TELEDYNE PRINCETON INSTRUMENTS
Everywhereyoulook™

Part of the Teledyne Imaging Group

PIXIS-XB System Manual

4411-0133
Issue 5
June 14, 2019

www.princetoninstruments.com

Revision History

Issue	Date	List of Changes
Issue 5	June 14, 2019	Issue 5 of this document incorporates the following changes: • Rebranded as Teledyne Princeton Instruments; • Converted to standard FrameMaker template.
Issue 4	April 20, 2016	Issue 4 of this document incorporates the following changes: • Removed the Declaration of Conformity.
Issue 3	October 19, 2015	Issue 3 of this document incorporates the following changes: • Updated the Declaration of Conformity.
Issue 2	November 15, 2013	Issue 2 of this document incorporates the following changes: • Updated the Declaration of Conformity. • Updated Warranty and Contact Information; • Global replacement of — "Sensor Readout Region" with "Region of Interest"; — "Sensor Readout expander" with "Readout expander"; • Updated WinX/32 installation procedure.
Issue 1	February 18, 2011	This is the initial release of this document.

Teledyne Princeton Instruments
3660 Quakerbridge Rd
Trenton, NJ 08619
TEL: 800-874-9789 / 609-587-9797
FAX: 609-587-1970

Table of Contents

List of Figures

List of Tables

Chapter 1: About this Manual

Thank you for purchasing a PIXIS-XB 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.

Please read the manual carefully before operating the camera. This will help you optimize the many features of this camera to suit your research needs.

If you have any questions about the information contained in this manual, contact the Teledyne Princeton Instruments customer service department. Refer to Contact Information on page 114 for complete contact information.

1.1 Intended Audience

This manual is intended to be used by scientists and other personnel responsible for the installation, setup, configuration, and acquisition of imaging data collected using an PIXIS-XB system.

This document provides all information necessary to safely install, configure, and operate the PIXIS-XB, beginning with the system's initial installation.

1.2 Related Documentation

Table 1-1 provides a list of related documentation and user manuals that may be useful when working with the PIXIS-XB camera system. To guarantee up-to-date information, always refer to the current release of each document listed.

Table 1-1: Related Documentation

Document Number	Document Title
4411-0046	WinView/32 Imaging Software User Manual
4411-0048	WinSpec/32 Spectroscopy Software User Manual
4411-0103	WinXTest Software User Manual
–	LightField 6 Online Help
–	PIXIS-XB Camera System Data Sheet

Teledyne Princeton Instruments maintains updated documentation and user manuals on their FTP site. Visit the Teledyne Princeton Instruments FTP Site to verify that the most recent user manual is available and being referenced:

ftp://ftp.piacton.com/Public/Manuals/Princeton Instruments

ftp://ftp.piacton.com/Public/Manuals/Acton

1.3 Document Organization

This manual includes the following chapters and appendices:

- Chapter 1, About this Manual
  This chapter provides information about the organization of this document, as well as related documents, safety information, and conventions used throughout the manual.
- Chapter 2, PIXIS-XB Camera System
  This chapter provides information about the camera, interface card, cables and application software.
- Chapter 3, Initial System Verification
  This chapter cross-references system setup procedures with relevant manuals and/or manual pages. It also provides high-level system block diagrams.
- Chapter 4, System Setup
  This chapter provides detailed instructions and procedures for setting up the camera for imaging applications and presents over-exposure protection considerations.
- Chapter 5, Operation
  This chapter provides step-by-step procedures for verifying system operation and discusses operational considerations associated with exposure, readout, and digitization.
- Chapter 6, Advanced Topics
  This chapter provides information about standard timing {Trigger Response} modes (i.e., 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
  This chapter provides recommended actions to take when problems are encountered.
- Appendix A, Technical Specifications
  This appendix provides technical specifications for the PIXIS-XB system and accessories.
- Appendix B, Outline Drawings
  This appendix provides outline drawings for the PIXIS-XB system and accessories.
- Appendix C, WinSpec/32/LightField Cross Reference
  This appendix provides alphabetically sorted tables which cross reference terms used by WinX/32 and LightField.
- Warranty and Service
  This chapter provides warranty and customer support contact information.

1.3.1 Conventions Used In this Document

WinX/32 is a generic term for WinSpec/32, WinView/32, and WinXTest/32 application software. Often WinX/32 and LightField use different terms for the same functions or parameters. When a topic pertains to both WinX and LightField, curly brackets { } are used to denote a LightField term or location.

Refer to Table 1-2 for the conventions utilized throughout this document.

Table 1-2: Terminology Conventions Used

Topic	Convention Used
WinX/32-Specific Topic	WinX/32 Term/Location
LightField-Specific Topic	LightField Term/Location
WinX/32 and LightField Shared Topic	WinX/32 Term/Location {LightField Term/Location}

1.4 Safety Related Symbols Used in this Manual

CAUTION!

A Caution provides detailed information about actions and/or hazards that may result in damage to the equipment being used, including but not limited to the possible loss of data.

WARNING!

A Warning provides detailed information about actions and/or hazards that may result in personal injury or death to individuals operating the equipment.

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.

1.5 PIXIS-XB Safety Information

Before turning on the power supply (air-cooled system or liquid-cooled system with a $CoolCUBE_{II}$ circulator,) 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.

WARNINGS!

1. If the PIXIS-XB camera system is used in a manner not specified by Teledyne Princeton Instruments, the protection provided by the equipment may be impaired.
2. If the equipment or the wall outlet 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 power rating as that of the original ones to avoid hazard due to electrical shock.

1.6 Precautions

To prevent permanently damaging the PIXIS-XB system, observe the following precautions at all times.

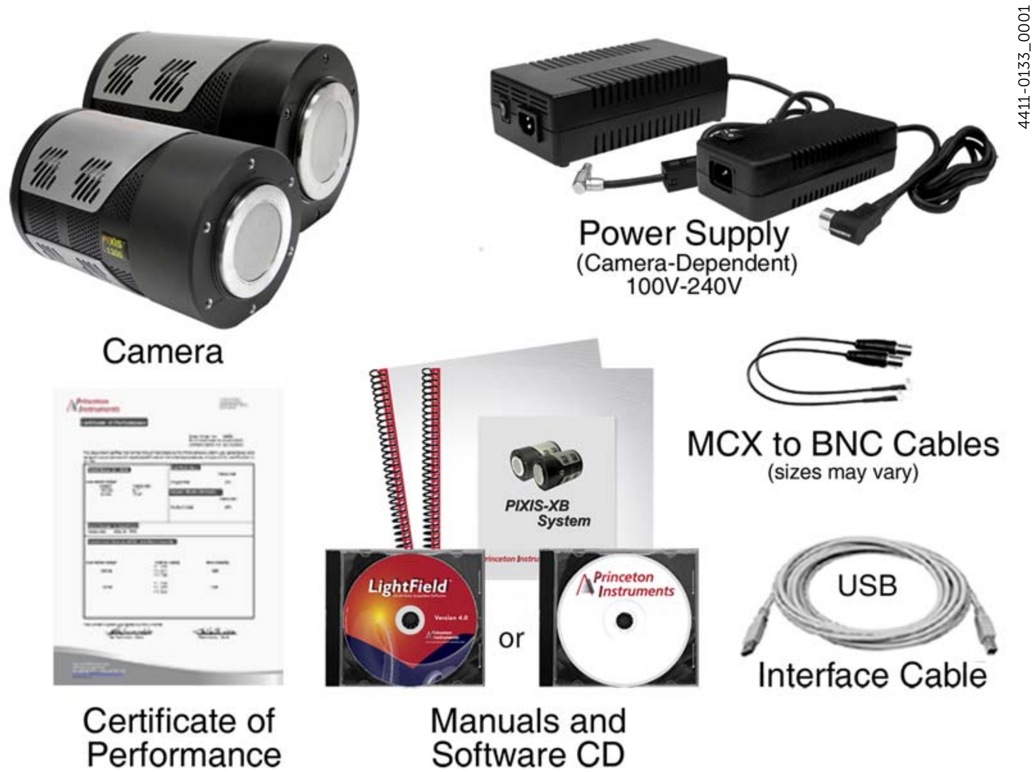
CAUTION!

1. 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.
2. When using high-voltage equipment (e.g., an arc lamp,) with the camera system, be sure to turn the camera power ON LAST and turn the camera power OFF FIRST.
3. Use caution when triggering high-current switching devices near the system (e.g., an arc lamp.) The CCD can be permanently damaged by transient voltage spikes. If electrically noisy devices are present, an isolated, conditioned power line or dedicated isolation transformer is highly recommended.
4. Do not block air vents on the camera. Preventing the free flow of air overheats the camera and may damage it.
5. If the PIXIS-XB camera system is used in a manner not specified by Teledyne Princeton Instruments, the protection provided by the equipment may be impaired.

Chapter 2: PIXIS-XB Camera System

This chapter provides an introduction to, and overview information about, Teledyne Princeton Instruments's PIXIS-XB camera system. Figure 2-1 shows those items that are typically included as part of a standard PIXIS-XB Camera system.

Figure 2-1: Typical PIXIS-XB System Components



Standard items for a typical air-cooled system include:

- PIXIS-XB Camera;
- Power Supply and Cable;
- Certificate of Performance;
- USB 2.0 Interface Cable;
- MCX to BNC Adapter Cables[a];
- Data Acquisition Software, including Installation Disk and manuals.

a. Length may vary

Standard items for a typical liquid-cooled system include:

- PIXIS-XB Camera;
- Power Supply and Cable;
- Certificate of Performance;
- USB 2.0 Interface Cable;
- MCX to BNC Adapter Cables[a];
- CoolCUBE$_{II}$ Coolant Circulator[b];
- Coolant Hoses[b];
- Data Acquisition Software, including Installation Disk and manuals.

a. Length may vary
b. Not illustrated in Figure 2-1.

2.1 PIXIS-XB Camera

PIXIS-XB cameras are designed specifically for applications such as:

- X-ray Photon Correlation Spectroscopy (XPCS);
- X-ray Intensity Fluctuation Spectroscopy (XIFS);
- X-ray Diffraction;
- X-ray Lithography;
- X-ray Spectroscopy.

The PIXIS-XB camera, illustrated in Figure 2-2, uses deep-depletion CCDs for direct detection of X-rays between <3 keV and 20 keV.

Figure 2-2: Typical PIXIS-XB Camera

4411-0133_0002

A thin beryllium window in front vacuum-seals the unit for deep cooling, protects the CCD, and reduces background by filtering low-energy X-rays.

The thermoelectric-cooled option delivers maintenance-free operation.

The software-selectable gains, output amplifiers, and readout speeds offer users highly flexible configuration capabilities to optimize system performance.

USB 2.0 electronics provide a plug-and-play interface with the host computer.

2.1.1 CCD Array

The PIXIS-XB camera system offers back-illuminated, deep-depletion CCDs as well as a front-illuminated, deep-depletion CCD (PIXIS-XB:1300R). The variety of array sizes allows 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 is already installed in the camera that you received and has been individually tested.

2.1.2 Cooling

Dark current is reduced in PIXIS-XB 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-XB model to the next. Refer to Table A-1, Typical Deepest Operating Temperature, on page 97, as well as the system-specific data sheet for cooling performance information.

2.1.2.1 Fan

Air-cooled PIXIS-XB cameras include an internal fan that:

- Removes heat from the Peltier device that cools the CCD array;
- Cools 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 acquired image.

For the fan to function properly, free circulation must be maintained between the sides of the PIXIS-XB camera and the laboratory atmosphere.

2.1.2.2 Coolant Ports

The camera coolant ports positioned on the side of the PIXIS-XB are not labeled. This is because coolant can flow through the camera in either direction. As is the case with circulating air, circulating coolant removes the heat produced by the Peltier device.

This method of heat removal is designed for vibration-free data acquisition.

For the circulating coolant to function properly, free air circulation must be maintained between the sides of the $\text{CoolCUBE}_{\text{II}}$ and the laboratory atmosphere.

⚠ CAUTION!

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

2.1.2.3 Coolant Hoses (Liquid-Cooled Systems)

4411-0133_0003

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

If a Teledyne Princeton Instruments CoolCUBE$_{II}$ circulator has been ordered with the camera, hoses are included with appropriate connectors on both ends.

NOTE:

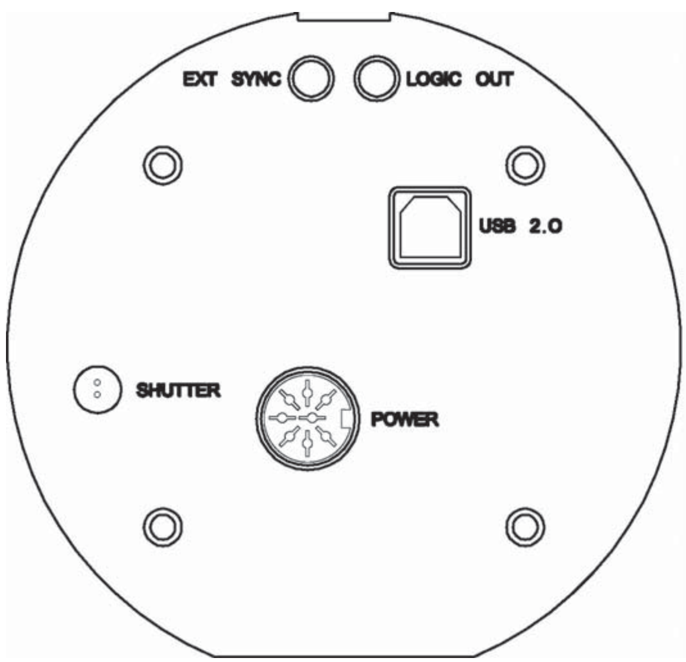
Part numbers for the hose, PIXIS-XB fittings, and CoolCUBE$_{II}$ fitting are:

- McMaster# MCM 5238K748 (3/8 ID, 5/8 OD tubing);
- CPC# MCD1004 (¼ NPT Valved Coupling Body) and McMaster# MCM 5346K35 (barbed hose fitting adapter for 3/8" hose ID X ¼" NPTF female pipe) at PIXIS-XB end;
- CPC# NS6D17006 (3/8 hose barb valved in-line coupling body) at CoolCUBE$_{II}$ end.

2.1.3 Rear Panel Connectors

Figure 2-3 shows the connectors and indicators found on the rear of the PIXIS-XB camera.

Figure 2-3: PIXIS-XB Rear-Panel Connectors and Indicators



4411-0133_0004

Refer to Table 2-1 for information about each connector.

Table 2-1: PIXIS-XB Power Supply Connectors and Indicators

Label	Description
EXT SYNC	TTL-compatible 0 to +3.3 V_{DC} logic input signal with a 10 kΩ pull-up resistor. Allows data acquisition and readout to be synchronized with external events. The MCX-to-BNC adapter cable is supplied with the PIXIS-XB system. Trigger edge can be positive- or negative-going as set in software. ***NOTE:*** Refer to Chapter 6, Advanced Topics, on page 61 for information about experiment synchronization and timing modes.
LOGIC OUT	TTL-compatible 0 to +3.3 V_{DC} programmable logic level output signal. The output of this connector can be programmed and can be inverted via the application software. ***NOTE:*** For complete information about the pin assignments for this connector, refer to Section 6.3, LOGIC OUT Control, on page 72.
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. ***NOTE:*** As of this printing, you can hot plug the PIXIS-XB camera whenever the WinX/32 application is not running (i.e., connect or disconnect from the camera or the host computer while the camera is powered ON.) For cameras built prior to November 1, 2005, you must exit the WinX/32 application and turn the camera power OFF before connecting/disconnecting the USB cable to the camera or host computer.
POWER	Input power for the PIXIS-XB camera. Refer to Section 2.1.4, PIXIS-XB Power Supply, for complete information.
SHUTTER	This 2-pin LEMO® connector is active when there is no internal shutter installed. Connects to, and provides drive pulses for, driving supported external shutters. Camera power must be OFF before connecting to or disconnecting from this connector. Customers are required to supply their own shutter cable. ***NOTE:*** Refer to Section A.4.1, SHUTTER Connector, on page 98 for pin out information.

2.1.4 PIXIS-XB Power Supply

All voltages required by PIXIS-XB camera systems are generated and delivered by a model-specific external power supply included with each PIXIS-XB camera using the supplied cables.

CAUTION!

Use of a power supply other than that provided with the PIXIS-XB camera may severely and permanently damage the camera and will void the camera warranty. For specific power supply requirements, contact Teledyne Princeton Instruments. Refer to Contact Information on page 114 for complete information.

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.

REFERENCES:

Refer to Section A.3, Camera Specifications, Power Supply Specifications, on page 96 for complete power supply technical specifications.

2.2 Cables

Table 2-2 provides information about the cables included with a standard PIXIS-XB Camera System.

Table 2-2: Standard PIXIS-XB Camera System Cables

Cable	Part Number	Description/Purpose	Length
USB 2.0	6050-0494	Connects the USB 2.0 connector on the rear of the PIXIS-XB with a USB card installed in the host computer. See Figure 2-3. 	16.4 ft [5 m]
MCX to BNC	6050-0540	Two (2) MCX to BNC adapter cables are included. These connect to the EXT SYNC and LOGIC OUT connectors on the rear of the PIXIS-XB. See Figure 2-3. 	Varies

2.3 Certificate of Performance

Each PIXIS-XB camera is shipped with a Certificate of Performance which states that the camera system has been assembled and tested according to approved Teledyne Princeton Instruments procedures. It documents the camera's performance data as measured during the testing of the PIXIS-XB 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.

2.4 Application Software

Teledyne Princeton Instruments offers a number of data acquisition software packages for use with PIXIS-XB camera systems, including:

- WinX/32

  The PIXIS-XB camera can be operated by using either WinView/32 or WinSpec/32, Teledyne Princeton Instruments' 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/32 and WinSpec/32 take full advantage of the versatility of the PIXIS-XB camera and even enhance it by making integration of the detection system into larger experiments or instruments an easy, straightforward endeavor.

- 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.

- Scientific Imaging ToolKit™ (SITK™)

  A collection of LabVIEW® VIs for scientific detectors and spectrographs. This third party software can be purchased from Teledyne Princeton Instruments.

- LightField®

  The PIXIS-XB camera can be operated using LightField, Teledyne Princeton Instruments' 64-bit Windows® 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 optional, patent-pending IntelliCal™ package is the highest-performance wavelength calibration software available, providing up to 10X greater accuracy across the entire focal plane than competing routines.
- 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.

  Refer to the PICam Programmer's Manual for the list of supported operating systems.

NOTE:

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

2.5 Accessories

Teledyne Princeton Instruments offers a number of optional accessories that are compatible with PIXIS-XB. For complete ordering information, contact Teledyne Princeton Instruments. Refer to Contact Information on page 114 for complete information.

2.5.1 Fiber Optic Extender Kit

4411-0133_0007

The specially designed fiber optic data interface kit allows the host computer and the USB2.0 camera head to be separated by up to 500 m 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.

2.5.2 CoolCUBE$_{II}$ with PIXIS-XB-Compatible Hoses

4411-0133_0008

Liquid-cooled PIXIS-XB 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 the 50:50 mixture of room temperature (23°C) water and ethylene glycol.

A set of PIXIS-XB-compatible coolant hoses (P/H: 7567-0002) are included.

To prevent voiding the PIXIS-XB warranty, only the circulator and hoses shipped with your system must be used.

2.5.3 External Shutters

The following external shutters are supported by, PIXIS-XB cameras as indicated:

- Small Array Cameras [i.e., PIXIS-XB:400 and PIXIS-XB:1024]
  - UNIBLITZ® VS25;
    25 mm optical shutter
- Large Array Cameras [i.e., PIXIS-XB:1300 and PIXIS-XB:2048]
  - UNIBLITZ CS45;
    45 mm optical shutter
  - UNIBLITZ XRS6
    6 mm x-Ray shutter
  - UNIBLITZ XRS14;
    14 mm x-Ray shutter
  - UNIBLITZ XRS25;
    25 mm x-Ray shutter.

NOTE:

For information about UNIBLITZ shutters by Vincent Associates, visit their website at www.uniblitz.com.

2.6 PIXIS-XB Camera and System Maintenance

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

2.6.1 Camera

Although there is no periodic maintenance that needs to be performed on a PIXIS-XB camera, users are advised to wipe it down with a clean damp cloth from time to time. This operation should only be done on external surfaces other than the Beryllium window since water can damage the window with all covers secured and the camera powered off. 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.

2.6.2 Beryllium Window

Cleaning may be necessary to remove oil or other contaminants from the surface of the window. Because a fingerprint left on the surface will disrupt the effectiveness of the final etch or coating and because of the potential toxicity, protective gloves should be worn when cleaning the window. To clean the window, wipe it down with isopropanol and a lint-free cloth. DO NOT use water. Beryllium is highly susceptible to localized pitting when in contact with the chloride and sulfate ions contained in ordinary water.

2.6.3 Repairs

Because the PIXIS-XB camera system contains no user-serviceable parts, repairs must be performed by Teledyne Princeton Instruments. Should the system need repair, contact Teledyne Princeton Instruments customer support for instructions. Refer to Contact Information on page 114 for complete information.

Save the original packing materials and use them whenever shipping the system or system components.

Chapter 3: Initial System Verification

Table 3-1 lists the sequence of actions required to install a PIXIS-XB system and prepare to gather data. Refer to the indicated references for additional information.

Refer to Section 3.1, System Block Diagrams, on page 24 for high-level block diagrams of typical system configurations.

Table 3-1: PIXIS-XB Installation Actions (Sheet 1 of 2)

Action	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, Unpack the System, on page 25.
2. Verify that all system components have been received.	Section 4.2, Verify 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 4.2, Verify Equipment and Parts Inventory, on page 26.
4. If the application software is not already installed in the host computer, install it.	Section 4.4, Install Application Software, on page 28 Software manual
5. If the USB 2.0 interface card is not already installed in the host computer, install it. Follow the manufacturer's instructions.	Host computer manufacturer's instructions
6. 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.	—
7. Air-Cooled System: Plug the power supply into the rear of the camera and plug the power supply into the power source.	—
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.	Section 4.6, PIXIS-XB-CoolCUBE$_{II}$ Connections, on page 32
8. Turn the Camera on.	—
9. Turn on the host computer and launch the application software.	Software Manual
10. Enter the hardware setup information or load the defaults from the camera.	Section 4.7, Configure Default System Parameters on page 33
11. Set the target array temperature.	Section 5.4.3, CCD Temperature, on page 50

Table 3-1: PIXIS-XB Installation Actions (Sheet 2 of 2)

Action	Refer to...
12. When the system reaches temperature lock begin acquiring data in focus mode.	Section 5.2, WinX/32 First Light Procedure on page 41. Section 5.3, LightField First Light Procedure on page 45.
13. After verifying that the camera sees, turn the camera supply OFF. If there is a circulator attached and running, turn it off as well.	

3.1 System Block Diagrams

This section provides typical system-level block diagrams.

Figure 3-1: Block Diagram: Typical Imaging Experiment with Air-Cooled PIXIS-XB

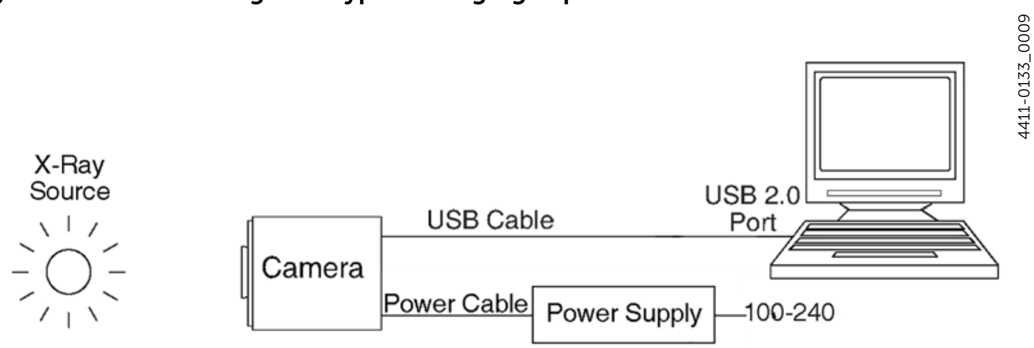
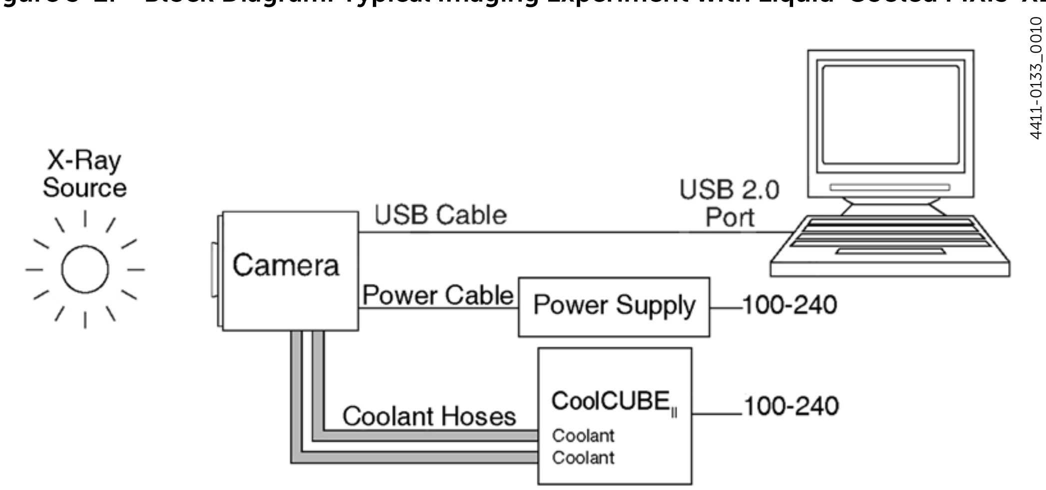


Figure 3-2: Block Diagram: Typical Imaging Experiment with Liquid-Cooled PIXIS-XB



Chapter 4: System Setup

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

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

- Camera head;
- Power supply;
- Cables.

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

Keep all of the original packing materials so you can safely ship the PIXIS-XB System Manual system to another location or return it for service if necessary. If you have any difficulty with any step of the instructions, contact Teledyne Princeton Instruments Customer Service. Refer to Contact Information on page 114 for complete information.

Hardware installation may consist of:

- Installing an interface card, if the appropriate card is not already resident.
- Mounting to a vacuum chamber.
- Connecting the camera to external triggering or monitoring equipment.

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

4.1 Unpack the System

During the unpacking, check 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, save the original packing materials so you can safely ship the camera system to another location or return it to Teledyne Princeton Instruments for repairs if necessary.

4.2 Verify Equipment and Parts Inventory

Verify all equipment and parts required to set up the PIXIS-XB system have been delivered.

A typical system consists of:

- Camera and Power Supply;
- CoolCUBE$_{II}$ Circulator and hoses (for liquid-cooled systems);
- Host Computer
  Can be purchased from Teledyne Princeton Instruments or provided by user.
  Refer to Section 4.3.2, Minimum Host Computer Requirements, on page 27 for complete information.
- USB cable
  Five (5) meter cable (6050-0494) is standard.
- Optional Items:
  - Application Software:
    - WinView/32 or WinSpec/32 (Version 2.5.25 or later) CD-ROM
    - LightField CD-ROM
    - Software User Manual (included with respective application software)
  - Fiber Optic Extender Kit

4.3 System Requirements

This section provides system requirement for the PIXIS-XB system.

4.3.1 Environmental Requirements

Storage Temperature

55°C

Operating Environment Temperature

5°C to +30°C.

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

Relative Humidity

50%, non-condensing

NOTE:

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

Ventilation

For the PIXIS-XB camera, allow at least one inch clearance for the side air vents.

When the camera is inside an enclosure, > 30 cfm air circulation and heat dissipation of 100 W is required.

Power

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

4.3.2 Minimum Host Computer Requirements

This section provides minimum Host Computer specifications.

NOTES:

1. Computers and operating systems undergo frequent revision. The following information is intended to provide an approximate indication of the computer requirements. Contact Teledyne Princeton Instruments Customer Service for specific requirements. Refer to Contact Information on page 114 for complete information.
2. The specifications listed are the MINIMUM required for a PIXIS-XB camera. A faster computer with larger memory (RAM) will greatly enhance the software performance during live operation.

4.3.2.1 WinX/32

The Host Computer must satisfy the following MINIMUM requirements when using WinView/32 or WinSpec/32:

- Windows® XP (32-bit with SP3 or later) or Vista (32-bit);
- 2 GHz Pentium® 4 (or greater);
- Native USB 2.0 support on the mother board or USB 2.0 Interface Card:
  - Orange Micro 70USB90011 USB2.0 PCI is recommended for desktop;
  - SIIG, Inc. USB 2.0 PC Card, Model US2246 for laptop);
- Minimum of 1 GB RAM;
- CD-ROM drive;
- Hard disk with a minimum of 1 GB available;

  A complete installation requires approximately 17-50 MB. The remainder is required for data storage, depending on the number and size of images/spectra collected.

  Disk level compression programs are not recommended.

  Drive speed of 10,000 RPM recommended.
- Super VGA monitor and graphics card supporting at least 65,535 colors with at least 128 MB of memory;

  Memory requirement is dependent on desired display resolution.
- Mouse or other pointing device.

4.3.2.2 LightField

The Host Computer must satisfy the following MINIMUM requirements when using LightField:

- Windows Vista® (64-bit) or Windows 7 (64-bit);
- 2 GHz dual core processor;
- 4 GB RAM;
- CD-ROM drive;
- Super VGA monitor and graphics card supporting at least 65535 colors with a minimum of 128 MB.
  Memory requirement is dependent on desired display resolution.
- Hard disk with a minimum of 1 GB available for installation.
  Additional space is required for data storage. The amount of space required depends on the number and size of images/spectra collected.
  Disk level compression programs are not recommended.
  Drive speed of 10,000 RPM recommended.
- Mouse or other pointing device.

4.4 Install Application Software

This section provides the procedures to install the data acquisition software.

4.4.1 WinX/32

Perform the following procedure to install WinView/32 or WinSpec/32 on the host computer:

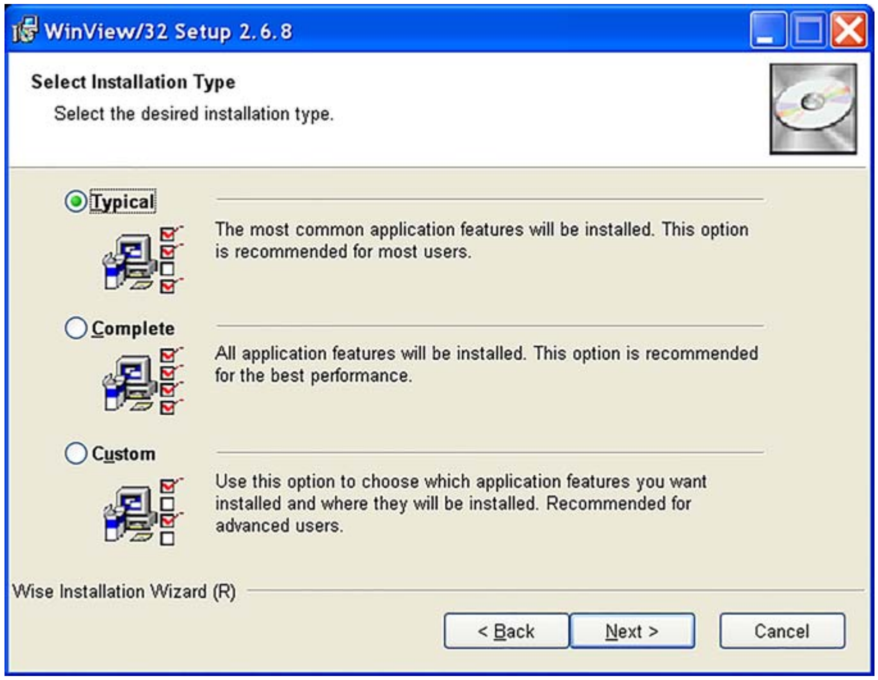
NOTES:

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 instructions.
2. Leave the USB cable disconnected from the camera until you have installed WinView/32.

1. Insert the CD-ROM into an appropriate drive on the host computer.
   The Installation Wizard will auto-run.
2. On the Select Installation Type dialog, click on
   - Typical to install the required drivers and the most installed program files
   - Custom to choose among the available program files or do not want to install the drivers;
   - Complete to install all application features.

   See Figure 4-1.

Figure 4-1: Typical WinView/32 Installation Dialog



4411-0133_0011

The required INF, DLL, and USB driver files will be placed in the appropriate Windows directories. Refer to Table 4-1.

Table 4-1: USB Driver Files and Corresponding Locations

Windows Version	USB INF Filename Located in `Windows/INF` directory[a]	USB Properties DLL Located in `Windows/System32` directory	USB Device Driver Name Located in `Windows/System32` Drivers directory
Windows XP Vista (32-bit) Windows 7 (32-bit)	`rsusb2k.inf` e.g., in `WINDOWS/INF`	`apausbprop.dll` e.g., in `WINDOWS/System32`	`apausb.sys` e.g., in `WINDOWS/System32/Drivers`

a. The INF directory may be hidden.

3. Verify the camera is connected to the host computer and that the camera power supply is turned on.
4. Reboot the host computer.
5. Upon rebooting, Windows will detect theTeledyne Princeton Instruments USB2 Interface hardware in the PIXIS-XB.

   You may be prompted to enter the directory path(s) for the `apausbprop.dll` and/or `apausb.sys` file(s), either by keyboard entry or by using the browse function.

4.4.2 LightField

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

NOTES:

1. Before proceeding, that the host computer's incorporates a 64-bit operating system.
2. Verify that the host computer supports USB 2.0. If it does not, install a USB 2.0 interface card per manufacturer's instructions.
3. If a USB key was supplied with the software, internet connectivity is not required. For earlier releases of LightField, an internet connection was typically required for product activation.

1. Insert the installation CD into an appropriate drive on the host computer. The Installation Wizard will auto-run. See Figure 4-2.

Figure 4-2: Typical LightField Installation Wizard Dialog

4411-0133_0012

2. Follow the on-screen prompts to install LightField.
3. Once the installation has been completed, reboot the host computer.
4. Connect the PIXIS-XB system components to the host computer and turn them on.
5. Launch LightField, activate it, and begin setting up the experiment.

4.5 Mount the Camera

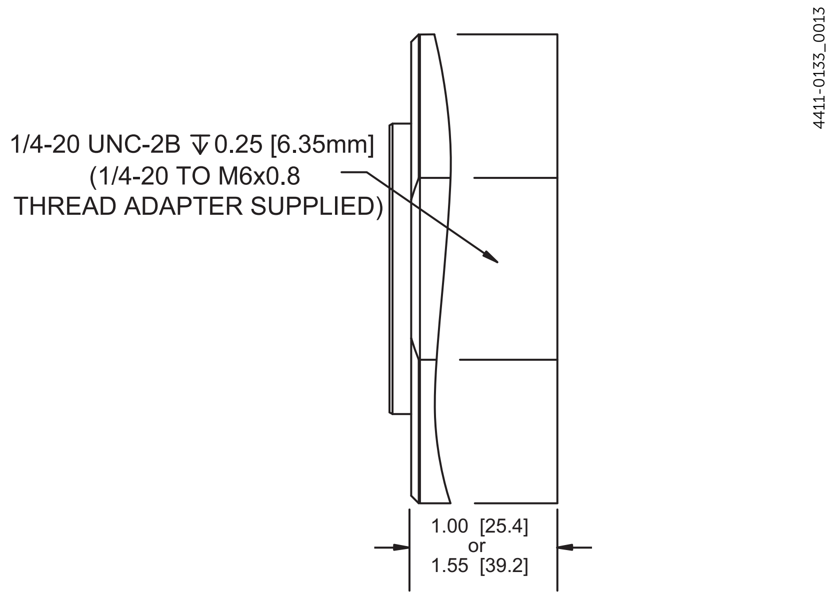
On the bottom of the camera near the front is a threaded hole (¼-20 tap, 0.25" deep) that can be used to mount the camera. A ¼-20 to M6 x 0.8 thread adapter is also supplied. See Figure 4-3.

NOTE:

The distance of the mounting hole from the front of the PIXIS-XB is either:

- 1.00 inch [25.4 mm], or
- 1.55 inch [39.2 mm].

Figure 4-3: Location of Threaded Mounting Hole on PIXIS-XB Cameras



Teledyne Princeton Instruments does not supply a vacuum interface flange but has provided a dimensioned drawing with the minimum design requirements for a customer-supplied flange. Refer to Figure B-5, Outline Drawing: Customer-Provided Vacuum Interface Flange, on page 105 for complete information.

4.6 PIXIS-XB-CoolCUBE$_{II}$ Connections

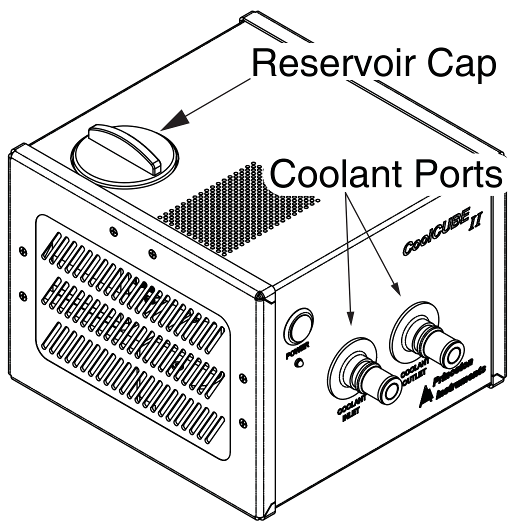
For liquid-cooled cameras, the CoolCUBE$_{II}$ circulator provides a vibration-free method of heat removal.

Perform the following procedure to connect a PIXIS-XB camera to the CoolCUBE$_{II}$:

1. Verify the camera and CoolCUBE$_{II}$ power switches are turned off.
2. Verify the CoolCUBE$_{II}$ a minimum of 6 inches [150 mm] below the PIXIS-XB. The vertical distance should not exceed 10 feet [3 m]. Typically, the camera is at table height and the circulator is on the floor.
3. Make the coolant connections between the circulator and the camera.

   It does not matter which hose from the circulator is plugged into a coolant port on the camera. See Figure 4-4.

Figure 4-4: Typical CoolCUBE$_{II}$ Circulator



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

   NOTE:

   Verify that there are no kinks in the hoses that impede the coolant flow. Lack of sufficient flow can seriously harm the detector and any resulting damage is not covered under warranty.

   Damage caused by water leaking into the PIXIS-XB voids the warranty.

4. Unscrew the reservoir cap located on the top of the CoolCUBE$_{II}$ and verify that the coolant reservoir contains coolant.

   If additional coolant is required, fill with a 50:50 mixture of water and ethylene glycol.
5. Screw the reservoir cap back in.
6. Plug the CoolCUBE$_{II}$ into a 100-240 V_{AC}, 47-63 Hz power source.

7. Turn the CoolCUBE$_{II}$ on. Verify there are no leaks or air bubbles in the hoses.

NOTE:

Small air bubbles (about the size of bubbles in soda) are common in the CoolCUBE$_{II}$ especially at start up and do not prevent normal operation.

- If there are no problems, proceed to step 8.
- If there are leaks or air bubbles:
  - Turn the CoolCUBE$_{II}$ off;
  - Correct the problem(s) by securing the hoses or adding more coolant to the reservoir;
  - Turn the CoolCUBE$_{II}$ back on;
  - Recheck and if there are no problems, proceed to step 8.

8. Turn the PIXIS-XB on.
9. Launch the application software.
10. Proceed to Section 4.7, Configure Default System Parameters.

4.7 Configure Default System Parameters

This section provides information about configuring default system parameters for both WinX/32 and LightField.

NOTE:

The procedures within this section assume that the appropriate computer interface has been previously installed.

4.7.1 WinX/32

Perform the following procedure to configure the default system parameters within WinX/32:

1. Verify the PIXIS-XB is connected to the host computer and that it is turned on.
2. Launch the appropriate WinX/32 application.

   The Camera Detection wizard will automatically run if this is the first time you have installed a Teledyne Princeton Instruments WinX/32 application (i.e., WinView/32, WinSpec/32, or WinXTest/32,) and a supported camera.

   Otherwise, if you installing a new camera type, click on the Launch Camera Detection Wizard... button on the Controller/CCD tab to start the wizard.
3. When the Welcome dialog is displayed, the checkbox should remain unselected. See Figure 4-5.

Figure 4-5: Typical WinX/32 Camera Detection Wizard: Welcome Dialog

4411-0133_0015

4. Click <u>N</u>ext >.
5. Follow the instructions on the subsequent dialogs to perform the initial hardware setup.

   This wizard enters default parameters on the Hardware Setup dialog tabs and gives you an opportunity to acquire a test image to confirm the system is working.

> **NOTE:**
>
> Refer to Section 5.2, WinX/32 First Light Procedure, on page 41 for a step-by-step procedure for basic system operation.

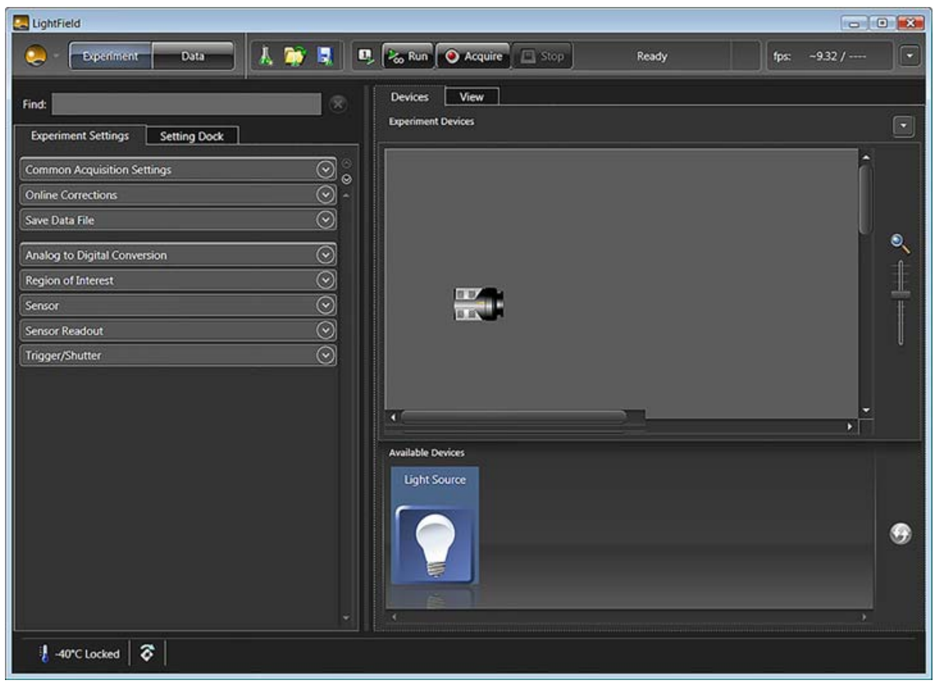
4.7.2 LightField

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

1. Verify the PIXIS-XB is connected to the host computer and that the PIXIS-XB 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 you drag an icon into the Experiment Devices area, the appropriate expanders will be loaded into the Experiment Settings stack on the left-hand side of the window.

   See Figure 4-6.

Figure 4-6: Typical LightField Experiment Workspace



4411-0133_0016

5. Since 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 data using the Run button; or
   - Acquiring data using the Acquire button.

NOTE:

Refer to Section 5.3, LightField First Light Procedure, on page 45 for a step-by-step procedure for basic system operation.

4.8 Connect an External Shutter

> ⚠ **CAUTION!**
> Connecting or disconnecting the shutter cable from the PIXIS-XB while the camera is ON can destroy the shutter or the shutter driver in the camera!

Although PIXIS-XB cameras do not have an internal shutter, supported external shutters can be connected to the Shutter connector on the rear of the PIXIS-XB camera.

4.8.1 Supported External Shutters

The set of supported external shutters varies by PIXIS-XB model as follows:

- PIXIS-XB: 400 and PIXIS-XB: 1024
  The following external slit shutters are supported:
  - UNIBLITZ VS25
    25 mm imaging shutter;
- PIXIS-XB: 1300 and PIXIS-XB: 2048
  The following external slit shutters are supported:
  - UNIBLITZ CS45
    45 mm imaging shutter;
  - UNIBLITZ XRS6
    6 mm x-ray shutter;
  - XRS14
    14 mm x-ray shutter;
  - XRS25
    25 mm x-ray shutter.

For current information about UNIBLITZ shutters by Vincent Associates, visit their website at http://www.uniblitz.com.

> ⚠ **CAUTION!**
> Electromechanical shutters typically have a lifetime of approximately one million cycles. Avoid running the shutter unnecessarily. Also avoid using shorter exposure times and higher repetition rates than are required.

4.8.2 Shutter Connection Procedure

Perform the following procedure to connect a supported external shutter to the PIXIS-XB camera:

1. Verify that the PIXIS-XB camera power supply is turned OFF.
2. Connect the shutter cable from a supported external shutter to the LEMO® connector on the rear of the camera.
   For additional information, refer to:
   - Section 2.5.3, External Shutters, on page 21,
   - Section 4.8.1, Supported External Shutters above;
   - Section A.4.1, SHUTTER Connector, on page 98.
3. Turn on the PIXIS-XB power supply.

4.9 Connect/Disconnect PIXIS-XB USB Cable

Effective November 1, 2005, you can hot plug the PIXIS-XB camera whenever the WinX/32 application is not running (i.e., connect or disconnect from the camera or the host computer while the camera is powered ON.)

For any cameras built prior to November 1, 2005, you must exit the WinX/32 application and turn the PIXIS-XB power OFF before connecting or disconnecting the USB cable from either the PIXIS-XB or host computer.

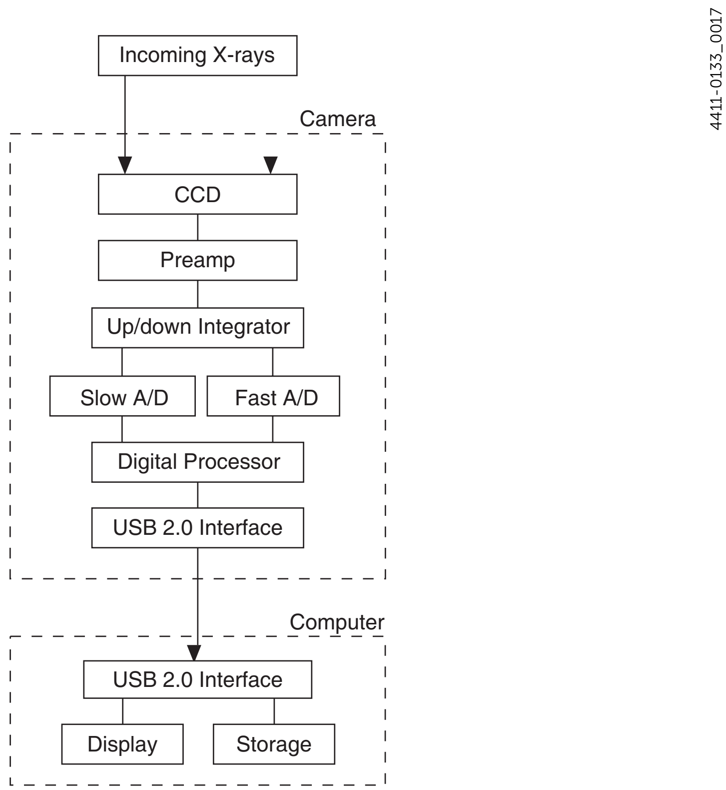
This page is intentionally blank.

Chapter 5: Operation

Once the PIXIS-XB camera has been installed as described in prior chapters, operation of the camera is straightforward. For most applications you simply establish optimum performance using the Focus mode (e.g., in WinView/32,) 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 respective software manuals.

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.

Figure 5-1: Block Diagram: PIXIS-XB Light Path



Whether or not data are displayed and/or stored depends on the data collection operation that has been selected in the application software. In WinX/32 and LightField, the data collection operations use the Experiment Setup parameters to establish the exposure time, the period during which the signal of interest is allowed to accumulate on the CCD. Typically, Focus {Preview} is used when setting up the system and Acquire is used for the collection and storage of data. Refer to Section 5.2, WinX/32 First Light Procedure, on page 41 and Section 5.3, LightField First Light Procedure, on page 45 for additional information.

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/32, 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/32, this could only happen in Fast Mode operation.

This chapter discusses the system on/off sequences followed by First Light procedures for imaging and spectroscopy applications. These procedures provide step-by-step instructions about how to initially verify system operation.

The last three sections discuss factors which affect exposure, readout, and digitization of the incoming signal. By understanding these factors and making adjustments to software settings you can maximize signal-to-noise ratio. Refer to Chapter 6, Advanced Topics, on page 61 for information about synchronizing data acquisition with external devices.

5.1 System On/Off Sequence

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

1. The PIXIS-XB camera must be powered ON before the WinX/32 application is launched in order to ensure communication between the camera and the computer. If the WinX/32 application is launched and the PIXIS-XB has not been turned 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/32 application, turn on the camera, and relaunch the application before you can set up experiments and acquire new data.
2. The WinX/32 application must be closed before turning the camera OFF. If you turn 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 you will be unable to acquire new data until you have closed the application, turned on the camera, and then relaunched the application.

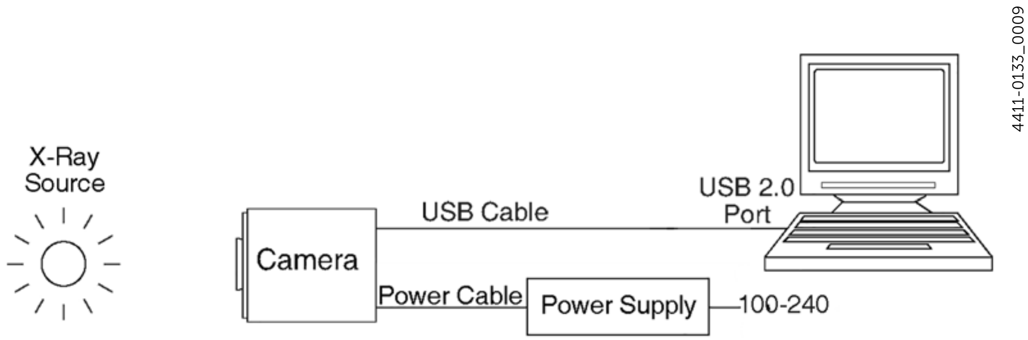
5.2 WinX/32 First Light Procedure

This section provides step-by-step instructions for verifying the operation of your PIXIS-XB system. The intent of this simple procedure is to help you gain basic familiarity with the operation of your system and to show that it is functioning properly. The procedure does not require an X-ray source. Once basic familiarity has been established, then operation with other operating configurations, ones with more complex timing modes, can be performed.

Once the PIXIS-XB system has been set up, operation of the camera is basically straightforward. In most applications you simply establish optimum performance using the Focus mode, select full frame, set the target camera temperature, and watch the dark charge decrease as the CCD temperature approaches the set temperature.

Figure 5-2 illustrates the system block diagram for First Light.

Figure 5-2: Block Diagram: Typical Imaging Experiment with Air-Cooled PIXIS-XB



This procedure assumes that:

- You have already set up your system in accordance with the information included in Chapter 4, System Setup, on page 25 and are verifying the camera system operation.
- You have read prior sections of this chapter.
- You are familiar with the application software.
- The system is being operated in imaging mode.

Perform the following procedure to configure WinView/32 to acquire an image for the first time:

NOTE:

The following procedure is based on WinView/32. You will need to modify it if you are using a different application (e.g., using WinSpec/32 in imaging mode.) Basic familiarity with the WinX/32 software is assumed. If this is not the case, you may want to review the software manual or have it available while performing this procedure.

1. If the system is liquid-cooled, verify that the CoolCUBE$_{II}$ is filled with a 50:50 mixture of ethylene glycol and water, and that the hose connections are secure. Refer to Section 4.6, PIXIS-XB-CoolCUBE$_{II}$ Connections, on page 32 for complete information.

2. When satisfied that these requirements are met:
   a. Turn on the CoolCUBE$_{II}$.

      It will power up and begin pumping coolant through the camera.
   b. Inspect the coolant hose connections to verify there are no leaks.
3. Turn on the power supply for the PIXIS-XB.

   NOTE:

   The PIXIS-XB must be turned on before launching WinView/32.

   WinView/32 must also be closed before turning off the PIXIS-XB.

4. Turn on the host computer's power and launch WinView/32.
5. Configure the system 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 you change the buffer size, you will have to reboot the computer for this memory allocation to be activated, and then relaunch WinView/32.
   - Controller ► Camera tab (Setup ► Hardware)

     Because the Camera Detection wizard (Hardware Setup wizard for earlier software version) has installed default values that are appropriate for your system, verify the following settings on this page:
     — Camera Name

       This information is read from the camera.
     — Controller Type

       This information is read from the camera.
     — Shutter Type

       None.
     — Readout <ode

       Select Full frame.
   - Detector Temperature (Setup ► Detector Temperature...)

     Use the default setting.

     When the array temperature reaches the set temperature, the Detector Temperature dialog will report that the temperature is LOCKED.

     Note that some overshoot may occur. This could cause temperature lock to be briefly lost and then quickly re-established.

     If you are reading the actual temperature reported by the application software, there may be a small difference between the set and reported temperature when lock is established. This is normal and does not indicate a system malfunction.

     Once lock is established, the temperature will be stable to within ±0.05°C.

     NOTE:

     The Detector Temperature dialog will not display temperature information while you are acquiring data.

   - Cleans and Skips tab (Setup ► Hardware)

     Click on Load Default Values and click Yes.

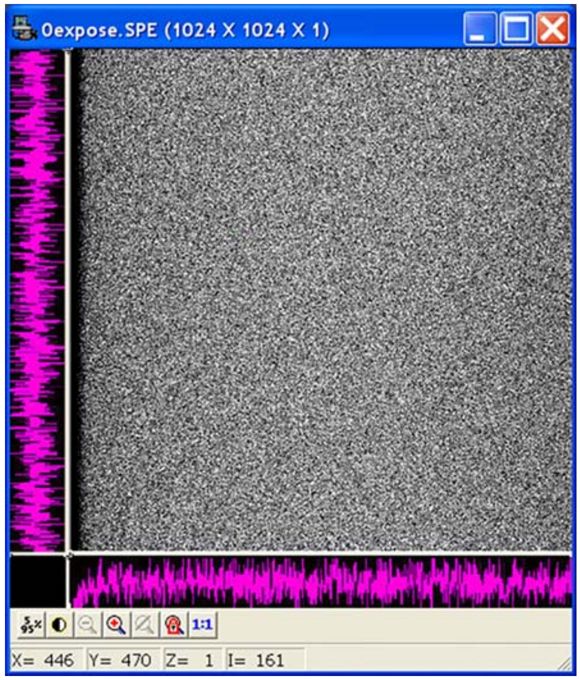
- Experiment Setup Main tab (Acquisition ► Experiment Setup...)
  - Exposure Time
    2 seconds
  - Accumulations & Number of Images
    1
- Experiment Setup ROI tab (Acquisition ► Experiment Setup...)
  This function defines the Region Of Interest (ROI).
  - Imaging Mode
    Select this mode if you are running WinSpec/32.
  - 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 vs. 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 Confirm Configuration

If you are using a WinX/32 application and the host computer's monitor for focusing, select Focus from the Acquisition menu. Successive images will be sent to the monitor as quickly as they are acquired. Since no X-ray source is being used, the acquired images will be of the camera's dark charge. Signal changes may be more easily seen on the cross-section views.

Figure 5-3 illustrates typical image data you might acquired with WinView/32 or Image mode with WinSpec/32. The horizontal and vertical cross sections have been turned on via the General tab (Display ► Layout).

Figure 5-3: Typical WinView/32 First Light Image Data



4411-0133_0018

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

This completes First Light for WinX/32 application software. If the system functioned as described, you can be reasonably sure it has arrived in good working order. In addition, you should have a basic understanding of how the system hardware is used.

5.3 LightField First Light Procedure

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

This procedure assumes that:

- You have already set up your system in accordance with the information included in Chapter 4, System Setup, on page 25 and are verifying the camera system operation.
- You have read prior sections of this chapter.
- You are familiar with the application software.
- The system is being operated in imaging mode.

Perform the following procedure to configure LightField to acquire an image for the first time:

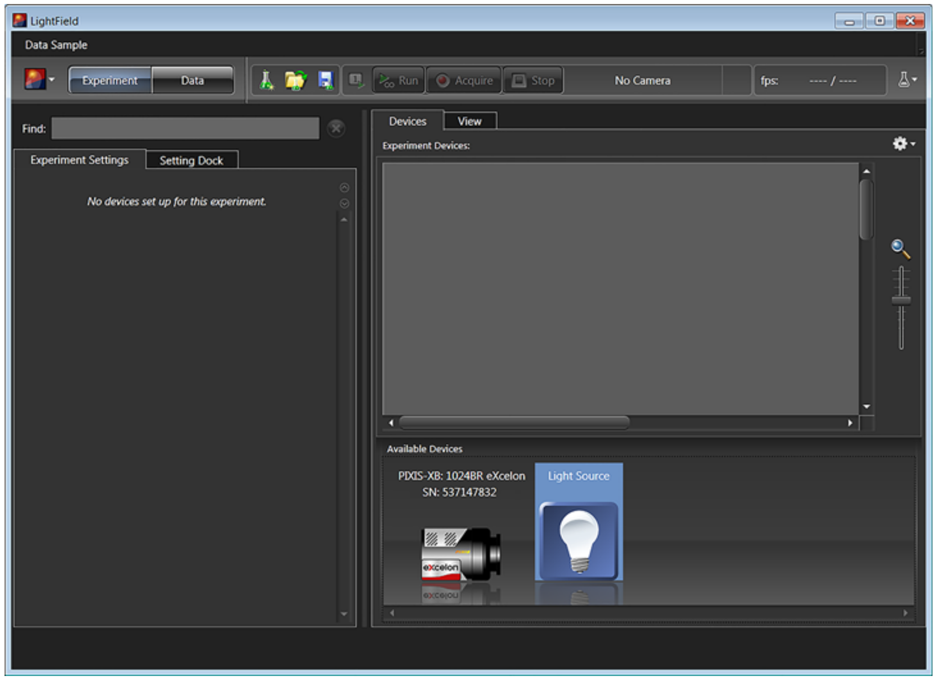
NOTE:

The following procedure is based on LightField. You will need to modify it if you are using a different application. Basic familiarity with LightField is assumed. If this is not the case, you may want to review the online help while performing this procedure.

1. If the system is liquid-cooled, verify that the CoolCUBE$_{II}$ is filled with a 50:50 mixture of ethylene glycol and water, and that the hose connections are secure. Refer to Section 4.6, PIXIS-XB-CoolCUBE$_{II}$ Connections, on page 32 for complete information.
2. When satisfied that these requirements are met:
   a. Turn on the CoolCUBE$_{II}$.

      It will power up and begin pumping coolant through the camera.
   b. Inspect the coolant hose connections to verify there are no leaks.
3. Turn on the power supply for the PIXIS-XB.
4. Turn on the host computer's power and launch LightField.
5. After LightField opens, an icon representing your camera will be shown in the Available Devices area. See Figure 5-4.

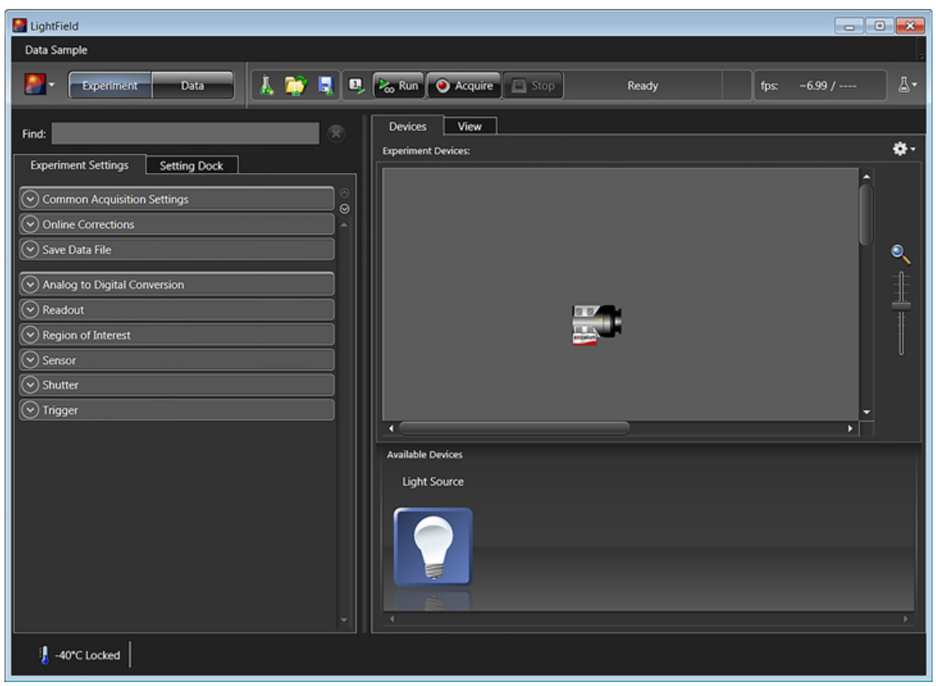
Figure 5-4: Typical LightField Available Devices Area



4411-0133_0019

6. Drag the icon into the Experiment Devices area. See Figure 5-5.

Figure 5-5: Typical LightField Experiment Devices Area



4411-0133_0020

NOTE:

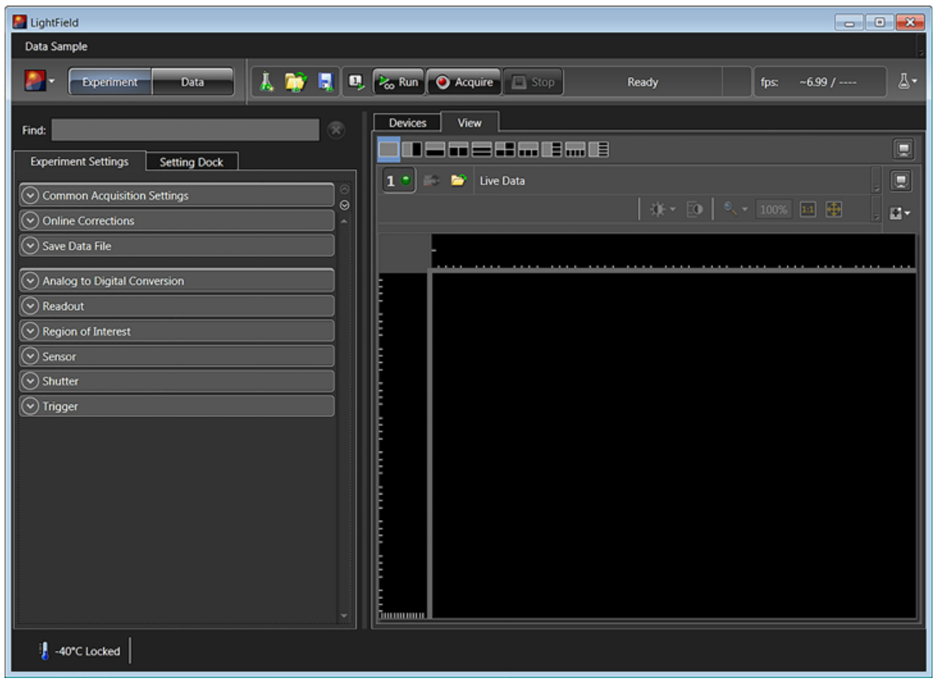
The Experiment Settings stack on the left now displays several expanders. Since this is a new experiment, the default settings for the PIXIS-XB are active.

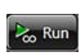
7. Open the Common Acquisition Settings expander and configure the Exposure Time to 100 ms.
8. The Status bar at the bottom of the window displays an icon for Temperature Status.

   Temperature Status reports the current temperature and whether the programmed temperature has been reached.

   Clicking on this icon opens the Sensor expander where the programmed temperature can be changed.
9. Click on the View tab just above Experiment Devices to view the Display area. See Figure 5-6.

Figure 5-6: Typical LightField View Tab Display

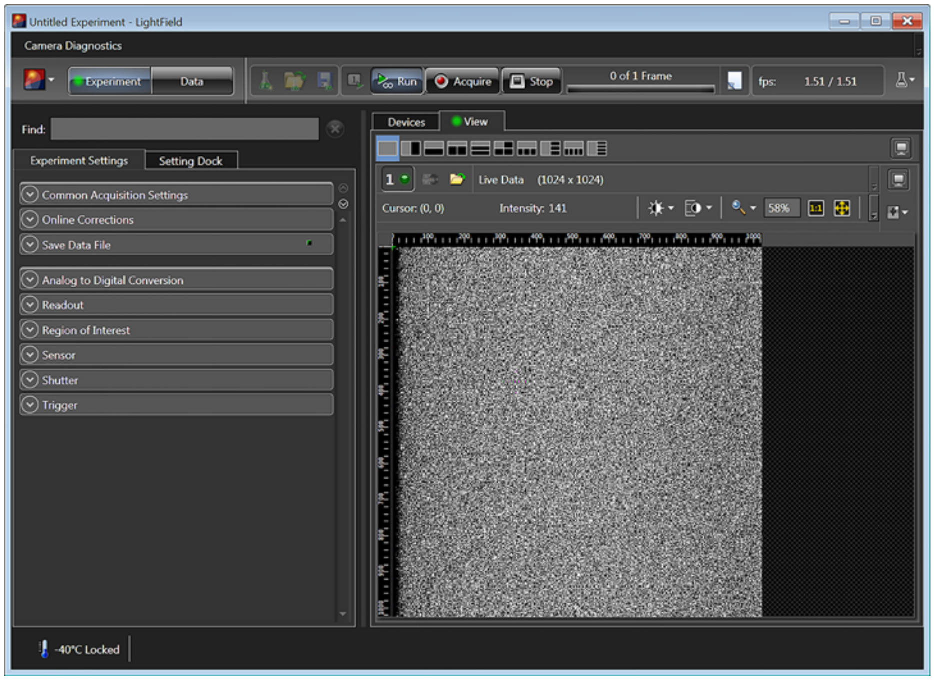


10. Click Run  to start Preview mode.

    In this mode, images are continuously acquired and displayed. Since no X-ray source is being used, the acquired images will be of the camera's dark charge.

    See Figure 5-7.

Figure 5-7: Typical LightField Acquired Image in View Tab



4411-0133_0022

11. Now that you have confirmed that the camera is working, close LightField, and turn off the camera.
12. This completes First Light for LightField. If the system functioned as described, you can be reasonably sure it has arrived in good working order. In addition, you should have a basic understanding of how the system hardware is used.

5.4 Exposure and Signal

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

5.4.1 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 programmed within the software, the pixels are read out serially.

CCD arrays perform three essential functions: photons are transduced to electrons, integrated and stored, and finally read out. CCDs are very compact and rugged and can withstand direct exposure to relatively high light levels, magnetic fields, and RF radiation. They are easily cooled and can be precisely thermally controlled to within a few tens of millidegrees.

5.4.2 Exposure Time

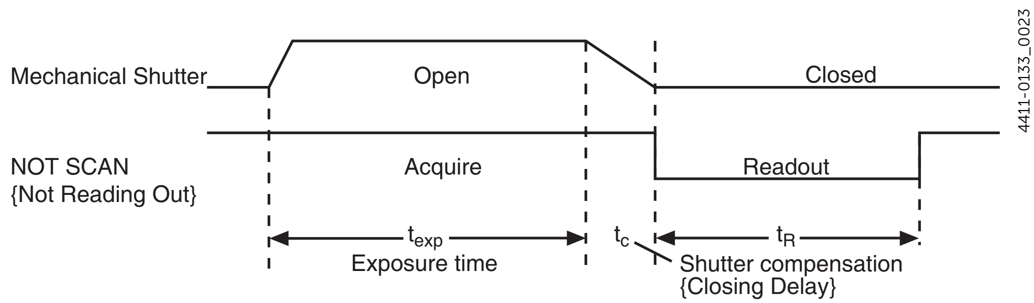
Exposure time, which is programmed on Experiment Setup ► Main tab {Common Acquisition Settings expander}, is the time between start acquisition and stop acquisition commands sent by the application software to the camera. In combination with triggers, these commands control when continuous cleaning of 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-XB 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-XB 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 72 for additional information.

Figure 5-8 shows the timing diagram for controlling a mechanical shutter with the NOT SCAN {Not Reading Out} signal.

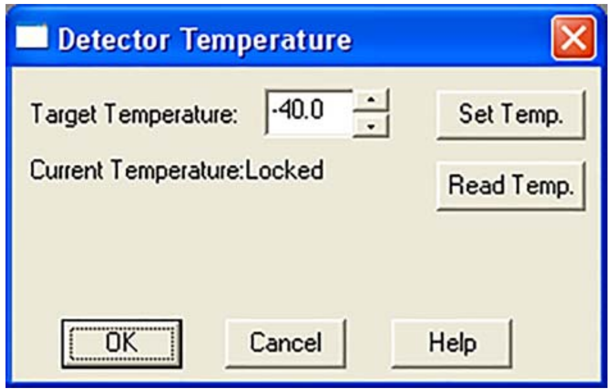
Figure 5-8: Timing Diagram: Mechanical Shutter Control



5.4.3 CCD Temperature

As stated earlier, lowering the temperature of the CCD generally enhances the quality of the acquired signal. When WinX/32 is the controlling software, temperature control is done via the Setup ► Detector Temperature dialog illustrated in Figure 5-9.

Figure 5-9: Typical WinX/32 Detector Temperature Dialog



When using LightField, temperature control is done on the Sensor expander.

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

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

The deepest operating temperature for a system depends on the CCD array size and packaging. Refer to Table A-1, Typical Deepest Operating Temperature, on page 97 for typical deepest cooling temperatures.

5.4.4 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 the case of cameras having a non-MPP array, such as deep-depletion devices.

With the light into the camera completely blocked, the CCD collects a dark charge pattern that is dependent on the exposure time and camera's 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.

CAUTION!

If you observe a sudden change in the baseline signal, 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 114 for complete information.

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.

5.4.5 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 advisable, with signal averaging to enhance Signal-to-Noise (S/R) Ratio accomplished through the software.

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

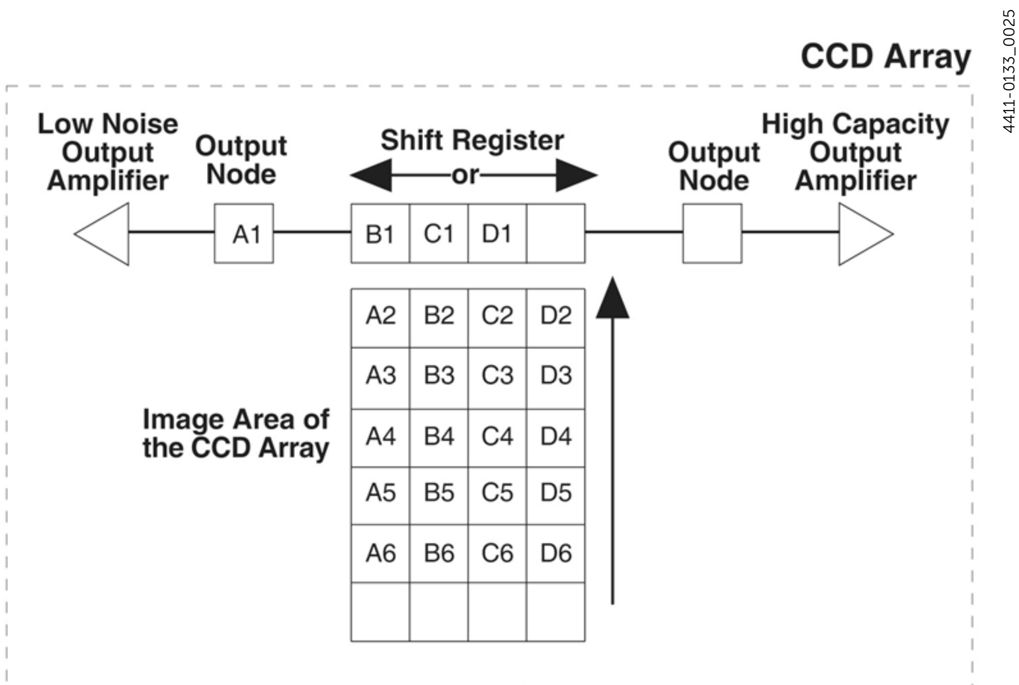
5.5 Readout

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.

See Figure 5-10.

Figure 5-10: Array Terms for a Dual Output Amplifier CCD



Both WinX/32 and LightField allow the following items to be specified:

- Type of Readout:
  - Full Frame;
  - Binned;
- Output Amplifier:
  - Low Noise;
  - High Capacity;
- Amount of Gain (i.e., the number of electrons required to generate an ADU.)

The following sections discuss each of these option.

5.5.1 Full Frame Readout

In Figure 5-11. the upper left section 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.

NOTE:

PIXIS-XB cameras offer the choice of amplifier:

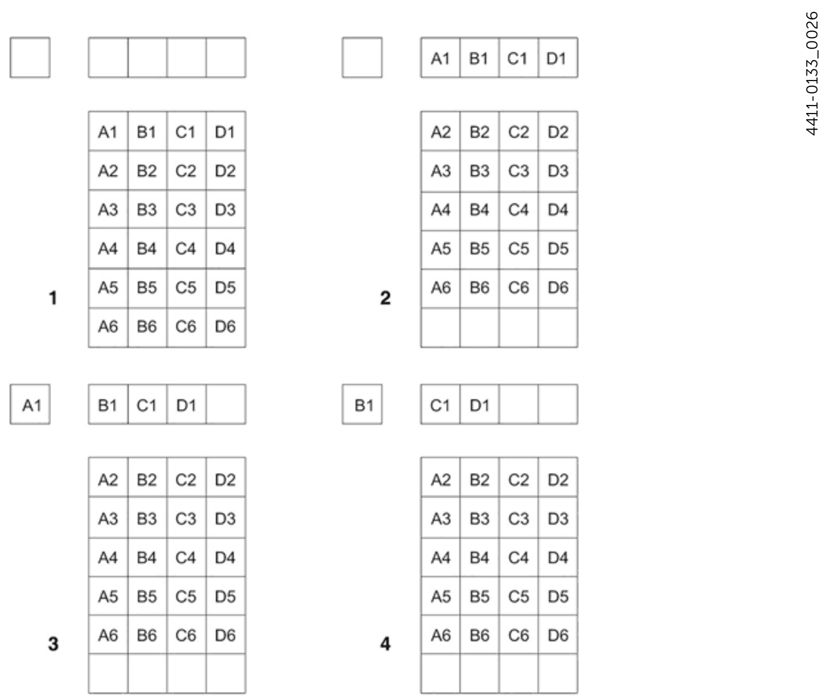
- Low Noise, or
- High Capacity.

Depending on the selected amplifier, the shift register may be read out to the right or to the left.

For simplicity, Figure 5-11 shows the readout to the left.

This section discusses readout at full resolution, where every pixel is digitized separately.

Figure 5-11: Full Frame at Full Resolution



Readout of the CCD begins with the simultaneous shifting of all pixels one row toward the shift register, in this case toward the top row. 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 the pixels in the imaging area of the CCD.

After the first row is moved into the shift register, the charge now in the shift register is shifted toward the output node, located at one end of the shift register. As each value is emptied into this node it is digitized. Only after all pixels in the first row have been digitized is the second row moved into the shift register.

The order of shifting in this example is therefore: A1, B1, C1, D1, A2, B2, C2, D2, A3, ...

After the 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 discussed below.

The time required to acquire a full frame at full resolution is:

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

where:

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

The readout time is approximated by:

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

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.

5.5.2 Binning

Binning is the process of adding the data from adjacent pixels together to form a single pixel, which is 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. The following sections describe each of these techniques.

5.5.2.1 Hardware Binning

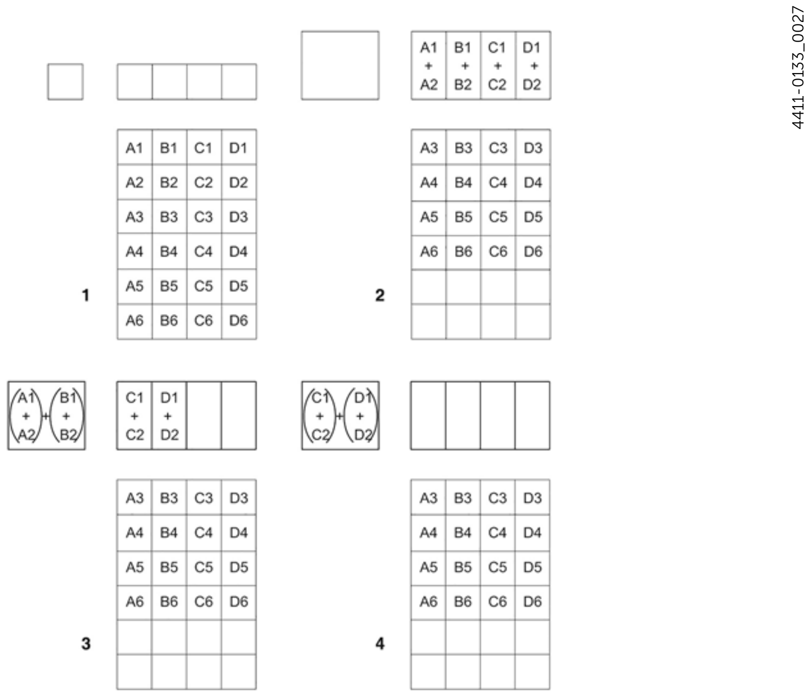
Hardware binning is performed on the CCD array before the signal is read out of the output amplifier.

For signal levels that are readout noise limited this method improves the 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 this comes 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 the spilling of charge back into the image area.

Figure 5-12 illustrates 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 5-12: Representation of 2 x 2 Binning



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

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

5.5.2.2 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 become 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 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.

5.5.2.3 Array Orientation

For square format CCDs (e.g., 512 x 512B, 1024 x 1024F/B,) you may orient the CCD to achieve binning along either direction of the CCD.

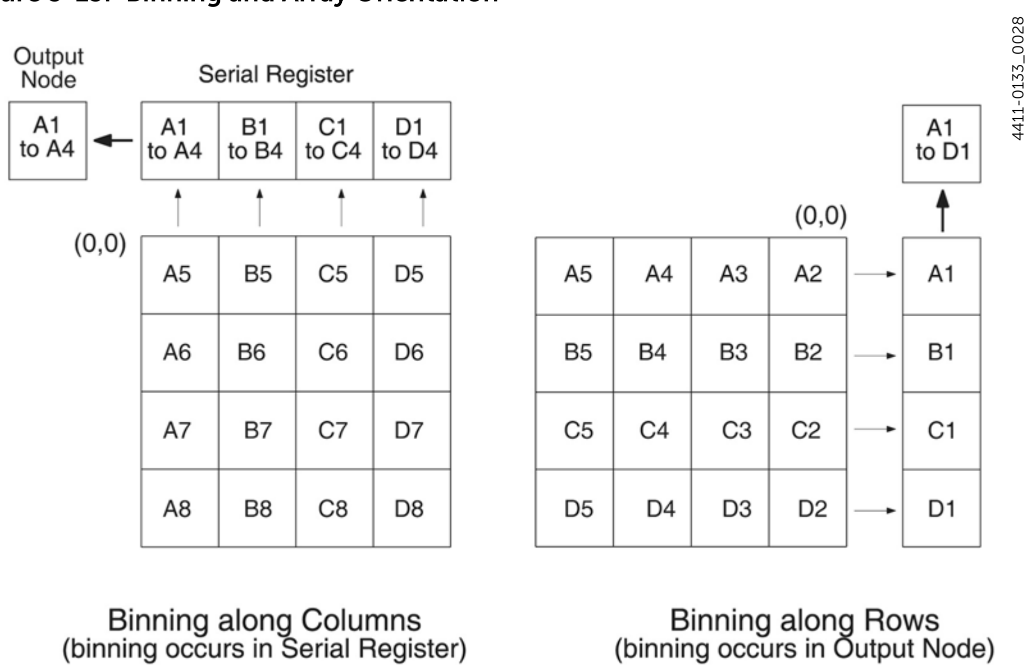
- Binning along columns provides maximum scan rate.
- Binning along the rows minimizes crosstalk and is therefore better for multi-spectral applications.

See Figure 5-13.

NOTE:

You can easily switch between these orientations by rotating the camera 90° and changing the binning parameters within the application software.

Figure 5-13: Binning and Array Orientation



5.5.3 Output Amplifier {Quality} Selection

The output amplifier amplifies the collected charge from the output node and outputs it as electrons/count. Although Figure 5-10 on page 52 shows an array with two output nodes and amplifiers (i.e., one set at each end of the shift register,) some PIXIS-XB systems are available with a single output node and amplifier. If your system has two output amplifiers, you can choose the output amplifier to be used (i.e., High Capacity or Low Noise,) 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 when you have intense light signals or signals with high dynamic range.
- Low Noise Amplifier

  Provides the highest sensitivity performance and is suitable when you have weak signals.

NOTE:

The choice of Output Amplifier {Quality} and Controller Gain {Analog Gain} settings should be considered together for the best signal capture. Examples of the interaction of output amplifier and controller gain selections are illustrated in Table 5-1 on page 58.

5.5.4 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}. The choices are:

- 1 {Low};

  Users who measure high-level signals may wish to select Low to allow 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.

The Certificate of Performance supplied with the camera lists the measured gain values at all settings.

Example

This example assumes the Low Noise Readout Port has been selected and that the actual incoming light level is identical in all three instances

Table 5-1 illustrates the effect of changing a controller gain setting and may not reflect actual performance. Actual gain at the 1, 2, and 3 settings depends on the CCD installed.

Table 5-1: Example of 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

In this example, the required electron counts to generate one ADU for the Low Noise amplifier 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 the images or spectra appear weak, you may want to 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 the images or spectra do not appear to take up the full dynamic range of the CCD array, you may want to change the gain setting to High.
  If the CCD array appears to be flooded with light, you may want to change the setting to Low.
- 3 {High} requires one electron to generate one ADU.
  Some noise sources are reduced.
  Because 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, you may want to change the setting to Medium or Low.

5.6 Digitization (Rate)

After gain has been applied to the signal, the Analog-to-Digital Converter (ADC) converts that analog information (continuous amplitudes) into a digital data (quantified, discrete steps) that can be read, displayed, and stored by the application software. The number of bits per pixel is based on both the hardware and the settings programmed into the camera through the software. Refer to Section 5.5, Readout, on page 52 for additional information.

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.

5.6.1 Digitization Rate {Speed}

PIXIS-XB cameras incorporate dual digitization (i.e., 100 kHz/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 and the 100 kHz conversion speed is used where noise performance is the paramount concern. Switching between the conversion speeds is completely under software control for total experiment automation.

NOTE:

In WinX/32, the ADC rate is configured on the Experiment Setup ► ADC tab.

In LightField, the speed is configured on the Analog-Digital Conversion expander.

5.6.2 ADC Offset {Bias}

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

To minimize the amount of this signal that gets digitized, the baseline has been offset by adding a voltage to the signal to bring the ADC output to a non-zero value, typically 500-600 counts. This offset value ensures that all the true variation in the signal can really be seen and not lost below the ADC's zero value. Since the offset is added to the signal, these counts only minimally reduce the range of the signal from 65535 (16-bit ADC) 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.

This page is intentionally blank.

Chapter 6: Advanced Topics

Previous chapters have discussed setting up the hardware and the software for basic operation. This chapter discusses topics associated with experiment synchronization.

Synchronization is set up on the Experiment Setup ► Timing tab in WinX/32 and on the Trigger and Shutter expanders in LightField.

This chapter discusses the following topics:

- Section 6.1, Timing Modes, begins on page 62

  Discusses Timing Modes {Trigger Response}, Shutter Control {Shutter Mode}, and Edge Trigger.

  Also included under this section is a discussion of the EXT SYNC connector, the input connector for a trigger pulse.
- Section 6.2, Fast and Safe Modes, begins on page 70

  Discusses the Fast and the Safe modes.

  - Fast is used for real-time data acquisition.
  - Safe is used in WinX/32 when coordinating acquisition with external devices or when the computer speed is not fast enough to keep pace with the acquisition rate.
- Section 6.3, LOGIC OUT Control, begins on page 72

  Discusses the EXT SYNC and LOGIC OUT output connectors on the rear of the PIXIS-XB. The levels at this connector can be used to monitor camera operation or synchronize external equipment.
- Section 6.4, Kinetics Mode, begins on page 73

  Describes how to set up and acquire data with the Kinetics Mode, a WinX/32 option, a standard feature with LightField.

  Kinetics allows full-frame CCDs to take time-resolved images/spectra.

  NOTE:

  Note that full-frame CCDs require mechanical or optical masking of the CCD array.

- Section 6.5, Custom Modes, begins on page 78

  Discusses Custom Chip {Custom Sensor} and Custom Timing modes.

  These modes allow you to specify an active sub-area of the CCD array and/or a faster vertical shift rate 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.

6.1 Timing Modes

The basic PIXIS-XB 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.

Table 6-1: PIXIS-XB 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-XB cameras do not use shutters, the Shutter Type selection on the Hardware Setup ► Controller/Camera tab should be None.

The shutter options available include:

- Normal;
- PreOpen {Open Before Trigger};

  This is available with the External Sync {Readout Per Trigger} and External Sync {Readout Per Trigger} with Continuous Cleans {Clean Until Trigger} modes.

  The shutter opens as soon as the PIXIS-XB 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.
- Disable Opened {Always Open};

  The shutter remains open and does not operate during an experiment.
- Disable Closed {Always Closed}.

  The shutter remains closed and does not operate during an experiment.

  This option is useful when making dark charge measurements.

Each of the three timing modes is described in the following sections. Timing diagrams and flow charts for each mode are provided. Except for Free Run where the modes of shutter operation are identical, both Normal and PreOpen signals are included.

The timing diagrams are appropriately labeled identifying the following:

- Exposure Time, t_{exp};
- Shutter Compensation Time, t_c;
- Readout Time, t_R.

Refer to Section 5.4.2, Exposure Time, on page 49 and Section 5.5, Readout, on page 52 for additional information.

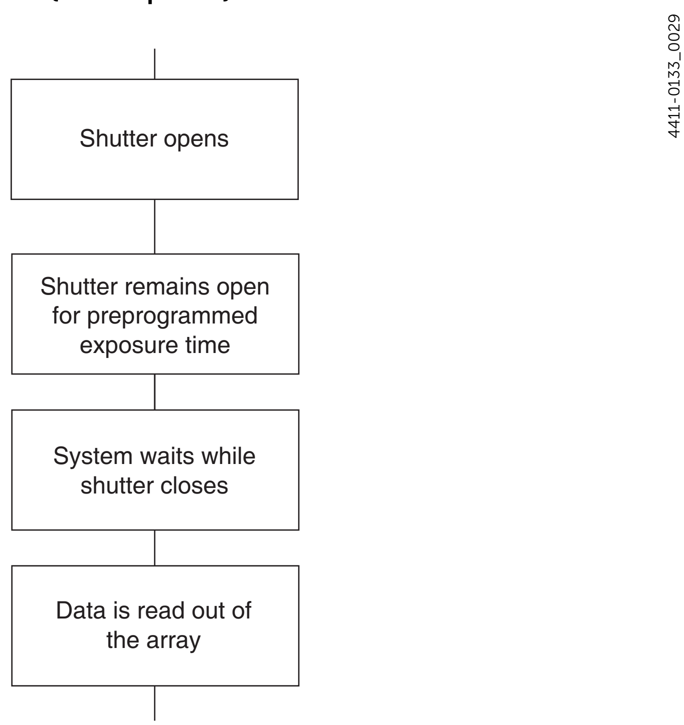
NOTE:

If there is no shutter selected in 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 is complete, and remains open for the exposure time, t_{exp}. Any External Sync signals are ignored. See Figure 6-1.

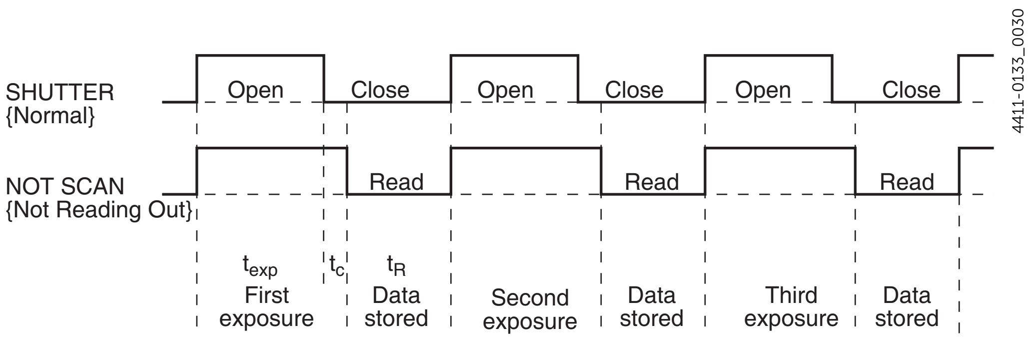
Figure 6-1: Flow Chart: Free Run {No Response}



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 are high repetition studies where the number of shots that occur during a single shutter cycle is so large that it appears to be continuous illumination.

Other experimental equipment can be synchronized to the 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 provided in the timing diagram illustrated in Figure 6-2.

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



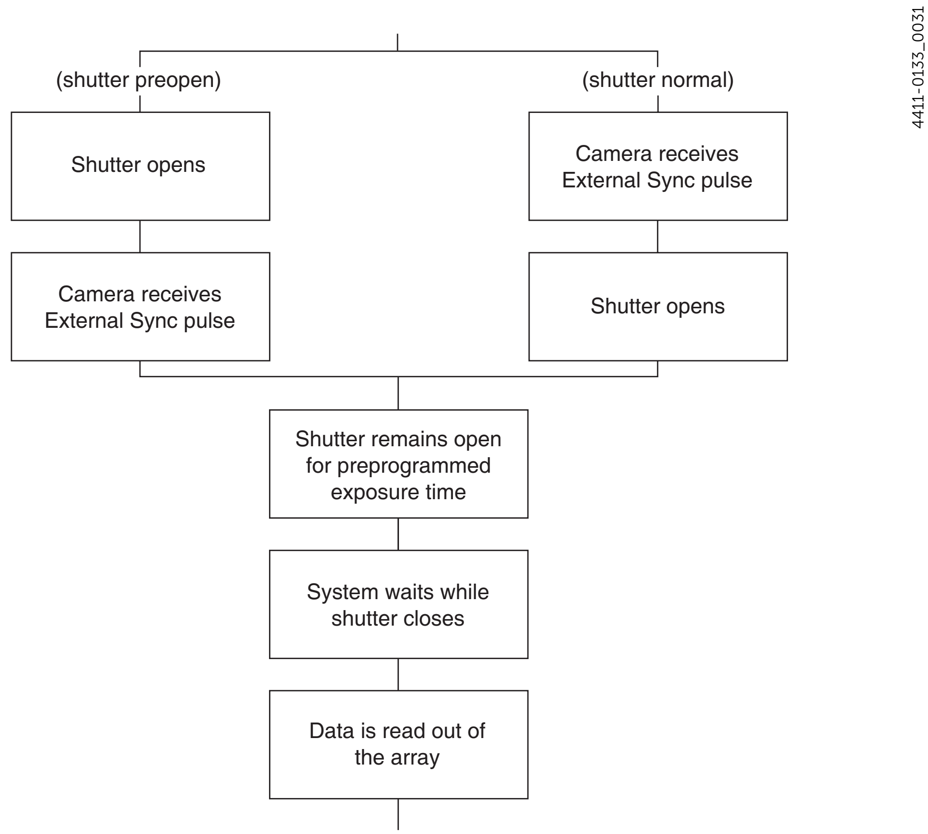
t_{exp} = Exposure Time
t_R = Readout Time
t_c = Shutter Compensation Time*
{Closing Delay}

Shutter Type	
Custom	0-21 sec (0-21,000 ms in 1 ms increments)

6.1.2 External Sync {Readout Per Trigger}

In this mode all exposures are synchronized to an external source. As shown in Figure 6-3, this mode can be used in combination with Normal or PreOpen {Open Before Trigger} shutter operation.

Figure 6-3: Flow Chart: External Sync Timing Options



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.

External synchronization depends on an edge trigger (i.e., negative- or positive-going,) 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:

- In WinX/32 this is programmed on the Experiment Setup ► Timing tab;
- In LightField this is programmed 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.

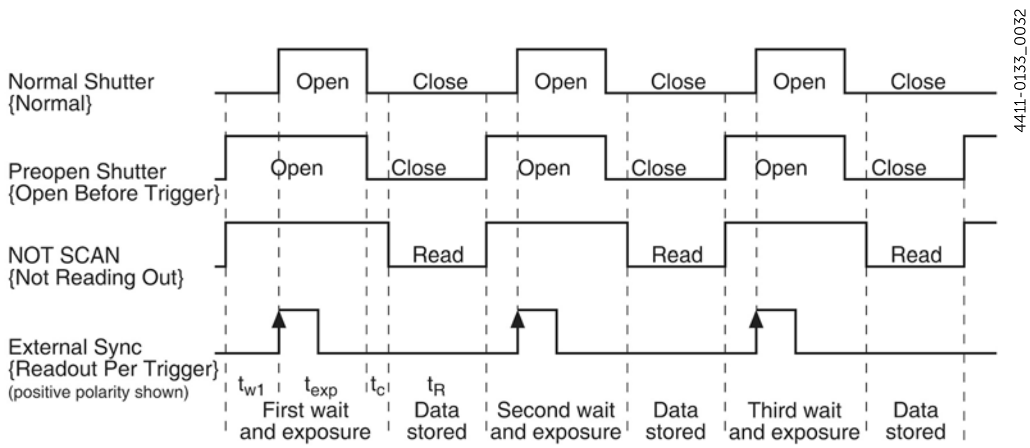
In PreOpen Shutter {Open Before Trigger} mode, on the other hand, shutter operation is only partially synchronized to the experiment. As soon as the camera is ready to collect data, the shutter opens. Upon arrival of the first External Sync pulse at the EXT SYNC connector, the shutter remains open for 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.

PreOpen {Open Before Trigger} mode is useful in cases 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. Its main drawback is that the CCD is exposed to any ambient light while the shutter is open between frames. If this ambient light is constant, and the triggers occur at regular intervals, this background can also be subtracted, providing that it does not saturate the CCD. As with the Normal Shutter {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.

See Figure 6-4 for the timing diagram.

Figure 6-4: Timing Diagram: External Sync, Positive Edge Trigger



NOTE:

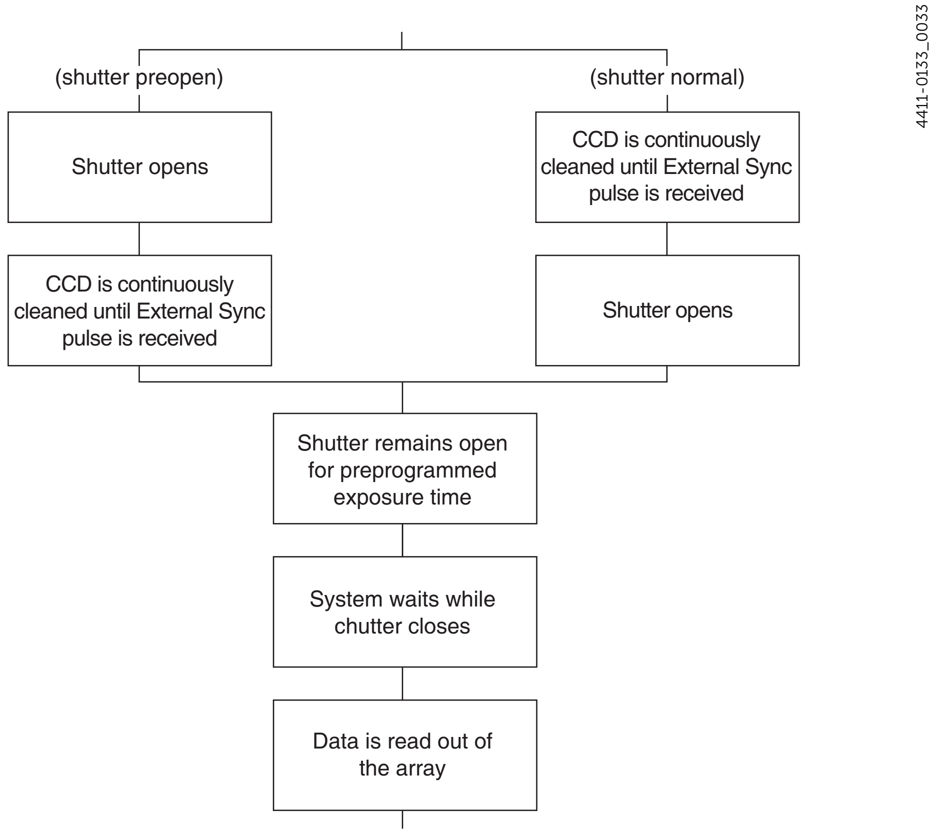
If the External Sync signal is still active at the end of the readout (i.e., it remains HIGH,) the hardware may interpret this as a second Sync pulse, and so on.

6.1.3 External Sync with Continuous Clean {Clean Until Trigger}

Another timing mode available with the PIXIS-XB is 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 has been received.

Figure 6-5 illustrates the flow chart for this mode.

Figure 6-5: Flow Chart: Continuous Clean {Clean Until Trigger}



Once the External Sync pulse trigger edge has been received, cleaning of the array stops as soon as the current row is shifted, and frame collection begins. A delay time of up to one row shift can be expected.

With Normal Shutter {Normal} operation the shutter is opened for the defined exposure time.

With PreOpen Shutter {Open Before Trigger} operation, the shutter is open during the Continuous Cleaning {Clean Until Trigger}, and once the External Sync pulse trigger edge has been received the shutter remains open for the set exposure time, then closes.

If the vertical rows are shifted midway when the External Sync pulse trigger edge arrives, the pulse is saved until the row shifting is completed, to prevent the CCD from getting out of step. As expected, the response latency is on the order of one vertical shift time, from 1-30 µs depending on the array. This latency does not prevent the incoming signal from being detected since photo generated electrons are still collected over the entire active area. However, if the signal arrival is coincident with the vertical shifting, image smearing of up to one pixel is possible. The amount of smearing is a function of the signal duration compared to the single vertical shift time.

Figure 6-6 and Figure 6-7 illustrate the timing diagrams for WinX/32 and LightField, respectively.

Figure 6-6: Timing Diagram: WinX/32 Continuous Cleans

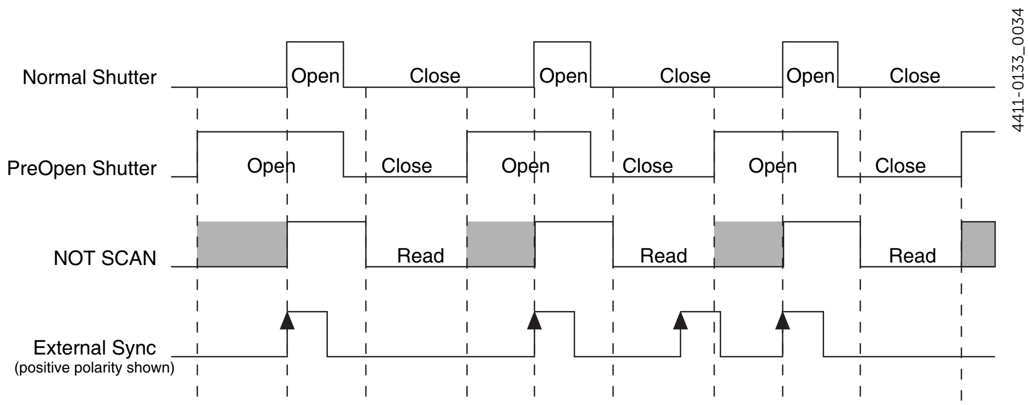
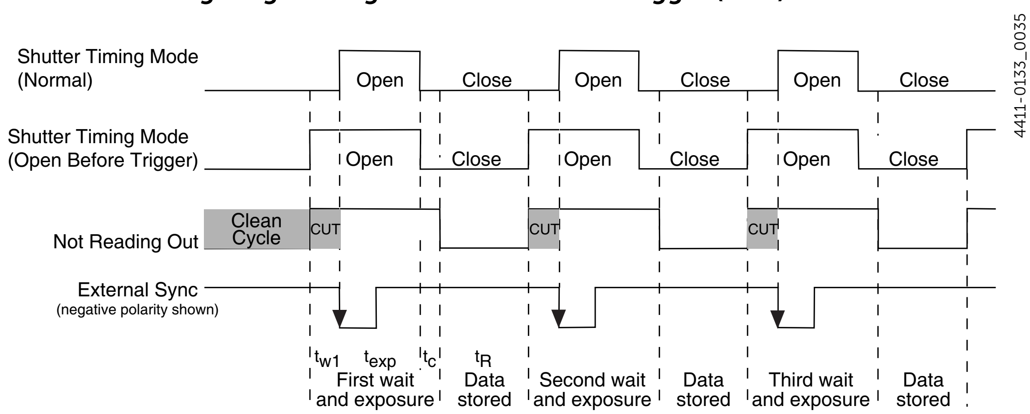


Figure 6-7: Timing Diagram: LightField Clean Until Trigger (CUT)



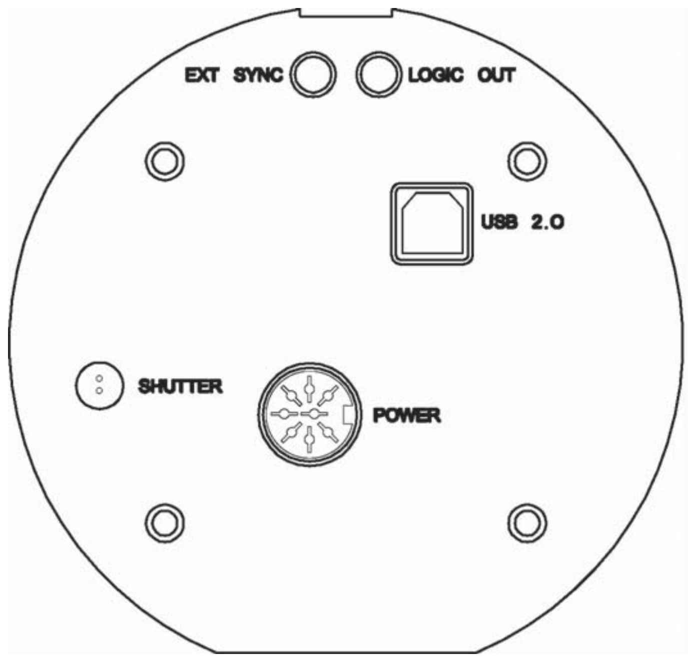
NOTE:

If the External Sync signal is still active at the end of the readout (i.e., it remains HIGH,) the hardware may interpret this as a second Sync pulse, and so on.

6.1.4 External Sync Trigger Input

The selected Timing Mode {Trigger Response} determines how the PIXIS-XB will respond to an External Sync pulse that is input at the EXT SYNC connector on the rear of the camera. See Figure 6-8.

Figure 6-8: PIXIS-XB Rear-Panel



Things to keep in mind when configuring 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}.

6.2 Fast and Safe Modes

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

- In Safe Mode, the host computer sends a start command and a stop command for each frame of a data sequence.
- In Fast Mode, the host computer sends one start command and one stop command for each data sequence. Once the start command has been sent, the selected timing mode and the shutter condition determine when charge will be allowed to fall on the CCD array.

In WinX/32, the choice of Fast or the Safe data collection is programmed on the Experiment Setup ► Timing tab. See Figure 6-9 for a comparison of the two modes.

In LightField, Fast data collection is always used.

6.2.1 Fast Mode [WinX/32. LightField]

In Fast operation, the PIXIS-XB runs according to the timing of the experiment with no interruptions from the host 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-XB has been sent the start command by the host computer, all frames are collected without further intervention from the host computer.

The advantage of this timing mode is that timing is controlled completely through hardware. A drawback to this mode is that the host computer only displays frames when it is not performing other tasks. Image display has a lower priority so the image on 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 host computer cannot keep up with the data rate.

NOTE:

LightField always uses Fast Mode

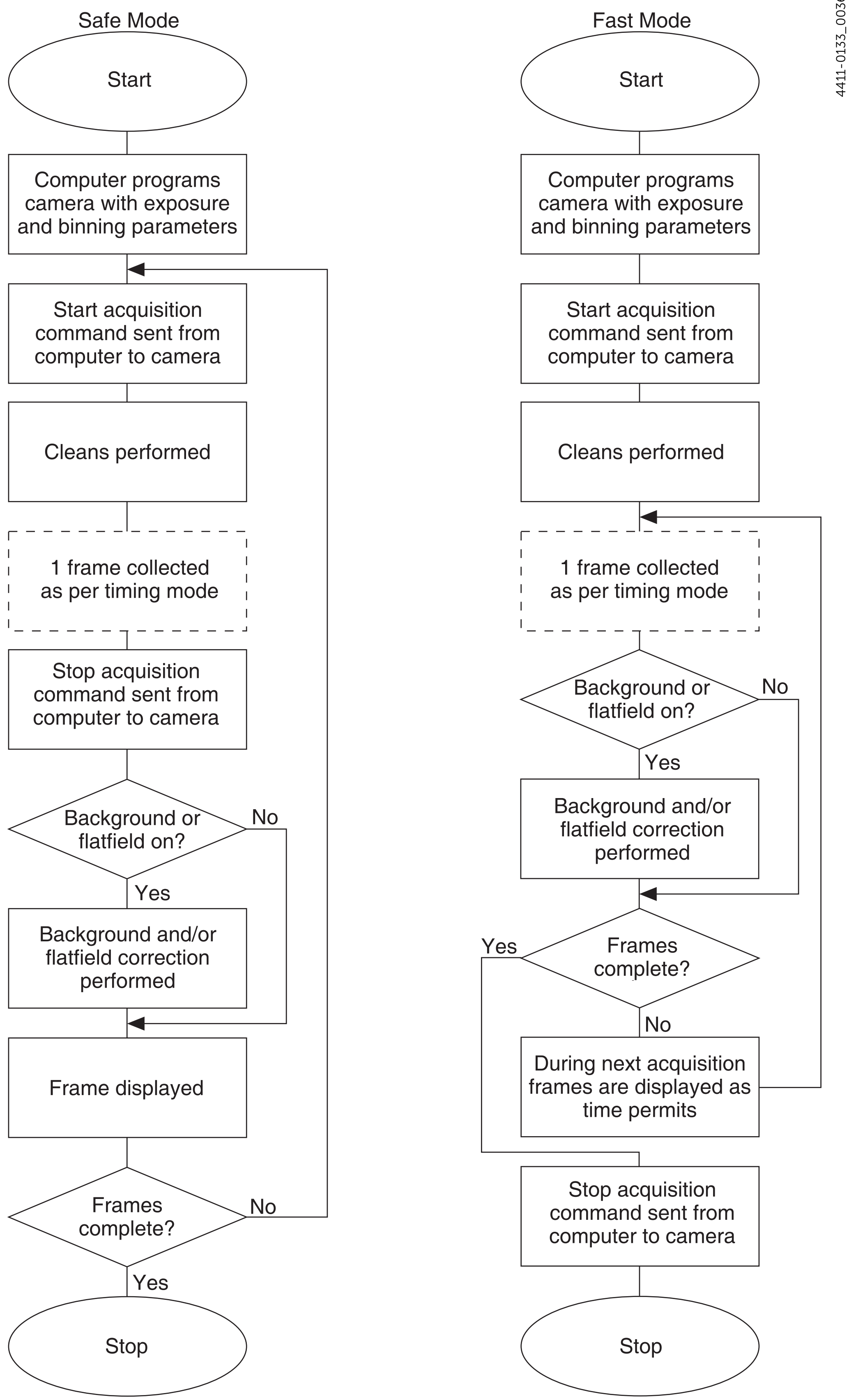
6.2.2 Safe Mode [WinX/32]

Safe Mode operation is useful when the PIXIS-XB is operated from a slower computer that cannot process incoming data fast 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, in Safe Mode operation, the host computer controls when each frame is taken. After each frame has been received, the host computer sends the Stop Acquisition command to the camera, instructing it to stop acquisition. Once that frame has been completely processed and displayed, another Start Acquisition command is issued by the host computer to the PIXIS-XB, allowing it to acquire the next frame. Display is therefore, at most, only one frame behind the actual data acquisition. One disadvantage of Safe mode is that events may be missed during the experiment since the PIXIS-XB is disabled for a short time after each frame.

NOTE:

When running WinX/32, Safe Mode must be used whenever the system is configured to use the optional Kinetics Mode. Refer to Section 6.4, Kinetics Mode, on page 73 for additional information about this mode.

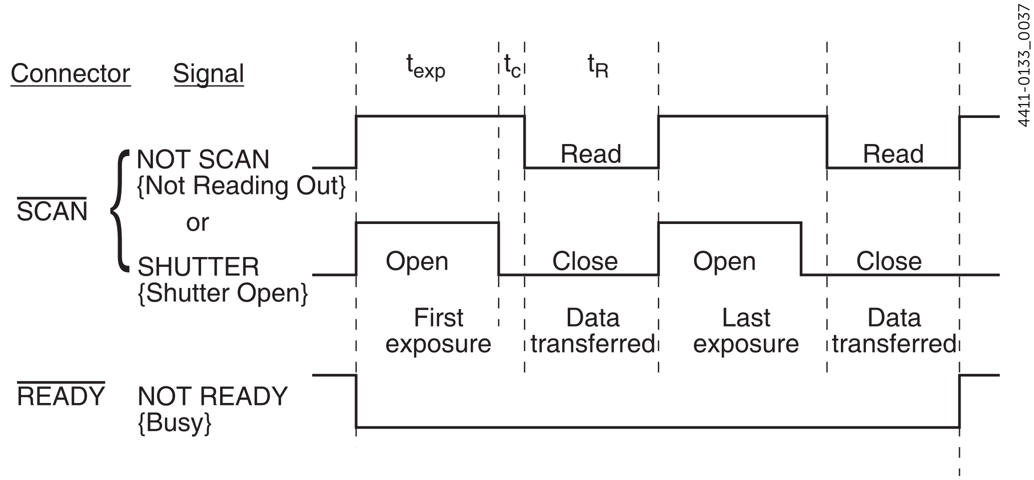
Figure 6-9: Flow Charts: Fast Mode and Safe Mode



6.3 LOGIC OUT Control

The TTL-compatible 0 to +3.3 V_{DC} logic signals 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. Figure 6-10 shows the timing diagram for key control signals when the acquisition of three frames of data has been programmed.

Figure 6-10: Timing Diagram: LOGIC OUT Control Signals



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}
  Logic LOW when the 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 has been programmed, it remains LOW until all frames have been acquired after which it goes HIGH.
- LOGIC 0 {Always Low
  The level at the connector is always LOW.
- LOGIC 1 {Always High}
  The level at the connector is always HIGH.

6.4 Kinetics Mode

NOTE:

Kinetics Mode is a purchased option for WinX/32 applications.

Kinetics Mode is included in the standard LightField application.

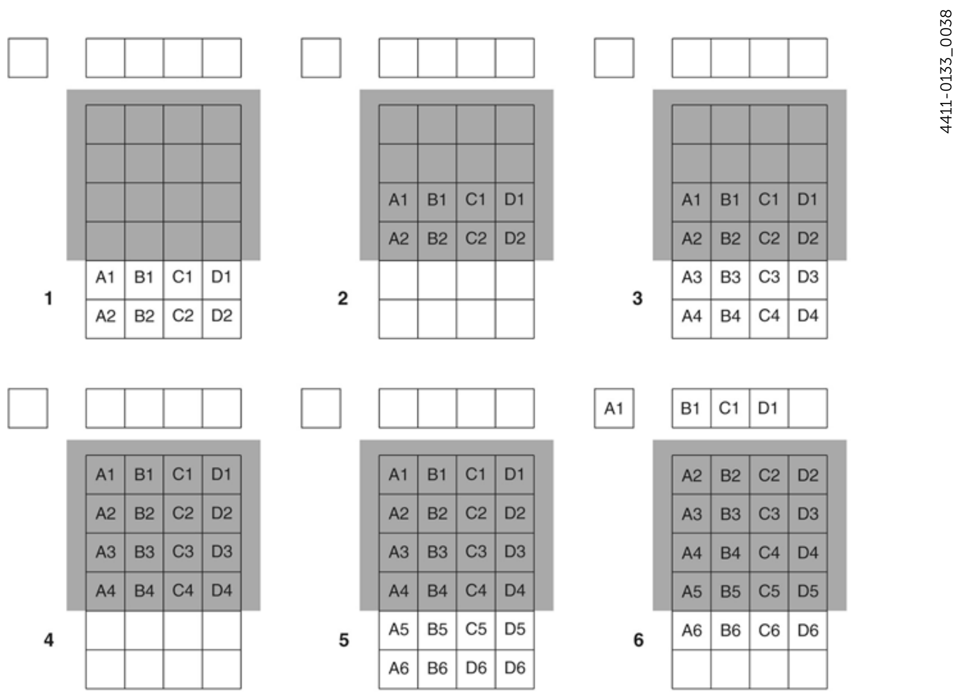
Kinetics mode uses the CCD to expose and store a limited number of images in rapid succession. The time it takes to shift each line (or row) on the CCD is as short as a few hundred nanoseconds to few microseconds, depending on the CCD. Therefore the time between images can be as short as a few microseconds.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

NOTE:

In WinX/32, if the Kinetics option has been installed in the PIXIS-XB, this readout mode will be made available when you select the appropriate camera type on the Hardware Setup dialog.

Figure 6-11 illustrates a simplified representation of kinetics mode.

Figure 6-11: Simplified Representation of Kinetics Readout

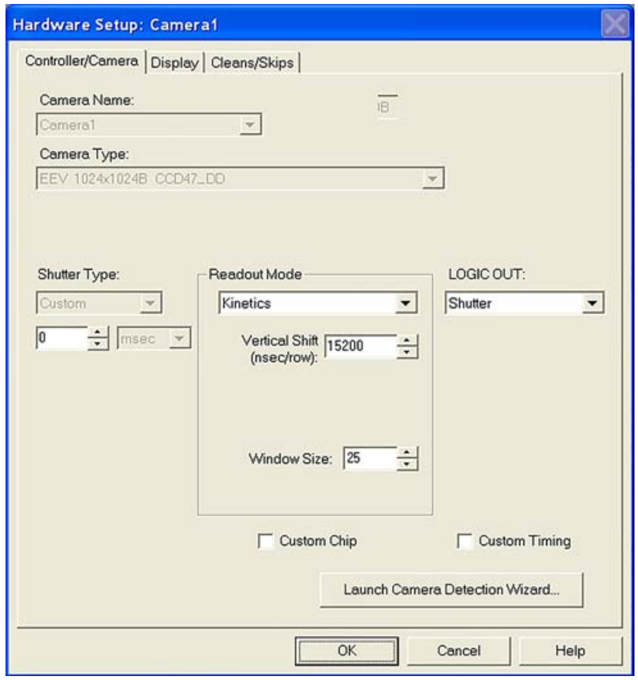


Returning to the 4 x 6 CCD example, 2/3 of the array is now masked, either mechanically or optically and there is a shutter or other external device controlling the exposure of the array to incoming X rays. The shutter opens to expose a 4 x 2 region. While the shutter remains open, charge is quickly shifted just under the mask, and the exposure is repeated. After a third image is collected the shutter is closed and the CCD is read out. Since the CCD can be read out slowly, very high dynamic range is achieved.

6.4.1 WinX/32 Configuration

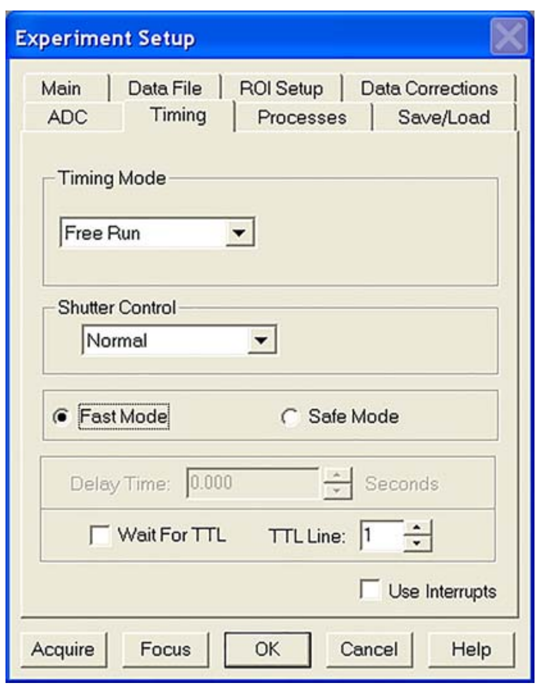
In WinX/32, Kinetics is configured on the Hardware Setup ► Controller/Camera tab and the Experiment Setup ► Timing tab. See Figure 6-12 and Figure 6-13.

Figure 6-12: WinX/32 Kinetics Configuration: Hardware Setup Dialog



4411-0133_0039

Figure 6-13: WinX/32 Kinetics Configuration: Experiment Setup Dialog

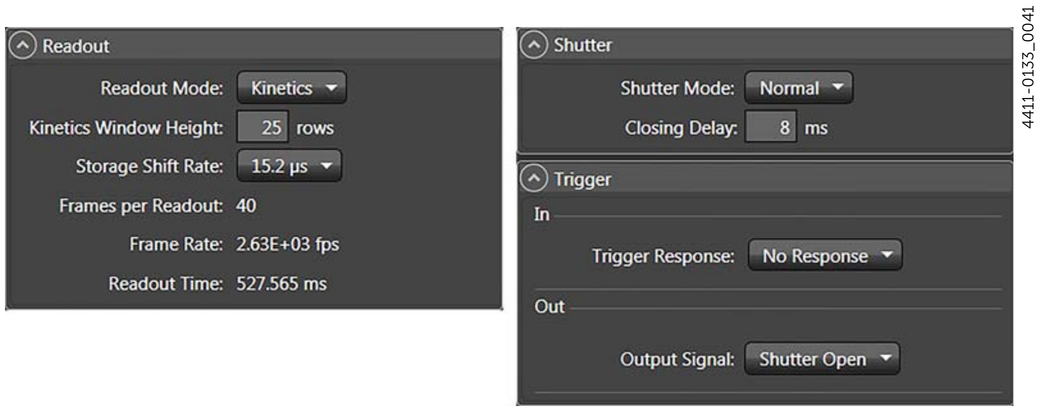


4411-0133_0040

6.4.2 LightField Configuration

In LightField, Kinetics is configured on the Readout, Shutter, and Trigger Expanders. See

Figure 6-14: LightField Kinetics Configuration: Readout, Shutter, and Trigger Expanders



6.4.3 Kinetics Timing Modes

Kinetics Mode operates with three timing modes:

- Free Run {No Response};
  Used for experiments that do not require any synchronization with the experiment.
- Single Trigger {Readout Per Trigger};
  Requires an external TTL pulse be applied to the PIXIS-XB 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 PIXIS-XB via the EXT SYNC connector on the rear of the camera.

6.4.3.1 Free Run {No Response}

In Free Run {No Response} Kinetics mode, the PIXIS-XB takes a series of images, each with the Exposure time that has been programmed in the software:

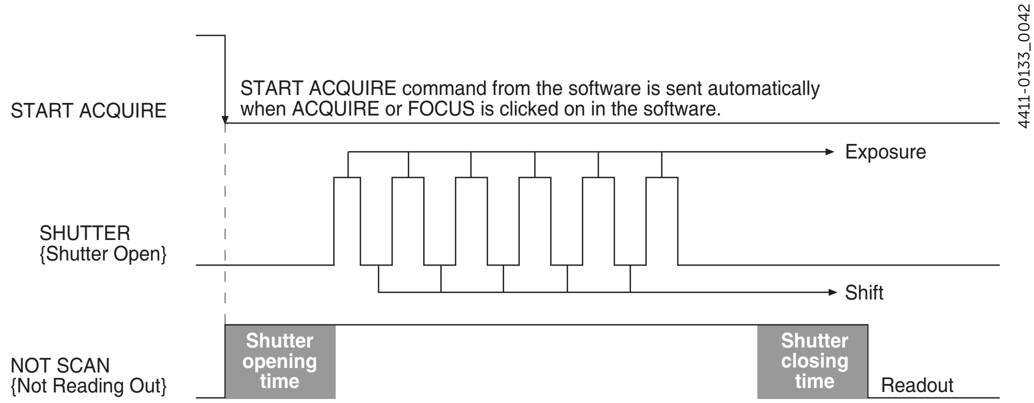
- WinX/32
  Exposure Time is configured on the Experiment Setup ► Main tab;
- LightField
  Exposure Time is configured on the Common Acquisition Settings expander.

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 inter-image time equals the Vertical Shift rate (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 (i.e., SHUTTER {Shutter Open},) or Readout signals (i.e., NOT SCAN {Not Reading Out},) are provided at the LOGIC OUT connector for timing measurements.

Figure 6-15 illustrates the timing diagram for Free Run {No Response} Kinetics mode.

Figure 6-15: Timing Diagram: Kinetics Mode Free Run {No Response}



Example

Recall to the readout example illustrated in Figure 6-11:

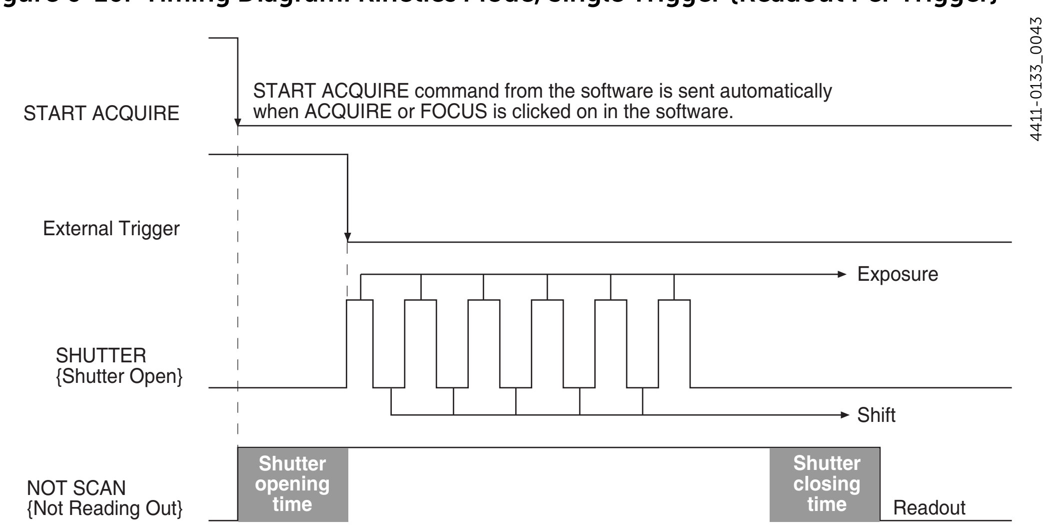
- There are 6 pixels perpendicular to the shift register;
- The Window Size is 2 pixels high;
- The number of frames is 3.

If the Vertical Shift rate for the CCD is 1600 ns/row, the Shift time will be 3200 ns per frame.

6.4.3.2 Single Trigger {Readout Per Trigger}

In Single Trigger {Readout Per Trigger} mode, the PIXIS-XB requires only one trigger to initiate an entire series of exposure-shift cycles. Figure 6-16 illustrates the timing diagram when a single external trigger pulse is used to acquire a burst of six frames.

Figure 6-16: Timing Diagram: Kinetics Mode, Single Trigger {Readout Per Trigger}



When Acquire or Focus {Run} is clicked, the shutter (if an external X-ray shutter has been installed,) is opened and the PIXIS-XB uses the Exposure Time that has been programmed into the software.

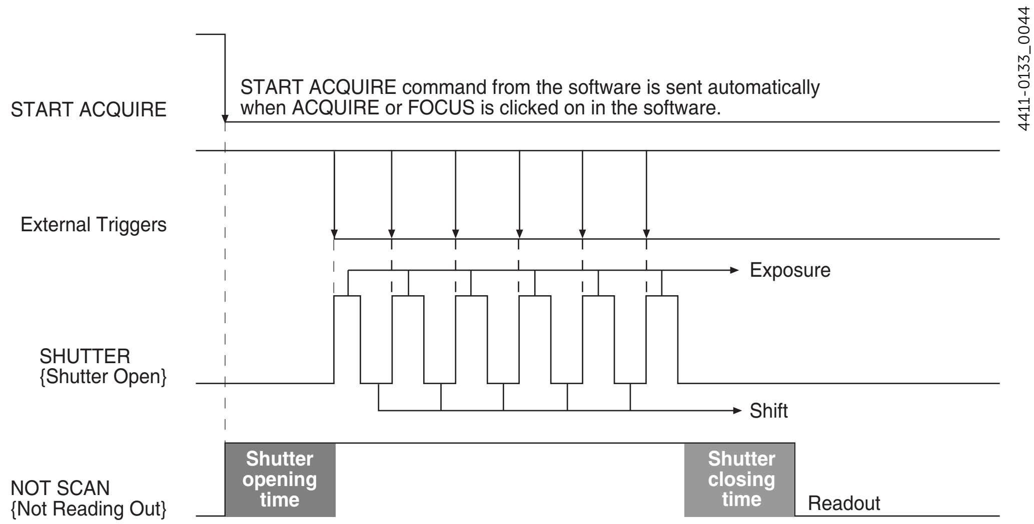
The trigger is applied at the EXT SYNC connector on the rear of the PIXIS-XB. After the series is complete, the shutter closes and the CCD is read out at normal speeds.

Once the readout is complete, the PIXIS-XB is ready for the next series of exposures.

6.4.3.3 Multiple Trigger {Shift Per Trigger}

In Multiple Trigger {Shift Per Trigger} mode, the shutter (if an external X-ray shutter has been installed,) 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. Figure 6-17 illustrates the timing diagram for this mode.

Figure 6-17: Timing Diagram: Kinetics Mode, Multiple Trigger {Shift Per Trigger}



This mode is useful when each subframe needs to be synchronized with a pulsed external light source such as a laser.

Once the series has been completed, 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.

6.5 Custom Modes

This section discusses the following custom modes that are supported by PIXIS-XB.

- Custom Chip {Custom Sensor}

  Custom Chip {Custom Sensor} allows the apparent size of the CCD array to be reduced.

  NOTE:

  Custom Chip is an available option for WinX/32.

  Custom Sensor is standard with LightField, but is sensor and readout mode-dependent.

- Custom Timing {Custom Timing}

  Custom Timing allows a faster vertical shift time to be configured.

  NOTE:

  Custom Timing is an available option for WinX/32.

  Custom Timing is standard with LightField, but is sensor and readout mode-dependent.

Each of these modes is described in the following sections.

6.5.1 Custom Chip {Custom Sensor}

In addition to Binning and ROI (both of which have been previously discussed, there is a third method of reducing Readout Time - Custom Chip {Custom Sensor}.

This feature allows you to redefine the size of the CCD's active area via software. Unlike defining a smaller Region Of Interest (ROI) which also involves reading out fewer pixels, this mode does not incur overhead from discarding or skipping the rest of the rows.

And, unlike both the Binning and ROI techniques, Custom Chip {Custom Sensor} relies on some form of array masking to ensure that no light falls outside the currently set active area.

6.5.1.1 WinX/32 Software Settings

WARNING!

Teledyne Princeton Instruments does not encourage users to modify these parameter values. For most applications, the default values will yield the best results.

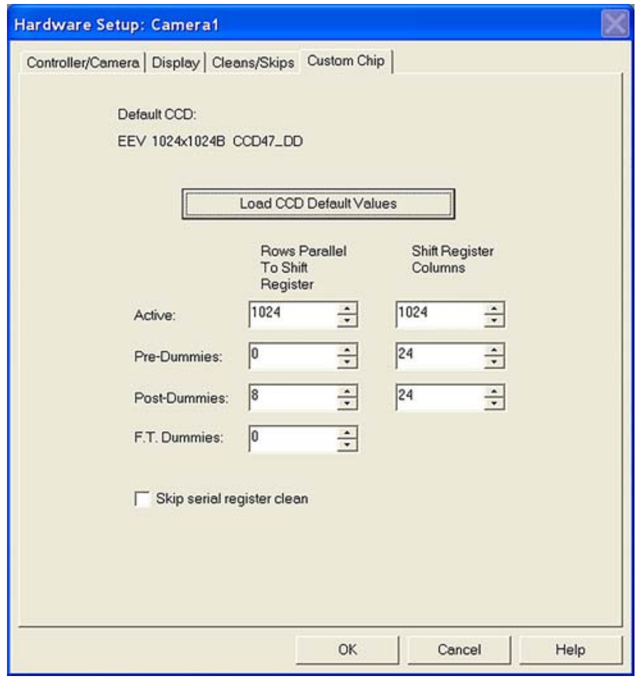
It is strongly recommended that Teledyne Princeton Instruments Customer Service be contacted for guidance before customizing the chip definition. Refer to Contact Information on page 114 for complete information.

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 6-18.

NOTE:

The default values conform to the physical layout of the CCD array and are optimum for most measurements.

Figure 6-18: Typical WinX/32 Custom Chip Tab



6.5.1.2 LightField Software Settings

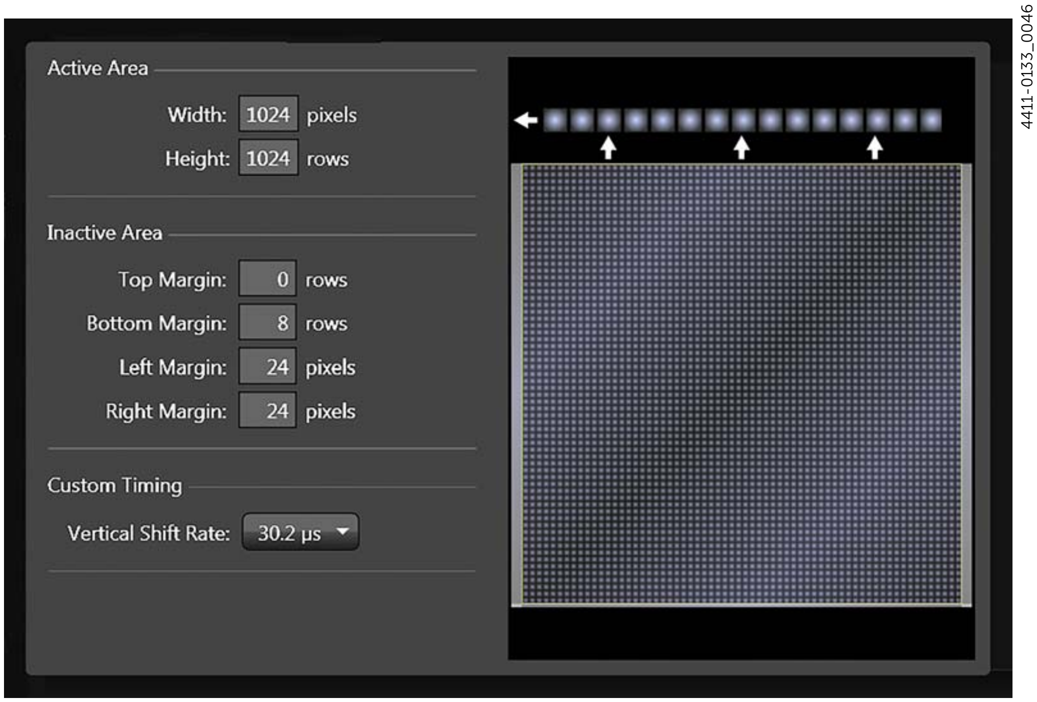
WARNING!

Teledyne Princeton Instruments does not encourage users to modify these parameter values. For most applications, the default values will yield the best results.

It is strongly recommended that Teledyne Princeton Instruments Customer Service be contacted for guidance before customizing the chip definition. Refer to Contact Information on page 114 for complete information.

The Custom Sensor dialog is accessed by opening the Sensor expander and clicking on the Custom Sensor button. Figure 6-19 illustrates a typical Custom Sensor dialog.

Figure 6-19: Typical LightField Custom Sensor Dialog



By changing the values in the Active fields, you can increase image acquisition speed 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. This will prevent 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

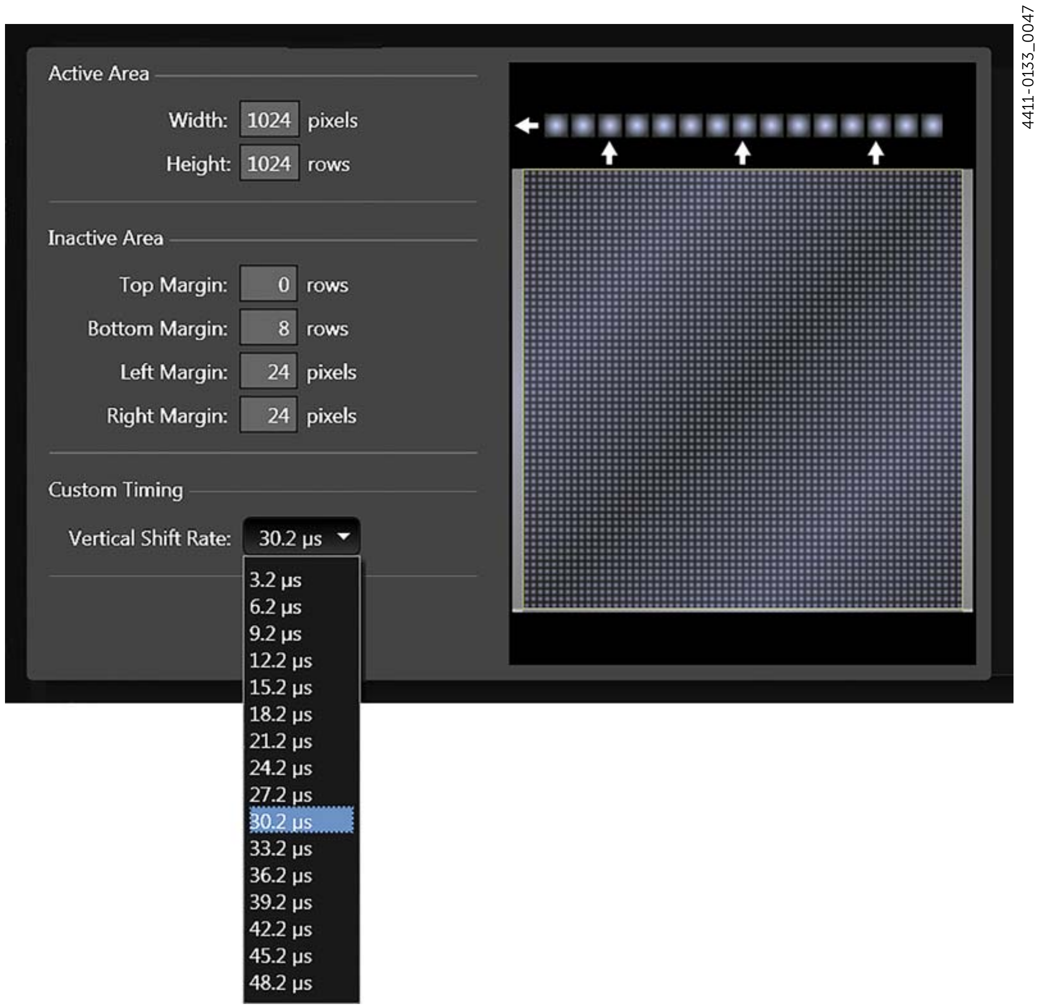
NOTE:

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

Custom Timing is fully supported by WinX/32 Version 2.5.18.1 and higher.

In LightField, Custom Timing is accessed via the Custom Sensor button on the Sensor expander. In the Custom Timing panel, you can select from among the listed vertical shift rate choices. See Figure 6-20.

Figure 6-20: Typical LightField Custom Timing Dialog

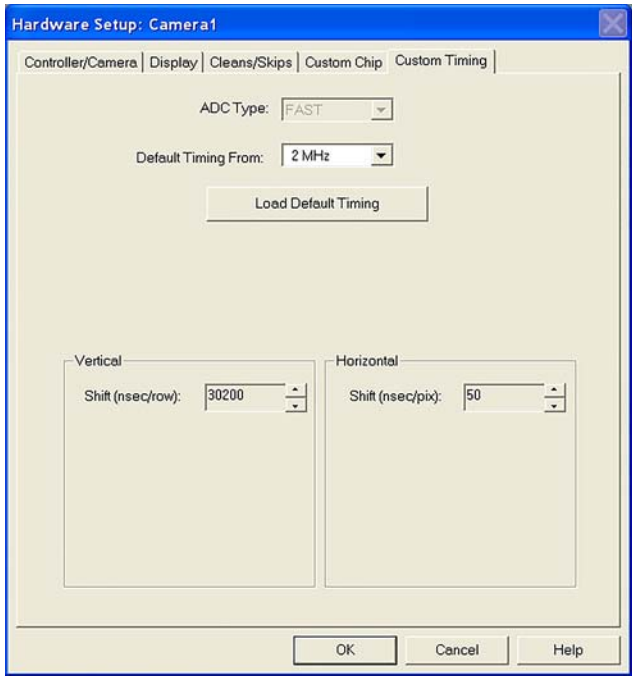


Vertical shift rate is the time required to shift one row into the serial register. The smaller the value, the faster charge will be shifted up one row at a time toward the serial register.

In WinX, if the Custom Timing option is present and selected, the equivalent function is located on the Custom Timing tab on the Hardware Setup dialog.

See Figure 6-21.

Figure 6-21: Typical WinX/32 Hardware Setup ► Custom Timing Tab



4411-0133_0048

Chapter 7: Troubleshooting

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

Refer to Table 7-1 for issues which have recommended troubleshooting procedures in this chapter.

Table 7-1: List of Recommended Troubleshooting Procedures

Issue	Information begins on...
Acquisition Started but Viewer Contents Do Not Update	page 84
Baseline Signal Suddenly Changes	page 84
Camera Stops Working	page 84
Camera1 (or Similar Name) in Camera Name Field	page 85
Controller is not Responding	page 86
CoolCUBE$_{II}$: Low Coolant (Air in Hoses)	page 87
Temperature Lock Cannot Be Achieved or Maintained	page 88
Camera Loses Temperature Lock	page 89
Gradual Deterioration of Cooling Capability	page 89
Data Loss or Serial Violation	page 89
Data Overrun Due to Hardware Conflict Message	page 90
Data Overrun Has Occurred Message	page 90
Device is Not Found	page 91
Device is Occupied	page 91
Error Creating Controller Message	page 92
Overexposed or Smeared Images	page 92
Program Error Message	page 93
Serial Violations Have Occurred. Check Interface Cable.	page 94
Shutter Failure	page 94
Vignetting	page 94

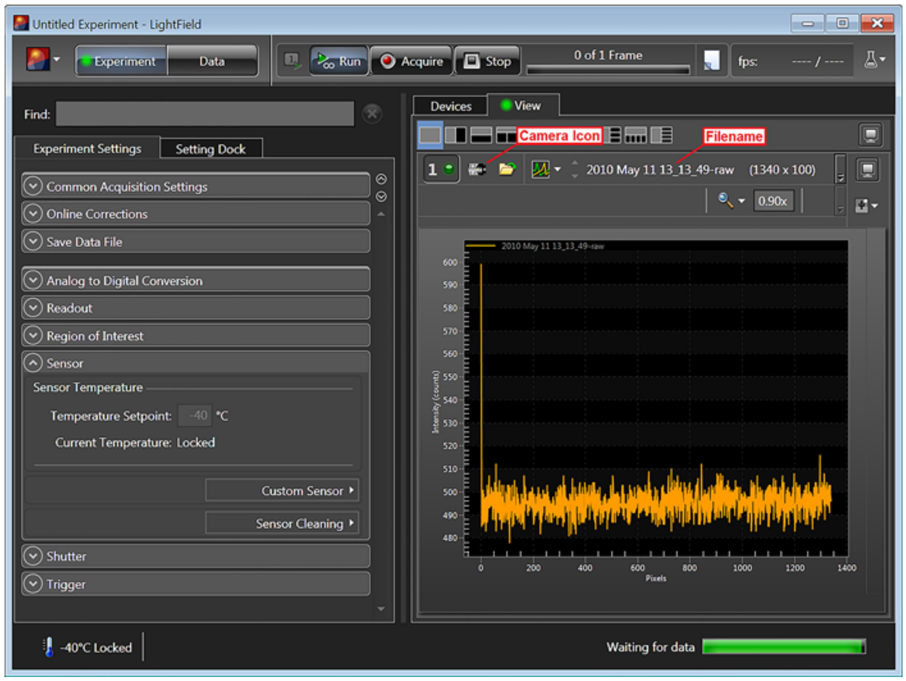
7.1 Acquisition Started but Viewer Contents Do Not Update

In LightField, live data is 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, check to see 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.

Figure 7-1: Typical LightField Acquisition Display



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.

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 114 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, begin with these simple checks:

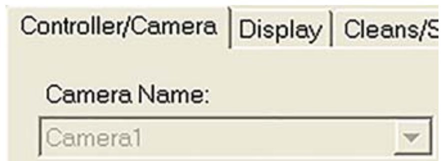
- Turn off all AC power.
- Verify that all cables are securely fastened.
- Turn the system on.

If the system still does not respond, contact Teledyne Princeton Instruments Customer Support. Refer to Contact Information on page 114 for complete information.

7.4 Camera1 (or Similar Name) in Camera Name Field

When the Camera Detection Wizard installs a new camera, the camera is automatically named Camera# where # = 1, 2, or 3 depending on the number of cameras detected. This name will appear in the Hardware Setup title bar and as the active camera on the Hardware Setup ► Controller/Camera tab. See Figure 7-2.

Figure 7-2: Typical Controller/Camera Tab with Camera1 in Camera Name Field

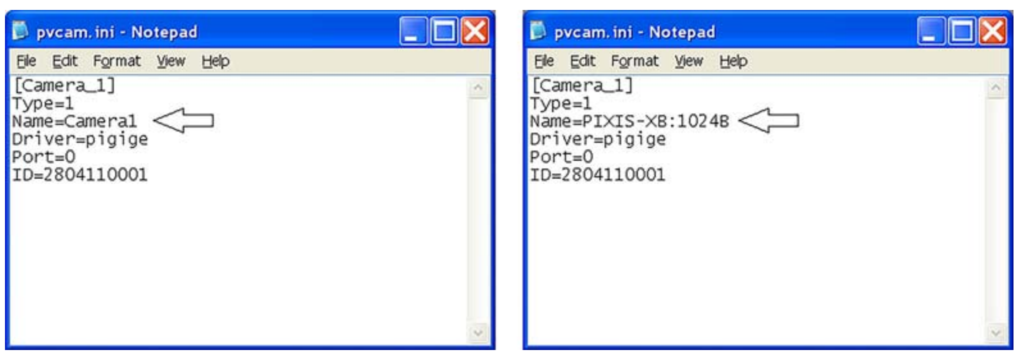


If you would prefer a more specific name, you can edit the file named `PVCAM.INI` which is stored in the Windows directory to rename the camera. The new name will then be used by the system until the Camera Detection Wizard is run again.

Perform the following procedure to change the default Camera Name:

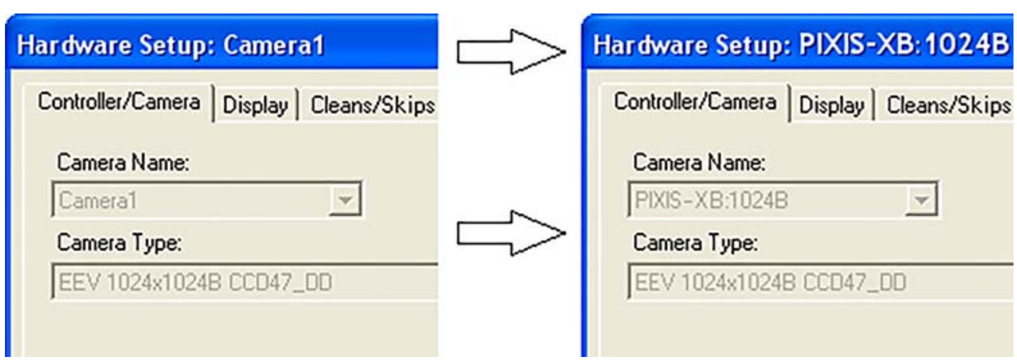
1. Close WinView/32 if it is running.
2. Using Notepad or similar text editor, open `PVCAM.INI` from the Windows directory (e.g., `C:\WINDOWS`.)
3. Edit the `Name` field. See Figure 7-3.

Figure 7-3: Editing `PVCAM.INI` Using Text Editor



4. Save the edited file.
5. The next time WinView/32 is launched, the new name will be displayed on the Hardware Setup dialog.

Figure 7-4: Typical Camera Name on Hardware Setup ► Controller/Camera Tab



6. If the Camera Detection Wizard is later run again, the Camera Name will revert to the default name (i.e., Camera#).

7.5 Controller is not Responding

If this message pops up when you click on OK after selecting the Interface Type during Hardware Setup (i.e., via the WinView/32 Setup menu,) the system has not been able to communicate with the PIXIS-XB. Check to see if camera has been turned ON and if the USB 2.0 interface card, its driver, and the USB cable have been installed.

- f the camera is ON, the problem may be with the USB 2 card, its driver, or the cable connections.
- If the interface card is not installed, close WinView/32 and turn the camera OFF.

  Follow the interface card installation instructions provided with the interface card, and cable the card to the USB 2 port on the rear of the camera.

  Then do a Custom installation of WinView/32 with the appropriate interface component selected.

  Be sure to deselect the interface component that does not apply to your system.
- If the interface card is installed in the computer and is cabled to the USB 2 port on the rear of the camera, close the application program and turn the camera OFF.

  Check the cable connections.
- If the interface card was installed after WinView/32 was installed, close WinView/32 and do a Custom installation of WinView/32 with the appropriate interface component selected.

  Be sure to deselect the interface component that does not apply to your system.

7.6 CoolCUBE$_{II}$: Low Coolant (Air in 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.

1. Unscrew the reservoir cap (on top of the CoolCUBEII) and make sure that the coolant reservoir contains coolant. If additional coolant is required, fill with a 50:50 mixture of water and ethylene glycol.
2. Screw the reservoir cap back in.
3. Verify the power switch is turned off before plugging in the CoolCUBE$_{II}$.
4. Plug the CoolCUBE$_{II}$ into a 100-240 V_{AC}, 47-63 Hz power source.
5. Turn on the CoolCUBE$_{II}$. Verify there are no leaks or air bubbles in the hoses.

   NOTE:

   Small bubbles (about the size of bubbles in soda) are common in the CoolCUBE$_{II}$ especially at startup and do not prevent proper operation.

   - If there are no problems, proceed to step 6.
   - If there are leaks or air bubbles, turn the CoolCUBE$_{II}$ off and correct the problem(s) by securing the hoses or adding more coolant to the reservoir. Turn on the CoolCUBE$_{II}$ and examine for problems.

     If there are no problems, proceed to step 6.
6. Turn on the PIXIS-XB.
7. Launch WinView/32.

7.7 Cooling Troubleshooting

This section provides recommended troubleshooting guidelines for general cooling-related issues that may be encountered.

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 2 inches [50 mm] clearance around the vented covers.
  If there is an enclosure involved, the enclosure must 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 Hoses), on page 87 for complete information.
- There may be air in the hoses. Add coolant.
  Refer to Section 7.6, CoolCUBE$_{II}$: Low Coolant (Air in Hoses), on page 87 for complete information.
- CoolCUBE$_{II}$ pump is not working.
  If you do not hear the pump running when the CoolCUBE$_{II}$ is powered on, turn off the CoolCUBE$_{II}$ and contact Teledyne Princeton Instruments Customer Support. Refer to Contact Information on page 114 for complete information.
- The CoolCUBE$_{II}$ is positioned higher than the PIXIS-XB.
  Reposition the CoolCUBE$_{II}$ so that it is a minimum of 6 inches [150 mm] below the PIXIS-XB.
  The vertical distance should not exceed 10 feet [3 m].
  Typically, the PIXIS-XB is at table height and the CoolCUBE$_{II}$ is on the floor.
- The PIXIS-XB vacuum has deteriorated and needs to be refreshed.
  Contact Teledyne Princeton Instruments Customer Support. Refer to Contact Information on page 114 for complete information.
- The target array temperature is not appropriate for your PIXIS-XB 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 PIXIS-XB, 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 PIXIS-XB 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

While unlikely with the PIXIS-XB camera (guaranteed permanent vacuum for the life of the camera,) if you see a gradual deterioration of the cooling capability, 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 Teledyne Princeton Instruments Customer Support to make arrangements to return the camera to the support facility. Refer to Contact Information on page 114 for complete information.

7.8 Data Loss or Serial Violation

You may experience either or both of these conditions if the host computer has been set up with Power Saving features enabled. This is particularly true for power saving with regard to the hard drive.

Verify that Power Saving features are disabled while you are running WinView/32.

7.9 Data Overrun Due to Hardware Conflict Message

Figure 7-5 illustrates the error that may be displayed when you try to acquire a test image, acquire data, or run in focus mode.

Figure 7-5: Typical Data Overrun/Hardware Conflict Dialog

4411-0133_0053

Check the CCD array size and then check the DMA buffer size. A large array (e.g., a 2048 x 2048 array,) requires a larger DMA buffer larger setting than that for a smaller array (e.g., a 512 x 512 array.)

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 the Setup ► Environment ► Environment dialog.
3. Increase the DMA buffer size to a minimum of 32 MB (64 MB if it is currently 32 MB or 128 MB if it is currently 64 MB,) click on OK, and close the WinX/32 application.
4. Reboot the host computer.
5. Launch the WinX/32 application and begin acquiring data or focusing.
   If you see the message again, increase the DMA buffer size.

7.10 Data Overrun Has Occurred Message

Due to memory constraints and the way that USB transfers data, a Data Overrun Has Occurred message may be displayed during data acquisition. If this message is displayed, perform one or more of the following actions:

1. Minimize the number of programs running in the background while you are acquiring data with WinView.
2. Run data acquisition in Safe Mode.
3. Add memory.
4. Use binning.
5. Increase the exposure time.
6. Defragment the hard disk.
7. Update the USB2 driver.

If the problem persists, your application may be USB 2.0 bus limited. Since the host computer controls the USB 2.0 bus, there may be situations where the host computer interrupts the USB 2.0 port. In most cases, the interrupt will go unnoticed by the user.

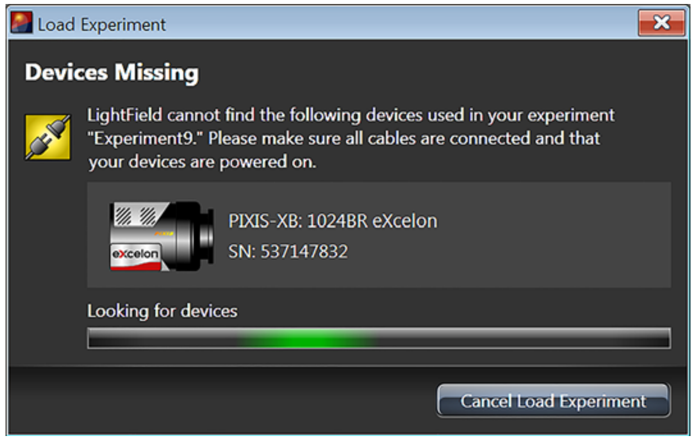
However, there are some instances when the data overrun cannot be overcome because USB 2.0 bus limitations combined with long data acquisition times and/or large data sets increase the possibility of an interrupt while data is being acquired. If your experiment requirements include long data acquisition times and/or large data sets, your application may not be suitable for the USB 2.0 interface.

If this is not the case and data overruns continue to occur, contact Teledyne Princeton Instruments Customer Support. Refer to Contact Information on page 114 for complete information.

7.11 Device is Not Found

When LightField is launched, it looks for devices (i.e., 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 dialog similar to that shown in Figure 7-6.

Figure 7-6: Typical LightField Devices Missing Dialog



4411-0133_0054

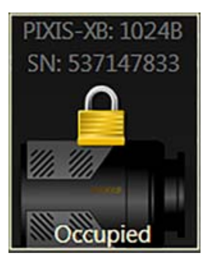
Perform the following to attempt to remedy this issue:

- 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, you can load the experiment after all the devices are available, you can start a new experiment design, or you can load a different experiment that matches the devices you are using.

7.12 Device is Occupied

Multiple instances of LightField can be running at the same time. However, a 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. See Figure 7-7.

Figure 7-7: Typical LightField Occupied Device Icon



4411-0133_0055

To make a device available to the current instance of LightField, either remove it from the Experiment Devices area in the other instance or close the instance that is using the device.

7.13 Error Creating Controller Message

Figure 7-8 shows typical messages that may be displayed if the PVCAM.INI file has been corrupted or if the PIXIS-XB was not turned on before launching WinView/32 and running the Camera Detection Wizard.

Figure 7-8: Typical WinView/32 Error Creating Controller Dialogs

4411-0133_0056

If one of these is displayed:

- Refer to Section 7.5, Controller is not Responding, on page 86;
- Run the Camera Detection Wizard.

7.14 Overexposed or Smeared Images

If an external shutter is being used, verify that the shutter is opening and closing correctly.

Possible shutter problems include:

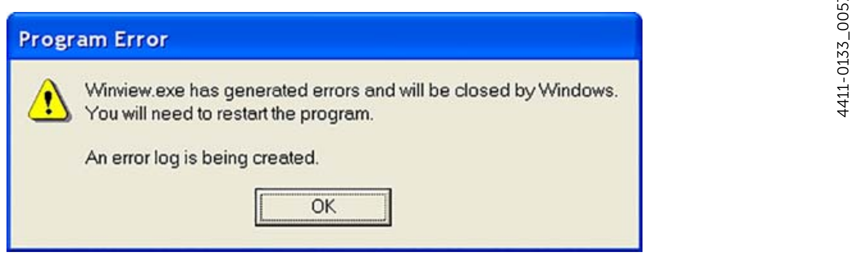
- Complete failure
  The shutter no longer operates at all. The shutter may:
  - Stick open resulting in overexposed or smeared images;
  - Stick closed resulting in no images being acquired.
- One leaf of the shutter may break and no longer actuate.

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

7.15 Program Error Message

Figure 7-9 illustrates the error that may be displayed when you try to acquire a test image, acquire data, or run in focus mode and the DMA buffer size is too small.

Figure 7-9: Typical Program Error Dialog



A large array (e.g., a 2048 x 2048 array,) requires a larger DMA buffer larger setting than that for a smaller array (e.g., a 512 x 512 array.)

Perform the following procedure to change the DMA buffer setting:

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

7.16 Serial Violations Have Occurred. Check Interface Cable.

Figure 7-10 illustrates the error that will be displayed when acquiring an image or focusing the PIXIS-XB and either (or both) of the following conditions exists:

- The PIXIS-XB is not turned ON.
- There is no communication between the PIXIS-XB and the host computer.

Figure 7-10: Typical Serial Violations Have Occurred... Dialog

4411-0133_0058

Perform the following to correct the problem:

1. If not already turned off, turn off the PIXIS-XB system.
2. Verify the host computer's interface cable is secured at both ends.
3. After verifying that the cable is connected, turn the PIXIS-XB system power on.
4. Click OK on the dialog and retry acquiring an image or running in focus mode.

NOTE:
This error message will also be displayed if you turn the camera system off or a cable becomes loose while the WinX/32 application software is running in Focus mode.

7.17 Shutter Failure

Refer to Section 7.14, Overexposed or Smeared Images, on page 92.

7.18 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 you do measure such reduction in response across the array, it may be the result of one or more of the following conditions:

- Condensation of water on the edges of the array has occurred.

  This should not happen unless the cooling/pumping instructions have not been followed, of there is a leak 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.

Appendix A: Technical Specifications

CAUTION!
All specifications are subject to change.

This appendix provides technical information and specifications for PIXIS-XB cameras and optional accessories. Additional information may be found on data sheets available on the Teledyne Princeton Instruments website (www.princetoninstruments.com).

A.1 CCD Arrays

Teledyne e2v CCD47-10:

1024 x 1024BR, deep-depletion, 13 μm x 13 μm pixels.

Teledyne Princeton Instruments Exclusive:

1340 x 400BR, deep-depletion, 20 μm x 20 μm pixels.

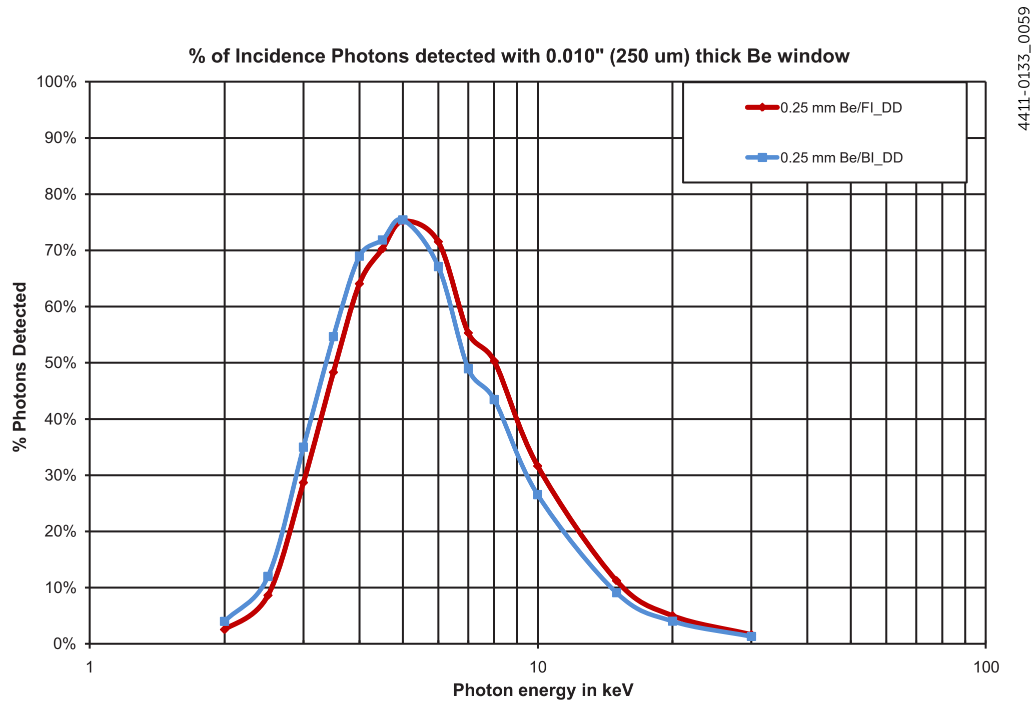
Teledyne Princeton Instruments Exclusive:

1340 x 1300R/BR, deep-depletion, 20 μm x 20 μm pixels.

NOTE:
The arrays listed are those that were available at the time that the manual was written. Contact Teledyne Princeton Instruments or visit the Teledyne Princeton Instruments website (www.princetoninstruments.com) for an updated list of arrays supported by the PIXIS-XB.

A.2 Quantum Efficiency

Figure A-1: PIXIS-XB Quantum Efficiency Curve



A.3 Camera Specifications

Cooling

Thermoelectric (air) or circulating liquid (CoolCUBE$_{II}$)

Gain

Software-selectable (high, medium, low)

Dimensions

Refer to Appendix B, Outline Drawings, on page 101.

Power Supply Specifications

DC power to camera is provided by an external, self-switching power supply.

Small Format Cameras (PIXIS-XB: 400, PIXIS-XB: 1024)

- Maximum Power Output: 80 W;
- Input: 100–240 V_{AC}; 47 to 63 Hz, 1.9 A;
- Output: +12 V_{DC} at 6.6 A Maximum;

Large Format Cameras (PIXIS-XB: 1300, PIXIS-XB: 2048)

- Maximum Power Output: 150 W;
- Input: 100–240 V_{AC}; 50/60 Hz, 2.0 A;
- Output: +12 V_{DC}, 12.5 A Maximum

Refer to Section A.4.2, POWER Connector, on page 98 for pinout diagrams and pin assignment information.

Fan (Air-Cooled Systems Only)

24 CFM fan capacity at full power.

Coolant Ports (Liquid-Cooled Systems Only)

Two interchangeable ¼" CPC valved quick disconnect fittings for connection to the $CoolCUBE_{II}$ circulator hoses.

Deepest Operating Temperature (with ambient air at +20°C)

Refer to Table A-1 for typical deepest operating temperatures.

Table A-1: Typical Deepest Operating Temperature

CCD Size	Typical
1024 x 1024	−90°C
1340 x 400	−90°C
1340 x 1300	−65°C (air cooled) −70°C ($CoolCUBE_{II}$)
2048 x 2048	−65°C (air cooled) −70°C ($CoolCUBE_{II}$)

Temperature Stability

±0.05°C; closed-loop stabilized-temperature control

Tripod Mount

¼-20 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.

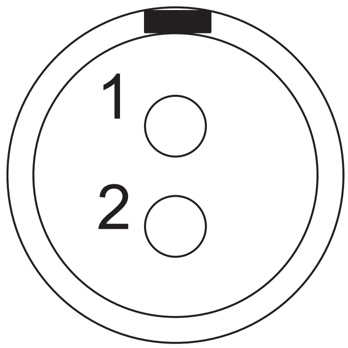
A.4 Connector Pinout Information

This section provides pinout information for rear panel connectors on PIXIS-XB cameras.

A.4.1 SHUTTER Connector

Figure A-2 provides the SHUTTER connector pinout diagram.

Figure A-2: Pinout Diagram: SHUTTER Connector, 2-Pin LEMO



Refer to Table A-2 for SHUTTER connector pin assignments.

Table A-2: Pin Assignments: SHUTTER Connector

Pin #	Description
1	$+V_{DC}$
2	Ground

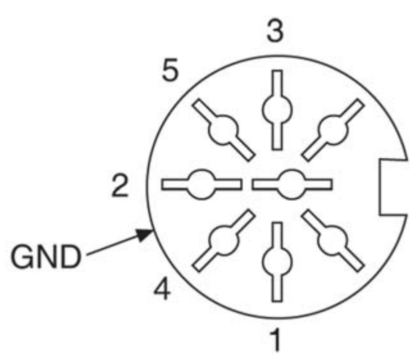
A.4.2 POWER Connector

This section provides information about the model-specific rear panel POWER connector.

A.4.2.1 Small Format PIXIS-XB: 400 and PIXIS-XB: 1024 Cameras

Figure A-3 provides the DIN POWER connector pinout diagram for small format PIXIS-XB cameras.

Figure A-3: Pinout Diagram: POWER Connector for PIXIS-XB: 400 and PIXIS-XB: 1024 Cameras



Refer to Table A-3 for POWER connector pin assignments for small format PIXIS-XB cameras.

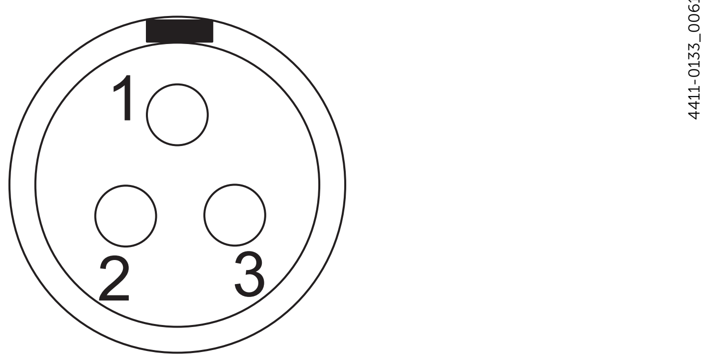
Table A-3: Pin Assignments: POWER Connector, PIXIS-XB: 400 and PIXIS-XB 1024 Cameras

Pin #	Description
1	Return
2	Return
3	+12 V_{DC}
4	Return
5	+12 V_{DC}
Shell	Ground

A.4.2.2 Large Format PIXIS-XB: 1300 and PIXIS-XB: 2048 Cameras

Figure A-4 provides the pinout diagram for the POWER connector for large format PIXIS-XB cameras.

Figure A-4: Pinout Diagram: POWER Connector for PIXIS-XB: 1300 and PIXIS-XB: 2048 Cameras



Refer to Table A-4 for POWER connector pin assignments for large format PIXIS-XB cameras.

Table A-4: Pin Assignments: POWER Connector, PIXIS-XB: 1300 and PIXIS-XB 2048 Cameras

Pin #	Description
1	+12 V_{DC}
2	Ground
3	Chassis

A.5 Options

Contact Teledyne Princeton Instruments Customer Service for information about options that are available for the PIXIS-XB system. Refer to Contact Information on page 114 for complete information.

This page is intentionally blank.

Appendix B: Outline Drawings

NOTE:

Dimensions are in inches [mm].

Figure B-1: Outline Drawing: Air-Cooled PIXIS-XB: 400 and PIXIS-XB: 1024

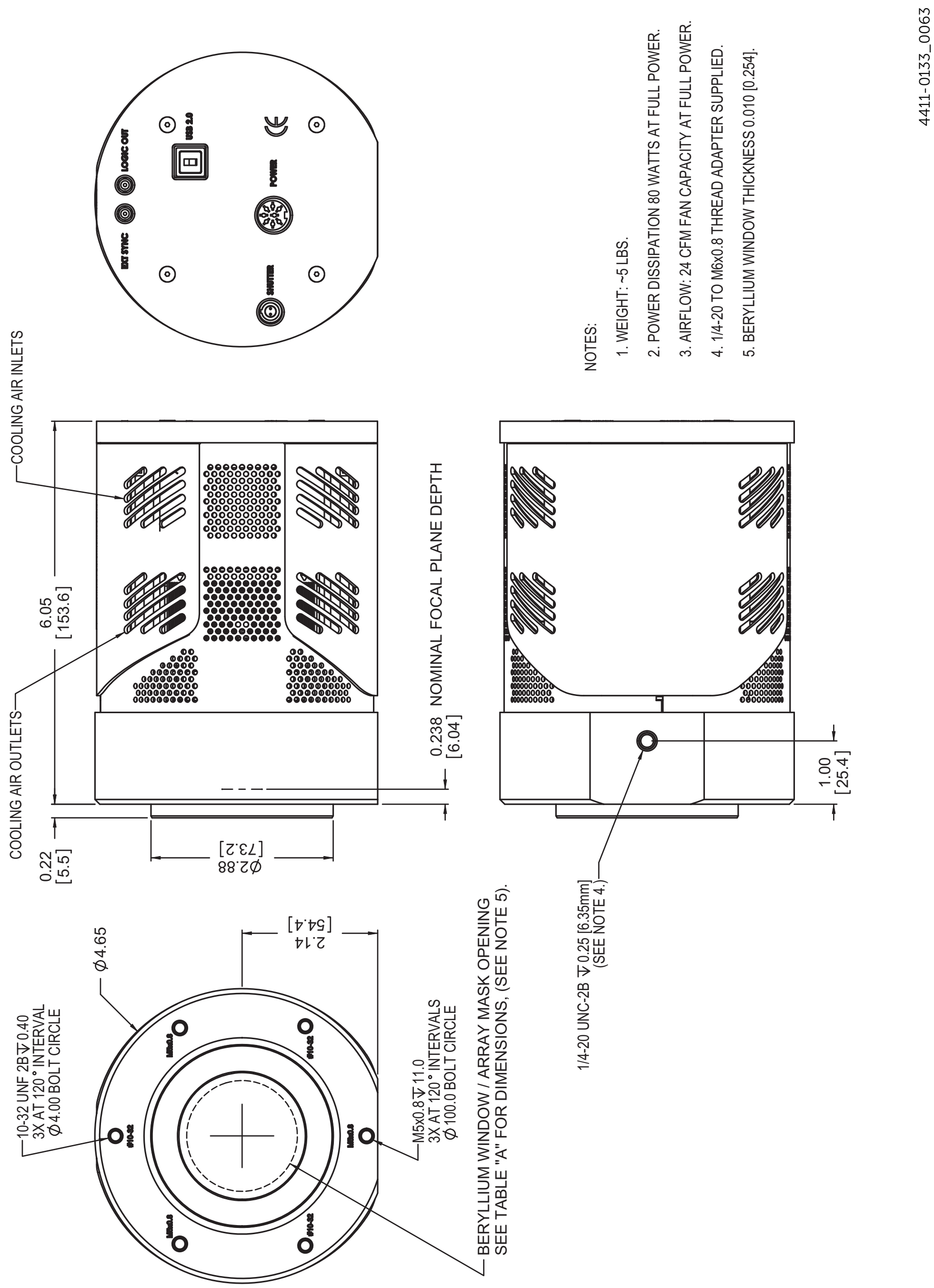


Figure B-2: Outline Drawing: Liquid-Cooled PIXIS-XB: 400 and PIXIS-XB: 1024

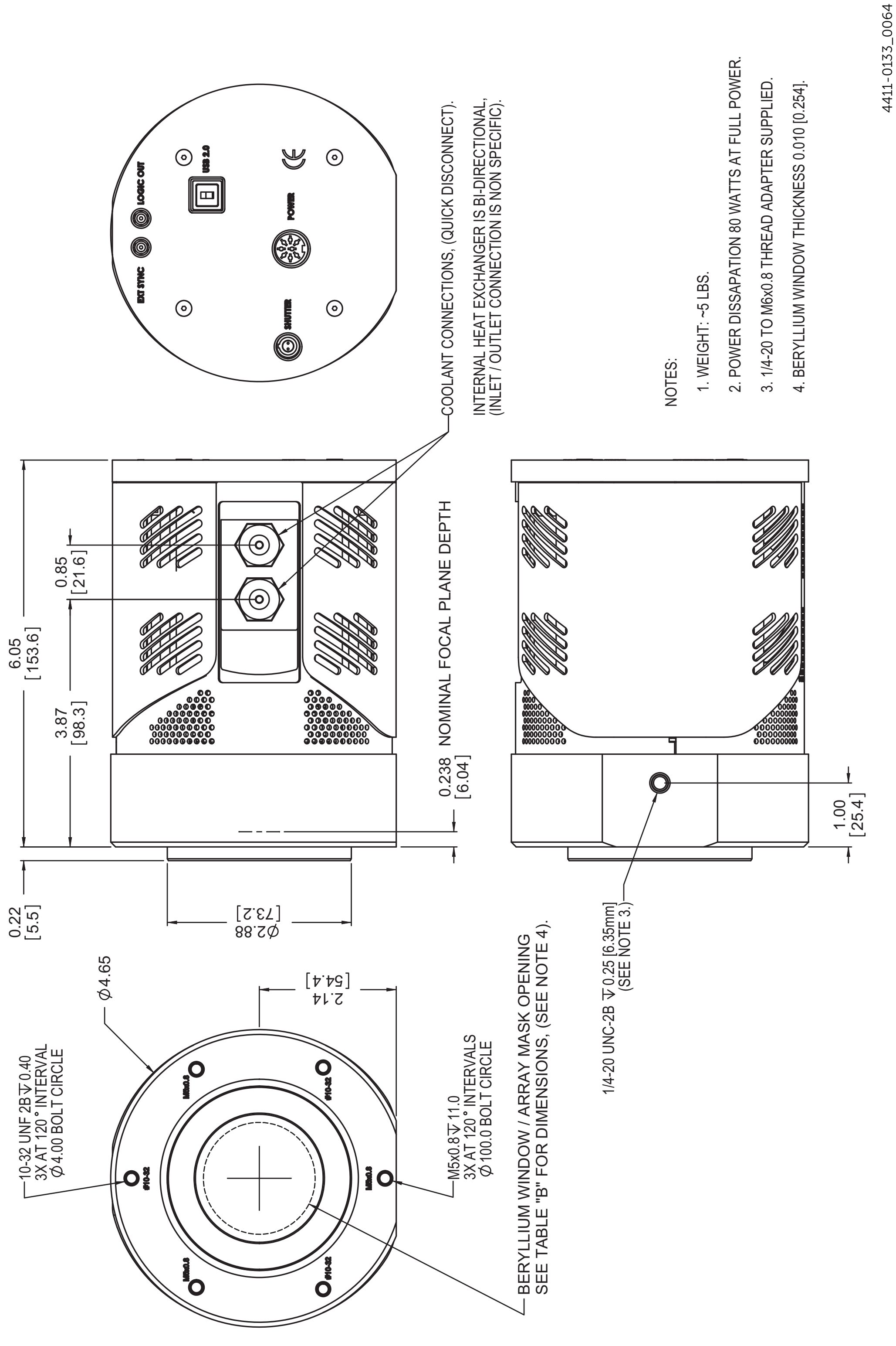


Figure B-3: Outline Drawing: Air-Cooled PIXIS-XB: 1300 and PIXIS-XB: 2048

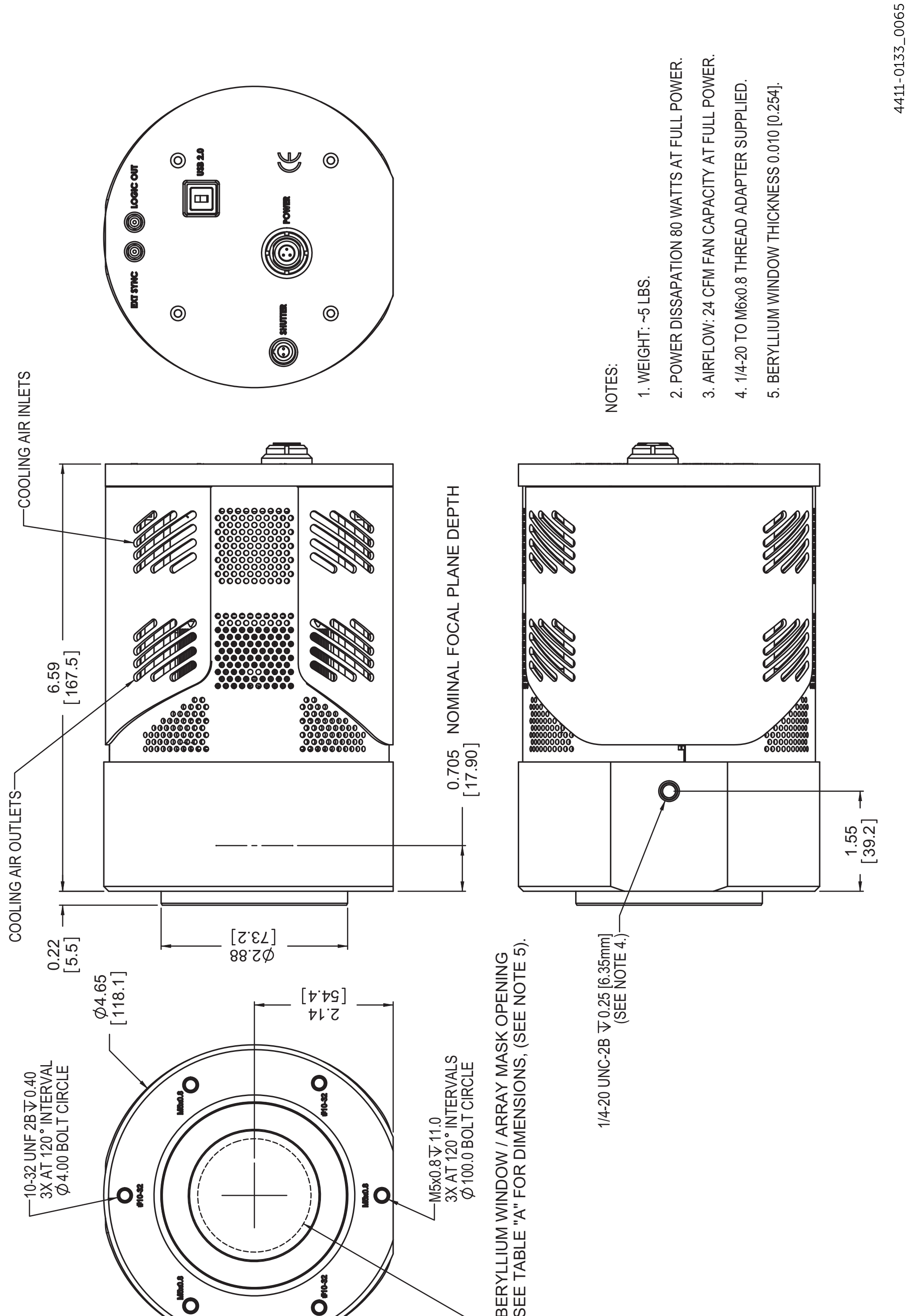


Figure B-4: Outline Drawing: Liquid-Cooled PIXIS-XB: 1300 and PIXIS-XB: 2048

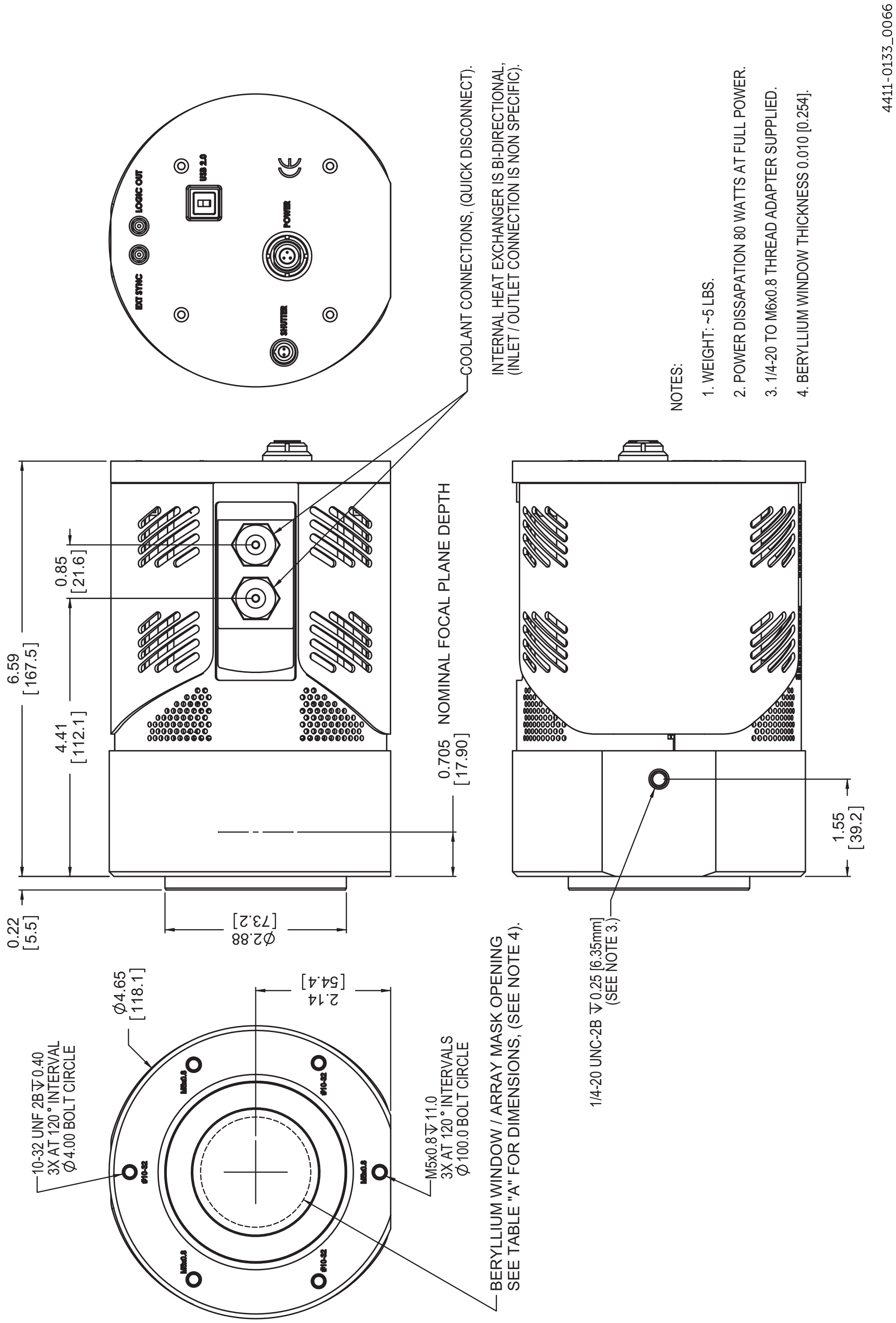


Figure B-5: Outline Drawing: Customer-Provided Vacuum Interface Flange

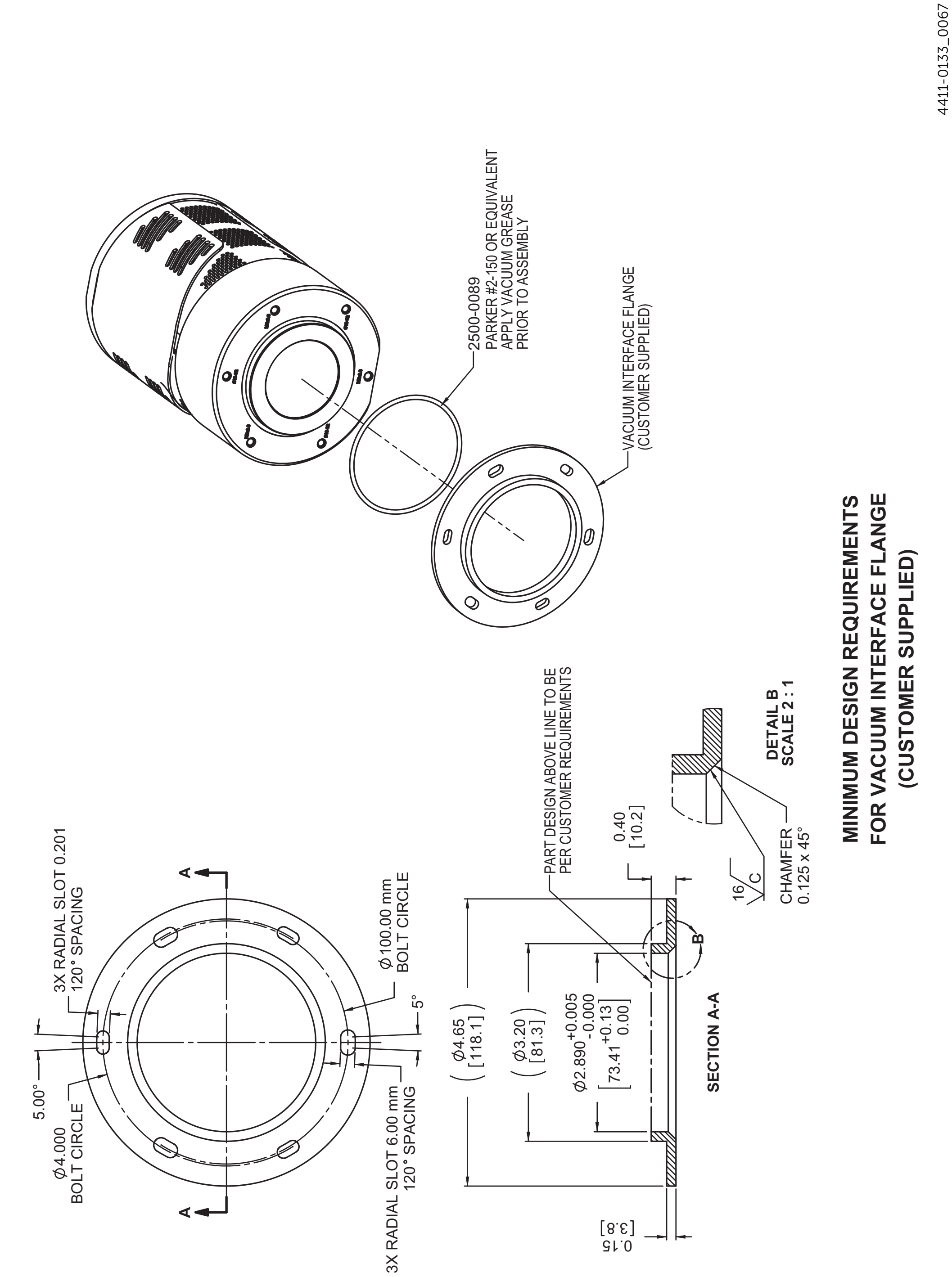
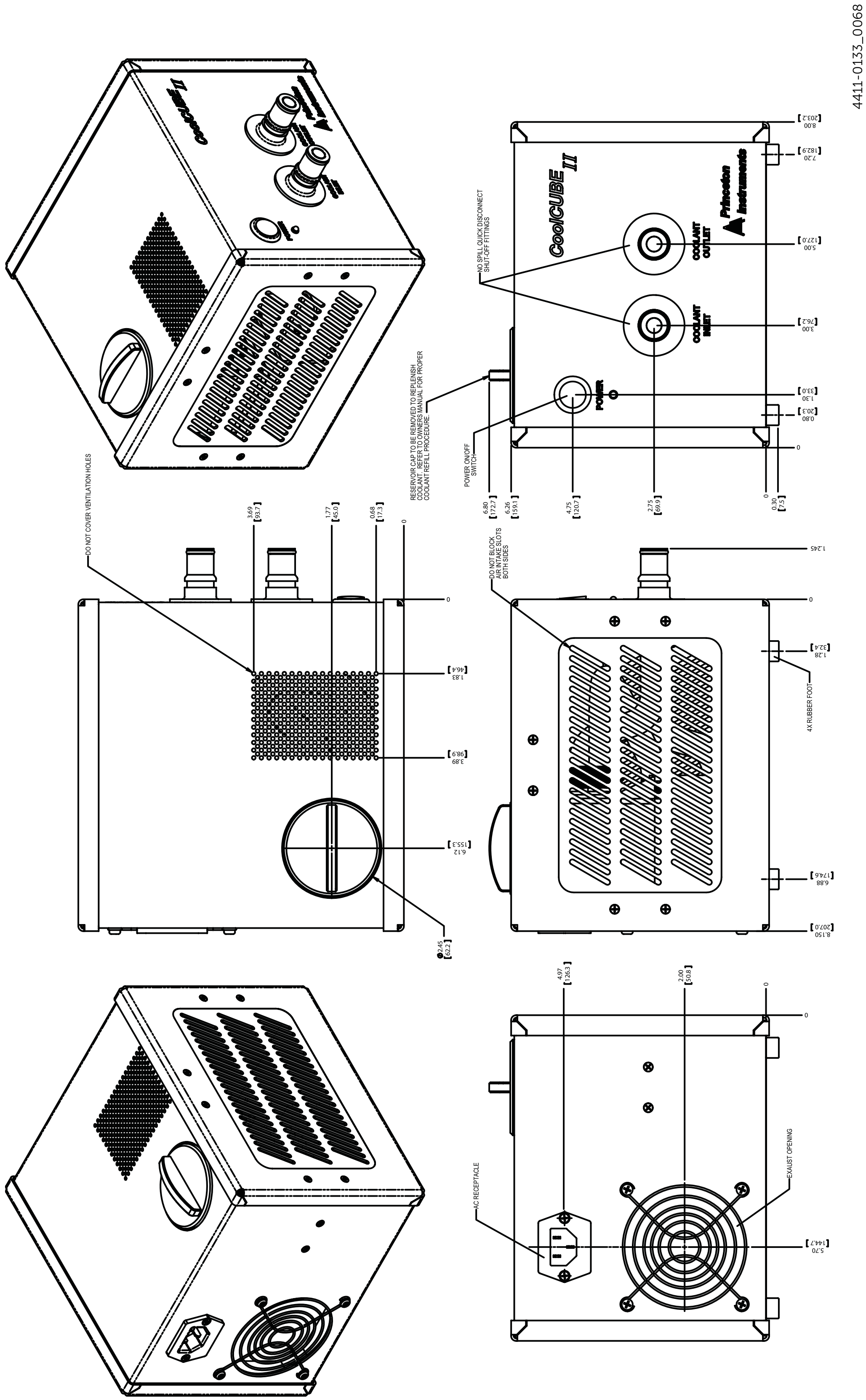


Figure B-6: Outline Drawing: CoolCUBE$_{II}$ Circulator



Appendix C: WinSpec/32/LightField Cross Reference

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

C.1 WinSpec/32-to-LightField Terminology

Refer to Table C-1 for a list of WinSpec/32 terms and their corresponding LightField terms.

Table C-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 C-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

C.2 LightField to WinSpec/32

Refer to Table C-2 for a list of LightField terms and their corresponding WinSpec/32 terms.

Table C-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 C-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.

This page is intentionally blank.

info@princetoninstruments.com
USA +1 877-474-2286 | **France** +33 (1) 60 86 03 65 | **Germany** +49 (0) 89 660 7793 | **UK & Ireland** +44 (0) 1628 472 346
Singapore +65 6408 6240 | **China** +86 10 659 16460 | **Japan** +81 (3) 5639 2741