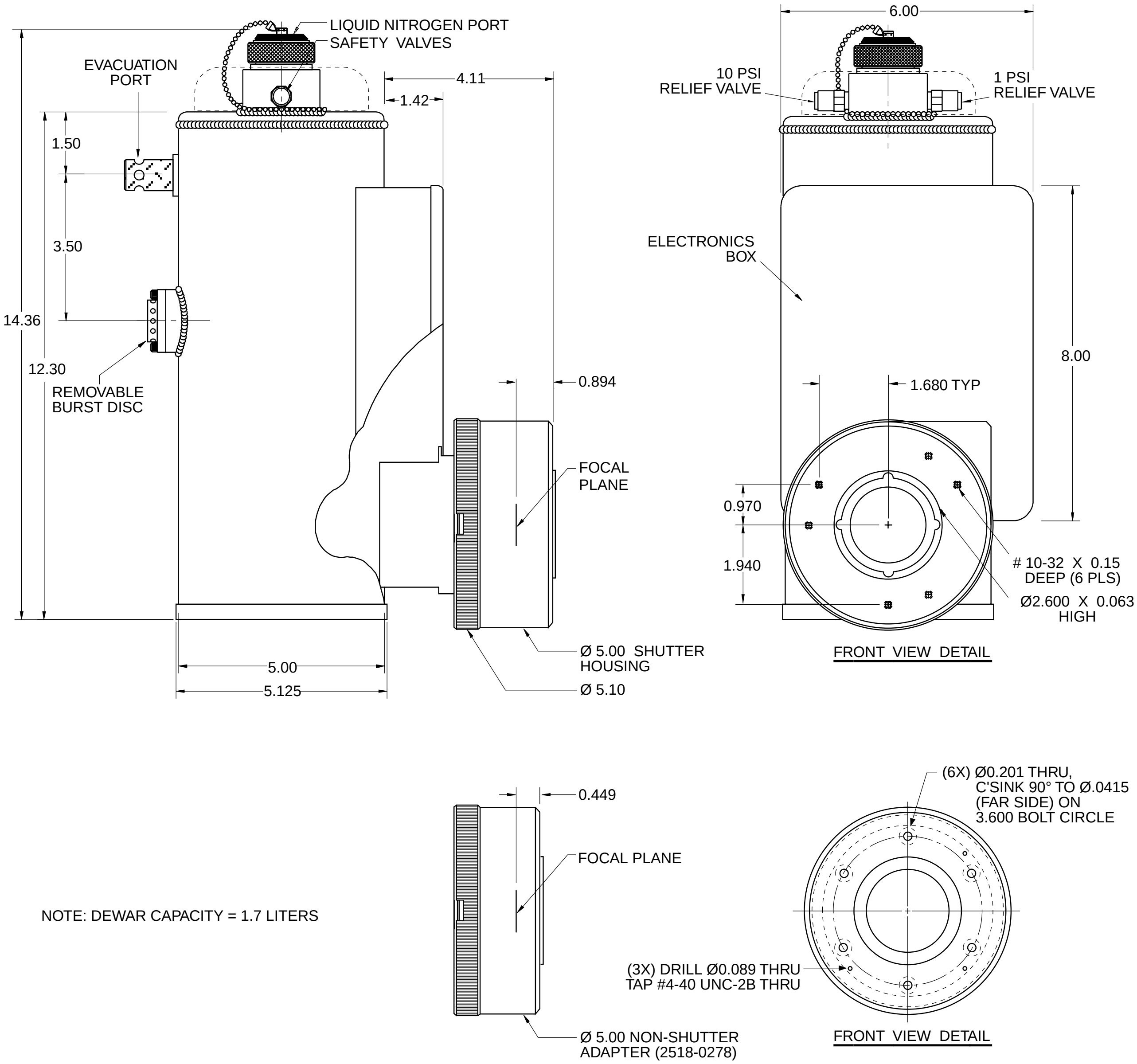


Figure 64. Side-Looking Dewar

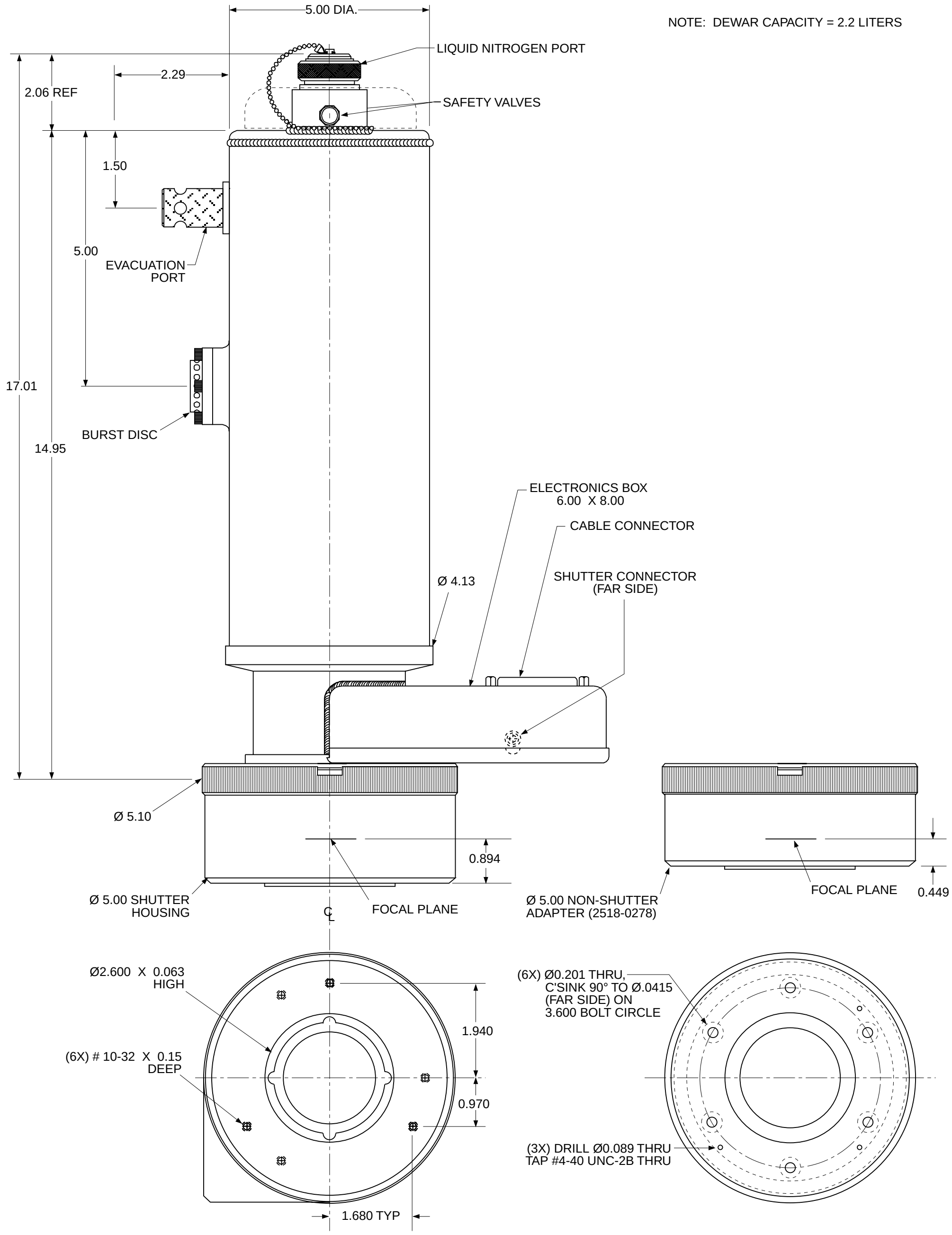


Figure 65. Down-Looking Dewar

VersArray$_{CT}$ Camera

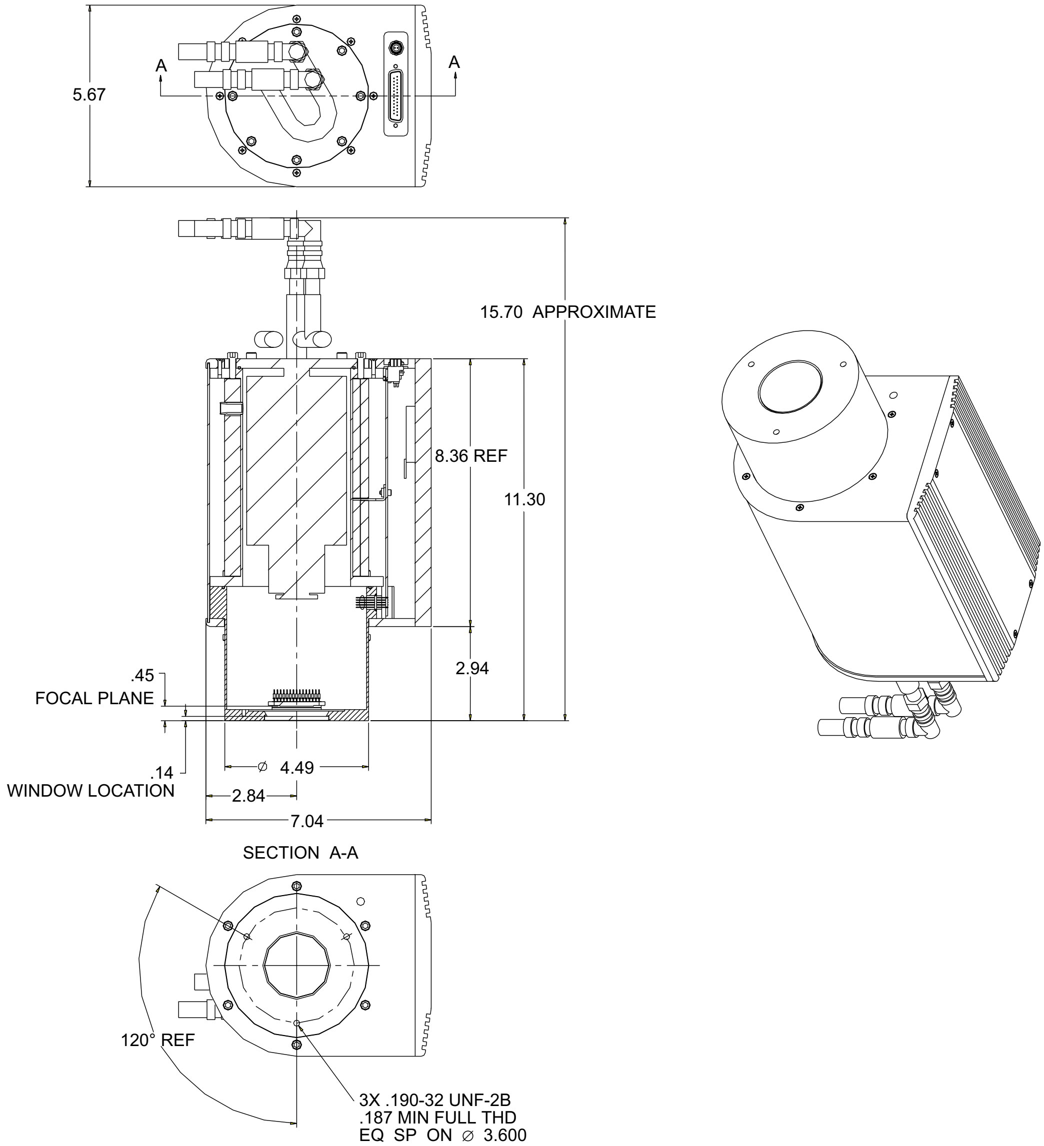


Figure 66. CRYOTIGER-Cooled Camera without Shutter

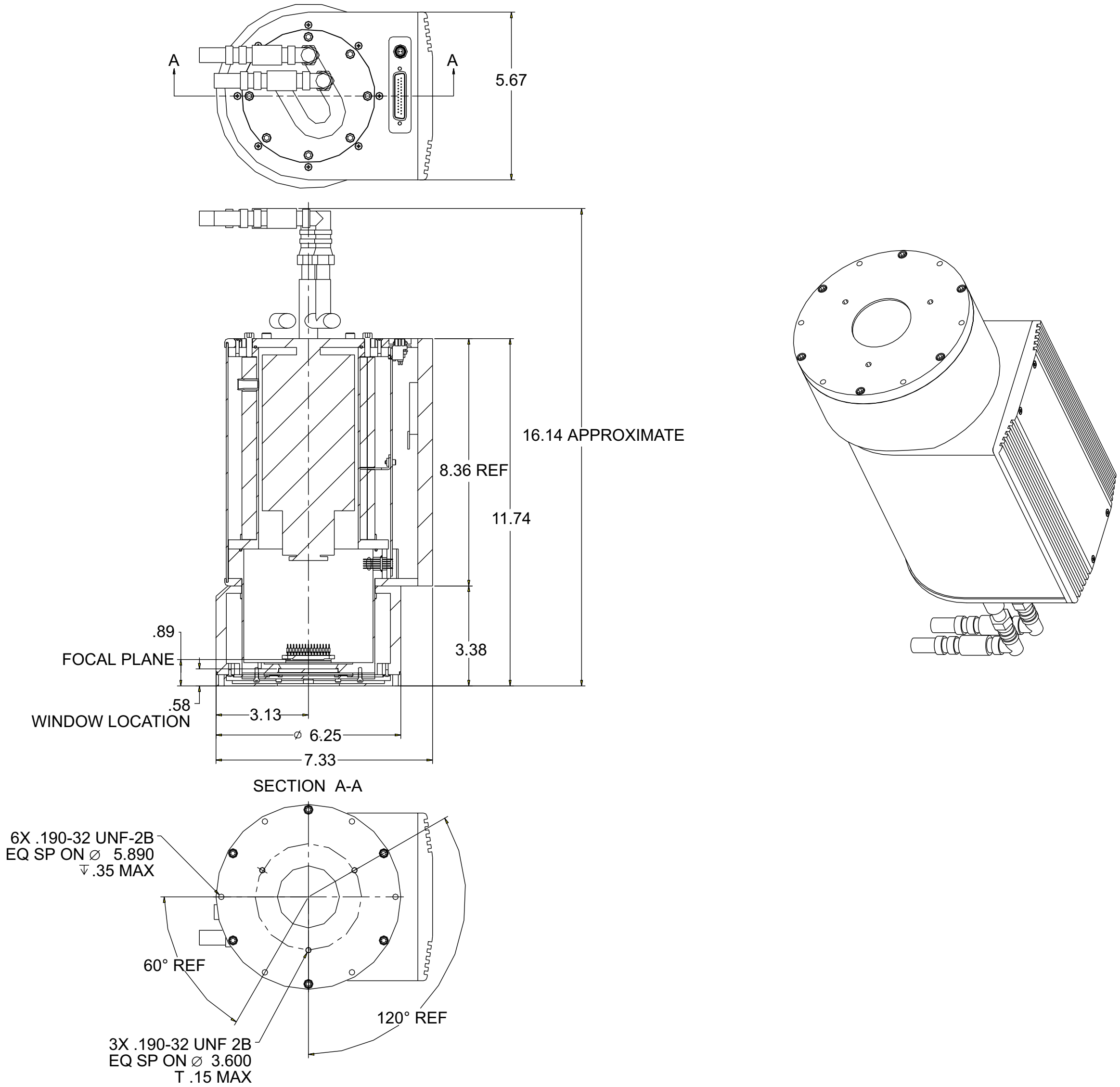


Figure 67. CRYOTIGER-Cooled Camera with Shutter

CRYOTIGER Compressor

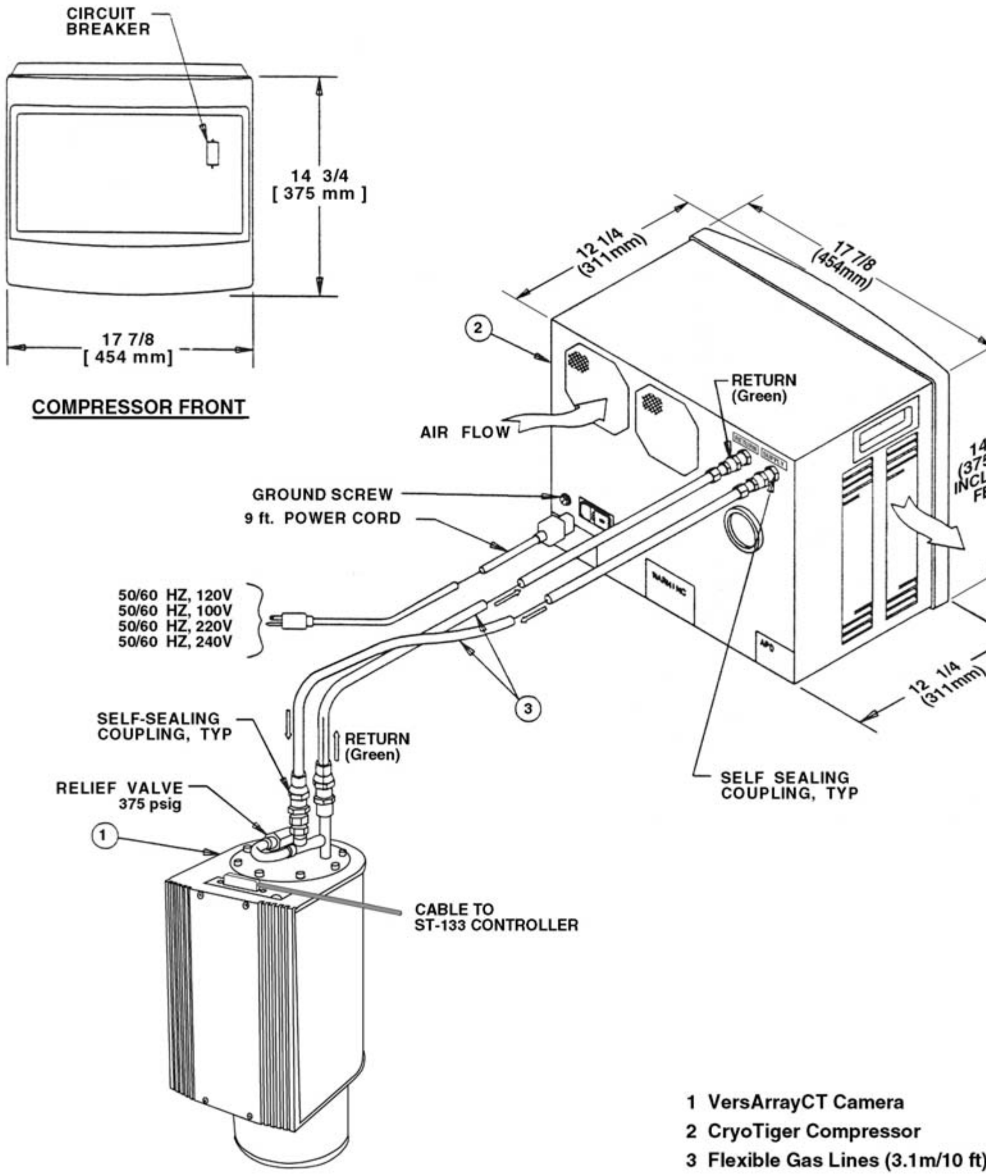


Figure 68. CRYOTIGER Compressor

ST-133A Controller

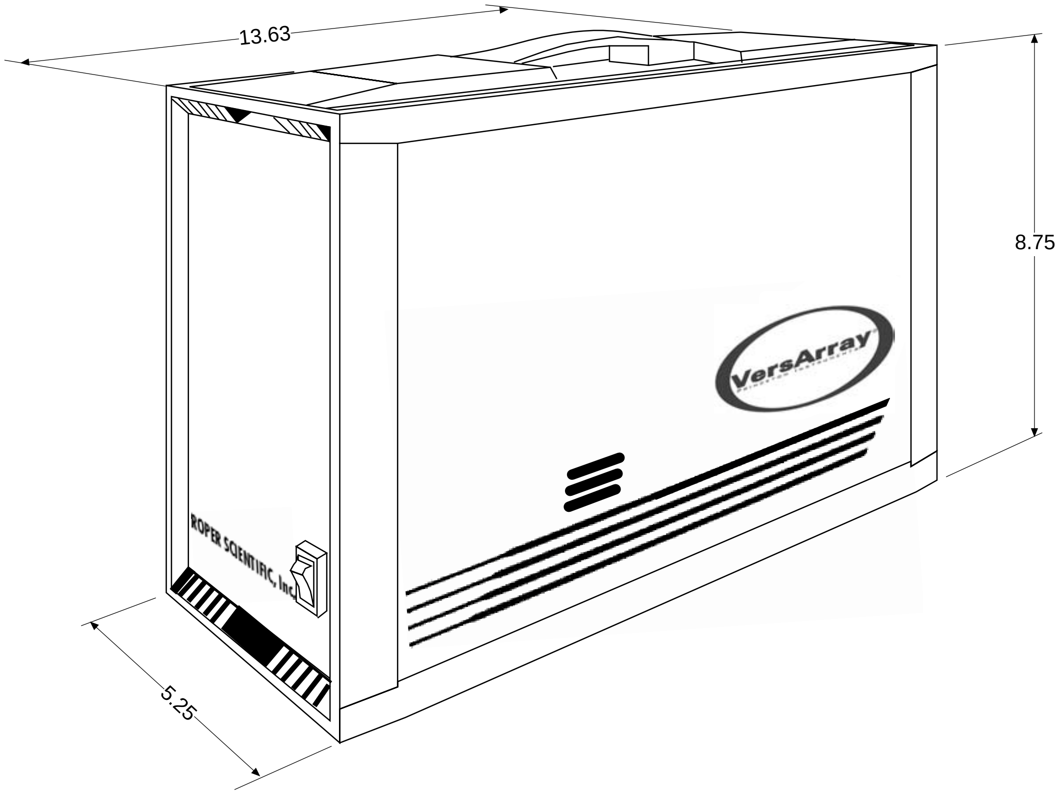


Figure 69. ST-133A

Appendix C
LN Autofill System

General Information

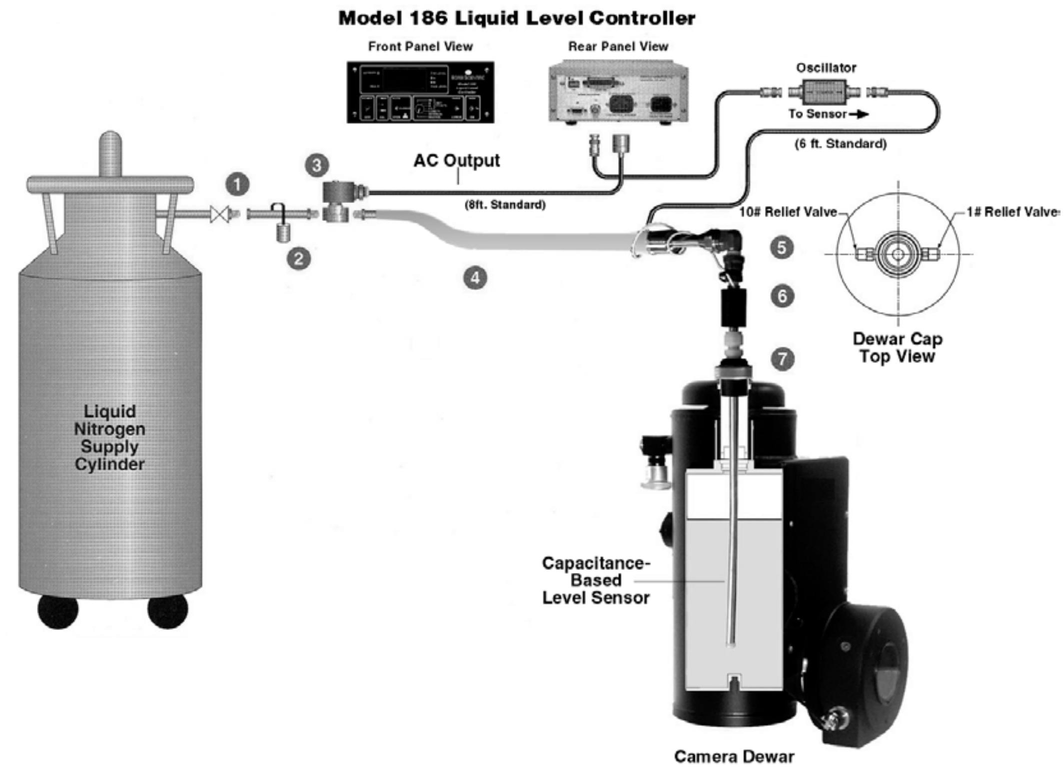


Figure 70. LN Autofill System

1. **Dewar Adapter:** ½" SAE flare nut x 3/8" Male NPT
2. **Safety Pressure Relief Valve:** 100 psi set pressure with gooseneck
3. **Solenoid Valve:** 9/32" orifice with 3/8" Female NPT, 100-120 VAC (Optional 200-240 VAC)
4. **Vacuum Jacketed Transfer Line:** 6-12 ft. Std. X ¼" ID, ¾" OD with ½" SAE flare nut on one end and integral Dewar nozzle on other end.
5. **Dewar Nozzle:** Length to fit application x ½" or 3/8" OD, with threaded male tip
6. **Liquid Level Sensor:** 3/8" OD Std. X length required.
7. **Dewar Cap Assembly**

The Princeton Instruments brand Autofill system uses a capacitance-based method for determining liquid level of the LN_2 in a side-looking or end-looking Dewar. When the liquid goes below the B setpoint, the system will fill the Dewar until the A setpoint is reached. All operational controls for the LN_2 level controller are located on the front panel of the Autofill Controller, with power, sensor, communication, and control connections at the rear.

Unpacking the System

1. Examine the shipping carton for any signs of damage and then check the contents. If damage is visible, save the shipping carton and contact the factory for further instructions.
2. Unpack the contents and remove all packaging materials.
3. Verify that you have received all items listed on the packing slip.

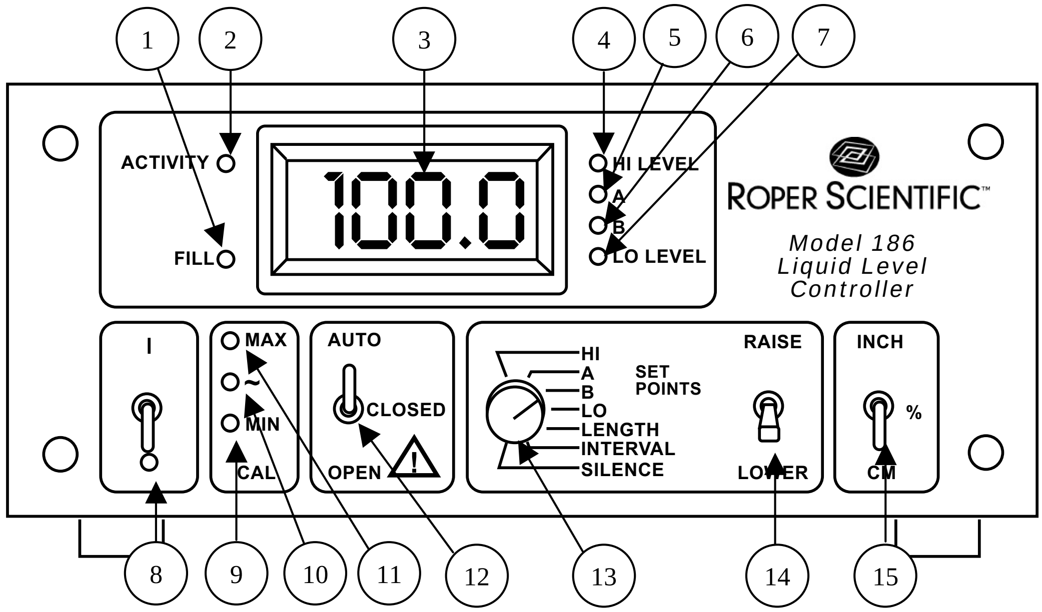
System Components

A typical Princeton Instruments brand autofill system has the following components:

LN-Cooled Camera	ST-133A Controller
Model 186 Liquid Level Controller	Sensor Assembly
Oscillator	Solenoid-operated Fill Valve
Cables	

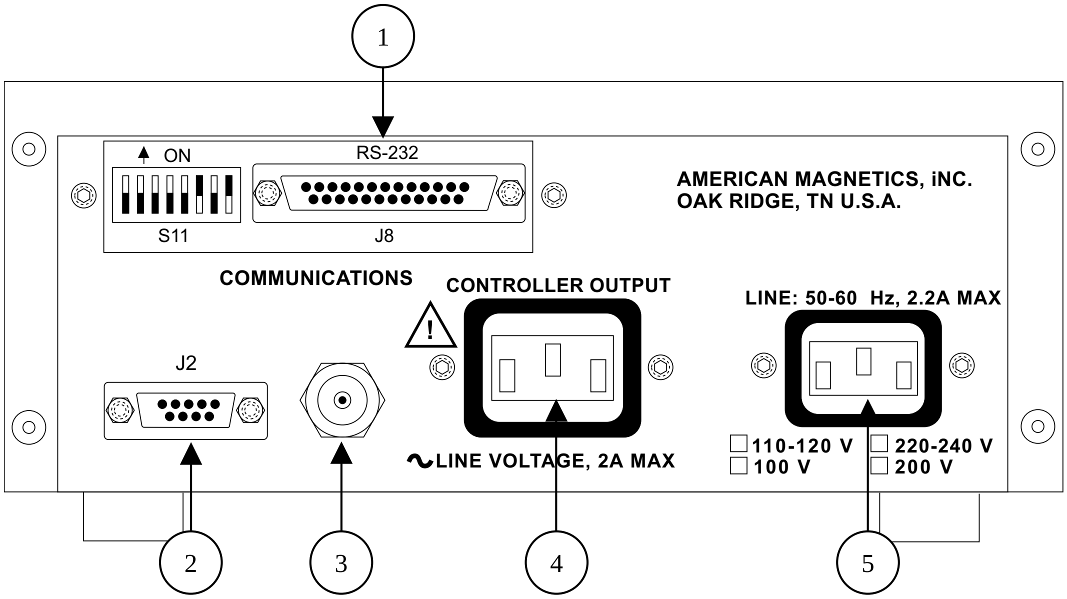
Model 186 Front and Rear Panel Controls and Connectors

Front Panel



1	Fill indication LED	**9**	MIN calibration push-button
2	Activity LED	**10**	Approximate calibration push-button
3	LED display	**11**	MAX calibration push-button
4	HI level LED	**12**	Fill toggle switch
5	A level LED (control band upper limit)	**13**	Control mode rotary switch
6	B level LED (control band lower limit)	**14**	Raise/lower toggle switch
7	LO level LED	**15**	Units Mode toggle switch
8	Power toggle switch		

Rear Panel



1	RS-232/422 communications port	**4**	Controller output receptacle to solenoid fill valve
2	Auxiliary DB-9 connector (see page 136 for pinout)	**5**	Input power connector
3	RG-59/U coaxial connector to oscillator unit via the extension cable		

Setting up the System

The following instructions assume that a PCI card has been installed in the host computer, the application software has been installed, and all cable connections for the host computer, ST-133A, and the camera have been made. The instructions also assume that a Liquid Nitrogen supply cylinder is available.

1. Rigidly mount the camera Dewar in place to ensure that the flexible transfer line does not cause the Dewar to move out of position.
2. Install the sensor assembly into the camera Dewar. Be careful not to damage the sensor in any way. Dents, crimps, bends, or other physical distortions in the thin wall capacitor will change the electrical characteristics, possibly causing calibration errors and/or disruption of proper instrument operation.

   Note: You may want to review the *Calibratio*n (page 125) and *Operation* (page 127) sections before installing the sensor.

3. Connect the oscillator to the cable coming from the sensor assembly. Make sure that you connect the cable to the correct end. Arrows on the oscillator indicate the correct orientation. You can also refer to the diagram on page 124.

Caution

Moisture or contaminants in any of the BNC coaxial connectors can short out the sensor and cause a false 'full' level indication or other erroneous readings. A pack of non-conductive electrical connection lubricant (ECL or "Dielectric Tune-up Grease") has been included with the liquid level sensor packaging to reduce the possibility of this occurring. If desired, apply a small amount of ECL to any of the BNC connectors that may be exposed to moisture. Mate the doped connectors then remove any excess ECL from the outside of the connector. Added protection can be achieved by covering the doped connections with a short section of heat-shrink tubing.

4. Using the J5 coaxial connector, connect the Model 186 controller to the oscillator using an RG-59/U coaxial cable.
5. Install the solenoid-operated fill valve by connecting the valve power cable to the AC Controller output receptacle on the rear panel of the Model 186. The fill valve has a 9/32-inch orifice and the input and output are tapped for 3/8 NPT. Operation of the controller output receptacle in AUTO mode should be avoided until the controller setpoints have been specified. See the *Operation* section for details on specifying the setpoints and selecting the operational mode for the controller output receptacle.

Caution

When using the solenoid-operated control valve with the Model 186, ensure the valve is configured for the operating voltage of the Model 186. Failure to do so will result in faulty operation and may also result in valve damage.

WARNING!

Before touching any of the controller output receptacle terminals or touching the wiring connected to these terminals, remove power to the Model 186 by unplugging it or turning the power switch to the off position.

The controller output receptacle conducts hazardous AC line voltage potentials. It is for use with equipment that has no accessible live parts. Conductors connected to its terminals must be insulated from user contact by reinforced or double insulation capable of withstanding 4250 V (impulse) for a 240 VAC Category II installation, or 2550 V (impulse) for a 120 VAC Category II installation.

This instrument is designed for operation from a single-phase power source for maximum safety. The controller output receptacle circuitry only switches the "line" ("hot") connection to the AC mains. If two-phase power is applied, any equipment connected to the controller output receptacle conducts hazardous AC voltage even when the controller output receptacle is not turned on.

WARNING!

The Model 186 operates on 50-60 Hz power and may be configured for 110-120 or 208-240 VAC ±10% (100 or 200 VAC ±10% for Japan and South Korea). The power requirements for each controller are marked on the calibration sticker on the bottom of the controller. Be sure your controller is configured for your power source prior to plugging in the powercord. Do not fail to connect the input ground terminal securely to an external earth ground.

6. Ensure the front panel switch is in the OFF position. Verify that the controller is configured for the proper operating voltage by referring to the calibration sticker

affixed to the bottom of the controller. If the operating voltage is correct, plug the powercord into the appropriate power receptacle.

WARNING!

Do not install the Model 186 in a manner that prevents removal of the powercord from the rear panel of the controller.

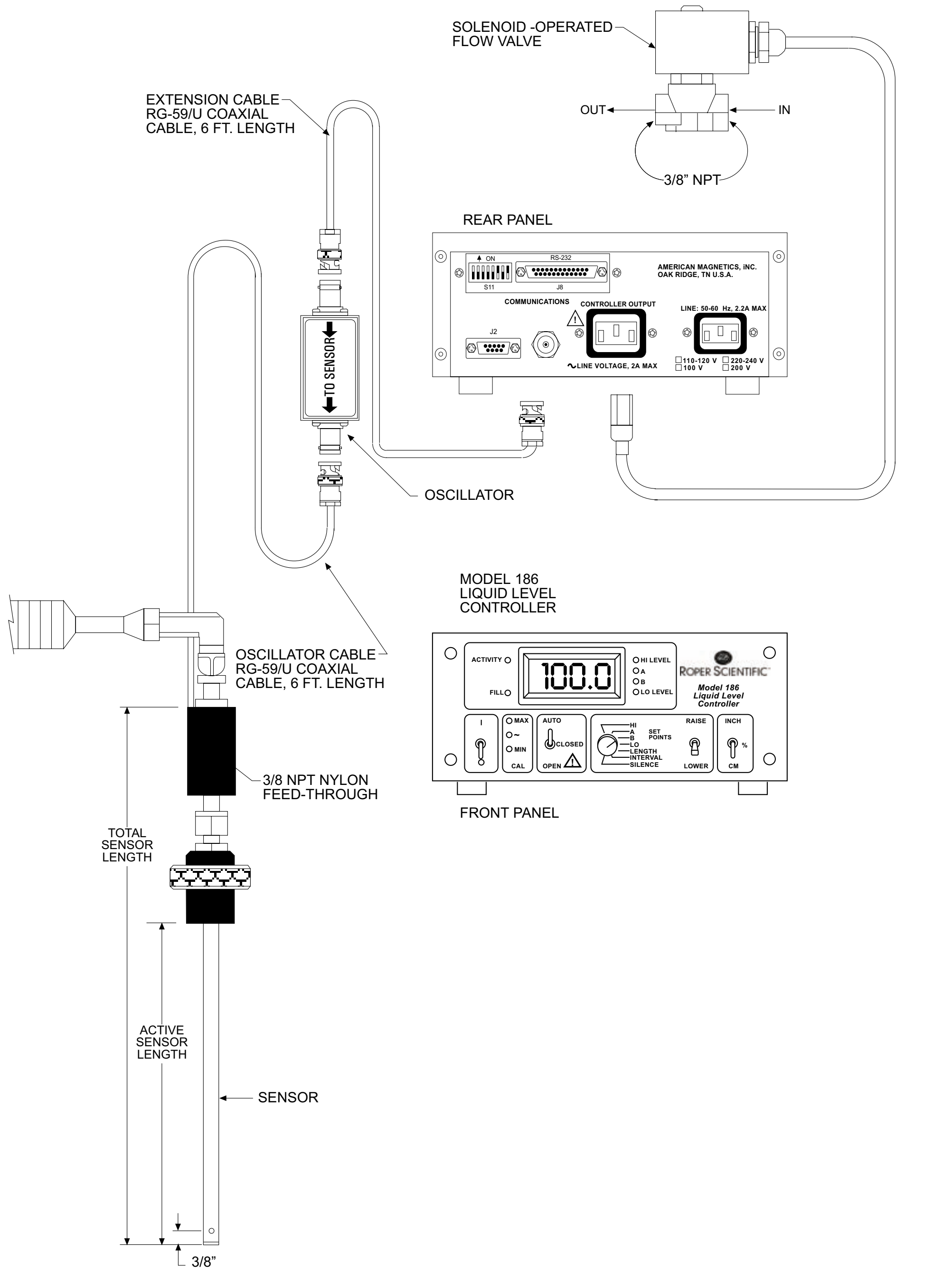


Figure 71. Model 186 Instrument, Control Valve and Sensor System Diagram

Calibration

Introduction

Model 186 controllers are calibrated at the factory for the supplied sensor. The calibration length and calibration liquid are listed on the calibration sticker on the bottom of the controller. If the factory calibration method utilized was approximate, the calibration length will be noted as an approximate value.

Relationship between Calibration and Sensor Length

The capacitance-based method of measuring the measuring the liquid level operates by measuring the frequency of an oscillator, which is contained in the oscillator/transmitter unit. As the liquid level varies, the value of the capacitance varies proportionally. A calibration is required to assure maximum accuracy for a specific sensor. The calibration MIN and MAX settings correspond to the maximum and minimum oscillation frequencies, respectively, for a given sensor configuration.

The LENGTH setting of the controller is only provided as a means of scaling the 0% (MIN) to 100% (MAX) range of the measurement to meaningful units of length. If the user wants to operate the sensor in units of length, it will be necessary to accurately measure the distance between the physical locations on the sensor corresponding to the MAX and MIN calibration points. The measured value for the length will be used in configuring the controller for operation.

Note: All references to “dielectric constant” herein refer to the unitless relative dielectric to ε_0 (ε_0 is the dielectric constant of a vacuum).

Calibration Procedure

Introduction

Before performing the *Calibration*, the MAX/MIN calibration points and the C_{adj} factor must be preset and the system must be fully set up so that LN can be added to the camera Dewar through the sensor assembly. Since the MAX/MIN calibration points and the C_{adj} factor have been set at the factory, you do not have to reset them to perform the following calibration.

1. Install the sensor in the Dewar and turn on the Model 186 with the sensor connected to the controller via the oscillator and extension cables (see the system diagram on page 124).
2. Begin filling the Dewar. While the sensor is cooling down, there may be a slow drift in the displayed liquid level. However, when the liquid actually touches the bottom of the sensor, contact with the liquid surface may become apparent by virtue of more random and frequent fluctuations in the displayed liquid level. The liquid level trace will also start to show an increasing profile with positive slope.
3. Once the indications of the contact between the sensor and liquid become readily apparent, press the MIN push-button through the small hole provided in the controller front panel. When the calibration point has been accepted, the display will show "bbb.b" and the pushbutton can then be released. This point is the 0% level of the sensor.

Note: If the sensor is installed in the Dewar with some small amount of liquid already in contact with the sensor, then the final MIN calibration point can be set before filling begins but after any thermally induced fluctuations in the observed output have diminished. However, note that the measured span of the liquid level is reduced by the initial level of liquid in contact with the sensor.

4. When LN vents from the Dewar, push the MAX pushbutton through the small hole provided in the Model 186 front panel. When the calibration data has been accepted, the display will show "bbb.b" and the pushbutton can then be released. The level on the sensor when the MAX button is pressed becomes the 100% level.

Note: If the controller displayed a 100% reading before venting occurs, then the MAX calibration point set prior to the current procedure has interfered. If this occurs, continue the liquid transfer until venting begins and then press the MAX calibration pushbutton.

Proceed to the *Operation* section for directions for configuring the controller.

Resetting the MAX/MIN Calibration Points and C_{adj} Factor

The MAX/MIN calibration points set at the factory should not need to be reset. However, if the sensor probe is slightly damaged (bent or dented), you may want to reset these points to compensate for the change in capacitance. The C_{adj} factor would have to be recalculated if you are changing from LN to a different liquid (and vice versa).

The following procedure should be performed before installing the sensor in the target Dewar.

1. Connect the extension and oscillator cables to the J5 coaxial connector on the rear panel of the controller (see page 124 for a system diagram). *Do not connect the sensor.* Turn on the controller. Press the MIN push-button through the small hole provided on the controller front panel. When the calibration point has been accepted, the display will show "bbb.b" and the push-button can then be released.

2. Connect the sensor to the oscillator cable (which is still connected to the controller via the extension cable). Press the MAX push-button through the small hole provided on the controller front panel. When the calibration point has been accepted, the display will show "bbb.b" and the push-button can then be released.

3. Calculate the factor C_{adj} using the following equation:

$$C_{adj} = 120\left[1 + \frac{2.1(L_{active})}{5.2(L_{total})}\right]\left[\frac{e-1}{0.454}\right]$$

   where L_{total} is the total sensor length in inches, L_{active} is the active sensor length in inches, and e is the dielectric constant of the target liquid.

4. Enter C_{adj} into the controller by placing the front panel control mode rotary switch in the SILENCE position. By using the RAISE/ LOWER toggle switch and holding it in the up or down position, adjust the displayed value up or down. The display will move slowly at first and then faster. Once near the desired value, simply release the switch momentarily and then resume changing the factor at the slower speed. Once the desired number has been reached, release the toggle switch.

5. Once the value for C_{adj} has been entered, momentarily press the CAL push-button labeled as "~" (the tilde character) through the small hole provided in the controller front panel. When the value has been accepted, the display will show "ddd.d" and the button can then be released.

Operation

Turn on the Model 186

After completion of the *Installation* and *Calibration* procedures, turn on the Model 186 switching the Power toggle to the POWER position. The LED display will briefly display AAAA and then indicate the liquid level, and the yellow ACTIVITY LED will begin blinking.

Note: The ACTIVITY LED provides visual indication that the microprocessor is making sensor readings. If a fault should develop which prohibits the microprocessor from operating correctly (such as a break in cabling) the LED will not blink or blink slowly, and the display will continuously show 100%.

Note: If the displayed level reading is below the LO SETPOINT level or exceeds the HI SETPOINT, an audible alarm will sound. To silence the alarm, rotate the control mode rotary switch on the front panel to the SILENCE position.

The controller is normally calibrated at the factory for the specific sensor supplied with the unit for use in a target liquid. If the need arises for recalibration, see the *Calibration* section.

Active Length Setting

The Model 186 was shipped with the length value set to the active sensor length. This setting allows the controller to scale the measurement to meaningful units of length (inches, centimeters, or percentage) for display. To *view* the present length setting, switch the Units Mode toggle to either the INCH or CM position. Turn the Control Mode knob to the LENGTH position. Push and *release* the RAISE/ LOWER toggle either up or down. The display will momentarily show the current length setting.

To *change* the length setting, use the RAISE/LOWER toggle switch to move the setting up or down by continuously holding it in the up or down position. The display will move slowly at first and then faster. Once near the desired value, simply release the switch momentarily and then resume changing the setpoint at the slower speed. The new active sensor length is permanently stored in memory. Check the value by momentarily placing the toggle switch in either position from the center position.

Note: The LENGTH adjustment can only be performed in the INCH or CM units modes. The LENGTH adjustment is inactive if the units are set for %.

HI and LO SETPOINTs

The HI and LO setpoints are used for alarm purposes only: they do not control filling the Dewar. To adjust the HI and LO setpoints, turn the Control Mode knob to the HI SETPOINT position or the LO SETPOINT position, respectively. Use the RAISE/LOWER toggle to adjust the respective setpoint in the same manner as described for the LENGTH adjustment. The setpoints may be located anywhere between 0% to 100% of the active sensor length. The HI and LO setpoint adjustments are compatible with all three units modes.

- When the measured liquid level exceeds the HI setpoint, the HI LEVEL LED on the front panel is turned on and a set of relay contacts are closed on the 9-pin D connector J2 on the rear panel (see page 136 for the pinout). When the level reaches or falls below the HI setpoint, the LED is extinguished and the relay contacts open.
- When the measured liquid level falls below the LO setpoint, the LO LEVEL LED on the front panel is turned on and a set of relay contacts are closed on the 9-pin D connector J2 on the rear panel (see page 136 for the pinout). When the level reaches or exceeds the LO setpoint, the LED is extinguished and the contacts open.

Notes:

1. The HI and LO contacts are both closed on power-off of the controller which is a state unique to the power-off condition.
2. If the LENGTH is adjusted subsequent to configuring the various setpoints, the percentage of active length will be maintained for all setpoints. For example, if the LENGTH is set to 100 cm and the HI SETPOINT is set to 80 cm, then adjusting the LENGTH to 150 cm will result in the HI SETPOINT being automatically scaled to 120 cm—i.e., the setting of 80% of active length is maintained.

A and B SETPOINTs

To adjust the A and B setpoints, which specify the upper and lower limits for the liquid level control band, turn the Control Mode knob to the A SETPOINT position or the B SETPOINT position, respectively. Use the RAISE/LOWER toggle switch to adjust the respective setpoint in the same manner as described for the LENGTH adjustment. The A and B setpoint adjustments are compatible with all three units modes.

- When the measured liquid level reaches or exceeds the A setpoint, the A LEVEL LED on the front panel is turned on, indicating that any filling operation should stop. When the level falls below the A setpoint, the LED is extinguished.
- When the measured liquid level falls below the B setpoint, the B LEVEL LED on the front panel is turned on, indicating the filling the Dewar should start. When the level reaches or exceeds the B setpoint, the LED is extinguished.
- In addition to the LED functions, the Controller Output receptacle may be turned on and off as discussed in the next section.

Note: The A setpoint must always be above the B setpoint. Both setpoints may be set from 0% to 100% of the LENGTH setting as long as A > B.

Setpoint	Value
Length	9.5 in.
C_{adj}	150
HI	90.0%
LO	0.1%
A	80.0%
B	5.0%
Interval	10.0 min.

Table 12. Typical Values for Setpoints

Controller Output Receptacle Operational Mode

The operation of the CONTROLLER OUTPUT receptacle is controlled by the Fill toggle switch on the front panel. Operation of the Fill toggle is as follows:

- **CLOSED** (or **OFF**)**:** With the controller power on and the Fill switch in the CLOSED position, the controller serves only as a level monitor, giving a level reading on the digital display and providing data via the communication port on the rear panel. All four setpoint LEDs (and associated J2 connector relay contacts) operate normally; however, the Controller Output receptacle will *always* be turned off.
- **OPEN** (or **ON**)**:** With the fill switch in the OPEN position, the rear panel Controller Output receptacle will be turned on, thereby starting flow if the solenoid-operated fill valve is properly connected. The FILL LED on the front panel will light indicating the presence of power at the Controller Output receptacle. **The operator is solely responsible for terminating the fill flow.**
- **AUTO:** With the Fill switch in the AUTO position, the Model 186 can automatically start and stop liquid fill via the control valve, thereby maintaining the level between the selected A and B setpoints. If the liquid level falls below the B setpoint, the rear panel Controller Output receptacle and front panel FILL LED are turned on. When the liquid level subsequently reaches or exceeds the A setpoint, the Controller Output receptacle and the FILL LED are turned off.

Fill Timer INTERVAL

An INTERVAL time-out of up to 600 minutes is provided to lessen the possibility of liquid overflow. The time-out feature is enabled when the controller is operated in the AUTO mode with an INTERVAL setting > 0. Once the liquid level falls below the B setpoint, an internal fill timer (whose period is the INTERVAL setting) begins to count down. If the liquid level does not reach the A setpoint before the timer expires, the display will flash rapidly and power to the rear panel Controller Output receptacle will be interrupted. To reset this function the Fill toggle must be momentarily placed in the ON position (to complete the filling process manually) or power to the controller must be momentarily turned off.

Note: The INTERVAL function is disabled when the INTERVAL setting is “0.0”. Adjusting the INTERVAL setting to “0.0” will also end any in-progress functions of the INTERVAL timer.

The INTERVAL setting can be changed by turning the Control Mode knob to the INTERVAL position and using the RAISE/LOWER toggle switch to adjust the setting up or down. The display will move slowly at first and then faster. Once near the desired value, which is displayed in minutes, release the switch momentarily and then continue changing the setpoint at the slower speed. The controller is shipped from the factory with a zero interval time.

Units Display Output

Place the Units Mode toggle in the position desired for the display output units during operation. The % position displays the percentage of active sensor length that is immersed in liquid.

Serial Communication

The 25-pin D-type connector on the rear panel of the controller is available for serial communications and data logger function.

Serial Port Connector and Cabling

An IBM-compatible computer’s serial port can be directly connected to the Model 186 via a standard PC modem cable. Refer to your computer’s documentation to determine which serial ports are available on your computer and the required connector type. The cable to connect two DB25 connectors is wired directly (i.e., pin 1 to pin 1, pin 2 to pin 2, etc.). If a DB9 connector is required at the computer interface, the connector translation is provided on page 136.

The Model 186 uses only three wires of the rear-panel DB25 connector: pin 2 (transmit), pin 3 (receive), and pin 7 (common). There is no software or hardware handshaking. The Model 186 is classified as a DCE (Data Communication Equipment) device since it transmits data on pin 3 and receives data on pin 2. The controller to which the Model 186 is attached must do the opposite, i.e., transmit on pin 2 and receive on pin 3 (the requirements for a DTE, or Data Terminal Equipment device). If a serial-to-parallel converter is used, it must be capable of receiving data on pin 3 or the cable connected to the Model 186 must interchange the wires between pins 2 and 3.

The Optional RS-422 connector pinout is provided on page 137.

Command/Return Termination Characters

All commands are transmitted and received as ASCII values and are case insensitive. The Model 186 always transmits *<CR><LF>* (i.e., a *carriage return* followed by a *linefeed*) at the end of a serial transmission. The Model 186 can accept *<CR>*, *<LF>*, *<CR><LF>*, or *<LF><CR>* as termination characters from an external computer.

The simplest method for communicating with the Model 186 via RS-232 is by using the interactive mode of a commercially available terminal emulation program. The Model 186 transmits and receives information at various baud rates and uses 8 data bits, no parity, and 1 stop bit. When the Model 186 receives a terminated ASCII string, it always sends back a reply as soon as the string is processed. *When sending commands to the Model 186, you must wait for the reply from the Model 186 before sending another command even if the reply consists of only termination characters.* Otherwise, the shared input/output command buffer of the Model 186 may become corrupted.

Serial Communication DIP Switch Settings

The 8 DIP switches located on the rear panel of the Model 186 are used to control various parameters of the RS-232 interface. Switches 6 through 8 control the baud rate of the interface. Switches 3 through 5 control the time interval between data output if the data logger function is enabled. Switch 2 controls the echo feature and Switch 1 enables the data logger function. Each of these features is fully discussed below.

Baud Rate Control

The Model 186 baud rate is controlled by switches 6 through 8 of the communication DIP switch on the rear panel. The unit is shipped with the baud rate set at 9600. The switch settings for various baud rates are (on = 1 or the up position):

DIP switch			
6	7	8	Baud rate
off	off	off	300
off	off	on	600
off	on	off	1200
off	on	on	2400
on	off	off	4800
on	off	on	9600

Echo Function

The Model 186 has an *echo* feature that is enabled or disabled by communication DIP switch 2. When the echo function is enabled, the Model 186 will echo the incoming command characters back to the transmitting device. The echo feature is useful when using an interactive terminal program on a host computer for communicating with the Model 186. The settings are:

DIP switch 2	Function
on	Echo On
off	Echo Off

Data Logger Function

Switch 1 of the communications DIP switch controls the data logger function. The unit is shipped with the data logger function disabled. This feature is normally used with a printer rather than a host computer, since a computer can be more usefully programmed utilizing the available command set. The data logger function generates a time relative to controller power-up and a corresponding level. The units of the level output are set by the Units Mode toggle switch. The time and corresponding level are formatted and output to the host device at regular intervals as specified by the switches 3 through 5. The settings for the data logger function are:

DIP switch 1	Function
on	Data Logger On
off	Data Logger Off

The host device can be a standard dot matrix printer connected via a serial-to-parallel converter, or connected directly with a printer capable of receiving serial data. Presumably, any serial-to-parallel converter that can be properly configured is acceptable. The Model 186 has been tested with a standard, low cost converter configured as a DTE device, 8 data bits, no parity, and 1 stop bit. In order to communicate with the host device, it is necessary to set the Model 186 to the identical baud rate of the host device.

Data Logger Output Interval

The interval between successive output from the data logger function is controlled by switches 3 through 5. The unit is shipped with the *data logger function* disabled (see above). The available intervals and the corresponding switch settings are (on = 1 or the up position):

DIP switch			Interval (minutes)
3	4	5	
off	off	off	1
off	off	on	2
off	on	off	5
off	on	on	10
on	off	off	20
on	off	on	30
on	on	off	60

Serial Command Set Reference

All commands sent to the Model 186 are processed and the Model 186 responds with a return value (if applicable) and termination. All return values are terminated with *<CR><LF>* (i.e., a *carriage return* followed by a *linefeed*). For those commands that do not return a value, the Model 186 will return the *<CR><LF>* termination only.

Commands for Controlling the Units of Measurement

The CM command sets the units of measurement to centimeters and the INCH command selects inches. The PERCENT command sets the units of measurement to the percentage of active sensor length that is immersed in liquid. **The units of measurement selected**

through the serial interface are controlled independently from the Units Mode toggle switch used for controlling the front panel display. The remote units setting is saved in permanent memory by the SAVE command and is restored at power-up. The UNIT command returns a one character value (and termination) indicating the current units—C for centimeters, I for inches, or % for percentage.

Command:	CM	Function:	Sets the units of measurement to centimeters	Returns:	<CR><LF>

Command:	INCH	Function:	Sets the units of measurement to inches	Returns:	<CR><LF>

Command:	PERCENT	Function:	Sets the measurement to % of sensor length	Returns:	<CR><LF>

Command:	UNIT	Function:	Returns the current units in use	Returns:	C, I, or % <CR><LF>

Commands for Configuring Permanent Memory

Command:	HI= <value>	Function:	Configures the HI setpoint limit	Returns:	<CR><LF>

Command:	LO= <value>	Function:	Configures the LO setpoint limit	Returns:	<CR><LF>

Command:	A= <value>	Function:	Configures the A setpoint (control band upper limit)	Returns:	<CR><LF>

Command:	B= <value>	Function:	Configures the B setpoint (control band lower limit)	Returns:	<CR><LF>

Command:	INTERVAL= <value>	Function:	Configures the fill timer in minutes	Returns:	<CR><LF>

Command:	LENGTH= <value>	Function:	Configures the active sensor length	Returns:	<CR><LF>

Command:	SAVE	Function:	Saves the configuration to permanent memory	Returns:	<CR><LF>

The HI and LO command configure the high and low setpoint limit values respectively. For example, HI=90.0 would configure the high setpoint limit to 90.0 in whichever units of measurement last selected through the serial interface. The A and B commands configure the upper limit and lower limit of the control band, respectively. The HI, LO, A, and B commands are compatible with the percent units selection.

The LENGTH command configures the active sensor length setting in the current units. LENGTH=35.0 would configure the active sensor length to 35.0 units of centimeters or inches.

Note: The LENGTH=<value> command will only function if CM or INCH are currently selected as the units of measurement. The LENGTH command does not configure the Model 186 if the units of measurement are PERCENT.

The INTERVAL command sets the fill timer in minutes as described in the *Operation* section on page 127. Setting the value of INTERVAL to 0 disables the fill timer function.

The SAVE command saves the HI, LO, A, B, INTERVAL, LENGTH, and current remote units settings to permanent memory. Saved settings are then recalled each time the power is turned off and then reapplied to the controller. If the configuration is changed from the front panel, the new settings are automatically saved to permanent memory.

Commands for Querying the Configuration

The HI, LO, A, B, INTERVAL, and LENGTH commands return the current configuration of the controller. Each return value is terminated with *<CR><LF>*.

Command:	HI	Function:	Returns the HI setpoint limit in the current units	Returns:	<value><CR><LF>

Command:	LO	Function:	Returns the LO setpoint limit in the current units	Returns:	<value><CR><LF>

Command:	A	Function:	Returns the A setpoint limit in the current units	Returns:	<value><CR><LF>

Command:	B	Function:	Returns the B setpoint limit in the current units	Returns:	<value><CR><LF>

Command:	INTERVAL	Function:	Returns the fill timer setting in minutes	Returns:	<value><CR><LF>

Command:	LENGTH	Function:	Returns the active sensor length in the current units	Returns:	<value><CR><LF>

Command for Returning a Level Measurement

Command:	LEVEL	Function:	Returns the liquid level in the current units	Returns:	<value><CR><LF>

The LEVEL command returns the liquid level in the current units selected through the communication interface.

Commands for Performing Remote Calibration

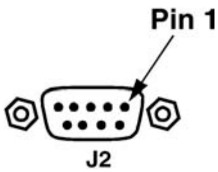
The calibration commands perform a remote calibration equivalent to activating the front panel MIN, MAX, and "**~**" (approximate) calibration buttons. The calibration is automatically saved to permanent memory. See the *Calibration* section for more information regarding calibration.

Command:	MINCAL	Function:	Performs a MIN calibration	Returns:	<CR><LF>

Command:	MAXCAL	Function:	Performs a MAX calibration	Returns:	<CR><LF>

Command:	APPROX=<value>	Function:	Performs an approximate calibration using *value* as the approximate calibration factor	Returns:	<CR><LF>

J2 Connector Pinout



Pin	Function
1	Not used
2	Not used
3	Not used
4	Not used
5 & 6	LO level relay contacts (dry)
7 & 8	HI level relay contacts (dry)
9	Not used

The HI level and LO level contacts are provided for external use by the customer. When a HI or LO level condition exists, the respective contact pairs are closed. All setpoints have 1/2 mm hysteresis, therefore the respective contact pairs may “chatter” if the liquid sloshes, bubbles, etc.

The HI level and LO level contacts also provide positive indication of a power-off condition. With a power-off condition, *both* the HI level and LO level contacts will be *closed*, which is a state unique to the power-off condition. The following table provides the specifications for the relay contacts:

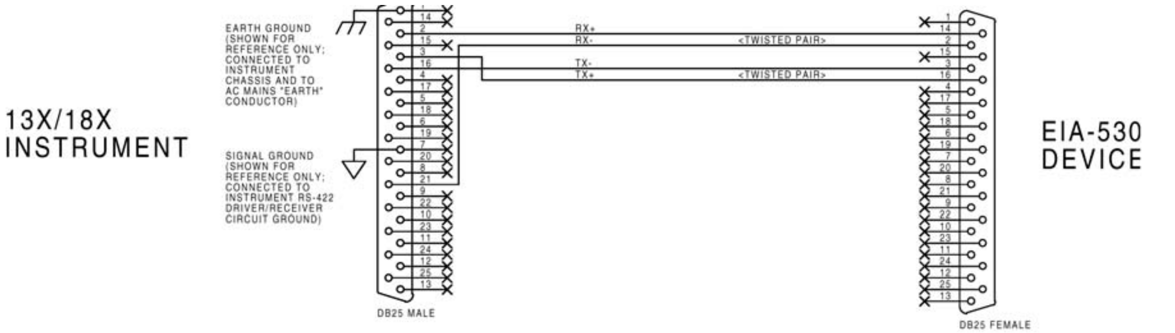
Max switching VA	10
Max switching voltage	30 VAC or 60 VDC
Max switching current	0.5 A
Max continuous current	1.5 A

RS-232 Cable DB-25 to DB-9 Translation

DB-25 Pin	DB-9 Pin
2	3
3	2
4	7
5	8
6	6
7	5
8	1
20	4
22	9

All other pins on the DB-25 connector are unused. This is standard PC modem cable wiring.

RS-422 Cable Wiring



13X/18X CONNECTOR	EIA-530 CONNECTOR	
RX+ (PIN 2)	TX+ (PIN 14)	TWISTED PAIR
RX- (PIN 21)	TX- (PIN 2)	
TX+ (PIN 3)	RX+ (PIN 16)	TWISTED PAIR
TX- (PIN16)	RX- (PIN 3)	

Dielectric Constants for Common Liquids

The table below contains relative dielectric constants for common cryogenic liquids at atmospheric pressure (unless otherwise noted).

Liquid	Dielectric Constant[*]
Argon (A)	1.53 @ -191°C
Nitrogen (N_2)	1.454 @ -203°C

Table 13. Dielectric Constants for Common Liquids

[*] Reference: Weast, Robert C. Ph.D., Editor, CRC Handbook of Chemistry and Physics 67th Edition, CRC Press, Inc., Boca Raton, FL, 1986 (pgs. E-49 through E-53).

Troubleshooting

The following paragraphs serve as an aid to assist a qualified service person (QSP) in troubleshooting a potential problem with the Model 186. If the QSP is not comfortable with troubleshooting the system, you may contact an authorized Roper Scientific Technical Support Representative for assistance. Refer to "Additional Technical Support" on page 141.

This controller contains CMOS components that are susceptible to damage by Electrostatic Discharge (ESD). Take the following precautions whenever the cover of the controller is removed.

1. Disassemble the controller only in a static-free work area.
2. Use a conductive workstation or work area to dissipate static charge.
3. Use a high resistance grounding wrist strap to reduce static charge accumulation.
4. Ensure all plastic, paper, vinyl, Styrofoam® and other static generating materials are kept away from the work area.
5. Minimize the handling of the controller and all static sensitive components.
6. Keep replacement parts in static-free packaging.
7. Do not slide static-sensitive devices over any surface.
8. Use only antistatic type solder suckers.
9. Use only grounded-tip soldering irons.

No level reading

1. Ensure that the controller is connected to a power source of proper voltage.

WARNING!

> If the controller has been found to have been connected to an incorrect power source, return the controller to Roper Scientific for evaluation to determine the extent of the damage. Frequently, damage of this kind is not visible and must be determined using test equipment. Connecting the controller to an incorrect power source could damage the internal insulation and/or the ground requirements, thereby, possibly presenting a severe life-threatening electrical hazard.

2. Verify continuity of the line fuse, F1, located on the controller printed circuit board.

WARNING!

> This procedure is to be performed only when the controller is completely turned off by removing the powercord from the power receptacle. Failure to do so could result in personnel coming in contact with high voltages capable of producing life-threatening electrical shock.

a. Ensure the controller is completely turned off by disconnecting the powercord from the power source. Disconnect the powercord from the connector located on the rear panel of the controller.

b. Remove the controller top cover and check the fuse F1 for continuity.

c. If the fuse is bad, replace with a 315 mA IEC 127-2 Type F Sheet II 5x20 mm fuse.

Caution

> Installing fuses of incorrect values and ratings could result in damage to the controller in the event of component failure.

d. Replace the fuse and securely fasten the controller top cover. Reconnect the powercord.

3. Verify the input voltage selector switch on the controller's printed circuit board is in the proper position for the available power receptacle at the customer's facility. Checking the input voltage selector requires removal of the top cover of the controller. Observe the same safety procedures as presented in step 2.

Erratic or erroneous level reading

1. Verify that the sensor is properly connected to the oscillator cable and the extension cable (see the system diagram on page 124).
2. Verify the cabling has no breaks or cuts.
3. If the Model 186 suddenly reads 100% without a corresponding level, there is a possibility of moisture in the connector at the top of the sensor. Disconnect the BNC connection and remove any moisture. Moisture or contaminants in any of the BNC coaxial connectors can short out the sensor and cause a false 'full' level indication or other erroneous readings. A pack of non-conductive electrical connection lubricant (ECL or "Dielectric Tune-up Grease") has been included with the liquid level sensor packaging to reduce the possibility of this occurring. Apply a small amount of ECL to any of the BNC connectors that may be exposed to moisture. Mate the doped connectors then remove any excess ECL from the outside of the connector. Added protection can be achieved by covering the doped connections with a short section of heat-shrink tubing.

   Note: MSDS sheets for the ECL are available upon request.
4. Ensure the oscillator unit is not exposed to large temperature gradients such as those that occur near Dewar vents. Extreme temperature changes of the oscillator unit can cause readout errors.
5. Rapidly varying or sloshing liquids will sometimes make one think the controller is in error when it is actually operating properly.
6. Capacitance-based sensors used in cryogenic liquid systems are sometimes exposed to humidified air when the cryogenic vessel is emptied. This often happens when a cold trap runs out of liquid. As the sensor warms, the electronics can show large errors (readings greater than 20% are not uncommon). This is due to the fact that air contains moisture that will condense between the cold sensing tubes. This small film of moisture can cause a shorted or partially shorted condition. The electronics may recognize this as a higher level reading and display some positive level. As the sensor warms over some period of time, the moisture can evaporate and the sensor will again approach the correct reading of 0%. This condition can also be corrected immediately if liquid nitrogen is added to the cold trap freezing the residual moisture. This is a physical phenomenon and does not indicate any problem with your Roper Scientific level equipment.
7. Verify the sensor is free of contaminants and not subject to any physical distortion. Disconnect the BNC connector at the top of the sensor and measure the sensor resistance by placing an ohmmeter across the center pin and the outer barrel of the connector. The resistance of the sensor should typically be >10 MΩ.

Controller output does not turn on

WARNING!

This procedure is to be performed only when the controller is completely turned off and the power-cord has been removed from the power receptacle. Failure to do so could result in personnel coming in contact with high voltages capable of producing life-threatening electrical shock.

1. Verify continuity of controller output fuses, F2 and F3, located on the controller printed circuit board.
   a. Ensure the controller is turned off and that the powercord is disconnected from the power source. Disconnect the powercord from the connector located on the rear panel of the controller.
   b. Remove the controller top cover and check the fuses F2 and F3 for continuity.
   c. If a fuse is bad, replace with a 2.5A IEC 127-2 Type F Sheet II 5x20 mm fuse.
   - Check your connected equipment for compliance with the output receptacle rating.

Caution

Installing fuses of incorrect values and ratings could result in damage to the controller in the event of component failure.

2. Replace the fuse and securely fasten the controller top cover. Reconnect the powercord.

Unit not responding to communications

1. Verify your communications cable integrity and wiring. See page 136 for the DB-25 to DB-9 translation for RS-232 cables.
2. Check to make sure you are sending the correct termination to the controller. Make sure the echo feature is set correctly for your application and the baud rate matches the setting of the host device. Check your host communications software and make sure it is recognizing the return termination characters from the controller. For serial communication, the return termination characters are *<CR><LF>*.
3. If the controller is responding repeatedly with *-8* as the return message, try a device clear command (DCL) or powering the controller off and then back on. Be sure you are sending valid commands.

Custom Instrument Configurations

Modifying the line voltage requirements

WARNING!

Before removing the cover of the controller, remove the power from the controller by disconnecting the powercord from the power receptacle. Failure to do this could expose the user to high voltages and could result in life-threatening electrical shock.

Caution

> The Model 186 controller operates on 50-60 Hz power and may be configured for 110-120 or 208-240 VAC ±10% (100 or 200 VAC ±10% for Japan and South Korea). The power requirements for each controller are marked on the rear panel. Be sure the controller's power requirements match your power source prior to plugging in the powercord. Do not fail to connect the input ground terminal securely to an external earth ground.

If the controller operating voltage needs to be changed, make sure the controller is turned off and that the powercord is disconnected from the power source. Remove the controller cover and slide the voltage selector switch on the main printed circuit board to the proper voltage. Replace the controller cover and *indelibly mark the rear panel indications to match the new configuration*.

Additional Technical Support

If the cause of a problem cannot be located, contact a Roper Scientific representative at (609) 587-9797 for assistance. The Roper Scientific technical support group may also be reached by Internet e-mail at techsupport@roperscientific.com. Additional technical information, latest software releases, etc. are available at the Roper Scientific World Wide Web site at: http://www.roperscientific.com

Do not return the Model 186 or other liquid level system components to Roper Scientific without prior return authorization.

Return Authorization

Items to be returned to Roper Scientific for repair (warranty or otherwise) require a return authorization number to ensure your order will receive proper attention. Please call a Roper Scientific representative at (609) 587-9797 for a return authorization number before shipping any item back to the factory.

Specifications

Level Measurements[a]

Resolution: 0.1%, 0.1 cm, or 0.1 in

Linearity: ±0.1%

Maximum Length Readout: 650.0 cm (255.9 in)

Operating Parameters

HI and LO Alarms: 0% to 100% adjustable

HI/LO Alarm Relay Contact Ratings: 10 VA, 30 VAC or 60 VDC, 0.5 A (normally open, closed on alarm)

A and B Control Setpoints: 0% to 100% adjustable

---

a. Under extreme radiated electromagnetic field conditions (3V/m at 450 MHz to 610 MHz), the accuracy may be degraded by an additional ±0.7%.

b. Units configured for Japan or South Korea cannot be configured for operation at other voltages without an internal transformer change, and vice-versa.

Controller Output: AC line voltage @ 2A max current

Fill Timer: 0.1 to 600.0 minutes

Power Requirements

Primary[b]: 110-120 or 208-240 VAC ±10% 50 - 60 Hz

For Japan or S. Korea: 100 or 200 VAC ±10%

Maximum Current: 2.2 A

Physical

Dimensions (Standard): 97 mm H x 213 mm W x 282 mm D (3.8" H x 8.4" W x 11.1" D)

Weight (Standard): 1.6 kg (3.6 lbs.)

Environmental

Ambient Temperature: Operating: 0 °C to 50 °C (32 °F to 122 °F)

Nonoperating: -20 °C to 60 °C (-4 °F to 140 °F)

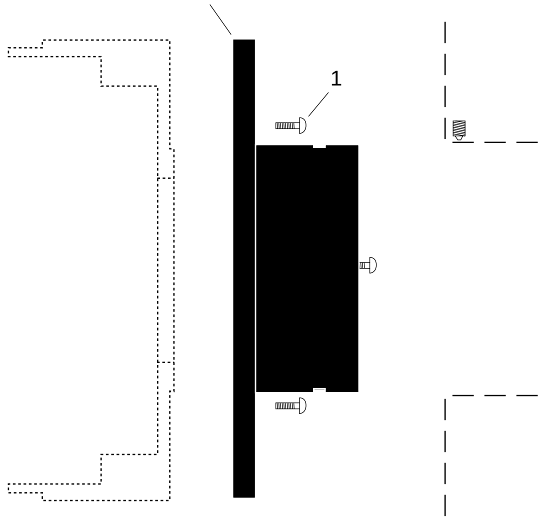
Relative Humidity: 0 to 95%; non-condensing

Appendix D
Spectrometer Adapters

Roper Scientific offers a variety of spectrometer adapters for LN- and NTE-based VersArray systems. The mounting instructions for these adapters are organized by spectrometer model, detector type, and adapter kit number. The table below cross-references these items with the page number for the appropriate instruction set.

Spectrometer	Detector Type	Adapter Kit No.	Page
Acton	LN with shutter, NTE with/without shutter		144
Chromex 250 IS	LN with shutter, NTE with/without shutter	7050-0089	145
ISA HR 320	LN with shutter, NTE with/without shutter	7050-0002	146
ISA HR 640	LN with shutter, NTE with/without shutter	7050-0014	147
JY TRIAX	NTE without shutter	7384-0072	148
SPEX 270M	LN with shutter, NTE with/without shutter	7050-0042	149
SPEX 500M	LN with shutter, NTE with/without shutter	7050-0018	150
SPEX TripleMate	LN with shutter, NTE with/without shutter	7050-0006	151

Acton (LN with shutter, NTE with or without shutter)



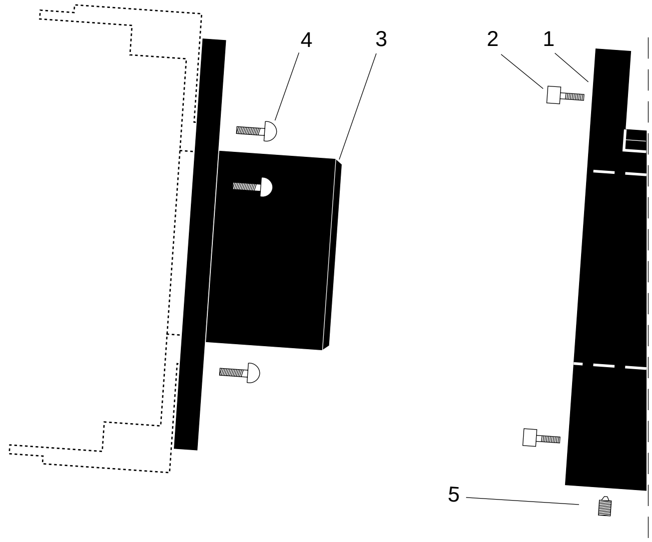
	Qty	P/N	Description
1.	3	2826-0127	Screw, 10-32 × 1/4, Button Head Allen Hex, Stainless Steel

Assembly Instructions

1. Make sure that the shipping cover has been removed from the detector port on the spectrometer.
2. Loosen the setscrews holding the Acton adapter in the spectrometer and remove the adapter.
3. Remove the spacer plate from the adapter by removing the three (3) socket head screws.
4. Mount the Acton adapter to the face of the detector drum housing (dashed outline in illustration) with the three (3) 1/4" long button head screws.
5. Gently insert the adapter into the spectrometer and fasten with the setscrews.

Note: Adapter parts are machined to provide a tight fit. It is necessary to rotate the detector back and forth when inserting into the spectrometer adapter. Do not force the two parts of the adapter together, as they can be permanently damaged by excessive force.

Chromex 250 IS (LN with shutter, NTE with or without shutter)



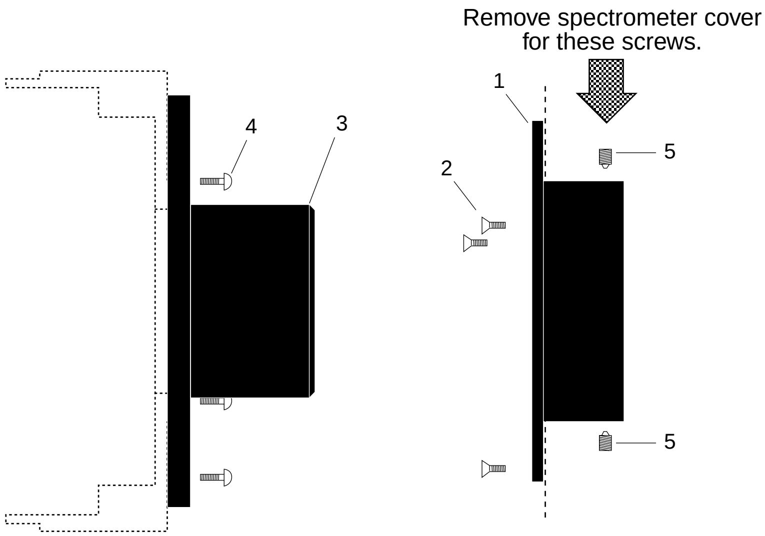
	Qty	P/N	Description
1.	1	2517-0901	Plate, Adapter-Female
2.	4	2826-0283	Screw, 10-32 × 3/4, Socket head, Stainless Steel, Hex, Black
3.	1	2518-0107	Adapter-Male, HR320
4.	3	2826-0127	Screw, 10-32 × 1/4, Button Head Allen Hex, Stainless Steel
5.	1	2826-0082	Set Screw, 10-32 × 1/4, Stainless Steel, Allen Hex, Nylon Tip

Assembly Instructions

1. Attach part 1 to the spectrometer (dashed line in illustration) with the socket head screws provided.
2. Attach part 3 to the detector with the three (3) 1/4" long button head screws provided.
3. Gently insert part 3 into part 1 and fasten with the setscrew.

Note: Adapter parts are machined to provide a tight fit. It is necessary to rotate the detector back and forth when inserting into the spectrometer adapter. Do not force the two parts of the adapter together, as they can be permanently damaged by excessive force.

ISA HR 320 (LN with shutter, NTE with or without shutter)



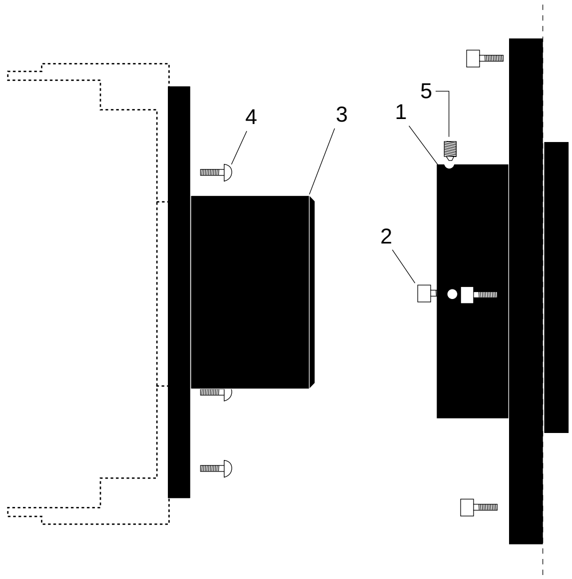
	Qty	P/N	Description
1.	1	2518-0106	Adapter-Female, HR320
2.	3	2826-0087	Screw, M5-10, Flat Head, Socket, Stainless Steel
3.	1	2518-0107	Adapter-Male, HR320
4.	3	2826-0127	Screw, 10-32 × 1/4, Button Head Allen Hex, Stainless Steel
5.	2	2826-0082	Set Screw, 10-32 × 1/4, Stainless Steel, Allen Hex, Nylon Tip

Assembly Instructions

1. Remove the spectrometer cover.
2. Insert part 1 into the spectrometer (dashed line in illustration), fasten with the flathead screws provided, and replace spectrometer cover.
2. Attach part 3 to the detector with the three (3) 1/4" long button head screws provided.
3. Gently insert part 3 into part 1 and fasten with the setscrews.
4. Replace the spectrometer cover.

Note: Adapter parts are machined to provide a tight fit. It is necessary to rotate the detector back and forth when inserting into the spectrometer adapter. Do not force the two parts of the adapter together, as they can be permanently damaged by excessive force.

ISA HR 640 (LN with shutter, NTE with or without shutter)



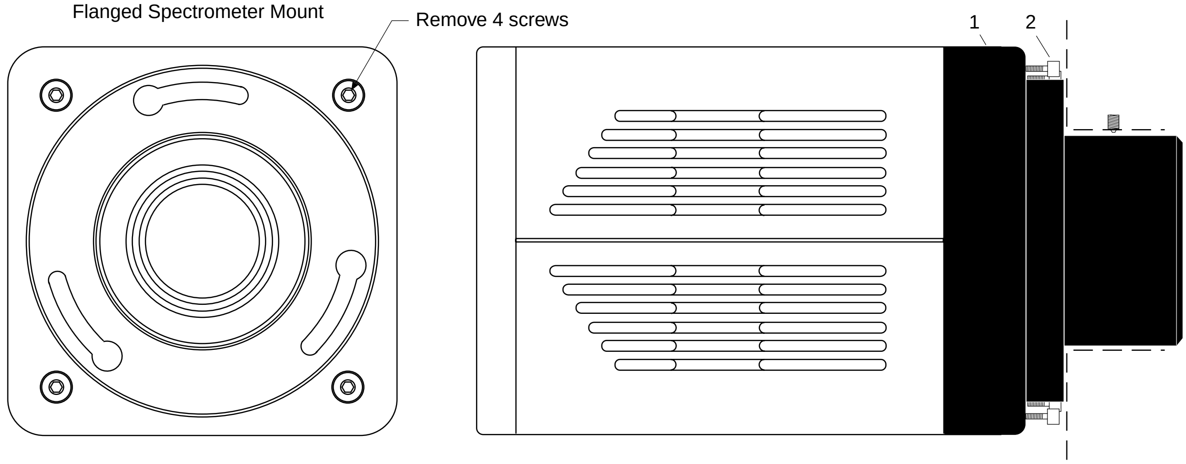
	Qty	P/N	Description
1.	1	2518-0203	Adapter-Female, HR640
2.	4	2826-0144	Screw, M4-.7 × 14, Socket Head Cap, Stainless Steel
3.	1	2518-0107	Adapter-Male, HR320
4.	3	2826-0127	Screw, 10-32 × 1/4, Button Head Allen Hex, Stainless Steel
5.	2	2826-0082	Set Screw, 10-32 × 1/4, Stainless Steel, Allen Hex, Nylon Tip

Assembly Instructions

1. Insert part 1 into the spectrometer (dashed line in illustration) and fasten with the socket head screws provided.
2. Attach part 3 to the detector with the three (3) 1/4" long button head screws provided.
3. Gently insert part 3 into part 1 and fasten with the setscrews.

Note: Adapter parts are machined to provide a tight fit. It is necessary to rotate the detector back and forth when inserting into the spectrometer adapter. Do not force the two parts of the adapter together, as they can be permanently damaged by excessive force.

JY TRIAX family (NTE without shutter)



	Qty	P/N	Description
1.	1	2518-1000	Adapter, TRIAX, NTE, 7377, 7376, 7413
2.	4	2826-0191	Screw, 10-32 × 5/8, Socket Head, Stainless Steel, Hex, Black

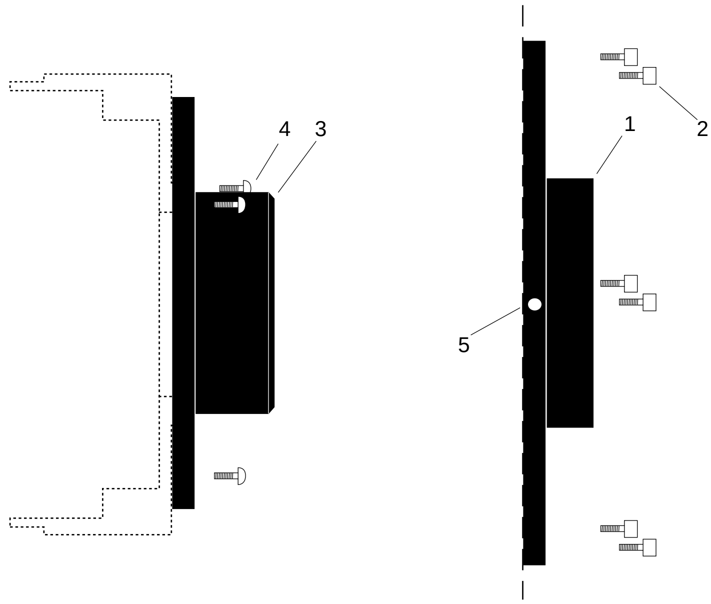
Typically, the adapter is shipped already mounted to the detector. The following procedure is provided in case you have ordered a JY TRIAX adapter for a shutterless MicroMAX NTE camera that you already own.

Assembly Instructions

1. While supporting the flange, remove the four (4) of the socket head screws from the front of the detector (see illustration above) and store these screws.
2. Using the four (4) screws provided with the adapter kit, mount part 1 to the front of the detector.
3. Remove the spectrometer cover.
4. Insert part 1 into the spectrometer and fasten it in place with the spectrometer setscrew.
5. Replace the spectrometer cover.

Note: Adapter parts are machined to provide a tight fit. It may be necessary to rotate the detector back and forth when inserting into the spectrometer adapter. Do not force the two parts of the adapter together, as they can be permanently damaged by excessive force

SPEX 270M (LN with shutter, NTE with or without shutter)



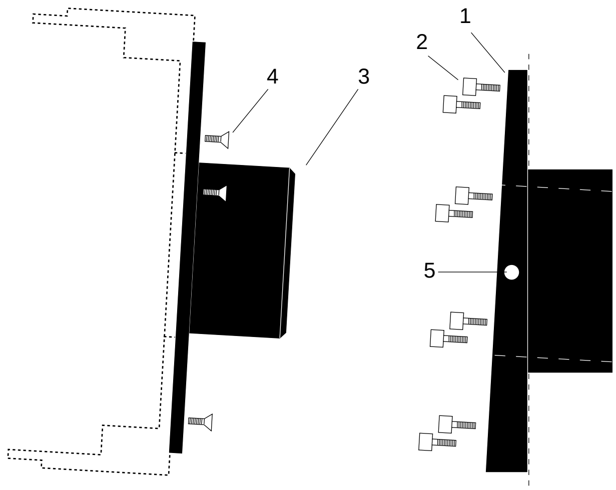
	Qty	P/N	Description
1.	1	2518-0691	Female Adapter Plate, 2.400 ID
2.	6	2826-0068	Screw, 6-32 × 3/8, Socket Head, Cap, Stainless Steel
3.	1	2518-0690	Adapter, Focusing, Male, Spec 270
4.	3	2826-0127	Screw, 10-32 × 1/4, Button Head, Hex, Stainless Steel
5.	2	2826-0073	Screw 6-32 × 1/8, Set, Allen Hex, Brass Tip

Assembly Instructions

1. Remove the cover of the spectrometer.
2. Attach part 1 to the inner wall of the spectrometer (dashed line in illustration) with the socket head screws provided.
3. Attach part 3 to the detector with the three (3) 1/4" long button head screws provided.
4. Gently insert part 3 into part 1 and fasten with the setscrews.
5. Replace the spectrometer cover.

Note: Adapter parts are machined to provide a tight fit. It is necessary to rotate the detector back and forth when inserting into the spectrometer adapter. Do not force the two parts of the adapter together, as they can be permanently damaged by excessive force.

SPEX 500M (LN with shutter, NTE with or without shutter)



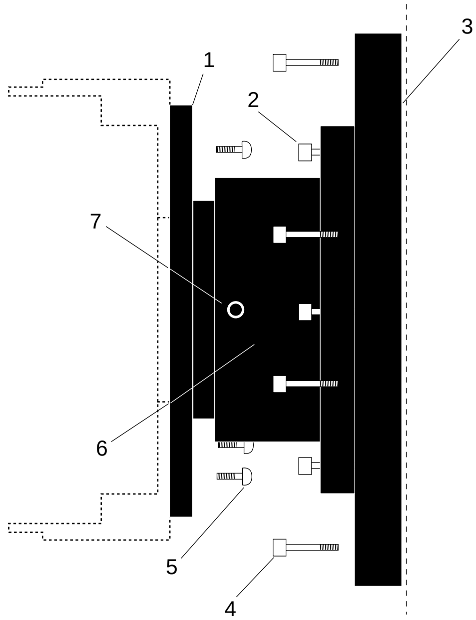
	Qty	P/N	Description
1.	1	2517-0214	Adapter-Female, Spex 500m
2.	8	2826-0170	Screw, 1/4-20 × 0.51, Low Socket Head Cap, Black
3.	1	2518-0223	Adapter-Male, Spex 500m
4.	3	2826-0134	Screw, 10-32 × 1/4, Flat Head Slot, Stainless Steel (Prontor)
5.	2	2826-0055	Screw, 8-32 × 14, Set Allen Hex, Nylon

Assembly Instructions

1. Insert part 1 into the spectrometer wall (dashed line in illustration) and fasten with the socket head screws provided.
2. Attach part 3 to the detector with the three (3) 1/4" long flathead screws provided.
3. Gently insert part 3 into part 1 and fasten with the setscrews.

Note: Adapter parts are machined to provide a tight fit. It is necessary to rotate the detector back and forth when inserting into the spectrometer adapter. Do not force the two parts of the adapter together, as they can be permanently damaged by excessive force.

SPEX TripleMate (LN with shutter, NTE with or without shutter)



	Qty	P/N	Description
1.	1	2518-0184	Adapter-Male, LN/TE, CCD/For Spex TripleMate
2.	4	2826-0128	Screw, 10-32 × 5/8, Socket Head Cap, Stainless Steel,
3.	1	2517-0163	Slit Mount, Spex
4.	4	2826-0129	Screw, 1/4-20 × 3/4, Socket Head Cap, Stainless Steel
5.	3	2826-0127	Screw, 10-32 × 1/4, Button Head, Hex, Stainless Steel (Prontor)
6.	1	2518-0185	Adapter-Female, Flange Spex
7.	2	2826-0082	Set Screw, 10-32 × 1/4, Stainless Steel, Allen Hex, Nylon Tip
	1	2500-0025	O-ring, 2.359x.139, Viton (installed)
	1	2500-0026	O-ring, 2.484x.139, Viton (installed)

Assembly Instructions

1. Mount the whole assembly onto the spectrometer.
2. Loosen setscrews and pull out part 1 far enough to enable access to screws with Allen wrench. Do not pull part 1 past the O-ring (If you do pull out part 1 completely, reinsert before attaching the detector).
3. Attach the detector to part 1 with the three (3) 1/4" button head screws provided.
4. Tighten the setscrews.

Note: Adapter parts are machined to provide a tight fit. It is necessary to rotate the detector back and forth when inserting into the spectrometer adapter. Do not force the two parts of the adapter together, as they can be permanently damaged by excessive force.

This page intentionally left blank.

Declarations of Conformity

This section of the VersArray manual contains the declarations of conformity for VersArray systems. VersArray systems encompass LN-cooled, NTE-cooled, and TEA-cooled camera heads and their associated controllers.

DECLARATION OF CONFORMITY

We,

ROPER SCIENTIFIC

(PRINCETON INSTRUMENTS)

3660 QUAKERBRIDGE ROAD

TRENTON, NJ 08619

Declare under our sole responsibility, that the product

ST-133A CONTROLLER w/LN CAMERA HEAD,

To which this declaration relates, is in conformity with general safety requirement for electrical equipment standards:

IEC 1010-1:1990, EN 61010-1:1993/A2:1995,

EN 61326 for Class A, 1998,

(EN 61000-4-2, EN 61000-4-3, EN 61000-4-4, EN 61000-4-5, EN 61000-4-6, EN 61000-4-11),

Which follow the provisions of the

CE LOW VOLTAGE DIRECTIVE 73/23/EEC

And

EMC DIRECTIVE 89/336/EEC.

Date: August 7, 2002
TRENTON, NJ

(PAUL HEAVENER)
Engineering Manager

DECLARATION OF CONFORMITY

We,

ROPER SCIENTIFIC

(PRINCETON INSTRUMENTS)

3660 QUAKERBRIDGE ROAD

TRENTON, NJ 08619

Declare under our sole responsibility, that the product

ST-133A 1MHz HIGH POWER CONTROLLER

w/NTE CAMERA HEAD,

To which this declaration relates, is in conformity with general safety requirement for electrical equipment standards:

IEC 1010-1:1990, EN 61010-1:1993/A2:1995,

EN 55011 for Group 1, Class A, 1991,

EN50082-1, 1991 (EN 61000-4-2, EN 61000-4-3, EN 61000-4-4),

Which follow the provisions of the

CE LOW VOLTAGE DIRECTIVE 73/23/EEC

And

EMC DIRECTIVE 89/336/EEC.

Date: August 20, 2002
TRENTON, NJ

(PAUL HEAVENER)
Engineering Manager

DECLARATION OF CONFORMITY

We,

ROPER SCIENTIFIC

(PRINCETON INSTRUMENTS)

3660 QUAKERBRIDGE ROAD

TRENTON, NJ 08619

Declare under our sole responsibility, that the product

ST-133A 1MHz HIGH POWER CONTROLLER

w/TEA CAMERA HEAD,

To which this declaration relates, is in conformity with general safety requirement for electrical equipment standards:

IEC 1010-1:1990, EN 61010-1:1993/A2:1995,

EN 55011 for Group 1, Class A, 1991,

EN50082-1, 1991 (EN 61000-4-2, EN 61000-4-3, EN 61000-4-4),

Which follow the provisions of the

CE LOW VOLTAGE DIRECTIVE 73/23/EEC

And

EMC DIRECTIVE 89/336/EEC.

Date: August 20, 2002
TRENTON, NJ

(PAUL HEAVENER)
Engineering Manager

Warranty & Service

Limited Warranty: Roper Scientific Analytical Instrumentation

Roper Scientific, Inc. ("Roper Scientific," us," "we," "our") makes the following limited warranties. These limited warranties extend to the original purchaser ("You", "you") only and no other purchaser or transferee. We have complete control over all warranties and may alter or terminate any or all warranties at any time we deem necessary.

Basic Limited One (1) Year Warranty

Roper Scientific warrants this product against substantial defects in materials and / or workmanship for a period of up to one (1) year after shipment. During this period, Roper Scientific will repair the product or, at its sole option, repair or replace any defective part without charge to you. You must deliver the entire product to the Roper Scientific factory or, at our option, to a factory-authorized service center. You are responsible for the shipping costs to return the product. International customers should contact their local Roper Scientific authorized representative/distributor for repair information and assistance, or visit our technical support page at www.roperscientific.com.

Limited One (1) Year Warranty on Refurbished or Discontinued Products

Roper Scientific warrants, with the exception of the CCD imaging device (which carries NO WARRANTIES EXPRESS OR IMPLIED), this product against defects in materials or workmanship for a period of up to one (1) year after shipment. During this period, Roper Scientific will repair or replace, at its sole option, any defective parts, without charge to you. You must deliver the entire product to the Roper Scientific factory or, at our option, a factory-authorized service center. You are responsible for the shipping costs to return the product to Roper Scientific. International customers should contact their local Roper Scientific representative/distributor for repair information and assistance or visit our technical support page at www.roperscientific.com.

Shutter Limited One Year Warranty

Roper Scientific warrants for a period of up to one (1) year after shipment the standard, factory-installed camera shutter of all our products that incorporate an integrated shutter. This limited warranty applies to the standard shutter installed in the camera system at the time of manufacture. *Non-standard shutters, special product request (SPR) shutters, and third-party shutter drive equipment carry NO WARRANTIES EXPRESSED OR IMPLIED.* Roper Scientific will supply, at no cost to the customer, up to one (1) replacement shutter during the warranty period. Roper Scientific will, at Roper Scientific's option, either ship a ready-to-install shutter to the customer site for installation by the customer according to the instructions in the product User Manual or arrange with the customer to return the camera system (or portion of the camera system) to the factory (or factory-authorized service center) for shutter replacement by us or a Roper Scientific-authorized agent. Responsibility for shipping charges is as described above under our Limited One (1) Year Warranty.

VersArray (XP) Vacuum Chamber Limited Lifetime Warranty

Roper Scientific warrants that the cooling performance of the system will meet our specifications over the lifetime of the VersArray (XP) detector or Roper Scientific will, at its sole option, repair or replace any vacuum chamber components necessary to restore the cooling performance back to the original specifications at no cost to the original purchaser. *Any failure to "cool to spec" beyond our Basic (1) year limited warranty from date of shipment, due to a non-vacuum-related component failure (e.g., any components that are electrical/electronic) is NOT covered and carries NO WARRANTIES EXPRESSED OR IMPLIED.* Responsibility for shipping charges is as described above under our Basic Limited One (1) Year Warranty.

Sealed Chamber Integrity Limited 24 Month Warranty

Roper Scientific warrants the sealed chamber integrity of all our products for a period of twenty-four (24) months after shipment. If, at anytime within twenty-four (24) months from the date of delivery, the detector should experience a sealed chamber failure, all parts and labor needed to restore the chamber seal will be covered by us. *Open chamber products carry NO WARRANTY TO THE CCD IMAGING DEVICE, EXPRESSED OR IMPLIED.* Responsibility for shipping charges is as described above under our Basic Limited One (1) Year Warranty.

Vacuum Integrity Limited 24 Month Warranty

Roper Scientific warrants the vacuum integrity of all our products for a period of up to twenty-four (24) months from the date of shipment. We warrant that the detector head will maintain the factory-set operating temperature without the requirement for customer pumping. Should the detector experience a Vacuum Integrity failure at anytime within twenty-four (24) months from the date of delivery all parts and labor needed to restore the vacuum integrity will be covered by us. Responsibility for shipping charges is as described above under our Basic Limited One (1) Year Warranty.

Image Intensifier Detector Limited One Year Warranty

All image intensifier products are inherently susceptible to Phosphor and/or Photocathode burn (physical damage) when exposed to high intensity light. Roper Scientific warrants, with the exception of image intensifier products that are found to have Phosphor and/or Photocathode burn damage (which carry NO WARRANTIES EXPRESSED OR IMPLIED), all image intensifier products for a period of one (1) year after shipment. *See additional Limited One (1) year Warranty terms and conditions above, which apply to this warranty.* Responsibility for shipping charges is as described above under our Basic Limited One (1) Year Warranty.

X-Ray Detector Limited One Year Warranty

Roper Scientific warrants, with the exception of CCD imaging device and fiber optic assembly damage due to X-rays (which carry NO WARRANTIES EXPRESSED OR IMPLIED), all X-ray products for one (1) year after shipment. Se*e additional Basic Limited One (1) year Warranty terms and conditions above, which apply to this warranty.* Responsibility for shipping charges is as described above under our Basic Limited One (1) Year Warranty.

Software Limited Warranty

Roper Scientific warrants all of our manufactured software discs to be free from substantial defects in materials and / or workmanship under normal use for a period of one (1) year from shipment. Roper Scientific does not warrant that the function of the software will meet your requirements or that operation will be uninterrupted or error free. You assume responsibility for selecting the software to achieve your intended results and for the use and results obtained from the software. In addition, during the one (1) year limited warranty. The original purchaser is entitled to receive free version upgrades. Version upgrades supplied free of charge will be in the form of a download from the Internet. Those customers who do not have access to the Internet may obtain the version upgrades on a CD-ROM from our factory for an incidental shipping and handling charge. *See Item 12 in the following section of this warranty ("Your Responsibility") for more information.*

Owner's Manual and Troubleshooting

You should read the owner's manual thoroughly before operating this product. In the unlikely event that you should encounter difficulty operating this product, the owner's manual should be consulted before contacting the Roper Scientific technical support staff or authorized service representative for assistance. If you have consulted the owner's manual and the problem still persists, please contact the Roper Scientific technical support staff or our authorized service representative. *See Item 12 in the following section of this warranty ("Your Responsibility") for more information.*

Your Responsibility

The above Limited Warranties are subject to the following terms and conditions:

1. You must retain your bill of sale (invoice) and present it upon request for service and repairs or provide other proof of purchase satisfactory to Roper Scientific.
2. You must notify the Roper Scientific factory service center within (30) days after you have taken delivery of a product or part that you believe to be defective. With the exception of customers who claim a "technical issue" with the operation of the product or part, all invoices must be paid in full in accordance with the terms of sale. Failure to pay invoices when due may result in the interruption and/or cancellation of your one (1) year limited warranty and/or any other warranty, expressed or implied.
3. All warranty service must be made by the Roper Scientific factory or, at our option, an authorized service center.
4. Before products or parts can be returned for service you must contact the Roper Scientific factory and receive a return authorization number (RMA). Products or parts returned for service without a return authorization evidenced by an RMA will be sent back freight collect.
5. These warranties are effective only if purchased from the Roper Scientific factory or one of our authorized manufacturer's representatives or distributors.
6. Unless specified in the original purchase agreement, Roper Scientific is not responsible for installation, setup, or disassembly at the customer's location.

7. Warranties extend only to defects in materials or workmanship as limited above and do not extend to any product or part which has:
   - been lost or discarded by you;
   - been damaged as a result of misuse, improper installation, faulty or inadequate maintenance or failure to follow instructions furnished by us;
   - had serial numbers removed, altered, defaced, or rendered illegible;
   - been subjected to improper or unauthorized repair; or
   - been damaged due to fire, flood, radiation, or other “acts of God” or other contingencies beyond the control of Roper Scientific.
8. After the warranty period has expired, you may contact the Roper Scientific factory or a Roper Scientific-authorized representative for repair information and/or extended warranty plans.
9. Physically damaged units or units that have been modified are not acceptable for repair in or out of warranty and will be returned as received.
10. All warranties implied by state law or non-U.S. laws, including the implied warranties of merchantability and fitness for a particular purpose, are expressly limited to the duration of the limited warranties set forth above. With the exception of any warranties implied by state law or non-U.S. laws, as hereby limited, the forgoing warranty is exclusive and in lieu of all other warranties, guarantees, agreements, and similar obligations of manufacturer or seller with respect to the repair or replacement of any parts. In no event shall Roper Scientific’s liability exceed the cost of the repair or replacement of the defective product or part.
11. This limited warranty gives you specific legal rights and you may also have other rights that may vary from state to state and from country to country. Some states and countries do not allow limitations on how long an implied warranty lasts, when an action may be brought, or the exclusion or limitation of incidental or consequential damages, so the above provisions may not apply to you.
12. When contacting us for technical support or service assistance, please refer to the Roper Scientific factory of purchase, contact your authorized Roper Scientific representative or reseller, or visit our technical support page at www.roperscientific.com.

Contact Information

Roper Scientific's manufacturing facility for this product is located at the following address:

Roper Scientific
3660 Quakerbridge Road
Trenton, NJ 08619 (USA)

Tel: 609-587-9797
Fax: 609-587-1970

Technical Support E-mail: techsupport@roperscientific.com

For technical support and service outside the United States, see our web page at www.roperscientific.com. An up-to-date list of addresses, telephone numbers, and e-mail addresses of Roper Scientific's overseas offices and representatives is maintained on the web page.

Index

P-R

S

T

U-Z