Princeton Instruments

PI-SX® System

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Chapter 1

Introduction

Description

The PI-SX® is a high-sensitivity digital system that incorporates a back-illuminated CCD without AR coating for low-energy x-ray imaging. The PI·SX features dual-speed digitization, 16-bit dynamic range, and a vacuum-open-nose configuration. To reduce dark noise, the PI·SX offers two cooling options: thermoelectric (for high-performance, maintenance-free operation) or liquid nitrogen (for very low dark current and longer exposures).

Figure 1. PI-SX Cameras

Princeton Instruments knows that a camera built to detect soft x-ray photons (~30 eV - ~3 keV) needs to meet deep-vacuum-interface requirements. The Princeton Instruments PI·SX™ line of digital cameras uses a vacuum flange and a back-illuminated CCD (without antireflection coating) to detect soft x-ray photons directly in the silicon. This design offers higher sensitivity, high dynamic range, and higher resolution.

The high sensitivity and resolution of these cameras in the energy range between 280 eV and 540 eV (water window: 23 - 45 angstroms) make them well suited for studying hydrated organic specimens at a resolution near that of an electron microscope, but without the complex sample-preparation requirements. Therefore, the PI·SX system offers high contrast, good penetration in micrometer-thick water layers, and the potential for high resolution. Furthermore, high-brilliance tunable x-ray sources at synchrotrons allow x-ray microscopes to achieve element-specific imaging, thus providing insight into structure composition.

The low-energy sensitivity of the PI·SX camera system also works well for diagnostics, EUV lithography, and applications of laser-produced plasmas. When plasmas are produced in tokamaks and other experiments, they frequently emit substantial soft x-rays (100 eV up to 10 keV). This can be used to spectroscopically characterize the plasma or image specimens irradiated with soft x-rays generated by the plasmas.

Design

Thermoelectrically (TE)-cooled PI-SX cameras have three distinct sections. The front enclosure contains the CCD array seated on a cold finger. This finger is in turn seated on a multi-stage Peltier thermoelectric cooler. The middle enclosure contains the heat exchanger from which heat is transferred out of the camera by forced air or circulating coolant. The rear enclosure contains the preamplifier and array driver boards. This keeps all signal leads to the preamplifier as short as possible, and also provides RF shielding.

The liquid nitrogen (LN)-cooled cameras also have a front enclosure in which the CCD array is seated on a cold finger. This finger is in contact with the LN Dewar and has a heater to regulate the CCD temperature. The front enclosure opens into the vacuum jacket that surrounds the internal LN Dewar. The Dewar is filled through a sealable top opening, and has two pressure relief valves operating at 1 and 10 psi to safely vent N_2 gas. The electronics enclosure contains the preamplifier and array driver board, keeping all signal leads to the preamplifier as short as possible, and providing complete RF shielding.

PI-SX System Components

The Princeton Instruments PI-SX® System normally contains the major components shown in Figure 2. Actual system components will depend on the system configuration ordered.

Figure 2. Standard System Components

Cooling and PI-SX Cameras

Introduction

Cameras in the PI-SX family are cooled either thermoelectrically (TE)- or cryogenically-cooled. Whether the cooling relies on TE-cooling (and perhaps aided with forced air or circulating liquid) or relies on cryogenic cooling, the intention is to remove heat from the CCD array. The combination of CCD array size and the type of cooling determine the amount of cooling that can be accomplished (see Table 1). Generally speaking, the lower the array temperature, the lower the dark current and, therefore, the greater the sensitivity.

PI-SX Camera Cooling Performance*						
	TE Cooling (°C)				LN cooling (°C)	
	Air		Chilled Water			
Model	Min	Typ	Min	Typ	Min	Typ
PI-SX:100 (1340x100)	-50	-60	N/A	N/A	-110	-120
PI-SX:400 (1340x400)	-50	-60	N/A	N/A	-110	-120
PI-SX:2k (2048x512)	-70	-75	N/A	N/A	N/A	N/A
PI-SX:512 (512x512)	-40	-45	-55	-60	-110	-120
PI-SX:1K (1024x1024)	-45	-50	-55	-60	-110	-120
PI-SX:1300 (1340x1300)	-40	-45	-45	-55	-100	-110
PI-SX:2048 (2048x2048)	-40	-45	-45	-55	-100	-110

* Ambient temperature of 20°C and vacuum level of 10^{-5} - 10^{-6} Torr or better are required to reach these temperatures.

Table 1. Cooling Performance vs. Camera Model

TE-Cooling

Thermoelectric-cooling for PI-SX cameras has been implemented in three different ways: Air-Assist, Liquid-Assist, or Liquid-Cooled. In all three cases, the camera has three distinct sections. The front section contains the CCD array seated on a cold finger. This finger is in turn seated on a multi-stage Peltier thermoelectric cooler. The back enclosure contains the heat exchanger. The electronics enclosure contains the preamplifier and array driver board. This design keeps all signal leads to the preamplifier as short as possible and also provides RF shielding. The difference in implementation is the mechanism for removing heat from the inside of the camera:

- ***Air-Assist:*** Incorporates an internal fan that cools the heat exchanger. Air is drawn in from the rear most vents on the side of the camera and is exhausted through the front most side vents.
- ***Liquid-Assist:*** Relies 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.

- ***Liquid-Cooled:*** Relies 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.***

Caution

The PI-SX TE-cooled camera requires the ST-133 Controller that has been shipped with it. Do not use that ST-133 Controller with an LN-cooled camera.

LN-Cooling

Cryogenically-cooled cameras use liquid nitrogen (LN_2) 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 array temperature is regulated by a heating element driven by closed-loop proportional control circuitry. A thermal sensing diode attached to the cooling block of the camera monitors the array temperature.

ATTENTION

With an LN-cooled camera, 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 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).

Grounding and Safety

The ST-133 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:

- Do not mix and match ST-133 Controllers and cameras. The controller shipped with your camera has been modified to operate with the camera included in the PI-SX system you ordered.
- Always switch off and unplug the ST-133 Controller before changing your system configuration in any way.
- The CCD array is very sensitive to static electricity. Touching the CCD array 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. Transient voltage spikes can permanently damage the array. 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 array.
- Never prevent the free flow of air through the equipment by blocking the air vents.
- Never operate a liquid-assisted or liquid-cooled-only PI-SX camera with coolant at a temperature below that specified for it.

Cleaning

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

Although there is no periodic maintenance that *must* be performed on a PI-SX camera or an ST-133 controller, 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.

Repairs

Save the original packing materials. Because the PI-SX camera system contains no user-serviceable parts, Princeton Instruments must do repairs. Should your system need repair, contact Princeton Instruments Customer Support for instructions (telephone, e-mail, and address information are provided on page 102 of this manual).

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

Princeton Instruments Customer Support

Refer to the contact information located on page 102 of this manual.

About this Manual

Manual Organization

This manual provides the user with all the information needed to install a PI-SX detector and place it in operation. Topics covered include a detailed description of the detector, installation, cleaning, specifications and more.

Note: The general identifier "ST-133" is used for both the ST-133A Controller and the ST-133B Controller. Where there is a difference, the specific identifier is used.

Chapter 1**, **Introduction provides an overview of the PI-SX cameras.

Chapter 2, System Component Descriptions provides information about the camera, controller, interface card, cables, and application software.

Chapter 3, Installation Overview cross-references PI-SX system setup actions with the relevant manuals and/or manual pages. It also contains system layout diagrams.

Chapter 4, System Setup provides detailed directions for setting up a PI-SX camera for imaging applications and presents overexposure protection considerations.

Chapter 5, Operation includes a simple procedure for verifying system operation and discusses operational considerations associated with exposure, readout, and digitization.

Chapter 6, Advanced Topics discusses standard timing modes (Free Run, External Sync, and Continuous Cleans), Fast and Safe triggering modes, and TTL control.

Chapter 7, Troubleshooting provides courses of action to take if you should have problems with your system.

Appendix A, Specifications includes PI-SX camera and ST-133 controller specifications.

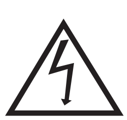
Appendix B, Outline Drawings includes outline drawings of the PI-SX cameras and of the ST-133A and ST-133B controllers.

Appendix C, USB 2.0 Limitations covers the currently known limitations associated with operating under the USB 2.0 interface.

Warranty & Service provides 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.

Chapter 2
System Component Descriptions

PI-SX Camera

CCD Array: The PI-SX cameras incorporate back-illuminated CCDs without AR coating for soft x-ray photon detection. The large array megapixel CCDs (full-frame devices with 100% fill factors) offer large imaging areas with the high spatial resolution necessary for soft x-ray applications.

Vacuum Mounts: Windowless and shutterless, PI-SX cameras are available with either Vacuum Open Nose (VON) or ConFlat flange mounts.

Connectors:

Controller: Power, control signals, and data are transmitted between the ST-133 and the PI-SX camera via the 25-pin D connector located on the rear of the camera. 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 external shutter. Controller power must be OFF before connecting to or disconnecting from this connector.

Cooling: Dark current is significantly reduced in PI-SX camera systems through air-cooled, liquid-assisted Thermoelectric (TE) or Cryogenic (LN_2) cooling of the CCD array.

TE Cooling

Peltier: An internal Peltier device directly cools the cold finger on which the CCD is mounted. The heat produced by the Peltier device is then removed by conduction to the internal heatsink. Heat is transferred out of the camera by conduction to the outside case or by the flow of coolant through the heatsink.

Fan: (NTE/NTE 2 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. Heat produced by the Peltier device is removed by the air drawn into the camera by the internal fan and exhausted through the side covers. 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 camera and the laboratory atmosphere.

Coolant Ports: Two 3/8" coolant ports are located on the side(s) of the camera. Instructions for setting up coolant flow are provided on page 36.

LN_2 Cooling

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_2). The Dewar for the end-on camera holds 2.2 liters of liquid nitrogen (LN_2).

An "all-directional" Dewar is available from Princeton Instruments. 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 camera. If you are uncertain, check the shipping paperwork to verify that your Dewar is an all-directional model.

ST-133 Controller

Electronics: The ST-133 Controller is a compact, high performance CCD Camera Controller for operation with Princeton Instruments cameras. Designed for high speed and high performance image acquisition, the ST-133 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 location and characteristics depend on the version of ST-133 Controller that was shipped with your system. In some versions, the power switch (located on the front panel as shown in Figure 3) has an integral indicator LED that lights whenever the ST-133 is powered. In other versions, the power switch is located on the back of the ST-133 and does not include an indicator LED.

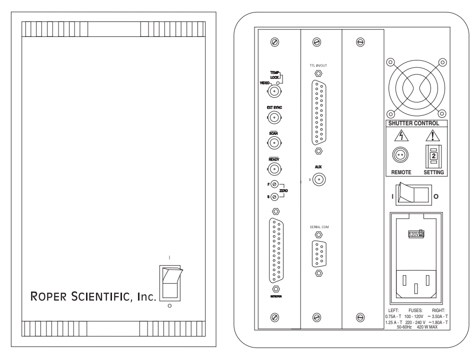


Figure 3. Power Switch Location (ST-133A and ST-133B)

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 7, pages 83-84.

WARNING!

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

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

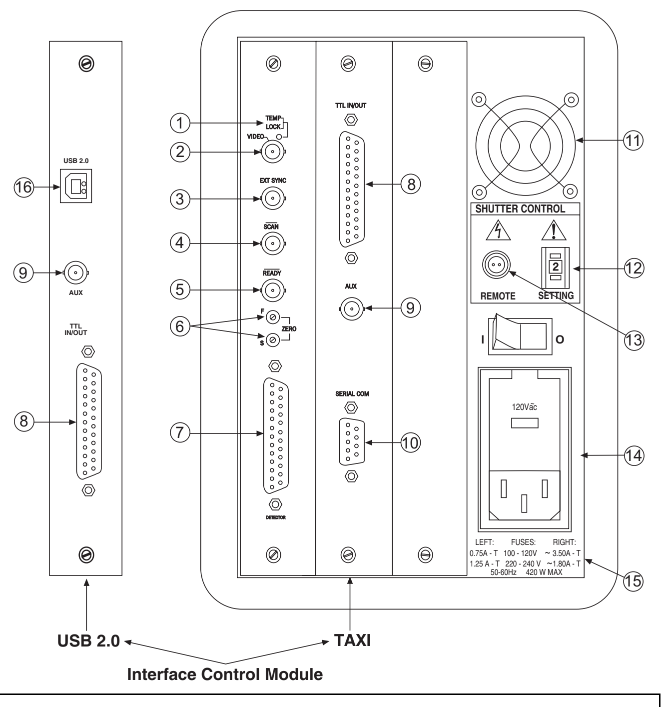
The **Interface Control Module**, which should always be located in the center slot, provides the following functions.

- TTL In/Out Programmable Interface
- Communications Control (TAXI or USB 2.0 protocol)

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. Depending on your system, either the TAXI or the USB 2.0 Interface Control Module will be installed in the second from the left slot (as you face the rear of the ST-133). In the figure, the TAXI module is shown in that position.

#	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/Aux Output:** If labeled Video, composite video output is provided at this connector. The amplitude is 1 V pk-pk and the source impedance is 75 Ω. Note that video output is not currently supported under USB 2.0. If labeled Aux, this output is reserved for future use.
3	**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.



#	Feature
4	$\overline{\text{SCAN}}$ **Output:** WinView/32 or WinSpec/32 (ver. 2.4 and higher) software selectable NOT SCAN or SHUTTER signal. Default is SHUTTER. NOT SCAN reports when the controller is finished reading out the CCD array. NOT SCAN is high when the CCD array is not being scanned, then drops low when readout begins, returning to high when the process is finished. The second signal, SHUTTER, reports when the shutter is opened and can be used to synchronize external shutters. SHUTTER is low when the shutter is closed and goes high when the shutter is activated, dropping low again after the shutter closes.
5	$\overline{\text{READY}}$ **Output:** Initially HIGH. After a Start Acquisition command, this output changes state on completion of the array cleaning cycles that precede the *first* exposure. Initially high, it goes low to mark the beginning of the *first* exposure. In free run operation it remains low until the system is halted. If a specific number of frames have been programmed, it remains low until all have been taken, then returns high.
6	**Zero Adjustment:** Bias potentiometers control the offset values of the Fast (F) and Slow (S) A/D converters. Preadjusted at factory. If potentiometers are not present, bias may be software-settable. The offset is a voltage that is added to the signal to bring the A/D output to a non-zero value, typically 50-100 counts. This offset value ensures that all the true variation in the signal can really be seen and not lost below the A/D "0" value. Since the offset is added to the signal, these counts only minimally reduce the range of the signal from 65535 to a value in the range of 50-100 counts lower. **CAUTION:** Do not adjust the offset values to zero, or some low-level data will be missed.
7	**Detector Connector:** Transmits control information to the camera and receives data back from the camera via the Detector-Controller cable.
8	**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 6, page 64
9	**AUX Output:** Reserved for future use.
10	**Serial COM Connector:** Provides two-way serial communication between the controller and the host computer. Uses TAXI protocol.
11	**Fan:** Cools the controller electronics. Runs continuously when the controller is turned on.
12	**Shutter Setting Selector:** Sets the shutter drive voltage. Dial is correctly set at the factory for the camera's internal shutter if one is present.
13	**Remote Shutter Connector:** Provides shutter-drive pulses for an external shutter. An ST-133 with the 70 V shutter option is required for a camera with the 40 mm shutter. A 70 V OPT label will be next to the Remote connector when this option is installed.
14	**Power Module:** Contains the powercord socket and two fuses. Depending on the ST-133 version, the power switch may be located directly above the power module.
15	**Fuse/Voltage Label:** Displays the controller's power and fuse requirements. This label may appear below the power module.
16	**USB 2.0 Connector:** Provides two-way serial communication between the controller and the host computer. Uses USB 2.0 protocol.

Cables

Detector-Controller: The standard 10' (3 m) cable (6050-0321) has DB-25 connectors with slide-latch locking hardware. This cable interconnects the Detector connector on the rear of the ST-133 with the Detector connector on the rear of the PI-SX camera. The Detector-Controller cable is also available in 6', 15', 20', and 30' lengths.

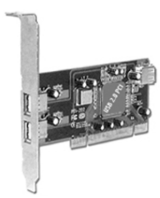
Interface Cable: Depending on the system configuration, either a USB or a TAXI cable will be shipped.

TAXI: The standard 25' (7.6 m) cable (6050-0148-CE) has DB-9 Male connectors with screw-down locking hardware. The TAXI (Serial communication) cable interconnects the "Serial Com" connector on the rear of the ST-133 with the Princeton Instruments (RSPI) high speed PCI card installed in the host computer. In addition to the standard length, this cable is available in 10', 50', 100', and 165' lengths. Also available are fiber optic adapters with fiber optic cables in 100, 300, and 1000 meter lengths.

USB 2.0: The standard 16.4' (5 m) cable (6050-0494) has USB connectors that interconnect the "USB 2.0" connector on the rear of the ST-133 with a USB card installed in the host computer.

Interface Card

PCI Card: The Princeton Instruments (RSPI) high speed PCI card is required when the system interface uses the TAXI protocol rather than USB 2.0. The PCI card plugs-into the host computer's motherboard and provides the serial communication interface between the host computer and the ST-133. Through WinView/32 or WinSpec/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.



USB 2.0 Card: This interface card is required when the system interface uses the USB 2.0 protocol rather the TAXI protocol and the computer does not have native USB 2.0 support. The USB 2.0 card plugs-into the host computer's motherboard and provides the communication interface between the host computer and the ST-133. The USB 2.0 PCI card (70USB90011) by Orange Micro is recommended for desktop computers; the SIIG, Inc. USB 2.0 PC Card, Model US2246 is recommended for laptop computers. See www.orangemicro.com or www.siig.com , respectively, for more information.

Application Software

WinView/32 is Princeton Instruments' 32-bit Windows® software package that 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 Princeton Instruments 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.

WinSpec/32 is Princeton Instruments' 32-bit Windows® software package for spectroscopy. It provides stand-alone comprehensive spectral acquisition, display, processing, and archiving functions. WinSpec gives you the ability to run automatic spectrometer control and calibration routines, as well as to move to any spectral window or change gratings without having to recalibrate. WinSpec also features snap-ins and macro record capability 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.

Scientific Imaging ToolKit™ (SITK™) is a collection of LabVIEW® VIs for scientific cameras and spectrographs. This third party software can be purchased from Princeton Instruments.

User Manuals

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

WinView/32 or WinSpec/32 User Manual: Optional. 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.

PVCAM Manual: This manual describes PVCAM parameters and ids and provides example code. Provided as PDF manual only.

Chapter 3
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 information.

WARNING At the first sign of condensation on the camera's inlet and/or outlet pipes, turn off the system. ***Damage to the camera as a result of condensation is not covered under warranty***.

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.	
2. Verify that all system components have been received.	
3. If the components show no signs of damage, verify that the appropriate voltage settings have been selected for the Controller.	Chapter 4, System Setup, page 26
4. If the WinView/32 or WinSpec/32 software is not already installed in the host computer, install it.	WinView/32 or WinSpec/32 manual
5. If the appropriate interface card is not already installed in the host computer, install it.	Chapter 4 System Setup, page 29
6. With the Controller and computer power turned OFF, connect the interface cable (TAXI or USB) to the Controller and the interface card in the host computer. Then tighten down the locking hardware.	Chapter 4 System Setup, page 33
7. Mount the camera to the vacuum port.	
8. Make the tubing connections between the coolant circulator and the camera.	Chapter 4, System Setup, page 36
9. With the ST-133 power turned **OFF**, connect the male end of the camera cable to the **Detector** port on the rear of the ST-133. Connect the female end of the cable to the connector on the rear of camera. Then secure the cable at both ends by engaging the slide-lock latches (or tighten the jackscrews if they were ordered at special request).	Figure 4, page 20 or Figure 5, page 21
10. Secure and evacuate the vacuum chamber.	
11. Turn on the ST-133.	

Action	Reference
12. Turn on the computer and begin running WinView/32 or WinSpec/32. When the computer boots, you may be asked for the location of the interface drivers.	Chapter 4, System Setup, page 30 (PCI drivers) or page 32 (USB drivers) WinView/32 or WinSpec/32 manual
13. Enter the hardware setup information.	Refer to the WinView/32 or WinSpec/32 manual.
14. If the system has liquid-assisted cooling or is liquid-cooled only, turn on the coolant circulator. The recommended flow rate is 2 liters/minute @ 25 psig (max).	
15. Set the target array temperature.	Chapter 5, Operation, page 37
16. If the system is cryogenically-cooled, fill the Dewar.	Chapter 5, Operation, page 38
17. When the system reaches temperature lock, begin acquiring data in focus mode.	

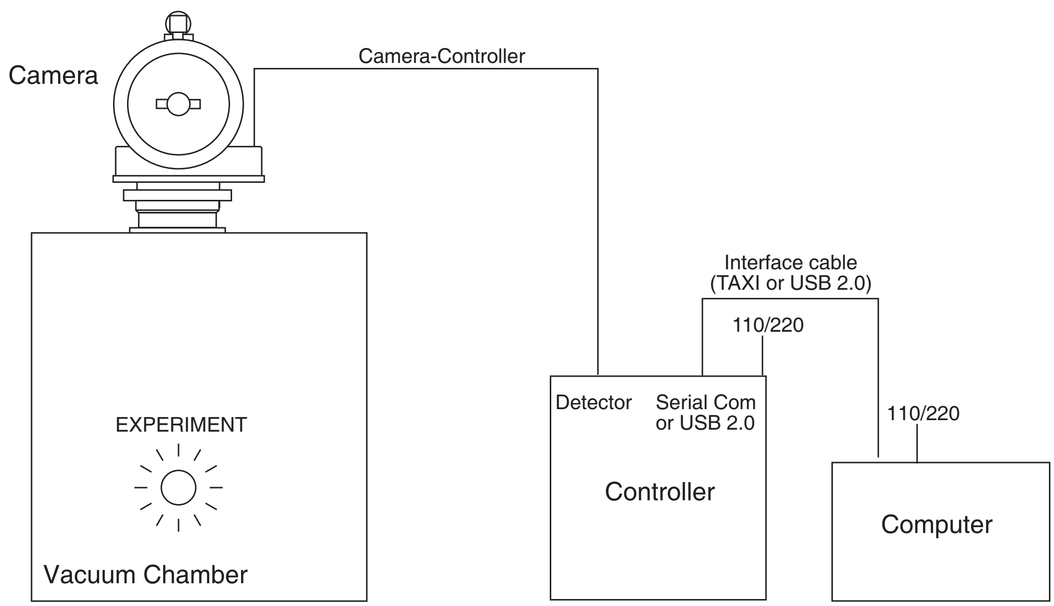


Figure 4. PI-SX LN System Diagram

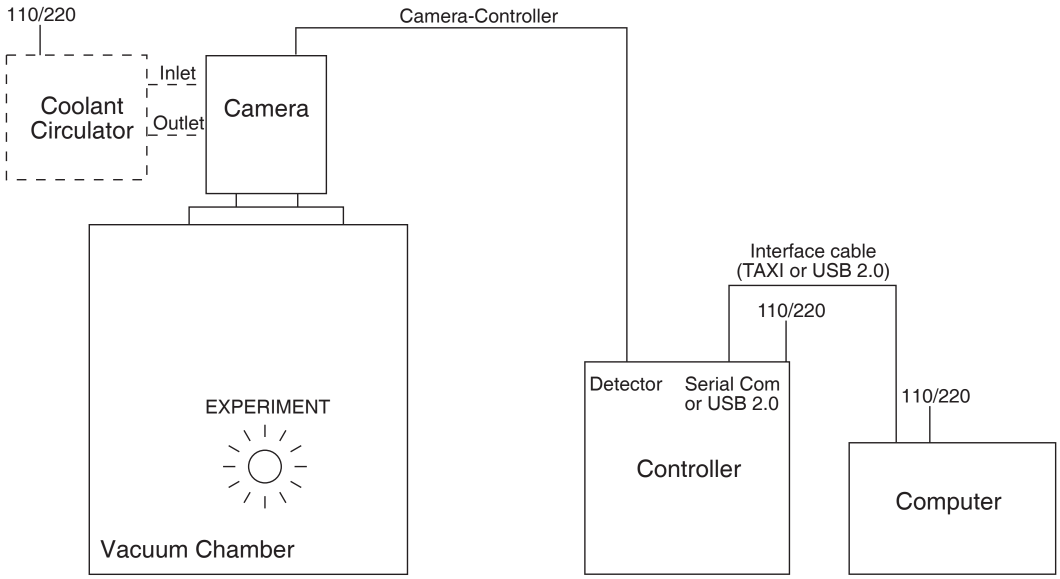


Figure 5. PI-SX TE System Diagram

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Chapter 4

System Setup

Unpacking the System

During the unpacking, check the system components for possible signs of shipping damage. If there are any, notify Princeton Instruments 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 Princeton Instruments 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 PI-SX system. A complete system consists of:

- **Camera** (TE- or LN-cooled).
- **ST-133 Controller:** Do not substitute any other controller for the controller supplied with your system.
- **Camera-Controller cable:** DB25 to DB25. Standard length is 10 ft (6050-0321). This cable is also available in 6', 15', 20', and 30' lengths.
- **Computer Interface Dependent Components:**
    - **Controller-Computer Interface cable:**
        - **TAXI cable:** DB9 to DB9 cable (6050-0148-CE is standard) or
        - **USB cable:** Five (5) meter cable (6050-0494) is standard
    - **Interface Card:**
        - **TAXI:** Princeton Instruments (RSPI) High Speed PCI Interface board or
        - **USB 2.0:** Native on motherboard or user-provided USB 2.0 Interface Card. If there is no native USB 2.0 support on the motherboard, the following USB 2.0 interface cards are recommended:
            - Orange Micro 70USB90011 USB2.0 PCI is recommended for desktop computers
            - SIIG, Inc. USB 2.0 PC Card, Model US2246 is recommended for laptop computers.
- **WinView/32 or WinSpec/32 CDROM:** This CD contains the WinView/32 or WinSpec/32 software and related manuals in PDF format.
- **User Manuals**: PI-SX System and WinView/32 or WinSpec/32 Software.
- **Host Computer:** Typically, the computer is user-supplied.

- **Coolant Circulator:** Not required by some systems. Can be purchased from Princeton Instruments. Typically, the coolant circulator and hoses are user-supplied.

System Requirements

Environmental

Storage temperature: ≤55°C;

Operating environment temperature: 5ºC to +30ºC; for NTE Cameras, the environment temperature range over which system specifications can be guaranteed is +18ºC to +23ºC

Relative humidity: <50% noncondensing. If LN-cooled cameras are operated under high humidity conditions, ice-buildup could occur around the vent valves. Operating liquid-assist TE-cooled cameras in high humidity environments can produce condensation inside the camera's electronic enclosure. Damage from humid condensation may not be covered by the product warranty.

Ventilation

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

ST-133: 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.

Coolant

WARNING!

COOLANT IS HARMFUL IF SWALLOWED.

KEEP OUT OF REACH OF CHILDREN.

PI-SX cameras with liquid-assisted 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

Camera: The PI-SX camera receives its power from the controller, which in turn plugs into a source of AC power.

ST-133: The ST-133 Controller can operate from any one of four different nominal line voltages: 100, 120, 220, or 240 V AC. Refer to the Fuse/Voltage label on the back of the ST-133 for fuse, voltage, and power consumption information.

Caution 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.

Host Computer

Note: Computers and operating systems all undergo frequent revision. The following information is only intended to give an approximate indication of the computer requirements. Please contact the factory to determine your specific needs.

Requirements for the host computer depend on the type of interface, TAXI or USB 2.0, that will be used for communication between the ST-133 and the host computer. Those requirements are listed below according to protocol.

TAXI Protocol:

- Computer with Pentium 4 or better processor and runs at 1 GHz or better.
- Windows® 95, Windows® 98SE, Windows® ME, Windows NT®, Windows® 2000, or Windows® XP operating system.
- Princeton Instruments (RSPI) High speed PCI serial card (or an unused PCI card slot). Computers purchased from Princeton Instruments are shipped with the PCI card installed if high speed PCI was ordered.
- Minimum of 256 Mbytes of RAM.
- CD-ROM drive.
- Hard disk with a minimum of 80 Mbytes available. A complete installation of the program files takes about 17 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.

USB 2.0 Protocol:

- Computer with Pentium 4 or better processor and runs at 1 GHz or better.
- Windows 2000 (with Service Pack 4), Windows XP (with Service Pack 1) or later operating system.
- Native USB 2.0 support on the motherboard or USB Interface Card (Orange Micro 70USB90011 USB2.0 PCI is recommended for desktop computers and the SIIG, Inc. USB 2.0 PC Card, Model US2246 is recommended for laptop computers).
- Minimum of 256 Mb of RAM.
- CD-ROM drive.
- Hard disk with a minimum of 80 Mbytes available. A complete installation of the program files takes about 17 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 Controller Voltage Setting

The Power Input 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 power input module.

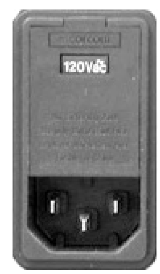


Figure 6. Controller Power Module

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 input module. The correct fuses for the country where the ST-133 is to be shipped are installed at the factory.

Note: On ST-133s, the voltage ranges and fuse ratings may be printed above or below the power module (Figure 6).

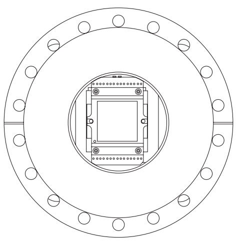
To Check the Controller's Voltage Setting:

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 71 for changing the voltage setting and fuses.

Mounting the Camera

WARNING! Because the PI-SX cameras are designed without a protective window, leave the shipping plate on until you are ready to mount the camera to a vacuum chamber. Long term exposure of the CCD array and its electronics increases the probability of ESD damage and contamination. *Open chamber products carry no warranty to the CCD device expressed or implied.*

Camera with ConFlat® Flange



1. Loosen and remove the ConFlat shipping plate mounting screws and remove the shipping plate.

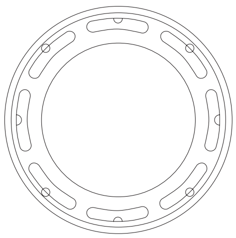
   Note: Before shipment, cameras are backfilled with dry Nitrogen at the factory to a pressure of 1 Atm. absolute.

2. Remove the shipping gasket. The shipping gasket for older units is an O-ring which should be kept for future use (see Step 3). Newer units have a copper sealing gasket which should be discarded.
3. Keep all shipping components (with the exception of the copper sealing gasket) for future use.
4. Clean the ConFlat flange sealing edges and grooves with a lint-free wipe and inspect the flange for any shipping damage before mounting the camera.
5. Remove the copper sealing gasket from the packaging and inspect it for any shipping damage.
6. Carefully seat the copper sealing gasket into the groove between the ConFlat flanges. If gasket retaining clamps are available, they can be used to hold the sealing gasket in place during installation.
7. Mate the ConFlat flange to the chamber. The outer flange mounting ring is rotatable. You must orient the outer flange to align the mounting holes correctly.
8. Immediately install a minimum of three (3) screws (typically 5/16 – 24 UNF for 4.5", 6", 6 ¾" and 8" flanges) to secure/support the camera. DO NOT TIGHTEN AT THIS TIME.
9. Align the camera to the application at this time.
10. Install the remaining screws into the ConFlat flange.
11. Tighten all screws (with a ½" open end or box wrench) to 180 ± 10 in.lbs. torque.
12. Princeton Instruments recommends a helium leak check upon initial vacuum pumpdown before operating the camera.

Camera with Vacuum Open Nose (VON) Flange

WARNING!

> Whenever a camera with an open nose is being handled, use **EXTREME CAUTION** to prevent damage to the CCD array. To prevent contamination, only handle a PI-SX camera with an open nose in a cleanroom environment. If the camera must be removed from a cleanroom environment, cover the array opening.



1. Clean the application sealing edges with a lint-free wipe.
2. Loosen and remove the shipping plate mounting screws and remove the shipping plate.

   Note: Before shipment, cameras are backfilled with dry Nitrogen at the factory to a pressure of 1 Atm. absolute.
3. Retain all shipping components for future use.
4. Verify that the sealing o-ring is positioned in the flange groove and mount the camera to the application.
5. Immediately install a minimum of 3 screws (typically 10/32 x ½" stainless) to secure/support the camera. DO NOT TIGHTEN AT THIS TIME.
6. Align the camera to the application at this time.
7. Install remaining screws at this time. Up to eight (8) screws can be used. Typically, four (4) are supplied with the camera.
8. Tighten all screws to 45 in.lbs. torque.
9. Princeton Instruments recommends a helium leak check upon initial vacuum pumpdown before operating the camera.

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 7), click on the **AUTO PCI** button to install the interface card drivers (the Princeton Instruments PCI and the USB drivers) and the most commonly installed program files. Select the **Custom** button if you would like to choose among the available program files. If the interface card was installed at the factory, the appropriate driver was installed at that time.

Figure 7. WinView Installation: Interface Card Driver Selection

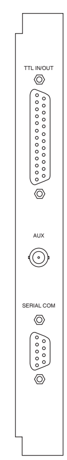
Note: WinView/32 and WinSpec/32 (versions 2.6.0 and higher) do not support the ISA interface.

Setting up the Communication Interface

PI-SX camera systems require either an installed Princeton Instruments (RSPI) PCI card or an installed USB2.0 interface card in the host computer. The type of interface card is dictated by the Interface Control Module installed in the ST-133 controller.

Setting up a PCI Interface

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



A Princeton Instruments (RSPI) PCI card must be installed in the host computer if the communication between computer and controller uses the TAXI protocol (i.e., the **Interface Control Module** installed in the ST-133 has a 9-pin **SERIAL COM** connector as shown in the figure at right). With TAXI protocol, the standard cable provided with an ST-133 is 7.6 meters (25 feet). Cable lengths up to 50 meters (164 feet) are available and the digitization rate may be as high as 2 MHz.

A computer purchased from Princeton Instruments will be shipped with the PCI card already installed. Otherwise, a PCI card will be shipped with the system and you will have to install it in the host computer at your location.

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

Caution

If using WinView/32 or WinSpec/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 in the Host Computer:

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. Refer to Chapter 9 "Troubleshooting", page 79 for instructions.

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

To Install the PCI Card Driver

The following information assumes that you have already installed the WinView/32 or WinSpec/32 software.

1. After you have secured the PCI card in the computer and replaced the cover, turn the computer on.
2. 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. Refer to the Table 2 for the appropriate file names and locations.

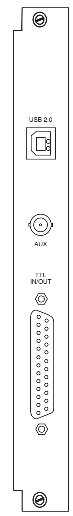
Windows Version	PCI INF Filename Located in "Windows"/INF directory*	PCI Device Driver Name Located in "Windows"/System32/Drivers directory
Windows® 2000 and XP	rspi.inf (in WINNT/INF, for example)	rspipci.sys (in WINNT/System32/Drivers, for example)
Windows NT®	N/A	pi_pci.sys
Windows® 95, 98, and Windows®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

* The INF directory may be hidden.

Table 2. PCI Driver Files and Locations

Setting up a USB 2.0 Interface

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



Your system has been configured to use the USB communication protocol if the **Interface Control Module** installed in the ST-133 has a **USB 2.0** connector as shown in the figure at right). The advantages to the USB 2.0 interface are that it uses a much higher data transfer rate than many common serial data formats (such as the TAXI protocol) and it simplifies the connection to external devices. USB supports "plug and play" -- you do not need to be heavily involved in the setup process.

USB 2.0 Limitations

- Maximum cable length is 5 meters (16.4 feet)
- For CCD devices with pixel resolution ≥ 4 Mb, 2 MHz is currently the upper digitization rate limit for the ST-133 Controller. Larger data sets may be subject to data overrun because of host computer interrupts during data acquisition.
- USB 2.0 is not supported by the Princeton Instruments PC Interface Library (Easy DLLS).
- Some WinView and WinSpec 2.5.X features are not fully supported with USB 2.0. Refer to Appendix C, page 97, for more information.

Note: If you are installing the USB 2.0 interface on a laptop, you will need to perform all of the operations described in this section. In addition, if you are using the recommended USB Interface Card (SIIG, Inc. USB 2.0 PC Card, Model US2246), you must replace the OrangeUSB USB 2.0 Host Controller driver installed for that card with the appropriate Microsoft driver. Instructions for making the replacement are included in ***"To Update the OrangeUSB USB 2.0 Driver"***.

To Update the OrangeUSB USB 2.0 Driver:

This procedure is highly recommended when a laptop computer will be used to communicate with the ST-133. As stated before, we recommend the SIIG, Inc. USB 2.0 PC Card, Model US2246 if USB 2.0 is not native to the laptop's motherboard. To reduce the instances of data overruns and serial violations, the OrangeUSB USB 2.0 Host Controller installed for the SIIG card, should be replaced by the appropriate Microsoft driver (Windows 2000 or Windows XP, depending on the laptop's operating system.)

Note: This procedure may also be performed for desktop computers that use the Orange Micro 70USB90011 USB2.0 PCI.

1. Download and install Microsoft Service Pack 4 (for Windows 2000) or Service Pack 1 (for Windows XP) if the service pack has not been installed.
2. From the Windows **Start** menu, select **Settings|Control Panel**.
3. Select **System** and then **System Properties**.
4. Select the **Hardware** tab and click on **Device Manager** button.
5. Expand **Universal Serial Bus Controllers**.
6. Right-mouse click on **OrangeUSB USB 2.0 Host Controller** and select **Properties**.
7. On the **Driver** tab, click on the **Update Driver…** button. You may have to wait a minute or so before you will be allowed to click on the button.
8. When the **Upgrade Device Driver Wizard** appears, click on **Next**. Select the **Search for a suitable driver …** radio button.
9. On the next screen select the **Specify a location** checkbox.
10. Browse and select the location. Click on **OK**.
11. In the **Driver Files Search Results** window, check the **Install one of the other drivers** check box.
12. Select the **NEC PCI to USB Enhanced Host Controller B1** driver. Click on **Next** and the installation will take place. When the **Completing the Upgrade Device Driver Wizard** window appears, click on **Finish**. You will then be given the choice of restarting the computer now or later. According to the window text, the hardware associated with the driver will not work until you restart the computer.

To Install the Princeton Instruments USB2 Interface:

The following information assumes that:

- You have verified that the host computer meets the required specifications for USB 2.0 communication with the PI-SX system (see page 25).
- A USB 2.0 board and its driver are installed in the host computer.
- The ST-133 has an installed USB 2.0 Interface Control module.
- You have already installed the WinView/32 or WinSpec/32 software (versions 2.5.15 and higher). Versions 2.5.15 and higher automatically install the driver and INF files required to support the USB 2.0 Interface Control module.

1. Before installing the Princeton Instruments USB2 Interface, we recommend that you defragment the host computer's hard disk. This operation reduces the time the computer spends locating files. Typically, the "defrag" utility "Disk Defragmenter" can be accessed from the Windows® Start menu and can usually accessed from the Programs/Accessories/System Tools subdirectory.
2. After defragmenting the hard disk, turn off the computer and make the USB cable connections between the host computer and the ST-133. Then, turn the ST-133 on before turning on the host computer.

3. At bootup, Windows will detect the Princeton Instruments USB2 Interface hardware (i.e., the USB 2.0 Interface Control module). You may be prompted to enter the directory path(s) for the apausbprop.dll and/or the apausb.sys file(s), 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, DLL, and USB driver file in the "Windows" directories shown below. Refer to the Table 3 below for the file locations.

Windows Version	USB INF Filename Located in "Windows"/INF directory*	USB Properties DLL Located in "Windows"/System32 directory	USB Device Driver Name Located in "Windows"/System32/Drivers directory
Windows® 2000 and XP	rsusb2k.inf (in WINNT/INF, for example)	apausbprop.dll (in WINNT/System32, for example)	apausb.sys (in WINNT/System32/Drivers, for example)

* The INF directory may be hidden.

Table 3. USB Driver Files and Locations

Connecting the Interface (Controller-Computer) Cable

TAXI® Cable (6050-0148-CE)

Turn the Controller power OFF (OFF = 0, ON = |) and the Computer power OFF before connecting or disconnecting the Controller-Computer (TAXI) cable.

To Connect the TAXI Cable:

1. Verify that the Controller power is OFF.
2. Verify that the Computer power is OFF.
3. Connect one end of the TAXI cable to the 9-pin port on the Interface card in the host computer.
4. Tighten down the screws to lock the connector in place.
5. Connect the other end of the cable to the "Serial Com" port on the rear of the Controller.
6. Tighten down the screws to lock the connector in place.

USB 2.0 Cable (6050-0494)

Turn the Controller power OFF (OFF = 0, ON = |) and the Computer power OFF before connecting or disconnecting the Controller-Computer (TAXI) cable.

To Connect the USB 2.0 Cable:

1. Verify that the Controller power is OFF.
2. Verify that the Computer power is OFF.
3. Connect one end of the USB cable to the USB port on the host computer.
4. Connect the other end of the cable to the USB 2.0 port on the rear of the Controller.

Connecting the Camera-Controller Cable

CAUTION Turn the Controller power OFF (OFF = 0, ON = |) before connecting or disconnecting the Camera-Controller cable.

To Connect the Camera-Controller Cable:

1. Verify that the Controller power is OFF.
2. Connect male end of the Camera-Controller cable (6050-0321) to the "Detector" port on the back of the Controller.
3. Move the slide latch over to lock the connector in place.
4. Connect the female end of the cable to the Camera.
5. Move the slide latch over to lock the connector in place.

Entering the Default Camera System Parameters into WinX (WinView/32, WinSpec/32, or WinXTest/32)

Software changes implemented in WinX version 2.15.9.6 affected the way in which default parameters were entered for camera systems. Therefore, two sets of instructions are included. Follow the instructions appropriate to the software version that you installed. Note that these instructions assume that you have performed the computer interface installation.

WinX Versions 2.5.19.6 and later

1. Make sure the ST-133 is connected to the host computer and that it is turned on.
2. Run the WinX application. The **Camera Detection wizard** will automatically run if this is the first time you have installed a Princeton Instruments WinX application (WinView/32, WinSpec/32, or WinXTest/32) and a supported camera. Otherwise, if you installing a new camera type, click on the **Launch Camera Detection Wizard…** button on the **Controller/CCD** tab page to start the wizard.
3. On the **Welcome** dialog (Figure 8), leave the checkbox unselected and click on **Next**.

Figure 8. Camera Detection Wizard - Welcome dialog box

4. Follow the instructions on the dialog boxes to perform the initial hardware setup: this wizard enters default parameters on the Hardware Setup dialog box tab pages and gives you an opportunity to acquire a test image to confirm the system is working.

WinX Versions before 2.5.19.6

1. Make sure the ST-133 is connected to the camera and the host computer and that it is turned on.
2. For ST-133s containing a TAXI Interface module, go to Step 5.
3. For ST-133s containing a USB 2.0 Interface module, run RSConfig from the **Windows|Start|Programs|Roper Scientific** menu or from the directory where you installed WinView, WinSpec, or WinXTest.
4. When the RSConfig dialog box (Figure 9) appears, you can change the camera name to one that is more specific or you can keep the default name "Camera1". When you have finished, click on the **Done** button.

Note: If the first camera in the list is not the "Princeton Style (USB2)", you will need to edit the PVCAM.INI file created by RSConfig. See the instructions in ***"Demo, High Speed PCI, and PCI(Timer) are Choices on Hardware Wizard:Interface dialog (Versions 2.5.19.0 and earlier)",*** page 76.

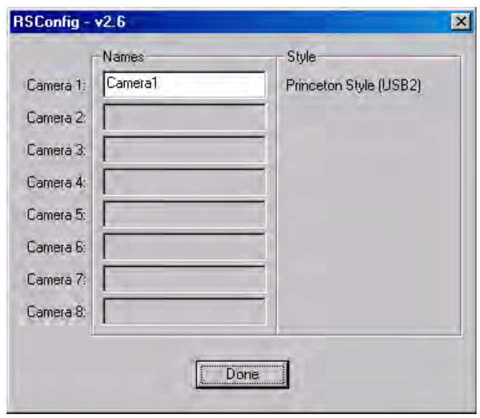


Figure 9. RSConfig dialog box

5. Open WinView and, from **Setup|Hardware…,** run the Hardware Setup wizard and make the appropriate selections for your system. After the wizard is finished, the **Controller/Camera** tab card will be displayed.

Note: If your system is using the USB 2.0 interface, click the **Yes** radio button if the PVCAM dialog box (Figure 10) is displayed. Otherwise, click **No** and continue through the wizard.

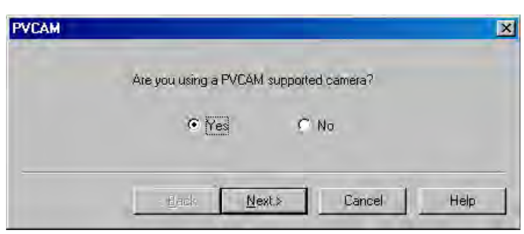


Figure 10. Hardware Setup wizard: PVCAM dialog box

6. You should now be able to set up experiments and acquire data. Run the software in focus mode to verify communication between the ST-133 and the host computer.

Making the Coolant Circulator-Camera Connections

WARNINGS!

1. Coolant flow should not begin through the camera unless the chamber to which it is mounted has been evacuated to at least 1 mTorr. If array cooling is begun before the chamber has been fully evacuated, there is a danger of condensation onto the array and the internal electronics. ***Such condensation could result in catastrophic damage to the camera and is not covered by the warranty.***
2. Sustained operation of these cameras at lower temperatures without providing either liquid or conduction cooling will permanently damage the camera. Such damage is not covered by the Warranty.

Cautions

1. Do not use any coolant fittings other than those supplied by Princeton Instruments. 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. PI-SX 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 PI-SX camera with coolant at a colder temperature 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.***

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 camera. 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.

Note: The chiller/circulator kit includes hose clamps and two 15' hoses. The hoses are constructed of 3/8" I.D., thick-wall PVC tubing. The hose clamps secure the tubing to male quick-disconnects.

To Secure the Hoses:

If the ports are on the same side of the camera (liquid-assisted cooling), either port can be the Inlet or Outlet. If the coolant ports are on opposite sides of the camera (liquid-cooled), connect the inflow and outflow tubing to the ports as indicated in Figure 11.

a. Insert the male quick-disconnect (on tubing) into the appropriate female quick-disconnect on the camera (Inlet or Outlet) until you hear a click.

b. 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.

c. Because of the automatic shutoffs, disconnecting the coolant supply is done by simply depressing the release tabs and removing the fittings. Reconnecting the supply is done by reinserting each fitting into the appropriate valve body until you hear a click.

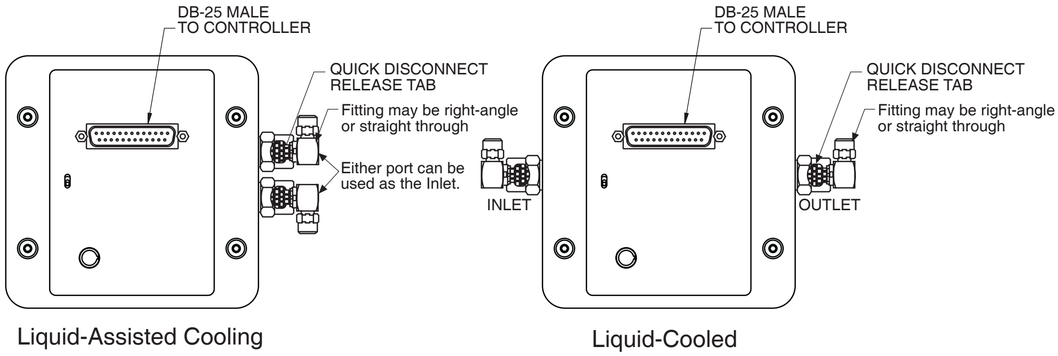


Figure 11. Inlet and Outlet Coolant Ports

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).

Setting the Camera Temperature

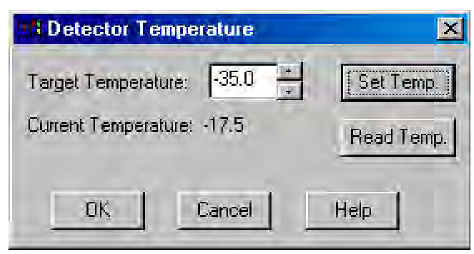


Figure 12. WinView/32 and WinSpec/32 Detector Temperature dialog box

The temperature is set directly from the application software. Once the desired array temperature has been set, the software controls the circuits in the camera so the array temperature is reduced (thermoelectrically-cooled operation) or the array temperature is raised (cryogenically-cooled operation) to the set value. The time required to reach and lock at the set temperature can vary over a considerable range, depending on such factors as the camera type, CCD array type, type of cooling, etc. On reaching that temperature, the control loop locks to the set temperature for stable and reproducible performance.

The TEMP LOCK indicator on the back of the controller lights GREEN to indicate that lock has been achieved (for more information, refer to the description of the ST-133 rear panel features, page 15). Application software, such as WinView/32 or WinSpec/32, also provides a temperature-locked indication.

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.

WARNING!

LN should not be added to a Dewar unless the chamber to which it is mounted has been evacuated to at least 1 mTorr. If array cooling is begun before the chamber has been fully evacuated, there is a danger of condensation onto the array and the internal electronics. ***Such condensation could result in catastrophic damage to the camera and is not covered by the warranty.***

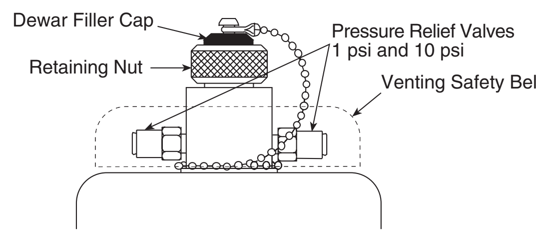


Figure 13. Dewar Ports and Valves

1. After the vacuum chamber, to which the camera is mounted, has been properly evacuated, loosen the retaining nut (Figure 13) 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.
4. Fill up the Dewar (approximately 1.7 liters for standard Dewar or 0.85 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.
5. 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.
6. Turn on the controller, begin running WinView (or WinSpec), and set the temperature to -80°C. This turns on the heater which regulates the CCD temperature and prevents the array from being cooled beyond its safe operating temperature (-100°C or -110°C, depending on the PI-SX model).

7. Start at least one data collection while the camera is cooling down.

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.

8. Once a temperature of -80°C has been achieved, maintain the CCD at that temperature for 2-3 hours, then reset the detector temperature 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 detector temperature can be set at the desired temperature without the intermediate -80°C stage. 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.

9. 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).

Dewar Venting

It is normal for there to be an occasional hiss from the 1 lb safety valve (at the top of the Dewar, see Figure 13) during operation. ***However, if the hissing is continuous or a louder hiss begins to come from the 10 lb safety valve, the 1 lb valve may be blocked by frost buildup or there may be a potentially catastrophic buildup of pressure inside the Dewar***.

Immediately turn off the camera and after putting on LN handling clothing, face and hand protection, slightly loosen the cap and depress the black Delrin top. If the top pushes back up, be extremely careful while further loosening the cap and removing the insert. Because of the internal pressure, the insert and the LN could erupt explosively from the Dewar. ***Remove all LN from the Dewar.***

Then, check the vacuum integrity of the chamber. Such a pressure buildup may be the result of a vacuum breach. Note that if a breach has occurred and normal atmosphere has entered the chamber, potentially catastrophic condensation could form on the face of the array and the electronics.

Holding Times

At its lowest operating temperature, Princeton Instruments' standard 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 or WinSpec 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.

Dewar Options

An optional "all-directional" Dewar, which can operate in any angular orientation, is available from Princeton Instruments. This Dewar type holds approximately 0.85 liters, roughly half as much LN as the Dewars for side-on and end-on cameras. The reduced capacity translates to half the hold time.

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.

When operating an all-directional Dewar in a 90° orientation, you can refill the Dewar only through a special 90° funnel that is also available from Princeton Instruments. 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.

Chapter 5
Operation

Introduction

Once PI-SX camera has been installed as explained in the preceding chapters, operation of the camera is straightforward. In most applications you simply establish optimum performance using the **Focus** mode (WinView/32 or WinSpec/32), set the target camera temperature, wait until the temperature has stabilized at the set temperature (see the "Setting the Camera Temperature" section in the previous chapter), and then do actual data acquisition in the **Acquire** mode.

During data acquisition, the CCD array is exposed to a source and charge accumulates in the pixels. After the defined exposure time, the accumulated signal is readout of the array, digitized, and then transferred to the host computer. Upon data transfer, the data is data is displayed and/or stored via the application software. This sequence is illustrated by the block diagram shown in Figure 14.

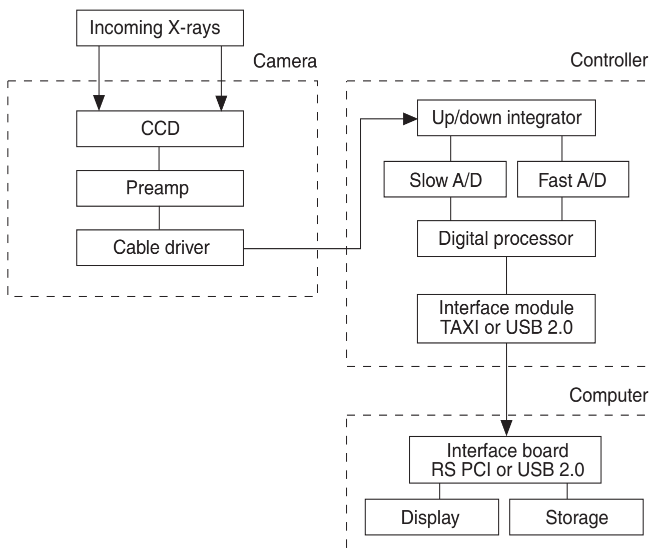


Figure 14. Block Diagram of Light Path in System

Whether or not the data is displayed and/or stored depends on the data collection operation (**Focus** or **Acquire**) that has been selected in the application software. In WinView and WinSpec, these operations use the Experiment Setup parameters to establish the exposure time (the period when signal of interest is allowed to accumulate on the CCD). As might be inferred from the names, **Focus** is more likely to be used in setting up the system (see the ***"First Light"*** discussions) and **Acquire** is then used for the collection and storage of data.

- In **Focus** mode, the number of frames and accumulations settings are ignored. A single frame is acquired and displayed, another frame is acquired and overwrites the currently displayed data, and so on until Stop is selected. No frames of data are stored. However, when Stop is selected, the File Save function can be used to save the currently displayed data. This mode is particularly convenient for familiarization and setting up. For ease in focusing, the screen refresh rate should be as rapid as possible, achieved by operating with axes and cross-sections off, and with Zoom 1:1 selected.
- In **Acquire** mode, every frame of data collected can be automatically stored (the completed dataset may include multiple frames with one or more accumulations). This mode would ordinarily be selected during actual data collection. One limitation of Acquire mode operation is that if data acquisition continues at too fast a rate for it to be stored, data overflow will eventually occur. This could only happen in Fast Mode operation.

The remainder of this chapter is organized to first talk about the system on/off sequences. Then the "First Light" procedure for imaging applications follows: this procedure provides step-by-step instruction on how to initially verify system operation. The last three sections discuss factors that affect exposure, readout, and digitization of the incoming signal. By understanding these factors and making adjustments to software settings, you can maximize signal quality. For information about synchronizing data acquisition with external devices, please refer to Chapter 6, Advanced Topics.

System On/Off Sequences

If your system is configured for the USB 2.0 communication interface, you must follow the system on/off sequences as stated below. These sequences ensure that communication is established and maintained between the camera and the host computer:

1. The PI-SX camera must be powered ON before WinView/32 or WinSpec/32 is opened to ensure communication between the camera and the computer. If WinView or WinSpec is opened and the PI-SX is not powered ON, many of the functions will be disabled and you will only be able to retrieve and examine previously acquired and stored data. You must close WinView or WinSpec, power the camera ON, and reopen WinView or WinSpec before you can set up experiments and acquire new data.
2. WinView/32 or WinSpec/32 must be closed before powering the camera OFF. If you power the camera OFF before closing WinView or WinSpec, the communication link with the camera will be broken. You can operate the program in a playback mode (i.e., examine previously acquired data) but will be unable to acquire new data until you have closed WinView or WinSpec, powered the camera ON, and then re-opened WinView or WinSpec.

First Light

This section provides step-by-step instructions for acquiring an imaging measurement after the camera is mounted to a vacuum chamber. The intention of this procedure is to help you gain basic familiarity with the operation of your system and to show that it is functioning properly. *The procedure does not require an x-ray source.* Once basic familiarity has been established, then operation with other operating configurations, ones with more complex timing modes, can be performed.

Once the PI-SX system has been installed, operation of the camera is basically straightforward. In most applications you simply establish optimum performance using the **Focus** mode (WinView/32 or WinSpec/32), 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.

Assumptions

The following procedure assumes that

- ***The camera has been mounted to a vacuum chamber*** that has been pumped down to remove any contaminants or moisture. ***A minimum of 1 mTorr is recommended.***
- You are verifying the camera system operation.
- You have read the previous sections of this chapter.
- You have made the appropriate cabling and coolant connections for your system.
- The system is liquid-cooled.

  Note: If your system is LN-cooled, you can run the camera at ambient without filling the Dewar.
- You are familiar with the application software.
- The system is being operated in imaging mode.

Cabling

If the system cables haven't been installed, connect them as instructed in Chapter 4.

Getting Started

1. If the system is liquid-cooled, double-check that the circulator is filled with water or a 50:50 mixture of ethylene glycol and water and that the hose connections are secure. When satisfied that these requirements are met, do the following.
   a. Turn on the circulator. The circulator will power up and begin pumping coolant through the camera. *See the circulator instruction manual for detailed information.*
   b. Inspect the coolant hose connections to be sure there are no leaks.
   c. Turn on the refrigeration, if this feature is available, and set the coolant temperature (+20°C). The compressor will start and cooldown will begin.

   Note: The coolant temperature should be no colder than +15°C at 50% relative humidity.

2. Verify that the line-voltage setting of the ST-133 is correct for the available power and switch ON the ST-133.
3. Block light from the window.
4. Turn on the power at the computer and start the application software (WinView/32 or WinSpec/32, for example).

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): Check the DMA Buffer size. Large arrays (2048x2048, for example) require a buffer size on the order of 32 Mbytes. 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 Camera 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.

- **Use PVCAM:** If you are using the USB 2.0 interface, verify that the box is checked.

  Note: This check box is not present on software versions 2.5.19.6 and higher.

- **Controller type:** ST-133
- **Controller version:** This value should be 3 or higher. Version 5 is the most recent controller version.
- **Camera type:** The array installed in your camera should appear in this field.
- **Shutter type:** Set the type to "None".
- **Readout mode:** Make sure "Full frame" is selected.

Detector Temperature (Setup|Detector Temperature…): -40°C for coolant at room temperature; for an LN-cooled with an empty Dewar, use the default temperature. When the array temperature reaches the set temperature, the green **Temp Lock** LED on the rear of the ST-133 will light and there will be a **locked** indication at the computer monitor.

Note: If you are using the USB 2.0 interface, the Detector Temperature dialog box will not display temperature information while you are acquiring data.

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

Note: This tab page is not available if you are using the USB 2.0 interface.

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).

- 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. Fast Mode:** Safe

General tab page (Display|Layout…): Select **Horizontal** and **Vertical** Cross Sections.

Acquiring Data

If you are using WinView/32 (or WinSpec/32), select **Focus** from the **Acquisition** menu. Successive images will be sent to the monitor as quickly as they are acquired. Since no x-ray source is being used, the acquired images will be of the camera's dark charge. Signal changes may be more easily seen on the cross-section views.

Figure 15 shows the kind of image data you might see in WinView (or in Image mode for WinSpec/32). The horizontal and vertical cross sections have been turned on via the **General** tab card (**Display|Layout**).

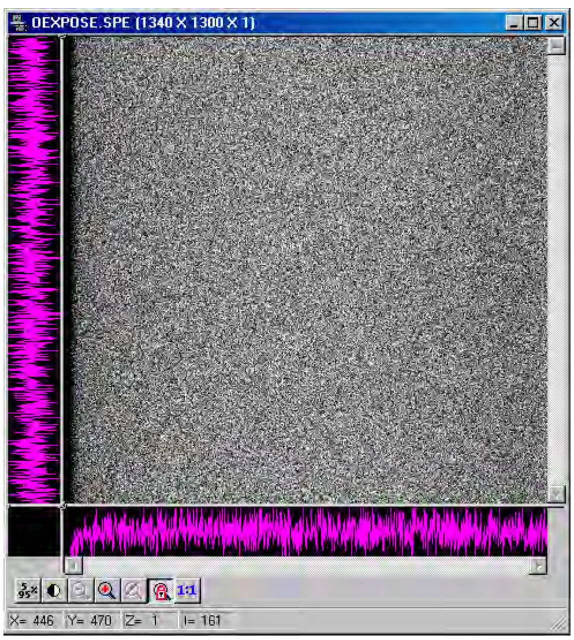


Figure 15. Example of WinView Data Acquired from First Light Procedure

Because the time to acquire and read out an image varies directly with the size of the CCD, the observed frame rate will vary greatly depending on the CCD installed. With a short exposure time, it is not uncommon for the frame readout time to be significantly longer than the exposure time.

This completes *First Light*. If the system functioned as described, you can be reasonably sure it has arrived in good working order. In addition, you should have a basic understanding of how the system hardware is used. A recommended procedure for powering down the camera is provided in the next section. Other topics, which could be quite important in certain situations, are discussed in the following chapters. See the appropriate application software manual for information on using the software to control the system.

Powering Down

The purpose of this procedure is to warm up the camera array and electronics after locked operation at temperatures below ambient. If the array and/or electronics temperature are below ambient when the vacuum chamber is vented, condensation on these components could occur.

1. While running WinView (or WinSpec), set the camera temperature to ambient.
   - If liquid cooling is being used, set the circulator's refrigeration On/Off switch to OFF. Continue to circulate liquid until ambient is reported on the Detector Temperature dialog and then turn off the circulator's main power switch.
   - If LN_2 is being used, there should be no LN_2 in the Dewar after ambient temperature is reached. Verify that the Dewar is empty.
2. After ambient temperature is reached, close WinView (or WinSpec) and then turn off the ST-133. This will turn off the camera.
3. While the previous steps should be sufficient to prevent condensation on the array and camera electronics when the chamber is vented, allow at least 30 minutes to pass before venting the vacuum chamber.

Exposure and Signal

Introduction

The following topics address factors that can affect the signal acquired on the CCD array. These factors include array architecture, exposure time, CCD temperature, dark charge, and saturation.

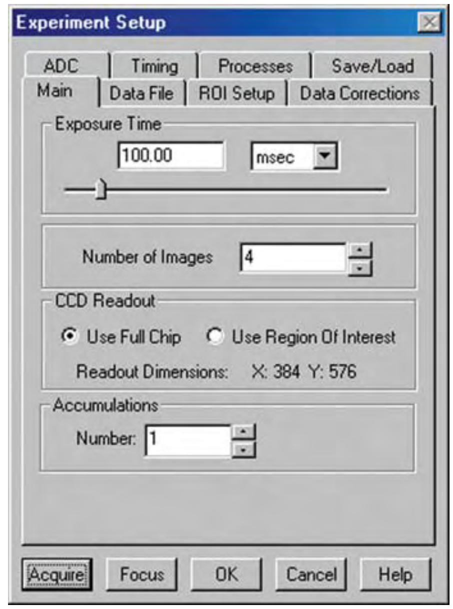
CCD Array Architecture

Charge coupled devices (CCDs) 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 (set in the software), the pixels are read out serially.

Exposure of the CCD surface to x-rays can eventually damage the CCD. Exposure to photons with 1.8 keV (silicon k-alpha) of energy will accelerate the damage significantly. The PI·SX design incorporates shields to prevent exposure of the most damage-sensitive portion of the CCD array (the shift register) to x-rays while maintaining as much open imaging area as possible.

Note: Because vacuum venting can contaminate the cooled surface of the CCD, we advise users to position a gate valve between the camera and the rest of the system. This is also highly recommended to prevent contamination.

Exposure Time



Exposure time (set on the **Experiment Setup|Main** tab page) is the time between start acquisition and stop acquisition commands sent by the application software to the camera. In combination with triggers, these commands control when continuous cleaning of the CCD stops and when the accumulated signal will be readout. The continuous cleaning prevents buildup of dark current and unwanted signal prior to the x-ray pulse. At the end of the exposure time, the CCD is readout and cleaning starts again.

Because PI-SX cameras do not incorporate an internal shutter, some signal may accumulate on the array while it is being readout. This continuous exposure of the array during readout may result in some smearing. However, exposures that are significantly longer than the readout time can be performed without a shutter, as the amount of smearing will be low.

If smearing or other factors require a shutter, the NOT SCAN or the SHUTTER signal at the ST-133's $\overline{\mathbf{SCAN}}$ output can be used to control a customer-supplied external x-ray shutter. By using one of the signals to synchronize the shutter operation with exposure, the CCD can be read out in darkness. Alternatively, the x-ray source can be interrupted elsewhere in the system while readout is taking place.

CCD Temperature

As stated before, regardless of the cooling method (TE or LN), lowering the temperature of the CCD will generally enhance the quality of the acquired signal. However, with cooling comes the possibility of condensation or of charge-trapping. Both issues are addressed below.

Condensation

WARNINGS

1. Condensation can cause damage to the camera and will void the warranty. If there are ***ANY*** signs of condensation on the camera's coolant pipes or on the CCD array, stop operation immediately and contact the factory for recommended corrective action.
2. Operating these cameras in air will result in damage to the CCD array.

PI-SX cameras depend on the vacuum environment for thermal isolation of the cooled CCD and for preventing condensation on it. Both the CCD array and the camera electronics are subject to damage from condensation if exposed to atmospheric moisture when cold.

To prevent condensation damage while the camera is mounted to the vacuum chamber:

- **Vacuum Chamber:** Make sure that the vacuum chamber has been pumped down to at least 1 mTorr, before cooling the camera below ambient, turning on coolant flow, or adding LN.
- **TE-cooled Camera:** Before venting a chamber, turn off the camera, turn off coolant flow, and allow the camera to warm up for at least thirty (30) minutes. ***Do not vent the chamber if coolant is still flowing through the camera.***
- **LN-cooled Camera:** Before venting a chamber, empty the Dewar. With the camera still on, bring the camera up to ambient temperature via the **Detector Temperature** dialog box. After the camera reaches ambient, vent the chamber.

Condensation can result in catastrophic damage to the camera and is not covered by the warranty.

Charge-Trapping

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 and then turned back on while the array is still cool, electrons will be trapped in the pixels, causing higher dark charge at low temperature. To remove that trapped charge, you would have to warm the array to ambient and then take it back down to the operating temperature.

Dark Charge

Dark charge (or dark current) is the thermally induced buildup of charge in the CCD over time. Even 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 set the camera temperature at the lowest CCD temperature within the recommended range for your camera (see Table 1, on page 9).

The statistical noise associated with dark 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 a thermoelectrically-cooled camera, dark charge is reduced by a factor of ~2 for every 6-7 degree reduction in temperature. In the case of cameras such as the PI-SX cameras, 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.

Notes:

1. 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 ADC. 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.

2. 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. Immediately turn off the system and contact Princeton Instruments Customer Support for instructions. See page 102 for contact information.

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 averaging, determined by either the saturation of the CCD pixels by the signal or the loss of dynamic range due to the buildup of dark charge in the pixels.

Readout

Introduction

After the exposure time has elapsed, the charge accumulated in the array pixels needs to be read out of the array, converted from electrons to digital format, and transmitted to the application software where it can be displayed and/or stored. Readout begins by moving charge from the CCD image area to the shift register. The charge in the shift register pixels, which typically have twice the capacity of the image pixels, is then shifted into the output node and then to the output amplifier where the electrons are grouped as electrons/count. This result leaves the CCD and goes to the preamplifier where gain is applied.

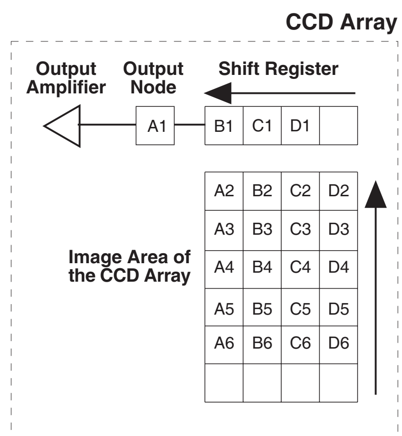


Figure 16. Array Terms for a CCD with a Single Output Amplifier

WinView and WinSpec allow you to specify the type of readout (full frame or binned), the output amplifier (if dual amplifiers are available), and the gain (the number of electrons required to generate an ADU).

Full Frame Readout

In this section, a simple 6 × 4 pixel CCD is used to demonstrate how charge is shifted and digitized. Full frame readout, for full frame CCDs, reads out the entire CCD surface at the same time.

The upper left drawing in Figure 17 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 row toward the "shift register," in this case the row at the top. The shift register is a single line of pixels along one edge 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.

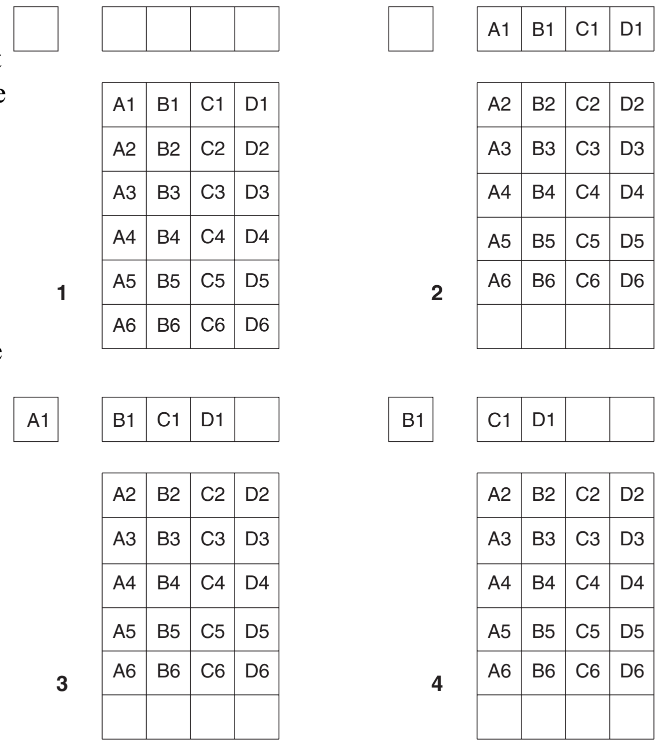


Figure 17. Full Frame at Full Resolution

After the first row 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 the output it is digitized. Only after all pixels in the first row are digitized is the second row moved into the shift register. The order of shifting in our example is therefore A1, B1, C1, D1, A2, B2, C2, D2, A3 ....

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:

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

where

t_R is the CCD readout time,

t_{exp} is the exposure time, and

t_c is the shutter compensation time (added to compensate for the time required to close a mechanical shutter). If there is no shutter selected in the software, this time will be approximately 0 ms.

The readout time is approximately given by:

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

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 on the CCD array *before* the signal is read out of the output amplifier. 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.

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.

Figure 18 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.

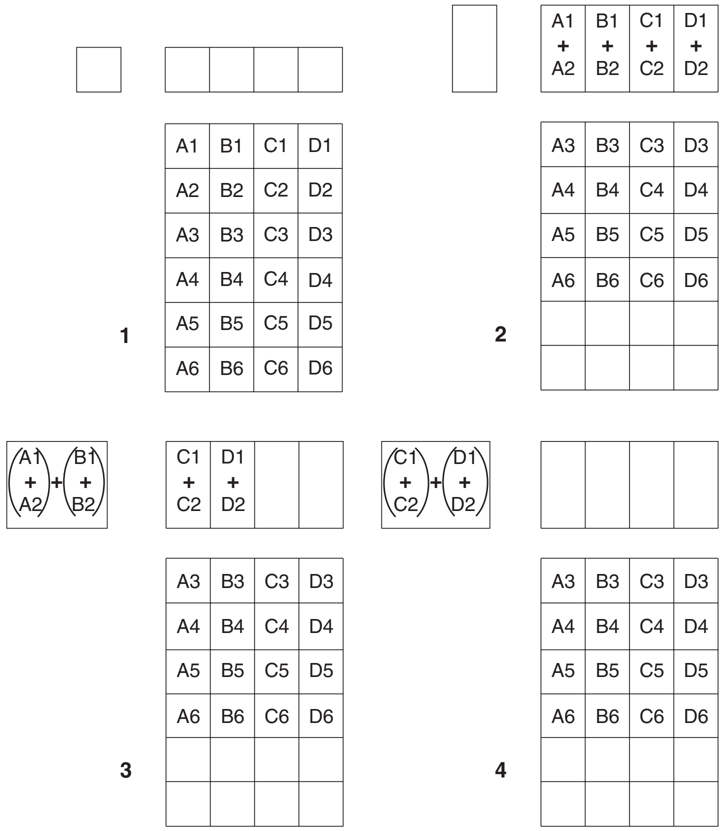


Figure 18. 2 × 2 Binning

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

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

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.

Output Amplifier Selection

The output amplifier amplifies the collected charge from the output node and outputs it as electrons/count. Although Figure 16 shows an array with a single output node and amplifier, some PI-SX systems are available with dual output nodes and amplifiers (one set at each end of the shift register). If your system has dual output amplifiers, you can choose the output amplifier to be used (High Capacity or Low Noise) via WinView/32 or WinSpec/32 on the **Acquisition|Experiment Setup…|Main** tab page:

- **High Capacity amplifier:** Provides a spectrometric well capacity that is approximately 3 times the well capacity for the Low Noise amplifier selection. High Capacity is suitable when you have intense light signals or signals with high dynamic range.
- **Low Noise amplifier:** Provides the highest sensitivity performance and is suitable when you have weak signals.

Note: The choice of output amplifier and analog gain setting should be considered together for the best signal capture.

Analog Gain Control

Note: A three-position gain control switch is located on the side of many of the LN-cooled cameras (Figure 19). If this switch is not there, analog gain may be changeable via the WinView or WinSpec software. If your camera is not designed for analog gain selection, these settings will not be accessible in the software.

Analog gain control (a function of the preamplifier) is used to change the relationship between the number of electrons acquired on the CCD and the Analog-to-Digital Units (ADUs or counts) generated. In WinView/32 and WinSpec/32, the analog gain choices vary depending on the CCD array and the number of output amplifiers:

- **Single Amplifier:** Typically, three settings are available: Low 2x, Medium 1x, and High 1/2x.
- **Dual Amplifier:** Typically, three settings are available: Low 2x, Medium 1x, and High 1/2x (Low-noise mode) or Low 4x, Medium 2x, and High 1x (High-capacity mode).

Analog gain is software-selectable in all of the new PI-SX cameras. In WinView and WinSpec (version 2.X and higher), analog gain selection is made on the **Acquisition|Experiment Setup…|ADC** tab card. If there is no Analog Gain parameter on that tab card, analog gain may not be selectable or it may be controlled by a gain switch on the camera, as is the case with older LN-cooled cameras (see Figure 19). When software-selection of Analog Gain is available, the software selection will override any hardware setting that may be selected at the camera.

The analog 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 switch set to **Medium**. In situations where the A/D range exceeds that of the array, it will generally be better to set the Analog Gain to **High** 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 **High**, which reduces some sources of electronics noise. Users who measure high-level signals may wish to select **Low** to allow digitization of larger signals.

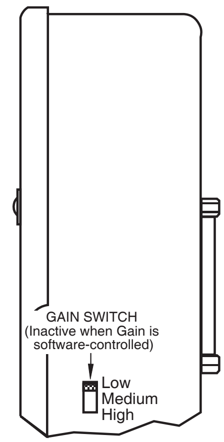


Figure 19. Analog Gain Switch on LN Camera

Example: The following descriptions assume that the actual incoming light level is identical in all three instances. ***The numbers used illustrate the effect of changing an analog gain setting and do not reflect actual performance: gain at the Low, Medium, and High settings depends on the CCD installed.***

Low requires four electrons to generate one ADU. Strong signals can be acquired without flooding the CCD array. If the gain is set to **Low** and the images or spectra appear weak, you may want to change the gain setting to **Medium** or **High**.

Medium requires two electrons to generate one ADU. If the gain is set to **Medium** and the images or spectra do not appear to take up the full dynamic range of the CCD array, you may want to change the gain setting to **High**. If the CCD array appears to be flooded with light, you may want to change the setting to **Low**.

High requires one electron to generate one ADU and some noise sources are reduced. Because fewer electrons are needed to generate an ADU, weaker signals can be more readily detected. Lower noise further enhances the ability to acquire weak signals. If the CCD array appears to be flooded with light, you may want to change the setting to **Medium** or **Low**.

Note: The baseline level may require adjustment if you change the analog gain. See the ***"ADC Offset"*** section on page 55 for more information.

Digitization

Introduction

After gain has been applied to the signal, the Analog-to-Digital Converter (ADC) converts that analog information (continuous amplitudes) into a digital data (quantified, discrete steps) that can be read, displayed, and stored by the application software. The number of bits per pixel is based on both the hardware and the settings programmed into the camera through the software (see ***"Readout",*** page 49).

Factors associated with digitization include the digitization rate and baseline signal. Depending on the camera model, you may be able change the speed at which digitization occurs and/or offset the baseline. These factors are discussed in the following paragraphs.

Digitization Rate

PI-SX systems incorporate dual digitization (100 kHz/1 MHz or 50kHz/1 MHz), which means that you have a choice of how quickly the data will be digitized. Dual digitization provides optimum signal-to-noise ratios at both readout speeds. 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. The 1 MHz conversion speed is used for the fastest possible data collection and the 100 kHz or 50 kHz conversion speed is used where noise performance is the paramount concern. Switching between the conversion speeds is completely under software control for total experiment automation.

Note: In WinView and WinSpec, the ADC rate can be changed on the **Experiment Setup|ADC** tab page.

ADC Offset

ADC offset (also known as baseline offset) provides another way of dealing with dark charge (see ***"Dark Charge"***, page 48). By offsetting the baseline signal, much of the background is ignored during conversion.

Offsetting the baseline is accomplished by adding a voltage to the signal to bring the A/D output to a non-zero value, typically 50-100 counts. This offset value ensures that all the true variation in the signal can really be seen and not lost below the A/D "0" value. Since the offset is added to the signal, these counts only minimally reduce the range of the signal from 65535 (16-bit A/D) to a value in the range of 50-100 counts lower.

Notes:

1. Do not be concerned about either the DC level of the baseline signal or its shape unless it is very high (i.e., > 1000 counts for LN-cooled or > 400 counts for TE-cooled).
2. The ADC Offset can be adjusted by using the F and S Zero pots located on the rear panel of the controller. If these pots are not present, the ADC Offset may be software-adjustable on the **Experiment Setup|ADC** tab page.
3. Do not adjust the offset values to zero or some low-level data will be missed.

CAUTION

If you observe a sudden change in the baseline signal, ***TURN OFF THE SYSTEM IMMEDIATELY*** (if the system is LN-cooled, remove the liquid nitrogen also) and contact Princeton Instruments Customer Support. See page 102 for contact information.

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Chapter 6

Advanced Topics

Introduction

Previous chapters have discussed setting up the hardware and the software for basic operation. This chapter discusses topics associated with experiment synchronization (set up on the **Experiment Setup|Timing** tab page in WinView and WinSpec).With the exception of Edge Trigger, the topics are addressed in order of their appearance on the Timing tab page (see Figure 20).

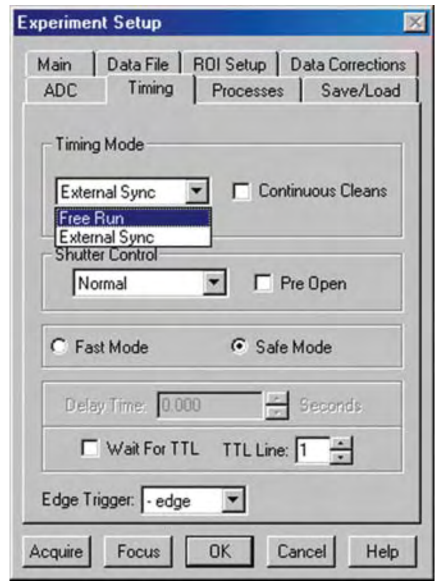

Figure 20. Timing tab page

"Timing Modes", the first topic, discusses Timing Modes, Shutter Control, and Edge Trigger. Also included under this topic is a discussion of the **EXT SYNC** connector, the input connector for a trigger pulse.

"Fast and Safe Modes", the second topic, discusses the Fast and the Safe speed modes. Fast is used for real-time data acquisition and Safe is used when coordinating acquisition with external devices or when the computer speed is not fast enough to keep pace with the acquisition rate.

"TTL Control", the final topic, discusses the TTL IN/Out connector on the rear of the ST-133 and how commands can be sent via TTL levels to and from the ST-133.

Standard Timing Modes

The chart to the right lists the timing mode combinations (selected on the **Experiment Setup|Timing** tab page). 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 with Continuous Cleans	Normal

Table 4. Camera Timing Modes

The basic ST-133 timing modes are Free Run, External Sync, and External Sync with Continuous Cleans. These modes are combined with the Shutter options to provide the widest variety of timing modes for precision experiment synchronization.

Note: Since PI-SX cameras do not use shutters, the **Shutter Type** selection on the **Hardware Setup|Controller/Camera** tab page should be "**None**".

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. PreOpen, available in the External Sync and External Sync with Continuous Cleans modes, opens the shutter as soon as the ST-133 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). Note that if there is no shutter selected in the software, the shutter compensation time (the time required to close a mechanical shutter) will be approximately 0 ms. For more information about these parameters, see the discussion of full frame readout, starting on page 49.

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.

Other experimental equipment can be synchronized to the ST-133 controller by using the output signal (software-selectable **SHUTTER** or **NOT SCAN** on the **Hardware Setup|Controller Camera** tab page) from the $\overline{\textbf{SCAN}}$ connector. Shutter operation and the NOT SCAN output signal are shown in Figure 22.

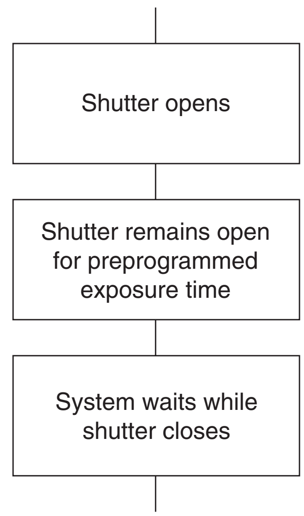

Figure 21. Free Run Timing Chart, Part of the Chart in Figure 27

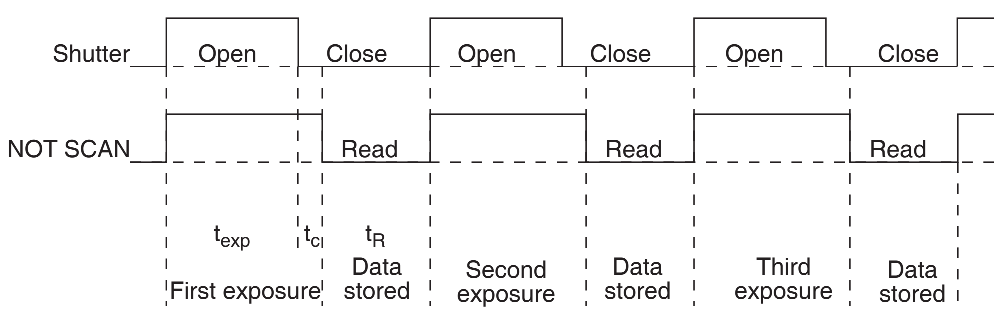

Figure 22. Free Run Timing Diagram

External Sync

In this mode all exposures are synchronized to an external source via signal input to the Ext Sync BNC on the back of the ST-133. To ensure synchronization, the trigger edge (negative- or positive-going) of the Ext Sync signal must be identified in the application software (in WinView and WinSpec, this is done on the **Experiment Setup|Timing** tab page). As shown in the flowchart, Figure 23, External Sync 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.

Because the external shutter requires a finite amount of time to open completely (shutter open time may be 5-28 msec depending on the shutter), the External Sync pulse trigger edge provided by the experiment should 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 trigger edge 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 trigger edge at the ST-133, 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.

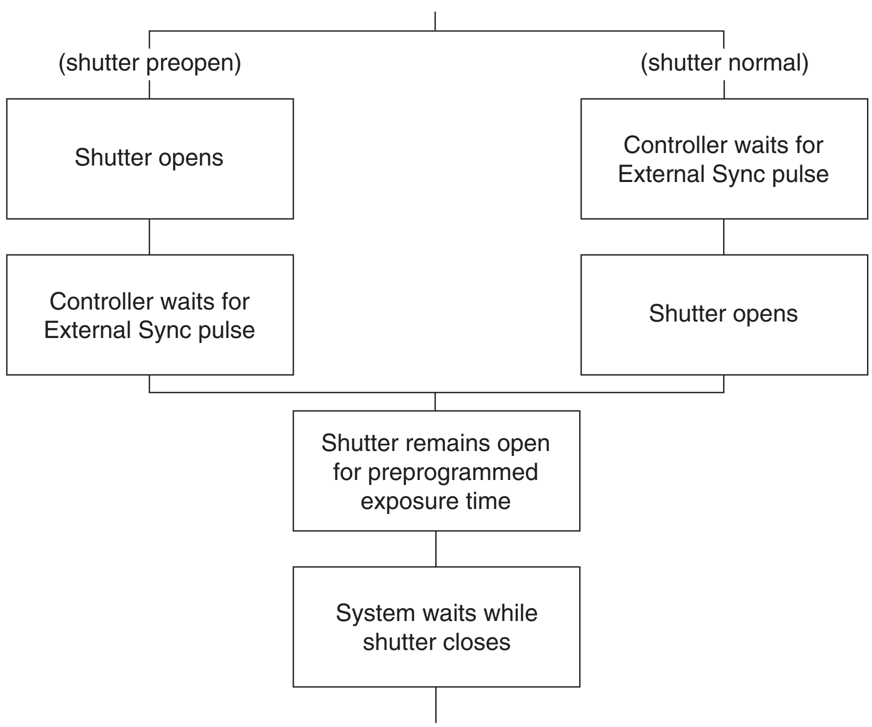

Figure 23. Chart Showing Two External Sync Timing Options

The PreOpen mode is useful in cases where an External Sync pulse trigger edge cannot be provided 5-28 msec (shutter open time) 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 (in Figure 24, this means that if it is still LOW) at the end of the readout, the hardware may interpret this as a second sync pulse, and so on.

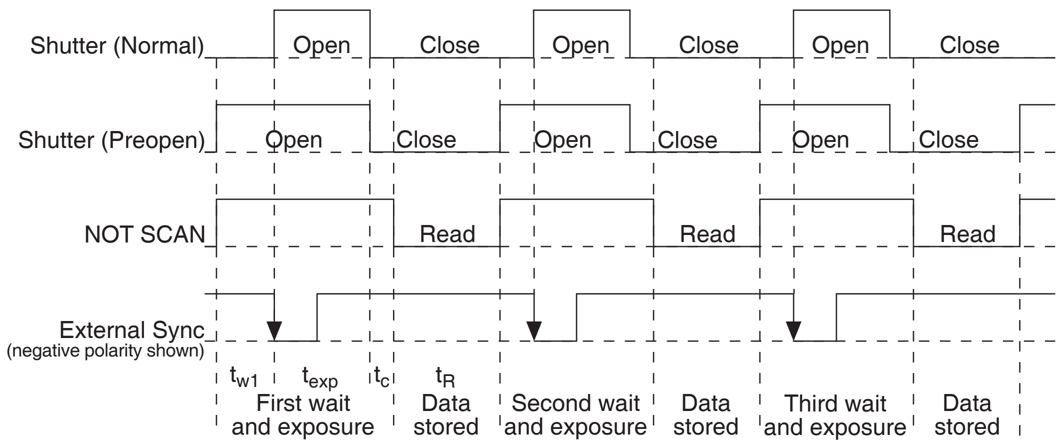

Figure 24. Timing Diagram for External Sync Mode (- edge trigger)

External Sync with Continuous Cleans

Another timing mode available with the ST-133 controller 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.

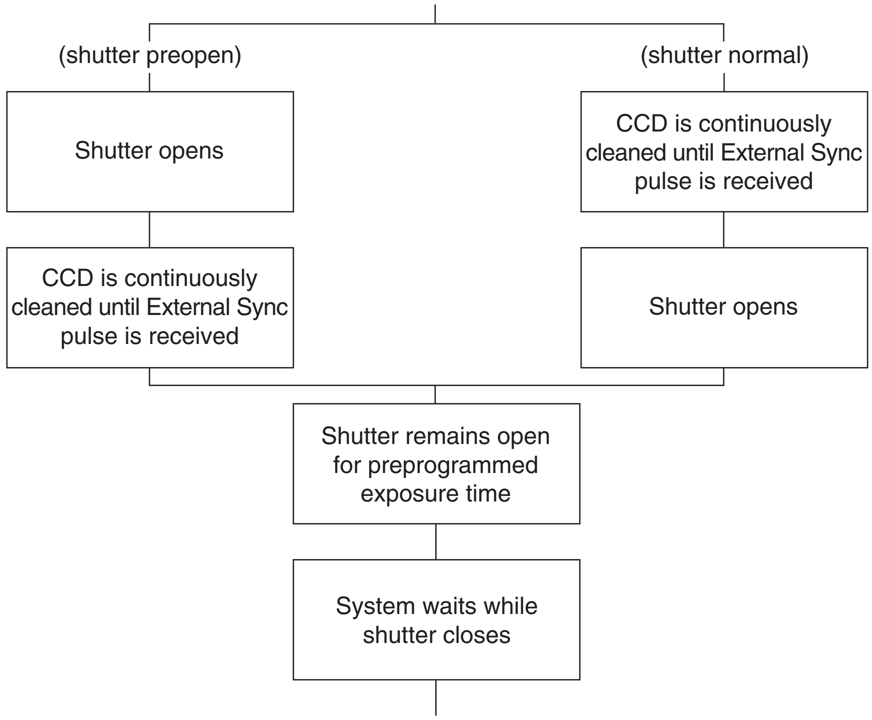

Figure 25. Continuous Cleans Operation Flowchart

Once the External Sync pulse is received, cleaning of the array stops as soon as the current row is shifted, and frame collection begins: a delay time of up to one row shift can be expected. 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 (in Figure 26, this means that if it is still LOW) at the end of the readout, the hardware may interpret this as a second sync pulse, and so on.

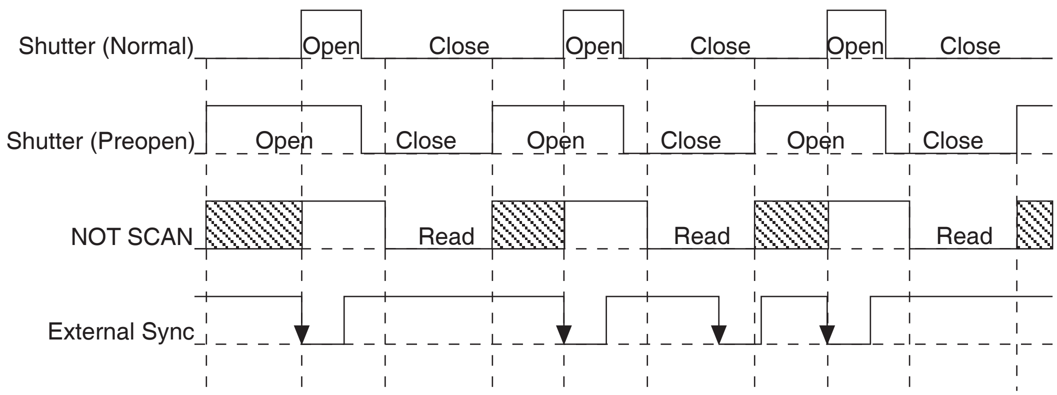

Figure 26. Continuous Cleans Timing Diagram (- edge trigger)

Fast and Safe Modes

The **Experiment Setup|Timing** tab page allows you to choose **Fast Mode** or **Safe Mode**. Figure 27 is a flow chart comparing the two modes. In Fast Mode operation, the ST-133 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-133 cannot collect the next frame until the previous frame has been completely processed.

Fast Mode operation is primarily for collecting “real-time” sequences of experimental data, where timing is critical and events cannot be missed. Once the ST-133 is sent the Start Acquisition command by the computer, all frames are collected without further intervention from the computer. The advantage of this triggering 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 video monitor connected to the VIDEO output will always display the current image.* 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 through software with external devices such as external shutters and filter wheels. As seen in Figure 27, in Safe Mode operation, the computer controls when each frame is taken. After each frame is received, the computer 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 Mode is that events may be missed during the experiment, since the ST-133 is disabled for a short time after each frame.

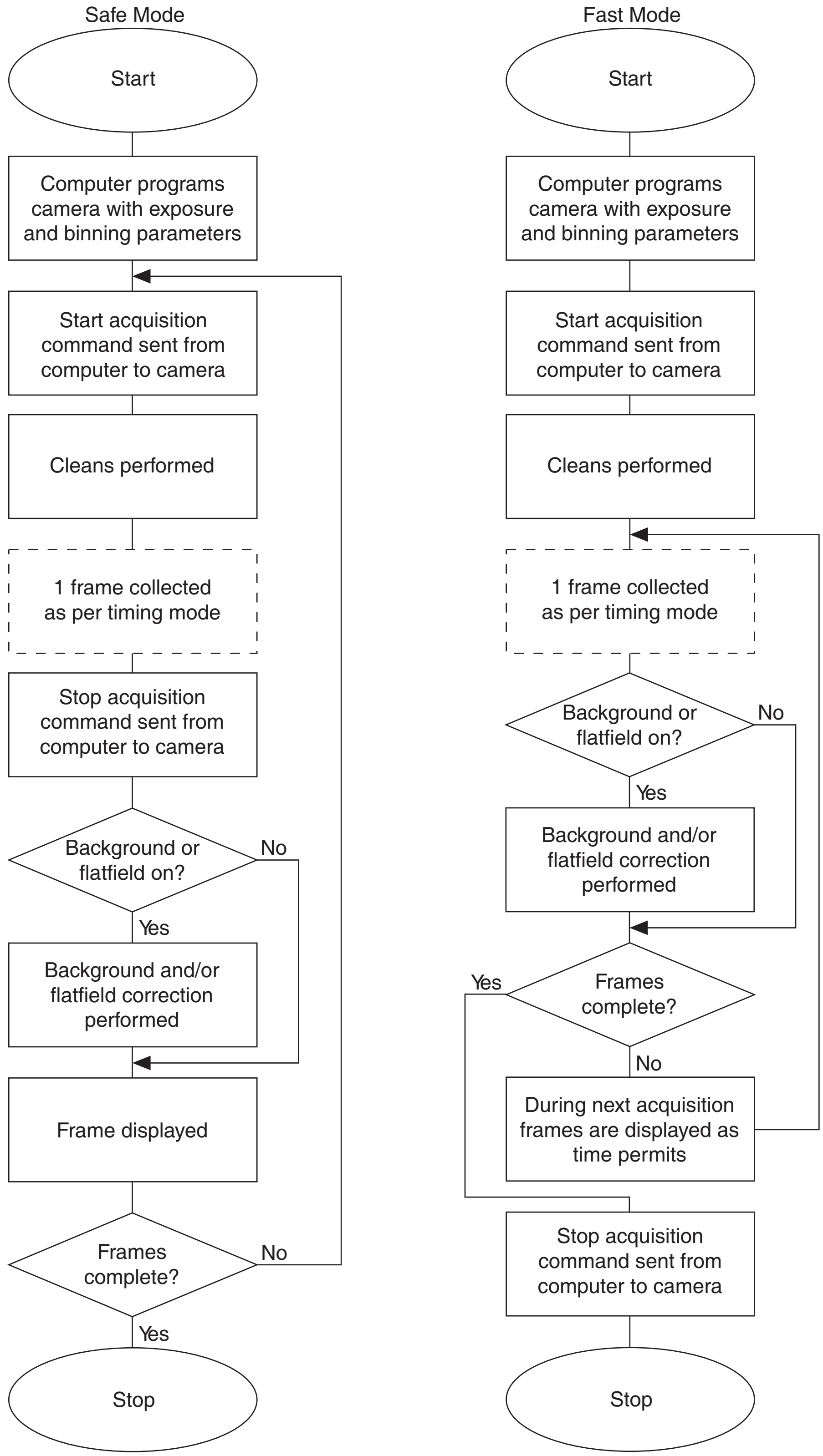

Figure 27. Chart of Safe Mode and Fast Mode Operation

TTL Control

Fully supported by WinView/WinSpec Version 2.5 when the communication protocol is TAXI (PCI), this feature is not supported when the protocol is USB 2.0.

Introduction

Princeton Instruments' WinView and WinSpec software packages 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 or Visual C++. 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-133 Controller. This connector provides 8 TTL lines in, 8 TTL lines out and an input control line. Figure 28 illustrates the connector and Table 6 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 5 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 5. 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 (or WinSpec/32). Typically, a program (for example, a macro) monitoring the experiment sets one or more of the TTL Outputs. Apparatus external to the PI-SX system 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		

Table 6. TTL In/Out Connector Pinout

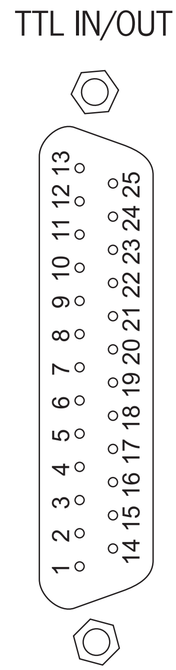

Figure 28. TTL In/Out Connector

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.

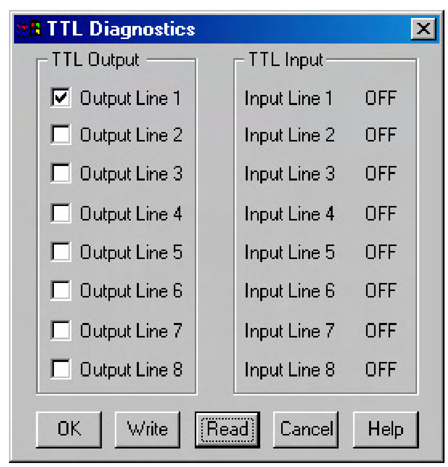

Figure 29. TTL Diagnostics dialog box

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 on the back of the ST-133. 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 Radio Shack® 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 6, 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-133.
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.

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Chapter 7
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	Page 70
Camera Stops Working	Page 70
Camera1 (or similar name) on Hardware Setup dialog box	Page 70
Changing the ST-133 Line Voltage and Fuses	Page 71
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Cooling Troubleshooting	Page 72
Data Loss or Serial Violation	Page 73
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Removing/Installing a Plug-In Module	Page 83
Serial violations have occurred. Check interface cable.	Page 85
Shutter Failure	Page 85
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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 Customer 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-133's Line Voltage and Fuses"*** on page 71.
- 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 Princeton Instruments Customer Support for further instructions.

If the system still does not respond, contact Princeton Instruments Customer Support.

Camera1 (or similar name) on Hardware Setup dialog box

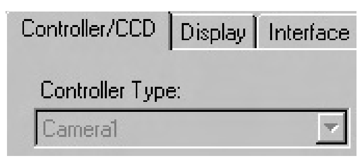


Figure 30. Camera1 in Controller Type (Camera Name) Field

If you see a default name such as Camera1 on the **Setup|Hardware|Controller/CCD** tab page, you may want to change it since this name is not particularly descriptive. Such a change is made by editing the PVCAM.INI file that is generated by Camera Detection wizard (or by the RSConfig.exe if you have software version 2.5.19.0 or earlier).

To change the default Camera Name:

1. Using **Notepad** or a similar text editor, open **PVCAM.INI**, which is located in the Windows directory (C:\WINNT, for example). You should see entries like the ones below.

   [Camera_1]
   Type=1
   Name=Camera1
   Driver=apausb.sys
   Port=0
   ID=523459

2. Change the "Name=" entry to something more meaningful for you (for example, ST133USB - to indicate that this is a PVCAM-based system using an ST-133 with a USB 2.0 interface) and save the edited file.

   [Camera_1]
   Type=1
   Name=ST133USB
   Driver=apausb.sys
   Port=0
   ID=523459

3. The new camera name will now appear in the **Controller Type** (**Camera Name)** field.

Changing the ST-133 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 31, 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 (Figure 32) and gently pry the assembly out.

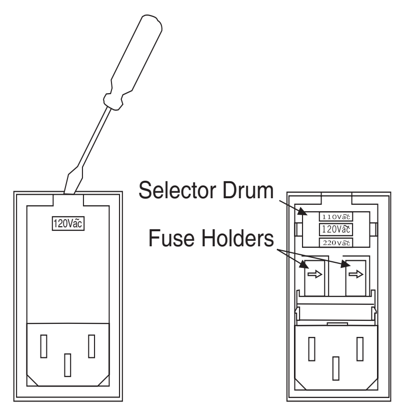


Figure 31. Power Input Module

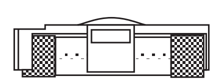


Figure 32. Fuse Holder

4. Refer to the Fuse/Voltage label (above or below the Power Module) to see which fuses are required by the selected voltage. If Controller power switch is on the back of the ST-133, the Fuse/Voltage label is located below the Power Module.
5. 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.

6. Close the power input module and verify that the correct voltage setting is displayed.
7. 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 WinView/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 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.
- If the interface card is installed in the computer and is cabled to the SERIAL COM port on the rear of the Controller, close WinView/32 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 WinView/32 has been installed, close that application and do a "Custom" installation 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

CAUTION

Operating a PI-SX liquid-assisted or 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.***

Camera doesn't achieve Temperature Lock

If the indicator doesn't turn green after 30 minutes:

- The temperature setting may be at a temperature colder than the specified limit or the environment could be particularly warm. If this occurs, try a higher temperature setting. *Make sure you are selecting a temperature that is acceptable for your particular camera and CCD array.*
- The coolant may not be flowing fast enough. Check the coolant flow rate.

- The connectors of the cable that interconnects the controller and the camera need to be secured.
- Airflow may be obstructed.

Camera loses Temperature Lock

The internal temperature of the camera is too high. This might occur if

- The operating environment is particularly warm.
- You are attempting to operate at a temperature colder than the specified limit.
- The coolant flow is insufficient.

If the camera loses temperature lock, 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.*

Data Loss or Serial Violation

You may experience either or both of these conditions if the host computer has been set up with Power Saving features enabled. This is particularly true for power saving with regard to the hard drive. Make sure that Power Saving features are disabled while you are running WinView/32 or WinSpec/32.

Data Overrun Due to Hardware Conflict message

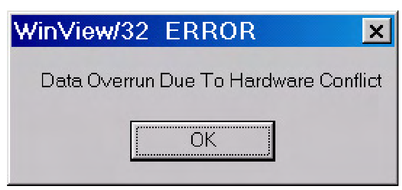


Figure 33. Data Overrun Due to Hardware Conflict dialog box

If this dialog box appears when you try to acquire a test image, acquire data, or run in focus mode, check the CCD array size and then check the DMA buffer size. A large array (for example, a 2048x2048 array), requires a larger DMA buffer larger setting than that for a smaller array (for example, a 512x512 array).

To change the DMA buffer setting:

1. Note the array size (on the **Setup|Hardware|Controller/CCD** tab page or the **Acquisition|Experiment Setup|Main** tab page Full Chip dimensions).
2. Open **Setup|Environment|Environment** dialog box.
3. Increase the DMA buffer size to a minimum of 32 Mb (64 Mb if it is currently 32 Mb or 128 Mb if it is currently 64 Mb), click on **OK**, and close WinView.
4. Reboot your computer.

5. Restart WinView and begin acquiring data or focusing. If you see the message again, increase the DMA buffer size.

Data Overrun Has Occurred message

Because of memory constraints and the way that USB transfers data, a "Data overrun has occurred" message may be displayed during data acquisition. If this message is displayed, take one or more of the following actions:

1. Minimize the number of programs running in the background while you are acquiring data with WinView/32 or WinSpec/32.
2. Run data acquisition in Safe Mode.
3. Add memory.
4. Use binning.
5. Increase the exposure time.
6. Defragment the hard disk.
7. Update the Orange Micro USB2 driver. See ***"To Update the OrangeUSB USB 2.0 Driver"***, page 31.

If the problem persists, your application may be USB 2.0 bus limited. Since the host computer controls the USB 2.0 bus, there may be situations where the host computer interrupts the USB 2.0 port. In most cases, the interrupt will go unnoticed by the user. However, there are some instances when the data overrun cannot be overcome because USB 2.0 bus limitations combined with long data acquisition times and/or large data sets increase the possibility of an interrupt while data is being acquired. If your experiment requirements include long data acquisition times and/or large data sets, your application may not be suitable for the USB 2.0 interface. Therefore, we recommend replacement of the USB 2.0 interface module with our TAXI interface module and Princeton Instruments (RSPI) high speed PCI card. If this is not the case and data overruns continue to occur, contact Customer Support (see page 102 for contact information).

Demo is only Choice on Hardware Wizard:Interface dialog (Versions 2.5.19.0 and earlier)

If RSConfig.exe has not been run and there is not an installed Princeton Instruments (RSPI) high speed PCI card, the Hardware Wizard will only present the choice "Demo" in the Interface dialog box (Figure 34). Clicking on **Next** presents an "Error Creating Controller. Error=129." message, clicking on **OK** presents "The Wizard Can Not Continue Without a Valid Selection!" message, clicking on **OK** presents the Interface dialog box again.

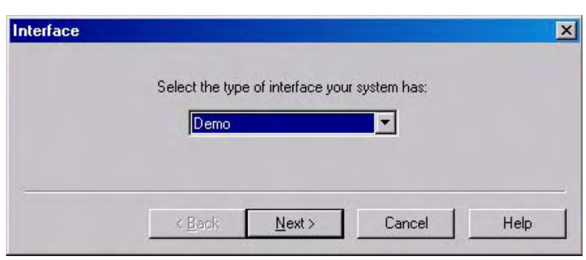


Figure 34. Hardware Wizard: Interface dialog box

At this point, you will need to exit WinView or WinSpec and run the RSConfig.exe program, which creates a file called PVCAM.INI. This file contains information required to identify the interface/camera and is referenced by the Hardware Wizard when you are setting up WinView/32 or WinSpec/32 with USB for the first time:

1. If you have not already done so, close WinView/32 or WinSpec/32.
2. Make sure the ST-133 is connected to the host computer and that it is turned on.
3. Run RSConfig from the **Windows|Start|Programs|Roper Scientific** menu or from the directory where you installed WinSpec.
4. When the RSConfig dialog box (Figure 35) appears, you can change the camera name to one that is more specific or you can keep the default name "Camera1". When you have finished, click on the **Done** button.

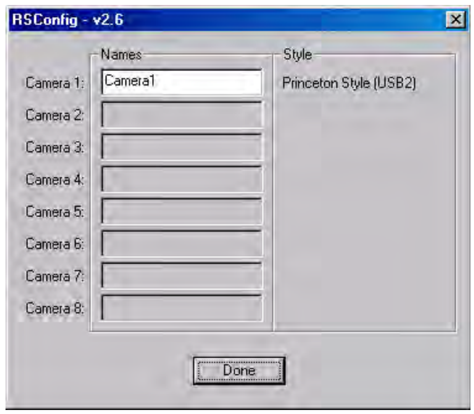


Figure 35. RSConfig dialog box

5. You should now be able to open WinView or WinSpec and, from **Setup|Hardware…,** run the Hardware Wizard.
6. When the PVCAM dialog box (Figure 36) is displayed, click in the **Yes** radio button, click on **Next** and continue through the Wizard. After the Wizard is finished, the **Controller/Camera** tab card will be displayed with the **Use PVCAM** checkbox selected. You should now be able to set up experiments and acquire data.

Figure 36. Hardware Wizard: PVCAM dialog box

Demo, High Speed PCI, and PCI(Timer) are Choices on Hardware Wizard:Interface dialog (Versions 2.5.19.0 and earlier)

If there is an installed Princeton Instruments (RSPI) high speed card in the host computer and you want to operate a camera using the USB 2.0 interface, the PVCAM.INI file (created by RSConfig.exe) must exist and the USB 2.0 supported camera must be the first camera listed on the RSConfig dialog box. PVCAM.INI, which contains information required to identify the interface/camera, is referenced by the Hardware Wizard when you are setting up WinView/32 or WinSpec/32 with USB for the first time. If the Wizard did not find a PVCAM.INI file or if RSConfig.exe was run but the USB 2.0 camera is the second camera listed on the RSConfig dialog box ([Camera_2] in the PVCAM.INI file), "Demo", "High Speed PCI", and "PCI(Timer)" will be selectable from the Wizard's Interface dialog box.

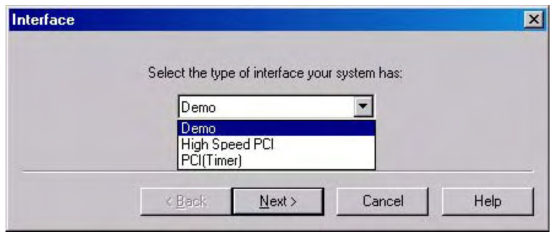


Figure 37. Hardware Wizard: Interface dialog box

At this point, you will need to run the RSConfig.exe program:

1. If you have not already done so, close WinView/32 or WinSpec/32.
2. Make sure the ST-133 is connected to the host computer and that it is turned on.
3. Run RSConfig from the **Windows|Start|Programs|Roper Scientific** menu or from the directory where you installed WinView or WinSpec.
4. When the RSConfig dialog box (Figure 38) appears, you can change the camera name to one that is more specific or you can keep the default name "Camera2". When you have finished, click on the **Done** button. You will next edit the generated PVCAM.INI file.

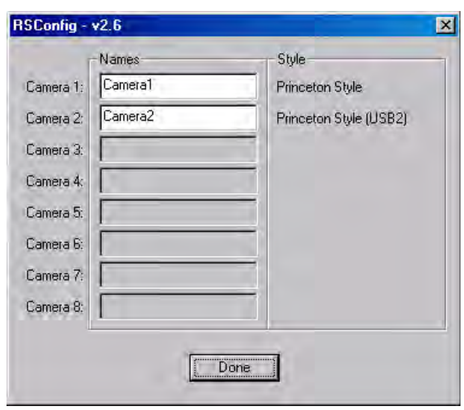


Figure 38. RSConfig dialog box: Two Camera Styles

5. Using **Notepad** or a similar text editor, open **PVCAM.INI**, which is located in the Windows directory (C:\WINNT, for example).

If the contents of the file look like:	Change the headings so the contents now look like:
[Camera_1]	**[Camera_2]**
Type=1	Type=1
Name=Camera1	Name=Camera1
Driver=rspipci.sys	Driver=rspipci.sys
Port=0	Port=0
[Camera_2]	**[Camera_1]**
Type=1	Type=1
Name=Camera2	Name=Camera2
Driver=apausb.sys	Driver=apausb.sys
Port=0	Port=0

Note: The [Camera_#] must be changed so the camera supported by the USB interface will be recognized (the USB driver is "apausb.sys"). For consistency, you may also want to change the camera names.

6. Save the file. With the ST-133 connected and on, open WinView/32 or WinSpec/32.

7. Run the Hardware Wizard.

8. When the PVCAM dialog box (Figure 39) is displayed, click in the **Yes** radio button, click on **Next** and continue through the Wizard. After the Wizard is finished, the **Controller/Camera** tab card will be displayed with the **Use PVCAM** checkbox selected. You should now be able to acquire data.

Figure 39. Hardware Wizard: PVCAM dialog box

Detector Temperature, Acquire, and Focus are Grayed Out (Versions 2.5.19.0 and earlier)

These functions and others will be deactivated if you have installed a camera being run under USB 2.0 and have opened WinView/32 or WinSpec/32 without having first turned on the ST-133. They will also be deactivated if you have installed a camera being run under USB 2.0 and a Princeton Instruments (RSPI) high speed PCI card was also detected when RSConfig.exe was run.

1. Check to see if the ST-133 is connected to the host computer and is turned on. If it is not connected or is connected but not turned on, go to Step 2. If it is connected and on, go to Step 3.

2. Close WinView or WinSpec, verify that the ST-133 is connected to the host computer, turn on the ST-133, and reopen WinView or WinSpec. The formerly grayed out functions should now be available.

3. If the ST-133 is connected and on, the USB 2.0 camera may not be listed as Camera 1 in the PVCAM.INI file.

4. Run RSConfig.exe (accessible from the **Windows|Start|Programs|Roper Scientific** menu). If the USB 2.0 camera is listed as Camera 2 (Princeton Style (USB2) in Figure 40), you will have to edit the PVCAM.INI file.

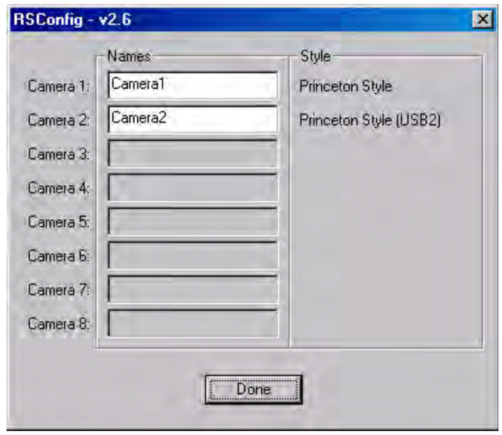


Figure 40. RSConfig dialog box: Two Camera Styles

5. Using **Notepad** or a similar text editor, open **PVCAM.INI**, which is located in the Windows directory (C:\WINNT, for example).

If the contents of the file look like:		Change the headings so the contents now look like:
[Camera_1] Type=1 Name=Camera1 Driver=rspipci.sys Port=0	→	**[Camera_2]** Type=1 Name=Camera1 Driver=rspipci.sys Port=0
[Camera_2] Type=1 Name=Camera2 Driver=apausb.sys Port=0	→	**[Camera_1]** Type=1 Name=Camera2 Driver=apausb.sys Port=0

Note: The [Camera_#] must be changed so the camera supported by the USB interface will be recognized (the USB driver is "apausb.sys"). For consistency, you may also want to change the camera names.

6. Save the file. With the ST-133 connected and on, open WinView/32 or WinSpec/32. The formerly grayed out functions should now be available.

Error Creating Controller message

This message may be displayed if you are using the USB 2.0 interface and have not run the RSConfig.exe program (see previous topic), if the PVCAM.INI file has been corrupted, or if the ST-133 was not turned on before you started WinView/32 or WinSpec/32 and began running the Hardware Wizard.

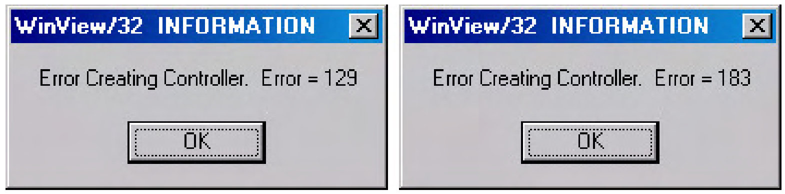


Figure 41. Error Creating Controller dialog box

Error 129: Indicates that the problem is with the PVCAM.INI file. Close WinView/32 or WinSpec/32, run RSConfig, make sure the ST-133 is on, reopen WinView or WinSpec, and begin running the Hardware Wizard.

Error 183: Indicates that the ST-133 is off. If you are running the Hardware Wizard when this message appears, click on **OK**, turn on the ST-133, and, on the PVCAM dialog box, make sure **Yes** is selected and then click on **Next**. The Hardware Wizard should continue to the Controller Type dialog box.

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 7. 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 (RSPI) PCI Serial Card	FF80-FFFF	15

Table 8. 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 Princeton Instruments' Customer 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

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 Princeton Instruments or an authorized service facility of Princeton Instruments.

ALT ESC to start another program), or running a screensaver program.

No CCD Named in the Hardware Wizard:CCD dialog (Versions 2.5.19.0 and earlier)

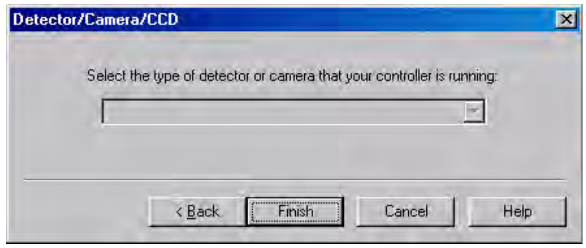


Figure 42. Hardware Wizard: Detector/Camera/CCD dialog box

If you have installed a USB 2.0 Interface Module in your ST-133, a blank field may be displayed in the Detector/Camera/CCD dialog box (Figure 42) if the ST-133 controller was made before January 2001. Earlier versions of the ST-133 did not contain non-volatile RAM (NVRAM), which is programmed with information about the controller and the camera. PVCAM, the program under which the Princeton Instruments USB works, retrieves the information stored in NVRAM so it can enter specific camera characteristics into WinView/32 or WinSpec/32.

Check the serial label on underside of your controller. If the first five characters are D1200 (December 2000) or earlier (J0797 or July 1997, for example), contact Customer Support to find out about an NVRAM controller upgrade.

No Images

See ***"Overexposed or Smeared Images"***, below.

Overexposed or Smeared Images

If an external shutter is being used, 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.

Program Error message

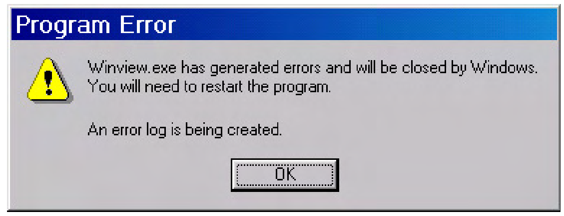


Figure 43. Program Error dialog box

This dialog may appear if you have tried to acquire a test image, acquire data, or run in focusing mode and the DMA buffer size is too small. A large array (for example, a 2048x2048 array), requires a larger setting than that for a smaller array (for example, a 512x512 array).

To correct the problem:

1. Click on **OK**.
2. Reboot WinView.
3. Note the array size (on the **Setup|Hardware|Controller/CCD** tab page or the **Acquisition|Experiment Setup|Main** tab page Full Chip dimensions). If your camera contains a large array (such as a 2048x2048 array), and the DMA buffer size is too small, there will not be enough space in memory for the data set.
4. Open **Setup|Environment|Environment** dialog box.
5. Increase the DMA buffer size to a minimum of 32 Mb (64 Mb if it is currently 32 Mb or 128 Mb if it is currently 64 Mb), click on **OK**, and close WinView.
6. Reboot your computer.
7. Restart WinView and begin acquiring data or focusing. If you see the message again, increase the DMA buffer size.

Removing/Installing a Plug-In Module

The ST-133 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 (either a TAXI or a USB 2.0 compatible module in the middle slot) are always provided. The third slot, however, is covered with a blank panel.

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.

WARNINGS!

1. 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.

2. Before handling any boards, take precautions to prevent electrostatic discharge (ESD). The modules are susceptible to ESD damage. Damage caused by improper handling is not covered by the Warranty.

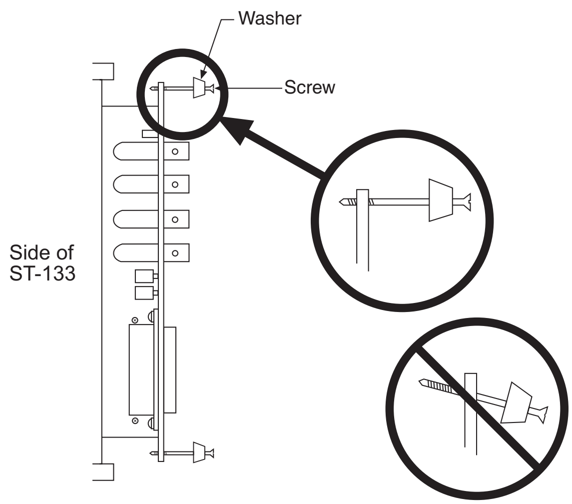


Figure 44. Module Installation

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.
4. Set the module aside in a safe place. If you are replacing it with another module, as in the case of exchanging a TAXI module with a USB 2.0 module, you may be able to use the packaging from the new module to store the module being replaced. This packaging is usually an antistatic bag that will protect the module components from electrostatic discharge.

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. Verify that the Controller has been turned OFF.
2. Remove the replacement module from its antistatic packaging. This packaging is designed to protect the module components from electrostatic discharge.
3. Rotate the two locking screws counterclockwise until the threads on the screws engage those of the module panel. *See Figure 44.* By doing this, the screws will be perfectly perpendicular to the module panel and will align perfectly when the module is inserted.
4. Insert the module so that the top and bottom edges of the board are riding in the proper guides.

5. 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.
6. 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! Tighten the screws to where they are just snug. Do ***not*** tighten them any further because you could easily bend the mating bracket.

Serial violations have occurred. Check interface cable.

Figure 45. Serial Violations Have Occurred dialog box

This error message dialog will appear if you try to acquire an image or focus the camera and either (or both) of the following conditions exists:

- The camera system is not turned ON.
- There is no communication between the camera and the host computer.

To correct the problem:

1. Turn **OFF** the camera system (if it is not already OFF).
2. Make sure the Detector-Controller cable is secured at both ends and that the computer interface cable is secured at both ends.
3. After making sure that the cables are connected, turn the camera system power **ON**.
4. Click **OK** on the error message dialog and retry acquiring an image or running in focus mode.

Note: This error message will also be displayed if you turn the camera system OFF or a cable comes loose while the application software is running in Focus mode.

Shutter Failure

See ***"Overexposed or Smeared Images"***, page 82.

Vignetting

All CCD arrays have been tested for uniformity and do not exhibit any 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 has occurred. This should not happen unless the cooling/pumping instructions, previously mentioned, were not followed, if a leak is occurring at the interface between the ConFlat and chamber, or if the Dewar has sprung a leak (a rare situation).
- The array is held with a special mask that has been designed to prevent damage to the horizontal register.

Appendix A
Specifications

General

Environmental

- Storage temperature: <55°C
- Operating environment: 5°C < T < 30°C
- Relative humidity: ≤50%; non condensing (not applicable for open-nose)

Temperature Stability

±0.05°C over recommended temperature range; dark charge stabilized to ±1.2%.

Power

Maximum internal heat dissipation in watts: 90

Controller Requirement

Requires ST-133.

CCD Arrays

Note: The following list may not be current. Contact the factory for up-to-date information on available chips and chip performance specifications.

PI-SX:100: Princeton Instruments exclusive array (1340x100), 20 x 20 µm pixels, back-illuminated, without AR coating, scientific grade, MPP

PI-SX:400: Princeton Instruments exclusive array (1340x400), 20 x 20 µm pixels, back-illuminated, without AR coating; scientific grade, MPP

PI-SX:512: e2V CCD77-0 (512x512), 24 x 24 µm pixels, back-illuminated, without AR coating, scientific grade, MPP

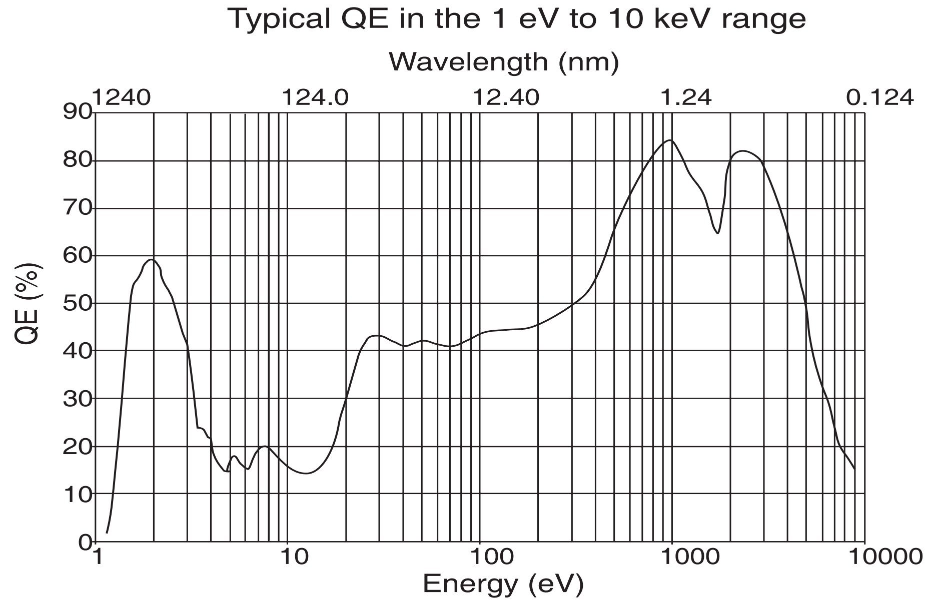
PI-SX:1K: e2V CCD47-10 (1024x1024), 13 x 13 µm pixels, back-illuminated, without AR coating, scientific grade, MPP

PI-SX:1300: Princeton Instruments exclusive array (1340x1300), 20 x 20 µm pixels, back-illuminated, without AR coating, scientific grade, MPP

PI-SX:2K: e2V CCD42-10 (2048x512), 13.5 x 13.5 µm pixels, back-illuminated, without AR coating, scientific grade, MPP

PI-SX:2048: e2V CCD42-40 (2048x2048), 13.5 x 13.5 µm pixels, back-illuminated, without AR coating, scientific grade, MPP

Quantum Efficiency



Note: QE for SITe 512 x 512 back-illuminated no-AR CCD; performance may vary slightly for other CCDs.

Cooling

PI-SX Camera Cooling Performance*						
Model	TE Cooling (°C)				LN cooling (°C)	
	Air		Chilled Water			
	Min	Typ	Min	Typ	Min	Typ
PI-SX:100 (1340x100)	-50	-60	N/A	N/A	-110	-120
PI-SX:400 (1340x400)	-50	-60	N/A	N/A	-110	-120
PI-SX:512 (512x512)	-40	-45	-55	-60	-110	-120
PI-SX:1K (1024x1024)	-45	-50	-55	-60	-110	-120
PI-SX:1300 (1340x1300)	-40	-45	-45	-55	-100	-110
PI-SX:2k (2048x512)	-70	-75	N/A	N/A	N/A	N/A
PI-SX:2048 (2048x2048)	-40	-45	-45	-55	-100	-110

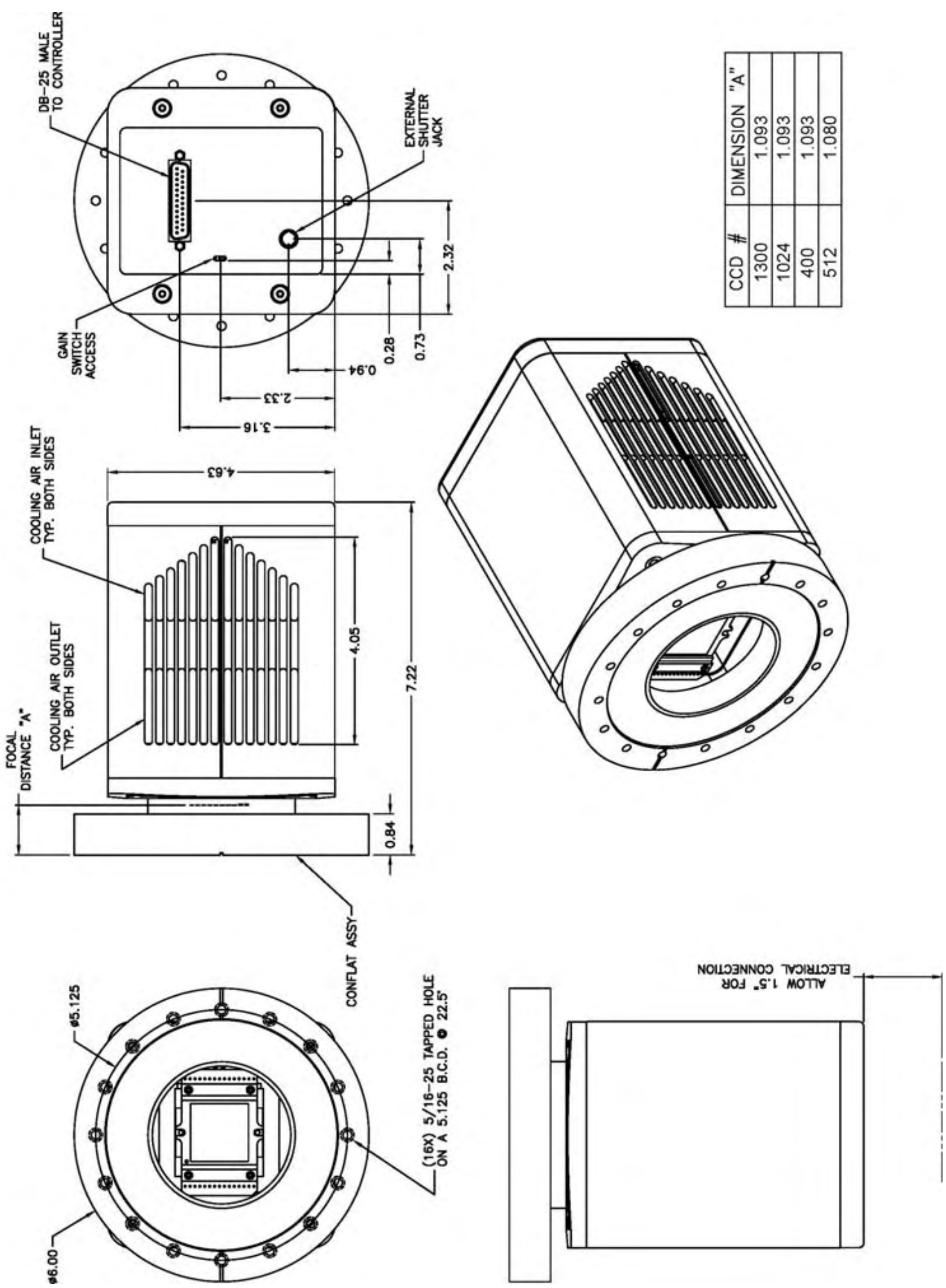
* Ambient temperature of 20°C and vacuum level of 10^{-5} - 10^{-6} Torr or better are required to reach these temperatures.

Table 9. Cooling Performance Chart

Appendix B
Outline Drawings

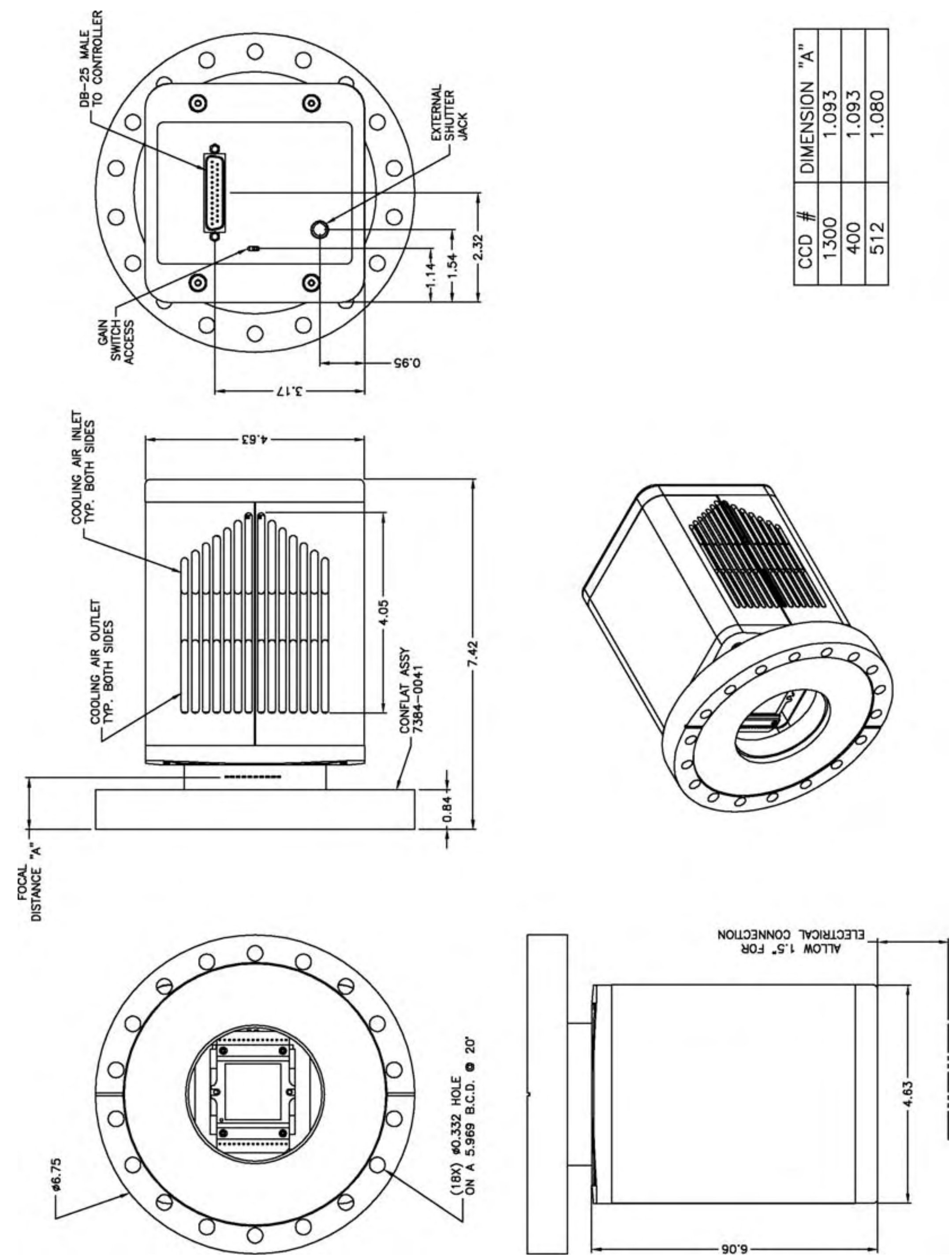
Note: *Dimensions are in inches.*

Current Models



CCD #	DIMENSION "A"
1300	1.093
1024	1.093
400	1.093
512	1.080

Figure 46. PI-SX TE-Cooled Camera (6.00" ConFlat Flange)



CCD #	DIMENSION "A"
1300	1.093
400	1.093
512	1.080

Figure 47. PI-SX TE-Cooled Camera (6.75" ConFlat Flange)

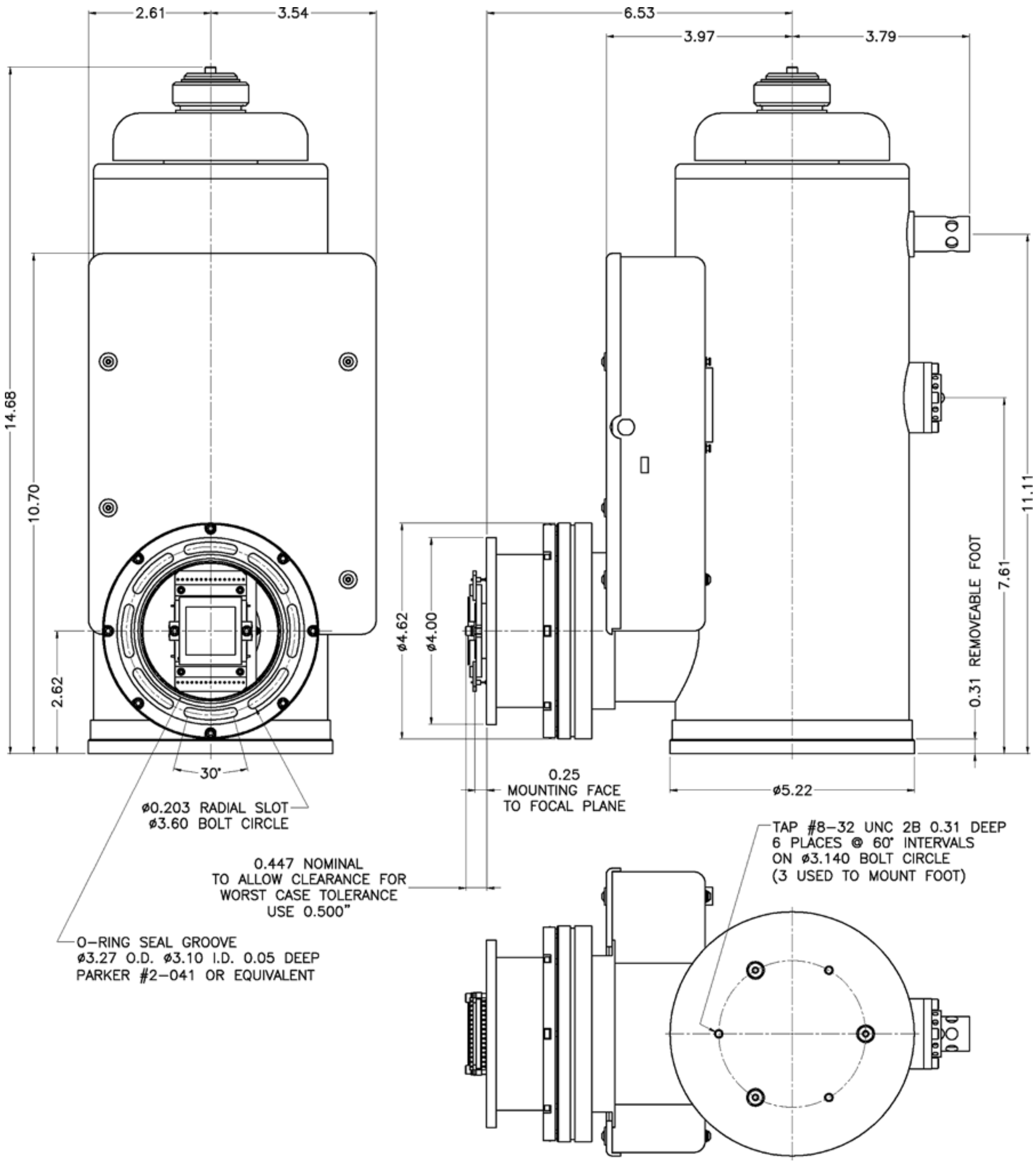


Figure 48. PI-SX LN-Cooled Camera (4.00" VON Flange)

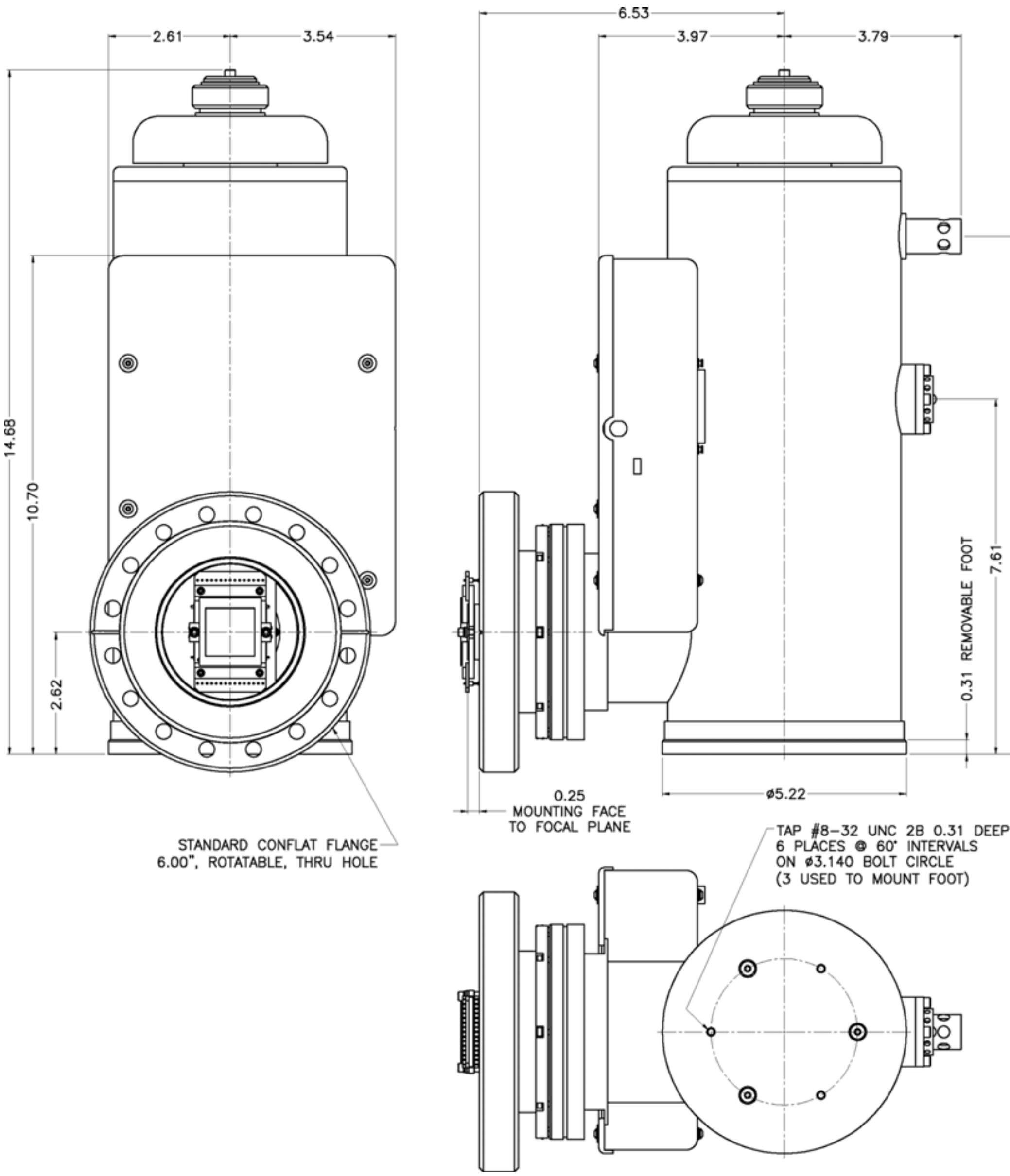


Figure 49. PI-SX LN-Cooled Camera (6.00" ConFlat Flange)

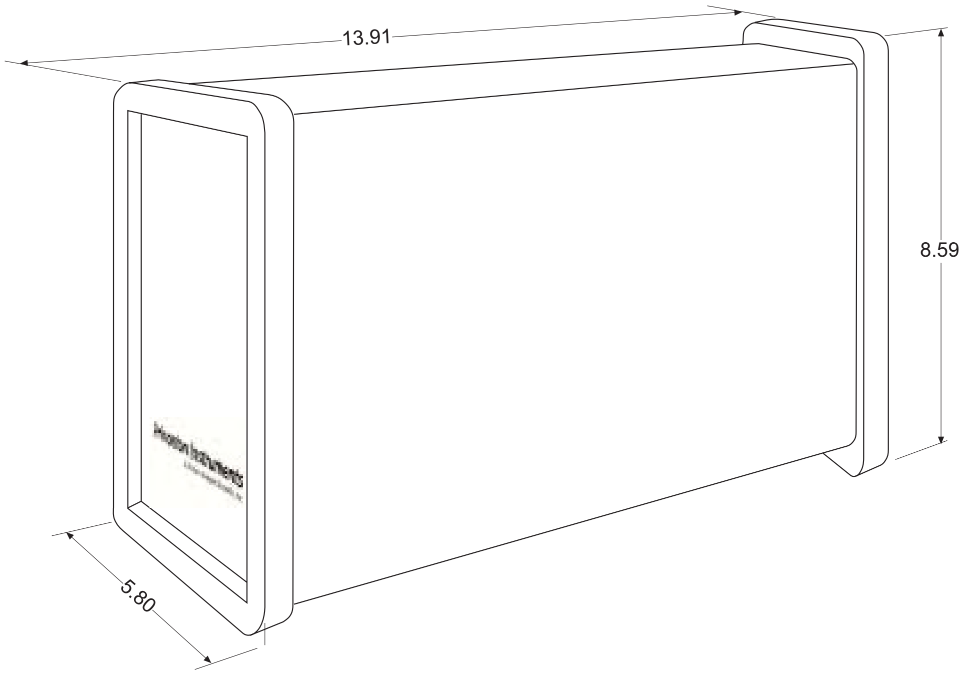


Figure 50. ST-133B Controller Outline Drawing

Earlier Models

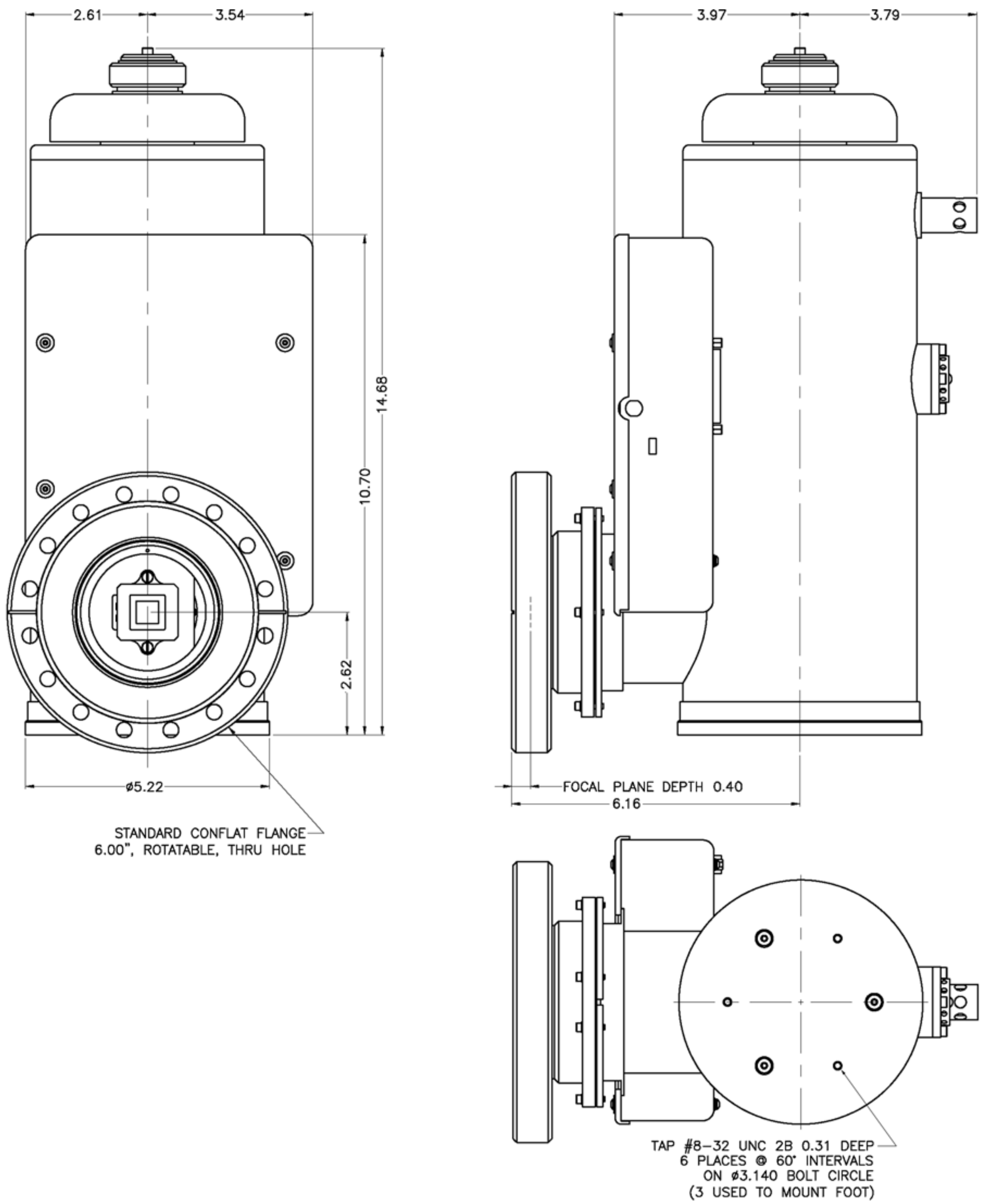


Figure 51. PI-SX LN-Cooled Camera (ConFlat Flange)

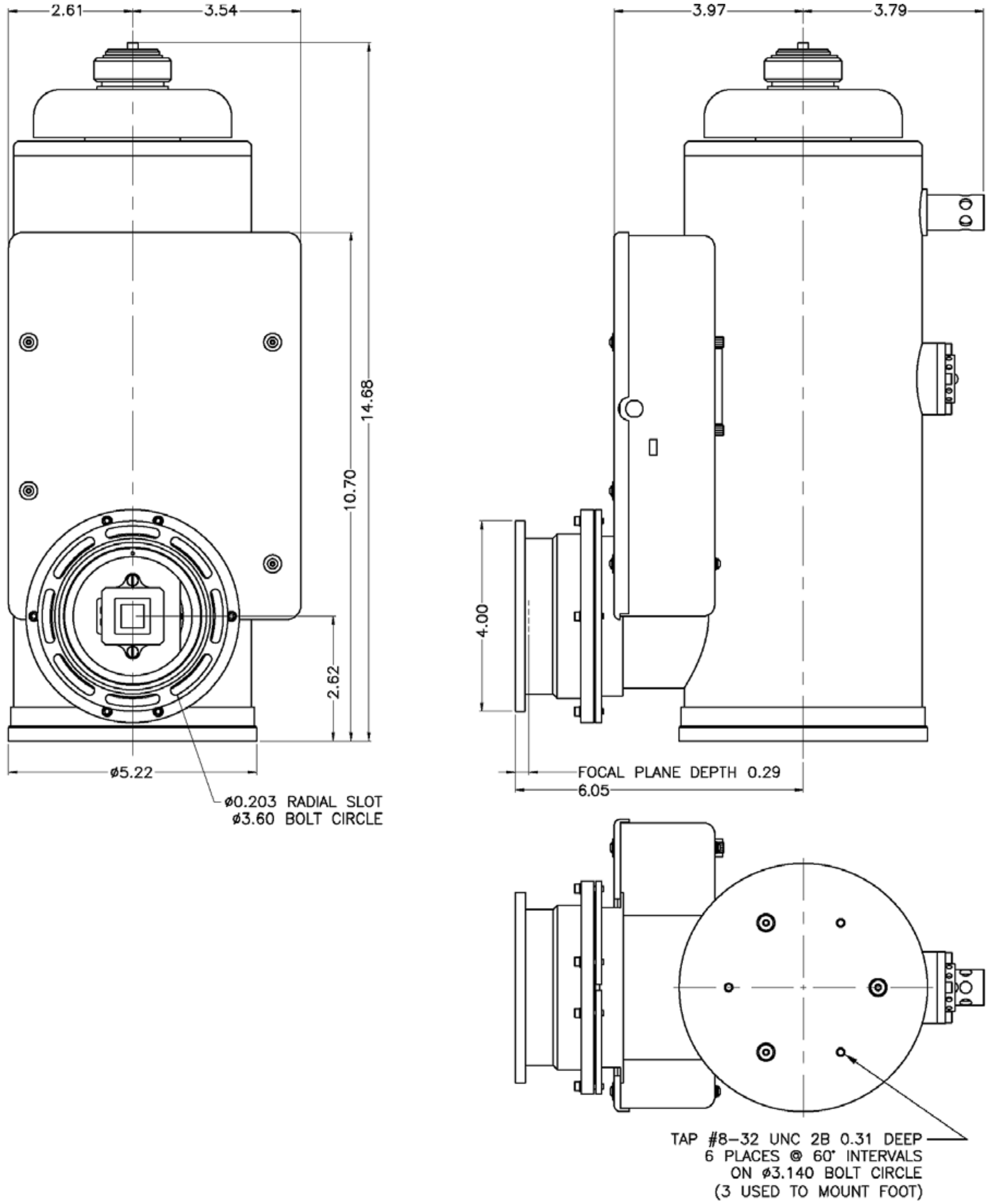


Figure 52. PI-SX LN-Cooled Camera (4.00" VON Flange)

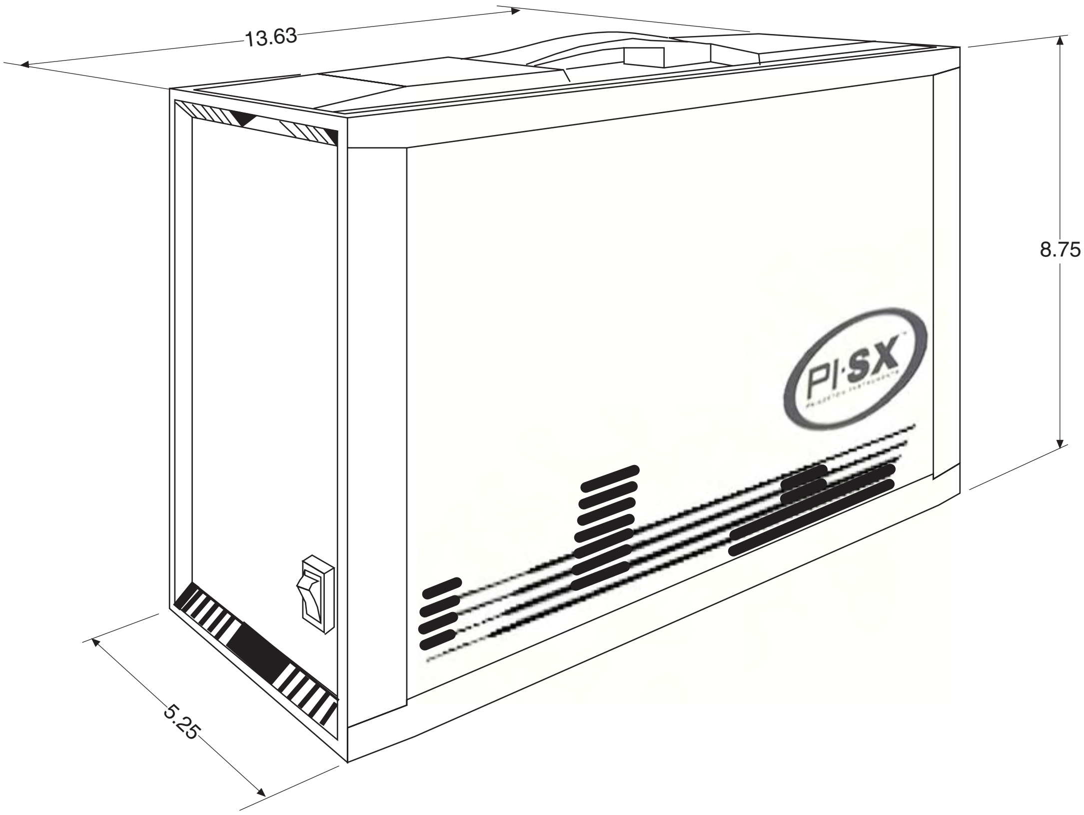


Figure 53. ST-133A Controller Outline Drawing

Appendix C
USB 2.0 Limitations

The following information covers the currently known limitations associated with operating under the USB 2.0 interface.

- Maximum cable length is 5 meters (16.4 feet)
- Upper Digitization Rate: 1 MHz for the PI-SX:2048. 2 MHz for all others.
- Large data sets and/or long acquisition times may be subject to data overrun because of host computer interrupts during data acquisition.
- USB 2.0 is not supported by the Princeton Instruments PC Interface Library (Easy DLLS).
- Some WinView/WinSpec 2.5.X features are not fully supported with USB 2.0. See the table below.

Feature	Supported with USB 2.0 in WinX 2.5.X	Remarks
Demo Port Capability	NO	
DIF	NO	
Kinetics	YES	WinX 2.5.18.1
Reset Camera to NVRAM Defaults	NO	
Temperature Lock Status except during Data Acquisition	YES	WinX 2.5.x doesn't utilize hardware lock status
Custom Timing	YES	WinX 2.5.18.1
Custom Chip	YES	WinX 2.5.18.1
Frames per Interrupt	NO	
Online Exposure	NO	
File Information	YES	Not all header info is currently available in WinX 2.5.x through PVCAM
Overlapping ROIs	NO	

Table 10. Features Not Supported under USB 2.0 (continued on next page)

Feature	Supported with USB 2.0 in WinX 2.5.X	Remarks
Macro Record	YES	Macros recorded for non-PVCAM cameras may have to be re-recorded to function
TTL I/O	NO	

Table 10. Features Not Supported under USB 2.0

Warranty & Service

Limited Warranty

Princeton Instruments, a division of Roper Scientific, Inc. ("Princeton Instruments", "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

Princeton Instruments 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, Princeton Instruments 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 Princeton Instruments 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 Princeton Instruments authorized representative/distributor for repair information and assistance, or visit our technical support page at www.piacton.com.

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

Princeton Instruments 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, Princeton Instruments will repair or replace, at its sole option, any defective parts, without charge to you. You must deliver the entire product to the Princeton Instruments factory or, at our option, a factory-authorized service center. You are responsible for the shipping costs to return the product to Princeton Instruments. International customers should contact their local Princeton Instruments representative/distributor for repair information and assistance or visit our technical support page at www.piacton.com.

Normal Wear Item Disclaimer

Princeton Instruments does not warrant certain items against defect due to normal wear and tear. These items include internal and external shutters, cables, and connectors. *These items carry no warranty, expressed or implied.*

XP Vacuum Chamber Limited Lifetime Warranty

Princeton Instruments warrants that the cooling performance of the system will meet our specifications over the lifetime of an XP detector or Princeton Instruments 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

Princeton Instruments 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

Princeton Instruments 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. Princeton Instruments 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

Princeton Instruments 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

Princeton Instruments 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. Princeton Instruments 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 Princeton Instruments 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 Princeton Instruments 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 Princeton Instruments.
2. You must notify the Princeton Instruments 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 Princeton Instruments factory or, at our option, an authorized service center.
4. Before products or parts can be returned for service you must contact the Princeton Instruments 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 Princeton Instruments factory or one of our authorized manufacturer's representatives or distributors.
6. Unless specified in the original purchase agreement, Princeton Instruments 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 Princeton Instruments.
8. After the warranty period has expired, you may contact the Princeton Instruments factory or a Princeton Instruments-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 Princeton Instruments' 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 Princeton Instruments factory of purchase, contact your authorized Princeton Instruments representative or reseller, or visit our technical support page at www.piacton.com.

Contact Information

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

Princeton Instruments
3660 Quakerbridge Road
Trenton, NJ 08619 (USA)

Tel: 800-874-9789 / 609-587-9797
Fax: 609-587-1970

Customer Support E-mail: techsupport@piacton.com

For immediate support in your area, please call the following locations directly:

America	1.877.4.PIACTON (877.474.2286)
Benelux	+31 (347) 324989
France	+33 (1) 60.86.03.65
Germany	+49 (0) 89.660.7793
Japan	+81 (3) 5639.2741
UK & Ireland	+44 (0) 28.3831.0171

Otherwise, see our Support web page at http://www.piacton.com. An up-to-date list of addresses and telephone numbers is posted on the http://www.piacton.com/Support page. In addition, links on this page to support topics allow you to send e-mail based requests to the Customer Support group.

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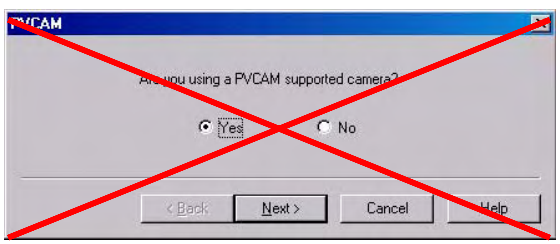
Camera Detection Wizard

Introduction

Version 2.5.19.6 of the WinX software (WinView, WinSpec, and WinXTest) introduced enhancements to the former Hardware Setup Wizard. Now called the Camera Detection Wizard, this function is used to load the WinX hardware setup parameter fields with default values for a WinX-compatible camera system. The Camera Detection Wizard runs automatically the first time you install WinX and can be launched at a later date if you decide to control a different WinX-compatible camera. The autodetection function can be used for both PVCAM-based camera systems (USB 1 interface, USB 2 interface, Photometrics PCI, PhotonMAX) and Princeton Instruments RS PCI (TAXI) interface-based systems.

Changes to the Software

- For PVCAM-based cameras (USB 1 interface, USB 2 interface, Photometrics PCI, PhotonMAX) ------- You no longer have to run the RSConfig.exe program --- this is done by the Camera Detection Wizard.
- <u>**ALL**</u> Win-X compatible camera systems can be set up via the autodetection function but only Princeton Instruments RS PCI (TAXI) interface-based systems can be set up using the manual function.
- The **PVCAM** dialog is no longer included in the wizard.



- The **Use PVCAM** checkbox is no longer present on the **Setup|Hardware|Controller/Camera** (or CCD) tab page.
- There is now a **Launch Camera Detection Wizard** button on the **Setup|Hardware|Controller/Camera** (or CCD) tab page.

Required by the Wizard

- You <u>**MUST**</u> use the autodetection mode for PVCAM-based cameras (USB 1 interface, USB 2 interface, Photometrics PCI, PhotonMAX). The function can also be used to detect Princeton Instruments RS PCI (TAXI) interface-based systems.
- Before you select autodetection, you must have connected the camera system to the host computer and have turned the camera system ON.
- Before selecting "Yes" for the Test Image, you must have connected the camera system to the host computer and have turned the camera system ON.

Camera Detection Wizard Flowchart