



PI-MTE™ System



©Copyright 2003-2013

Princeton Instruments, a division of Roper Industries, Inc.
3660 Quakerbridge Rd
Trenton, NJ 08619
TEL: 800-874-9789 / 609-587-9797
FAX: 609-587-1970

All rights reserved. No part of this publication may be reproduced by any means without the written permission of Princeton Instruments, a division of Roper Industries, Inc. ("Princeton Instruments").

Printed in the United States of America.

Kapton is a registered trademark of E. I. du Pont de Nemours and Company.

LabVIEW is a registered trademark of National Instruments Corporation.

Linux is a registered trademark of Linus Torvalds.

Macintosh is a trademark of Apple Computer, Inc., registered in the U.S. and other countries.

Pentium is a registered trademark of Intel Corporation.

PI-MTE is a trademark of Roper Industries, Inc.

Scientific Imaging ToolKit and SITK are trademarks of R Cubed Software Consultants, LLC.

Swagelok is a registered trademark of Crawford Fitting Company Corporation.

TAXI is a registered trademark of AMD Corporation.

VCR is a registered trademark of Cajon Company Corporation.

Microsoft, Windows, Windows XP, Windows Vista, and Windows 7 are registered trademarks of Microsoft Corporation.

The information in this publication is believed to be accurate as of the publication release date. However, Princeton Instruments does not assume any responsibility for any consequences including any damages resulting from the use thereof. The information contained herein is subject to change without notice. Revision of this publication may be issued to incorporate such change.

Table of Contents

Chapter 1 Introduction	9
Description.....	9
Design	9
Grounding and Safety	9
Precautions.....	10
Cleaning	11
Repairs	11
Manual Overview	11
Chapter 2 System Component Descriptions	13
PI-MTE Camera.....	13
ST-133 Controller.....	13
Cables	16
Interface Card	17
Vacuum Port Adapter	17
Application Software	18
User Manuals	18
Optional Components	18
Chapter 3 Installation Overview	19
Chapter 4 System Setup	21
Unpacking the System	21
Checking the Equipment and Parts Inventory	21
System Requirements	22
Environmental	22
Ventilation.....	22
Coolant	22
Power.....	23
Host Computer	23
Verifying Controller Voltage Setting	24
Installing the WinView/32 Application Software	25
Setting up the Communication Interface	25
Setting up a PCI Interface	25
Setting up a USB 2.0 Interface.....	27
Connecting the Interface (Controller-Computer) Cable	30
TAXI [®] Cable (6050-0148-CE)	30
USB 2.0 Cable (6050-0494).....	30
Connecting the Detector-Controller Cable	30
Non-Vacuum	30
Vacuum	31
Entering the Default Camera System Parameters into WinView	32
Making the Coolant Connections	33

Chapter 5 Operation	35
Introduction.....	35
System On/Off Sequences	37
First Light	37
Assumptions.....	37
Cabling	37
Getting Started	38
Setting the Parameters.....	38
Acquiring Data	39
Powering Down Procedure.....	40
Cooling	41
Introduction	41
Condensation.....	41
Exposure and Signal	42
Introduction	42
CCD Array Architecture	42
Exposure Time	43
Temperature Control	43
Dark Charge	44
Saturation	45
Clean Cycles.....	45
Continuous Cleans	46
Readout	46
Introduction	46
Full Frame Readout.....	46
Binning.....	47
Hardware Binning.....	47
Software Binning.....	48
Background Subtraction.....	49
Digitization	49
Introduction	49
Digitization Rate	49
ADC Offset	50
Chapter 6 Advanced Topics	51
Introduction.....	51
Standard Timing Modes	51
Free Run	52
External Sync	53
External Sync with Continuous Cleans.....	55
Fast and Safe Modes.....	56
TTL Control.....	58
Introduction	58
TTL In	58
Buffered vs. Latched Inputs	59
TTL Out	59
TTL Diagnostics Screen.....	60
Hardware Interface.....	60
Example	61

Chapter 7 Troubleshooting	63
Introduction.....	63
Baseline Signal Suddenly Changes	64
Camera1 (or similar name) on Hardware Setup dialog box	64
Changing the ST-133 Line Voltage and Fuses	65
Controller Is Not Responding.....	67
Cooling Troubleshooting.....	67
Camera does not achieve temperature lock.....	67
Out-of-Vacuum Operation Cooling and Internal Vacuum Level.....	67
Camera loses temperature lock	68
Data Loss or Serial Violation	69
Data Overrun Due to Hardware Conflict.....	69
Data Overrun Occurred.....	70
Error Creating Controller message	70
Error Occurs at Computer Powerup	71
Program Error	73
Removing/Installing a Plug-In Module.....	74
Securing the Detector-Controller Cable Slide Latch.....	76
Serial violations have occurred. Check interface cable.....	77
Appendix A Specifications	79
PI-MTE Camera.....	79
CCD Arrays.....	79
Environmental	80
Power.....	80
Cooling.....	80
ST-133	80
Appendix B Outline Drawings	83
Appendix C VCR and Swagelok Fittings	87
VCR® Fittings	87
Installation.....	87
Gasket Replacement.....	88
Swagelok® Fittings	88
Installation.....	88
High Pressure Applications or High-Safety-Factor Systems	89
Retightening Instruction.....	89
Appendix D Visible <-> Open Nose Change Instructions	91
Introduction.....	91
Replacing the Visible Nose with the Open Nose	91
Replacing the Open Nose with the Visible Nose	93
Appendix E USB 2.0 Limitations	95
Declaration of Conformity	97

Warranty & Service	99
Limited Warranty:	99
Basic Limited One (1) Year Warranty	99
Limited One (1) Year Warranty on Refurbished or Discontinued Products.....	99
XP Vacuum Chamber Limited Lifetime Warranty	99
Sealed Chamber Integrity Limited 12 Month Warranty	100
Vacuum Integrity Limited 12 Month Warranty	100
Image Intensifier Detector Limited One Year Warranty	100
X-Ray Detector Limited One Year Warranty	100
Software Limited Warranty.....	100
Owner's Manual and Troubleshooting	101
Your Responsibility	101
Contact Information.....	102
Index	103

Figures

Figure 1. PI-MTE Camera	9
Figure 2. Power Switch Location (ST-133A and ST-133B)	14
Figure 3. PI-MTE System Diagram	20
Figure 4. Controller Power Module.....	24
Figure 5. WinView/32 Installation: Select Installation Type dialog.....	25
Figure 6. Camera Detection Wizard - Welcome dialog.....	32
Figure 7. Coolant Ports	33
Figure 8. Block Diagram of Signal Path in System.....	36
Figure 9. Example of WinView Data Acquired from First Light Procedure	40
Figure 10. Clean Cycles in Freerun Operation	45
Figure 11. Array Terms for a CCD with a Single Output Amplifier.....	46
Figure 12. Full Frame at Full Resolution	47
Figure 13. 2 × 2 Binning for Images.....	48
Figure 14. Timing tab page.....	51
Figure 15. Free Run Timing Chart, Part of the Chart in Figure 21	52
Figure 16. Free Run Timing Diagram	53
Figure 17. Chart Showing Two External Sync Timing Options	54
Figure 18. Timing Diagram for External Sync Mode (- edge trigger).....	54
Figure 19. Continuous Cleans Operation Flowchart	55
Figure 20. Continuous Cleans Timing Diagram (- edge trigger).....	56
Figure 21. Chart of Safe Mode and Fast Mode Operation	57
Figure 22. TTL In/Out Connector	60
Figure 23. TTL Diagnostics dialog box.....	60
Figure 24. Camera1 in Controller Type (Camera Name) Field.....	64
Figure 25. Power Module	66
Figure 26. Voltage Selector Drum.....	66
Figure 27. Fuse Holder	66
Figure 28. Data Overrun Due to Hardware Conflict dialog box	69
Figure 29. Error Creating Controller dialog box	70
Figure 30. Program Error dialog box.....	73

Figure 31. Module Installation	74
Figure 32. Serial Violations Have Occurred dialog box	77
Figure 33. PI-MTE Camera (3-01-06 and later)	83
Figure 34. PI-MTE Camera (8-01-05 and later)	84
Figure 35. PI-MTE Camera (8-01-05 and earlier)	85
Figure 36. ST-133A Controller.....	86
Figure 37. ST-133B Controller.....	86
Figure 38. VCR Fittings	87

Tables

Table 1. PCI Driver Files and Locations	26
Table 2. USB Driver Files and Locations.....	29
Table 3. Camera Timing Modes	51
Table 4. Bit Values with Decimal Equivalents: 1 = High, 0 = Low.....	59
Table 5. TTL In/Out Connector Pinout	60
Table 6. Fuse Ratings	65
Table 7. I/O Address & Interrupt Assignments before Installing Serial Card.....	71
Table 8. I/O Address & Interrupt Assignment after Installing Serial Card	72
Table 9. Features Supported under USB 2.0 (continued on next page)	95

This page intentionally left blank.

Introduction

Description

The PI-MTE camera is ideally suited for operation inside a vacuum chamber. State-of-the-art CCD arrays are available for the PI-MTE camera that enable outstanding performance in a wide range of X-ray Imaging and Spectroscopy applications. The PI-MTE camera is also suitable for medium-low light applications that require small size or steel case ruggedness.

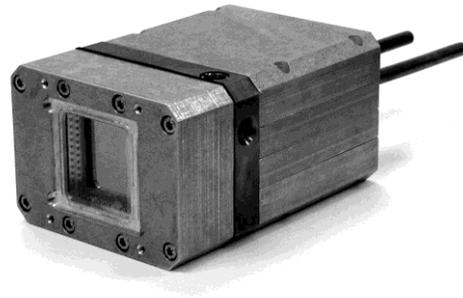


Figure 1. PI-MTE Camera

Design

PI-MTE 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 two-stage Peltier thermoelectric cooler. The middle enclosure contains the heat exchanger. 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.

Grounding and Safety

The ST-133 Controller that controls the PI-MTE camera 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 power cord 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.

WARNING! If the PI-MTE camera system is used in a manner not specified by Princeton Instruments, the protection provided by the equipment may be impaired.

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

WARNING!

Replacement power cords or power plugs must have the same polarity and power rating 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-MTE system you ordered. The "System ID" number on the camera and the controller serial labels must be the same.
- 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 can destroy it. Operations requiring contact with the device can only be performed at the factory.
- If you are using high-voltage equipment (such as an arc lamp) with your camera system, be sure to turn the controller power ON LAST and turn the controller power OFF FIRST.
- Use caution when triggering high-current switching devices (such as an arc lamp) near your system. The CCD can be permanently damaged by transient voltage spikes. If electrically noisy devices are present, an isolated, conditioned power line or dedicated isolation transformer is highly recommended.
- Never connect or disconnect any cable while the system is powered on. Reconnecting a charged cable may damage the CCD.
- Never prevent the free flow of air through the Model ST-133 by blocking the air vents.
- Never operate a liquid-assisted PI-MTE camera with coolant at a temperature below that specified for it.

Cleaning

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.

Normally, PI-MTE cameras operated in vacuum will remain clean by virtue of the vacuum. Periodic cleaning of the controller is encouraged in accordance with the controller manual.

Although there is no periodic maintenance that *must* be performed on the PI-MTE camera, users of a non-vacuum camera 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.

Note: Some discoloration of the copper portions of the camera may occur. This is normal and has no effect on operation.

Repairs

Save the original packing materials. Because the PI-MTE camera system contains no user-serviceable parts, repairs must be done by Princeton Instruments. 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.

Manual Overview

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

Notes:

1. 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.
2. "WinX" is a generic term for WinView, WinSpec, and WinXTest application software.

Chapter 1, Introduction provides general information about the PI-MTE camera system including information about precautions, cleaning, repairs, and the manual structure.

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

Chapter 3, Installation Overview provides directions for setting up the system components.

Chapter 4, System Setup provides detailed directions for setting up a PI-MTE camera for imaging applications.

Chapter 5, Operation discusses baseline signal and noise, setting and maintaining temperature control, and verifying camera operation.

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 camera specifications.

Appendix B, Outline Drawings includes outline drawings of the PI-MTE camera and the ST-133A and ST-133B Controllers.

Appendix C, VCR and Swagelok Fittings includes instructions for assembling VCR[®] and Swagelok[®] tube fittings.

Appendix D, Visible <-> Open Nose Change Instructions includes instructions for changing the PI-MTE nose from its visible nose (with test lens) to its open nose configuration and vice versa.

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

Declaration of Conformity is the Declaration of Conformity for MTE2 Camera Head with ST-133 Controller (i.e., PI-MTE system).

Warranty and Service details the limited warranties for Princeton Instruments equipment and software.

System Component Descriptions

PI-MTE Camera



CCD Arrays: The PI-MTE:1300B and PI-MTE:2048B incorporate a back-illuminated CCD without AR coating for very low-energy x-ray detection. With 20×20-micron (1300B) or 13.5×13.5-micron (2048B) pixels and 100% fill factor, these systems offer a large imaging area with very high spatial resolution and dynamic range.

Cooling: Dark current is significantly reduced in PI-MTE camera systems through liquid-assisted Thermo-electric (TE) cooling of the CCD array.

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 the flow of coolant through the heatsink.

Coolant Ports: Two 1/4" coolant ports are located at the rear of the camera. Connection to a vacuum flange is via VCR fittings (or Swagelok fittings) and stainless steel, flexible hoses. Instructions for setting up coolant flow are provided on page 32.

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

ST-133 Controller



Electronics: The ST-133 controller is a compact, high performance CCD Detector Controller for operation with Princeton Instruments brand* detectors. Designed for high speed and high performance image acquisition, the ST-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.

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

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 2, 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.

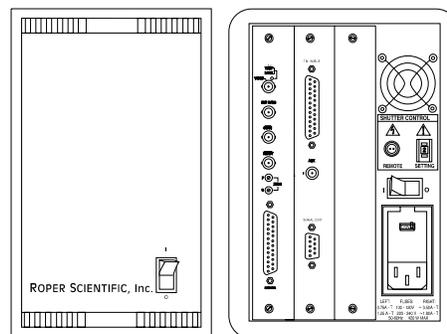


Figure 2. Power Switch Location (ST-133A and ST-133B)

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 back-plane 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 described on the following page. Removing and inserting boards is described in Chapter 7, page 74.

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 must always be located in the left-most slot, provides the following functions.

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

The **Interface Control Module**, which must 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 rear panel connector descriptions are keyed to the accompanying figure. The Fuse/Voltage label will be above or below the Power Module.

#	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 $\pm 0.05^\circ\text{C}$.		
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 $75\ \Omega$. 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 $10\ \text{k}\Omega$ pullup resistor. Allows data acquisition and readout to be synchronized with external events. Through software, positive or negative (default) triggering can be selected.		
4	SCAN Output: WinView/32 (ver. 2.4 and higher) software selectable NOT SCAN or SHUTTER signal. Default is SHUTTER.		10
5	READY Output: Initially HIGH. After a Start Acquisition command, this output changes state on completion of the array cleaning cycles that precede the <i>first</i> exposure. Initially high, it goes low to mark the beginning of the <i>first</i> 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.		11
6	Zero Adjustment: Bias potentiometers control the offset values of the Fast (F) and Slow (S) A/D converters. Preadjusted at factory. For 2 MHz controllers, baseline offset values are set at the factory and are not user-changeable. CAUTION: Do not adjust the offset values to zero, or some low-level data will be missed.		12
7	Detector Connector: Transmits control information to the camera and receives data back from the camera via the Detector-Controller cable.		13
		14	

#	Feature	#	Feature
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. Refer to " <i>TTL Control</i> ", page 58.	15	Fuse/Voltage Label: Displays the controller's power and fuse requirements. This label may appear below the power module.
9	AUX Output: Reserved for future use.	16	USB 2.0 Connector: Provides two-way serial communication between the controller and the host computer. Uses USB 2.0 protocol.

Cables



Vacuum-Compatible Camera-Vacuum Cable: This 1-meter cable has DB-25 connectors that interconnect the DB-25 connector on the back of the camera and a 25-pin D connector on a compatible vacuum flange. Available in Kapton[®] flat cable (6050-0467) or in low vacuum cable with braided sleeve (6050-0475). The low vacuum cable is also available in 1.5 meter and 2 meter lengths.



Detector-Controller: (6050-0526) 50 kHz/2 MHz systems: The standard 3' cable has DB-25 connectors (one with slide-latch locking hardware to secure at the controller and the other with screws for securing to a vacuum flange). This cable interconnects the Detector connector on the rear of the ST-133 and the DB-25 connector on a compatible vacuum flange.

Detector-Controller: (6050-0483) 100 kHz/1 MHz systems: The standard 6' cable has DB-25 connectors (one with slide-latch locking hardware to secure at the controller and the other with screws for securing to a vacuum flange). This cable interconnects the Detector connector on the rear of the ST-133 and the DB-25 connector on a compatible vacuum flange.

Note: *If the PI-MTE camera is being operated out-of-vacuum* (i.e., with the visible nose, containing a quartz window, mounted to the front of the camera for operation in a non-vacuum environment), an optional 10' cable (6050-0321), with slide latches at both ends, is available to directly interconnect the PI-MTE camera and the ST-133. Detector-Controller. Cables 15' and 20' long are also available for *out-of-vacuum operation*.

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.



Vacuum Compatible Flexible Tubing: The stainless-steel vacuum-compatible $\frac{1}{4}$ "-OD, 36"-long flexible tubing (2825-0449) interconnects between the camera water tubings and the vacuum feed through a $2\frac{3}{4}$ " ConFlat flange.



Vacuum Compatible Camera Flanges: The $2\frac{3}{4}$ " ConFlat flange with two pipes ($\frac{1}{4}$ " OD) and VCR fittings (2825-0562) (or with Swagelok fittings (2825-0447) for earlier systems) and the $4\frac{1}{2}$ " ConFlat flange with 25-pin D-sub connector (2825-0448) are included with the system.



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, 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. Refer to www.orangemicro.com or www.siig.com, respectively, for more information.

Vacuum Port Adapter



The Vacuum Port Adapter (2518-0943) with O-ring screws into the vacuum port on the side of the PI-MTE. This allows you to connect the camera (with visible nose) to a vacuum pump and pump it down to at least 1 mTorr before using the camera in a non-vacuum environment.

Application Software



The Princeton Instruments WinView/32 software package provides comprehensive image acquisition, display, processing, and archiving functions so you can perform complete data acquisition and analysis without having to rely upon third-party software. WinView/32 provides reliable control over most 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.

PVCAM is the standard software interface for cooled CCD cameras from Princeton Instruments. 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.

Note: Linux® drivers are also available.

User Manuals



PI-MTE System User Manual: This manual describes how to install and use the PI-MTE system components. The most up-to-date version of this manual and other Princeton Instruments manuals can be found and downloaded from [ftp://ftp.princetoninstruments.com/Public/Manuals/Princeton Instruments](ftp://ftp.princetoninstruments.com/Public/Manuals/Princeton%20Instruments). The most current versions of Acton manuals are located at <ftp://ftp.princetoninstruments.com/Public/Manuals/Acton>.

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

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

Optional Components



ThermoCUBE with PI-MTE-compatible Hoses (PN 8243-0002): The ThermoCUBE is a compact liquid chiller that is designed for Princeton Instruments' Quad-RO and PI-MTE deep cooled cameras. ThermoCUBE, with a self-contained water reservoir that provides chilled liquid circulation for efficiently cooling the cameras, is ideal for applications that require vibration-free and/or thermally stable environments.

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.	Chapter 4, page 21
2. Verify that all system components have been received.	Chapter 4, page 21
3. With the ST-133 turned OFF , verify that the appropriate line voltage and fuses have been installed in the ST-133 controller.	Chapter 4, page 24
4. If using WinView/32 software to control your system, install that software if it has not already been installed.	Refer to the WinView/32 manual.
5. If the appropriate interface card is not already installed in the host computer, install it.	Chapter 4, page 25
6. With the computer and ST-133 both 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, page 30
7. The PI-MTE camera (designed for use in a vacuum) is shipped with a visible nose in place so you can initially set up the camera for operation outside of a vacuum chamber. The "First Light" procedure in Chapter 5 steps you through verification of the camera's operation while it is outside of the chamber. You can also practice using the software before changing the camera nose for vacuum chamber operation. Go to Step 9 for non-vacuum operation. Go to Step 8 to prepare the camera for vacuum operation.	Chapter 5, page 37
8. Skip this step for non-vacuum operation. If the camera is to be operated in a vacuum chamber, first replace the visible nose with the open nose in a cleanroom environment. Then, mount the camera in the vacuum chamber.	Appendix D, page 91

Action	Reference
9. Make the tubing connections between the coolant circulator and the camera. If the camera is being operated in vacuum, additional tubing connections to the intermediate vacuum flange will be required.	Chapter 4, page 32; Appendix C
10. 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 vacuum flange (vacuum operation) or to the rear of the PI-MTE camera (non-vacuum operation). Secure both ends of the cable.	Non-Vacuum: Chapter 4, page 30 Chapter 7 Troubleshooting, page 76
11. If the camera is being operated in vacuum, the additional vacuum-compatible cable will be required. This cable is very fragile so handle it with care when mounting it to the vacuum flange and the back of the camera. Secure the cable at both ends.	Vacuum Chamber: Chapter 4, page 31 Chapter 7 Troubleshooting, page 76
12. Skip this step for non-vacuum operation. Secure and evacuate the vacuum chamber.	
13. Turn on the ST-133.	
14. Turn on the computer and begin running the application software.	Refer to the WinView/32 manual.
15. Enter the hardware setup information.	Refer to the WinView/32 manual.
16. Turn on the coolant circulator. The recommended flow rate is 2 liters/minute.	
17. Set the target array temperature.	Chapter 5, page 43
18. When the system reaches temperature lock, begin acquiring data in focus mode.	

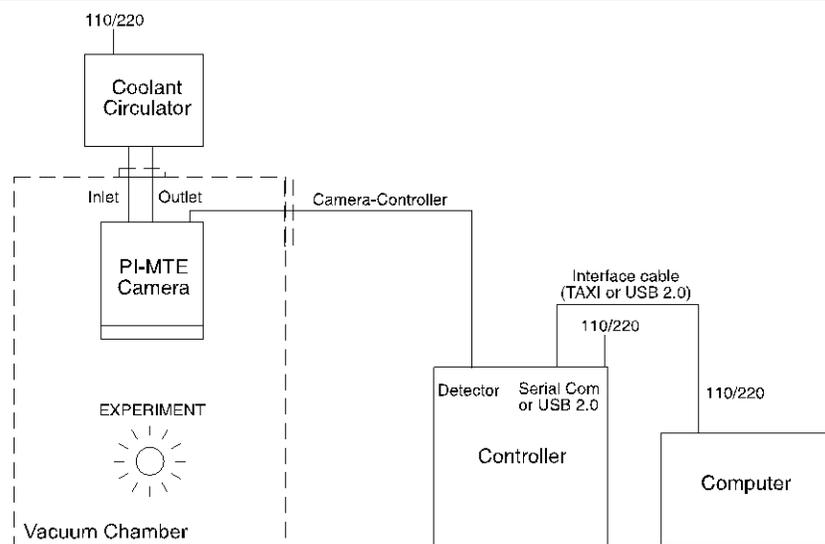


Figure 3. PI-MTE System Diagram

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 system. A complete PI-MTE system consists of:

- **Camera:** PI-MTE
- **ST-133 Controller:** Do not substitute any other controller for the controller supplied with your system. *The "System ID" number on the controller and camera serial labels must match.*
- FRAGILE** → • **Camera to Vacuum Flange cable:** Vacuum-compatible DB25 to DB25, 3 ft.
- **Vacuum Flange to Controller cable:**
 - **100 kHz/1 MHz system:** DB25 to DB25, 6 ft or
 - **50 kHz/2 MHz system:** DB25 to DB25, 3 ft
- **Power cable**
- **Vacuum Flange:** 2 3/4" with two feed-through pipes with male VCR fittings (or Swagelok fittings for earlier systems).
- **Vacuum Flange:** 4 1/2" with DB25 connectors.
- **Vacuum Open Nose**
- **Swagelok Fittings** (for earlier systems)
- **Flexible Hoses:** Two 30" stainless steel flexible hoses used to connect camera coolant ports to vacuum flange. Hoses for more recent systems have female VCR fittings.
- **Vacuum Port Adapter and O-ring**
- **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 (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).
- **WinView/32 CD-ROM:** This CD contains the WinView/32 imaging software and related manuals in PDF format.
- **User Manuals:** PI-MTE System and WinView/32 Imaging Software.
- **Host Computer:** Typically, the computer is user-supplied.
- **Coolant Circulator:** Not required by some systems. Typically, the coolant circulator and hoses are user-supplied.

System Requirements

Environmental

- Storage temperature: $<55^{\circ}\text{C}$
- Operating environment: $5^{\circ}\text{C} < T < 30^{\circ}\text{C}$
- Relative humidity: $\leq 50\%$; non-condensing (not applicable for open-nose)

Ventilation

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.

A PI-MTE camera has been designed for heat removal via circulating coolant (50:50 mixture of ethylene glycol and water) for proper operation.

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

WARNING! If the flow rate is restricted or lower, then the camera can be damaged due to overheating or it may not reach temperature.

Fluid Pressure: 25 psig (maximum).

Inlet/Outlet Port Locations:

VCR male fittings (or Swagelok fittings for earlier systems) and flexible stainless steel hoses are provided to make the hose connections between the camera and an intermediate vacuum flange. *The ports are not interchangeable.*

Coolant Temperature: +10°C to +15°C, typical.

WARNING! If a lower temperature is set, there can be condensation on the external tubing or if the camera is being used outside of a vacuum chamber, condensation may occur on or inside the camera. Damage due to condensation may not be covered by the warranty.

Power

Camera: The PI-MTE 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.

The plug on the power 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 power 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:

- PC with 200 MHz Pentium® II (or better).
- Windows® XP, Windows Vista® (32-bit), or Windows 7 (32-bit) 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 32 Mbytes of RAM for CCDs up to 1.4 million pixels. Collecting multiple images or spectra at full frame or high speed may require 128 Mbytes or more of RAM.
- CD-ROM drive.
- Hard disk with a minimum of 80 Mbytes available. A complete installation of the program files takes about 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:

- PC with Pentium 3 or better processor and runs at 1 GHz or better.
- Windows® XP (with Service Pack 1), Windows Vista® (32-bit), or Windows 7 (32-bit) 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 power cord connector. The appropriate voltage setting is set at the factory and can be seen on the power input 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.

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 Input Module.
2. If the setting is correct, continue with the installation. If it is not correct, follow the instructions on page 64 for changing the ST-133 Controller's voltage setting and fuses.



Figure 4. Controller Power Module

Installing the WinView/32 Application Software

Administrator privileges are required under Windows® XP, Windows Vista® and Windows® 7 to install software and hardware.

The following installation is performed via the WinView/32 software installation CD.

1. Insert the CD and follow the installation wizard prompts.
2. On the **Select Installation Type** dialog (see Figure 5), click on the **Typical** radio button to install the required drivers and the most commonly installed program files. Select the **Custom** radio button if you would like to choose among the available program files or do not want to install the drivers. **Complete** installs all of the application features.
3. Verify the camera is connected to the host computer and that the camera power supply is turned on.
4. Reboot the computer if prompted to do so.

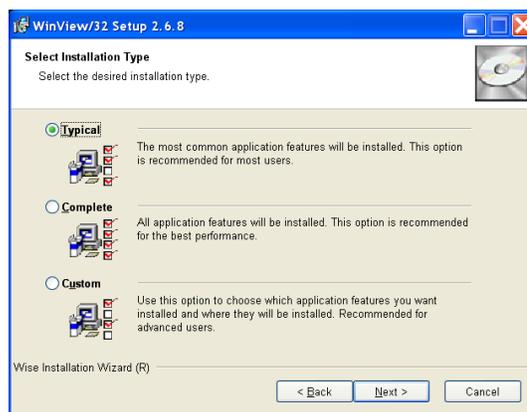


Figure 5. WinView/32 Installation: Select Installation Type dialog

Setting up the Communication Interface

PI-MTE2 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® XP, Windows Vista® and Windows® 7 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) and the digitization rate may be as high as 2 MHz. Cable lengths up to 50 meters (165 feet) are also available.

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 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. Verify that the card is firmly seated and secure it.
6. Replace and secure the computer cover and turn on only the computer. If an error occurs at bootup, either the PCI card has not been installed properly or there is an address or interrupt conflict. Refer to Chapter 7 "Troubleshooting", page 71 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 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 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 Table 1 below 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 [®] XP, Windows Vista [®] , and Windows [®] 7	rspi.inf (in WINNT/INF, for example)	rspipci.sys (in WINNT/System32/Drivers, for example)

* The INF directory may be hidden.

Table 1. PCI Driver Files and Locations

Setting up a USB 2.0 Interface

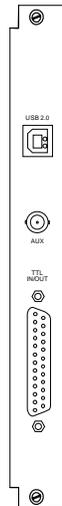
Administrator privileges are required under Windows® XP, Windows Vista® and Windows® 7 to install software and hardware.

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)
- 2 MHz is currently the upper digitization rate limit for the ST-133 Controller. 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 2.5.X features are not fully supported with USB 2.0. Refer to Appendix E, page 95, 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 strongly 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 with the appropriate Microsoft driver (Windows XP, Windows Vista, or Windows 7 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 1 (for Windows XP only) if the service pack has not been previously 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-MTE system (refer to page 23).
- 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 software.

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 be 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 automatically put the required INF, DLL, and USB driver files in the "Windows" directories shown below. Refer to the Table 2 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® XP, Windows Vista®, or Windows® 7	<code>rsusb2k.inf</code> (e.g., WINNT/INF)	<code>apausbprop.dll</code> (e.g., WINNT/System32)	<code>apausb.sys</code> (e.g., WINNT/System32/Drivers)

* The INF directory may be hidden.

Table 2. 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 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.
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 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 Detector-Controller Cable

Non-Vacuum

Follow this procedure if you are using the camera in a non-vacuum environment. When operating the camera outside of a vacuum, the camera will typically have the visible nose already installed. If the visible nose is not installed, refer to Appendix D, "*Replacing the Open Nose with the Visible Nose*", page 93, for installation instructions.

CAUTION

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

To Connect the Detector-Controller Cable:

The following procedure assumes that you have a cable (such as the 6050-0321) with slide latches at both ends. If you do not, follow the instructions for **Vacuum** but do not change the visible nose to the open nose.

1. Verify that the Controller power is OFF.
2. Connect male end of the Detector-Controller cable to the "Detector" port on the back of the Controller.

3. Move the slide latch over to lock the connector in place. Refer to "*Securing the Detector-Controller Cable Slide Latch*", page 76.
4. Connect the female end of the cable to the camera.
5. Slide the latch until it locks on the posts.

Vacuum

Follow this procedure if you are using the camera in a vacuum chamber. Before operating the camera in a vacuum chamber, you will need to remove the visible nose that was installed on the camera before it was shipped. Refer to Appendix D, "*Replacing the Visible Nose with the Open Nose*", page 91 for more information. Two cables are used in this procedure: one for inside the vacuum chamber and the other for connection to the ST-133 outside of the chamber.

CAUTION

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

FRAGILE

The 3' long vacuum-compatible cable is fragile and should be handled very carefully to prevent wire breakage at the connector ends. Never pull on the cable wires when connecting the cable to or disconnecting it from the cable connectors on the vacuum flange, or the camera.

To Connect the Detector-Controller Cables:

1. Verify that the Controller power is OFF.
2. Connect male end of the 6' long Detector-Controller cable to the "Detector" port on the back of the Controller. *Use the 3' long Detector-Controller cable if you have a 2 MHz system.*
3. Move the slide latch over to lock the connector in place. Refer to "*Securing the Detector-Controller Cable Slide Latch*", page 76.
4. Connect the female end of the cable to the vacuum flange.
5. Screw the connector in place.
6. Carefully secure the 3' long vacuum-compatible cable to the inside of the vacuum flange. Use a 3/32" hex tool to tighten down the screws.
7. Connect the end of the cable with the slide latch to the back of the camera and slide the latch until it locks on the posts.

Entering the Default Camera System Parameters into WinView

The following instructions assume that you have performed the computer interface installation.

1. Make sure the ST-133 is connected to the host computer, that it is turned on and that the computer recognizes the camera peripheral.
2. Run the WinView/32 application. The **Camera Detection wizard** will automatically run if this is the first time you have installed a Princeton Instruments WinView/32 application and a supported camera. Click on the Setup tab and then select the Hardware function. Then select the “Launch Camera Detection Wizard...” button in the **Controller/Camera** tab to start the wizard. Otherwise, if you are installing a new camera type, click on the **Launch Camera Detection Wizard...** button on the **Controller/CCD** tab to start the wizard.
3. On the **Welcome** dialog (Figure 6), leave the checkbox unselected and click on **Next**.



Figure 6. Camera Detection Wizard - Welcome dialog

4. Follow the instructions on the dialogs to perform the initial hardware setup: this wizard enters default parameters on the **Hardware Setup** dialog tabs and gives you an opportunity to acquire a single test image to confirm the system is working. Note that this is a test image and it is not acquired using the settings needed for true data acquisition.

Note: For a step-by-step procedure on basic system operation, refer to the WinView/32 “*First Light*” section starting on page 37.

Making the Coolant Connections

CAUTION

1. 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.
2. Coolant should be no colder than +10° C to +15° C to prevent condensation at 50% relative humidity. Operating the camera with coolant at a colder temperature could cause induced condensation in the electronics enclosure and possible catastrophic damage to the camera when the camera is operating outside of a vacuum enclosure. ***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 camera and the vacuum flange. Stainless steel flexible hoses (30" long) with female VCR fittings (Swagelok fittings were provided for earlier systems) are provided to make the connections. Instructions for VCR fittings and for Swagelok fittings can be found in Appendix C of this manual.

Note: Figure 7 shows the correct coolant ports for the incoming and outgoing coolant. These ports are ***NOT INTERCHANGEABLE***.

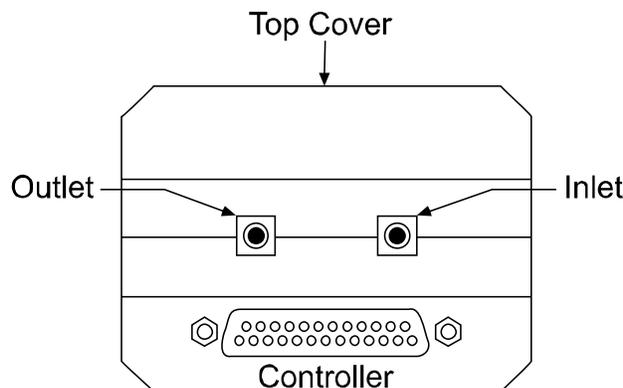


Figure 7. Coolant Ports

3. 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.
4. Make the hose connections between the vacuum flange and the chiller/coolant circulator. The tubing should be no longer than necessary.

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).

This page intentionally left blank.

Operation

Introduction

The PI-MTE camera family has been designed for mobile operation inside a vacuum chamber. These cameras can be mounted on a movable arm in vacuum to image a subject from more than one direction. Designed for operation with an ST-133 controller, these cameras incorporate a two-stage thermoelectric cooler with heat dissipation to circulating water or other (non-cryogenic) liquid coolant. These cameras can be provided with vacuum-compatible electrical cabling and coolant hoses and with corresponding feedthroughs mounted on a vacuum flange. These options provide for connection of the camera controller and liquid coolant system (outside the vacuum) to the camera head itself (inside the vacuum). The typical CCD operating temperature for PI-MTE series cameras extends to -40°C with +15°C circulating coolant; the operating temperature is somewhat lower with refrigerated coolant. No mechanical shutter is present on these units.

A two-stage Peltier effect thermoelectric cooler, driven by closed-loop proportional-control circuitry, cools the CCD. A thermal sensor attached to the cooling block of the camera monitors its temperature.

WARNING

Two front sections (noses) are available for the PI-MTE camera: an open nose for work inside a vacuum chamber and a visible nose (with quartz window) for operation in an atmospheric environment. When the open nose is on the camera, **EXTREME** caution must be used to avoid damage to the CCD array. The nose opening should remain covered when the camera is not in the vacuum chamber. ***Operation in atmosphere should NEVER be attempted with the open nose.*** The CCD array is not protected from contamination by this nose. **It is best not to open this nose except in a cleanroom environment.**

Once the PI-MTE camera has been installed (and optics have been adjusted if the visible nose is being used), operation of the camera is basically straightforward. In most applications you simply establish optimum performance using the **Focus** mode (WinView/32) and then do actual data acquisition in the **Acquire** mode. 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 displayed and/or stored via the application software. This sequence is illustrated by the block diagram shown in Figure 8.

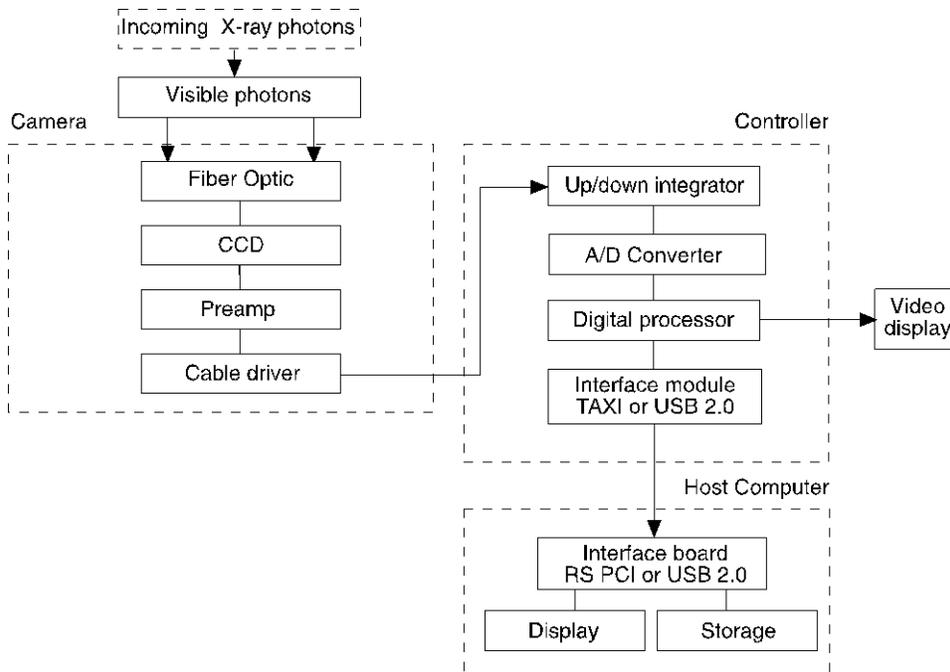


Figure 8. Block Diagram of Signal Path in System

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, 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).

- 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-MTE camera must be powered ON before WinView/32 is opened to ensure communication between the camera and the computer. If WinView is opened and the PI-MTE 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, power the camera ON, and reopen WinView before you can set up experiments and acquire new data.
2. WinView/32 must be closed before powering the camera OFF. If you power the camera OFF before closing WinView, 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, powered the camera ON, and then re-opened WinView.

First Light

This section provides step-by-step instructions for acquiring an imaging measurement outside of a vacuum environment (the visible nose is installed on the camera). 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 before removing the visible nose and installing the camera in a vacuum environment. Once basic familiarity has been established, then operation with other operating configurations, ones with more complex timing modes, can be performed.

Assumptions

The following procedure assumes that:

1. The camera still has the visible nose installed (the camera is shipped with this nose) and that you are verifying the camera system operation.
2. You have read Chapter 4 and the previous sections of this chapter.
3. You have made the appropriate cabling and coolant connections for your system.
4. The system is liquid-cooled.
5. You are familiar with the application software.
6. The system is being operated in imaging mode.
7. The target is a sharp image, text, or a drawing that can be used to verify that the camera is "seeing" and can be used to maximize focus.

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 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. *Refer to 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.
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, 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 (2048 × 2048, 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): Because the **Camera Detection Wizard (Hardware Wizard** for earlier software version) installed default values appropriate for your system, verify the settings on this page. To reload the defaults, you click on the **Load Defaults From Controller** button on this tab page to load the default settings.

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

Detector Temperature (Setup|Detector Temperature...): +20°C for the First Light procedure. To see when the array temperature reaches and stabilizes at the target temperature, leave the Detector Temperature dialog box open. When the target temperature is reached, the dialog box will report that the Current Temperature has **Locked**.

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).

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

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

- **Timing Mode:** Free Run
- **Shutter Control:** Normal
- **Safe Mode vs. Fast Mode:** Safe

Acquiring Data

If you are using WinView/32, select **Focus** from the **Acquisition** menu. Successive images will be sent to the monitor as quickly as they are acquired. Since the camera is shipped without a shutter, the images may smear if the exposure time is short. Figure 9 shows the kind of data you might see in WinView.

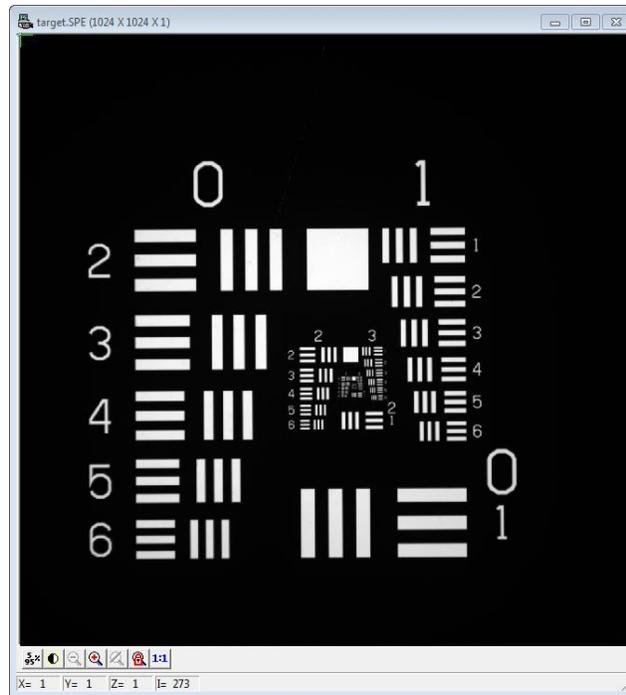


Figure 9. Example of WinView Data Acquired from First Light Procedure

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.

After you have powered down the camera system, you can then prepare the camera for installation in a vacuum chamber. Please follow the instructions provided in "*Replacing the Visible Nose with the Open Nose*" on page 91.

Powering Down Procedure

To prevent condensation damage to the camera, it is recommended that camera warm-up be carefully controlled. Proper warm-up of the camera after operation at temperatures below ambient is performed as follows.

1. Set the circulator's refrigeration On/Off switch to OFF.
2. While running WinView, gradually bring the camera temperature up in 10°C steps from its current lock temperature to ambient temperature. To accomplish this, open the **Detector Temperature** dialog box, set the target temperature to 10°C above the current lock temperature, wait until lock is reached, and then raise it again in 10°C steps until ambient temperature is reached.
3. After ambient temperature is reached, close WinView and then set the ST-133 Controller's Power switch to OFF. This will turn off the camera.
4. Set the circulator's main power switch to OFF.

5. The previous steps should be sufficient to prevent condensation from occurring on the camera (its array, electronics, and /or coolant ports). ***However, if the camera is currently in an evacuated vacuum chamber, you may also want to allow at least 30 minutes to pass before venting the vacuum chamber.***
6. This completes the warm-up procedure.

Cooling

Introduction

The PI-MTE cameras were developed for operation inside a vacuum chamber. A two-stage Peltier effect device provides the primary CCD cooling and the waste heat is removed by circulating liquid coolant.

WARNINGS

Sustained operation of these cameras without providing liquid cooling will permanently damage the camera. Such damage is not covered by the Warranty.

PI-MTE cameras are provided with 1/4" tubing fittings (Cajon Ultra-Torr®) for the circulation of liquid coolant. Use of water/glycol solution (i.e., automotive antifreeze,) is preferred. Avoid using any corrosive liquid. Set the coolant flow rate to 2 liters/minute. The temperature of the coolant is usually a compromise among a number of competing factors including the camera ambient conditions. Princeton Instruments typically uses 10° to 15°C coolant for testing.

Operated in a vacuum chamber, a standard PI-MTE camera will achieve an array temperature of -40°C with 15°C coolant. An evacuated camera with the visible nose and operated in the laboratory atmosphere will achieve an array temperature of -25°C with 15°C coolant.

Condensation

WARNING

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, on the CCD, or on the interior CCD window (if so equipped), stop operation immediately and contact the factory for recommended corrective action.

The CCD array and electronics are subject to damage from condensation if exposed to atmospheric moisture when cold. The following paragraphs discuss condensation risk factors and their prevention.

Before operating in atmosphere with a PI-MTE camera designed for vacuum chamber operation, check the temperature and humidity levels. If the conditions are such that running with chilled coolant will result in condensation, you should only circulate room temperature coolant through the camera. Condensation damage may occur if the coolant pipes become cold enough to condense water from the atmosphere or if water condenses on the CCD array as a result of deterioration of the internal vacuum. ***At the first sign of condensation on the coolant pipes or CCD array, turn off the system immediately and contact the factory for corrective action advice.***

Operating a PI-MTE with the visible nose in atmosphere can result in condensation if the camera has not been evacuated to at least 1 mTorr before running with chilled coolant (coolant should be no colder than +10° C to +15° C to prevent condensation at 50% relative humidity). Over time the vacuum will degrade, so always evacuate a visible nose camera before running it in atmosphere. ***At the first sign of condensation on the coolant pipes or the CCD array, turn off the system immediately.***

An open-nose PI-MTE camera inside a vacuum chamber is subject to condensation if the chamber is vented too soon after powering off the camera. Failure to turn off the coolant flow to a camera in a vacuum chamber can also result in condensation when the chamber is vented. In addition, because vacuum venting can contaminate the cooled surface of the CCD, we advise you to position a gate valve between the camera and the rest of the system. This is also highly recommended to prevent contamination.

WARNING

PI-MTE cameras that use the open nose depend on the vacuum environment for thermal isolation of the cooled CCD and for preventing condensation on it. Operating these cameras in air will result in damage to the CCD array. In vacuum chamber operation, after the camera has been turned off *and the coolant flow stopped*, the camera should be allowed to warm up for at least thirty (30) minutes before the vacuum chamber is vented.

To prevent condensation damage while the camera is mounted in 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 or turning on coolant flow.
- **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.***

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 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.

PI-MTE series cameras do not incorporate an internal shutter. In addition, only full-frame CCDs (as opposed to frame-transfer CCDs) are available at this writing*. Because PI-MTE

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.

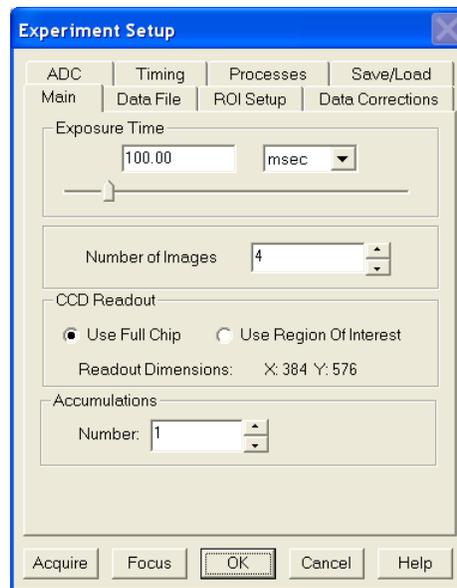
If smearing or other factors require a shutter, the NOT SCAN or the SHUTTER signal at the ST-133's **SCAN** output can be used to control a customer-supplied external x-ray shutter. By using one of the signals to synchronize the shutter operation with exposure, the CCD can be read out in darkness. Alternatively,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

Temperature Control

Lowering the temperature of the CCD will generally enhance the quality of the acquired signal. The temperature is set directly from the application software and it takes from 10-20 minutes for the PI-MTE to reach and lock at the set temperature. The TEMP LOCK indicator on the back of the controller then lights GREEN to indicate that lock has been achieved (for more information, refer to the "*ST-133 Controller*" section in Chapter 2). Application software, such as WinView/32, also provides a temperature-locked indication.

Notes:

1. Temperature regulation does not reach its ultimate stability for at least 30 minutes after temperature lock is established. Also note that the thermoelectric cooler has no capability to heat the CCD. These cameras are therefore more thermally stable at lower temperatures.
2. Because vacuum venting can contaminate the cooled surface of the CCD, we advise you to position a gate valve between the camera and the rest of the system. This is also highly recommended to prevent contamination.



* Please contact your Princeton Instruments representative for special applications or requirements.

As previously mentioned in the "*Cooling*" topic, page 41, cooling also means the possibility of condensation. PI-MTE cameras when operated in the open nose configuration 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.

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.

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

Dark Charge

Dark charge (or dark current) is the thermally-induced buildup of charge in the CCD over time and varies widely from one CCD array to another. This charge integrates in the pixel wells whenever the camera is on, whether or not data is being acquired, and could result in the loss of dynamic range. In the case of cameras with MPP type arrays, the average dark charge is extremely small. However, the dark-charge distribution is such that a significant number of pixels may exhibit a much higher dark charge, limiting the maximum practical exposure. Dark charge effect is more pronounced in the case of cameras having a non-MPP array.

Because dark charge is thermally-induced, reducing the array temperature significantly reduces the rate at which dark charge accumulates in the pixel wells. Even so, enough dark charge could accumulate in the pixels between data acquisitions to affect dynamic range at the beginning of an exposure. To prevent this from happening, clean cycles (refer to "Clean Cycles", below) repeatedly shift and discard any signal that has integrated on the array while waiting for a Start Acquisition command.

After the Start Acquisition command is received by the controller and exposure begins, both the signal of interest and dark charge integrate on the array. The longer the exposure time and the warmer the camera, the larger and less uniform the dark charge will appear. To minimize the dark charge contribution to the acquired signal, you should operate with the lowest temperature possible for your camera. Reducing the exposure time may also be helpful.

To further reduce the dark charge contribution to an acquired signal, you can perform background subtraction, which subtracts a dark charge background from raw data acquired using the same experiment conditions. (Refer to "*Background Subtraction*", page 49).

Notes:

1. Do not be concerned about either the DC level of this background noise or its shape unless it is very high, i.e., > 1000 counts with 16 bit A/D. What you see is not noise. It is a fully subtractable readout pattern. Refer to "*Background Subtraction*", page 49, for more information.
2. Offset and excess noise problems are more likely to occur if the controller and camera were not 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 camera's vacuum enclosure. **Immediately** turn off the controller. *Then, contact Princeton Instruments Customer Support for further instructions. Refer to page 106 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.

Clean Cycles

As stated before, dark charge integrates on the array whenever the camera is on, whether or not data acquisition is occurring. To minimize the dark charge and other noise in the pixel wells when data acquisition is idle, the Clean Cycles function shifts accumulated charge in a predefined number of rows to the shift register and then discards it.

Clean cycles start when you turn the controller on and a clean pattern is programmed into the controller. At the end of a cycle, the controller checks to see if a Start Acquisition command has been received. If it has been received, the user-defined number of cleans (typically 0) will be then performed before the exposure time starts. If a Start Acquisition command has not been received, the next clean cycle begins.

The number of rows that are shifted and discarded during a clean cycle are defined in the application software. The most effective cleaning occurs when the number of rows equals the number of rows on the CCD. However, you need to keep in mind that a clean cycle must be completed before a Start Acquisition command will be implemented. The more rows in a cycle, the greater the delay between the command receipt and the beginning of an exposure. Because of this timing issue, the number of rows per clean cycle is usually much smaller than the number of rows on the array.

The timing diagram below is for an experiment set up to acquire three (3) images in Freerun timing mode with normal shutter operation selected. In this diagram, clean cycles occur before the first exposure and after the last readout period. They do not need to occur between exposures since each readout cleans the array before the next exposure starts.

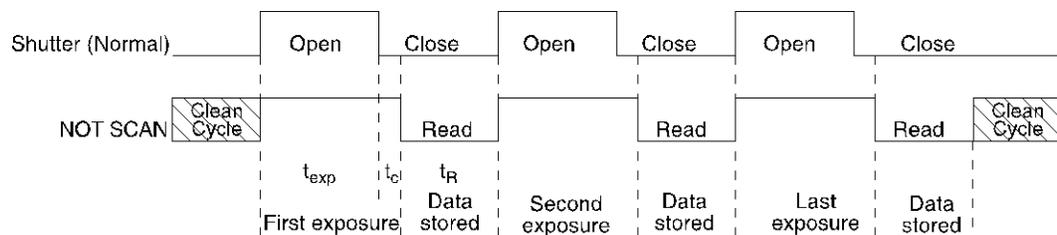


Figure 10. Clean Cycles in Freerun Operation

Note: The start of the exposure is signaled by **NOT SCAN** going high but will not occur until the current clean cycle and the additional user-defined number of cleans (typically 0) have finished. "Number of Cleans" is defined on the **Setup|Hardware Setup|Cleans/Skips** tab page. If you enter a value other than "0", you will further delay the start of the exposure by that number of clean cycles.

Continuous Cleans

The Continuous Cleans function is provided when the start of an exposure is tied to an external trigger (i.e., the experiment is being run in **External Sync** timing mode). The continuous clean cycles are defined by the same parameter values as the standard clean cycles. The difference is that continuous clean cycles occur between **NOT SCAN** going high and External Sync going low. When the External Sync trigger arrives during a continuous clean cycle, that cycle must be completed before the exposure will begin. In time critical experiments, the number of rows per clean (set on the **Hardware Setup|Controller/Camera** tab page) should be 1 or 2 to minimize the delay. Refer to "*External Sync with Continuous Cleans*", page 55 for more information.

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.

WinView allows you to specify the type of readout (full frame or binned) 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.

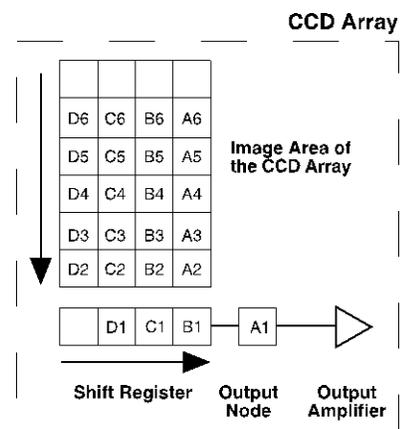


Figure 11. Array Terms for a CCD with a Single Output Amplifier

The upper left drawing in Figure 12 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.

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.

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.

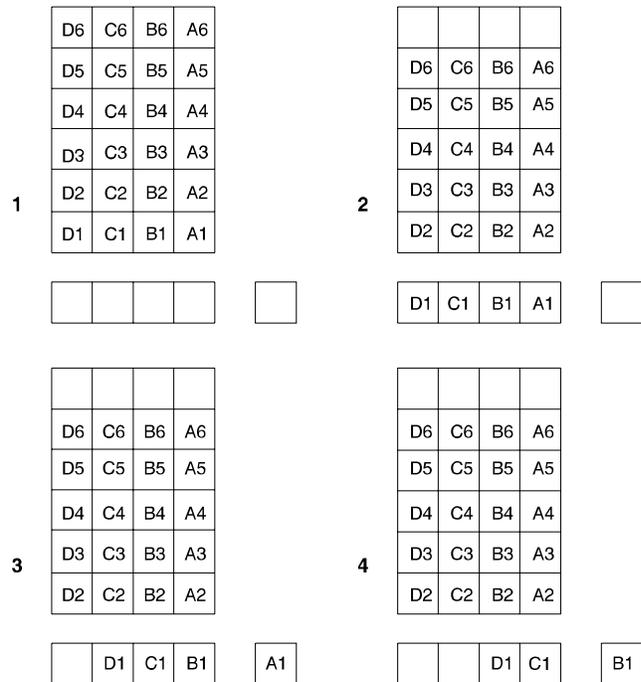


Figure 12. Full Frame at Full Resolution

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 13 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.

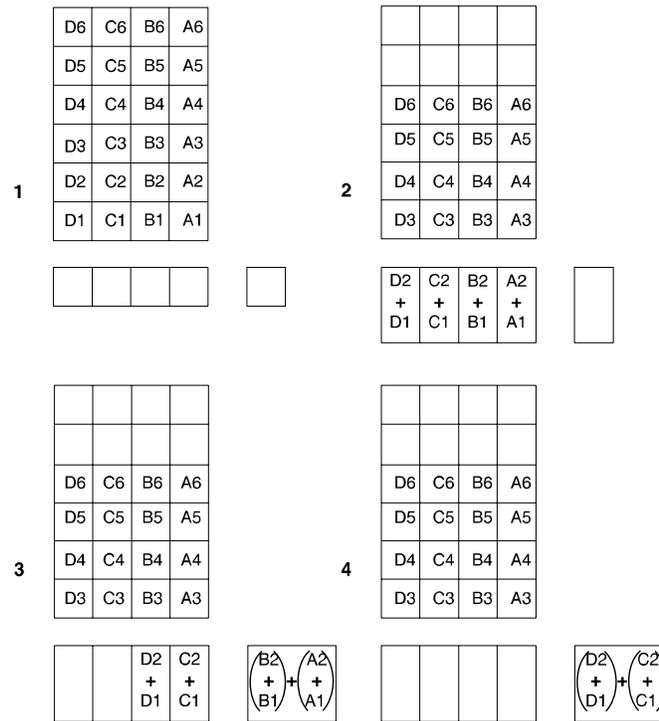


Figure 13. 2×2 Binning for Images

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.

Background Subtraction

Each CCD has its own dark charge pattern or background that can be subtracted from the total acquired signal. By subtracting this background, you can eliminate the dark charge, which might otherwise hide low-intensity signal.

To set up for background subtraction, set up the experiment conditions for acquiring the actual image (detector temperature, exposure time, region of interest, timing mode, etc.) and then, while blocking the incoming signal from the array, acquire a dark charge “background image” under those conditions. Once the background image is acquired, save it to disk.

After storing the background to disk, you have two choices for background subtraction: automatic or post-processing.

- **Automatic:** This approach requires that you activate "Background" and specify the background filename on the **Acquisition| Experiment Setup|Data Corrections** tab page before acquiring an image. When you acquire an image, the specified background file data will automatically be subtracted from the raw image data before the corrected data is displayed and is available for storage to disk.
- **Post-Processing:** If you prefer to acquire and preserve the raw image data, make sure that "Background" is not active on the **Acquisition|Experiment Setup|Data Corrections** tab page. Then, acquire the image, save the raw image data to disk, and, via the Image Math function, subtract the background file data from the raw image data. The subsequent data can then be saved to a separate file.

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 (refer to "**Readout**", page 46).

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

During readout, an analog signal representing the charge of each pixel (or binned group of pixels) is digitized. The number of bits per pixel is based on both the hardware and the settings programmed into the camera through the software.

The ST-133 100 kHz/1 MHz Controller has a single A/D converter that can be run at either 100 kHz or 1 MHz. The choice of digitization speed is made via the application software.

The ST-133 2 MHz controller provides six digitization rates (from 50 kHz up to 2 MHz), providing optimum signal-to-noise ratios at all 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 2 MHz conversion speed permits the fastest possible data collection and the 100 kHz or 50 kHz conversion speed is suitable for use where noise performance is the paramount concern. Switching between the conversion speeds is completely under software control for total experiment automation.

Note: For the 2 MHz controller, ADC baseline offset levels are preset at the factory and are not user-adjustable.

ADC Offset

ADC offset (also known as baseline offset) provides another way of dealing with dark charge (refer to "*Dark Charge*", page 44). 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.

The ability to shift the baseline depends on the controller used in your system. For 100 kHz/1 MHz controllers, the offset values for the Fast (F) and Slow (S) A/D converters are preadjusted at the factory but may be adjusted via the Zero Adjustment potentiometers on the back of the controller. In the case of 2 MHz controllers, the potentiometers are not present and you cannot change the factory set baseline offsets for the six digitization speeds: changes to the baseline offsets must be performed at the factory.

Once you have entered the acquisition parameters, wait for temperature lock to occur and then wait 30 minutes for the camera temperature to completely stabilize. Then try taking a few dark charge readings.

Notes:

1. Do not be concerned about either the DC level of this background or its shape unless it is very high, i.e., >400 counts. What you see is not noise. It is a fully subtractable readout pattern. Each CCD has its own dark charge pattern, unique to that particular device. Every device has been thoroughly tested to ensure its compliance with Princeton Instruments' demanding specifications.
2. 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** and contact the factory Customer Support Department. Refer to page 102 for contact information.

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). With the exception of Edge Trigger, the topics are addressed in order of their appearance on the Timing tab page (see Figure 14).

"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.

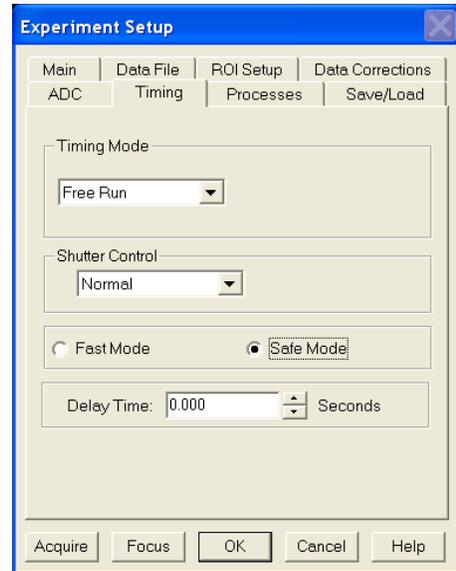


Figure 14. Timing tab page

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.

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.

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

Table 3. Camera Timing Modes

Note: Since PI-MTE 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, refer to the discussion of full frame readout, starting on page 46.

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 **SCAN** connector. Shutter operation and the NOT SCAN output signal are shown in Figure 16.

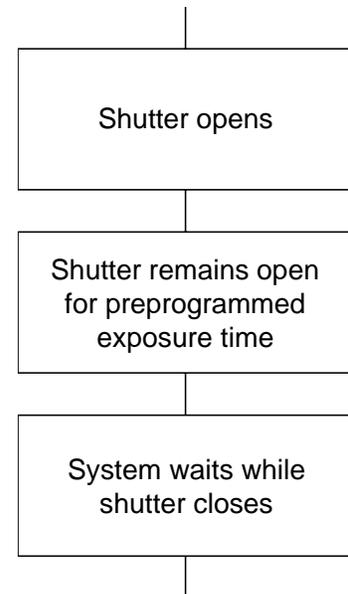


Figure 15. Free Run Timing Chart, Part of the Chart in Figure 21

* 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.

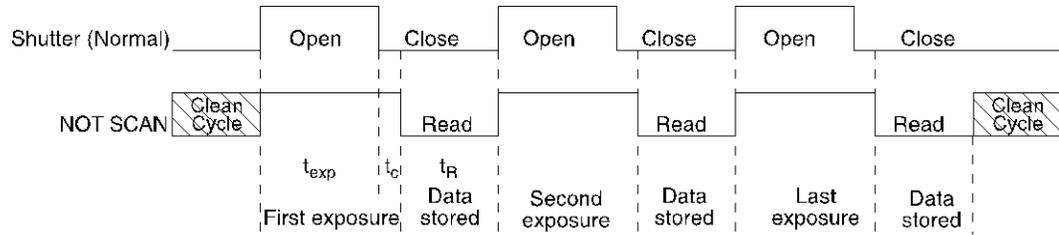


Figure 16. Free Run Timing Diagram

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, this is done on the **Experiment Setup|Timing** tab page). As shown in the flowchart, Figure 17, 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.

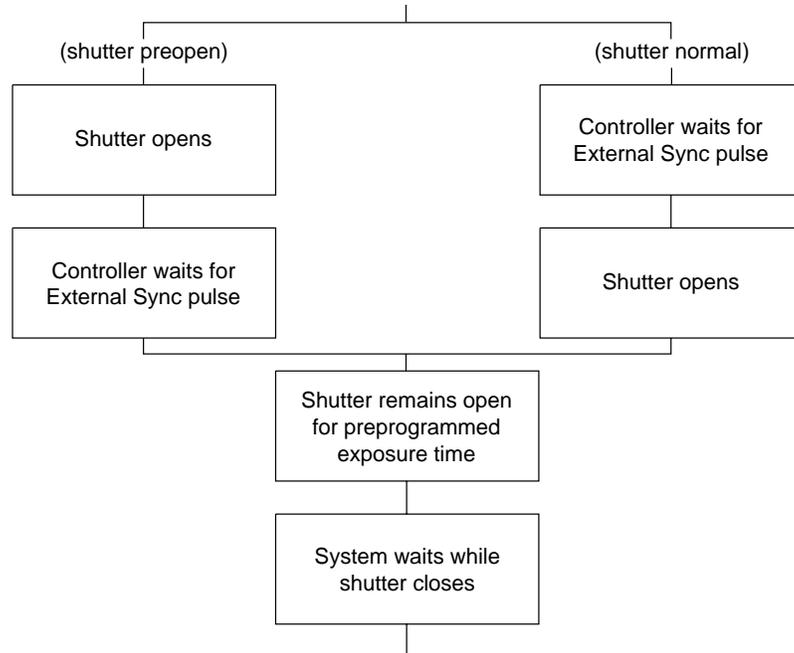


Figure 17. Chart Showing Two External Sync Timing Options

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 18, 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.

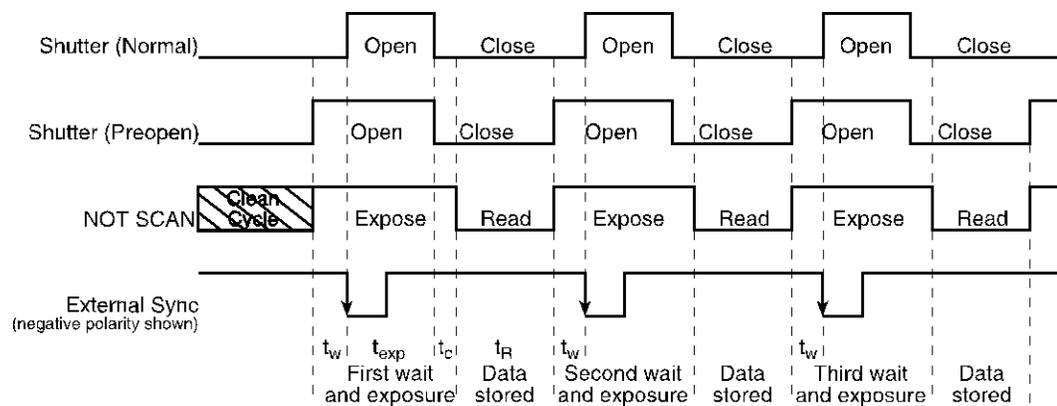


Figure 18. Timing Diagram for External Sync Mode (- edge trigger)

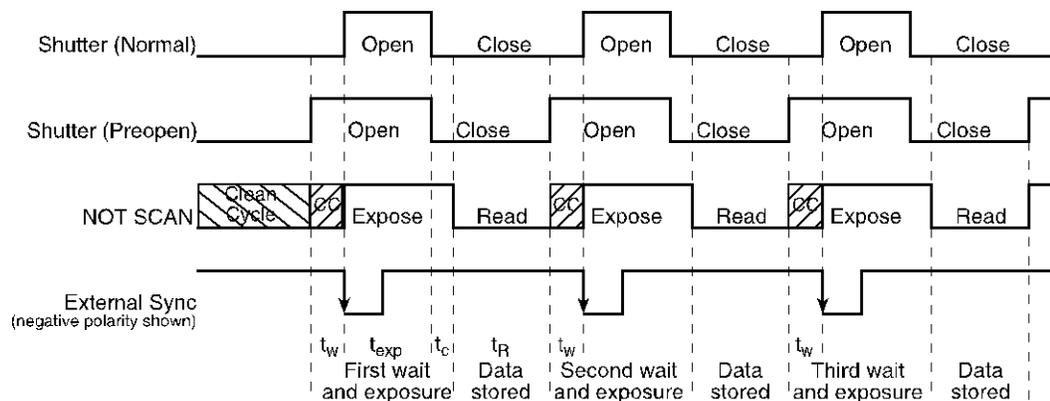


Figure 20. Continuous Cleans Timing Diagram (- edge trigger)

Figure 20 shows the same timing diagram as Figure 18 with the addition of continuous cleans (indicated by the shaded areas labeled CC). Continuous cleans are additional clean cycles and defined by the same parameter values as the standard clean cycles.

Fast and Safe Modes

The WinView **Experiment Setup|Timing** tab page allows you to choose **Fast Mode** or **Safe Mode**. Figure 21 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 21, 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.

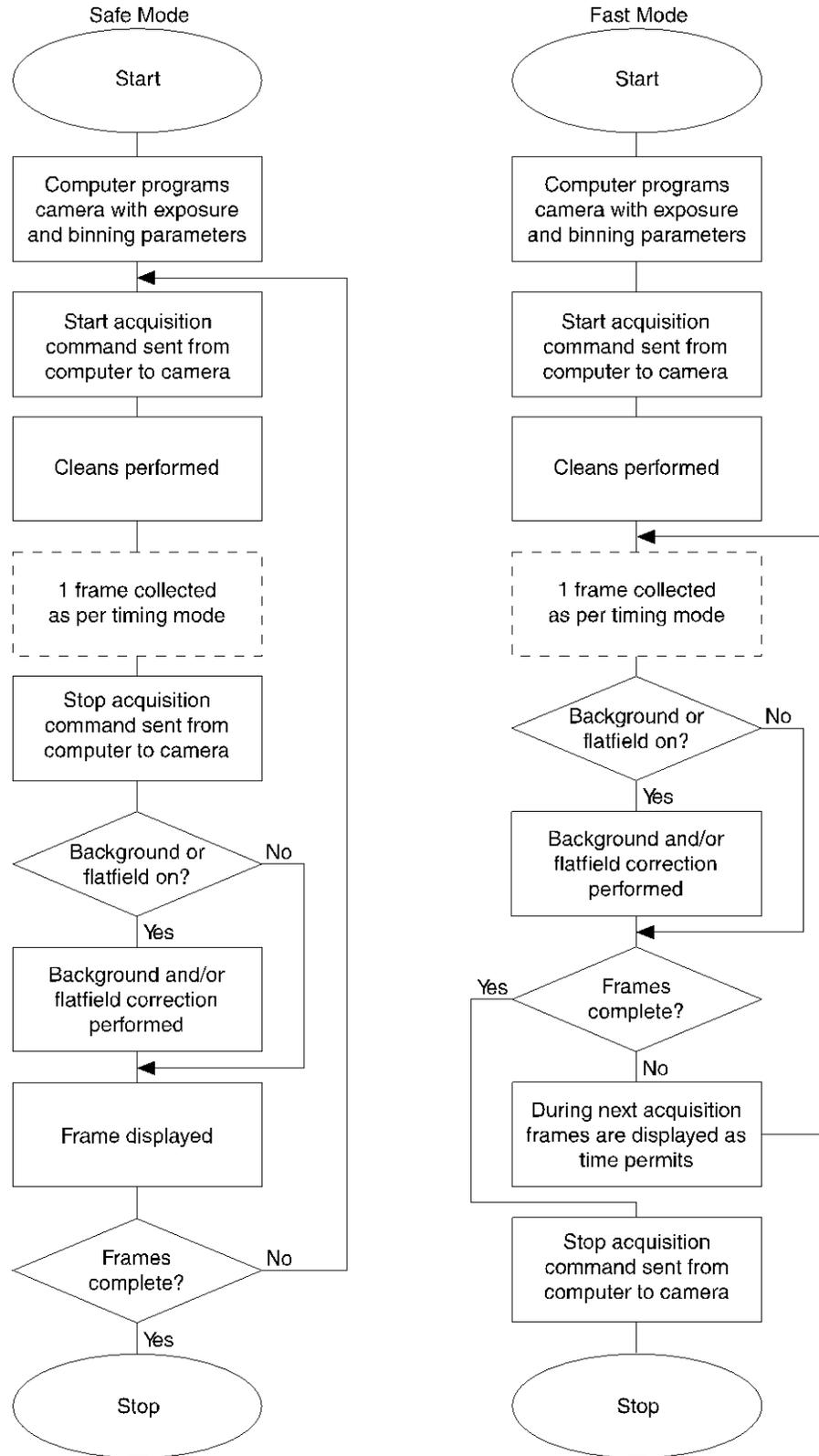


Figure 21. Chart of Safe Mode and Fast Mode Operation

TTL Control

Fully supported by WinView/WinSpec Version 2.6.x 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++. Refer to 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 22 illustrates the connector and Table 5 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 4 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 4. 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-MTE 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 5. TTL In/Out Connector Pinout

TTL IN/OUT

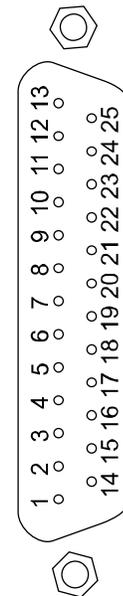


Figure 22. TTL In/Out Connector

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.

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).

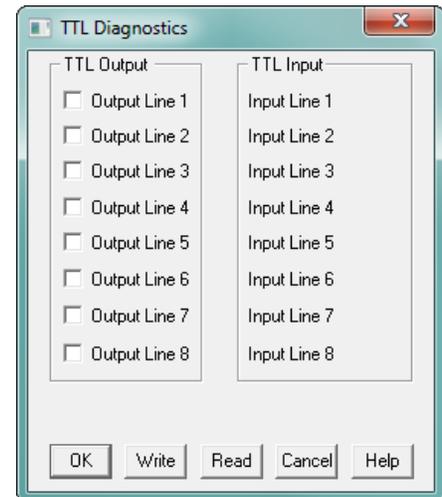


Figure 23. TTL Diagnostics dialog box

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 5, 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.

This page intentionally left blank.

Chapter 7

Troubleshooting

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

Introduction

The following issues have corresponding troubleshooting sections in this chapter.

Baseline Signal Suddenly Changes	Page 64
Camera1 (or similar name) on Hardware Setup dialog box	Page 64
Changing the ST-133 Line Voltage and Fuses	Page 64
Controller Is Not Responding	Page 67
Cooling Troubleshooting	Page 67
Data Loss or Serial Violation	Page 69
Data Overrun Due to Hardware Conflict	Page 69
Data Overrun Occurred	Page 70
Error Creating Controller message	Page 70
Error Occurs at Computer Powerup	Page 71
Program Error	Page 73
Removing/Installing a Plug-In Module	Page 74
Securing the Detector-Controller Cable Slide Latch	Page 76
Serial violations have occurred. Check interface cable.	Page 77

Baseline Signal Suddenly Changes

In-Vacuum Operation: If you observe a sudden change in the baseline signal, turn off the controller. *Contact the factory Customer Support Dept. for further instructions. Refer to page 102 for contact information.*

Out-of-Vacuum Operation: If you observe a sudden change in the baseline signal, you may have excessive humidity in the vacuum enclosure of the camera. Turn off the controller and have the camera repumped before resuming normal operation. *Contact the factory Customer Support Dept. for further instructions. Refer to page 102 for contact information.*

Camera1 (or similar name) on Hardware Setup dialog box

When a PVCAM-based camera is detected/selected during the Camera Detection wizard, a default name (e.g., Camera1,) will be shown in the Detected Hardware table and will be entered in the **Camera Name** field on the **Setup|Hardware|Controller/CCD** tab as well as in the Hardware Setup title bar. See Figure 24.

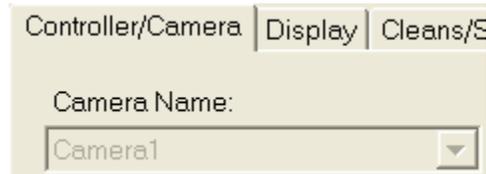
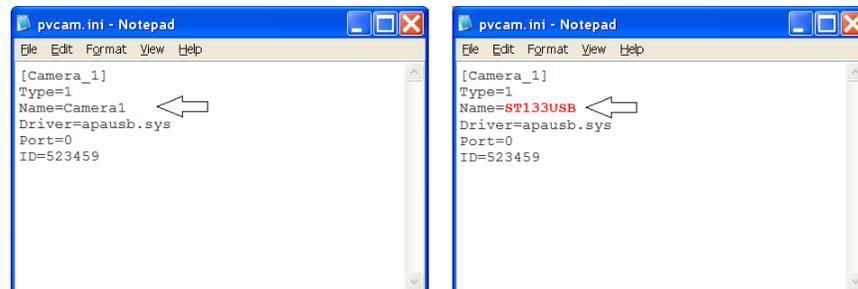


Figure 24. Camera1 in Controller Type (Camera Name) Field

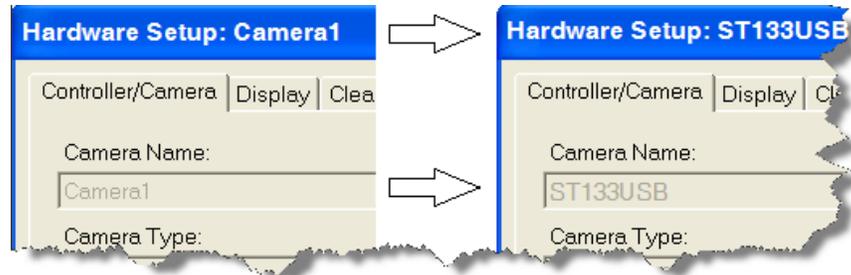
Because this name is not particularly descriptive, you may want to change it. Such a change is made by editing the PVCAM.INI file that is generated by Camera Detection wizard.

To change the default Camera Name:

1. Close WinView if it is running.
2. Using **Notepad** or a similar text editor, open **PVCAM.INI**, which is located in the Windows directory (C:\WINDOWS, for example).
3. Edit the **Name** field.



4. Save the edited file.
5. The next time you start WinView, the new name will be displayed on the **Hardware Setup** dialog.



6. If you later re-run the Camera Detection Wizard, the name will be changed back to the default name (i.e., Camera1.)

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 module. If your voltage source changes, you will need to change the voltage setting and you may need to change the fuse configuration.

Input Voltage	Fuses		Type
	Left	Right	
100/120 V _{AC}	0.75 A	2.50 A	Slow Blow
220/240 V _{AC}	0.30 A	1.25 A	Slow Blow

Table 6. Fuse Ratings

WARNING! Use proper fuse values and types for the controller and detector to be properly protected.

To Change Voltage and Fuse Configuration:

WARNING! Before opening the power module, turn the Controller OFF and unplug the power cord.

1. Verify that the power supply is turned OFF and the power cord is unplugged.
2. As shown in Figure 25, place the flat side of a flat bladed screwdriver parallel to the back of the Controller and behind the small tab at the top of the power module, and twist the screwdriver slowly but firmly to pop the module open.
3. To change the voltage setting, roll the selector drum until the setting that is closest to the actual line voltage is facing outwards.
4. Turn the drum to the desired voltage and put the drum back into the module with that setting facing straight out of the module.
5. Confirm the fuse ratings by removing the two white fuse holders. To do so, simply insert the flat blade of the screwdriver behind the front tab of each fuse holder and gently pry the assembly out.

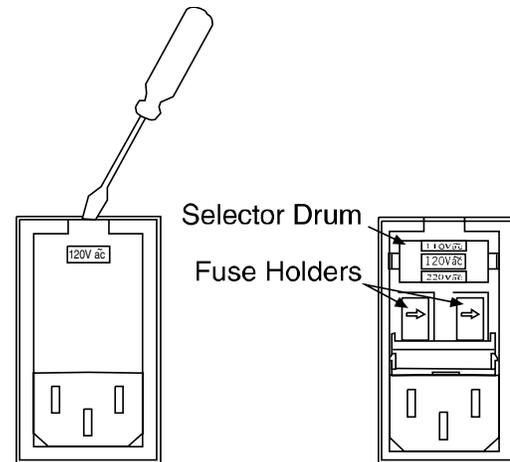


Figure 25. Power Module

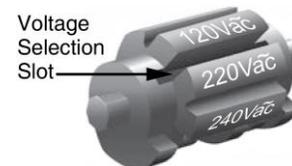


Figure 26. Voltage Selector Drum

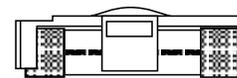
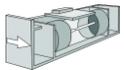


Figure 27. Fuse Holder

6. Refer to Table 6 or the Fuse/Voltage label (above or below the Power Module) to determine which fuses are required by the selected voltage. If the Controller power switch is on the back of the ST-133, the Fuse/Voltage label is located below the Power Module.
7. 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. 
8. Close the power module and verify that the correct voltage setting is displayed. For example, if you wanted 220 VAC, you should see 220 Vac in the window. 
9. Verify that the Controller power switch is in the OFF position and then plug the power cord back into the power 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 the 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 WinView/32 and turn the Controller OFF. Follow the interface card installation instructions in Chapter 4 and cable the interface card to the SERIAL COM port on the rear of the Controller. Then do a "Custom" installation of WinView with the appropriate interface component selected: "PCI Interface". Be sure to deselect any 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 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 has been installed, close WinView and do a "Custom" installation of WinView with the appropriate interface component selected: "PCI Interface". Be sure to deselect any interface component that does not apply to your system.

Cooling Troubleshooting

Camera does not achieve temperature lock

If the indicator does not 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.

Out-of-Vacuum Operation Cooling and Internal Vacuum Level

With time, there may be a gradual deterioration of the camera's vacuum. This may affect temperature performance and it may no longer be possible to achieve temperature lock at the lowest temperatures. In the kind of low-light imaging applications for which cooled CCD cameras are so well suited, it is highly desirable to maintain the system's temperature performance because lower temperatures provide less thermal noise and better signal-to-noise ratio.

If your PI-MTE is designed for in-vacuum applications: Vacuum deterioration is normal for PI-MTE cameras that are designed for operation in vacuum chambers but are temporarily being operated with a visible nose in air. The elastomer gasket between the nose and the middle enclosure is not intended to provide a permanent vacuum. If you have the appropriate equipment and personnel with the necessary expertise available, you may pump down the camera at your facility (refer to steps 12-18 on page 94).

If your PI-MTE is designed for out-of-vacuum applications: The camera will have an Indium seal between the nose and the middle enclosure. If you have the appropriate equipment and personnel with the necessary expertise available, you may pump down the camera at your facility (refer to steps 12-18 on page 94).

WARNING

The CCD array is subject to damage from condensation if exposed to the atmosphere when cold. For this reason, the camera should be kept properly evacuated or backfilled with dry nitrogen, free of oil or other contaminants.

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 -100° C.*

Note: If the **Detector Temperature** dialog box is open, the following message will be displayed in the box when thermal overload is detected: "***Detector Overheated! Consult operations manual or contact PI Technical Support if problem persists.***"

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.

Data Overrun Due to Hardware Conflict



Figure 28. 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 2048×2048 array), requires a larger DMA buffer larger setting than that for a smaller array (for example, a 512×512 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 Occurred

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, perform 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.
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. Refer to "*To Update the OrangeUSB USB 2.0 Driver*", page 28.

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, you will not notice the interrupt. 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) PCI card. If this is not the case and data overruns continue to occur, contact Customer Support (refer to page 102 for contact information).

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, if the PVCAM.INI file has been corrupted, or if the ST-133 was not turned on before launching WinView/32 and running the Hardware Wizard.

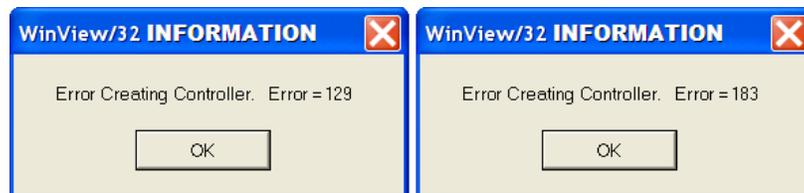


Figure 29. Error Creating Controller dialog box

Error 129: Indicates the problem is with the PVCAM.INI file. Close WinView/32, run RSConfig, verify the ST-133 is on, reopen WinView, and run 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, verify **Yes** is selected, and then click on **Next**. The Hardware Wizard should proceed 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 card 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 you 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 you have 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 which 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 Assignment 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 does not 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 you 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 is 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, although 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.

Program Error

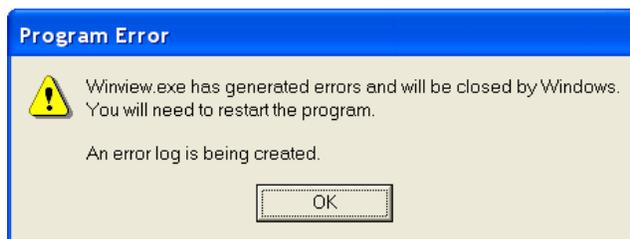


Figure 30. Program Error dialog box

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 (e.g., a 2048 × 2048 array), requires a larger setting than that for a smaller array (e.g., 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 2048 × 2048 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.

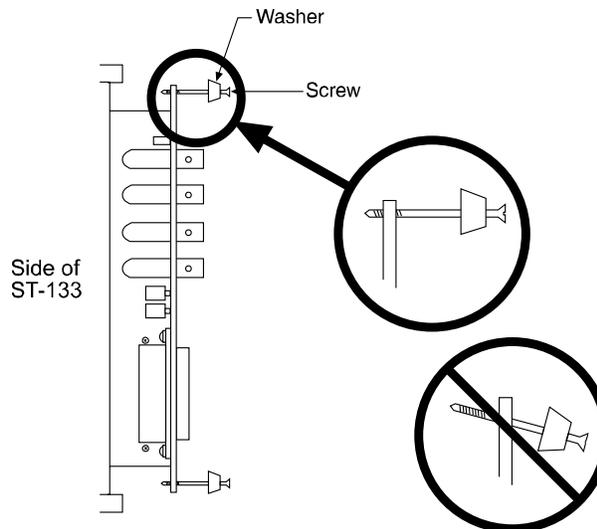


Figure 31. Module Installation

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:

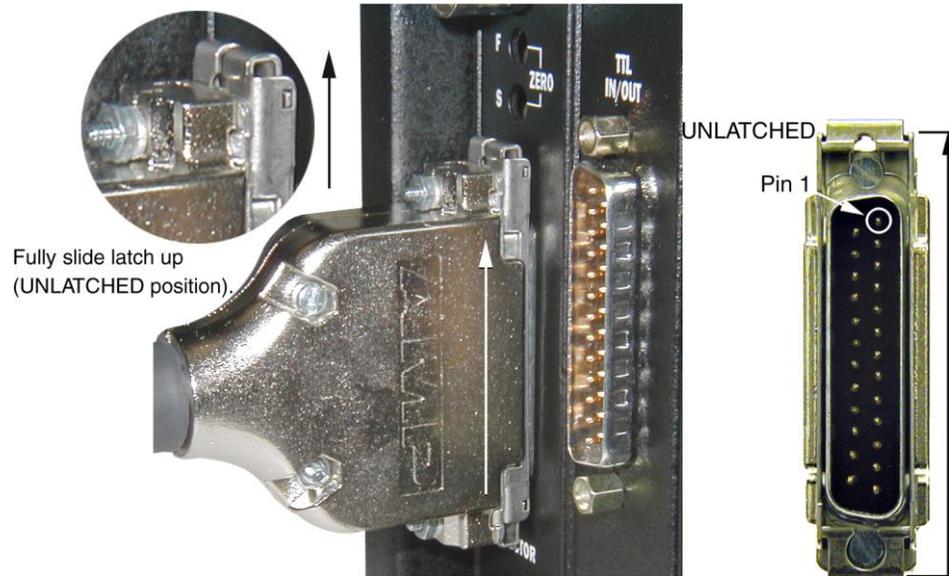
1. Verify that the Controller has been turned OFF.
2. Remove the replacement module from its antistatic packaging. This packaging is designed to protect the module components from electrostatic discharge.
3. Rotate the two locking screws counterclockwise until the threads on the screws engage those of the module panel. *See Figure 31.* 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.

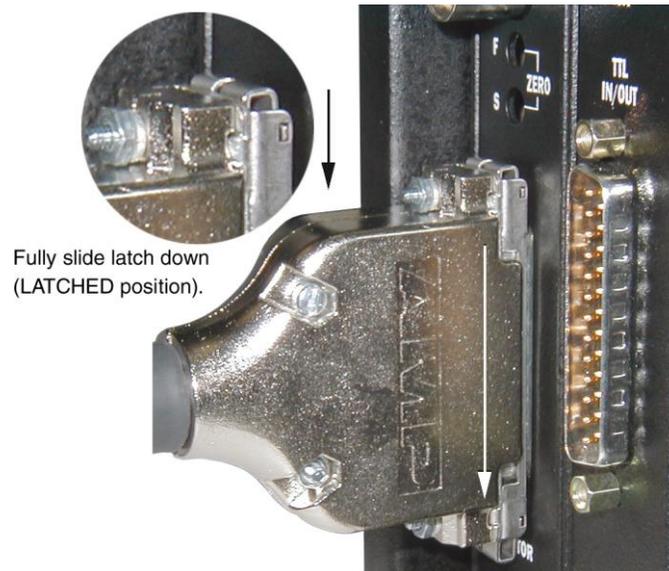
Securing the Detector-Controller Cable Slide Latch

Some Princeton Instruments Detector-Controller cables use a slide latch to secure the Detector-Controller cable to the DETECTOR connector on the back of the ST-133. Incorrectly plugging this cable into the connector and improperly securing the slide latch may prevent communication with the PI-MTE (the camera may appear to stop working).

1. Before trying to plug in the cable, slide the latch up (toward Pin 1). Then, plug the cable into the DETECTOR connector on the ST-133.



2. Slide the latch down. You may hear a click when the latch locks.



3. Verify that the connector is fully secured.

If you are having trouble sliding the latch, slightly pull the connector out and then slide the latch into its locked position.

Serial violations have occurred. Check interface cable.



Figure 32. *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.

This page intentionally left blank.

Specifications

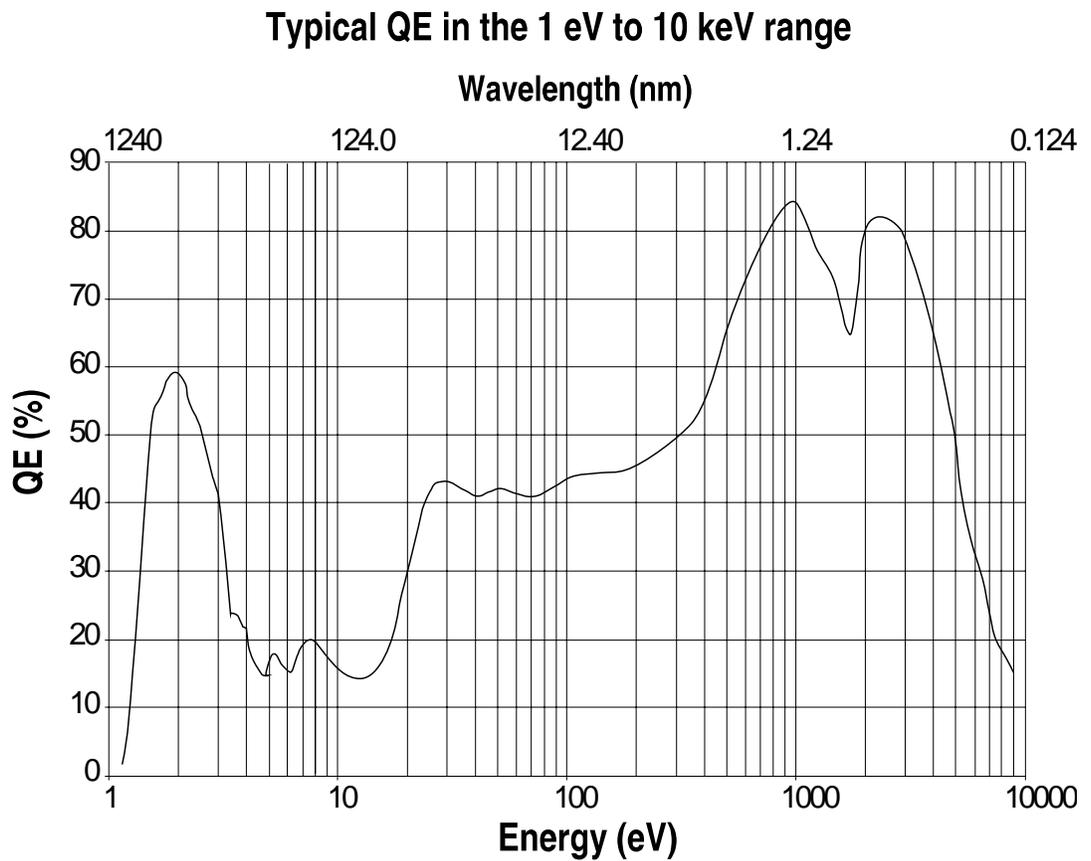
PI-MTE Camera

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.

Princeton Instruments Exclusive: 1340×1300 B, No AR, MPP, $20 \times 20 \mu\text{m}$ pixels

e2v CCD42-40: 2048×2048 B, No AR, MPP, $13.5 \times 13.5 \mu\text{m}$ pixels



Environmental

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

Power

Maximum internal heat dissipation in watts: 90

Cooling

- -40°C with in-vacuum operation and circulating coolant at +15°C
- -25°C with the visible nose and circulating coolant at +15°C.

ST-133

ST-133A Dimensions: 5.25 in (13.34 cm) width; 13.63 in (34.62 cm) length; 8.75 in (22.23 cm) height; 13 lb (5.9 kg) weight

ST-133B Dimensions: 5.80 in (14.72 cm) width; 13.91 in (35.33 cm) length; 8.59 in (21.82 cm) height; 12.5 lb (5.7 kg) weight

Connectors:

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

EXT SYNC: TTL input (BNC) to allow data acquisition to be synchronized with external events. Sense can be positive or negative going as set in software. Synchronization and Trigger Modes are discussed in Chapter 6.

SCAN: TTL output (BNC) for monitoring camera status. TTL low when array is being read; otherwise high.

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

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

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

TTL Input: external sync

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

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

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

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

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

Power Consumption: Refer to the Fuse/Voltage label on the back of the ST-133.

Readout Bits/Pixel: 1300B: 16 bits @ 50 kHz to 2 MHz
2048B: 16 bits @ 50 kHz to 1 MHz

This page intentionally left blank.

Appendix B

Outline Drawings

Note: Dimensions are in inches (mm).

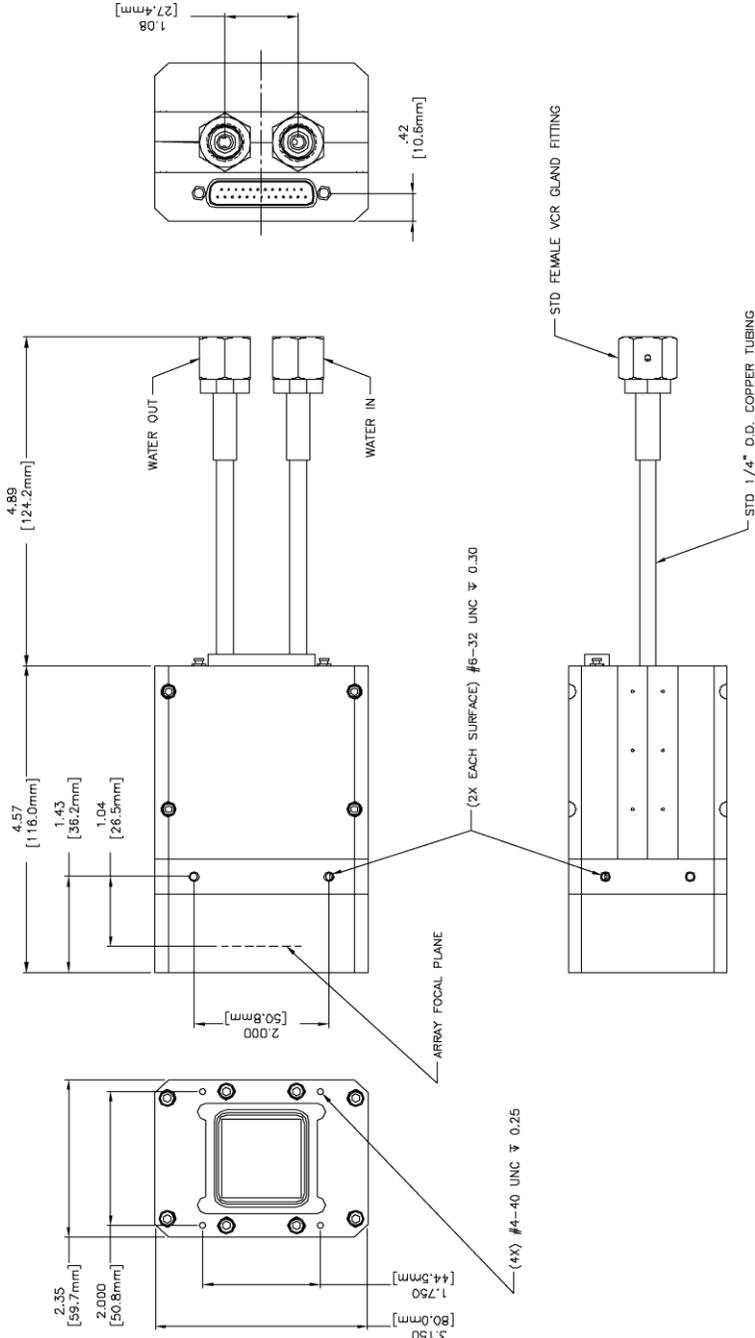


Figure 33. PI-MTE Camera (3-01-06 and later)

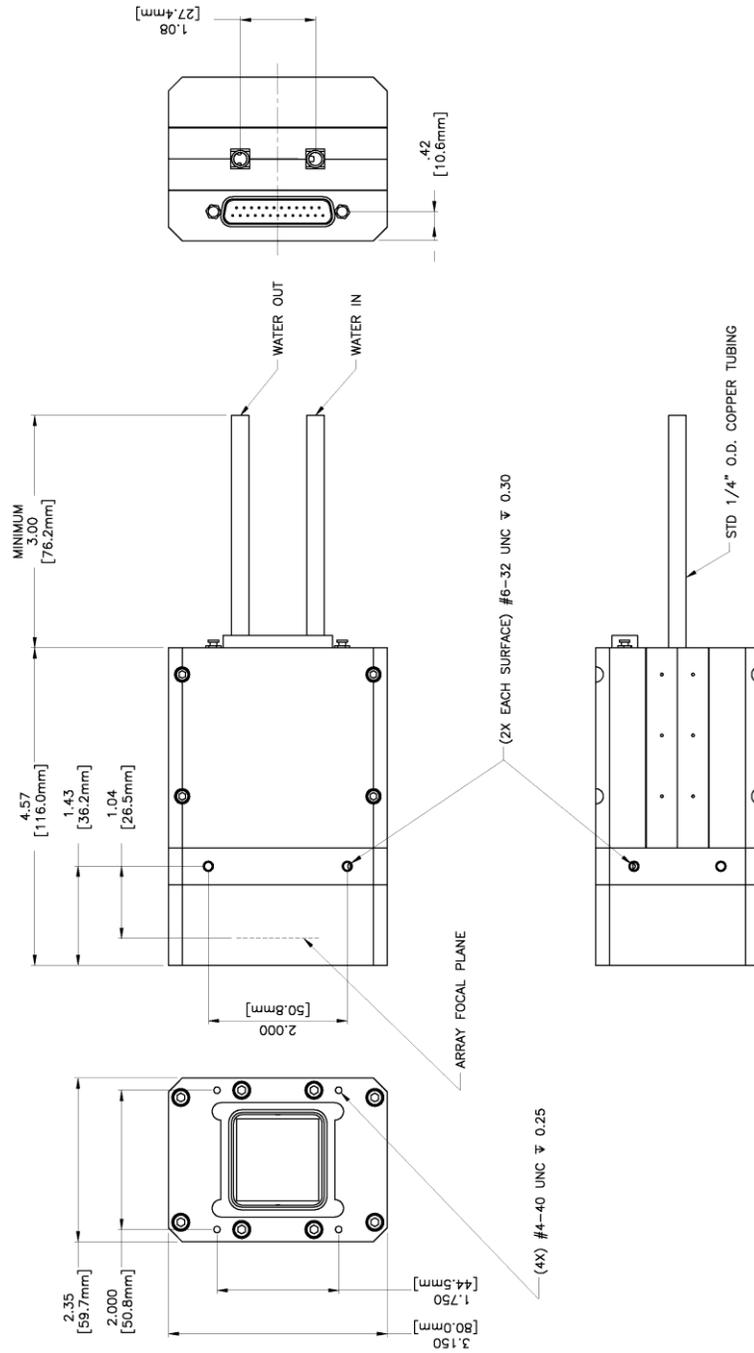
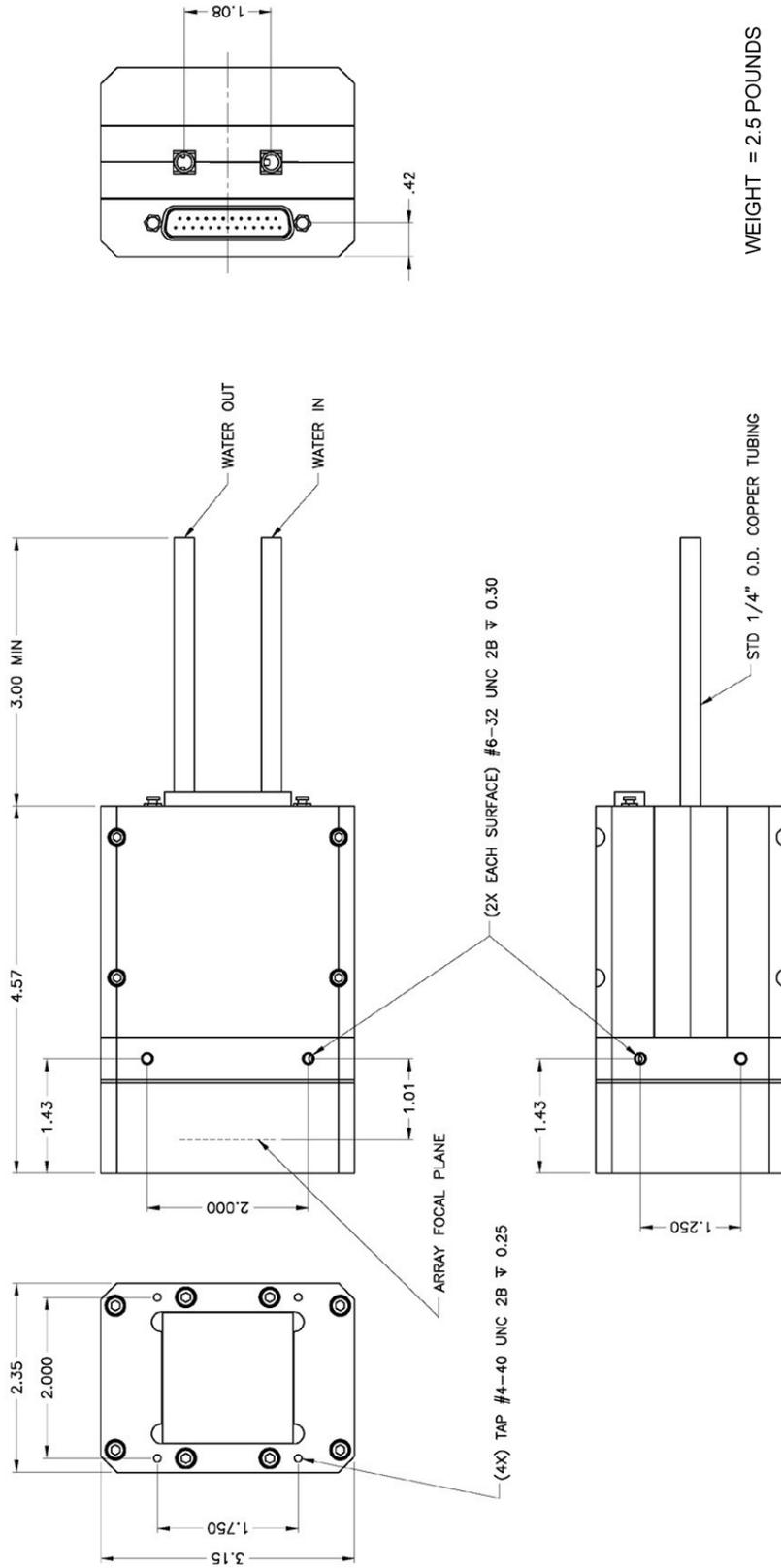


Figure 34. PI-MTE Camera (8-01-05 and later)



WEIGHT = 2.5 POUNDS

Figure 35. PI-MTE Camera (8-01-05 and earlier)

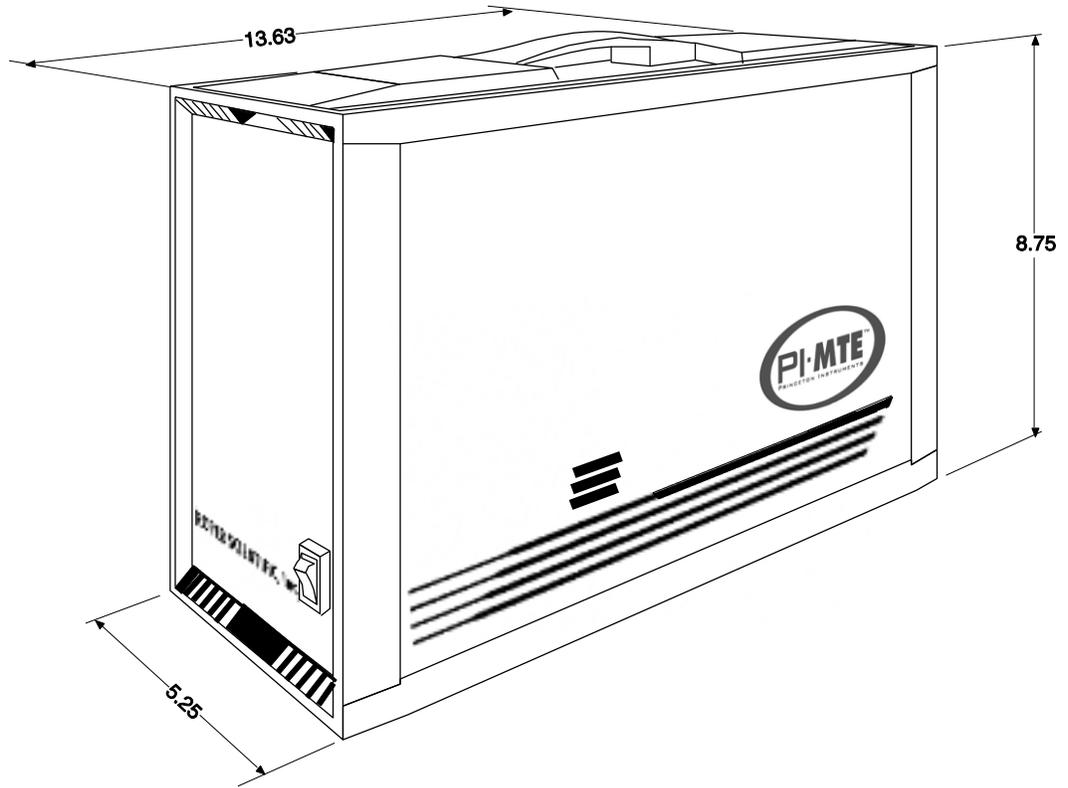


Figure 36. ST-133A Controller

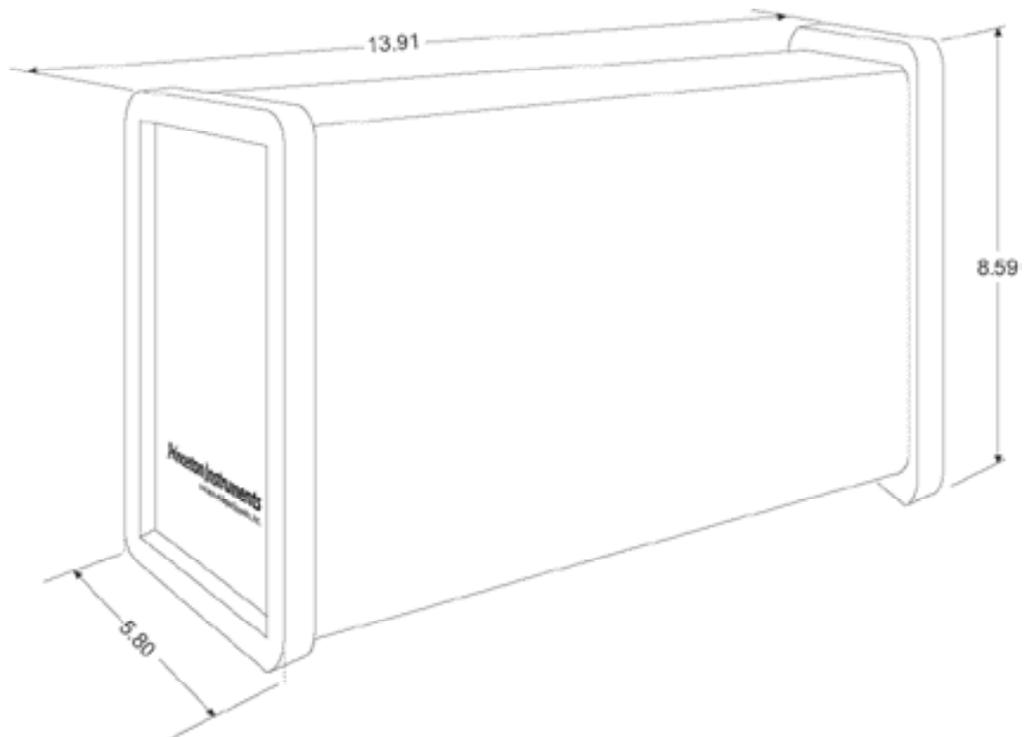


Figure 37. ST-133B Controller

VCR and Swagelok Fittings

VCR® Fittings

Installation

The VCR fittings are completely assembled and are ready to be connected. Fittings on the PI-MTE coolant pipes are VCR size 1/4" male glands with gasket retainer assemblies containing copper gaskets. The flex tubing has female fittings on both ends and the 2 3/4" ConFlat has male fittings on both ends.

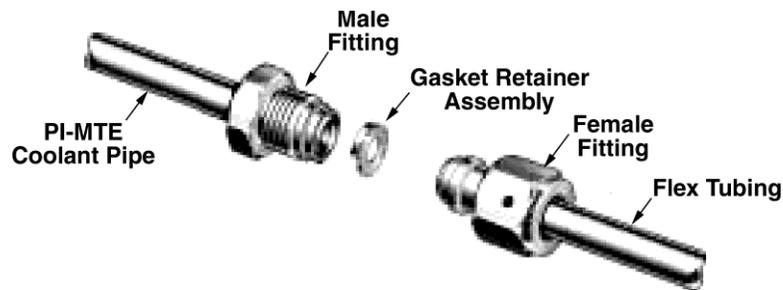
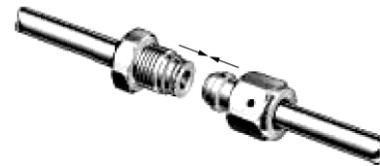
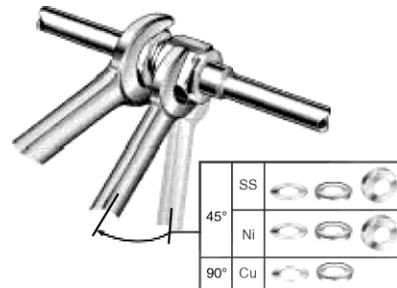


Figure 38. VCR Fittings

1. Verify that the gasket retaining assembly with copper gasket has been installed on the male fitting. Align the male and female fittings.
2. Finger-tighten the connection. For the next step you will need two open-end wrenches.
3. Place one wrench on the male fitting and hold it in place as you use the other wrench to rotate the female fitting 90° CW. For stainless steel or nickel gaskets, rotate 45° CW.



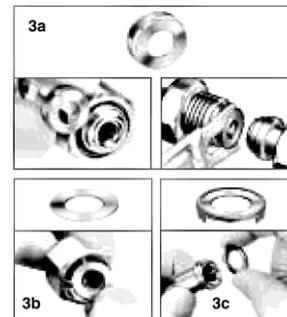
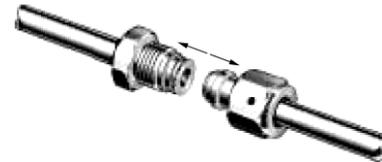
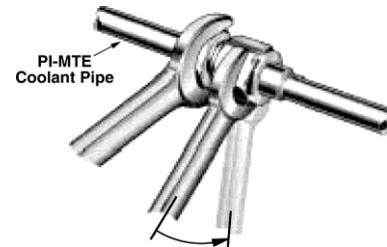
Finger-tight



Gasket Replacement

To ensure proper sealing, gaskets should be replaced before re-connecting previously connected fittings.

1. Place one wrench on the male fitting and hold it in place as you use the other wrench to rotate the female fitting CCW.
2. Fully loosen the connection.
3. Remove the gasket retaining assembly from the tip of the male fitting. Replace the copper gasket and clip the assembly back onto the fitting.
4. Follow the Installation instructions to reconnect the fittings.



Swaglok® Fittings

Installation

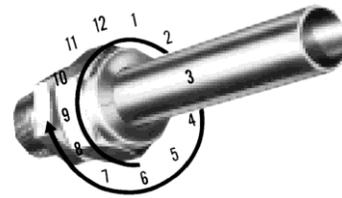
Swagelok Tube Fittings come completely assembled, finger-tight, and are ready for immediate use. Disassembly before use is unnecessary and could result in dirt or foreign material getting into the fitting and causing leaks.

Swagelok Tube Fittings are installed in three (3) easy steps, as follows:

1. Simply insert the tubing into the Swagelok Tube Fitting. Make sure that the tubing rests firmly on the shoulder of the fitting and that the nut is finger-tight.
2. Before tightening the Swagelok nut, scribe the nut at the 6 o'clock position.



3. Hold the fitting body steady with a backup wrench and tighten this nut $1\frac{1}{4}$ turns. Watch the scribe mark, making one complete revolution and continue to the 9 o'clock position.



By scribing the nut at the 6 o'clock position as it appears to you, there will be no doubt as to the starting position. When the nut is tightened $1\frac{1}{4}$ turns to the 9 o'clock position, you can easily see that the fitting has been properly tightened.

Use of the Gap Inspection Gauge ($1\frac{1}{4}$ turns from finger-tight) ensures sufficient pull-up.

Notes:

1. For $1/16''$, $1/8''$, $3/16''$, 2 mm, 3 mm and 4 mm size tube fittings, only $3/4$ turn from finger tight is necessary.
2. A Swagelok Hydraulic Swaging unit must be used for assembly of Swagelok Tube Fittings onto $1\frac{1}{4}''$, $1\frac{1}{2}''$, 2", 28 mm, 32 mm, and 38 mm outside diameter steel and stainless steel tubing.

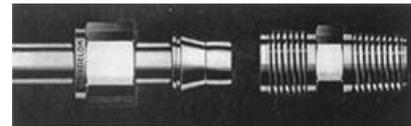
High Pressure Applications or High-Safety-Factor Systems

Due to variations in tubing diameters, a common starting point is desirable. Using a wrench, tighten the nut to the SNUG position. Snug is determined by tightening the nut until the tubing will not rotate freely (by hand) in the fitting. *If tube rotation is not possible, tighten the nut approximately $1/8$ turn from the finger-tight position.* At this point, scribe the nut at the 6 o'clock position and tighten the nut $1\frac{1}{4}$ turns. The fitting will now hold pressures well above the rated working pressure of the tubing.

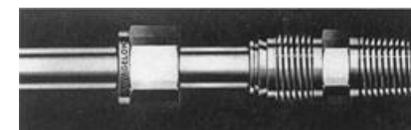
Retightening Instruction

Connections can be disconnected and retightened many times. The same reliable leak-proof seal can be obtained every time the connection is remade. Directions follow.

1. Fitting shown in the disconnected position



2. Insert tubing with preswaged ferrules into fitting body until front ferrule seats.



3. Tighten nut by hand. Rotate nut to the original position with a wrench. *An increase in resistance will be encountered at the original position.*



Then tighten slightly with the wrench. Smaller tube sizes will take less tightening to reach the original position, while larger tube sizes will require more tightening. The wall thickness will also have an effect on tightening.

This page intentionally left blank.

Appendix D

Visible <-> Open Nose Change Instructions

Introduction

The PI-MTE camera is shipped with a visible nose on the front of the camera. The visible nose typically includes a test lens and is designed to protect the camera during shipment and to allow you to verify system operation in a non-vacuum environment. Because you will probably be using the camera in a vacuum chamber, you will need to replace the visible nose with the open nose before mounting the camera in the chamber.

Replacing the Visible Nose with the Open Nose

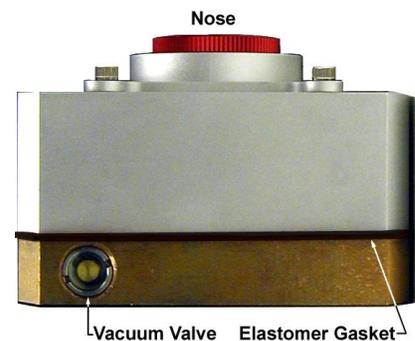
The PI-MTE cameras are normally shipped with the visible nose and elastomer gasket installed. This nose, containing a quartz window, allows the camera to be operated in a non-vacuum environment and protects the CCD array from damage and contamination. If the camera is to be used in a vacuum chamber, the visible nose will have to be replaced by the open nose. ***This operation must be performed in a cleanroom environment. Read through the whole procedure before attempting it.***

WARNINGS!

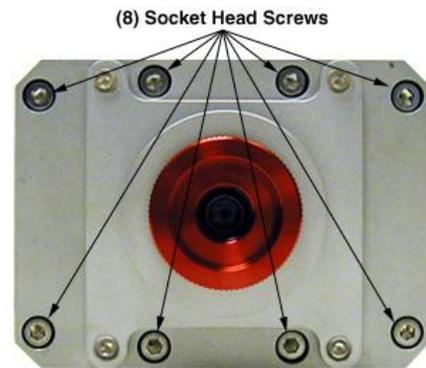
Whenever the open nose is on the camera, **EXTREME CAUTION** must be used to prevent damage to the CCD array. To prevent contamination, only handle a PI-MTE with an open nose in a cleanroom environment. If the camera must be removed from a cleanroom environment, cover the array opening. Note that the camera is even more vulnerable with no nose in place.

Because the CCD array and/or the bond wires could be damaged when performing this operation, be very careful when replacing the nose. ***Damage to the array and/or bond wires during such an operation is not covered under warranty.***

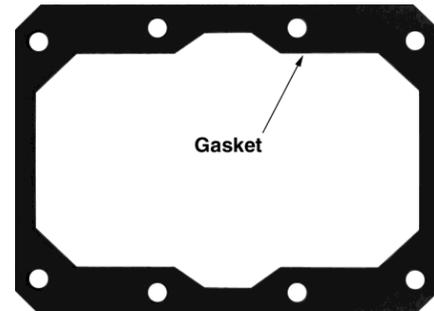
1. Place the PI-MTE with visible nose in a cleanroom environment.
2. Position the camera with the Vacuum Valve at the top.
3. Using a screwdriver that closely fits the notches in the valve screw, slowly vent the camera by turning the valve screw counterclockwise. If the screwdriver is too small, the valve screw could be damaged.



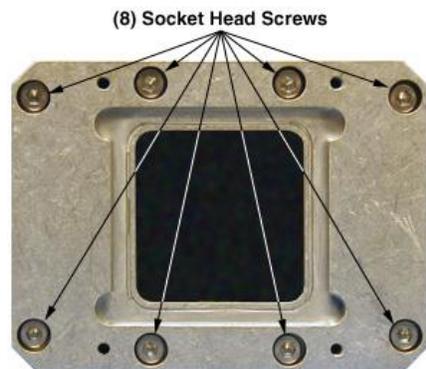
4. After the vacuum is fully vented, clamp or support the camera with the CCD array looking up.
5. Loosen, by one turn, each of the eight (8) socket head screws on the face of the nose.
6. After all of the 8 screws have been loosened one turn, remove all 8 screws.
7. "Rock" the nose slightly to be sure the elastomer gasket has released.
8. Be careful in performing the next step. Unless you are careful, the CCD array and/or the bond wires could be damaged. Such damage is not covered under warranty.
9. Remove the nose in a direction perpendicular to the CCD plane. Do not slip the nose sideways.



10. Remove the elastomer gasket.
11. Store the nose and gasket in a secure location for future use.



12. Being very careful, mount the open nose with the 8 screws previously removed. (The elastomer gasket is not required.) In a criss-cross pattern, tighten the screws to 15 in-lbs.
13. Cover the nose opening whenever the camera is not in the vacuum chamber.



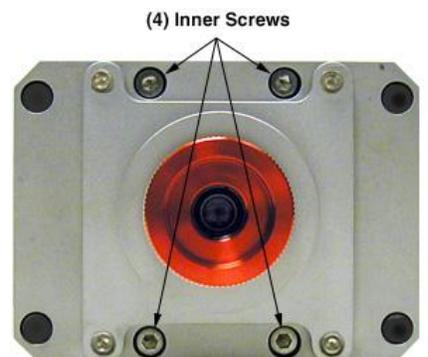
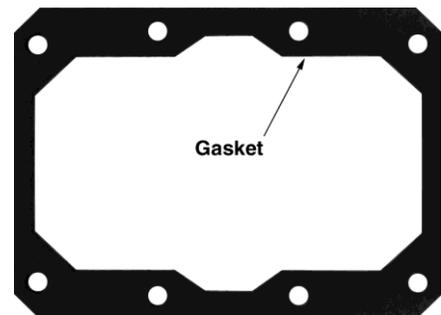
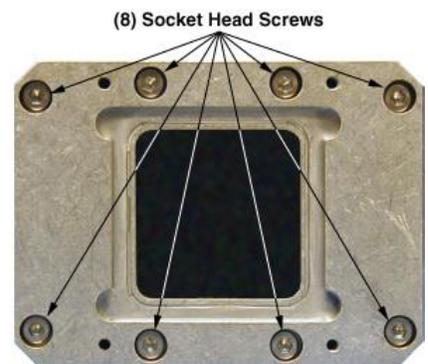
Replacing the Open Nose with the Visible Nose

This operation should be performed in a cleanroom environment to prevent possible contamination of the CCD array.

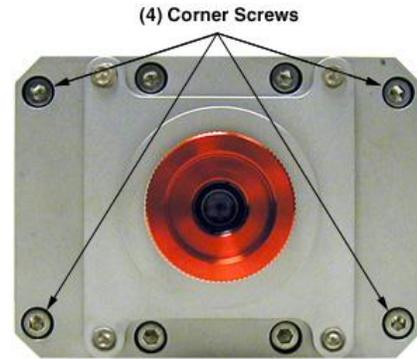
WARNINGS! Whenever the open nose is on the camera, **EXTREME CAUTION** must be used to prevent damage to the CCD array. To prevent contamination, only handle a PI-MTE with an open nose in a cleanroom environment. If the camera must be removed from a cleanroom environment, cover the array opening. Note that the camera is even more vulnerable with no nose in place.

Because the CCD array and/or the bond wires could be damaged when performing this operation, be very careful when replacing the nose. ***Damage to the array and/or bond wires during such an operation is not covered under warranty.***

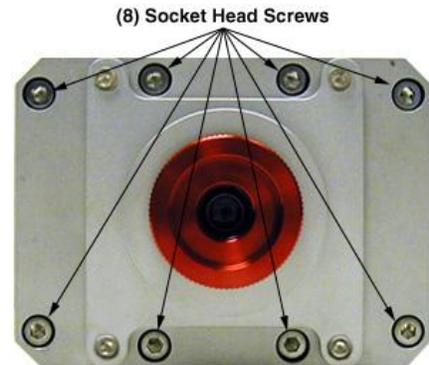
1. Place the PI-MTE with open nose in a cleanroom environment.
2. Clamp or support the camera with the CCD array looking up.
3. Loosen, by one turn, each of the eight (8) socket head screws on the face of the nose.
4. After all of the 8 screws have been loosened one turn, remove all 8 screws.
5. Be careful in performing the next step. Unless you are careful, the CCD array and/or the bond wires could be damaged. Such damage is not covered under warranty.
6. Remove the nose in a direction perpendicular to the CCD plane. Do not slip the nose sideways.
7. Store the nose in a secure location for future use.
8. Prepare the visible nose and gasket by placing the gasket on the rear of the nose and threading the 4 inner screws through the gasket.
9. Very carefully, mount the visible nose to the camera and secure the 4 screws previously placed in the nose.



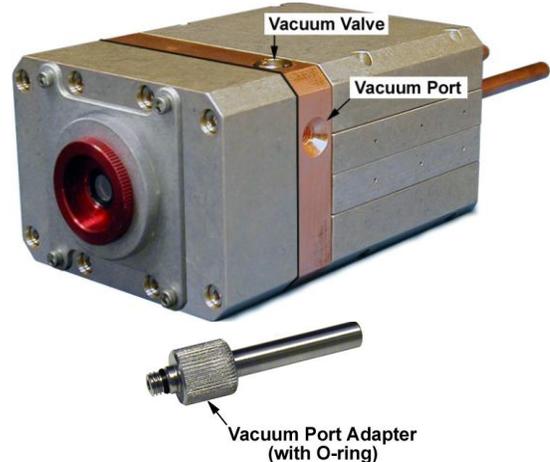
10. Then install the remaining 4 corner screws.



11. Using a criss-cross pattern, torque the 8 screws to 15 in-lbs.



12. Verify that the O-ring seal is in place on the vacuum port adapter and that it is in good condition.
13. Screw the vacuum port adapter into the Vacuum Port on the side of the camera.
14. Connect the vacuum port adapter to a vacuum pump. If using an oil pump, be sure to use a good oil trap.



15. Start the vacuum pump and then open the Vacuum Valve. Use a screwdriver that closely fits the notches in the valve screw.
16. Evacuate the camera to 1 mTorr (or lower) for optimum performance.
17. Tighten the Vacuum Valve screw and then stop the vacuum pump.
18. Disconnect the vacuum port adapter and store it.

Appendix E

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)
- 2 MHz is currently the upper digitization rate limit for the ST-133 Controller.
- 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 2.5.X features are not fully supported with USB 2.0. Refer to 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	YES	WinX 2.5.x doesn't utilize hardware lock status
PTG	YES	
Virtual Chip	NO	
Custom Timing	YES	WinX 2.5.18.1
Custom Chip	YES	WinX 2.5.18.1
Frames per Interrupt	NO	
RS170 (Video Output)	NO	
Online Exposure	YES	
File Information	YES	Not all header info is currently available in WinX 2.5.x through PVCAM
Overlapping ROIs	NO	

Table 9. Features 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 8. Features Supported under USB 2.0

Declaration of Conformity

DECLARATION OF CONFORMITY

We, the undersigned

Manufacturer: Roper Scientific (Princeton Instruments)
Address, City: 3660 Quakerbridge Road, Trenton, NJ 08619
Country: USA

Authorized Representative in Europe: Roper Scientific, GmbH
Address, City: Rosenheimer Landstr. 87, D-85521, Ottobrunn
Country: Germany

Certify and declare under our sole responsibility that the following apparatus:

ST-133B Controller with MTE2 Camera Head,
Model ID Prefix: MTE

Conforms to the emissions requirements of EN61326-1:2006; Clause 7.2:

CISPR 11 Edition 4: 2003	Conducted Emissions, Group 1, Class A
CISPR 11 Edition 4: 2003	Radiated Emissions, Group 1, Class A
IEC 61000-3-2: 2000	Harmonics
IEC 61000-3-3: 2002	Flicker

Conforms to the immunity requirements of EN61326-1:2006; Table 1:

IEC 61000-4-2: 2001	Electrostatic Discharge
IEC 61000-4-3: 2002	Radiated Immunity
IEC 61000-4-4: 2004	EFT/Burst, Power Leads, and I/O Cables
IEC 61000-4-5: 2001	Surge Immunity, Power Leads
IEC 61000-4-6: 2003	Conducted Immunity, Power Leads, and I/O Cables
IEC 61000-4-11: 2004	Voltage Dips and Interrupts

And follows the provisions of Low Voltage Directive and Safety:

CE Low Voltage Directive 2006/95/EC
EMC Directive 2004/108/EC
Product Safety Regulations and Standards IEC 61010-1:2010

The technical documentation is kept at the following address:

Company: Princeton Instruments
Address, City, State: 3600 Quakerbridge Rd, Trenton, NJ 08619
Country: USA
Telephone Number: +1 800.874.9789/+1 609.587.9797
Fax Number: +1 609.587.1970

Name and Position of Person Binding the Manufacturer or his Authorized Representative:

William Asher
President

Signature: *William E. Asher*
Date: 17 December 2013

This page intentionally left blank.

Warranty & Service

Limited Warranty:

Princeton Instruments, a division of Roper Industries, 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.princetoninstruments.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.princetoninstruments.com.

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 style detector (has all metal seals) 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 12 Month Warranty

Princeton Instruments warrants the sealed chamber integrity of all our products for a period of twelve (12) months after shipment. If, at anytime within twelve (12) 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 12 Month Warranty

Princeton Instruments warrants the vacuum integrity of “Non-XP” style detectors (do not have all metal seals) for a period of up to twelve (12) 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 twelve (12) 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. *See 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;
 - has been damaged as a result of misuse, improper installation, faulty or inadequate maintenance, or failure to follow instructions furnished by us;
 - has had serial numbers removed, altered, defaced, or rendered illegible;
 - has been subjected to improper or unauthorized repair;
 - has been damaged due to fire, flood, radiation, or other "acts of God" or other contingencies beyond the control of Princeton Instruments; or
 - is a shutter which is a normal wear item and as such carries a onetime only replacement due to a failure within the original 1 year Manufacturer warranty.
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.princetoninstruments.com.

Contact Information

Princeton Instruments' 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@princetoninstruments.com

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

North America	800 899 1144 (toll free) or 609 587 9797
France	+33 (1) 60 86 03 65
Germany	+49 (0) 89 660 7793
Japan	+81 (3) 5639 2741
UK & Ireland	+44 (0) 1628 472 346
Singapore	+65 6408 6240
China	+86 10 659 16460

Otherwise, refer to our Support web page at www.princetoninstruments.com.

An up-to-date list of addresses and telephone numbers is posted on the www.princetoninstruments.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.

Index

#-B

64-pin DIN connector	14
70 V shutter drive option	15
A/D converters	50
AC power requirements	23
Analog/Control module	14
AUX BNC connector	80
Background DC level	44, 50
Background subtraction	53
Back-plane	14
Baseline signal	44, 50
excessive humidity	45
factory set for 2 MHz controller	50
ST-133 zero adjustment	15
sudden change in	45
Binning	
computer memory burden	48
hardware	47
on-chip	47
readout time	48
resolution loss	48
software	48
effect on S/N ratio	48
high light level measurements	49
shot-noise limited measurements	49
well capacity	48
Blooming	45

C

Cables	
fiber optic	16
PCI interface	16
TAXI	16
USB 2.0	16
Camera Detection wizard	32, 64
Cautions	
baseline signal shift	50, 64
coolant pH	33
coolant temperature	33, 42
DMA and Interrupt	71
excessive humidity in CCD chamber	45
zero adjustments	15

CCD array	
blooming	45
maximum on-chip integration	45
readout theory	47
shift register	47
signal-to-noise ratio vs on chip integration time	45
theory of operation	42
well capacity	45
Clean cycles	45
Cleaning	11
Cold finger	9
Composite video output	15
Condensation	44
Connectors	
ST-133, READY	15
ST-133, SCAN	15
ST-133, AUX Output	16
ST-133, Detector	15
ST-133, External Sync	15
ST-133, Serial COM (TAXI)	15
ST-133, TTL In/Out	16
ST-133, USB 2.0	16
ST-133, Video Output	15
Contact information	102
Continuous cleans	46
Controller modules	14
Coolant	
flow rate	41
mixture ratio	22
pH of	33
port locations	23
ports	23
temperature control	22
tubing sizes	23
Coolant circulator	
coolant flow rate	33
coolant temperature	33, 42
fluid pressure, maximum	33
installation	33
Cooling	13
Cooling and vacuum	67
Cooling block	35
Customer support	102

D-E

Dark charge.....	54
definition of	44
dynamic range	44, 45
temperature dependence	44
typical values	44
Dark current	44
Detector connector (ST-133).....	15
Digitization	49
DMA buffer size.....	38
Drawings, dimensioned	83–86
Dynamic range.....	44, 45
Enclosures	
CCD	9
electronics	9
heat-removal block and coolant	9
Environmental conditions.....	22, 80
Excessive humidity	45
Exposure and Readout.....	35
Exposure time	52
External Sync	
background subtraction.....	53
dark charge accumulation	54
input pulse.....	53
shutter synchronization	53
timing.....	53
timing mode	53
External synchronization	<i>See External Sync</i>

F

Fan	15, 22
Fast Mode.....	56
data acquisition	56
flowchart	57
image update lag	56
Fiber optic cable (PCI optional).....	16
First images procedure.....	37
First light	37
Flow rate, coolant	33
Fluid pressure, flow rate	33
Freerun	
experiments best suited for	52
timing	
diagram.....	53
flowchart	52
mode of data synchronization	52
Full frame readout.....	47
Fuse	
replacement	65
requirements.....	23

G-I

Gasket replacement.....	88
Grounding and safety (ST-133).....	9
Hardware binning	47
High pressure applications.....	89
High-Safety factor systems	89
Hose connections	33
Humidity, in vacuum enclosure	64
I/O Address conflicts	71
IEC Publication 348	9
Installation	
coolant circulator	33
hose connections	33
PCI card driver.....	26
PCI drivers.....	25
software	25
tubing.....	33
USB 2.0 driver	29
Interface card	
driver installation	25
PCI	
High Speed PCI.....	26
PCI(Timer)	26
Interface Control module.....	14
Interrupt conflicts.....	71
ISA serial card	
I/O address, DMA channel, and interrupt level	71

L-O

Line voltage selection	
procedure	65
selector drum	24
Maintenance.....	11
Memory allocation.....	38
Module	
installation	75
removal.....	74
NOT READY signal.....	15
NOT SCAN signal	15, 52
Outline drawings	
PI-MTE.....	85

P

PCI card driver installation.....	26
PCI serial interface card	
diagnostics software	72
fiber optic adapters	16
installation	26
non-conforming peripheral cards	73
Peltier effect	35

- PI-MTE**
- cooling
 - Cajon Ultra Torr tubing fittings..... 41
 - condensation 42
 - coolant flow rate 41
 - liquid coolant 41
 - enclosures 9
 - outline drawing..... 83, 84, 85
 - system components 21
 - temperature range 35
 - Plug-in modules, installation and removal 74
 - Power cord..... 23
 - Power down procedure 40
 - Power module 15
 - Power requirements 23
 - Power switch and indicator..... 14
 - Powerup procedure..... 38
 - Preopen Shutter mode..... 53
 - Princeton Instruments USB2 driver installation..... 29
 - Procedures
 - familiarization and checkout..... 37
 - First images..... 37
 - line voltage selection and line fuse 65
 - plug-in module installation/removal 75
 - Programmable TTL interface
 - connector 16
 - pinout levels 58
 - PVCAM.INI 64
- R**
- Readout**
- background subtraction..... 50
 - binning 47
 - hardware..... 47
 - software 48
 - pattern subtraction 50
 - subsection of array 47
 - time 52
- Requirements**
- power 23
 - ventilation 22
- Resolution, loss of with binning 48
- S**
- S/N ratio..... 45, 48
- Safe Mode**
- as used for setting up 56
 - fast image update..... 56
 - flowchart 57
 - missed events 56
- Saturation..... 45
- Shift register..... 47
- Shutter**
- external synchronization..... 52
 - modes
 - Disable 52
 - Normal 52
 - Preopen..... 52, 53
 - shutter setting selector 15
 - ST-133 connector..... 15
- SHUTTER signal 15, 52
- Signal-to-noise ratio
 - on-chip integration..... 45
- Slide latch operation 76
- Software binning..... 49
- Specifications**
- CCD array 79
 - PI-MTE..... 80
 - ST-133 80
- ST-133 Controller**
- description of 13
 - External Sync 15
 - fuse/voltage label 16
 - grounding and safety 9
 - power module 15
 - power requirements 23
 - Serial COM (TAXI) 15
 - TTL In/Out 16
 - USB 2.0 16
 - zero adjustment 15
- ST-133 Temperature Lock LED** 15
- Swagelok fittings**
- high pressure/high-safety factor..... 89
 - installation 88
 - retightening..... 89
- System power down..... 40
- System powerup..... 38
- T**
- TAXI**
- cable 16
 - interface card 17
- Technical support 102
- Temperature**
- effect of vacuum deterioration 67
 - problems 67
 - setting 43
 - thermal cutout switch 68
- Temperature Lock LED..... 15
- Thermal cutout switch 68
- ThermoCUBE** 18
- Thermoelectric cooler..... 9, 35
- Timing control..... 56
- Timing modes 52

Troubleshooting		Warnings (cont.)	
camera1 in Camera Name field	64	open nose	91, 93
TTL In/Out		opening the ST-133 power module	66
hardware interface	60	overtightening the ST-133 module screws	75
pin assignments	58	protective grounding	9
ST-133 connector	16	replacement power cord	10
Tubing connections.....	33	ST-133 fuse type	65
Tygon tubing.....	22	ST-133 module installation/removal under	
U-V		power	74
Upgrade Device Driver wizard.....	28	touching the CCD array	10
USB 2.0		Warranties	
cable	16	image intensifier detector	100
data overrun	70	one year	99
installation	29	one year on refurbished/discontinued products	
interface card.....	17	99
Vacuum deterioration	67	owner's manual and troubleshooting.....	101
Vacuum port adapter	17, 94	sealed chamber.....	100
VCR fittings		software	100
gasket replacement	88	vacuum integrity	100
installation	87	XP vacuum chamber.....	99
Ventilation requirements	22	x-ray detector	100
W-Z		your responsibility	101
Warnings		Website	102
camera warmup requirements.....	41	Well capacity	45
cleaning.....	11	blooming.....	45
condensation damage.....	41, 44	restrictions on hardware binning	48
Controller/Camera cable	14	saturation	45
coolant hazard	22	Wizard	
coolant pH.....	33	Upgrade Device Driver	28
module installation/removal under power.....	14	Wizard, Camera Detection	32, 64
nose replacement	35, 91, 93	Zero adjustment	<i>See</i> Baseline signal