

PIXIS-XO System Manual



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May 23, 2019

Revision History

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Table of Contents

Chapter 1:	Introduction	9
1.1	PIXIS®-XO	9
1.2	Advanced Design	9
1.3	Grounding and Safety	10
1.4	Precautions	10
1.5	Cleaning	11
1.5.1	Camera	11
1.6	Storage	11
1.7	Service Notes	11
1.8	About this Manual	12
1.8.1	Manual Organization	12
1.8.2	Safety Related Symbols Used in this Manual	13
Chapter 2:	System Description	15
2.1	Standard Components	15
2.1.1	PIXIS-XO Camera	16
2.1.2	PIXIS-XO Power Supply	18
2.1.3	Cables	18
2.1.4	Certificate of Performance	18
2.1.5	User Manuals	18
2.2	Optional System Components	19
2.2.1	Application Software	19
2.2.2	Fiber Optic Extender Kit	20
2.2.3	CoolCUBE _{II} with PIXIS-XO Compatible Hoses	20
2.2.4	Coolant Hoses	20
Chapter 3:	Initial System Verification	21
3.1	Air-Cooled System Block Diagrams	23
3.2	Liquid-Cooled System Block Diagrams	24
Chapter 4:	System Setup	25
4.1	Unpacking the System	25
4.2	Checking the Equipment and Parts Inventory	26
4.3	System Requirements	26
4.3.1	Camera Ventilation	26
4.3.2	Power Requirements	26
4.3.3	Host Computer Specifications	27
4.3.3.1	WinX Requirements	27
4.3.3.2	LightField Requirements	28
4.4	Install the Application Software	29
4.4.1	Install WinX	29
4.4.2	Install LightField	31
4.5	Connect the PIXIS-XO to a CoolCUBE _{II}	32

4.6	Configure Default System Parameters	34
4.6.1	WinX	34
4.6.2	LightField	35
4.7	Connect an External Shutter	36
4.7.1	External Shutter Cable Connection	36
4.8	Connecting/Disconnecting the PIXIS-XO USB Cable	36
Chapter 5:	Operation	37
5.1	System On/Off Sequencing [WinX Applications Only]	38
5.2	WinX First Light Instructions	39
5.2.1	Acquire Data	41
5.3	LightField First Light Instructions	43
5.3.1	Acquiring Data	46
5.4	Mount Camera to a Vacuum Chamber	47
5.4.1	Camera with ConFlat® Flange	48
5.5	Exposure and Signal	49
5.5.1	CCD Array Architecture	49
5.5.2	Exposure Time	49
5.5.3	CCD Temperature	50
5.5.4	Dark Charge	50
5.5.5	Saturation	51
5.6	Readout	52
5.6.1	Full Frame Readout	52
5.6.2	Binning	54
5.6.2.1	Hardware Binning	54
5.6.2.2	Software Binning	55
5.6.2.3	Array Orientation	56
5.6.3	Output Amplifier {Quality} Selection	57
5.6.4	Controller Gain	57
5.7	Digitization (Rate)	59
5.7.1	Digitization Rate {Speed}	59
5.7.2	ADC Offset (Bias)	59
Chapter 6:	Advanced Topics	61
6.1	Timing Modes	62
6.1.1	Free Run {No Response}	63
6.1.2	External Sync {Readout Per Trigger}	64
6.1.3	External Sync with Continuous Cleans {Clean Until Trigger} Timing	66
6.1.4	EXT SYNC Trigger Input	67
6.2	Fast and Safe Modes	68
6.2.1	Fast Mode (WinX and LightField)	68
6.2.2	Safe Mode (WinX only)	69
6.3	LOGIC OUT Control	71
6.4	Kinetics Mode	72
6.4.1	Kinetic Timing Modes	73
6.4.1.1	Free Run (Non-Triggered) Mode	73
6.4.1.2	Single Trigger Mode	75
6.4.1.3	Multiple Trigger Mode	75
6.5	Custom Modes	76
6.5.1	Custom Chip {Custom Sensor}	76
6.5.1.1	Software Settings	76
6.5.2	Custom Timing	78

Chapter 7: Troubleshooting	81
7.1 Acquisition Started but Viewer Contents Do Not Update	82
7.2 Baseline Signal Suddenly Changes	82
7.3 Camera Stops Working	82
7.4 Camera1 (or similar name) in Camera Name Field	83
7.5 Controller Is Not Responding	84
7.6 CoolCUBE _{II} : Low Coolant (Air in the Hoses)	84
7.7 Cooling Troubleshooting	86
7.7.1 Temperature Lock Cannot be Achieved or Maintained	86
7.7.2 Camera loses Temperature Lock	86
7.7.3 Gradual Deterioration of Cooling Capability	87
7.8 Data Loss or Serial Violation	87
7.9 Device is Occupied	87
7.10 Overexposed or Smearred Images	87
7.11 Shutter Failure	87
7.12 Vignetting	88
7.13 Error Messages	88
7.13.1 Data Overrun Due to Hardware Conflict	88
7.13.2 Data Overrun Has Occurred	89
7.13.3 Device Is Not Found	89
7.13.4 Error Creating Controller	90
7.13.5 Program Error	91
7.13.6 Serial Violations Error	92
Appendix A: Technical Specifications	93
A.1 Mechanical Dimensions	93
A.2 Environmental Specifications	93
A.3 CCD Specifications	94
A.3.1 Mask Openings	95
A.3.2 Quantum Efficiency	95
A.4 Power Specifications	96
A.5 Camera Information	97
A.5.1 Mounts	97
A.5.2 Connectors	97
A.6 External Shutters	99
A.7 Options	99
Appendix B: Outline Drawings	101
B.1 PIXIS-XO Camera with 4.5" ConFlat Flange	102
B.2 PIXIS-XO Camera with 6.0" ConFlat	104
B.3 CoolCUBE _{II} Circulator	106
Appendix C: Backfilling for Storage or Shipment	107
Appendix D: WinSpec/32/LightField Cross Reference	109
D.1 WinSpec/32-to-LightField Terminology	109
D.2 LightField to WinSpec/32	111

Warranty and Service	113
Limited Warranty	113
Basic Limited One (1) Year Warranty	113
Limited One (1) Year Warranty on Refurbished or Discontinued Products	113
XP Vacuum Chamber Limited Lifetime Warranty	113
Sealed Chamber Integrity Limited 12 Month Warranty	114
Vacuum Integrity Limited 12 Month Warranty	114
Image Intensifier Detector Limited One Year Warranty	114
X-Ray Detector Limited One Year Warranty	114
Software Limited Warranty	114
Owner's Manual and Troubleshooting	115
Your Responsibility	115
Contact Information	116

List of Figures

Figure 2-1: Typical System Components	15
Figure 3-1: Initial System Checkout Imaging Experiment Layout (Air-cooled Camera)	23
Figure 3-2: Typical Imaging Experiment Layout (Air-cooled Camera)	23
Figure 3-3: Typical Spectroscopy Experiment Layout (Air-cooled Camera)	23
Figure 3-4: Initial System Checkout Imaging Experiment Layout (Liquid-cooled Camera)	24
Figure 3-5: Typical Imaging Experiment Layout (Liquid-cooled Camera)	24
Figure 3-6: Typical Spectroscopy Experiment Layout (Liquid-cooled Camera)	24
Figure 4-1: Typical WinView/32 Setup Dialog	29
Figure 4-2: Typical LightField Installation Wizard Dialog	31
Figure 4-3: Typical Camera Detection Wizard Dialog	34
Figure 4-4: Typical LightField Experiment Workspace	35
Figure 5-1: PIXIS-XO System Block Diagram	37
Figure 5-2: Block Diagram: Recommended Setup for Initial System Verification	39
Figure 5-3: Sample First Light Data Acquired (WinView)	42
Figure 5-4: Block Diagram: Recommended Setup for Initial System Verification	43
Figure 5-5: Typical LightField Available Devices Area	44
Figure 5-6: Typical LightField Experiment Devices Area	45
Figure 5-7: Typical LightField View Area	46
Figure 5-8: Typical LightField View Area Displaying an Image	46
Figure 5-9: Timing Diagram: Mechanical Shutter Operation and NOT SCAN Signal	49
Figure 5-10: Typical WinX Detector Temperature Dialog	50
Figure 5-11: CCD with a Dual Output Amplifier	52
Figure 5-12: Full Frame at Full Resolution	52
Figure 5-13: 2 x 2 Binning	54
Figure 5-14: Effect Array Orientation Has on Binning	56
Figure 6-1: Free Run {No Response} Timing Flow Chart	63
Figure 6-2: Timing Diagram: Free Run {No Response}	63
Figure 6-3: Flowchart: Two External Sync Timing Options	64
Figure 6-4: Timing Diagram: External Sync Mode (Positive-Edge Trigger)	65
Figure 6-5: Flowchart: Continuous Cleans {Clean Until Trigger}	66
Figure 6-6: Timing Diagram: WinX Continuous Cleans	67
Figure 6-7: Timing Diagram: LightField Clean Until Trigger (CUT)	67

Figure 6-8:	Rear Panel: PIXIS-XO Camera	67
Figure 6-9:	High-level Flow Chart of Safe and Fast Mode Operation.	70
Figure 6-10:	Comparison of NOT SCAN {Not Reading Out}, SHUTTER {Shutter Open}, and NOT READY {Busy} Logic Output Levels	71
Figure 6-11:	Kinetics Readout	72
Figure 6-12:	Typical WinX Configuration Dialogs: Kinetics Readout	73
Figure 6-13:	Typical LightField Configuration Expanders: Kinetics Readout.	74
Figure 6-14:	Timing Diagram: Free Run Mode	74
Figure 6-15:	Timing Diagram: Single Trigger Mode	75
Figure 6-16:	Timing Diagram: Multiple Trigger Mode	75
Figure 6-17:	WinX: Custom Chip Tab	77
Figure 6-18:	LightField: Sensor Pane.	77
Figure 6-19:	WinX: Custom Timing, Vertical Shift Configuration	78
Figure 6-20:	LightField: Custom Timing Expander.	79
Figure 7-1:	Typical Acquisition Display.	82
Figure 7-2:	Camera1 in Camera Name Field	83
Figure 7-3:	Editing Camera Name in a Text Editor.	83
Figure 7-4:	Camera Names Displayed within the Hardware Setup Dialog	83
Figure 7-5:	Occupied Device	87
Figure 7-6:	Typical Data Overrun Due to Hardware Conflict Error Dialog	88
Figure 7-7:	Typical Devices Missing Error Dialog	89
Figure 7-8:	Typical Error Creating Controller Error Message Dialog	90
Figure 7-9:	Typical Program Error Dialog	91
Figure 7-10:	Typical Serial Violations Error Dialog	92
Figure A-1:	Typical PIXIS-XO Quantum Efficiency Curve	95
Figure B-1:	Outline Drawing: Air Cooled PIXIS-XO with 4.5" ConFlat Flange	102
Figure B-2:	Outline Drawing: Liquid Cooled PIXIS-XO with 4.5" ConFlat Flange	103
Figure B-3:	Outline Drawing: Air Cooled PIXIS-XO with 6.0" ConFlat Flange	104
Figure B-4:	Outline Drawing: Liquid Cooled PIXIS-XO with 6.0" ConFlat Flange	105
Figure B-5:	Outline Drawing: CoolCUBE _{II} Circulator.	106
Figure C-1:	CCD Masks in Place on Front of Camera.	107
Figure C-2:	Shipping Plate Mounted to Camera	107
Figure C-3:	Shipping Plate Valve and Fill Port Adapter	108

List of Tables

	Revision History	2
Table 3-1:	PIXIS-XO Initial System Verification Procedure	21
Table 4-1:	Windows XP Installation Directories for WinX USB Files and Drivers	30
Table 5-1:	Controller Gain {Analog Gain} versus Readout Port	58
Table 6-1:	Camera Timing Modes	62
Table 7-1:	Issues with Recommended Troubleshooting Guidelines.....	81
Table A-1:	PIXIS-XO Environmental Specifications	93
Table A-2:	CCD Array Specifications by PIXIS-XO Model	94
Table A-3:	PIXIS-XO CCD Mask Opening Sizes	95
Table A-4:	Power Specifications: External PIXIS-XO Power Supplies	96
Table A-5:	Compatible External Shutters by PIXIS-XO Model	99
Table D-1:	WinSpec/32-to-LightField Cross Reference.....	109
Table D-2:	LightField-to-WinSpec/32 Cross Reference.....	111

Chapter 1: Introduction

1.1 PIXIS[®]-XO

Thank you for purchasing a PIXIS-XO camera system from Teledyne Princeton Instruments. Since 1981, Teledyne Princeton Instruments has been the legendary name behind the most revolutionary spectroscopy and imaging products for cutting edge research.

PIXIS-XO represents the most advanced camera design and utilizes years of experience and expertise in low energy x-ray imaging.

Among the many state of the art features are its integrated controller, all metal seal design for deep vacuum compatibility, deep thermoelectric air-cooling, and compact design. Currently the platform supports several imaging and spectroscopy CCDs. Please visit www.princetoninstruments.com for the current list of supported CCDs.



4411-0111_0001

1.2 Advanced Design

PIXIS-XO is a fully integrated camera system. The camera contains all of the electronics necessary to read out and control the CCD device. For instance, it houses precision analog-to-digital converters (ADCs) positioned close to the CCD for lowest noise and has USB 2.0 electronics for the plug-and-play interface with the host computer.

The easy-to-use PIXIS-XO camera system offers all basic CCD camera functions, such as region-of-interest (ROI) selection and binning, all under software control. It also provides advanced triggered operation as well as programmable TTL output.

Teledyne Princeton Instruments knows that a camera built to detect soft x-ray photons (~30 eV - ~3 keV) needs to meet deep-vacuum-interface requirements. The Teledyne Princeton Instruments PIXIS-XO line of digital cameras uses a vacuum flange and a back-illuminated CCD (without anti-reflection coating) to detect soft x-ray photons directly in the silicon. This design offers higher sensitivity, high dynamic range, higher resolution, and a detection range from ~1.13 eV to ~10 keV.

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

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

To utilize the full potential of the PIXIS-XO camera system, read the manual completely.

1.3 Grounding and Safety

Before turning on the power supply, 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.

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 rating as that of the original item to avoid hazard due to electrical shock.

1.4 Precautions

To prevent permanently damaging the system, observe all of the following precautions:

- 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 camera power ON LAST and turn the camera 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, the use of an isolated, conditioned power line or dedicated isolation transformer is strongly recommended.
- Do not block air vents on the camera. Preventing the free flow of air overheats the camera and may damage it.

1.5 Cleaning



WARNING!

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

1.5.1 Camera

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

1.6 Storage

Before storing the PIXIS-XO camera, re-mount the shipping plate and backfill the camera with dry Nitrogen to a pressure of 1 Atmosphere absolute via the valve and the fill port located on the edge of the plate. Refer to [Appendix C, Backfilling for Storage or Shipment](#), on page 107 for complete information.

1.7 Service Notes



WARNING! RISK OF ELECTRIC SHOCK!

The PIXIS-XO camera system contains no user-serviceable parts. When required, refer all service to qualified personnel. Contact Customer Support for assistance. Refer to [Contact Information](#) on page 116 for complete contact information.

Save all original packing materials so that the system can be safely packaged and shipped to another location or returned for repairs.

- Before packing the camera, re-mount the shipping plate and backfill the camera with dry Nitrogen to a pressure of 1 Atmosphere absolute via the valve and the fill port located on the edge of the plate. Refer to [Appendix C, Backfilling for Storage or Shipment](#), on page 107 for complete information.
- Use the original packing materials whenever shipping the system or system components.

1.8 About this Manual

This manual provides users with the information necessary to install a PIXIS-XO camera and place it in operation. Topics covered include a detailed description of the cameras in the PIXIS-XO family, installation, applications, cleaning, specifications and more.



NOTES:

1. "WinX" is a generic term for WinView/32, WinSpec/32, and WinXTest application software.
2. In many instances, WinX and LightField® use different terms for the same functions or parameters. Unless the topic is specifically for WinX or LightField, curly brackets { } are used to denote a LightField term or location. When the topic applies to both application programs, the WinX term will be followed by the {LightField term.} for example, when Continuous Cleans is used, it will be followed by {Clean Until Trigger}. This convention is also used when a location for setting a parameter is mentioned. For example, Exposure Time is set on the Experiment Setup ► Main tab {Common Acquisition Settings expander}.

1.8.1 Manual Organization

This manual includes the following chapters and appendices:

- [Chapter 1, Introduction](#)
Provides an overview of the PIXIS-XO cameras.
- [Chapter 2, System Description](#)
Provides information about the camera, interface card, cables and application software.
- [Chapter 3, Initial System Verification](#)
Cross-references system setup actions with the relevant manuals and/or manual pages. It also contains system layout diagrams.
- [Chapter 4, System Setup](#)
Provides detailed directions for setting up the camera for imaging applications and presents over-exposure protection considerations.
- [Chapter 5, Operation](#)
Provides step-by-step procedures for verifying system operation and discusses operational considerations associated with exposure, readout, and digitization.
- [Chapter 6, Advanced Topics](#)
Discusses standard timing {Trigger Response} modes (Free Run {No Response}, External Sync {Readout Per Trigger}, and Continuous Cleans {Clean Until Trigger}), Fast and Safe modes, Logic Output control, Kinetics mode, and Custom modes.
- [Chapter 7, Troubleshooting](#)
Provides courses of action to take if you should have problems with your system.

- [Appendix A, Technical Specifications](#)
Provides camera specifications.
- [Appendix B, Outline Drawings](#)
Provides outline drawings of the camera and the CoolCUBE_{II} circulator.
- [Appendix C, Backfilling for Storage or Shipment](#)
Provides step-by-step instructions for backfilling the camera with dry Nitrogen before storing or shipping the PIXIS-XO camera.
- [Appendix D, WinSpec/32/LightField Cross Reference](#)
Provides two alphabetically sorted tables (WinX to LightField and LightField to WinX) that cross reference terms used in the two applications.
- [Warranty and Service](#)
Provides the warranty and customer support contact information.

1.8.2 Safety Related Symbols Used in this Manual

The following symbols and terminology are used throughout this manual:



CAUTION!

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



WARNING! RISK OF ELECTRIC SHOCK!

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

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Chapter 2: System Description

This chapter provides information about standard components included with a PIXIS-XO system, as well as optional accessories that may be ordered from Teledyne Princeton Instruments.

2.1 Standard Components

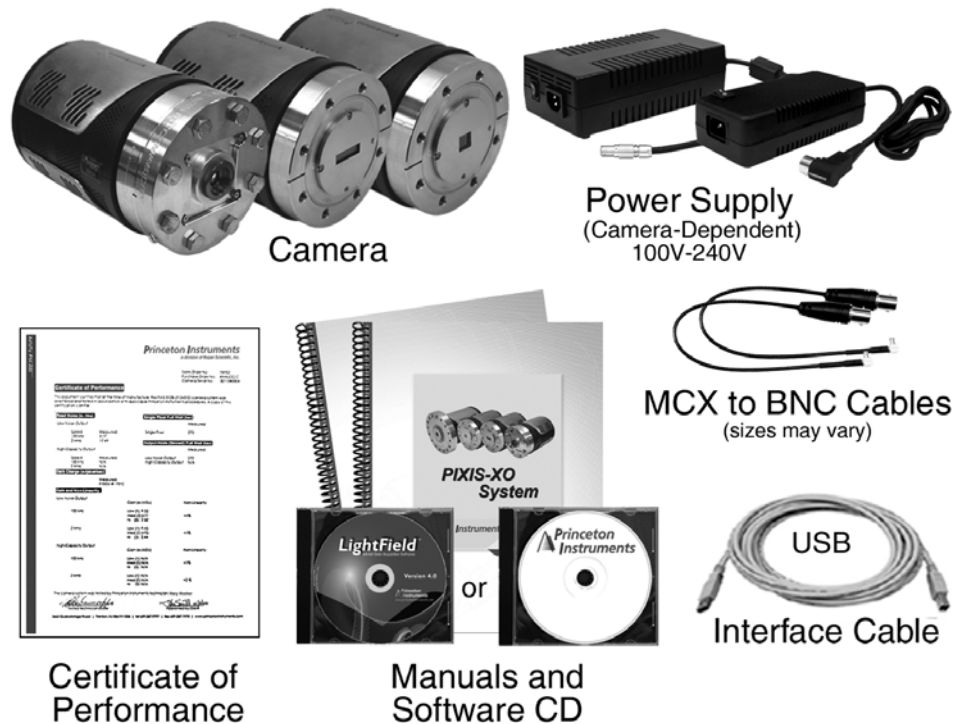
A typical air-cooled PIXIS-XO system, illustrated in [Figure 2-1](#), includes the following standard items:

- Camera with a Certificate of Performance;
- Power Supply;
- USB 2.0 interface cable for the host computer system;
- MCX to BNC adapter cables;
- User manual.

A typical liquid-cooled PIXIS-XO system includes:

- All items included with an air-cooled system;
- A CoolCUBE_{II} circulator with hoses.

Figure 2-1: Typical System Components



4411-0111_0002

Additional information about each of these items is presented in the following sections.

2.1.1 PIXIS-XO Camera



CCD Array: The PIXIS-XO camera system offers back-illuminated and back-illuminated deep-depletion CCDs without AR coating in a variety of array sizes that allow you to precisely match the sensor to your application. Only scientific-grade devices are used in order to ensure the highest image fidelity, resolution, and acquisition flexibility required for scientific X-ray imaging and spectroscopy. Teledyne Princeton Instruments has developed exclusive CCDs with unmatched quantum efficiency and low noise to offer the utmost in sensitivity. Large full wells, square pixels, and 100% fill factors provide high dynamic range and excellent spatial resolution. Your choice of CCD has already been installed in the camera that you have received, and it has been individually tested.

Vacuum Mounts: Windowless and shutter-less, PIXIS-XO cameras have ConFlat flange mounts.

Cooling: Dark current is reduced in PIXIS-XO camera systems through thermoelectric cooling of the CCD arrays. Cooling by this method uses a multi-stage Peltier cooler in combination with air-circulation or circulating coolant. To prevent condensation and contamination from occurring, cameras cooled this way should be mounted on a vacuum chamber. Due to CCD size/packaging differences, the lowest achievable temperature can vary from one PIXIS-XO model to the next. Please refer to the specific system's data sheet for cooling performance.

Fan: Air-cooled cameras contain an internal fan, the purpose of which is to:

- Remove heat from the Peltier device that cools the CCD array;
- Cool the electronics.

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

Coolant Ports: The camera coolant ports are located on the side of the camera and are not labeled. This is because coolant can flow through the camera in either direction. As is the case with circulating air (refer to the prior discussion,) circulating coolant removes the heat produced by the Peltier device. This means of heat removal is designed to provide vibration-free data acquisition. For the circulating coolant to function properly, free air circulation must be maintained between the sides of the CoolCUBE_{II} and the laboratory atmosphere.



WARNING!

Use only the hoses and circulator shipped with the PIXIS-XO system. Attaching any other hoses or circulator voids the warranty.



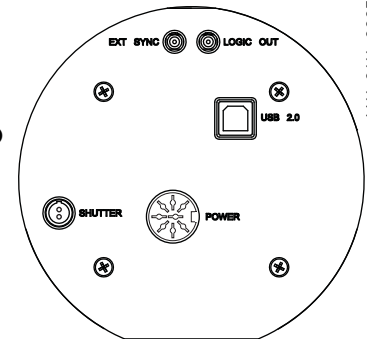
Shipping Plate: A shipping plate is mounted to the open nose of the PIXIS-XO camera to protect the interior of the camera from contamination or damage during shipment. Before shipment, the shipping plate is mounted to the camera and then the interior is backfilled with dry Nitrogen to a pressure of 1 Atmosphere absolute via the valve and fill port on the edge of the plate.

The shipping plate includes an integral C-mount lens for first light verification of camera operation. After confirming the setup, remove the shipping plate and store it and its mounting hardware in a safe location. Before storing or shipping the camera, install the shipping plate and backfill the camera with dry Nitrogen to a pressure of 1 Atmosphere absolute. Refer to [Appendix C, Backfilling for Storage or Shipment](#), on page 107 for the correct procedure.

Connectors:

- USB 2.0

Control signals and data are transmitted between the camera and the host computer via the USB port located on the rear of the camera. As of this printing, you can hot plug the PIXIS-XO camera whenever the WinX application is not running (i.e., connect or disconnect from the camera or the host computer while the camera is powered ON.) In the case of cameras built before November 1, 2005, you must exit the WinX application and turn the camera power OFF before connecting the USB cable to or disconnecting it from the camera or host computer.



- Shutter

LEMO[®] connector provides the shutter drive pulses for driving compatible external shutters.



NOTE:

Refer to [Section A.6, External Shutters](#) on page 99 for information about compatible external shutters.

Camera power must be OFF before connecting to, or disconnecting from, this connector.

- LOGIC OUT

0 to +3.3V programmable logic level output (TTL-compatible). The output of this connector can be programmed and can also be inverted via the application software. For additional information about each output signal, refer to [Section 6.3, LOGIC OUT Control](#), on page 71.

- EXT SYNC

0 to +3.3V Logic level input (TTL-compatible) that has a 10 k Ω pull-up resistor. Allows data acquisition and readout to be synchronized with external events. Through software, positive or negative (default) edge triggering can be selected.

- Power

The power connector is dependent on the specific camera purchased:



PIXIS-XO:100, 400, 1024, and 2K:

DIN Connector: 12 V_{DC} (6.6 A max) input from power supply.



PIXIS-XO:1300 and 2048:

LEMO Connector: 12 V_{DC} (12.5 A max) input from power supply.

2.1.2 PIXIS-XO Power Supply

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

2.1.3 Cables



USB 2.0 Cable: A standard 16.4 foot (5 meter) USB cable (P/N: 6050-0494) is included with the PIXIS-XO system. This cable connects the USB 2.0 connector on the rear of the PIXIS-XO camera to the host computer on which an appropriate USB card has been installed.



MCX to BNC Adapter Cables: Two MCX to BNC adapter cables are included with the PIXIS-XO system. These mount to the EXT SYNC and the LOGIC OUT connectors on the rear of the PIXIS-XO.

2.1.4 Certificate of Performance



Each PIXIS-XO camera has a Certificate of Performance. This certificate states that the camera system has been assembled and tested according to approved Teledyne Princeton Instruments procedures. It documents the camera performance data as measured during the testing of the PIXIS-XO and lists the following camera- and customer-specific information:

- Sales Order Number;
- Purchase Order Number;
- Camera Serial Numbers.

This information is useful when contacting Teledyne Princeton Instruments Customer Support.

2.1.5 User Manuals

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

Up-to-date versions of Teledyne Princeton Instruments' manuals are available for download from:

ftp://ftp.piaccton.com/Public/Manuals/Princeton_Instruments/

Up-to-date versions of Teledyne Acton Research manuals are available for download from:

<ftp://ftp.piaccton.com/Public/Manuals/Acton/>

2.2 Optional System Components

Optional items include:

- [Application Software:](#)
- [Fiber Optic Extender Kit](#)
- [CoolCUBE_{II} with PIXIS-XO Compatible Hoses](#)

Information about each of these optional items is provided in the following sections.

2.2.1 Application Software

The following application software is available from Teledyne Princeton Instruments:



- **WinX**
The PIXIS-XO camera can be operated by using either WinView/32 or WinSpec/32, Princeton Instrument's 32-bit Windows® software packages designed specifically for high-end imaging and spectroscopy, respectively. The Teledyne Princeton Instruments' software provides comprehensive image/spectral capture and display functions. The package also facilitates snap-ins to permit advanced operation. Using the optional built-in macro record function, you can also create and edit your own macros to automate a variety of operations. WinView and WinSpec take full advantage of the versatility of the PIXIS-XO camera and even enhance it by making integration of the detection system into larger experiments or instruments an easy, straightforward endeavor.

Includes the appropriate users manual which 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®**
The standard software interface for cooled CCD cameras from Teledyne 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.



- **LightField®**
The PIXIS-XO can be operated using LightField, Princeton Instrument's 64-bit Windows Vista® and Windows® 7 compatible software package. LightField combines complete control over Teledyne Princeton Instruments' cameras and spectrographs with easy-to-use tools for experimental setup, data acquisition and post-processing. LightField makes data integrity priority #1 via automatic saving to disk, time stamping and retention of both raw and corrected data with full experimental details saved in each file. LightField works seamlessly in multi-user facilities, remembering each user's hardware and software configurations and tailoring options and features accordingly.

The user manual describes how to install and use the LightField application program (for 64-bit Windows Vista® and Windows® 7 operating systems). A PDF version of this manual is provided on the installation CD. Additional information is available in the program's on-line help.



- **PICam**
The standard 64-bit software interface for cooled CCD cameras from Teledyne Princeton Instruments. PICam is an ANSI C library of camera control and data acquisition functions. Currently, the interface supports Windows Vista and Windows 7.

**NOTE:**

PIXIS-XO may also be operated by several other third-party software packages. Please check with the providers of the packages for compatibility and support information.

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

2.2.2 Fiber Optic Extender Kit



The specially designed fiber optic data interface kit allows the computer and the USB2.0 camera head to be separated by up to 500 meters without the loss of data. The kit consists of two compact, high speed transceivers (interface modules) for completely transparent operation between the host computer and the camera. The FO kit is ideal for hazardous or high EMI environments. This optional kit supports PIXIS, Spec-10, VersArray and PI-MAX family of products as well as Teledyne Acton Research Series spectrographs with USB2.0 data interface.

2.2.3 CoolCUBE_{II} with PIXIS-XO Compatible Hoses



Liquid-cooled PIXIS-XO cameras provide a low-vibration system for data acquisition. Instead of using a fan to remove heat, these cameras incorporate a closed loop system of circulating fluid. The CoolCUBE_{II} circulator unit continuously pumps a 50:50 mixture of room temperature (23°C) water and ethylene glycol. To prevent the voiding of the warranty, use only the circulator and hoses shipped with the system. (PN 7567-0002)

2.2.4 Coolant Hoses



Quick-disconnects that mate with the coolant ports on the PIXIS-XO have been installed on one end of each hose. Refer to the coolant circulator's specifications regarding circulator-compatible hose fittings.

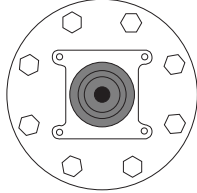
When a Teledyne Princeton Instruments CoolCUBE_{II} circulator is included in the order with a PIXIS-XO camera, hoses are supplied with appropriate connectors on both ends.

**NOTE:**

Associated part numbers are:

- Hose: McMaster P/N MCM 5238K748;
 - PIXIS-XO Fittings: CPC P/N MCD1004 and McMaster P/N MCM 5346K35;
 - CoolCUBE_{II} Fittings: CPC P/N NS6D17006.
-

Chapter 3: Initial System Verification



The PIXIS-XO is shipped with a shipping plate (with integral C-mount test lens or a C-mount camera body cap) mounted to the ConFlat flange and the camera has been backfilled with dry Nitrogen at the factory to a pressure of 1 Atmosphere absolute. The initial checkout of the system requires that this shipping plate remain on the ConFlat until system performance has been verified.



NOTE:

Removing the shipping plate voids the warranty on the CCD array.

Table 3-1, and Figure 3-1 through Figure 3-6 provide an overview of the sequence of actions required to install a PIXIS-XO system and prepare to gather data. Refer to the indicated references for detailed information.

Table 3-1: PIXIS-XO Initial System Verification Procedure (Sheet 1 of 2)

Action	For additional information, refer to...
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.	Section 4.1, Unpacking the System , on page 25.
2. Verify that all system components have been received.	Section 4.2, Checking the Equipment and Parts Inventory , on page 26
3. If the components show no signs of damage, verify that the appropriate power cord has been supplied with the power supply.	Section 4.3.2, Power Requirements , on page 26.
4. If the application software is not already installed on the host computer, install it.	Section 4.4, Install the Application Software , on page 29. Applicable software manual
5. If the USB2 interface card is not already installed in the host computer, install it per the manufacturer's instructions.	Manufacturer's instructions
6. Do not remove the shipping plate from the front of the camera.	
7. With the power supply disconnected from the camera, connect the USB cable to the USB port at the rear of the camera and to the USB port at the computer.	

Table 3-1: PIXIS-XO Initial System Verification Procedure (Sheet 2 of 2)

Action	For additional information, refer to...
<p>8. Air-Cooled System: Plug the power supply into the rear of the camera and plug the power supply into the power source.</p> <p>Liquid-Cooled System: Plug the power supply into the rear of the camera and plug the power supply into the power source. Make the hose connections to the camera. Plug the circulator into the power source. Add coolant if necessary. Turn on the circulator.</p>	<p>—</p> <p>Section 4.5, Connect the PIXIS-XO to a CoolCUBE_{II}, on page 32.</p>
<p>9. Turn the camera ON.</p>	
<p>10. Turn on the computer and begin running the application software.</p>	<p>Applicable software manual</p>
<p>11. Enter the hardware setup information or load the defaults from the camera.</p>	<p>Section 4.6, Configure Default System Parameters, on page 34. Chapter 5, Operation, on page 37.</p>
<p>12. When the system reaches temperature lock, begin acquiring data in focus mode. (The factory default temperature is -20°C which is the minimum available with dry Nitrogen backfill.)</p>	
<p>13. After verifying that the camera sees, turn the camera supply OFF.</p>	
<p>14. Remove the eight (8) bolts securing the shipping plate to the camera, and store the shipping plate and bolts.</p>	<p>Section 5.4.1, Camera with ConFlat[®] Flange, on page 48.</p>
<p>15. Mount the camera to the vacuum port.</p>	<p>Section 5.4.1, Camera with ConFlat[®] Flange, on page 48.</p>
<p>16. Secure and evacuate the vacuum chamber.</p>	<p>Section 5.4.1, Camera with ConFlat[®] Flange, on page 48.</p>

3.1 Air-Cooled System Block Diagrams

Figure 3-1: Initial System Checkout Imaging Experiment Layout (Air-cooled Camera)

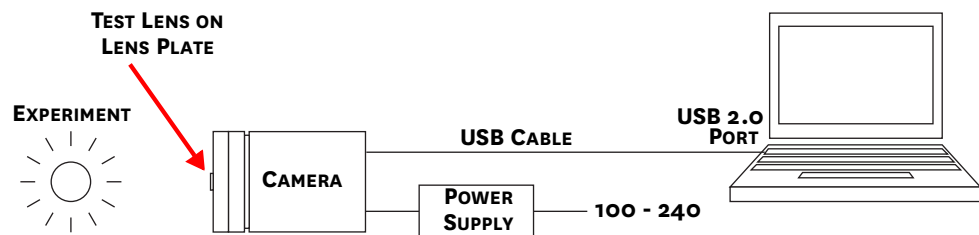


Figure 3-2: Typical Imaging Experiment Layout (Air-cooled Camera)

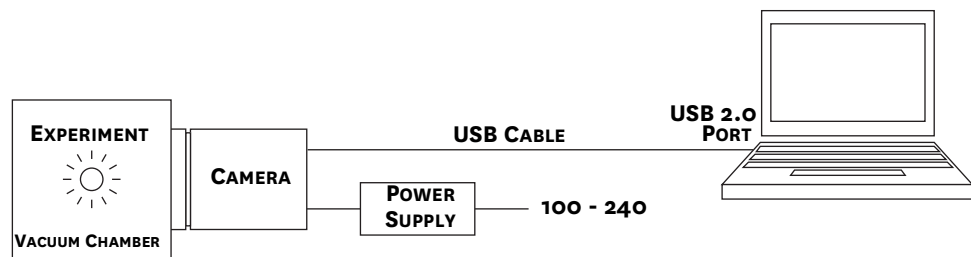
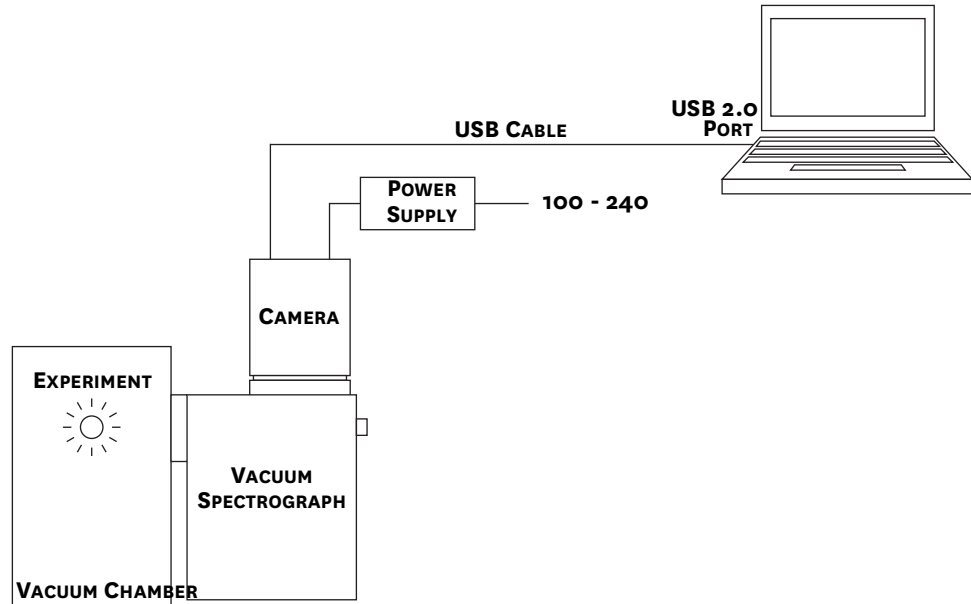
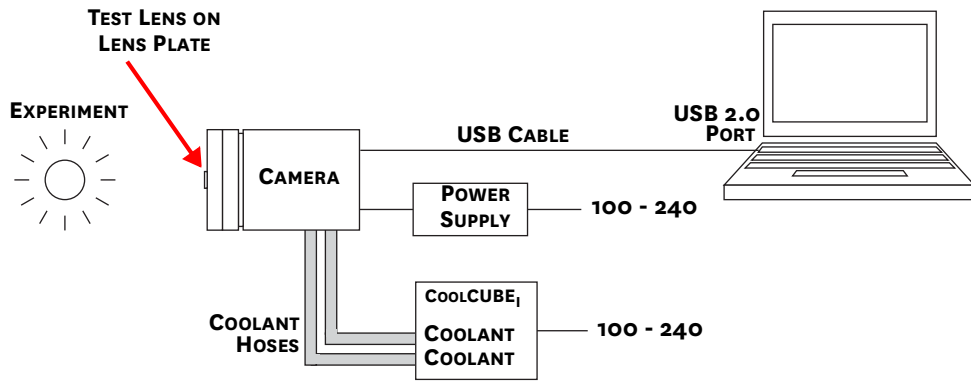


Figure 3-3: Typical Spectroscopy Experiment Layout (Air-cooled Camera)



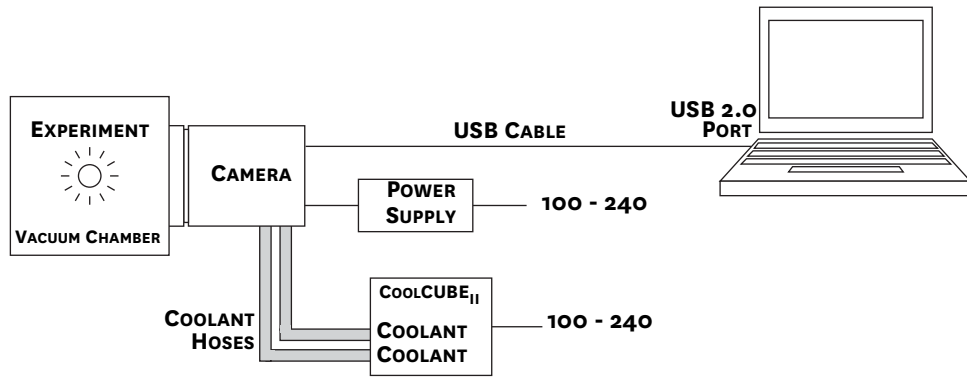
3.2 Liquid-Cooled System Block Diagrams

Figure 3-4: Initial System Checkout Imaging Experiment Layout (Liquid-cooled Camera)



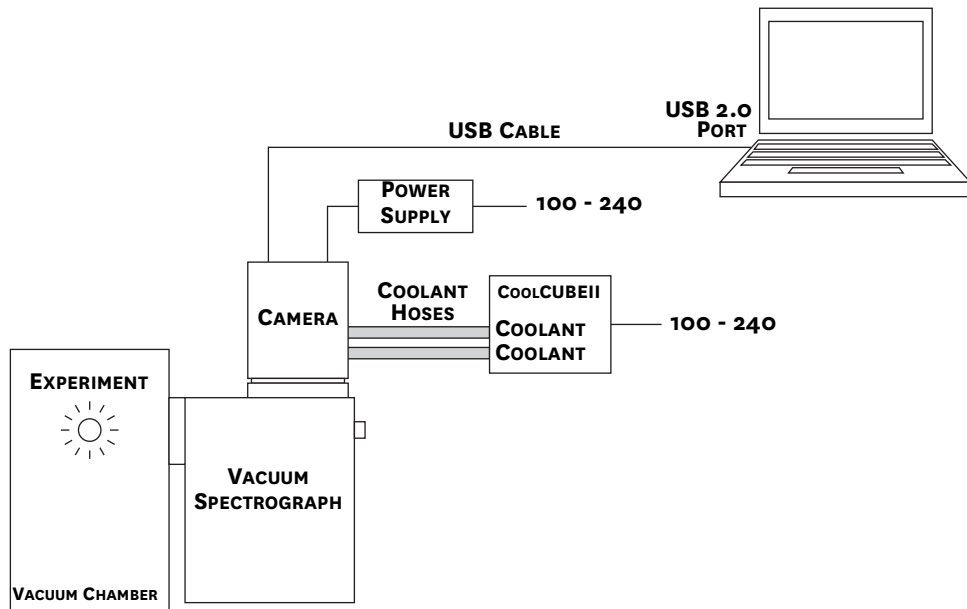
4411-0111_0007

Figure 3-5: Typical Imaging Experiment Layout (Liquid-cooled Camera)



4411-0111_0008

Figure 3-6: Typical Spectroscopy Experiment Layout (Liquid-cooled Camera)



4411-0111_0009

Chapter 4: System Setup



NOTE:

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

A PIXIS-XO camera system consists of three hardware components:

- Camera head;
- Power supply;
- Cables.

All components and cables required for the customer-specified configuration are included with the shipment. The PIXIS-XO system has been specially configured and calibrated to match the camera options specified at the time of purchase. The CCD and coating that was ordered have been installed in the camera head.

Keep all original packing materials so the PIXIS-XO system can safely be shipped to another location or returned for service if necessary. If any difficulty is experienced at any time, call Teledyne Princeton Instruments Customer Support. Refer to [Contact Information](#) on page 116 for complete contact information.

A hardware installation may include:

- Installing an interface card if the appropriate card has not been installed;
- Mounting to a vacuum chamber;
- Connecting the camera to external triggering or monitoring equipment.

Software installation depends on the application software that will be used to run the system. Refer to the user manual provided with the software for information about installing and setting it up.

4.1 Unpacking the System

During unpacking, inspect the system components for possible signs of shipping damage. If there are any, notify Teledyne Princeton Instruments immediately and file a claim with the carrier. If damage is not apparent but the camera cannot be operated, internal damage may have occurred in shipment. After unpacking the system, retain all original packing materials so the camera system can safely be shipped to another location or returned to Teledyne Princeton Instruments for repairs if necessary.

4.2 Checking the Equipment and Parts Inventory

Verify that all required equipment and parts necessary to set up the PIXIS-XO system have been received.

A complete system consists of:

- Standard Equipment:
 - Camera
 - Power Supply
 - CoolCUBE_{II} Circulator and hoses (Liquid-Cooled Systems Only)
 - Host Computer
 - Can be purchased from Teledyne Princeton Instruments or provided by user. For enhanced performance, a fast hard drive (i.e., 10,000 rpm,) and 2 GB RAM is recommended.
 - Depending on the application software being used, the host computer should be loaded with one of the following supported operating systems:
 - WinView/32 or WinSpec/32
 - Windows[®] XP (32-bit, SP3 or later) or Vista[®] (32-bit).
 - LightField
 - Windows[®] Vista (64-bit) or Windows[®] 7 (64-bit)
 - USB cable: Five (5) meter cable (6050-0494) is standard.
 - PIXIS-XO System User Manual
- Optional Equipment
 - Application Software:
 - WinView/32 or WinSpec32 (Ver. 2.5.25 or later) CD-ROM (optional)
 - LightField CD-ROM (optional)
 - Software User Manual (provided with application software)
 - Fiber Optic Extender Kit

4.3 System Requirements

This section summarizes PIXIS-XO System requirements.

4.3.1 Camera Ventilation

A minimum of one inch clearance surrounding all PIXIS-XO camera side air vents is required. When the camera is operating inside an enclosure, >30 cfm air circulation and heat dissipation of 100 W is required.

4.3.2 Power Requirements

Camera: The PIXIS-XO camera receives its power from the supplied self-switching DC power supply which in turn plugs into an AC power source.

Power Supply: The receptacle on the power supply should be compatible with the line-voltage power cords in common use in the region to which the system is being shipped. If the power supply's receptacle is incompatible, a compatible adapter should be installed on the line cord, taking care to maintain the proper polarity to protect the equipment and assure user safety.

Refer to [Section A.4, Power Specifications](#), on page 96 for complete power specifications.

4.3.3 Host Computer Specifications

Host Computer specifications vary based on which data acquisition software is being used. This section provides minimum host Computer specifications by software package.

**NOTES:**

1. Computers and operating systems undergo frequent revision. The following information is intended to provide an approximate indication of the computer requirements. Contact the factory to confirm specific requirements.
2. The specifications listed are the MINIMUM required for a PIXIS-XO camera. A faster computer with a minimum of 5 GB RAM and a fast hard drive (e.g., 10,000 rpm,) will greatly improve system performance during live mode operation.

4.3.3.1 WinX Requirements

When running WinX data acquisition software, the host computer must satisfy the following requirements:

- 32-bit Operating System
 - Windows® XP (with SP3 or later);
 - Windows® Vista;
- 2 GHz Pentium® 4 (or greater).
- Native USB 2.0 support on the mother board, or USB 2.0 Interface Card
Recommended Interface Cards:
 - Desktop applications: Orange Micro 70USB90011 USB2.0 PCI;
 - Laptop applications: SIIG, Inc. USB 2.0 PC Card, Model US2246;
- 1 GB RAM minimum;
- CD-ROM drive;
- 10,000 rpm (recommended) hard disk with a minimum of 1 GB available space. A complete WinX installation requires 17-50 MB of space. The remaining space is required for data storage, and is dependent on the number and size of images/spectra collected.

**NOTE:**

Disk level compression programs are NOT recommended.

- Super VGA monitor and graphics card supporting at least 65,535 colors with a minimum of 128 MB of memory.

**NOTE:**

Memory requirement is dependent on the desired display resolution.

- Mouse or other pointing device.

4.3.3.2 LightField Requirements

When running LightField data acquisition software, the host computer must satisfy the following requirements:

- 64-bit Operating System
 - Windows® Vista;
 - Windows® 7;
- 2 GHz dual core processor;
- 4 GB RAM minimum;
- CD-ROM drive;
- 10,000 rpm (recommended) hard disk with a minimum of 1 GB available space. Additional space is required for data storage, and is dependent on the number and size of images/spectra collected.

**NOTE:**

Disk level compression programs are NOT recommended.

- Super VGA monitor and graphics card supporting at least 65,535 colors with a minimum of 128 MB of memory.

**NOTE:**

Memory requirement is dependent on the desired display resolution.

- Mouse or other pointing device.

4.4 Install the Application Software

This section provides installation procedures for WinX and LightField data acquisition software.



NOTE:

If the application software has already been installed, proceed to:

- [Section 4.5, Connect the PIXIS-XO to a CoolCUBE_{II}](#), on page 32 for liquid-cooled systems; or
- [Section 4.6, Configure Default System Parameters](#), on page 34 for air-cooled systems.

4.4.1 Install WinX

Perform the following procedure to install WinX on the host computer:



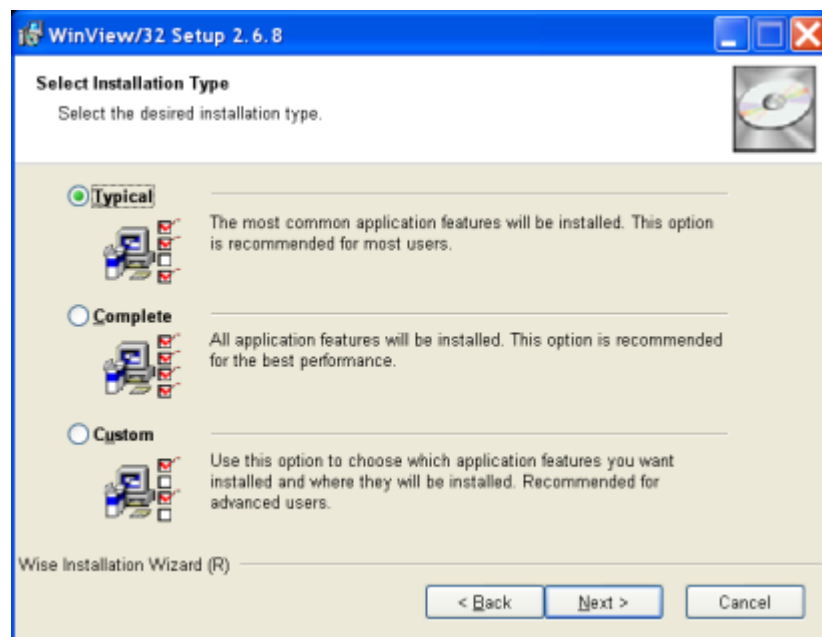
NOTES:

1. Before proceeding, verify that the host computer supports USB 2.0. If it does not, install a USB 2.0 interface card per manufacturer's installation instructions.
2. The USB interface cable between the camera and the host computer should remain disconnected until after WinView/32 or WinSpec/32 (version 2.5.25 or higher) has been completely installed.

1. Insert the WinView/32 or WinSpec/32 software installation CD into an appropriate drive on the host computer.

The installation wizard launches, and the setup dialog is displayed. See [Figure 4-1](#).

Figure 4-1: Typical WinView/32 Setup Dialog



2. Select the radio button corresponding to the type of install to be performed:
 - Typical installs the most commonly installed program files and features;
 - Complete installs all application features;
 - Custom allows for the selection of specific features and files for installation.
 The required INF, DLL, and USB drivers will be copied into the appropriate subdirectories as indicated in [Table 4-1](#).

Table 4-1: Windows XP Installation Directories for WinX USB Files and Drivers

Driver/File	Directory	Filename
Setup Information INF	WINXP/INF ^a	rsusb2k.inf
Properties DLL	WINXP/System32	apausbprop.dll
Device Driver	WINXP/System32/Drivers	apausb.sys

a. This subdirectory may be hidden.

3. Click Next > to begin the installation.
4. Once the installation is complete, connect the PIXIS-XO camera to the host computer.
5. Turn on the power supply for the camera.
6. Reboot the computer.
7. During startup, Windows will detect the Teledyne Princeton Instruments USB2 Interface hardware in the PIXIS-XO.

4.4.2 Install LightField

Perform the following procedure to install LightField on the host computer:

1. Verify that a 64-bit operating system has been installed on the host computer, such as:
 - Windows Vista;
 - Windows 7.
2. Verify that the host computer supports USB 2.0.
If it does not support USB 2.0, install a USB 2.0 interface card per the manufacturer's installation instructions.
3. Verify that the host computer is connected to the Internet. An Internet connection may be required for product activation.
4. Insert the LightField installation CD into an appropriate drive on the host computer.
The installation wizard will autostart, and the setup dialog will be displayed. See [Figure 4-2](#).

Figure 4-2: Typical LightField Installation Wizard Dialog



4411-0111_0011

5. After the installation finishes, reboot the host computer.
6. Connect the PIXIS-XO system components to the host computer and power them on.
7. Launch LightField and activate it according to on-screen instructions.

4.5 Connect the PIXIS-XO to a CoolCUBE_{II}

For liquid-cooled PIXIS-XO cameras, the CoolCUBE_{II} circulator provides a vibration-free method of heat removal.

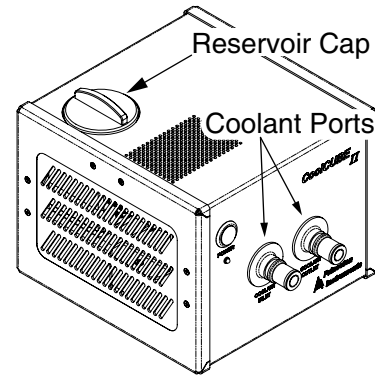
Perform the following procedure to connect a CoolCUBE_{II} circulator to the PIXIS-XO system:

1. Verify that the camera and the circulator power switches are each in the off position.
2. Verify that the circulator is positioned below the camera as follows:
 - A minimum of 6 inches (150 mm) below, and
 - No more than 10 feet (3 m) below.

Typically, the camera is at table height and the circulator is nearby on the floor.

3. Install the coolant hoses from the circulator to the camera. Because the coolant ports on the camera are bidirectional, either hose from the circulator can be attached to either coolant port on the camera.

It is recommended that the hoses be secured to the camera hose barbs with the clamp supplied.



NOTES:

1. Verify that there are no kinks in the hoses that could possibly impede coolant flow. Lack of sufficient flow can seriously harm the detector. Any resulting damage is not covered under warranty.
2. Damage caused by water leaking into the PIXIS-XO also voids the warranty.

4. Unscrew the reservoir cap located on top of the CoolCUBE_{II} and verify that the coolant reservoir contains coolant.
If additional coolant is required, fill the tank with a 50:50 mixture of water and ethylene glycol.
5. Screw the reservoir cap back in.
6. Plug the circulator into a 100-240 V_{AC}, 47-63 Hz power source.



7. Turn the circulator on. Verify there are no leaks or air bubbles in the hoses.

**NOTE:**

Small air bubbles, approximately the size of bubbles found in soda, are common in the CoolCUBE_{II}, particularly during startup, and do not prevent proper operation.

- a. If no problems are observed, proceed to step 8.
 - b. If leaks or air bubbles are observed, turn the circulator off and correct the problem(s) by securing the hoses or adding more coolant to the reservoir.
 - c. Once the system has been inspected, turn the circulator back on. If no problems are observed, proceed to step 8.
8. Turn the camera on.
 9. Launch the application software.

4.6 Configure Default System Parameters

Proceed to the following sections for information about the initial configuration of default system parameters:

- [Section 4.6.1, WinX](#);
- [Section 4.6.2, LightField](#), on page 35.

4.6.1 WinX

Perform the following procedure to configure default system parameters within WinX:

1. Verify the PIXIS-XO is connected to the host computer and that it is turned on.
2. Launch the WinX application.

The Camera Detection Wizard runs automatically if this is the first time a Teledyne Princeton Instruments WinX application (i.e., WinView/32, WinSpec/32, or WinXTest/32,) and a supported camera are being installed.

Otherwise, when installing a new camera type, click on the Launch Camera Detection Wizard... button on the Controller/CCD tab to launch the wizard.

See [Figure 4-3](#).

Figure 4-3: Typical Camera Detection Wizard Dialog



4411-0111_0013

3. On the Welcome dialog, verify that the check box is unselected.
4. Click **N**ext > to continue.
5. Follow the on-screen instructions to complete the initial hardware setup. This wizard automatically enters default parameters on the Hardware Setup dialog tabs and provides the opportunity to acquire a test image to confirm proper system operation.



REFERENCES:

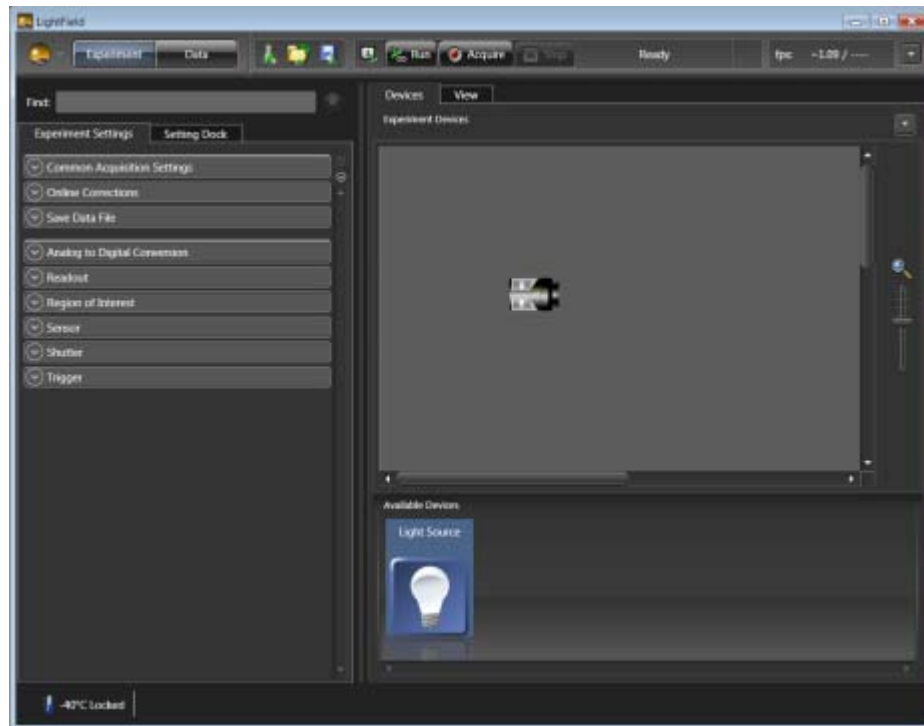
For step-by-step information about basic system operation, refer to [Section 5.2, WinX First Light Instructions](#), on page 39.

4.6.2 LightField

Perform the following procedure to configure default system parameters in LightField:

1. Verify the PIXIS-XO is connected to the host computer and that the camera power supply is turned on.
2. Launch LightField.
3. While LightField is starting up, it will detect the available device(s) and load the appropriate icons into the Available Devices area in the Experiment workspace.
4. When an icon is dragged into the Experiment Devices area, the appropriate expanders will be loaded into the Experiment Settings stack on the left-hand side of the window as shown in [Figure 4-4](#).

Figure 4-4: Typical LightField Experiment Workspace



4411-0111_0014

Because this is a new experiment, the default settings will automatically be entered for the experiment device(s). These settings will allow you to begin previewing (Run button) or acquiring (Acquire button) data.



REFERENCES:

For step-by-step information about basic system operation, refer to [Section 5.3, LightField First Light Instructions](#), on page 43.

4.7 Connect an External Shutter



WARNING!

Disconnecting or connecting the shutter cable to the camera while the camera is ON can destroy the shutter or the shutter driver in the camera!



CAUTION!

Electromechanical shutters have a typical lifetime of approximately one million cycles. Avoid operating the shutter unnecessarily. Also avoid using shorter exposure times and higher repetition rates than are required.

Although PIXIS-XO cameras do not have an internal shutter, an external shutter may be connected to the camera using the Shutter connector on the rear of the camera. Refer to [Section A.6, External Shutters](#), on page 99 for information about compatible external shutters.

4.7.1 External Shutter Cable Connection

Perform the following procedure to connect an external shutter to a compatible PIXIS-XO camera:

1. Verify that the PIXIS-XO camera is turned OFF (i.e., the power supply is OFF.)
2. Connect the shutter cable from the external, camera-dependent shutter to the LEMO[®] connector on the rear of the camera. Refer to [Section A.5.2, Connectors](#), on page 97 for additional information.
3. Power the PIXIS-XO camera on.

4.8 Connecting/Disconnecting the PIXIS-XO USB Cable

Effective November 1, 2005, a PIXIS-XO camera can be connected and/or disconnected from the host computer while the PIXIS-XO camera remains powered on provided the WinX application software has already been exited and shut down.

For cameras built prior to November 1, 2005, the WinX application software must first be exited and shut down, and the PIXIS-XO camera powered OFF before connecting or disconnecting the USB cable from the camera or host computer.

Chapter 5: Operation

This chapter provides information about:

- Required system on/off sequencing when using WinX application software;
- First Light procedures for imaging and spectroscopy applications; These are step-by-step procedures describing initial system verification.
- Factors that affect exposure, readout, and digitization of incoming signals. Understanding these factors and making appropriate adjustments to software settings allow the signal-to-noise ratio to be maximized.



REFERENCES:

For information about synchronizing data acquisition with external devices, refer to [Chapter 6, Advanced Topics](#), on page 61.

Once a PIXIS-XO camera has been installed, operation of the camera is straightforward. In most applications you simply establish optimum performance using the Focus mode (in WinView/32, for example,) set the target camera temperature, wait until the temperature has stabilized, and then do actual data acquisition in the Acquire mode. Additional considerations regarding experiment setup and equipment configuration are addressed in the software manual.

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 are displayed and/or stored via the application software. This sequence is illustrated by the block diagram shown in [Figure 5-1](#).

Whether or not the data are displayed and/or stored depends on the data collection operation that has been selected in the application software. In WinX and LightField, the data collection operations use the Experiment Setup parameters to establish the exposure time (i.e., the period when signal of interest is allowed to accumulate on the CCD.) Focus {Preview} is more likely to be used when configuring the system (refer to [Section 5.2, WinX First Light Instructions](#), and [Section 5.3, LightField First Light Instructions](#).) while Acquire is typically used for data collection and storage.

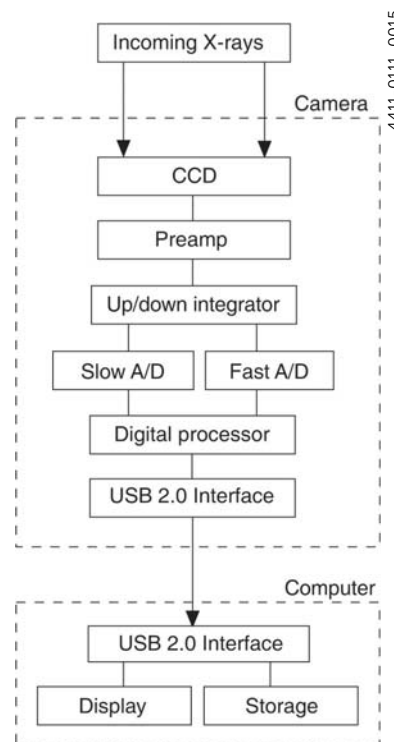


Figure 5-1: PIXIS-XO System Block Diagram

4411-0111_0015

Briefly:

- In Focus {Preview} mode, the number of frames is 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. In WinX, the last frame acquired before Stop is selected can be stored. In LightField, this frame cannot be stored. Focus {Preview} 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 may eventually occur. In WinX, this could only happen in Fast Mode operation.

5.1 System On/Off Sequencing [WinX Applications Only]

When using WinView/32 and WinSpec/32 data acquisition software, the following on/off sequences must be followed in order to establish and maintain a communication link between the camera and the host computer:

1. The PIXIS-XO camera must be powered ON before the WinX application has been launched to ensure communication between the camera and the computer. If the WinX application is launched and the PIXIS-XO 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 the WinX application, power the camera ON, and relaunch the application before configuring experiments and acquiring new data.
2. The WinX application must be closed before powering the camera OFF. If you power the camera OFF before closing the application, 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 the application, powered the camera ON, and then relaunched the application.

5.2 WinX First Light Instructions



WARNING!

PIXIS-XO cameras have been designed without a protective window. Therefore, the shipping plate must remain in place until camera operation has been verified and the camera is ready to be mounted to a vacuum chamber. Long term exposure of the CCD array to the environment increases the probability of physical damage to the array, ESD damage, and contamination of the CCD array surface.

Open chamber products carry no warranty, neither expressed nor implied, on the CCD device.



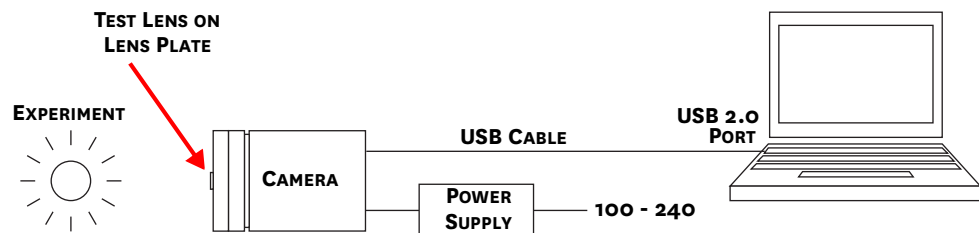
CAUTION!

Removing the shipping plate voids the warranty on the CCD array.

This section provides a step-by-step procedure for acquiring an imaging measurement prior to mounting the PIXIS-XO camera to a vacuum chamber for the first time. The intent of this procedure is to gain basic familiarity with the operation of the system and to demonstrate that it is functioning properly. Once basic operation has been established, the shipping plate can be removed, the camera can be mounted to a vacuum chamber, and operation with other configurations requiring more complex timing modes can be performed.

Figure 5-2 illustrates the block diagram of the recommended equipment setup for initial system verification.

Figure 5-2: Block Diagram: Recommended Setup for Initial System Verification



This procedure assumes:

- The shipping plate has not been removed from the front of the camera.
- The system has been setup according to instructions in [Chapter 4, System Setup](#), on page 25, and camera operation is being verified.
- Previous sections of this chapter have been read.
- Familiarity with the application software.
- The system is being operated in imaging mode.
- The target is a sharp image, text, or drawing that can be used to verify that the camera is "seeing."

Perform the following procedure to configure WinX for the first time:

**NOTE:**

The following procedure is based on WinView/32. If a different application is being used, then some modifications to the procedure may be required (e.g., configure WinSpec.32 for imaging mode.) Basic familiarity with the WinX software is assumed. If this is not the case, review the software manual or have it available while performing this procedure.

1. Mount a test target in front of the camera.
2. Apply power to the PIXIS-XO camera by toggling the power switch on the rear of the power supply to the ON position.

**NOTE:**

The camera must be turned on before launching WinX. Similarly, WinX must be closed before turning the camera off.

3. Turn on the computer power.
4. Launch the application software.
5. Configure the software parameters as follows:
 - Environment dialog (Setup ► Environment)
Verify that the DMA Buffer size is a minimum of 32 MB. Large arrays may require a larger buffer size. If the buffer size is changed, the host computer must be rebooted for the memory allocation to be activated, and WinView/32 must be launched again.
 - Controller ► Camera tab (Setup ► Hardware)
The Camera Detection wizard (i.e., Hardware Setup wizard for prior software versions,) has configured default values appropriate for the system. These settings should be verified.
 - Camera name: This information is read from the camera.
 - Controller type: This information is read from the camera.
 - Shutter type: None.
 - Readout mode: Select Full frame.

- Detector Temperature (Setup ► Detector Temperature...)
When shipped, the camera is back-filled with dry nitrogen, and the default temperature is set to -20°C. When the array temperature reaches the set temperature, the Detector Temperature dialog reports that the temperature is LOCKED. Some overshoot may occur which may cause temperature lock to be briefly lost and quickly re-established. If you are reading the actual temperature reported by the application software, there may be a small difference between the set and reported temperature when lock is established. This is normal and does not indicate a system malfunction. Once lock is established, the temperature will be stable to within $\pm 0.05^\circ\text{C}$.

**NOTE:**

The Detector Temperature dialog does not display temperature information during data acquisition.

- Cleans and Skips tab (Setup ► Hardware)
Click on Load Default Values and click on Yes.
- Experiment Setup ► Main tab (Acquisition ► Experiment Setup...)
— Exposure Time: 2 seconds
— Accumulations & Number of Images: 1
- Experiment Setup ► ROI tab (Acquisition ► Experiment Setup...)
Use this function to define the Region of Interest (ROI).
— Imaging Mode: Select this mode when running WinSpec.
— Clicking on Full loads the full size of the chip into the edit boxes.
- Experiment Setup ► Timing tab (Acquisition ► Experiment Setup...)
— Timing Mode: Free Run
— Shutter Control: Normal
— Safe Mode or Fast Mode: Safe
- Experiment Setup ► ADC tab (Acquisition ► Experiment Setup...)
Set the ADC Rate to 2 MHz and verify CCD is not saturating at 2 seconds. If saturation is occurring, further reduce ambient light. This will minimize smearing when testing the performance of the camera without a shutter.
- General tab (Display ► Layout...)
Select Horizontal and Vertical Cross Sections.

5.2.1 Acquire Data

Perform the following procedure to acquire data and confirm proper system operation:

1. Darken the room.
2. Determine if there is a lens mounted to the front of the shipping plate.
 - If the shipping plate has a red C-mount test lens installed, this may be used for the acquisition.
 - If the shipping plate has a C-mount camera body cap in place, a user-supplied C-mount lens must be installed.
 - Cameras such as the PIXIS-XO:1300 and PIXIS:2048 require a user-supplied F-mount lens to be installed.

3. When using WinX, select Focus from the Acquisition menu.
4. Adjust the lens aperture, intensity scaling, and focus for the best image as viewed on the computer monitor.

Imaging tips include:

- Begin with the lens blocked off and then set the lens to the smallest possible aperture (i.e., the largest f-stop number.)
- Verify there is a suitable target in front of the lens. An object with text or graphics works best.
- Examine the brightest regions of the image to determine if the A/D converter is at full-scale.



NOTE:

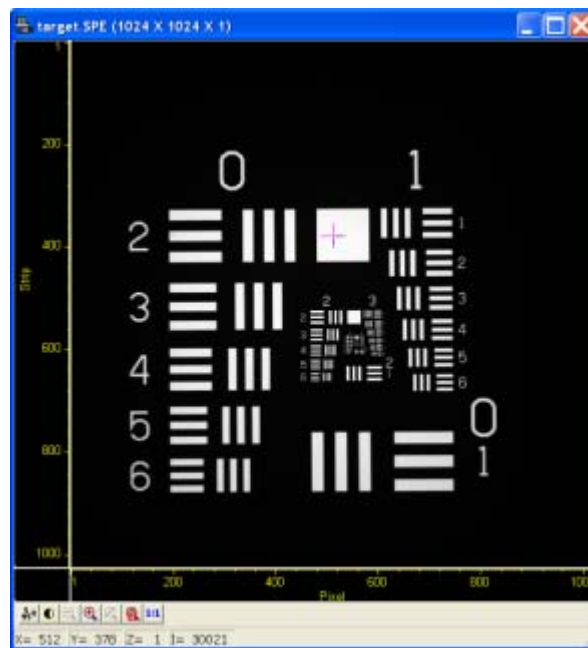
A 16-bit A/D is at full scale when the brightest parts of the image reach an intensity of 65535.

Adjust the aperture so that it is slightly smaller (i.e., a higher f-stop,) than the setting where maximum brightness occurs on any part of the image.

- Set the focus adjustment of the lens for maximum sharpness in the viewed image.

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 too short. [Figure 5-3](#) illustrates typical image data that may be seen within WinView.

Figure 5-3: Sample First Light Data Acquired (WinView)



4411-0111_0017

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.

5.3 LightField First Light Instructions



WARNING!

PIXIS-XO cameras have been designed without a protective window. Therefore, the shipping plate must remain in place until camera operation has been verified and the camera is ready to be mounted to a vacuum chamber. Long term exposure of the CCD array to the environment increases the probability of physical damage to the array, ESD damage, and contamination of the CCD array surface.

Open chamber products carry no warranty, neither expressed nor implied, on the CCD device.



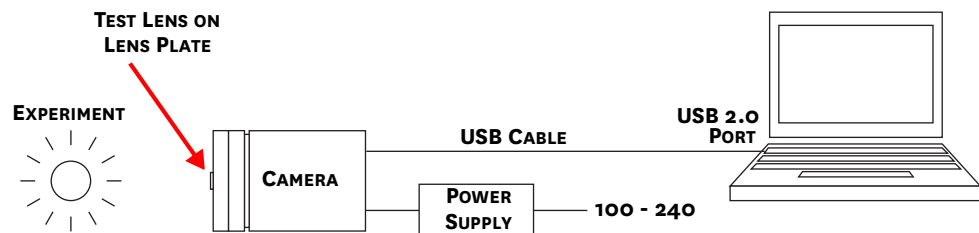
CAUTION!

Removing the shipping plate voids the warranty on the CCD array.

This section provides step-by-step instructions for acquiring an imaging measurement prior to mounting the PIXIS-XO camera to a vacuum chamber for the first time. The intent of this procedure is to gain basic familiarity with the operation of the system and to demonstrate that it is functioning properly. Once basic operation has been established, the shipping plate can be removed, the camera can be mounted to a vacuum chamber, and operation with other configurations requiring more complex timing modes can be performed.

Figure 5-4 illustrates the block diagram of the recommended equipment setup for initial system verification.

Figure 5-4: Block Diagram: Recommended Setup for Initial System Verification



4411-0111_0004

This procedure assumes:

- The shipping plate has not been removed from the front of the camera.
- The system has been setup according to instructions in [Chapter 4, System Setup](#), on page 25, and camera operation is being verified.
- Previous sections of this chapter have been read.
- Familiarity with the application software.
- The system is being operated in imaging mode.
- The target is a sharp image, text, or drawing that can be used to verify that the camera is "seeing."

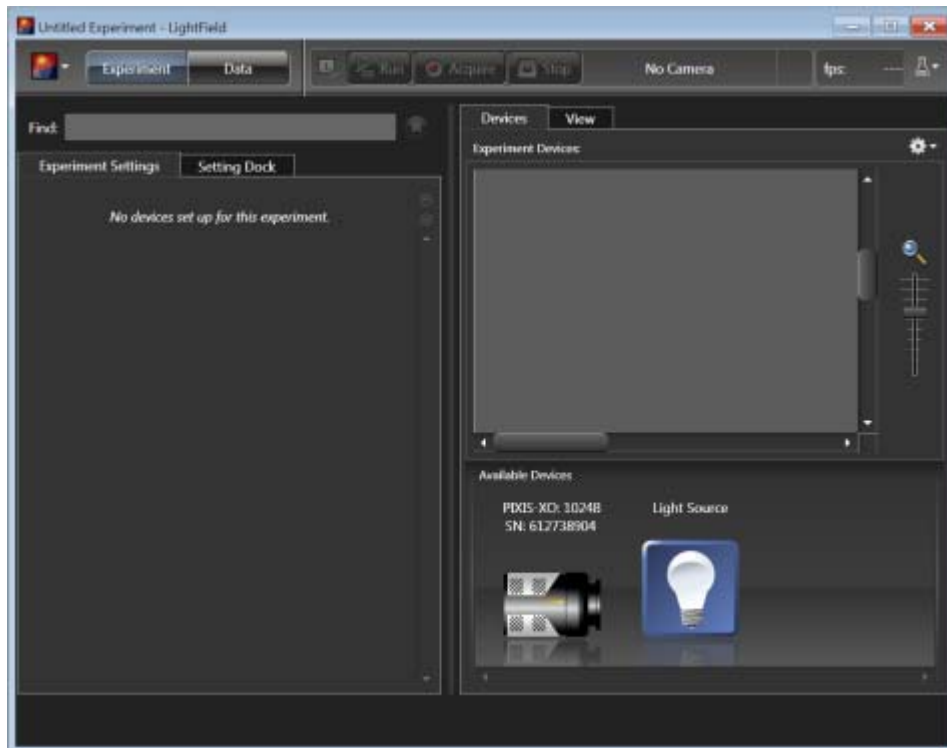
Perform the following procedure to configure LightField for the first time:

**NOTE:**

The following procedure is based on LightField. Basic familiarity with LightField is assumed. If this is not the case, review the software manual or have it available while performing this procedure.

1. Mount a test target in front of the PIXIS-XO camera.
2. Apply power to the PIXIS-XO camera by toggling the power switch on the rear of the power supply to the ON position.
3. Turn on the host computer.
4. Launch the LightField application software.
Once launched, an icon representing the PIXIS-XO camera will be displayed within the Available Devices area. The camera illustrated in [Figure 5-5](#) is a PIXIS-XO:1024B.

Figure 5-5: Typical LightField Available Devices Area



5. Drag the camera icon into the Experiment Devices area. See [Figure 5-6](#).

Figure 5-6: Typical LightField Experiment Devices Area



4411-0111_0019



NOTE:

The Experiment Settings stack on the left now displays several expanders. Because this is a new experiment, the default settings for the camera will be active.

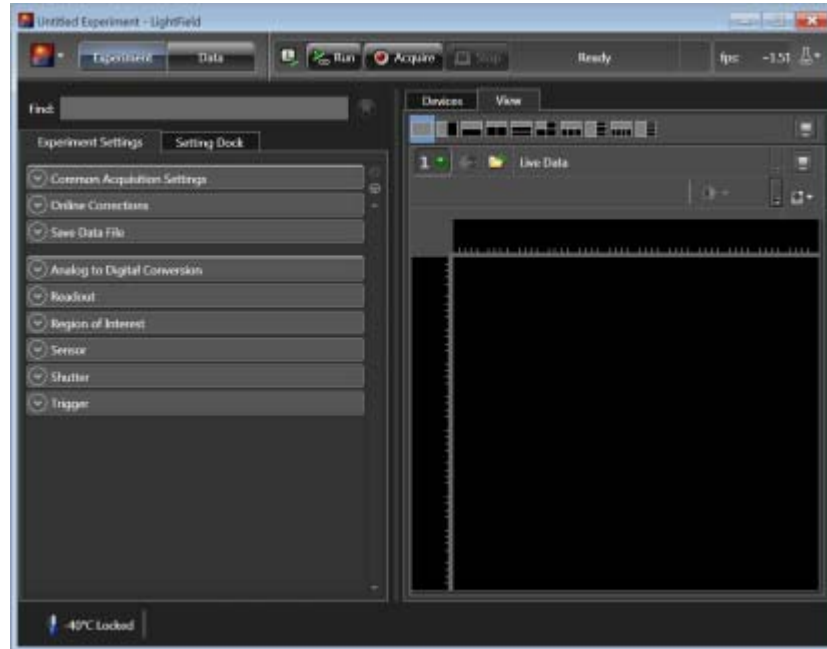
6. Open the Common Acquisition Settings expander and configure the Exposure Time to 2 seconds.
7. The Status bar located at the bottom of the window displays an icon for temperature status. Temperature status reports the current temperature and whether the set temperature has been reached. Click on the icon to open the Sensor expander so that the set temperature can be changed.

5.3.1 Acquiring Data

Perform the following procedure to acquire data and confirm proper system operation:

1. Darken the room.
2. Click on the View tab just above Experiment Devices to change to the display area. [Figure 5-7](#) illustrates a typical View Area.

Figure 5-7: Typical LightField View Area



4411-0111_0020


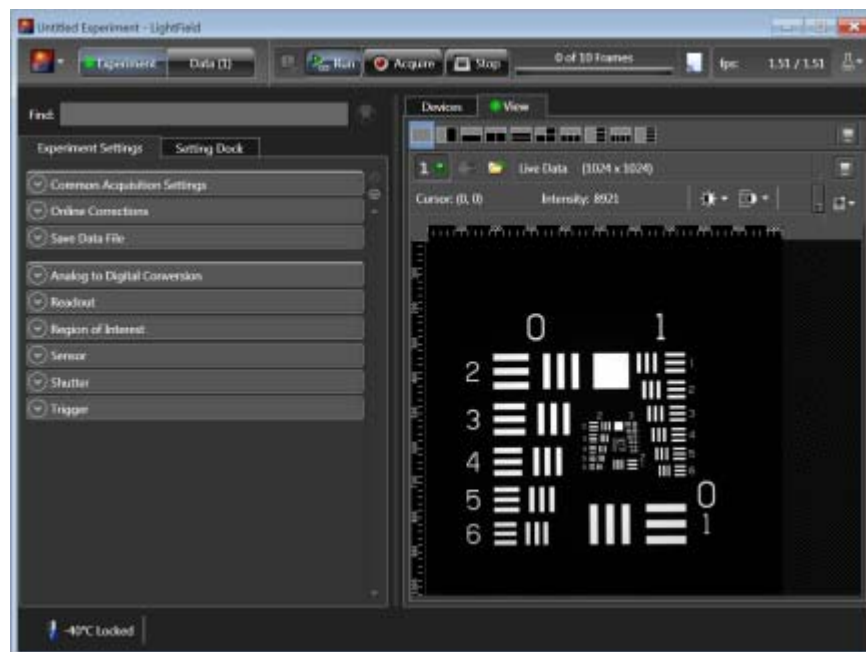
3. Click on the Run button  to start Preview mode. In this mode, images will be continuously acquired and displayed. See [Figure 5-8](#).

Figure 5-8: Typical LightField View Area Displaying an Image



4411-0111_0021

4. Adjust the lens aperture, intensity scaling, and focus for the best image as viewed on the computer monitor.

Imaging tips include:

- Begin with the lens blocked off and then set the lens at the smallest possible aperture (i.e., largest f-stop number.)
- Verify there is a suitable target in front of the lens. An object with text or graphics works best.
- Examine the brightest regions of the image to determine if the A/D converter is at full-scale.

**NOTE:**

A 16-bit A/D is at full scale when the brightest parts of the image reach an intensity of 65535.

Adjust the aperture so that it is slightly smaller (i.e., higher f-stop,) than the setting where maximum brightness occurs on any part of the image.

- Set the focus adjustment of the lens for maximum sharpness in the viewed image.
5. After the camera has been focused, either:
 - Stop Preview mode;
 - Continue Preview mode;
 - Begin Acquire mode;
 - Wait for the CCD to reach the operating temperature before entering Acquire mode.

5.4 Mount Camera to a Vacuum Chamber

**WARNING!**

PIXIS-XO cameras have been designed without a protective window. Therefore, the shipping plate must remain in place until camera operation has been verified and the camera is ready to be mounted to a vacuum chamber. Long term exposure of the CCD array to the environment increases the probability of physical damage to the array, ESD damage, and contamination of the CCD array surface.

Open chamber products carry no warranty, neither expressed nor implied, on the CCD device.

5.4.1 Camera with ConFlat® Flange



NOTE:

Removing the shipping plate voids the warranty on the CCD array. Do not remove this shipping plate until camera operation has been verified. For complete, step-by-step instructions to verify proper camera operation prior to mounting it to a vacuum chamber, refer to:

- [Section 5.2, WinX First Light Instructions](#), on page 39; or
- [Section 5.3, LightField First Light Instructions](#), on page 43.

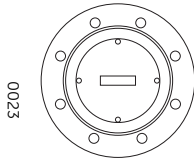
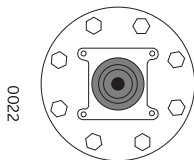
Perform the following procedure to mount a PIXIS-XO to a vacuum chamber:

1. Loosen and remove the eight (8) bolts securing the shipping plate and remove the shipping plate.



NOTE:

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



2. Remove and discard the copper sealing gasket.
3. Retain all shipping materials (with the exception of the copper sealing gasket) for future use.
4. Clean the ConFlat flange sealing edges and grooves with a lint-free wipe and inspect the flange for any shipping damage before mounting the camera.
5. Remove the copper sealing gasket from the packaging and inspect it for any shipping damage.
6. Carefully seat the copper sealing gasket into the groove between the ConFlat flanges. If gasket retaining clamps are available, they may be used to hold the sealing gasket in place during installation.
7. Mate the ConFlat flange to the chamber. The outer flange mounting ring is able to be rotated. You must orient the outer flange to align the mounting holes correctly.
8. Immediately install a minimum of three (3) screws (English or metric) to secure/support the camera. **DO NOT TIGHTEN THESE SCREWS AT THIS TIME.**
9. Align the camera to the application at this time.
10. Install the remaining screws into the ConFlat flange.
11. Use a 1/2" torque wrench to tighten all screws to 180 ± 10 in-lbs. torque.
12. Teledyne Princeton Instruments recommends a helium leak check upon initial vacuum pump down before operating the camera.

5.5 Exposure and Signal

This section provides information about factors that affect the signal acquired on the CCD array. These factors include array architecture, exposure time, CCD temperature, dark charge, and saturation.

5.5.1 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 (as configured in the software,) the pixels are read out serially.

CCD arrays perform three essential functions:

- Photons are transduced to electrons;
- These electrons are then integrated and stored as charge;
- Finally, the accumulated charge is read out.

CCDs are very compact and rugged and can withstand direct exposure to relatively high light levels, magnetic fields, and RF radiation. They are easily cooled and their temperature can be precisely controlled to within a few tens of millidegrees.

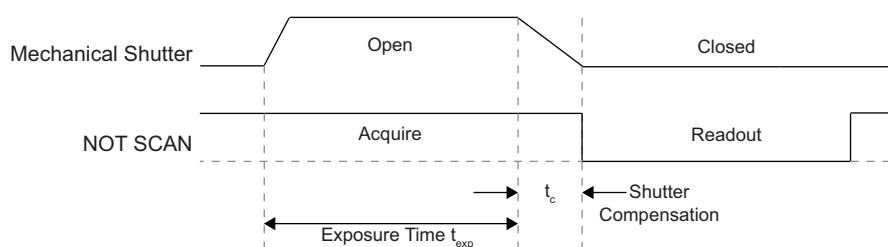
5.5.2 Exposure Time

Exposure time, which is configured on the Experiment Setup ► Main tab {Common Acquisition Settings expander} 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 before the start of the exposure time. At the end of the exposure time, the CCD is readout and cleaning starts again.

Because PIXIS-XO 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-like operation, the NOT SCAN {Not Reading Out} or the SHUTTER {Shutter Open} signal at the LOGIC OUT connector on the rear of the PIXIS-XO can be used to synchronize the x-ray source or an x-ray shutter with the exposure-readout cycle so the CCD can be read out in darkness. Refer to [Section 6.3, LOGIC OUT Control](#), on page 71 for additional information. [Figure 5-9](#) illustrates the timing diagram for a mechanical shutter with respect to the NOT SCAN signal.

Figure 5-9: Timing Diagram: Mechanical Shutter Operation and NOT SCAN Signal



4411-0111_0024

5.5.3 CCD Temperature

As stated previously, lowering the temperature of the CCD will generally enhance the quality of the acquired signal.

- When WinX is the controlling software, temperature control is done via the Detector Temperature dialog accessed from the Setup menu. See [Figure 5-10](#).
- When LightField is being used, temperature control is done on the Sensor expander.



Figure 5-10: Typical WinX Detector Temperature Dialog

Once the target Array Temperature {Temperature Setpoint} has been set, the software controls the camera's cooling circuits to reach set array temperature. Once that temperature has been achieved, the control loop locks to that temperature for stable and reproducible performance. When temperature lock has been achieved (i.e., the temperature is within 0.05°C of the configured value,) the current temperature is Locked. The on-screen indication allows easy verification of temperature lock.

The time required to achieve lock can vary widely depending on factors such as the camera type, CCD array type, ambient temperature, etc. Once lock has been achieved, focusing can begin. However, Teledyne Princeton Instruments recommends waiting an additional twenty minutes before taking quantitative data so that the system has time to achieve optimum thermal stability.

The deepest operating temperature for a system depends on the CCD array size and packaging. Refer to [Table A-2](#) on page 94 for typical deepest cooling temperatures.

5.5.4 Dark Charge

Dark charge, or dark current, is the thermally induced buildup of charge in the CCD over time. The statistical noise associated with this charge is known as dark noise. Dark charge values vary widely from one CCD array to another and are exponentially temperature dependent. In the case of cameras with MPP type arrays, the average dark charge is extremely small. Dark charge effect is more pronounced in cameras having a non-MPP array such as deep-depletion devices.

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

**NOTE:**

Do not be concerned about the DC level of this background. What you see is not noise. It is a fully subtractable bias pattern. Simply acquire and save a dark charge "background image" under conditions identical to those used to acquire the "actual" image. Subtracting the background image from the actual image will significantly reduce dark-charge effects.

**CAUTION!**

If a sudden change in the baseline signal is observed, there may be excessive humidity in the camera vacuum enclosure. Turn off the camera and contact Teledyne Princeton Instruments Customer Support. Refer to [Contact Information](#) on page 116 for complete information.

5.5.5 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 shorter exposure is recommended with signal averaging to enhance S/N (Signal-to-Noise ratio) accomplished through the software.

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

5.6 Readout

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

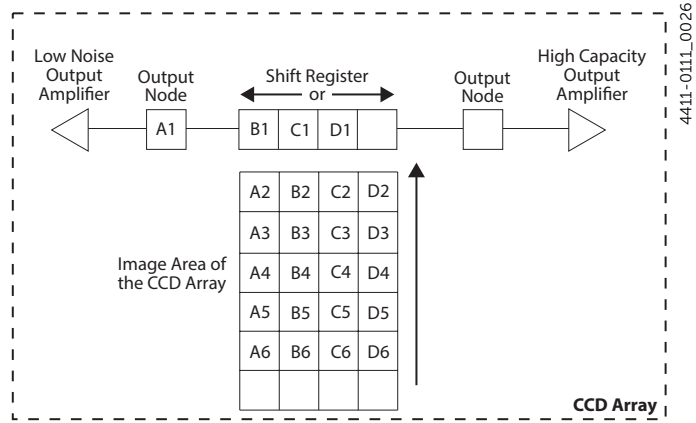


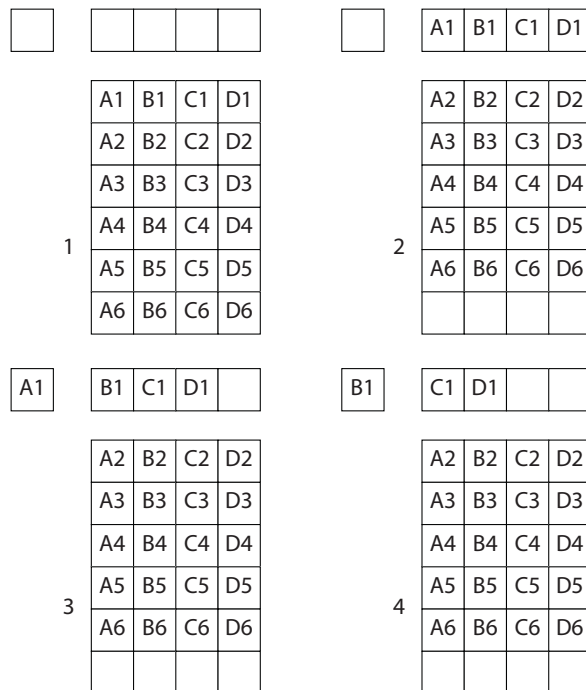
Figure 5-11: CCD with a Dual Output Amplifier

WinX and LightField allow the type of readout (i.e., full frame or binned,) the output amplifier, and gain (i.e., the number of electrons required to generate an ADU,) to be specified.

5.6.1 Full Frame Readout

The upper left section of Figure 5-12 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 describes readout at full resolution, where every pixel is digitized separately.

Figure 5-12: Full Frame at Full Resolution



NOTE: PIXIS-XO cameras offer the choice of amplifier (i.e., low noise or high capacity.) Depending on the selected amplifier, the shift register may be read out to the right or to the left. This drawing shows the readout to the left.

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

After the first row has been moved into the shift register, the charge now in the shift register is shifted toward the output node, located at one end of the shift register. As each value is "emptied" into this node it is digitized. Only after all pixels in the first 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 has been shifted out of each pixel the remaining charge is zero, meaning that the array is immediately ready for the next exposure.

The equations that determine the rate at which the CCD is read out are described below.

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

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

where:

- t_R is the CCD readout time,
- t_{exp} is the exposure time, and
- t_c is the shutter compensation time.

The readout time, t_R , is approximated by:

$$(2) \quad t_R = [N_x \cdot N_y(t_{\text{sr}} + t_v)] + (N_x \cdot t_i)$$

where:

- t_R is the CCD readout time;
- N_x is the smaller dimension of the CCD;
- N_y is the larger dimension of the CCD;
- t_{sr} is the time needed to shift one pixel out of the shift register;
- t_v is the time needed to digitize a pixel;
- t_i is the time needed to shift one line into the shift register.

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

5.6.2 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.

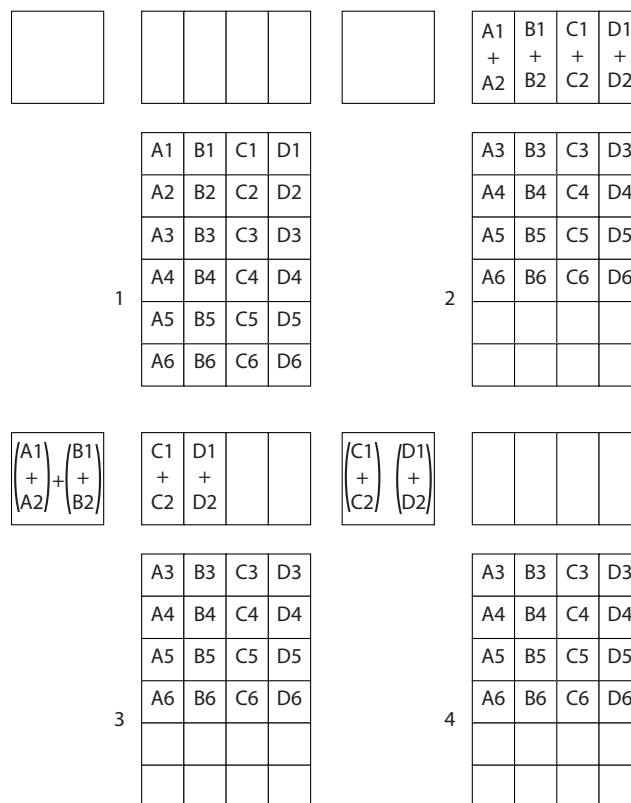
5.6.2.1 Hardware Binning

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

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

Figure 5-13 shows an example of 2 x 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. 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 5-13: 2 x 2 Binning



4411-0111_0028

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

$$(3) \quad t_R - \left[N_x \cdot N_y \cdot \left(\frac{t_{sr}}{n} + \frac{t_v}{n^2} \right) \right] + (N_x \cdot t_i)$$

where:

- t_R is the CCD readout time;
- N_x is the smaller dimension of the CCD;
- N_y is the larger dimension of the CCD;
- n is the number of pixels being binned;
- t_{sr} is the time needed to shift one pixel out of the shift register;
- t_v is the time needed to digitize a pixel;
- t_i is the time needed to shift one line into the shift register.

5.6.2.2 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 corrupted.

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.

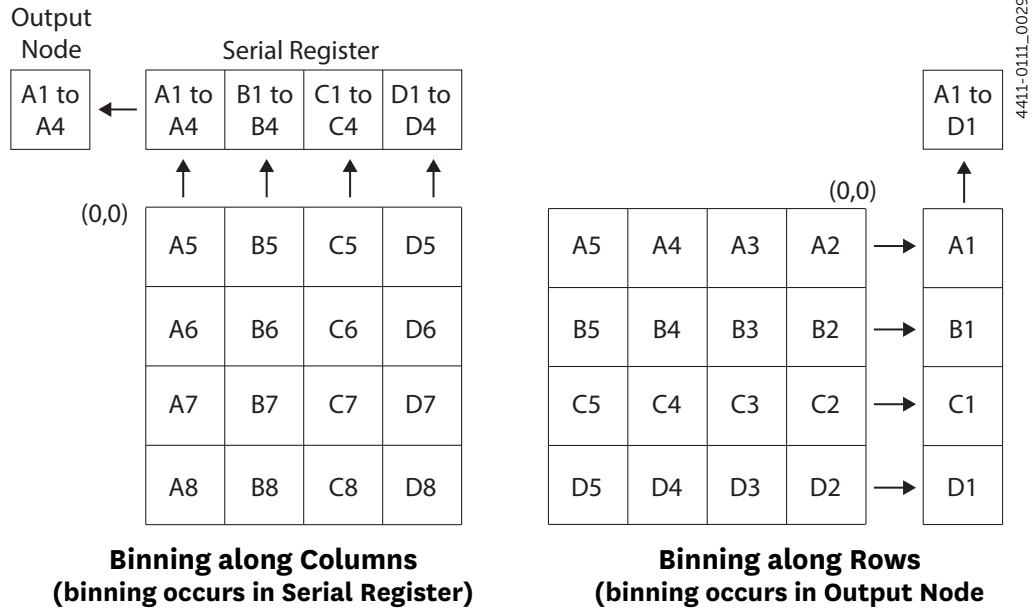
5.6.2.3 Array Orientation

For square format CCDs (e.g., 512 × 512B or 1024 × 1024F/B,) the CCD may be oriented to achieve binning along either direction of the CCD.

- Binning along columns provides maximum scan rate.
- Binning along the rows minimizes crosstalk and is therefore better for multi-spectral applications.

See [Figure 5-14](#).

Figure 5-14: Effect Array Orientation Has on Binning



NOTE:

Switching between these orientations is easily achieved by rotating the camera 90° and changing the binning parameters within the application software.

5.6.3 Output Amplifier {Quality} Selection

The output amplifier amplifies the collected charge from the output node and outputs it as electrons/count. Although [Figure 5-11](#) shows an array with two output nodes and amplifiers (i.e., one set at each end of the shift register,) some PIXIS-XO systems are available with a single output node and amplifier. If the system has two output amplifiers, the output amplifier to be used (i.e., High Capacity or Low Noise,) can be selected via the Acquisition ► Experiment Setup... ► ADC tab {Quality on the Analog to Digital Conversion expander}.

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

**NOTE:**

The selection of Output Amplifier {Quality} and Controller Gain {Analog Gain} setting should be considered together for the best signal capture. Examples of the relationship between output amplifier and controller gain selections are illustrated in [Table 5-1](#) on page 58.

5.6.4 Controller Gain

Controller gain, a function of the preamplifier, is software-selectable and is used to change the relationship between the number of electrons acquired on the CCD and the Analog-to-Digital Units (ADUs or counts) generated. Selecting the amount of gain is done on the Acquisition ► Experiment Setup... ► ADC tab {Analog to Digital Conversion expander}. Available selections are:

- 1 {Low};
Users who measure high-level signals may opt to select Low to allow the digitization of larger signals.
- 2 {Medium};
Medium is suitable for experiments within the mid-level intensity range.
- 3 {High}.
Users who consistently measure low-level signals may wish to select High, which requires fewer electrons to generate an ADU and reduces some sources of noise.

**NOTE:**

The Certificate of Performance provided with the camera provides measured gain values for all settings.

Example

This example assumes:

- The Low Noise Readout Port has been selected.
- The actual incoming light level is identical for all three instances.

**NOTE:**

The numbers used illustrate the effect of changing a controller gain setting and may not reflect actual performance.

Amount of gain for the three settings (i.e., 1, 2, and 3,) is CCD dependent.

[Table 5-1](#) lists typical controller gain values associated with each readout port.

Table 5-1: Controller Gain {Analog Gain} versus Readout Port

Readout Port {Quality}	Controller Gain {Analog Gain} Selection		
	1 {Low}	2 {Medium}	3 {High}
Low Noise	4 e ⁻ /count	2 e ⁻ /count	1 e ⁻ /count
High Capacity	16 e ⁻ /count	8 e ⁻ /count	4 e ⁻ /count

When using the Low Noise readout port, typical, corresponding gain settings are:

- **1 {Low}**
Requires four electrons to generate one ADU.
Strong signals can be acquired without flooding the CCD array. If the gain is set to Low and acquired images or spectra appear weak, change the gain setting to Medium or High.
- **2 {Medium}**
Requires two electrons to generate one ADU.
 - If the gain is set to Medium and acquired images or spectra do not appear to take up the full dynamic range of the CCD array, try changing the gain setting to High.
 - If the CCD array appears to be flooded with light, try changing the setting to Low.
- **3 {High}**
Requires one electron to generate one ADU and some noise sources are reduced.
Since fewer electrons are required to generate an ADU, weaker signals can be more readily detected. Lower noise further enhances the ability to acquire weak signals. If the CCD array appears to be flooded with light, change the setting to Medium or Low.

5.7 Digitization (Rate)

After gain has been applied to the signal, the Analog-to-Digital Converter (ADC) converts that analog information (continuous waveform) 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 [Section 5.6, Readout](#), on page 52.

Factors associated with digitization include the digitization rate and baseline offset. The speed at which digitization occurs is software-selectable, but baseline offset is factory-set. These factors are discussed in the following sections.

5.7.1 Digitization Rate {Speed}

PIXIS-XO cameras incorporate dual digitization (i.e., 100 kHz and 2 MHz,) which means that there is a choice of how quickly the data will be digitized. Dual digitization provides optimum signal-to-noise ratios at both readout speeds. Because the readout noise of CCD arrays increases with the readout rate, it is sometimes necessary to trade off readout speed for high dynamic range. The 2 MHz conversion speed is used for the fastest possible data collection, while the 100 kHz conversion speed is used where noise performance is the primary concern. Switching between the conversion speeds is completely under software control for total experiment automation.

**NOTE:**

Within WinX, the ADC rate can be changed on the Experiment Setup ► ADC tab.

Within LightField, the speed is changed on the Analog-Digital Conversion expander.

5.7.2 ADC Offset (Bias)

With the camera completely blocked, the CCD will collect a dark charge pattern that is dependent on the exposure time and camera temperature. The longer the exposure time and the warmer the camera, the larger this background will appear. To minimize the amount of this signal that becomes digitized, the baseline has been offset by adding a voltage to the signal to bring the A/D output to a non-zero value, typically 500-600 counts. This offset value ensures that the true variation in the signal can actually 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 500-600 counts lower.

**NOTE:**

It is important to note that the bias level is not noise. It is a fully subtractable readout pattern. Every device has been thoroughly tested to ensure its compliance with Teledyne Princeton Instruments' demanding specifications.

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Chapter 6: Advanced Topics

Previous chapters discussed the configuration of hardware and software for basic operation. This chapter discusses the following topics associated with experiment synchronization:

- **Timing Modes**
Describes Timing Modes {Trigger Response}, Shutter Control {Shutter Mode}, and Edge Trigger. Also included in this section is a description of the EXT SYNC connector, the input connector for a trigger pulse.
- **Fast and Safe Modes**
Describes Fast and Safe modes. Fast is used for real-time data acquisition. Safe is used in WinX when coordinating acquisition with external devices or when the computer speed is not fast enough to keep pace with the acquisition rate.
- **LOGIC OUT Control**
Describes the EXT SYNC and LOGIC OUT output connectors on the rear of the PIXIS-XO. The levels at this connector can be used to monitor camera operation or synchronize external equipment.
- **Kinetics Mode**
Describes how to set up and acquire data using Kinetics Mode which allows full-frame CCDs to take time-resolved images/spectra.



NOTE:

Full-frame CCDs require mechanical or optical masking of the CCD array.

- **Custom Modes**
Describes Custom Chip {Custom Sensor} and Custom Timing modes. These modes allow an active sub-area of the CCD array and/or a faster vertical shift rate to be specified for the purpose of increased frame rate (pixels outside of the area are not read.) Custom Chip {Custom Sensor} mode requires mechanical or optical masking of the array to prevent smearing.

Depending on the data acquisition software being used, experiment synchronization parameters are located as follows:

- When using WinX, parameters are found on the Experiment Setup ► Timing tab.
- When using LightField, parameters are found on the Trigger and Shutter expanders.

6.1 Timing Modes

Basic PIXIS-XO timing modes are:

- Free Run {No Response};
- External Sync {Readout Per Trigger};
- External Sync {Readout Per Trigger} with Continuous Cleans {Clean Until Trigger}.

These timing modes are combined with the Shutter options to provide the widest variety of timing modes for precision experiment synchronization. Refer to [Table 6-1](#) for additional information about camera timing modes.

Table 6-1: Camera Timing Modes

Mode	Shutter Condition
Free Run {No Response}	Normal
External Sync {Readout Per Trigger}	Normal
External Sync{Readout Per Trigger}	PreOpen {Open Before Trigger}
External Sync {Readout Per Trigger} with Continuous Cleans {Clean Until Trigger}	Normal
External Sync {Readout Per Trigger} with Continuous Cleans {Clean Until Trigger}	PreOpen {Open Before Trigger}



NOTE:

Since PIXIS-XO cameras do not use shutters, the Shutter Type selection on the Hardware Setup ► Controller/Camera tab should be set to None.

The shutter options available include:

- Normal;
- Disable Opened {Always Open}
When selected, the shutter will not operate during the experiment and remains in the open position.
- Disable Closed {Always Closed}
When selected, the shutter will not operate during the experiment and remains in the closed position. This option is useful when making dark charge measurements.
- PreOpen {Open Before Trigger}
When selected, the shutter opens as soon as the PIXIS-XO 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.
This option is available with the following Timing {Trigger Response} modes:
 - External Sync {Readout Per Trigger};
 - External Sync {Readout Per Trigger} with Continuous Cleans {Clean Until Trigger}.

The shutter timing is shown in the timing diagrams provided in the following sections. Except for Free Run {No Response}, 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). Exposure time and readout are discussed in greater detail in [Chapter 5, Operation](#).



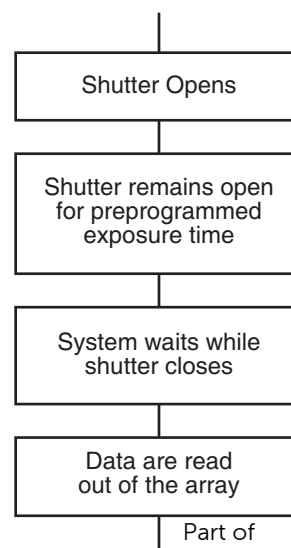
NOTE:

If no shutter has been selected within the software, the shutter compensation time (i.e., the time required to close a mechanical shutter,) will be approximately 0 ms.

6.1.1 Free Run {No Response}

In Free Run {No Response} mode the camera does not synchronize with the experiment in any way. The shutter opens as soon as the previous readout has been completed, 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, an X-ray source, or a DC lamp. Other experiments that can utilize this mode include 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.

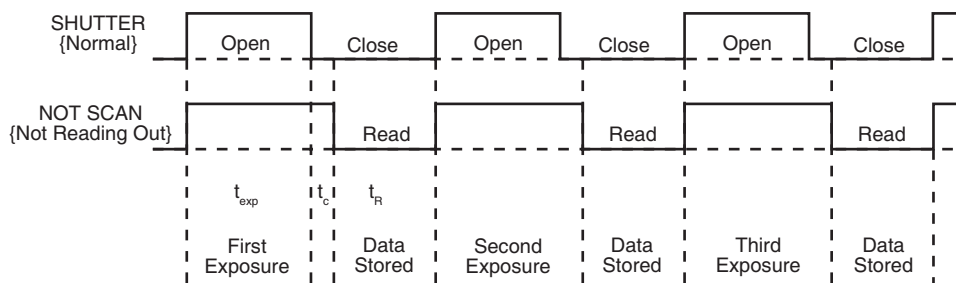
Other experimental equipment can be synchronized to the camera by using the software-selectable output signal SHUTTER {Normal} or NOT SCAN {Not Reading Out} on the Hardware Setup ► Controller Camera tab {Trigger/Shutter expander} from the LOGIC OUT connector. Shutter operation and the NOT SCAN {Not Reading Out} output signal are illustrated in [Figure 6-2](#).



4411-0111_0030

Figure 6-1: Free Run {No Response} Timing Flow Chart

Figure 6-2: Timing Diagram: Free Run {No Response}



4411-0111_0031

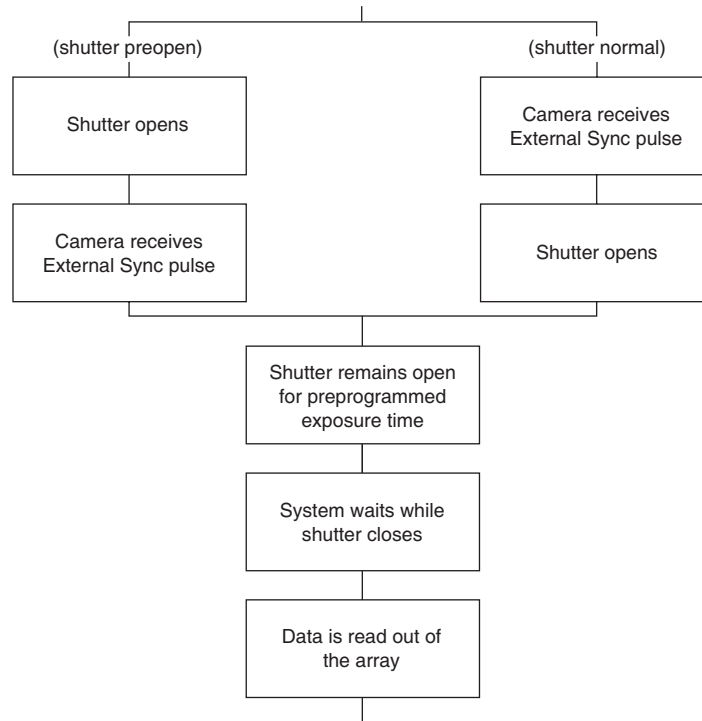
t_{exp} = Exposure Time
 t_R = Readout Time
 t_c = Shutter Compensation Time * {Closing Delay}

Shutter Type	*Shutter Compensation Time {Closing Delay}
Custom	0 - 21 seconds 0 - 21,000 ms, in 1 ms increments

6.1.2 External Sync {Readout Per Trigger}

In this mode all exposures are synchronized with an external source. As illustrated in [Figure 6-3](#), this mode can be used in combination with Normal or PreOpen {Open Before Trigger} shutter operation. In Normal Shutter {Normal} mode, the camera waits for an External Sync pulse and then opens the shutter for the programmed exposure period. As soon as the exposure is complete, the shutter closes and the CCD array is read out. The shutter requires up to 8 ms or more to open completely, depending on the shutter model.

Figure 6-3: Flowchart: Two External Sync Timing Options



4411-0111_0032

External synchronization depends on an edge trigger (negative- or positive-edge) which must be supplied to the Ext Sync connector on the back of the camera. The type of edge must be identified in the application software to ensure that the shutter opening is initiated by the correct edge:

- Within WinX, this is specified on the Experiment Setup ► Timing tab;
- Within LightField, this is specified on the Trigger/Shutter expander.

Since the shutter requires up to 8 ms to fully open, the External Sync pulse provided by the experiment must precede the actual signal by at least that much time. If not, the shutter will not be open for the duration of the entire signal, or the signal may be missed completely.

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

In the PreOpen {Open Before Trigger} mode, shutter operation is only partially synchronized with the experiment. As soon as the camera is ready to collect data, the shutter opens. Upon arrival of the first External Sync pulse at the Ext Sync connector, 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.

The PreOpen {Open Before Trigger} mode is useful in applications where an External Sync pulse cannot be provided 8 ms (or the length of time a mechanical shutter takes to open) before the actual signal occurs. The primary drawback is that the CCD is exposed to ambient light while the shutter is open between frames. If this ambient light is constant and triggers occur at regular intervals, this background can be subtracted provided it does not saturate the CCD. As with the Normal Shutter {Normal} mode, accurate background subtraction may not be possible for the first frame.

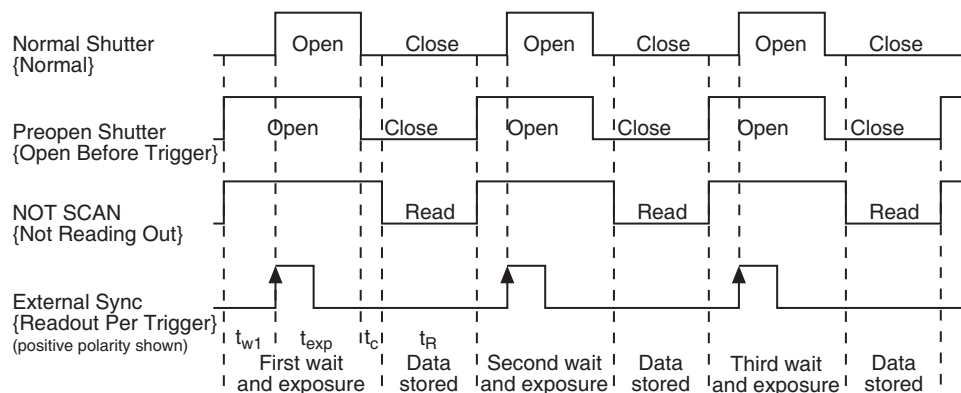
Also note that, in addition to signal from ambient light, dark charge accumulates during the wait time (t_w). Any variation in the external sync frequency also affects the amount of dark charge, even if light is not falling on the CCD during this time.



NOTE:

If EXT SYNC remains active at the end of the readout, the hardware may interpret this as a second sync pulse, and so on. In [Figure 6-4](#), EXT Sync is active when it is HIGH/Logic 1.

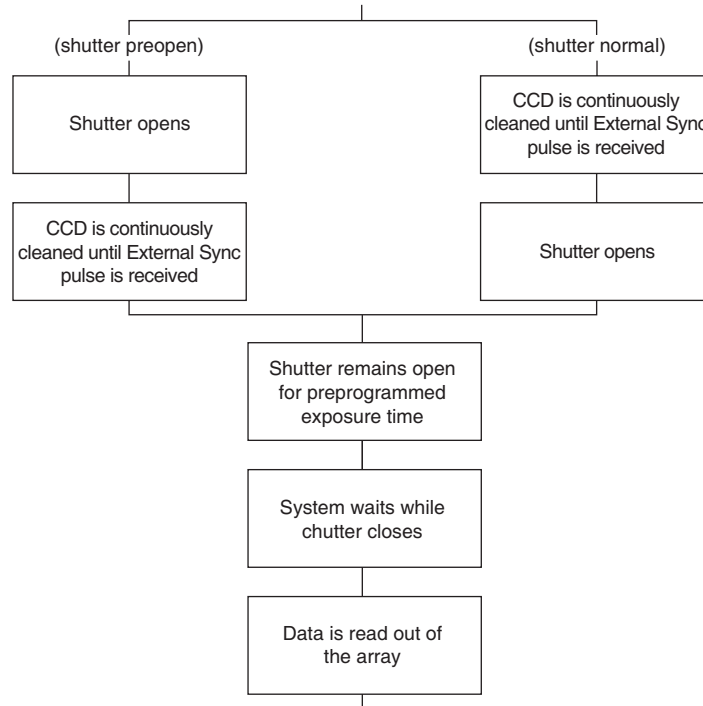
Figure 6-4: Timing Diagram: External Sync Mode (Positive-Edge Trigger)



6.1.3 External Sync with Continuous Cleans {Clean Until Trigger} Timing

Another timing mode available with the PIXIS-XO is called Continuous Cleans {Clean Until Trigger}. In addition to the standard cleaning of the array which occurs after the camera has been enabled, this mode removes any charge from the array until the moment the External Sync pulse trigger edge is received. As shown in Figure 6-5, this mode can also be used in combination with Normal or PreOpen {Open Before Trigger} shutter operation.

Figure 6-5: Flowchart: Continuous Cleans {Clean Until Trigger}



4411-0111_0034

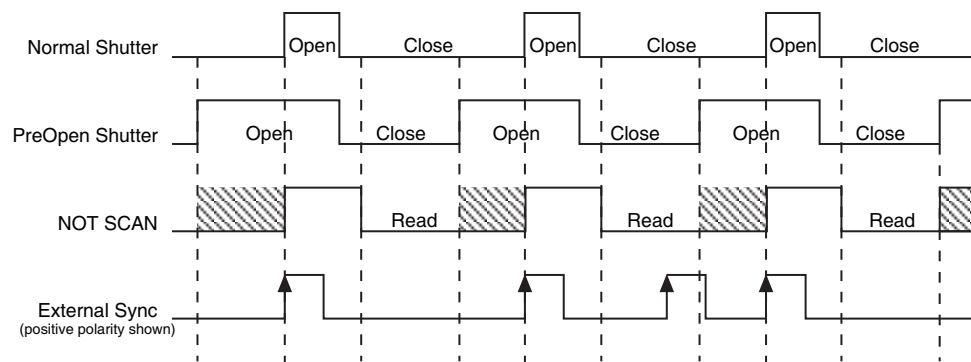
Once the External Sync pulse trigger edge is received, cleaning of the array stops as soon as the current row is shifted, and frame collection begins. A delay of up to one row shift can be expected. With Normal Shutter {Normal} operation the shutter is opened for the set exposure time. With PreOpen Shutter {Open Before Trigger} operation, the shutter is open during the Continuous Cleaning {Clean Until Trigger}. Once the External Sync pulse trigger edge has been received, the shutter then remains open for the set exposure time and then closes. If the vertical rows are shifted midway when the External Sync pulse trigger edge arrives, the pulse is saved until row shifting has been completed to prevent the CCD from becoming "out of step." As expected, the response latency is on the order of one vertical shift time (i.e., ~1-30 μ s, depending on the array.) This latency does not prevent the incoming signal from being detected since photo-generated electrons continue to be collected over the entire active area. However, if the signal arrival is coincident with the vertical shifting, image smearing of up to one pixel is possible. The amount of smearing is a function of the signal duration compared to the single vertical shift time.



NOTE:

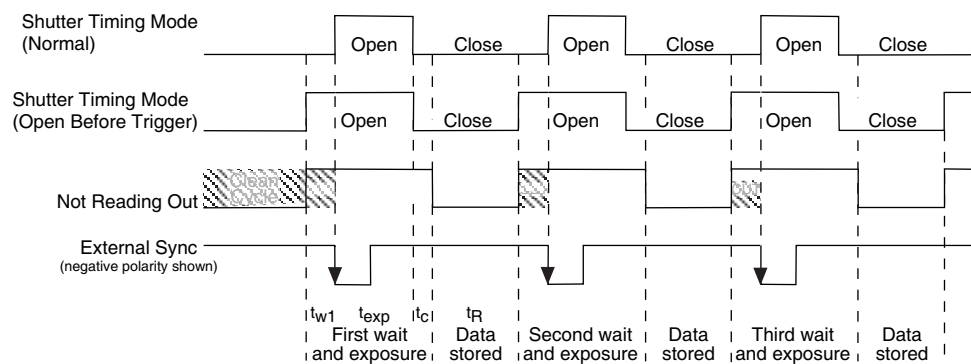
If EXT SYNC remains active at the end of the readout, the hardware may interpret this as a second sync pulse, and so on. In Figure 6-6, EXT Sync is active when it is HIGH/Logic 1.

Figure 6-6: Timing Diagram: WinX Continuous Cleans



4411-0111_0035

Figure 6-7: Timing Diagram: LightField Clean Until Trigger (CUT)



4411-0111_0036

6.1.4 EXT SYNC Trigger Input

The selected Timing Mode {Trigger Response} determines how the camera will respond to an External Sync pulse that is input at the EXT SYNC connector on the rear of the camera. Things to keep in mind when setting up the External Sync pulse input are:

- Pulse Height
0 to +3.3 V_{DC} TTL-compatible logic levels.
- Pulse Width
Trigger edge frequency
The time between trigger edges.
- EXT SYNC Connector Impedance
High impedance.
- Trigger Edge {Polarity}
+ (rising) or - (falling) edge must be indicated on the Experiment Setup ► Timing tab {Trigger/Shutter expander}.

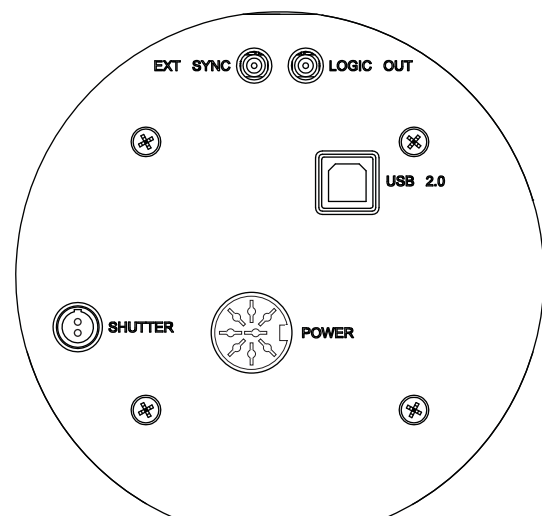


Figure 6-8: Rear Panel: PIXIS-XO Camera

4411-0111_0003

6.2 Fast and Safe Modes

The PIXIS-XO has been designed to allow the greatest possible flexibility when synchronizing data collection with an experiment. The fundamental difference between Fast and Safe modes is how often the acquisition start and acquisition stop commands are sent by the computer for a data collection sequence.

- In Safe Mode, the computer sends a start and a stop command for each frame of a data sequence.
- In Fast Mode, the computer sends only one start and one stop command for each data sequence.

Once a start command has been sent, the selected timing mode, in combination with the shutter condition, determines when charge will be allowed to fall on the CCD array.

In WinX, the choice of Fast or Safe data collection is configured on the Experiment Setup ► Timing tab. The flowcharts in [Figure 6-9](#) on page 70 illustrate the differences between the two modes.



NOTE:

LightField always uses Fast Mode.

6.2.1 Fast Mode (WinX and LightField)

In Fast operation, the PIXIS-XO runs according to the timing of the experiment, with no interruptions from the computer. Fast operation is primarily for collecting “real-time” sequences of experimental data, where timing is critical and events cannot be missed. Once the PIXIS-XO is sent the start command by the computer, all frames are collected without further intervention from the computer. The advantage of this timing mode is that timing is controlled completely through hardware. A drawback to this mode is that the computer will only display frames when it is not performing other tasks. Image display has a lower priority, so the image on the screen may lag several images behind. A second drawback is that a data overrun may occur if the number of images collected exceeds the amount of allocated RAM or if the computer cannot keep up with the data rate.



NOTE:

LightField always uses Fast Mode.

6.2.2 Safe Mode (WinX only)

Safe Mode operation is useful when the camera is operated from a slower computer that cannot process incoming data quickly enough. It is also useful when data collection must be coordinated with external devices such as external shutters and filter wheels. As shown in [Figure 6-9](#) on page 70, when operating in Safe Mode the computer controls when each frame is taken. After each frame has been received, the camera sends a Stop Acquisition command to the camera, instructing it to stop data acquisition. Once the current frame has been completely processed and displayed, another Start Acquisition command is issued from the computer to the camera, allowing it to capture the next frame. Display is therefore, at most, only one frame behind the actual data collection. One disadvantage of Safe mode is that events may be missed during the experiment since the PIXIS-XO is disabled for a short time following each frame.

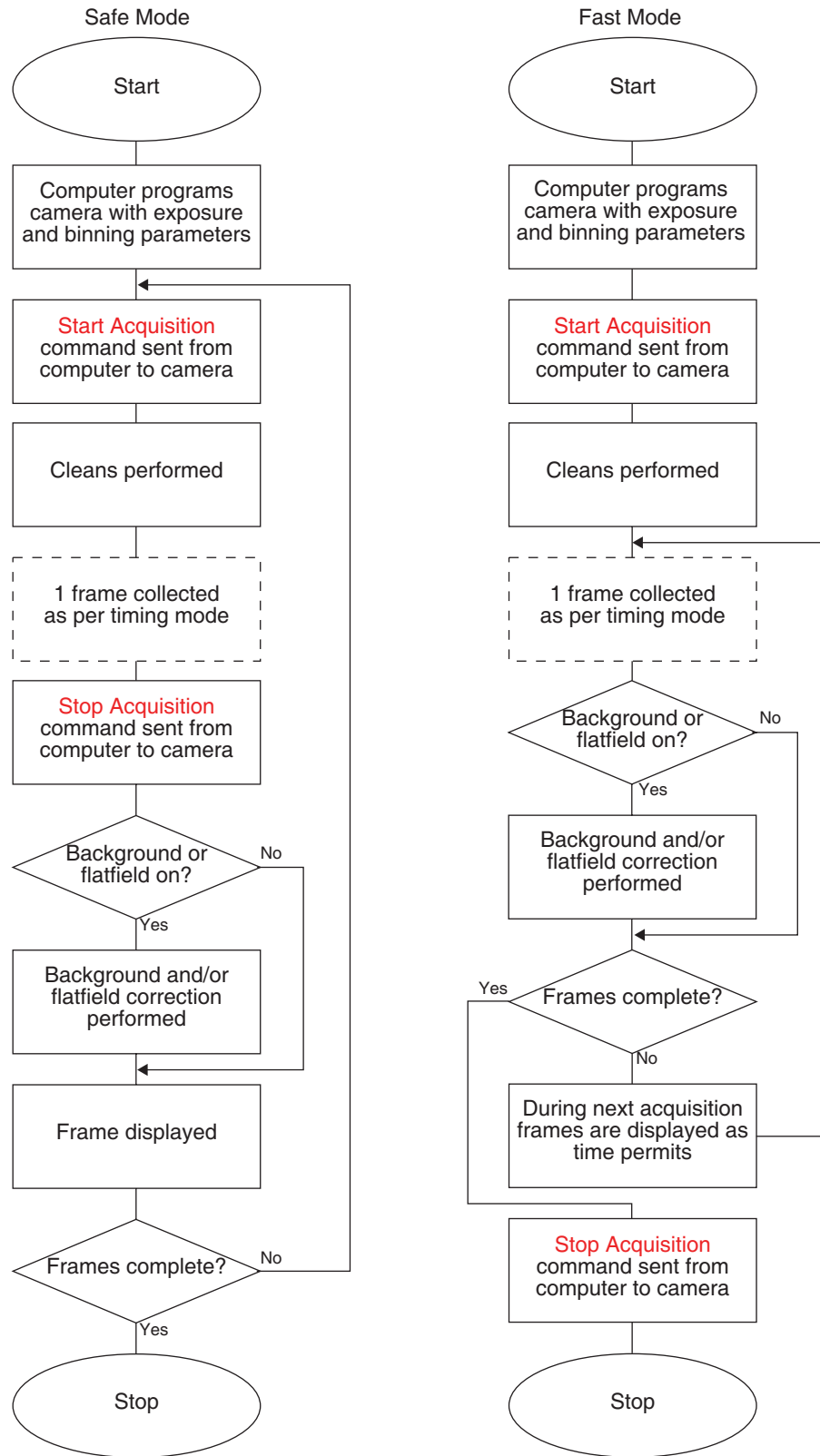


NOTE:

When running WinX, Safe Mode must be used whenever the system is configured for Kinetics Mode.

Refer to [Section 6.4, Kinetics Mode](#), on page 72 for additional information about this type of image acquisition and readout.

Figure 6-9: High-level Flow Chart of Safe and Fast Mode Operation

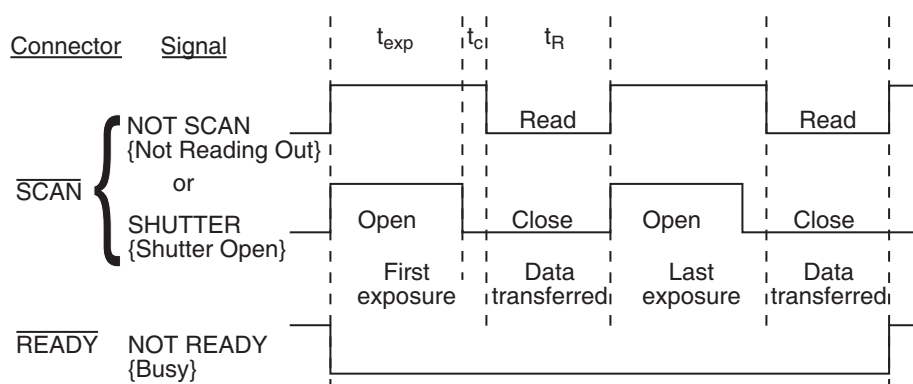


6.3 LOGIC OUT Control

The TTL-compatible logic level output (i.e., 0 to +3.3 V_{DC}) from the LOGIC OUT connector on the rear panel can be used to monitor camera status and control external devices. By default, the logic output level is high while the action is occurring. The timing of the level changes depends on the output type selected on the Hardware Setup ► Controller/Camera tab {Trigger/Shutter expander}:

- NOT SCAN {Not Reading Out}
At a logic low when CCD is being read. Otherwise high.
- SHUTTER {Shutter Open}
Logic high when the shutter is open. The output precisely brackets shutter-open time (exclusive of shutter compensation, t_c) and can be used to control an external shutter or to inhibit a pulser or timing generator.
- NOT READY {Busy}
After a Start Acquisition command, this output changes state upon completion of the array cleaning cycles that precede the first exposure. Initially high, it goes low to mark the beginning of the first exposure. In free run operation, it remains low until the system is halted. If a specific number of frames have been programmed, it remains low until all have been taken and then returns high. The timing diagram illustrated in [Figure 6-10](#) assumes three frames have been programmed.

Figure 6-10: Comparison of NOT SCAN {Not Reading Out}, SHUTTER {Shutter Open}, and NOT READY {Busy} Logic Output Levels



- LOGIC 0 {Always Low}
The level at the connector is low.
- LOGIC 1 {Always High}
The level at the connector is high.

6.4 Kinetics Mode

Kinetics mode uses the CCD to expose and store a limited number of images in rapid succession. The time it takes to shift each line (or row) on the CCD is as short as a few hundred nanoseconds to few microseconds, depending on the CCD. Therefore the time between images can be as short as a few microseconds. Kinetics mode allows full frame CCDs to take time-resolved images/spectra. Optical or mechanical masking of the array is required.

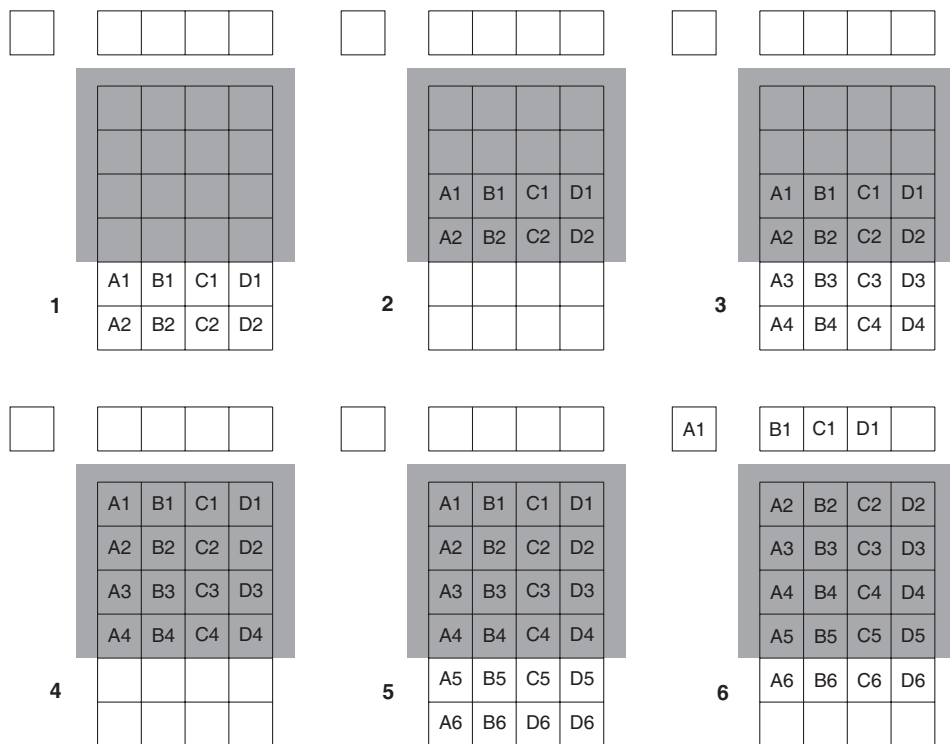


NOTE:

In WinX, if the Kinetics has been installed in the PIXIS-XO, this readout mode will be made available when you select the appropriate camera type on the Hardware Setup dialog.

Figure 6-11 is a simplified illustration of kinetics mode. Returning to the 4 × 6 CCD example, in this case 2/3 of the array is masked, either mechanically or optically, and there is a shutter (or other external device) controlling the exposure of the array to incoming X-rays. The shutter opens to expose a 4 × 2 region. While the shutter remains open, charge is quickly shifted just under the mask, and the exposure is repeated. After a third image has been acquired, the shutter is closed and the CCD is read out. Since the CCD can be read out slowly, very high dynamic range is achieved. Shifting and readout are shown in Figure 6-11.

Figure 6-11: Kinetics Readout



4411-0111_0039

6.4.1 Kinetic Timing Modes

Kinetics mode operates with three timing modes:

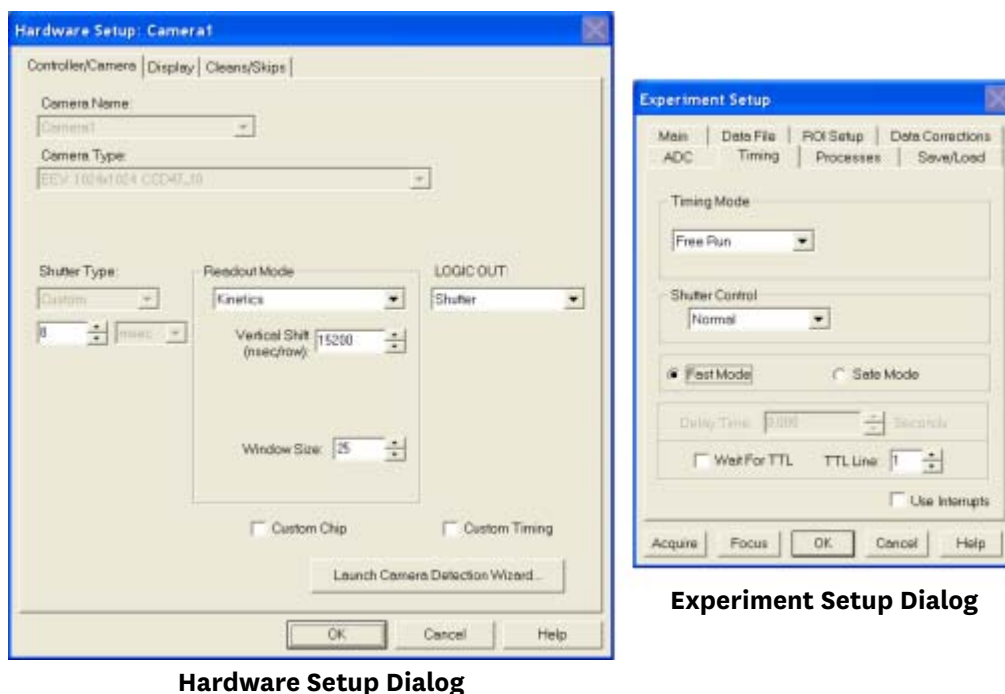
- Free Run {No Response}
Used for experiments that do not require any synchronization with the experiments.
- Single Trigger {Readout Per Trigger}
Requires an external TTL pulse be applied to the camera via the Ext Sync connector on the rear of the camera.
- Multiple Trigger {Shift Per Trigger}.
Requires an external TTL pulse be applied to the camera via the Ext Sync connector on the rear of the camera.

6.4.1.1 Free Run (Non-Triggered) Mode

In Free Run (No Response) Kinetics mode, the PIXIS-XO takes a series of images, each with the Exposure time configured through the software:

- In WinX, exposure time is configured on the Experiment Setup ► Main tab. See [Figure 6-12](#).
- In LightField, exposure time is configured on the Common Acquisition Settings expander. See [Figure 6-13](#).

Figure 6-12: Typical WinX Configuration Dialogs: Kinetics Readout

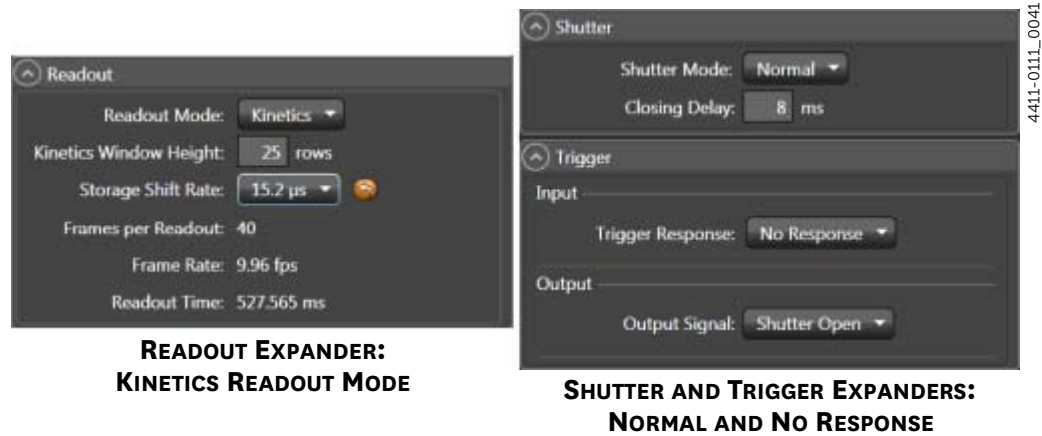


4411-0111_0040

Hardware Setup Dialog

Experiment Setup Dialog

Figure 6-13: Typical LightField Configuration Expanders: Kinetics Readout



The time between image frames, which may be as short as a few microseconds, is limited by the time required to shift an image under the mask. This time equals the Vertical Shift rate (specified in ns/row) multiplied by the Window Size (the number of rows allocated for an image frame.) The exact number of frames depends on the selected Window Size and is equal to the number of pixels perpendicular to the shift register divided by the Window Size.

Integrate signals (SHUTTER {Shutter Open}) or Readout signals (NOT SCAN {Not Reading Out}) are provided at the LOGIC OUT connector for timing measurements.

Example

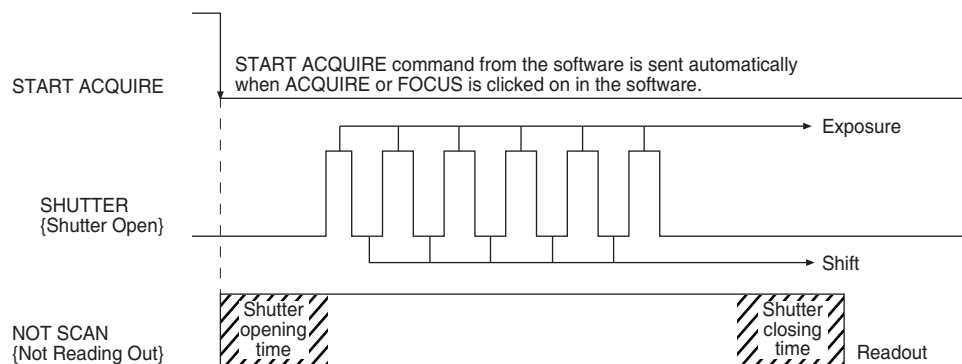


NOTE:

This example references the readout configuration illustrated in [Figure 6-11](#) on page 72.

In this example, there are 6 pixels perpendicular to the shift register, and the Window Size is 2 pixels high. The number of frames is 3. If the Vertical Shift rate for the CCD is 1600 ns/row, the Shift time is 3200 ns per frame.

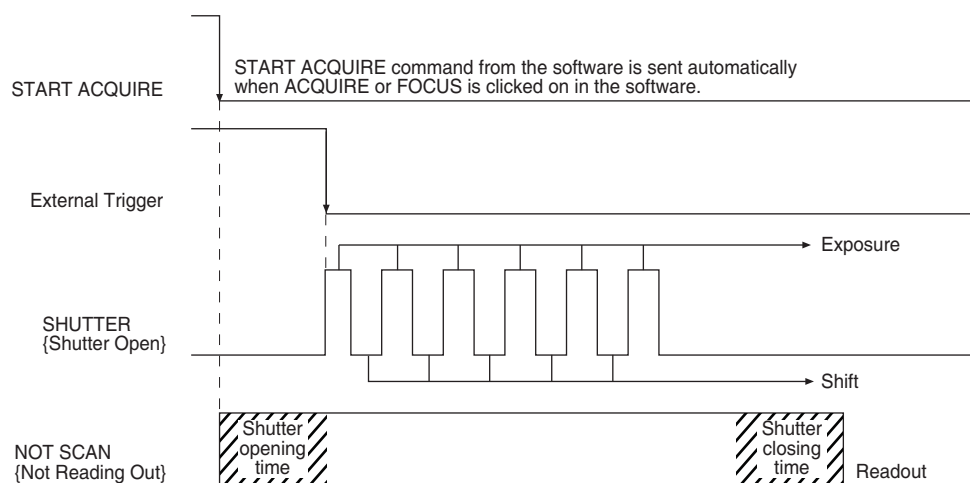
Figure 6-14: Timing Diagram: Free Run Mode



6.4.1.2 Single Trigger Mode

In single trigger mode, the camera requires only one trigger to initiate an entire series of “exposure-shift” cycles as shown in Figure 6-15. When Acquire or Focus {Run} is clicked, the shutter (if there is an external X-ray shutter) is opened and the camera uses the exposure time as entered in the software. The trigger is applied at the Ext Sync connector on the rear of the PIXIS-XO. After the series is complete, the shutter closes and the CCD is read out at normal speeds. Once the readout is complete, the camera is ready for the next series of exposures. This timing diagram is illustrated in Figure 6-15 where a single External trigger pulse is used to collect a burst of six frames.

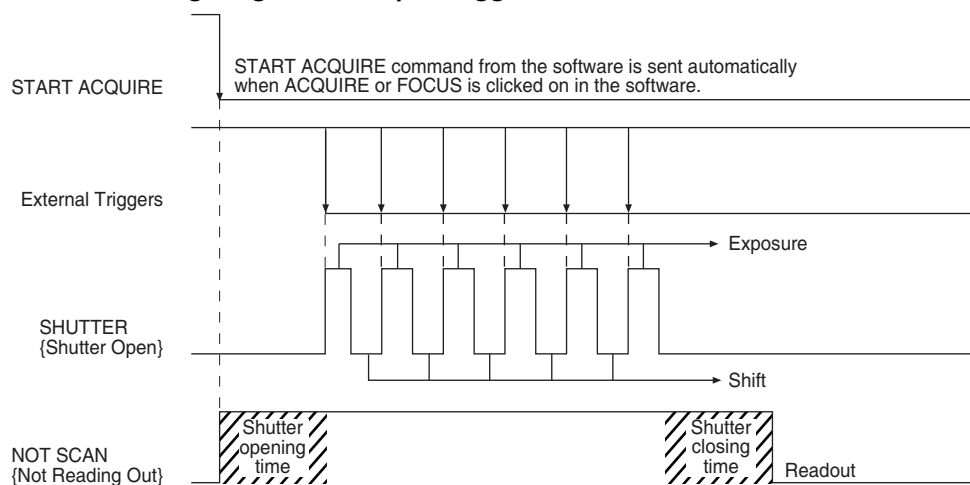
Figure 6-15: Timing Diagram: Single Trigger Mode



6.4.1.3 Multiple Trigger Mode

In multiple trigger mode, the shutter (if there is an external X-ray shutter) is opened when Acquire or Focus {Run} is clicked and each “exposure-shift” cycle in the acquisition is triggered independently by a pulse applied at the Ext Sync connector. This mode is useful when each sub-frame needs to be synchronized with a pulsed external light source such as a laser. Once the series is complete, the shutter closes and readout begins. Since the shutter is open during the entire series of images, irregularly spaced external pulses will result in exposures of different lengths. Once the series has been read out the camera is ready for the next series. This timing diagram is illustrated in Figure 6-16 where a series of six frames is collected with six External Sync pulses.

Figure 6-16: Timing Diagram: Multiple Trigger Mode



6.5 Custom Modes

The following custom modes are supported:

- Custom Chip and Custom Timing modes are available as an option for WinX applications.
- Custom Sensor and Custom Timing are both standard with LightField although their availability is dependent upon the specific sensor and readout mode.

These modes are intended to allow data acquisition at the fastest possible rates for a camera. Custom Chip {Custom Sensor} allows the apparent size of the CCD array to be reduced, while Custom Timing allows a faster vertical shift time to be selected.

6.5.1 Custom Chip {Custom Sensor}

Custom Chip {Custom Sensor} provides a third way of reducing Readout Time in addition to Binning and ROI. This feature allows the size of the CCD's active area to be redefined via software. Unlike selecting a smaller region of interest (ROI) which also involves reading out fewer pixels, this mode does not incur overhead from discarding or skipping the remaining rows. And, unlike both Binning and ROI, Custom Chip {Custom Sensor} relies on a form of array masking to ensure that no light falls outside the currently set active area.



NOTE:

Custom Chip is a WinX option.
Custom Sensor is standard with LightField although availability is sensor-dependent.

6.5.1.1 Software Settings

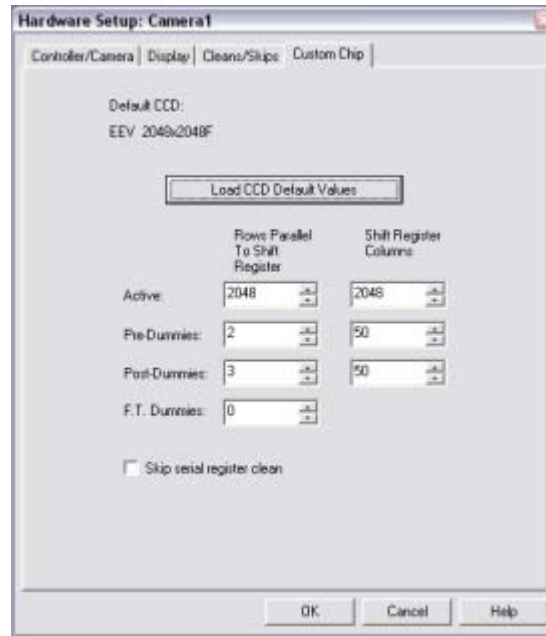


CAUTION!

Teledyne Princeton Instruments does not encourage users to change these parameter settings. For most applications, the default settings will provide the best results. It is strongly advised that the factory be contacted for guidance before customizing the chip definition.

In WinX, if Custom Chip has been installed, selecting the Show Custom Chip check box on the Controller/Camera tab adds the Custom Chip tab to the Hardware Setup dialog. See [Figure 6-17](#). The default values conform to the physical layout of the CCD array and are optimal for most measurements.

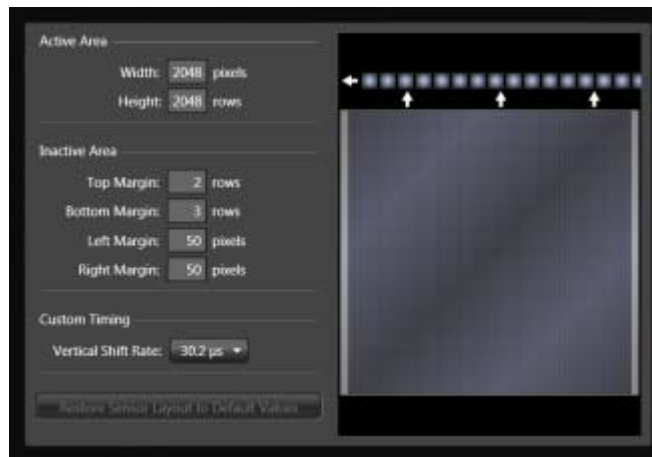
Figure 6-17: WinX: Custom Chip Tab



4411-0111_0045

In LightField, the Custom Sensor pane is accessed by opening the Sensor expander and clicking on the Custom Sensor button. See [Figure 6-18](#).

Figure 6-18: LightField: Sensor Pane



4411-0111_0046

By changing the values in the Active fields, image acquisition speed can be increased by reducing the size of the active area in the definition. The result will be faster but lower resolution data acquisition. Operating in this mode would ordinarily require that the chip be masked so that only the reduced active area is exposed, thus preventing unwanted charge from spilling into the active area or being transferred to the shift register.

By default, if there are no Pre-Dummy rows, the serial register will be cleared before rows are shifted. If the Skip Serial Register Clean box is selected when there are no Pre-Dummy rows, the register clean out will be skipped and the chip readout will be faster. This feature is not available for PVCAM-supported cameras.


NOTE:

In LightField, the Clean Serial Register function only appears in the Sensor Cleaning pane when the Inactive Area Top Margin has been set to 0 rows. Deselect the check box to deactivate the serial register cleaning.

6.5.2 Custom Timing

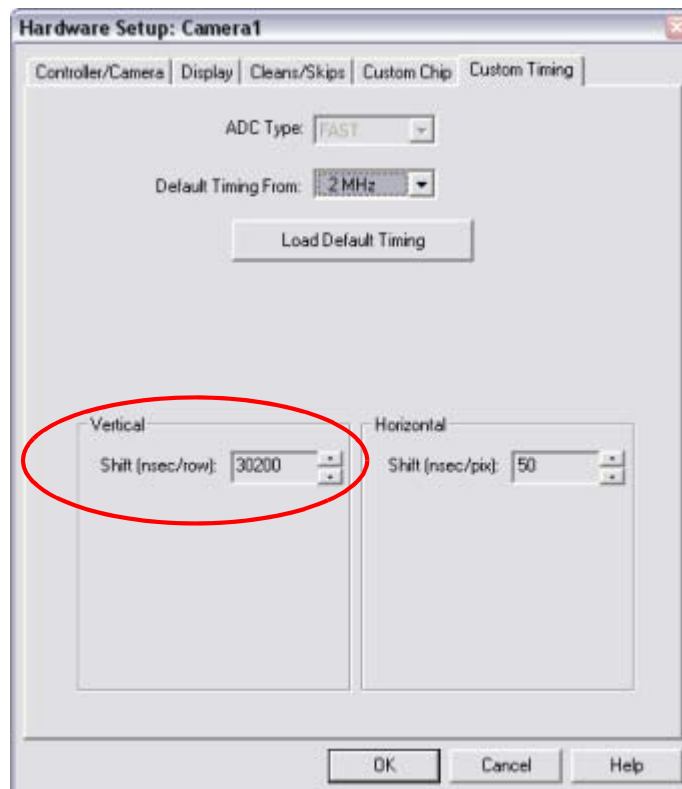
Vertical Shift rate is the time required to shift one row into the serial register. The smaller this value, the faster charge can be shifted up, one row at a time, toward the serial register.

In WinX, when the Custom Timing option is available and selected, Vertical Shift, in nsec/row, is configured on the Custom Timing tab found on the Hardware Setup dialog. See [Figure 6-19](#).


NOTE:

The Custom Timing option is fully supported by WinX versions 2.5.18.1 and later.

Figure 6-19: WinX: Custom Timing, Vertical Shift Configuration

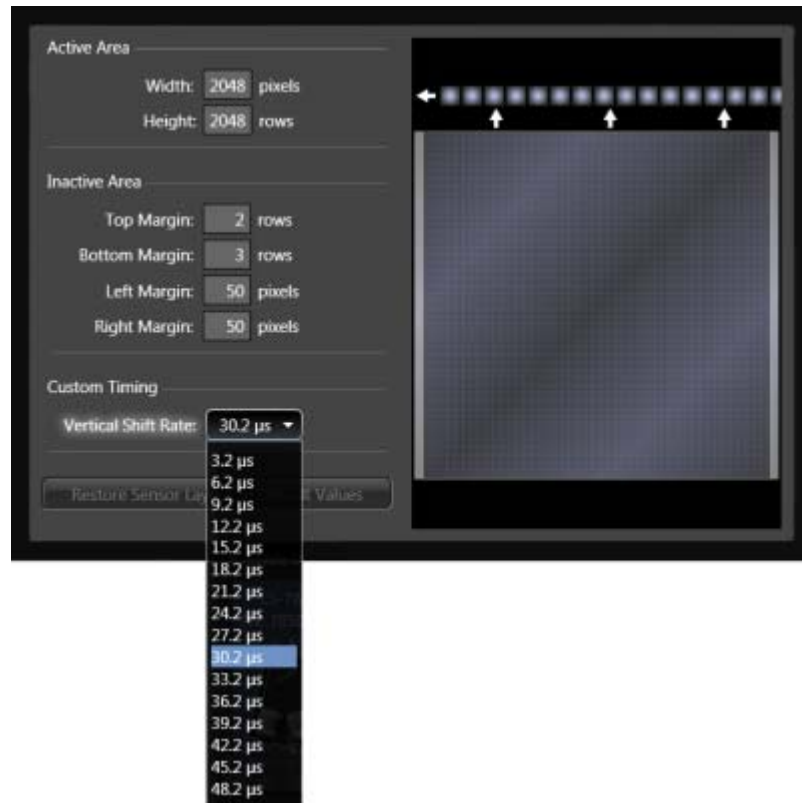


4411-0111_0048

In LightField, Custom Timing is accessed via the Custom Sensor button on the Sensor expander. Within the Custom Timing panel, select from among the listed vertical shift

rate choices. See [Figure 6-20](#).

Figure 6-20: LightField: Custom Timing Expander



NOTE:

Custom Timing is standard with LightField for full frame CCD cameras.

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Chapter 7: Troubleshooting



WARNING!

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

Recommended troubleshooting guidelines are available for many issues that may occur while working with a PIXIS-XO system. Refer to [Table 7-1](#) for additional information.

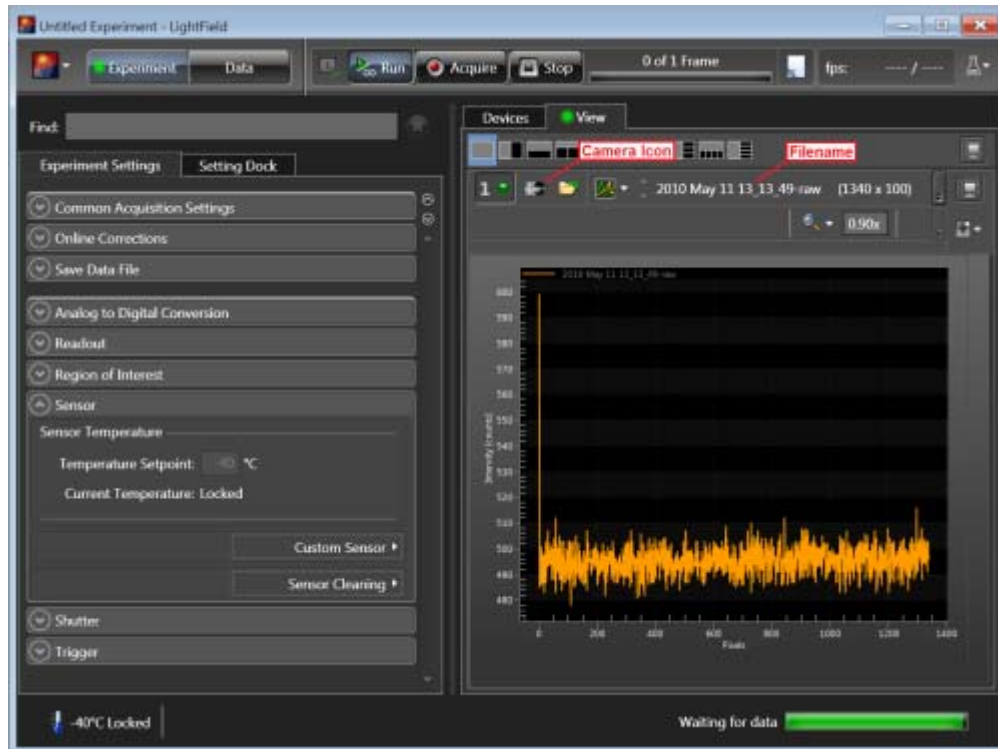
Table 7-1: Issues with Recommended Troubleshooting Guidelines

Issue	Refer to...
Acquisition Started but Viewer Contents Do Not Update	page 82
Baseline Signal Suddenly Changes	page 82
Camera Stops Working	page 82
Camera1 (or similar name) in Camera Name Field	page 83
Controller Is Not Responding	page 84
CoolCUBE_{II}: Low Coolant (Air in the Hoses)	page 84
Temperature Lock Cannot be Achieved or Maintained	page 86
Camera loses Temperature Lock	page 86
Gradual Deterioration of Cooling Capability	page 87
Data Loss or Serial Violation	page 87
Device is Occupied	page 87
Overexposed or Smeared Images	page 87
Shutter Failure	page 87
Vignetting	page 88
Data Overrun Due to Hardware Conflict	page 88
Data Overrun Has Occurred	page 89
Device Is Not Found	page 89
Error Creating Controller	page 90
Program Error	page 91
Serial Violations Error	page 92

7.1 Acquisition Started but Viewer Contents Do Not Update

In LightField, live data are normally displayed in the Experiment workspace viewer as it is being acquired (Preview or Acquire mode.) If the viewer is not being updated and acquisition is occurring, determine if there is a filename in the top row of the viewer. For example, in [Figure 7-1](#), the filename 2010 May 11 13_13_49.raw is displayed. If there is a filename, click on the camera icon. The file data will be cleared from the viewer and the live data will then be displayed.

Figure 7-1: Typical Acquisition Display



4411-0111_0049

7.2 Baseline Signal Suddenly Changes

A change in the baseline signal is normal if the temperature, gain, or speed setting has been changed. If this occurs when none of these settings have been changed, there may be excessive humidity in the camera vacuum enclosure. Turn off the camera and contact Teledyne Princeton Instruments Customer Support. Refer to [Contact Information](#) on page 116 for complete information.

7.3 Camera Stops Working

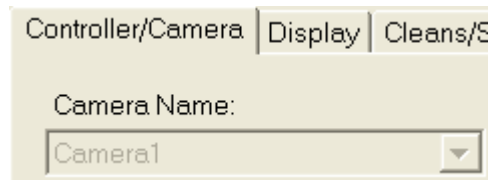
Problems with the host computer system or software may have side effects that appear to be hardware problems. If you are sure the problem is in the camera system hardware, perform the following simple system checks:

- Turn off all AC power.
- Verify that all cables are securely fastened.
- Turn the system on.

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

7.4 Camera1 (or similar name) in Camera Name Field

Figure 7-2: Camera1 in Camera Name Field



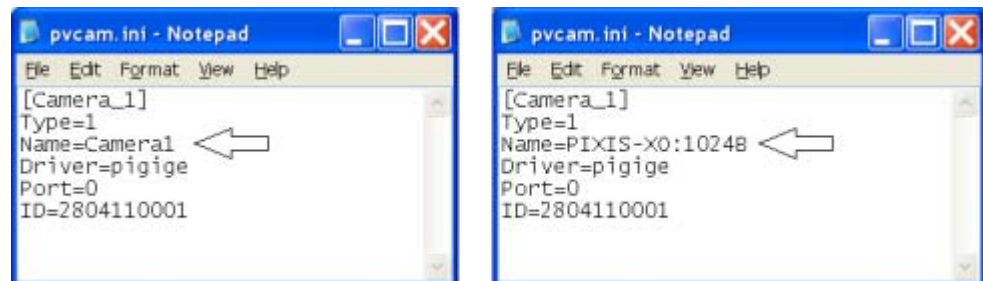
4411-0111_0050

When the Camera Detection Wizard installs a new camera, the camera is automatically named Camera#, where # = 1, 2, 3, ..., depending on the number of cameras that have been detected. This name appears in the Hardware Setup title bar and as the active camera on the Hardware Setup ► Controller/Camera tab. If desired, a more descriptive name can be assigned by editing the `PVCAM.INI` file which is located in the Windows directory. The new name will then be used by the system until the Camera Detection Wizard is run again.

Perform the following procedure to change the default Camera Name:

1. Close the application program if it is running.
2. Using Notepad (or another text editor,) open `PVCAM.INI` from the Windows directory.
3. Edit the Name. See [Figure 7-3](#).

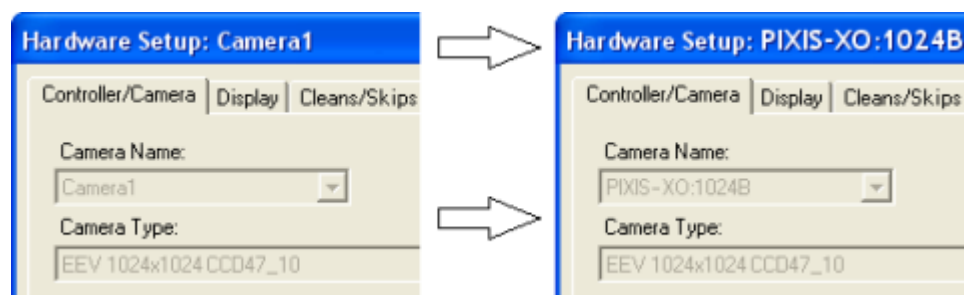
Figure 7-3: Editing Camera Name in a Text Editor



4411-0111_0051

4. Save the edited file.
5. The next time the WinX application is launched, the new name will be displayed on the Hardware Setup dialog. See [Figure 7-4](#).

Figure 7-4: Camera Names Displayed within the Hardware Setup Dialog



4411-0111_0052



NOTE:

If the Camera Detection Wizard is launched after renaming each camera, the default names will revert to Camera#.

7.5 Controller Is Not Responding

If this message is displayed when clicking OK after selecting the desired Interface Type during Hardware Setup (within the WinX Setup menu,) it indicates that the system has not been able to communicate with the camera. Verify that the camera has been turned ON and that the USB 2.0 interface card, its driver, and the USB cable have been installed.

- If the camera is ON, the problem may be with the USB 2 card, its driver, or the cable connections.
- If a USB 2 interface card has not been installed, close the WinX application program and turn the camera OFF. Follow the installation instructions provided with the interface card, and connect the card to the USB 2 port on the rear of the camera using an appropriate cable. Perform a Custom installation of WinX with the appropriate interface component selected. Be sure to deselect the interface component that does not apply to the system.
- If a USB 2 interface card has been installed in the host computer and is connected to the USB 2 port on the rear of the camera, close the application program and turn the camera OFF. Verify all cable connections.
- If the USB 2 interface card was installed after the application program had been installed, close the application program and do a Custom installation of WinX with the appropriate interface component selected. Be sure to deselect the interface component that does not apply to the system.

7.6 CoolCUBE_{II}: Low Coolant (Air in the Hoses)



WARNING!

If more than two inches (50.8 mm) of the coolant line is filled with air, the pump will stop working and may be damaged. If flow stops while the pump is on, turn off the CoolCUBE_{II} and add coolant.

Perform the following procedure to troubleshoot low coolant issues:

1. Unscrew the reservoir cap located on top of the CoolCUBE_{II} and verify that the coolant reservoir contains coolant. If additional coolant is required, add a 50:50 mixture of water and ethylene glycol to bring the coolant level up to the required level.
2. Screw the reservoir cap back in.
3. Verify the power switch is turned off before plugging in the circulator.
4. Plug the circulator into a 100-240 V_{AC}, 47-63 Hz power source.

5. Turn the circulator on. Verify there are no leaks or air bubbles in the hoses.

**NOTE:**

Small air bubbles, approximately the size of bubbles in soda, are common in the CoolCUBE_{II}, particularly immediately following startup. These bubbles do not prevent proper operation.

- If there are no problems, proceed to step 6.
 - If there are leaks or air bubbles, turn the circulator off and correct the problem(s) by securing the hoses or adding more coolant to the reservoir. Turn the circulator back on. Recheck and if there are no problems, proceed to step 6.
6. Turn the camera on.
 7. Start the application software.

7.7 Cooling Troubleshooting

This section provides recommended troubleshooting guidelines for cooling-related issues.

7.7.1 Temperature Lock Cannot be Achieved or Maintained

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

- Ambient temperature greater than +23°C. This condition affects TE-cooled cameras. If ambient is greater than +23°C, you will need to cool the camera environment or raise the set temperature.
- Airflow through the camera and/or circulator is obstructed. The camera needs to have approximately two (2) inches (50 mm) clearance around the vented covers. If there is an enclosure involved, the enclosure needs to have unrestricted flow to an open environment. The camera vents its heat out the vents near the nose. The air intake is near the rear of the camera.
- A hose is kinked. Unkink the hose.
- Coolant level is low. Add coolant. Refer to [Section 7.6, CoolCUBE_{II}: Low Coolant \(Air in the Hoses\)](#), on page 84.
- There may be air in the hoses. Add coolant. Refer to [Section 7.6, CoolCUBE_{II}: Low Coolant \(Air in the Hoses\)](#), on page 84.
- Circulator pump is not working. If you do not hear the pump running when the CoolCUBE_{II} is powered on, turn off the circulator and contact Customer Support.
- The circulator is higher than the camera. Reposition the circulator so that it is 6 inches (150 mm) or more below the camera. The vertical distance should not exceed 10 feet (3 m.) Typically, the camera is at table height and the circulator is on the floor.
- The camera vacuum has deteriorated and needs to be refreshed. Contact Customer Support.
- The target array temperature is not appropriate for your particular camera and CCD array.
- The camera's internal temperature may be too high, such as might occur if the operating environment is particularly warm or if you are attempting to operate at a temperature colder than the specified limit. TE cameras are equipped with a thermal-protection switch that shuts the cooler circuits down if the internal temperature exceeds a preset limit. Typically, camera operation is restored automatically in about ten minutes. Although the thermo-protection switch will protect the camera, you are nevertheless advised to power down and correct the operating conditions that caused the thermal-overload to occur.

7.7.2 Camera loses Temperature Lock

The internal temperature of the camera is too high. This might occur if the operating environment is particularly warm or if you are trying to operate at a temperature colder than the specified limit. If this happens, an internal thermal overload switch will disable the cooler circuits to protect them. Typically, camera operation is restored in about ten minutes. Although the thermal overload switch will protect the camera, users are advised to power down and correct the operating conditions that caused the thermal overload to occur.

7.7.3 Gradual Deterioration of Cooling Capability

Although unlikely with the PIXIS-XO camera which has a guaranteed permanent vacuum for the life of the camera, if a gradual deterioration of the cooling capability is observed, there may be a gradual deterioration of the camera's vacuum. This can affect temperature performance such that it may be impossible to achieve temperature lock at the lowest temperatures. In the kind of applications for which cooled CCD cameras are so well suited, it is highly desirable to maintain the system's lowest temperature performance because lower temperatures result in lower thermal noise and better the signal-to-noise ratio. Contact the factory to make arrangements for returning the camera to the support facility.

7.8 Data Loss or Serial Violation

Either, or both, of these conditions may be observed if the host computer has been configured with Power Saving features enabled. This is particularly true for power saving with regard to the hard drive. Verify that Power Saving features are disabled while running the WinX application.

7.9 Device is Occupied

Multiple instances of LightField can be running at the same time. However, any device currently being used by one instance of LightField will be shown in the Available Devices area as Occupied for all other instances of LightField as illustrated in [Figure 7-5](#).

To make a device available within the current instance of LightField, either:

- Remove it from the Experiment Devices area within the other instance, or
- Close the specific instance of LightField that is using the device.

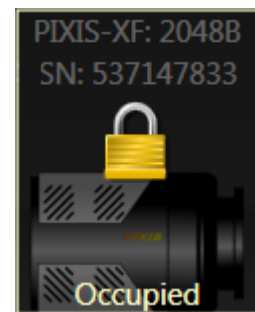


Figure 7-5: Occupied Device

7.10 Overexposed or Smeared Images

If an external shutter is being used, verify that the shutter is opening and closing correctly. Possible shutter problems include a complete failure such that the shutter no longer operates at all.

Other shutter failures may include:

- Sticking while open which will result in overexposed or smeared images;
- Sticking closed which will result in no images being acquired;
- One leaf of the shutter may break and no longer actuate.

High repetition rates and short exposure times rapidly increases the number of shutter cycles and hastens the time when the shutter will have to be replaced.

7.11 Shutter Failure

Refer to [Section 7.10, Overexposed or Smeared Images](#), on page 87.

7.12 Vignetting

All CCD arrays have been tested for uniformity and do not exhibit any vignetting (i.e., reduction of response,) at the extreme ends of the array.

If a reduction in response is observed across the array, it may be the result of one or more of the following conditions:

- Water condensation on the edges of the array has occurred. This should not occur if the previously discussed cooling/pumping instructions have been followed.
- If a leak is occurring at the interface between the ConFlat and chamber.

The array is held with a special mask that has been designed to prevent damage to the horizontal register.

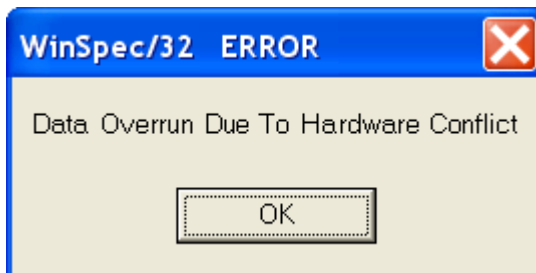
7.13 Error Messages

This section provides troubleshooting guidelines for common error messages that may be displayed.

7.13.1 Data Overrun Due to Hardware Conflict

If an error message dialog similar to that shown in [Figure 7-6](#) appears while acquiring a test image, acquiring data, or running in focus mode, check the CCD array size and then check the DMA buffer size. A large array (e.g., a 2048x2048 array,) requires a larger DMA buffer larger setting than that for a smaller array (e.g., a 512x512 array.)

Figure 7-6: Typical Data Overrun Due to Hardware Conflict Error Dialog



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Perform the following procedure to change the DMA buffer setting:

1. Note the array size on the Setup ► Hardware ► Controller/CCD tab or the Acquisition ► Experiment Setup ► Main tab Full Chip dimensions.
2. Open Setup ► Environment ► Environment dialog.
3. Increase the DMA buffer size to a minimum of 32 MB.
 - If the DMA buffer size is currently 32 MB, increase it to 64 MB;
 - If the DMA buffer size is currently 64 MB, increase it to 128 MB.
4. Click OK.
5. Close the WinX application.
6. Reboot the host computer.
7. Launch the WinX application and begin acquiring data or focusing.



NOTE:

If the error message is displayed again, increase the DMA buffer size further.

7.13.2 Data Overrun Has Occurred

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

- Minimize the number of programs running in the background while acquiring data with the WinX application.
- Run data acquisition in Safe Mode.
- Add memory.
- Use binning.
- Increase the exposure time.
- De-fragment the hard disk.
- Update the USB2 driver.

If the problem persists, the application may be USB 2.0 bus limited. Since the host computer controls the USB 2.0 bus, there may be situations where the host computer interrupts the USB 2.0 port. In most cases, the interrupt will go unnoticed by the user. However, there are some instances when the data overrun cannot be overcome because USB 2.0 bus limitations combined with long data acquisition times and/or large data sets increase the possibility of an interrupt while data is being acquired. If an experiment's requirements include long data acquisition times and/or large data sets, the application may not be suitable for the USB 2.0 interface. If this is not the case and data overruns continue to occur, contact Customer Support. Refer to [Contact Information](#) on page 116 for complete contact information.

7.13.3 Device Is Not Found

Once LightField has launched, it looks for devices (e.g., cameras, spectrographs, and filters,) that are powered on and connected via a communications interface to the host computer. If it cannot find a device that was used in the last experiment, it will continue to look for it and display a message similar to that shown in [Figure 7-7](#).

Figure 7-7: Typical Devices Missing Error Dialog



The following actions may be performed when this message is displayed:

- Verify the device is connected and powered on. If LightField cannot find a spectrograph that is connected and powered on, turn the spectrograph off and back on. LightField should now find it.
- Cancel the load. Canceling a load means that the last used experiment will not be loaded automatically when LightField opens. However, the experiment can be loaded after all devices are available, you can start a new experiment design, or you can load a different experiment that matches the devices you are using.

7.13.4 Error Creating Controller

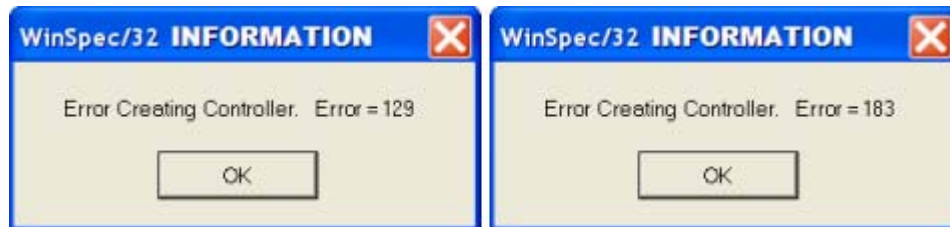
This error message may be displayed when the USB 2.0 interface is being used and one of the following has occurred:

- The `RSConfig.exe` program has not been run;
- The `PVCAM.INI` file has become corrupted; or
- The PIXIS-XO was not powered on before launching the WinX application and the Hardware Wizard was run.

As illustrated in [Figure 7-8](#), two error codes may be displayed as part of this fault to help identify the problem:

- **Error 129**
Indicates that the problem is with the `PVCAM.INI` file. Close the WinX application, run `RSConfig.exe`, verify that the PIXIS-XO is the first camera, verify the PIXIS-XO is powered on, reopen the WinX application and begin running the Hardware Wizard.
- **Error 183**
Indicates that the PIXIS-XO is off. If you are running the Hardware Wizard when this message appears, click on OK, power on the PIXIS-XO, and, on the PVCAM dialog, make sure Yes is selected and then click on Next. The Hardware Wizard should continue to the Controller Type dialog.

Figure 7-8: Typical Error Creating Controller Error Message Dialog



4411-0111_0056

7.13.5 Program Error

This error message may be displayed when acquiring a test image, acquiring data, or running in focus mode when the DMA buffer size is too small. A large array (e.g., a 2048x2048,) requires a larger DMA buffer than a smaller array (e.g., a 512x512.)

Figure 7-9 illustrates a typical Program Error dialog.

Figure 7-9: Typical Program Error Dialog



4411-0111_0057

Perform the following procedure to resolve this issue:

1. Within the error dialog, click OK.
2. Close the WinX application.
3. Launch the WinX application.
4. Determine the array size. This can be found on the Setup ► Hardware ► Controller/CCD tab or the Acquisition ► Experiment Setup ► Main tab and is indicated in the Full Chip dimension field.
If the PIXIS-XO camera includes a large array (e.g., 2048x2048,) and the DMA buffer size is too small, there will not be enough space in memory for the data set.
5. Open the Setup ► Environment ► Environment dialog.
6. Increase the DMA buffer size to a minimum of 32 MB.
 - If the DMA buffer size is currently 32 MB, increase it to 64 MB;
 - If the DMA buffer size is currently 64 MB, increase it to 128 MB.
7. Click OK.
8. Close the WinX application.
9. Reboot the host computer.
10. Launch the WinX application and begin acquiring data or focusing.



NOTE:

If the error message is displayed again, increase the DMA buffer size further.

7.13.6 Serial Violations Error

This error is displayed when acquiring an image or focusing the camera and one 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.

Figure 7-10 illustrates a typical Serial Violations Error dialog.

Figure 7-10: Typical Serial Violations Error Dialog



0058

Perform the following procedure to resolve this issue:

1. If not already turned off, turn off the camera system.
2. Verify the computer interface cable is securely connected at both ends.
3. Turn on power to the camera system.
4. Click OK within the error message dialog and attempt to acquire an image or run in focus mode.



NOTE:

This error message will also be displayed if camera system power is turned off or a cable becomes loose while the WinX application software is running in Focus mode.

Appendix A: Technical Specifications



NOTE:

All specifications are subject to change. For complete information about performance, available options, and accessories, contact the factory or visit the Teledyne Princeton Instruments website at www.princetoninstruments.com.

This appendix provides technical information and specifications for the family of PIXIS-XO camera systems, and, where appropriate, optional accessories.

A.1 Mechanical Dimensions

Refer to [Appendix B, Outline Drawings](#), on page 101 for dimension information.

A.2 Environmental Specifications

Refer to [Table A-1](#) for environmental specifications for the PIXIS-XO system.

Table A-1: PIXIS-XO Environmental Specifications

Parameter	Specification		
	Minimum	Nominal	Maximum
Storage Temperature	–	–	55°C
Operating Temperature ^a	5°C		30°C
Operating Ambient Relative Humidity	<50% (non-condensing)		
Temperature Stability	±0.05°C (Closed-loop stabilized-temperature control)		

a. The environment temperature range over which system specifications can be guaranteed is +18°C to +23°C.



NOTE:

Cooling performance may degrade if ambient temperature is above +23°C.

A.3 CCD Specifications

Refer to [Table A-2](#) for a comparison of PIXIS-XO CCD array specifications.

Table A-2: CCD Array Specifications by PIXIS-XO Model (Sheet 1 of 2)

Parameter	100B	100BR	400B	400BR
CCD	P.I Proprietary	P.I Proprietary	P.I Proprietary	P.I Proprietary
Illumination	Back	Back	Back	Back
Deep Depletion	No	Yes	No	Yes
AR Coating ^a	No	No	No	No
Mode	MPP	NIMO	MPP	NIMO
Architecture				
Resolution	1340 x 100	1340 x 100	1340 x 400	1340 x 400
Pixel Size	20 μm x 20 μm	20 μm x 20 μm	20 μm x 20 μm	20 μm x 20 μm
Active Area	26.8 mm x 2 mm	26.8 mm x 2 mm	26.8 mm x 8 mm	26.8 mm x 8 mm
Deepest Cooling Temperature ^b				
TE Air Cooled	-90°C (typical) -75°C (guaranteed)			
Liquid Cooled ^c	—	—	—	—

Parameter	1024B	1024BR	1300B	2KB	2048B
CCD	e2v CCD47-10	e2v CCD47-10	P.I Proprietary	e2v CCD42-10	e2v CCD42-40
Illumination	Back	Back	Back	Back	Back
Deep Depletion	Yes	Yes	No	No	No
AR Coating ^a	No	No	No	No	No
Mode	MPP	NIMO	AIMO	MPP	MPP
Architecture	Full Frame	Full Frame		Full Frame	Full Frame
Resolution	1024 x 1024	1024 x 1024	1340 x 1300	2048 x 512	2048 x 2048
Pixel Size	13 μm x 13 μm	13 μm x 13 μm	20 μm x 20 μm	13.5 μm x 13.5 μm	13.5 μm x 13.5 μm
Active Area	13.3 mm x 13.3 mm	13.3 mm x 13.3 mm	26.8 mm x 26.0 mm	27.6 mm x 6.9 mm	27.6 mm x 27.6 mm

Table A-2: CCD Array Specifications by PIXIS-XO Model (Sheet 2 of 2)

Deepest Cooling Temperature ^b					
TE Air Cooled	-70°C (typical) -65°C (guaranteed)	-70°C (typical) -65°C (guaranteed)	-65°C (typical) -55°C (guaranteed)	-75°C (typical) -70°C (guaranteed)	-65°C (typical) -55°C (guaranteed)
Liquid Cooled ^c	—	—	-70°C (typical) -60°C (guaranteed)	—	-70°C (typical) -60°C (guaranteed)

- a. AR coated devices are ineffective for x-ray energies < 500eV.
b. At +20°C ambient air temperature
c. CoolCUBE_{II} required

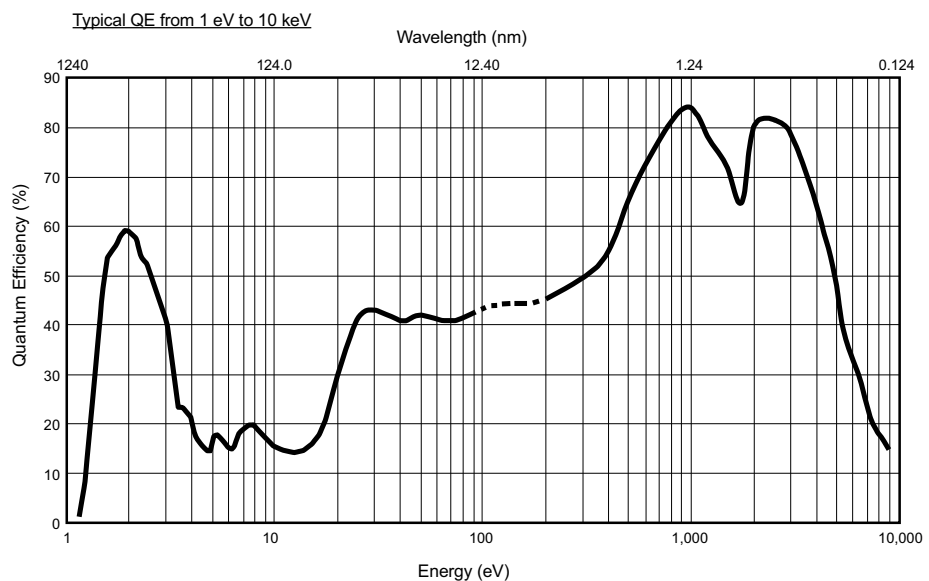
A.3.1 Mask Openings

Refer to [Table A-3](#) for information about mask openings for PIXIS-XO cameras.

Table A-3: PIXIS-XO CCD Mask Opening Sizes

PIXIS-XO	Array Size	Image Area inches [mm]	Mask Opening inches [mm]
100B/BR	1340 x 100	1.055 x 0.0787 [26.8 x 2.0]	1.052 x 0.076 [26.721 x 1.930]
400B/BR	1340 x 400	1.055 x 0.315 [26.8 x 8.0]	1.052 x 0.311 [26.721 x 7.899]
1024B/BR	1024 x 1024	0.524 x 0.524 [13.3 x 13.3]	0.520 x 0.520 [13.208 x 13.208]
1300B	1340 x 1300	1.055 x 1.024 [26.8 x 26.0]	1.051 x 1.020 [26.698 x 25.898]
2KB	2048 x 512	1.087 x 0.272 [27.6 x 6.9]	1.083 x 0.266 [27.508 x 6.756]
2048B	2048 x 2048	1.087 x 1.087 [27.6 x 27.6]	1.083 x 1.083 [27.508 x 27.508]



A.3.2 Quantum Efficiency

Figure A-1: Typical PIXIS-XO Quantum Efficiency Curve

A.4 Power Specifications

All DC voltages required by PIXIS-XO cameras are generated by an external power supply and then delivered to the camera using a custom power cable. Refer to [Table A-4](#) for power specifications for external PIXIS-XO power supplies.

Table A-4: Power Specifications: External PIXIS-XO Power Supplies

Parameter	Specification			Unit
	Minimum	Nominal	Maximum	
PIXIS-XO: 100 ▶ 400 ▶ 1024 ▶ 2K				
				
Input Voltage	100	120 220	240	V _{AC}
Input Current	—	—	1.9	A _{AC}
Input Frequency	47	50 60	63	Hz
Output Voltage	—	12	—	V _{DC}
Output Current	—	—	6.6	A _{DC}
Power Output	—	—	80	W
PIXIS-XO: 1300 ▶ 2048				
				
Input Voltage	100	120 220	240	V _{AC}
Input Current	—	—	2	A _{AC}
Input Frequency	47	50 60	63	Hz
Output Voltage	—	12	—	V _{DC}
Output Current	—	—	12.5	A _{DC}
Power Output	—	—	150	W

A.5 Camera Information

- Cooling: Thermoelectric (air); liquid (CoolCUBEII)
- Gain: Software-selectable (high, medium, low)
- Tripod Mount: 1/4-20 x 0.25" mounting hole at bottom of camera. M6 threaded adapter supplied with system.
- A/D Converters: Dual digitizers with 100 kHz/2 MHz readout rates. Software-selectable. Low-speed operation gives better noise performance; high-speed operation allows faster data acquisition.

A.5.1 Mounts

- ConFlat: 4.5" (English or metric thread)
- ConFlat: 6.0" (English thread, metric thread, or through hole)

A.5.2 Connectors

The PIXIS-XO includes the following input/output connectors:

- EXT SYNC
MCX connector. An MCX-to-BNC adapter cable is included with the system. 0 to +3.3 V_{DC} logic level input to allow data acquisition to be synchronized with external events.
Trigger edges can be configured within software to be positive- or negative-edge.



REFERENCES:

Refer to [Chapter 6, Advanced Topics](#), on page 61 for additional information about Synchronization and Timing Modes.

- LOGIC OUT
MCX connector. An MCX-to-BNC adapter cable is included with the system. 0 to +3.3 V_{DC} logic level output for monitoring camera status.
The logic output is software-selectable to be:
 - NOT SCAN {Not Reading Out}
Logic low when CCD is being read; otherwise high.
 - SHUTTER {Shutter Open}
The output precisely brackets shutter-open time (exclusive of shutter compensation) and can be used to control an external shutter or to inhibit a pulser or timing generator.
 - NOT READY {Busy}
The output changes state on completion of the array cleaning cycles that precede the first exposure. Initially high, it goes low to mark the beginning of the first exposure. In free run operation, it remains low until the system is halted. If a specific number of frames have been programmed, it remains low until all have been taken, then returns high.
 - LOGIC 0 {Always Low}
Logic low.

- LOGIC 1 {Always High}
Logic high.



REFERENCES:

Refer to [Chapter 6, Advanced Topics](#), on page 61 for additional information about Logic Out Control.

- Shutter
2-pin LEMO connector.



PIN 1: +VDC
PIN 2: GROUND

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Active where there is no internal shutter. Used for connecting to an external shutter.

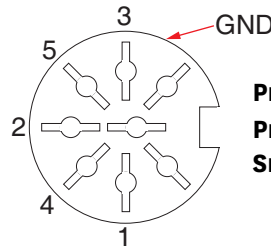


NOTE:

Customers must supply their own shutter cable.

Refer to [Table A-5](#) on page 99 for information about external shutters that are compatible with PIXIS-XO cameras.

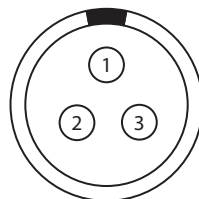
- USB 2.0
USB B Female connector. A USB A/B cable is included with the system. Data link to computer via USB cable inserted at this connector. Cable length of 5 meters is standard. Other lengths may be available. Contact Customer Support for more information. Refer to [Contact Information](#) on page 116 for complete information.
- Power
 - PIXIS-XO:100, 400, 1024, and 2K
8-pin DIN connector.
12 V_{DC}, 6.6 A maximum input from power supply for small array cameras



PIN 3, 5: +12 VDC
PIN 1, 2, 4: RETURN
SHELL: GROUND

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- PIXIS-XO:1300 and 2048
3-pin LEMO connector.
12 V_{DC}, 12.5 A maximum input from power supply for large array cameras.



PIN 1: +12VDC
PIN 2: GROUND
PIN 3: CHASSIS

4411-0111_0064

- Fan
Air-cooled systems only.
24 CFM fan capacity at full power.
- Coolant Ports
Liquid-cooled systems only.
Two interchangeable 1/4" CPC valve quick disconnect fittings for connection to the CoolCUBE_{II} circulator hoses.

A.6 External Shutters

Table A-5 provides a list of compatible external shutters.

Table A-5: Compatible External Shutters by PIXIS-XO Model

Shutter		Small Array				Large Array	
Model	Size	100	400	1024	2K	1300	2048
UniBlitz [®] VS25	25 mm	Yes	Yes	Yes	Yes	—	—
UniBlitz CS45	45 mm	—	—	—	—	Yes	Yes
UniBlitz XRS6 (X-ray)	6 mm	—	—	—	—	Yes	Yes
UniBlitz XRS14 (X-ray)	14 mm	—	—	—	—	Yes	Yes
UniBlitz XRS25 (X-ray)	25 mm	—	—	—	—	Yes	Yes

Technical information and data sheets for UniBlitz shutters are available from the Vincent Associates website www.uniblitz.com.

A.7 Options

Contact the factory for information about available options.

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Appendix B: Outline Drawings



NOTE:

All dimensions are expressed in inches [mm].

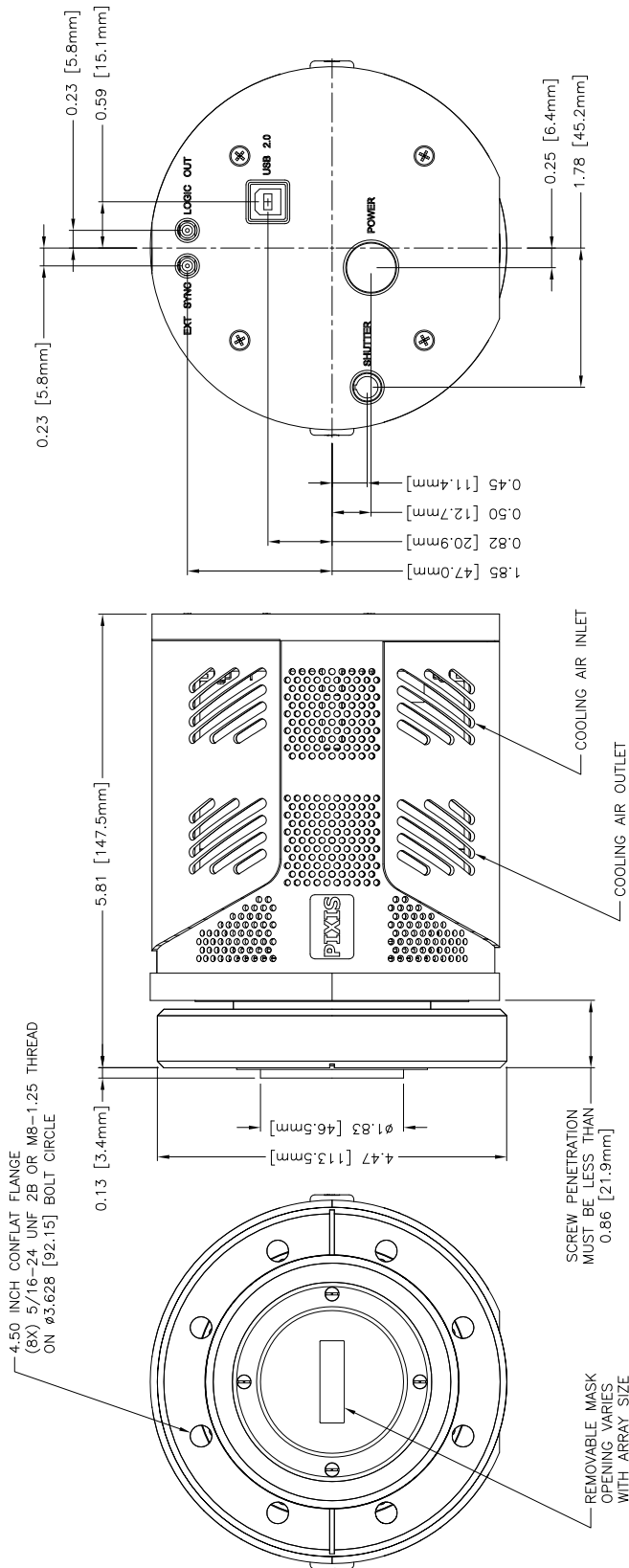
This appendix provides mechanical outline drawings and dimensions for the following PIXIS-XO System components:

- [PIXIS-XO Camera with 4.5" ConFlat Flange](#);
- [PIXIS-XO Camera with 6.0" ConFlat](#);
- [CoolCUBEII Circulator](#).

For information about system specifications and ratings, refer to [Appendix A, Technical Specifications](#), on page 93.

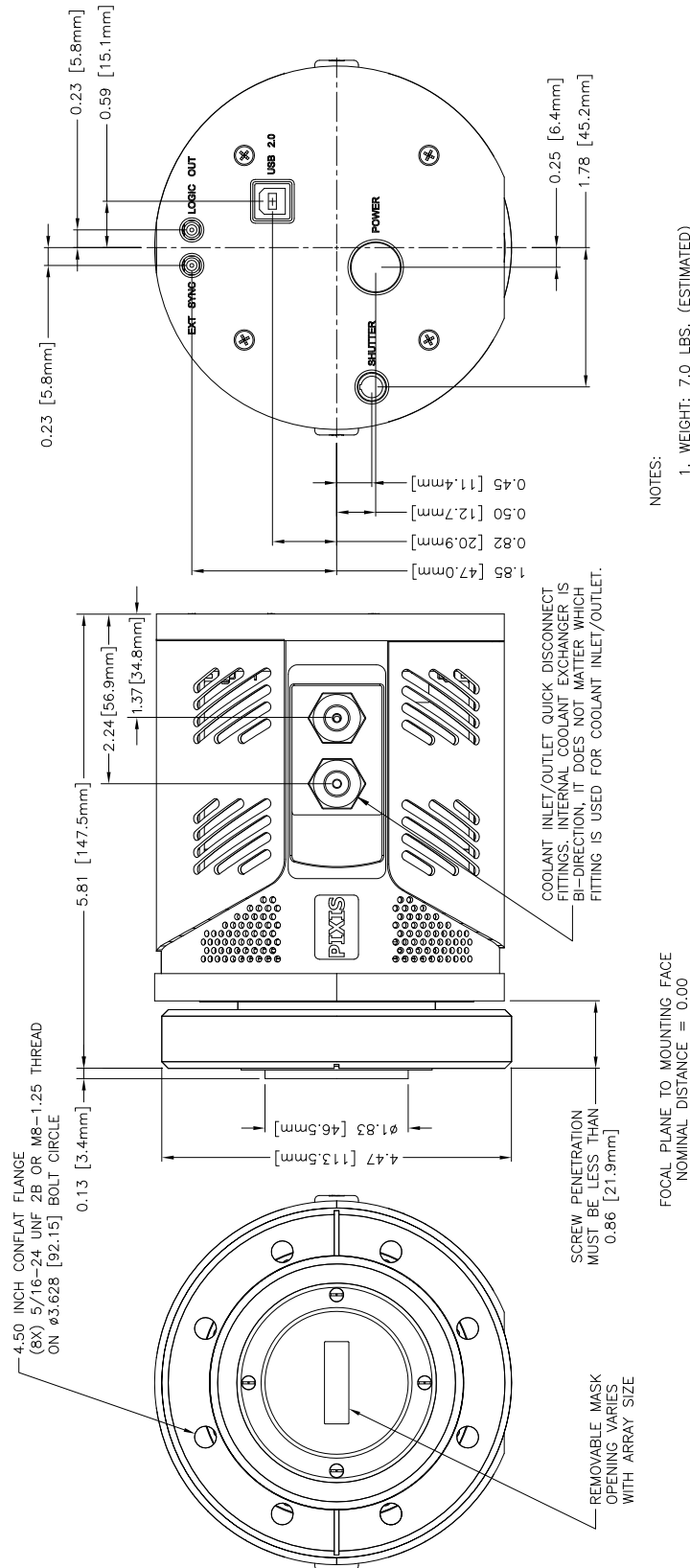
B.1 PIXIS-XO Camera with 4.5" ConFlat Flange

Figure B-1: Outline Drawing: Air Cooled PIXIS-XO with 4.5" ConFlat Flange



- NOTES:
1. WEIGHT: 6.5 LBS. (ESTIMATED)
 2. POWER DISSIPATION: 80 WATTS AT FULL POWER.
 3. AIRFLOW: 24 CFM FAN CAPACITY AT FULL POWER.

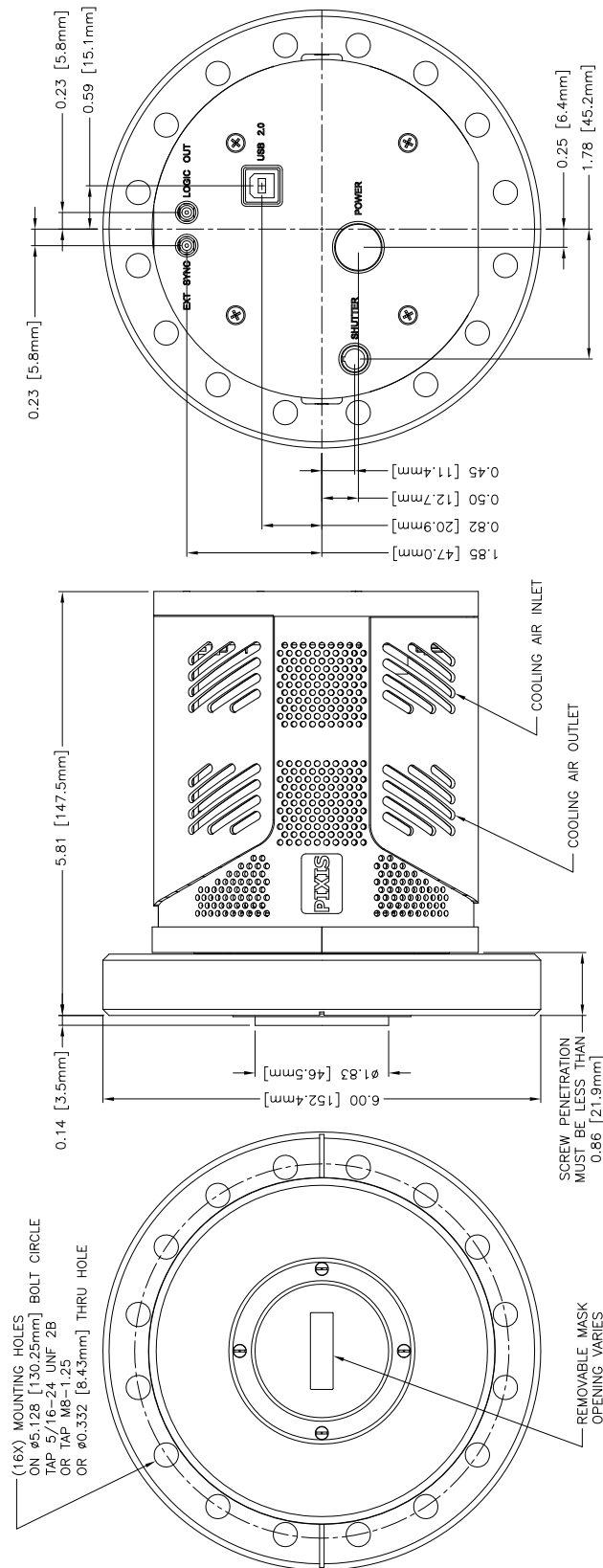
Figure B-2: Outline Drawing: Liquid Cooled PIXIS-XO with 4.5" ConFlat Flange



- NOTES:
1. WEIGHT: 7.0 LBS. (ESTIMATED)
 2. POWER DISSIPATION: 80 WATTS AT FULL POWER.

B.2 PIXIS-XO Camera with 6.0" ConFlat

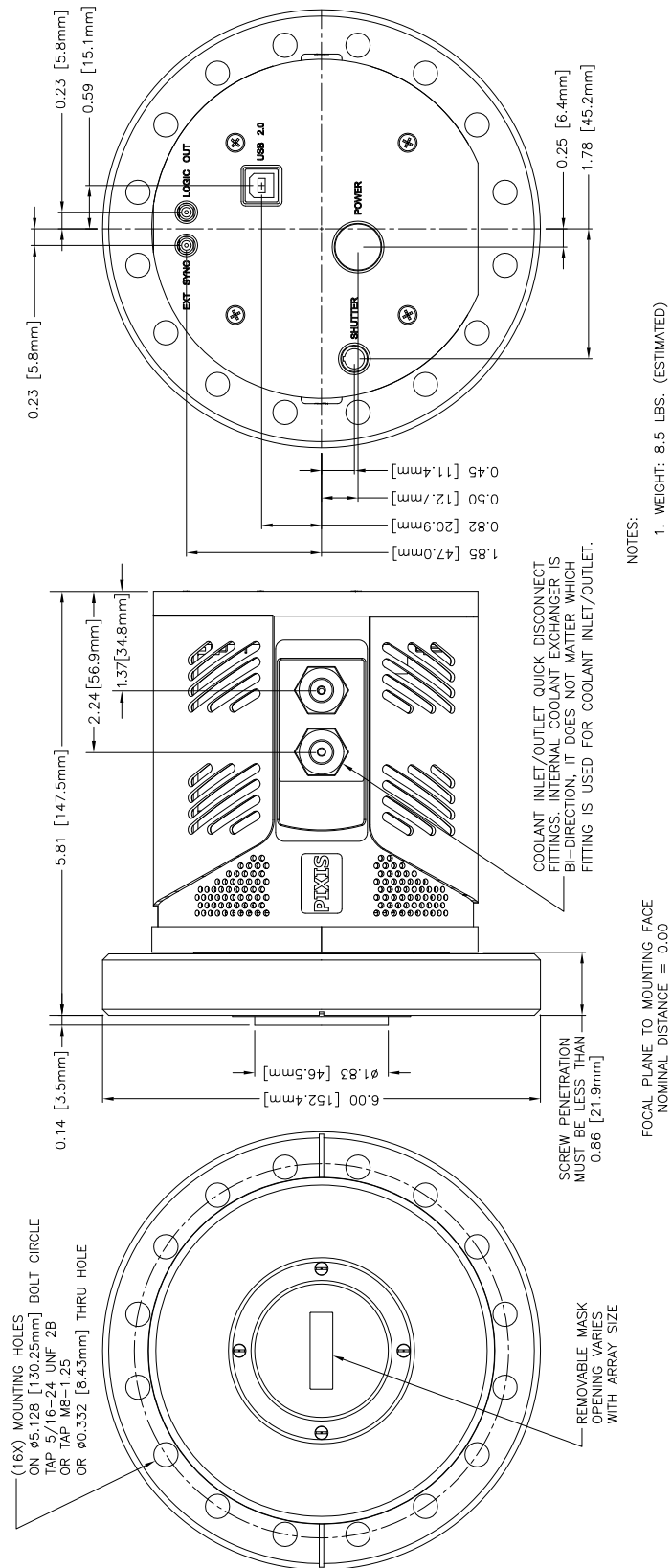
Figure B-3: Outline Drawing: Air Cooled PIXIS-XO with 6.0" ConFlat Flange



NOTES:

1. WEIGHT: 8.0 LBS. (ESTIMATED)
2. POWER DISSIPATION: 80 WATTS AT FULL POWER.
3. AIRFLOW: 24 CFM FAN CAPACITY AT FULL POWER.

Figure B-4: Outline Drawing: Liquid Cooled PIXIS-XO with 6.0" ConFlat Flange

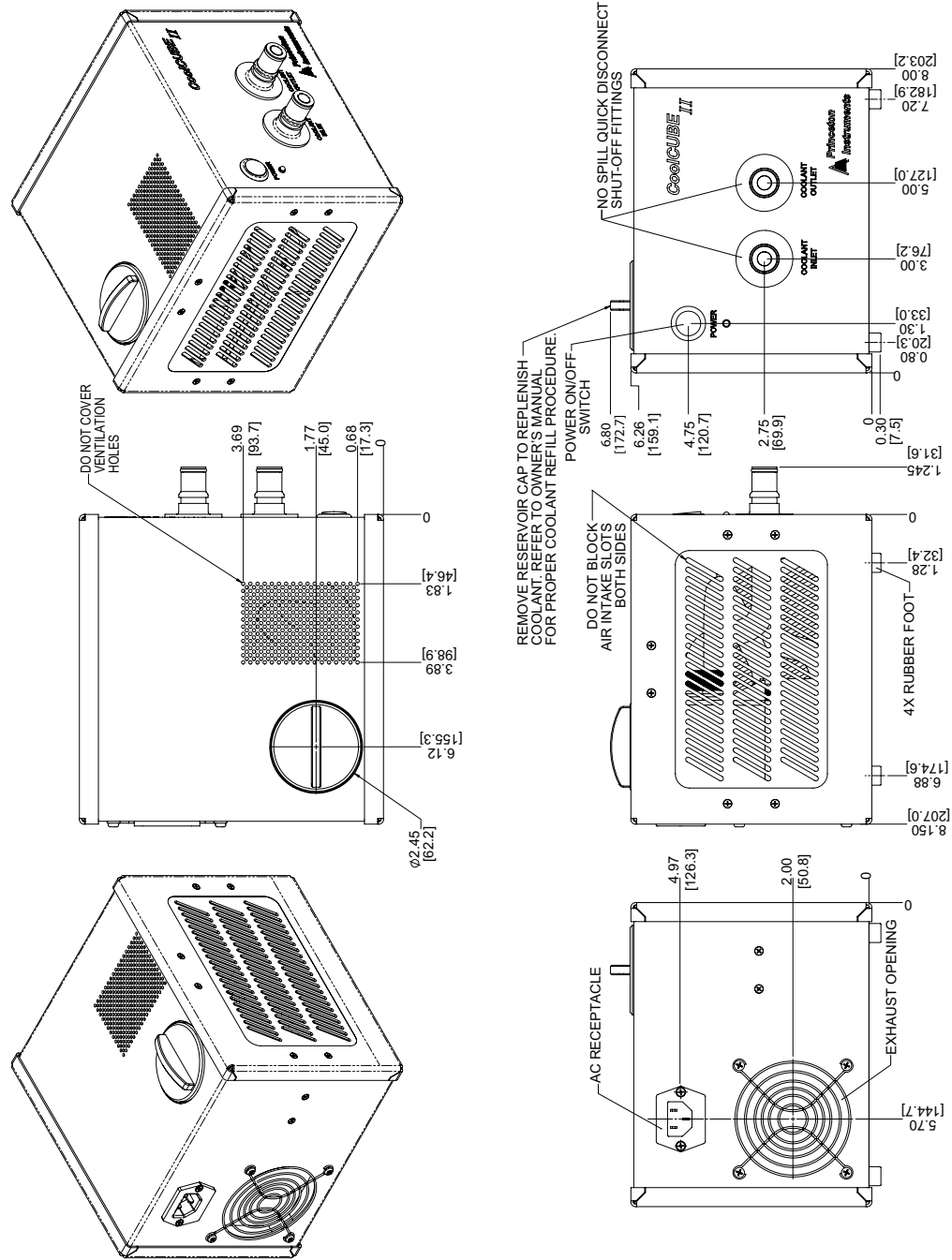


- NOTES:
1. WEIGHT: 8.5 LBS. (ESTIMATED)
 2. POWER DISSIPATION: 80 WATTS AT FULL POWER.

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B.3 CoolCUBE_{II} Circulator

Figure B-5: Outline Drawing: CoolCUBE_{II} Circulator



4411-0111_0069

Appendix C: Backfilling for Storage or Shipment

To protect the camera while in storage or during shipment, you need to re-mount the shipping plate to the front of the camera: this plate was mounted to the camera before it was shipped to you from the factory. In addition, you will need to backfill the camera with dry Nitrogen.



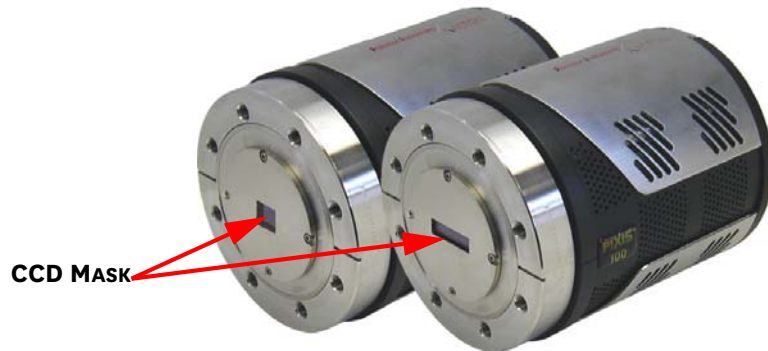
WARNING!

Verifying that the CCD mask is in place and slowly opening the valve prevents potential damage to fragile parts.

Perform the following procedure to backfill a PIXIS-XO camera:

1. Verify that the CCD mask is in place. The mask may have a square or rectangular opening depending on the CCD.

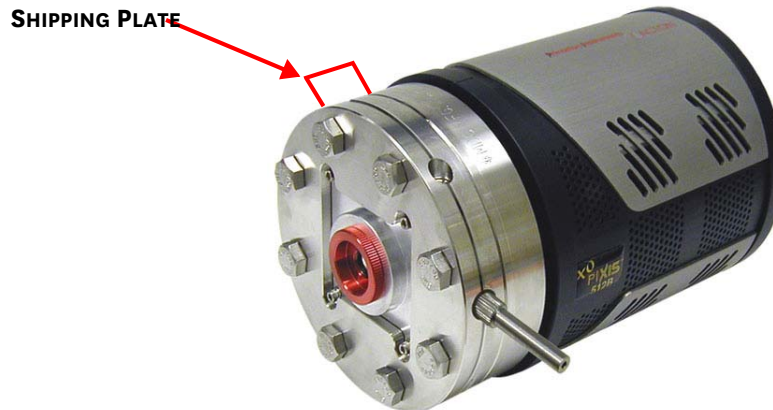
Figure C-1: CCD Masks in Place on Front of Camera



4411-0111_0070

2. Using the original bolts and rubber ConFlat gasket, mount the shipping plate to the face of the camera. Tighten down the bolts at this time.

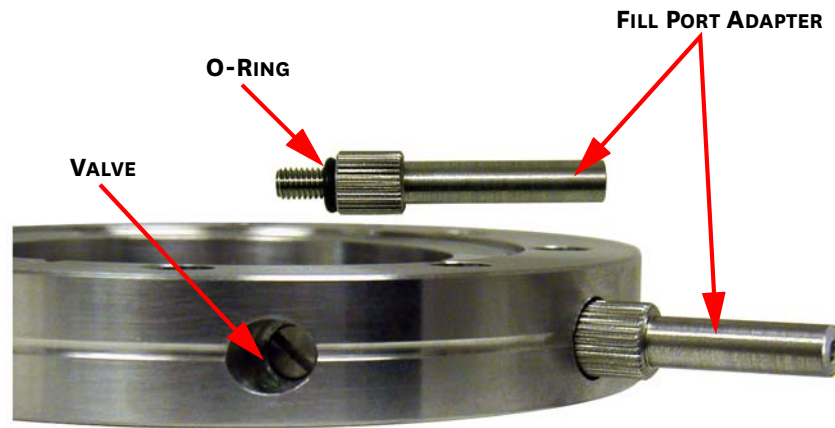
Figure C-2: Shipping Plate Mounted to Camera



4411-0111_0071

3. Using a flat screwdriver, close the valve (i.e., screw it in completely.)

Figure C-3: Shipping Plate Valve and Fill Port Adapter



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4. If it is not already attached to the shipping plate, screw in the fill port adapter (with O-ring).
5. Attach a hose from a dry nitrogen source to the fill port adapter.
6. Start the dry nitrogen flow at 1 Atmosphere maximum and slowly open the valve to allow the gradual displacement of air with the dry nitrogen. You should feel gas exiting from the open valve.
7. When the valve is fully open, continue the gas flow for at least five (5) minutes to insure the backfill compartment is completely filled with dry nitrogen and all of the moisture is out.
8. Close the valve.
9. Shut off the gas flow and remove the hose. You can leave the fill port adapter in place or you can remove and store it.
10. The PIXIS-XO camera is now ready for shipment or storage.

Appendix D: WinSpec/32/LightField Cross Reference

This appendix provides cross reference information for terminology used within the WinSpec/32 and LightField application software packages.

D.1 WinSpec/32-to-LightField Terminology

Refer to [Table D-1](#) for a list of WinSpec/32 terms and their corresponding LightField terms.

Table D-1: WinSpec/32-to-LightField Cross Reference (Sheet 1 of 2)

WinSpec/32 Term	LightField Term
Active Rows Parallel to Shift Register	Active Height
Active Shift Register Columns	Active Width
ADC Rate	Speed
ADC Resolution	Bit Depth
Continuous Cleans	Clean Until Trigger
Controller Gain	Analog Gain
Custom Chip	Custom Sensor
Custom Timing	Custom Timing
Disabled Closed (Shutter)	Always Closed (Shutter)
Disabled Open (Shutter)	Always Open (Shutter)
Dual Trigger Mode	Shift Per Trigger
Easy Bin	Sensor Readout Region expander functions
Edge Trigger	Trigger Determined By
External Sync	Readout Per Trigger
F.T. Dummies or Frame Transfer Dummies	Active Area: Top Margin
Focus	Preview or Run
Free Run	No Response
Logic Out	Output Signal
Logic Out: Logic 0	Output Signal: Always Low
Logic Out: Logic 1	Output Signal: Always High
Logic Out: Not Ready	Output Signal: Busy
Logic Out: Not Scan	Output Signal: Not Reading Out

Table D-1: WinSpec/32-to-LightField Cross Reference (Sheet 2 of 2)

WinSpec/32 Term	LightField Term
Logic Out: Shutter	Output Signal: Shutter Open
Minimum Block Size	Final Section Height
Normal Shutter	Normal (Shutter)
Number of Blocks	Final Section Count
Number of Cleans	Number of Clean Cycles
Number of Strips per Clean	Clean Cycle Height
Post-Dummy Rows Parallel to Shift Register	Active Area: Bottom Margin
Post-Dummy Shift Register Columns	Active Area: Right Margin
Pre-Dummy Rows Parallel to Shift Register	Active Area: Top Margin
Pre-Dummy Shift Register Columns	Active Area: Left Margin
PreOpen (Shutter)	Open Before Trigger (Shutter)
Readout Port	Quality
Shutter Close Compensation Time	Closing Delay
Shutter Control	Shutter Mode
Shutter Open Compensation Time	Opening Delay
Single Trigger Mode (DIF)	Readout Per Trigger
Skip Serial Register Clean (deselected)	Clean Serial Register
Target Temperature	Temperature Setpoint
Timing Mode	Trigger Response

D.2 LightField to WinSpec/32

Refer to [Table D-2](#) for a list of LightField terms and their corresponding WinSpec/32 terms.

Table D-2: LightField-to-WinSpec/32 Cross Reference (Sheet 1 of 2)

LightField Term	WinSpec/32 Term
Active Area: Bottom Margin	Post-Dummy Rows Parallel to Shift Register
Active Area: Left Margin	Pre-Dummy Shift Register Columns
Active Area: Right Margin	Post-Dummy Shift Register Columns
Active Area: Top Margin	F.T. Dummies or Frame Transfer Dummies
Active Area: Top Margin	Pre-Dummy Rows Parallel to Shift Register
Active Height	Active Rows Parallel to Shift Register
Active Width	Active Shift Register Columns
Always Closed (Shutter)	Disabled Closed (Shutter)
Always Open (Shutter)	Disabled Open (Shutter)
Analog Gain	Controller Gain
Bit Depth	ADC Resolution
Clean Cycle Height	Number of Strips per Clean
Clean Serial Register	Skip Serial Register Clean (deselected)
Clean Until Trigger	Continuous Cleans
Closing Delay	Shutter Close Compensation Time
Custom Sensor	Custom Chip
Custom Timing	Custom Timing
Final Section Count	Number of Blocks
Final Section Height	Minimum Block Size
No Response	Free Run
Normal (Shutter)	Normal Shutter
Number of Clean Cycles	Number of Cleans
Open Before Trigger (Shutter)	PreOpen (Shutter)
Opening Delay	Shutter Open Compensation Time
Output Signal	Logic Out
Output Signal: Always High	Logic Out: Logic 1
Output Signal: Always Low	Logic Out: Logic 0
Output Signal: Busy	Logic Out: Not Ready
Output Signal: Not Reading Out	Logic Out: Not Scan
Output Signal: Shutter Open	Logic Out: Shutter

Table D-2: LightField-to-WinSpec/32 Cross Reference (Sheet 2 of 2)

LightField Term	WinSpec/32 Term
Preview	Focus
Quality	Readout Port
Readout Per Trigger	External Sync
Readout Per Trigger (DIF)	Single Trigger (DIF)
Sensor Readout Region expander functions	Easy Bin
Shift Per Trigger (DIF)	Dual Trigger Mode (DIF)
Shutter Mode	Shutter Control
Speed	ADC Rate
Temperature Setpoint	Target Temperature
Trigger Determined By	Edge Trigger
Trigger Response	Timing Mode

Warranty and Service

Limited Warranty

Teledyne 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

Teledyne 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, Teledyne 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 Teledyne 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 Teledyne 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

Teledyne 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, Teledyne 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 Teledyne Princeton Instruments factory or, at our option, a factory-authorized service center. You are responsible for the shipping costs to return the product to Teledyne Princeton Instruments. International customers should contact their local Teledyne 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

Teledyne 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 Teledyne 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

Teledyne 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

Teledyne 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. Teledyne 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. *Refer to 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

Teledyne 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. *Refer to 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

Teledyne 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. Teledyne 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 CDROM from our factory for an incidental shipping and handling charge. *Refer to Item 12 in [Your Responsibility](#) of this warranty 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 Teledyne 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 Teledyne Princeton Instruments technical support staff or our authorized service representative. Refer to Item 12 in *Your Responsibility* of this warranty 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 Teledyne Princeton Instruments.
2. You must notify the Teledyne 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 Teledyne 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 Teledyne 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 Teledyne Princeton Instruments factory or one of our authorized manufacturer's representatives or distributors.
6. Unless specified in the original purchase agreement, Teledyne 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 Teledyne 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 Teledyne Princeton Instruments factory or a Teledyne 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 Teledyne 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 Teledyne Princeton Instruments factory of purchase, contact your authorized Teledyne Princeton Instruments representative or reseller, or visit our technical support page at www.princetoninstruments.com.

Contact Information

Teledyne Princeton Instruments' manufacturing facility for this product is located at the following address:

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

Tel: 1-800-874-9789 / 1-609-587-9797

Fax: 1-609-587-1970

Customer Support E-mail: techsupport@princetoninstruments.com

Refer to <http://www.princetoninstruments.com/support> for complete support and contact information, including:

- Up-to-date addresses and telephone numbers;
- Software downloads;
- Product manuals;
- Support topics for Teledyne Princeton Instruments' product lines.

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www.princetoninstruments.com



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