



PHOTON MAX System



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Introduction

Thank you for purchasing a PhotonMAX camera system from Princeton Instruments/Acton. Your system has been thoroughly tested to meet the exacting standards of PI/Acton and to meet the demanding requirements of many low light level imaging applications.

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.

PhotonMAX™ Cameras

The new PhotonMAX™ cameras feature on-chip multiplication gain, a technology that enables the multiplication of photon generated charge right on the CCD. This approach offers an effective alternative to traditional ICCD cameras for many nongated, low-light applications.



The PhotonMAX:512B, the first in the series, features square, 16 x 16 μm pixels in a 512 x 512, frame-transfer format. The PhotonMAX:1024B incorporates a larger 1024x1024, 13 μm pixels frame-transfer CCD. The back-illuminated EMCCDs with dual amplifiers ensure optimal performance not only for applications that demand the highest available sensitivity but also for those requiring a combination of high quantum efficiency and wide dynamic range. Deep thermoelectric cooling and state-of-the-art electronics are employed to help suppress system noise. The camera can be operated at 10 MHz for high-speed imaging or more slowly for high-precision photometry. Supravidéo frame rates are achievable via subregion readout.

EMCCD Technology and On-Chip Multiplication Gain

The principal difference between an electron-multiplying CCD (EMCCD) and a traditional CCD is the presence of an extended serial register in the new device (see Figure 1). Electrons are accelerated from pixel to pixel in the extended portion of the serial register (also referred to as a multiplication register) by applying higher-than-typical CCD clock voltages. This causes secondary electrons to be generated in the silicon by impact ionization. The degree of multiplication gain is controlled by increasing or decreasing the clock voltages for this register (gain is exponentially proportional to the voltage). Although the probability of generating secondary electrons is fairly low (typically 0.01 per stage), over the large number of stages of a typical multiplication register, the total gain can be quite high.

This technology combines the ease of use and robustness of a traditional CCD with the gain capabilities of an intensified CCD in a single device. The combination of this technology with frame-transfer readout makes the PhotonMAX cameras excellent choices for experiments where fast framing and low light sensitivity are required.

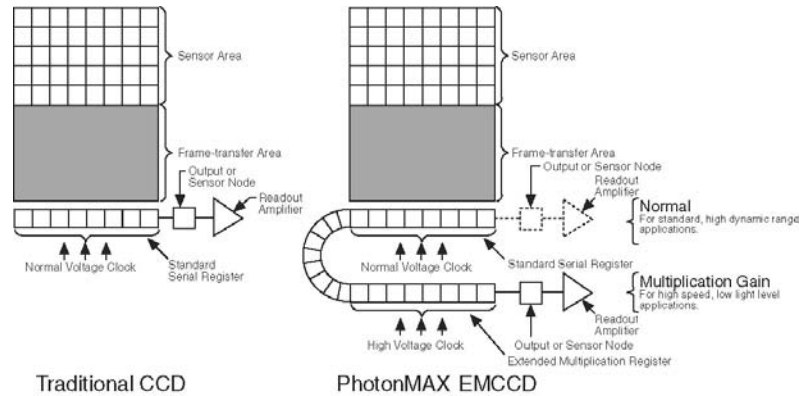


Figure 1. Comparison of Traditional CCD and PhotonMAX EMCCD Array Structures

Note: As the on-chip multiplication introduces additional noise, it is recommended that the multiplication be used only as required. For more information, refer to the "On-Chip Multiplication Gain" technical note. This technical note can be accessed by going to the Princeton Instruments web site at www.princetoninstruments.com.

Integrated Controller

The operation of the PhotonMAX camera is regulated by its internal controller. These electronics contain the circuitry required to accept input from the host computer and software and convert it to appropriate control signals for the camera. These signals include extensive capabilities for synchronizing the operation of the PhotonMAX system with the rest of your experiment. The controlling electronics also collect the analog signal from the CCD, digitize it, and send it to the computer.

The PhotonMAX allows you to specify read rate, binning parameters, and regions of interest — all under software control. For instance, if your experiment requires rapid image acquisition, then the CCD's on-chip binning can be set to increase frame rates.

Grounding and Safety

Before turning on the power supply (air-cooled camera) or circulator (liquid-cooled camera), the ground prong of the powercord plug must be properly connected to the ground connector of the wall outlet. The wall outlet must have a third prong, or must be properly connected to an adapter that complies with these safety requirements.

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

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

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

Precautions

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

- The CCD array is very sensitive to static electricity. Touching the CCD can destroy it. Operations requiring contact with the device can only be performed at the factory.
- If you are using high-voltage equipment (such as an arc lamp) with your camera system, be sure to turn the camera power ON LAST and turn the camera power OFF FIRST.
- Use caution when triggering high-current switching devices (such as an arc lamp) near your system. The CCD can be permanently damaged by transient voltage spikes. If electrically noisy devices are present, an isolated, conditioned power line or dedicated isolation transformer is highly recommended.
- Do not block air vents on the camera. Preventing the free flow of air overheats the camera and may damage it.

UV Coating

Caution

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

Cleaning

WARNING!

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

Camera

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

Optical Surfaces

As a good practice, the camera must be closed/capped off with the supplied dust cover or lens cap when not in use. Should a need to clean the optical window arise due to the accumulation of atmospheric dust, we advise that the *drag-wipe* technique be used. This involves dipping a clean cellulose lens tissue into clean anhydrous methanol, and then dragging the dampened tissue over the optical surface to be cleaned. Do not allow any other material to touch the optical surfaces. Pay extra attention if the optical window is coated with AR (anti-reflection) materials as they can be susceptible to scratches. Please contact factory if you have any questions.

Repairs

Because the PhotonMAX camera system contains no user-serviceable parts, repairs must be performed by Princeton Instruments. Should your system need repair, contact Princeton Instruments customer support for instructions. For contact information, refer to page 94 of this manual.

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

About this Manual

Manual Organization

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

Note: "WinX" is a generic term for WinView/32, WinSpec/32, and WinXTest application software.

Chapter 1, Introduction provides an overview of the PhotonMAX cameras.

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

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

Chapter 4, System Setup provides detailed directions for setting up the camera for imaging or spectroscopic applications and presents over-exposure protection considerations.

Chapter 5, Operation discusses a number of topics, including cooling and effects of high humidity and includes a step-by-step procedure for verifying system operation.

Chapter 6, Advanced Topics discusses standard timing modes (Free Run, External Sync, and Continuous Cleans), Fast and Safe speed modes, Logic Level control, and the Kinetics mode option.

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

Appendix A, Specifications includes camera specifications.

Appendix B, Outline Drawings includes an outline drawing of the C-mount PhotonMAX cameras and the CoolCUBE circulator.

Declaration of Conformity contains the Declaration of Conformity for PhotonMAX systems.

Warranty & Service contains the warranty and customer support contact information.

Safety Related Symbols Used in this Manual

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



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

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Chapter 2

System Component Descriptions

System Components

Standard Components

A typical air-cooled PhotonMAX system consists of the camera, a power supply with power cable, a PCI card for your computer, a data cable, an I/O cable, and the user manual. A typical liquid-cooled system consists of the camera, a coolant circulator with hoses, a PCI card for your computer, a data cable, power cable, an I/O cable, and the user manual.



Figure 2. Typical Air-Cooled System Components

Optional System Components

Optional items include the WinView/WinSpec application software and manual, Scientific Imaging ToolKit™ (SITK™) for LabVIEW®, fiber optic interface, fiber optic cables, and C-mount adapters.

PhotonMAX Camera



CCD Array: The PhotonMAX camera system offers CCDs in a variety of array sizes that allow you to precisely match the sensor to your application. Only scientific-grade devices are used in order to ensure the highest image fidelity, resolution, and acquisition flexibility required for scientific imaging. Large full wells, square pixels, and 100% fill factors provide high dynamic range and excellent spatial resolution. Unichrome (exclusive Princeton Instruments technology) and other UV-enhancement coatings can be used to further improve the quantum efficiency of these CCDs in the ultraviolet.

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

The camera needs to have at least two (2) inches (50 mm) clearance around the vented covers. The ambient temperature needs to be less than 20°C (above this temperature, the CCD temperature can begin to degrade). If the camera is inside an enclosure, the enclosure needs to have unrestricted air flow to an open environment.

Fan: Air-cooled cameras contain an internal fan. Its purpose is:

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

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

Connectors:

DATA: 20-pin, high-density connector for data transfer.

I/O: DB26, high-density connector for input/output control signals.

POWER: 5-pin, LEMO connector for camera power.

Coolant Ports: Liquid-cooled cameras only. Interchangeable inlet/outlet ports. Use only the hoses and circulator shipped with your system. Attaching any other hoses or circulator voids the warranty.



CoolCUBE Coolant Circulator



Liquid-cooled PhotonMAX 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 circulator unit provides the power to the camera and continuously pumps the 50:50 mixture of room temperature (20°C) water and ethylene glycol. To prevent voiding the warranty, use only the circulator and hoses shipped with your system.

Cables



Data Cable: The Data cable (6050-0545) has 20-pin, high-density (MDR-20) connectors for interconnecting the camera and the host computer.



I/O Cable: (Optional) The I/O cable (6050-0546) has a female, DB26, high-density connector that connects to the I/O connector. The five (5) BNCs at other end of the cable provide access to the following five I/O signals (that can be used to input a trigger to initiate data acquisition, to monitor frame readout status, and to control an external shutter): Trigger In, Trigger Invert, Frame Readout, Expose Out, and Shutter Out. Refer to "**I/O Connector Pinout**", page 80, for more information.



Circulator-Camera Power Cable: (For Liquid-Cooled Version Only): The 10' (3 m) power cable (6050-0564) has a Lemo connector on each end and connects between the circulator to the camera to provide the camera power.

Certificate of Performance



Each PhotonMAX camera has a Certificate of Performance. This certificate states that the camera system was assembled and tested according to approved Princeton Instruments procedures. It documents the camera performance data as measured during the testing of your PhotonMAX and lists the Sales Order, Purchase Order, and Camera Serial numbers (useful if you ever need to contact Princeton Instruments Customer Support).

User Manuals



PhotonMAX System User Manual: This manual describes how to install and use the PhotonMAX camera and its components.

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

Optional Components:

Application Software



WinX/32 (WinView or WinSpec): The PhotonMAX camera can be operated by using either WinView/32 or WinSpec/32, Princeton Instrument's 32-bit Windows® software packages designed specifically for high-end imaging and spectroscopy, respectively. The Princeton Instruments' software provides comprehensive image/spectral capture and display functions. The package also facilitates snap-ins to permit advanced operation. Using the optional built-in macro record function, you can also create and edit your own macros to automate a variety of operations. WinView and WinSpec take full advantage of the versatility of the PhotonMAX 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 Princeton Instruments. It is a library of functions that can be used to control and acquire data from the camera when a custom application is being written. For example, in the case of Windows, PVCAM is a dynamic link library (DLL). Also, it should be understood that PVCAM is solely for camera control and image acquisition, not for image processing. PVCAM places acquired images into a buffer, where they can then be manipulated using either custom written code or by extensions to other commercially available image processing packages.

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

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



Fiber Optic Interface

The optional fiber optic interface (2475-0041) allows you to operate the PhotonMAX from up to 300 meters away. This is an excellent solution for operating the camera at telescopes or in hazardous locations. The two transceiver boxes are connected via an LC-to-LC, duplex, 62.5/125 µm fiber optic cable (see below).



Fiber Optic Cable

Optional fiber optic cables can be ordered separately in 100m (2475-0042), 200m (2475-0043), and 300m (2475-0044) lengths.

C- to Spectroscopy Adapter

A C- to Spectroscopy-mount adapter can be ordered separately.

Chapter 3

Installation Overview

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

| Action | Reference |
|--|---|
| 1. If the system components have not already been unpacked, unpack them and inspect their carton(s) and the system components for in-transit damage. | Chapter 4 System Setup, page 21 |
| 2. Verify that all system components have been received. | Chapter 4 System Setup, page 22 |
| 3. If the components show no signs of damage, verify that the appropriate power cord has been supplied with the power supply. | Chapter System Setup, page 22 |
| 4. If the application software is not already installed in the host computer, install it. | Chapter 4 System Setup, page 25 & Software manual |
| 5. If the PCI interface card is not already installed in the host computer, install it. | Refer to computer manufacturer's instructions |
| 6. Depending on application, attach lens to the camera or mount the camera to a spectrometer. | Chapter 4 System Setup, page 23 |
| 7. With the power supply disconnected from the camera, connect the Data cable to the DATA port at the rear of the camera and to the DATA port on the installed PCI card. | |
| 8. 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: Make the hose and power connections to the camera and plug the circulator into the power source. Add coolant if necessary. Turn on the circulator. | Chapter 4 System Setup, page 24 |
| 9. Turn the camera ON. | |
| 10. Turn on the computer and begin running the application software. | Software manual |
| 11. Enter the hardware setup information. | Software manual |
| 12. Set the target array temperature. | Chapter 5 Operation, page 42 |
| 13. When the system reaches temperature lock, wait an additional 20 minutes and then begin acquiring data in focus mode. | Chapter 5 Operation, page 30 or page 35 |

| Action | Reference |
|--|---|
| 14. Adjust the focus for the best image or spectral lines. If you are using WinSpec/32, you may want to use the Focus Helper function for spectroscopy applications. | Chapter 5 Operation, page 30 or page 35 |

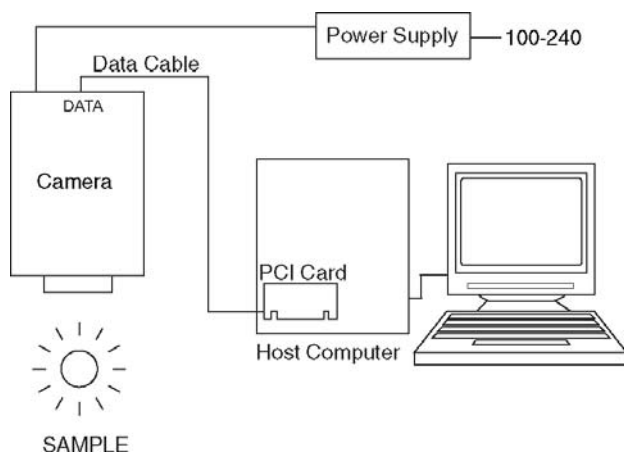


Figure 3. Typical Imaging Experiment Layout with Air-cooled Camera

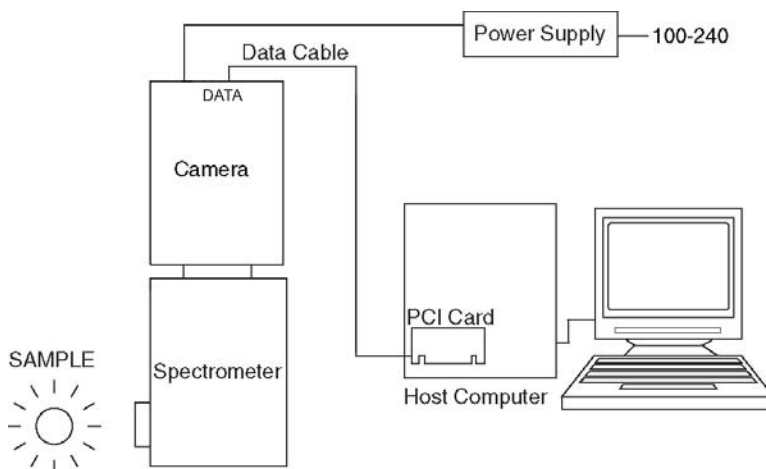


Figure 4. Typical Spectroscopy Experiment Layout with Air-cooled Camera

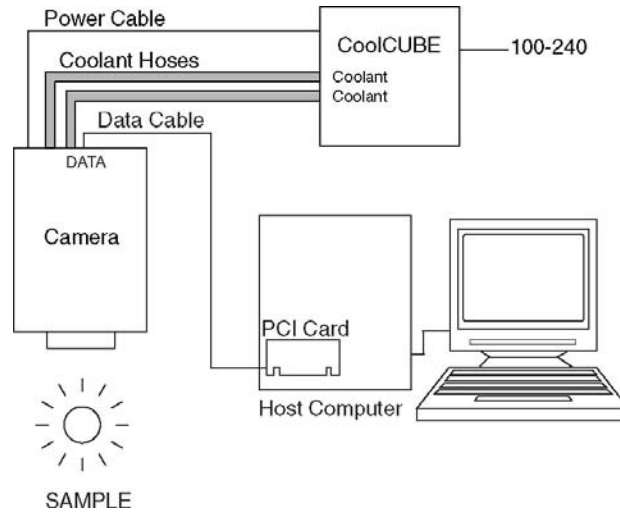


Figure 5. Typical Imaging Experiment Layout with Liquid-cooled Camera

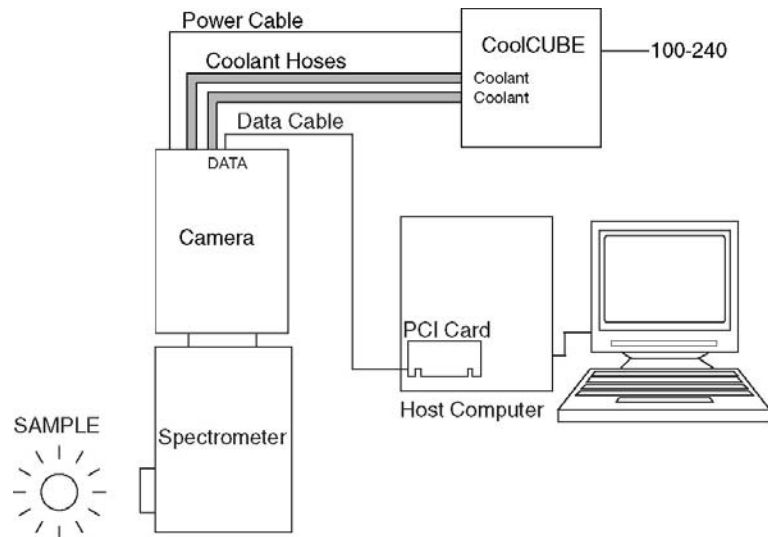


Figure 6. Typical Spectroscopy Experiment Layout with Liquid-cooled Camera

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System Setup

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

Introduction

A PhotonMAX™ camera system consists of four hardware components:

- Camera
- Power supply (or a CoolCUBE coolant circulator for liquid-cooled versions)
- PCI card
- Cables: DATA, I/O (optional), and Power

All of the components and cables required for your configuration should be included with your shipment. Your PhotonMAX system has been specially configured and calibrated to match the camera and readout rate options specified at the time of purchase. The CCD and coating you ordered has been installed in your camera head.

Keep all the original packing materials so you can safely ship the PhotonMAX system to another location or return it for service if necessary. If you have any difficulty with any step of the instructions, call Princeton Instruments Customer Support. For contact information, refer to page 94.

Hardware installation consists of:

- Installing an interface card.
- Attaching a lens to a C-mount on the camera or to a C- to F-mount adapter.
- Connecting the camera to an external shutter, if one is required.
- Mounting the camera to a spectrometer (for spectroscopy applications).
- Software installation depends on the application software you will be using to run the system. Refer to the manual supplied with the software for information about installing and setting it up.

Unpacking the System

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

Checking the Equipment and Parts Inventory

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

- **Camera**
- **Power Supply** (or a CoolCUBE coolant circulator for liquid-cooled versions)
- **Host Computer:** Can be purchased from Princeton Instruments or provided by user.
- **Computer Interface Components:**
 - **Data cable:** 15 ft (5 meter) cable (6050-0545) is standard.
 - **Proprietary PCI Card**
- **I/O cable: (Optional)** 2 ft (.6 meter) cable (6050-0546) with DB26 connector at one end and five (5) BNCs at the other end.
- **PhotonMAX System User Manual**
- **WinView/32 or WinSpec32 CD-ROM** (optional)
- **Software User Manual**

System Requirements

Environmental Requirements

Storage temperature: $\leq 55^{\circ}\text{C}$

Operating environment temperature: 5°C to $+30^{\circ}\text{C}$; the environment temperature range over which system specifications can be guaranteed is $+20^{\circ}\text{C}$

Relative humidity $\leq 50\%$; non-condensing

Note: For TE-cooled cameras, the cooling performance may degrade if the room temperature is above $+20^{\circ}\text{C}$.

Ventilation

Camera: Allow at least two (2) inches (50 mm) clearance around the vented covers. The air needs to be less than 25°C (above this temperature the CCD temperature can begin to degrade). Where the camera is inside an enclosure, the enclosure needs to have unrestricted flow to an open environment. The camera vents its heat out the vents near the nose. The air intake is near the rear of the camera.

Power

Camera: The PhotonMAX camera receives its power from the supplied power supply (or the liquid circulator unit), which in turn plugs into a source of AC power.

Power Supply: The receptacle on the power supply should be compatible with the line-voltage line cords in common use in the region to which the system is shipped. If the power supply receptacle is incompatible, a compatible adapter should be installed on the line cord, taking care to maintain the proper polarity to protect the equipment and assure user safety. For the liquid-cooled version, power to the camera is supplied via the CoolCUBE circulator unit.

Maximum Power Output: 96 W

Input: 100-240 VAC, 47-63 Hz, 3 A

Output: 12 VDC at 8 A maximum

Host Computer

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

- Windows® 2000, or Windows® XP or later operating system
- 1 GHz Pentium® 4 (or greater)
- 1 GB RAM (or greater)
- CD-ROM drive
- At least one unused PCI card slot
- Super VGA monitor and graphics card supporting at least 65535 colors with at least 128 Mbyte of memory. Memory requirement is dependent on desired display resolution.
- Hard disk with a minimum of 80 Mbytes available. A complete installation of the program files takes about 17 Mbytes and the remainder is required for data storage, depending on the number and size of images/spectra collected. Disk level compression programs are not recommended. Drive speed of 10,000 RPM recommended.
- Mouse or other pointing device.

Note: The above requirements are the minimum for operating a PhotonMAX camera. A faster computer with larger memory (RAM) will greatly enhance the software performance during live mode operations.

Attaching a Lens to a C- Mount Adapter

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

PhotonMAX cameras for imaging applications incorporate an integral C-mount adapter. *Other mounts may be available. Consult the factory for specific information relating to your needs. See page 94 for Information on accessing the Princeton Instruments Customer Support Dept.*

Mounting the Lens

C-mount lenses simply screw into the front of these cameras. Tighten the lens by hand only.

Notes:

1. C-mount cameras are shipped with a dust cover lens installed. Although this lens is capable of providing surprisingly good images, its throughput is low and the image quality is not as good as can be obtained with a high-quality camera lens. Users should replace the dust-cover lens with their own high-quality laboratory lens before making measurements.
2. If the CCD is cooled to low temperatures (below -50°C), exposure to ambient light will over-saturate it. This may increase dark charge significantly. If the camera remains saturated after all light sources are removed, you may have to bring the camera back to room temperature to restore dark charge to its original level.
3. Saturation is not harmful to a non-intensified camera.

Adjusting the C-Mount Adapter

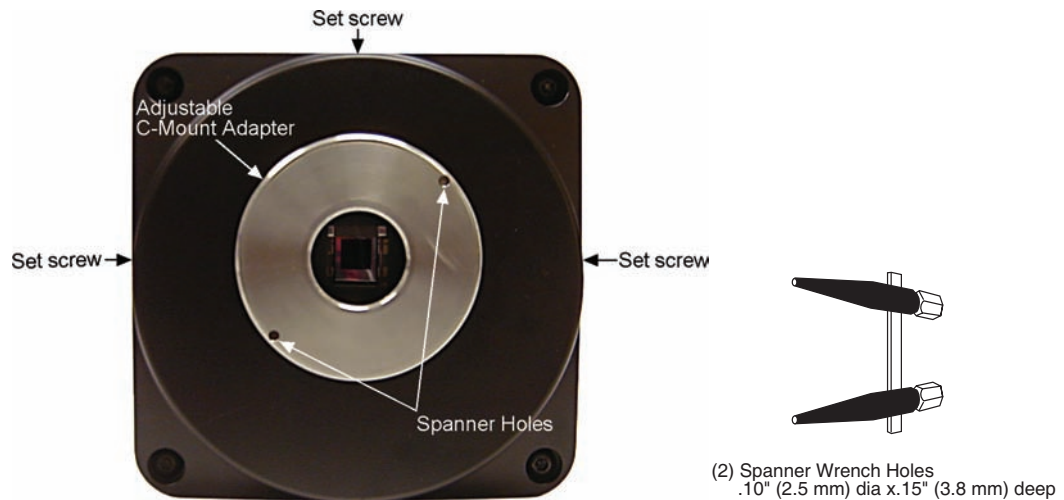


Figure 7. Adjustable C-Mount Adapter

The PhotonMAX features an adjustable C-mount adapter that allows you to change the focal depth. Use the hex key supplied with your system (or a .050" hex key) to adjust the adapter: loosen the three setscrews, rotate the ring to the desired height and tighten the screws to lock the adapter in place.

Note: To lock the setscrews, the face of the adapter should be no further than .1" (2.5 mm) out from the front surface of the camera nose.

Caution

The C-mount lens thread-depth should be .21" (5.3 mm) or less. Otherwise, depending on the adapter in-out location, the lens could bottom out and damage the CCD window. If you are not certain of the thread depth, remove the adapter from the camera nose, thread the lens into the adapter until the lens threads are flush with the back surface of the adapter. Note the depth at the front surface, remove the lens, and then re-insert the adapter into the camera nose.

Making the Camera-Circulator Connections

For liquid-cooled cameras, the CoolCUBE circulator provides the camera power and provides a vibration-free method of heat removal.

1. Make sure the camera and the circulator power switches are turned off.
2. Make sure the circulator is 6 inches (150 mm) or more below the camera. The vertical distance should not exceed 10 feet (3 m). Typically, the camera is at table height and the circulator is on the floor.
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.

Note: Make sure 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

4. Plug the circulator into a 100-240 VAC, 47-63 Hz power source.

5. Turn the circulator on.
6. Turn the camera on.
7. Start the application software.

Software Installation

Notes:

1. If you have multiple cameras from Roper Scientific (PI and PM brands) on the same host computer, it may be necessary to edit the PVCAM.INI file. Refer to Chapter 7 for instructions.
2. Leave the interface cable disconnected from the camera until you have installed WinView/32 or WinSpec/32.

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

1. On the **Select Components** dialog box (see Figure 8), click on the **AUTO PCI** button to install the required drivers and the most commonly installed program files. Select the **Custom** button if you would like to choose among the available program files or do not want to install the drivers.
2. Make sure the camera is connected to the host computer and that the camera power supply is turned on.
3. Reboot the computer.
4. At bootup, Windows will detect the PCI card.

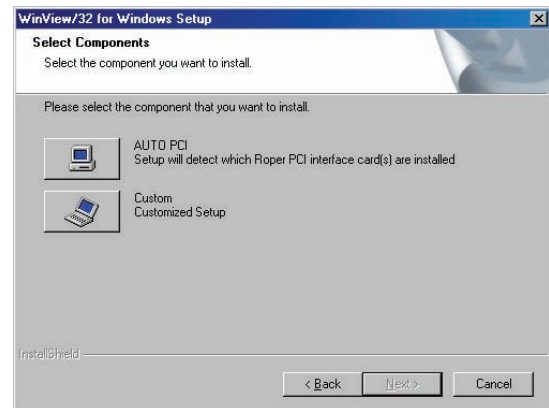


Figure 8. WinView Installation: Select Components dialog box

If you selected **AUTO PCI** during the application software installation, WinView/32 or WinSpec/32 automatically put the required driver files in the "Windows" directories shown below. If you are prompted for the locations of these files, refer to Table 1.

| Windows Version | Inf File Name/Location | Device Driver Name/Location |
|-------------------------------|---------------------------------------|--|
| Windows® 2000 and Windows® XP | pmwdm.inf (in WINNT/Inf, for example) | pmwdm2k.sys (in WINNT/System32/Drivers, for example) |

Table 1. Driver Files and Locations

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

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

WinX Versions 2.5.19.6 and later

1. Make sure the PhotonMAX is connected to the host computer and that it is turned on.
2. Run the WinX application. The **Camera Detection wizard** will automatically run if this is the first time you have installed a Princeton Instruments WinX application (WinView/32, WinSpec/32, or WinXTest/32) and a supported camera. Otherwise, if you installing a new camera type, click on the **Launch Camera Detection Wizard...** button on the **Controller/CCD** tab page to start the wizard.
3. On the **Welcome** dialog (Figure 9), leave the checkbox unselected and click on **Next**.

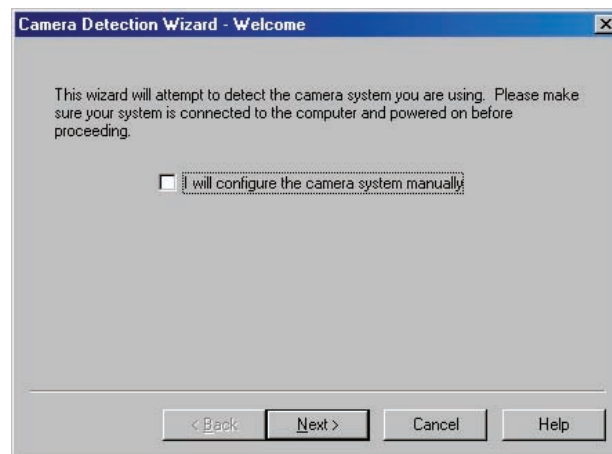


Figure 9. Camera Detection Wizard - Welcome dialog box

4. Follow the instructions on the dialog boxes to perform the initial hardware setup: this wizard enters default parameters on the **Hardware Setup** dialog box tab pages and gives you an opportunity to acquire a single test image to confirm the system is working. Note that this is a test image and it is not acquired using the settings needed for true data acquisition.
5. To finalize the setup, make the following selections on the **Controller/Camera** tab page so you can control the camera and acquire data at the default **Detector Temperature** setting:
 - On the **Controller/Camera** tab page: Select "**Frame Transfer**" as the Readout Mode.
 - On the **Cleans** tab page: Select "**Clear Pre-Sequence**".

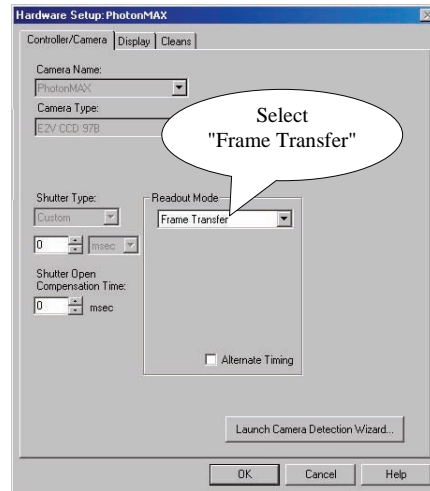


Figure 10. Controller/Camera tab page

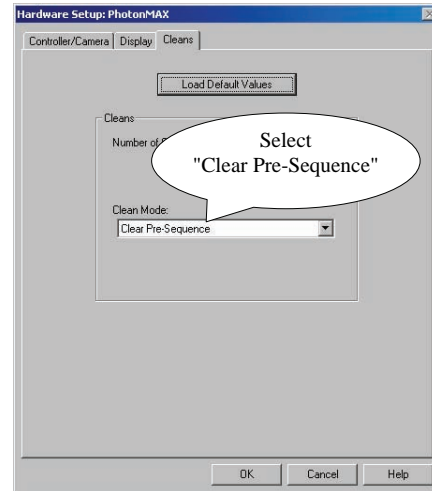


Figure 11. Cleans tab page

WinX Versions before 2.5.19.6: Run RSConfig.exe

1. Make sure the PhotonMAX is connected to the host computer and that it is turned on.
2. Run RSConfig from the **Windows|Start|Programs|Roper Scientific** menu or from the directory where you installed WinView, WinSpec, or WinXTest.
3. When the RSConfig dialog box (Figure 12) appears, you can change the camera name to one that is more specific or you can keep the default name "Camera1". When you have finished, click on the **Done** button.

Note: If the first camera in the list is not the "PM Style (PCI)" PhotonMAX camera, please refer to *"Editing the PVCAM.INI File"* on page 75 for instructions on editing the PVCAM.INI file.

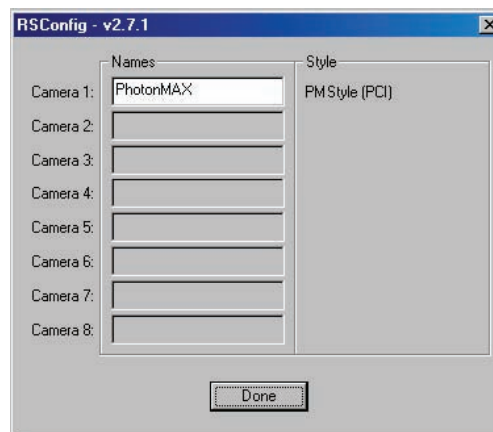


Figure 12. RSConfig dialog box

4. Open the WinX application and, from **Setup|Hardware...**, run the Hardware Setup wizard.
5. When the PVCAM dialog box (Figure 13) is displayed, click in the **Yes** radio button, click on **Next** and continue through the wizard. After the wizard is finished, the

Controller/Camera tab page will be displayed with the **Use PVCAM** checkbox selected.



Figure 13. Hardware Setup wizard: PVCAM dialog box

6. After making the following selections on the **Controller/Camera** tab page, you should now be able to control the camera and acquire data at the default **Detector Temperature** setting:
 - On the **Controller/Camera** tab page: Select "**Frame Transfer**" as the Readout Mode.
 - On the **Cleans** tab page: Select "**Clear Pre-Sequence**".

Note: For a step-by-step procedure on basic system operation, refer to the appropriate "**First Light**" section, beginning on page 30 (Imaging applications) or page 35 (Spectroscopy applications).

Operation

Introduction

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

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

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

- In **Focus** mode, the number of frames and accumulations settings are ignored. A single frame is acquired and displayed, another frame is acquired and overwrites the currently displayed data, and so on until Stop is selected. Only the last frame acquired before Stop is selected can be stored. When Stop is selected, the File Save function can be used to save the currently displayed data. This mode is particularly convenient for familiarization and setting up. For ease in focusing, the screen refresh rate should be as rapid as possible, achieved by operating with axes and cross-sections off, and with Zoom 1:1 selected.
- In **Acquire** mode, every frame of data collected can be automatically stored (the completed dataset may include multiple frames with one or more accumulations). This mode would ordinarily be selected during actual data collection. One limitation of Acquire mode operation is that if data acquisition continues at too fast a rate for it

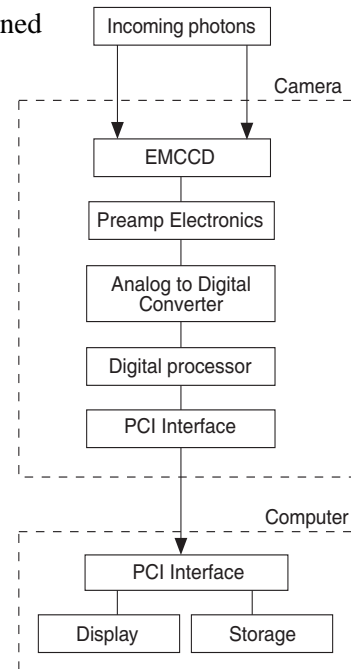


Figure 14. Block Diagram of PhotonMAX System

to be stored, data overflow will eventually occur. This could only happen in Fast Mode operation.

The remainder of this chapter provides "First Light" procedures (these provide step-by-step instruction on how to initially verify system operation) and discusses factors that affect exposure, readout, and digitization of the incoming signal. By understanding the exposure, readout, and digitization factors and making adjustments to software settings you can maximize signal-to-noise ratio. For information about synchronizing data acquisition with external devices, please refer to *Chapter 6, Advanced Topics*.

First Light (Imaging)

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

Assumptions

The following procedure assumes that

1. You have already set up your system in accordance with the instructions in the previous chapters.
2. You have read the previous sections of this chapter.
3. You are familiar with the application software.
4. The system is being operated in imaging mode.
5. The target is a sharp image, text, or a drawing that can be used to verify that the camera is "seeing" and can be used to maximize focus.

Getting Started

1. Mount a test target in front of the camera.
2. Power ON the camera (the power switch is on the back of the camera).

Note: The camera must be turned on before WinView/32 or WinSpec/32 is opened, and WinView/32 or WinSpec/32 must be closed before the camera is turned off.

3. Turn on the computer power.
4. Start the application software.
5. Block light from the lens.

Setting the Parameters

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

Set the software parameters as follows:

Controller/Camera tab page (Setup|Hardware): These parameters should be set automatically to the proper values for your system.

- **Use PVCAM:** Verify that this box is checked.

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

- **Controller type:** This information is read from the camera.
- **Camera type:** This information is read from the camera.
- **Shutter type:** Custom (System dependent).
- **Readout mode:** Available modes are read from the camera. Select **Frame Transfer**.

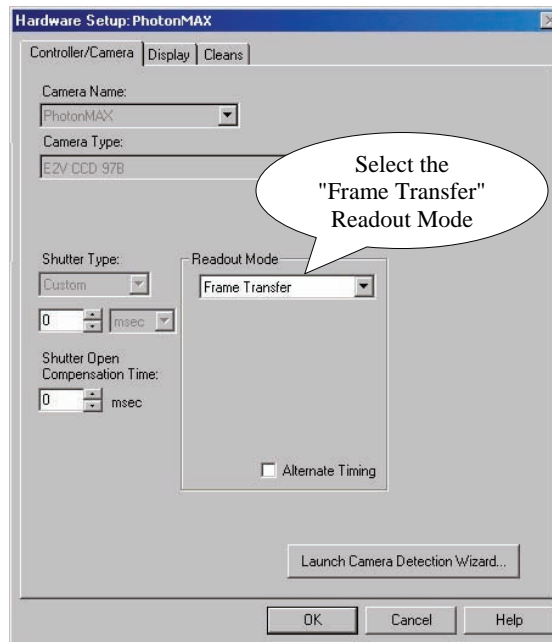


Figure 15. Controller/Camera tab page

Cleans tab page (Setup|Hardware): Select **Clear Pre-Sequence** as the Clean Mode.

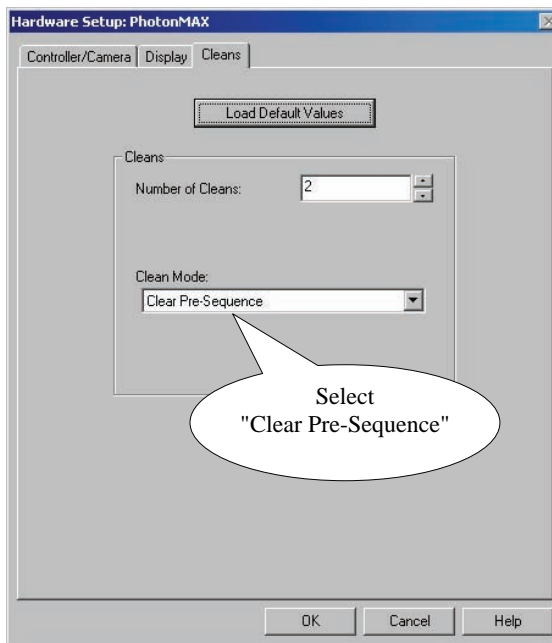


Figure 16. Cleans tab page

Detector Temperature (Setup|Detector Temperature...): The default temperature setting is read from the camera. When the array temperature reaches the set temperature, the **Detector Temperature** dialog box will report that the temperature is **LOCKED** (Figure 17 shows the default temperatures for the PhotonMAX:512B and 1024B). 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 $\pm 0.05^\circ\text{C}$.

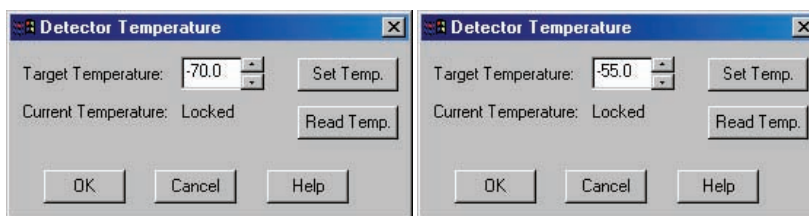


Figure 17. Detector Temperature dialog box (512B on left, 1024B on right)

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

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

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

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

Use this function to define the region of interest (ROI).

- **Imaging Mode:** Select this mode if you are running WinSpec.
- Clicking on **Full** loads the full size of the chip into the edit boxes.

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

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

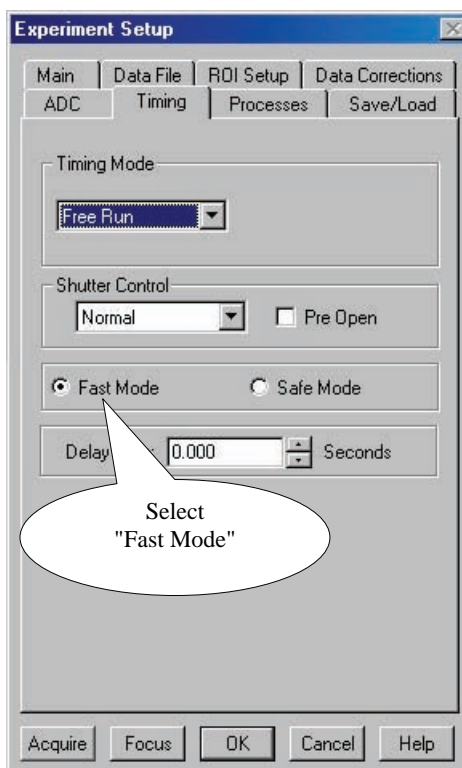


Figure 18. Experiment Setup|Timing tab page

Acquiring Data

1. If you are using WinView/32 and the computer monitor for focusing, select **Focus** from the **Acquisition** menu. Successive images will be sent to the monitor as quickly as they are acquired.
2. Adjust the lens aperture, intensity scaling, and focus for the best image as viewed on the computer monitor. Some imaging tips follow:
 - Begin with the lens blocked off and then set the lens at the smallest possible aperture (largest f-stop number).
 - Make sure there is a suitable target in front of the lens. An object with text or graphics works best.
 - Adjust the intensity scaling (by clicking the **5%-95%** button at the bottom left corner of the data window) and adjust the lens aperture until a suitable setting is found. Once you've determined that the image is present, select a lower setting for better contrast. Check the brightest

regions of the image to determine if the A/D converter is at full-scale. A *16-bit A/D is at full scale when the brightest parts of the image reach an intensity of 65535*. Adjust the aperture to where it is just slightly smaller (higher f-stop) than the setting where maximum brightness on any part of the image occurs.

- Set the focus adjustment of the lens for maximum sharpness in the viewed image.
3. After you have focused the camera, you can stop **Focus** mode, continue **Focus** mode, begin **Acquire** mode, or wait for the CCD to reach the operating temperature before going to **Acquire** mode.

First Light (Spectroscopy)

The following paragraphs provide step-by-step instructions for operating PhotonMAX in a spectroscopy setup for the first time. The intent of this simple procedure is to help you gain basic familiarity with the operation of your system and to show that it is functioning properly. Once basic familiarity has been established, then operation with other operating configurations, ones with more complex timing modes, can be performed. An underlying assumption for the procedure is that the camera is to be operated with a spectrograph (such as an Acton SpectraPro™ 2356) on which it has been properly installed. A suitable light source, such as a mercury pen-ray lamp, should be mounted in front of the entrance slit of the spectrograph. Any light source with line output can be used. *Standard fluorescent overhead lamps have good calibration lines as well.* If there are no "line" sources available, it is possible to use a broadband source such as tungsten for the alignment. If this is the case, use a wavelength setting of 0.0 nm for alignment purposes.

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

Assumptions

The following procedure assumes that

1. You have already set up your system in accordance with the instructions in previous chapters.
2. You have read the previous sections of this chapter.
3. You are familiar with the application software.
4. The system is being operated in spectroscopy mode.

Getting Started

1. Set the spectrometer entrance slit width to minimum (10 μm if possible).
2. Mount the camera to the spectrometer exit port.
3. Power ON the (the power switch is on the back of the camera).
4. Turn on the computer power.
5. Start the application software.

Setting the Parameters

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

Set the software parameters as follows:

Controller/Camera tab page (Setup|Hardware): These parameters should be set automatically to the proper values for your system.

- **Use PVCAM:** Verify that this box is checked.

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

- **Controller type:** This information is read from the camera.
- **Camera type:** This information is read from the camera.
- **Shutter type:** Custom (System dependent).
- **Readout mode:** Available modes are read from the camera. Select **Frame Transfer**.

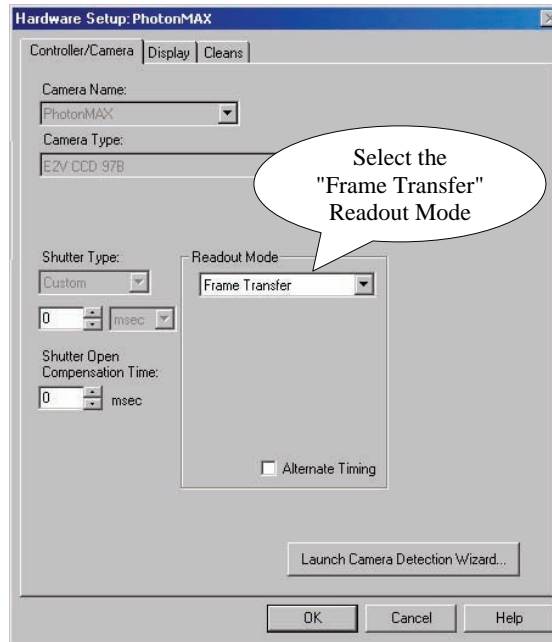


Figure 19. Controller/Camera tab page

Detector Temperature (Setup|Detector Temperature...): The default temperature setting is read from the camera. When the array temperature reaches the set temperature, the **Detector Temperature** dialog box 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 $\pm 0.05^{\circ}\text{C}$.

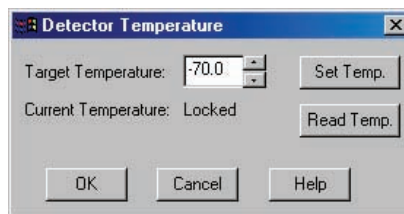


Figure 20. Detector Temperature dialog box

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

Cleans tab page (Setup|Hardware): Select **Clear Pre-Sequence** as the Clean Mode.

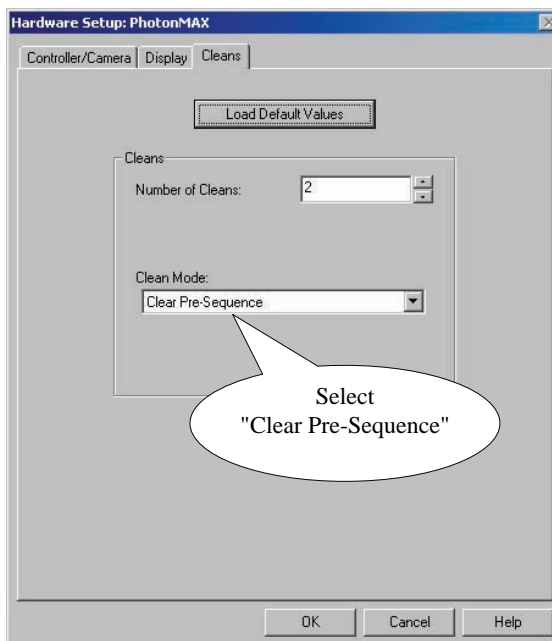


Figure 21. Cleans tab page

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

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

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

Use this function to define the region of interest (ROI).

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

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

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

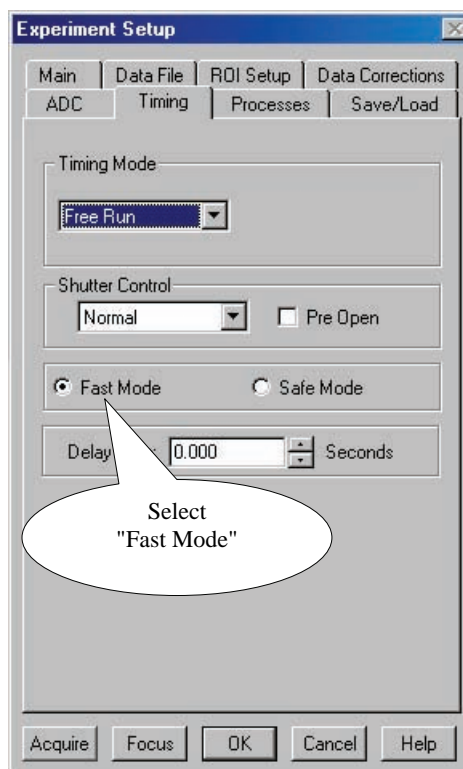


Figure 22. Experiment Setup/Timing tab page

Focusing

The mounting hardware provides two degrees of freedom, focus and rotation. In this context, focus means to physically move the camera back and forth through the focal plane of the spectrograph. The approach taken is to slowly move the camera in and out of focus and adjust for optimum while watching a live display on the monitor, followed by rotating the camera and again adjusting for optimum. The following procedure, which describes the focusing operation with an Acton SP-2356 spectrograph, can be easily adapted to other spectrographs.

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

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

3. Set the slit to 25 μm . *If necessary, adjust the Exposure Time to maintain optimum (near full-scale) signal intensity.*

4. In WinSpec, select **Focus** (on the **Acquisition** menu or on the **Experiment Setup** dialog box) to begin data accumulation. Data will be continuously acquired and displayed but will not be stored until you stop acquisition and use the **Save** function on the File menu.
5. Slowly move the camera in and out of focus. You should see the spectral line go from broad to narrow and back to broad. Leave the camera set for the narrowest achievable line. You may want to use the **Focus Helper** function (**Process|Focus Helper...**) to determine the narrowest line width: it can automatically locate peaks and generate a report on peak characteristics during live data acquisition (see the WinSpec/32 on-line help for more information).

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

- **Long focal-length spectrographs such as the Acton SP-2356:** The mounting adapter includes a tube that slides inside another tube to move the camera in or out as required to achieve optimum focus.
 - **Short focal-length spectrographs:** There is generally a focusing mechanism on the spectrograph itself which, when adjusted, will move the optics as required to achieve proper focus.
 - **No focusing adjustment:** If there is no focusing adjustment, either provided by the spectrograph or by the mounting hardware, then the only recourse will be to adjust the spectrograph's focusing mirror.
6. Next adjust the rotation. You can do this by rotating the camera while watching a live display of the line. The line will go from broad to narrow and back to broad. Leave the camera rotation set for the narrowest achievable line.

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

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

Exposure and Signal

Exposure Time

Exposure time (set on the **Experiment Setup|Main** tab page) is the time between commands sent by the application software to start and stop signal accumulation on the CCD. In combination with triggers, these commands control when continuous cleaning of the CCD stops and when the accumulated signal will be read out. 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.

If smearing or other factors require a shutter, the **SHUTTER OUT** signal from the I/O cable can be used to control a customer-supplied external shutter.

The *effective* exposure time of the array depends on the active Exposure-Readout mode (Overlapped or Non-Overlapped).

Overlapped: In this mode, the effective exposure time depends on the frame readout time. When the set exposure time is greater than or equal to the frame readout time, the effective exposure time is the set exposure time. However, if the set exposure time is less than the frame readout time, the first exposure will be the set exposure time and subsequent exposures in a sequence will be exposed for the frame readout time.

Non-Overlapped: In this mode, the effective exposure time is the set exposure time.

For detailed information on these modes, see *Exposure-Readout Modes*, page 48.

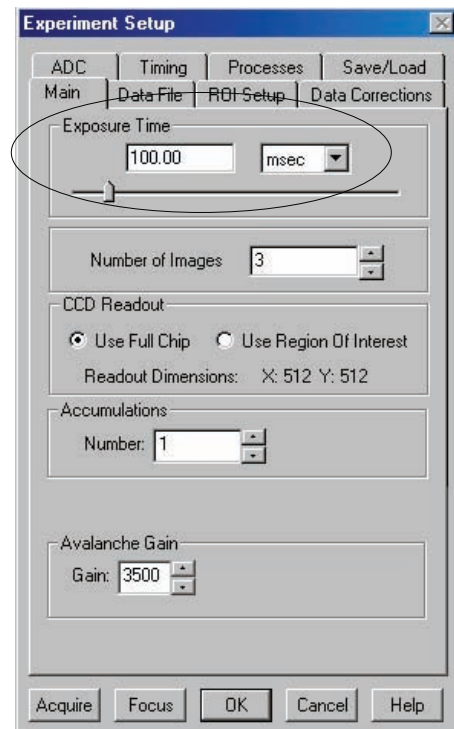


Figure 23. Setting the Exposure Time (Experiment Setup/Main tab page)

Avalanche Gain (Multiplication Gain)

As explained previously, the PhotonMAX uses a unique CCD capable of multiplying the charge (electrons) generated in the pixels. When the multiplication is sufficiently high, it is possible to see extremely low-light events. The amount of multiplication is controlled by the voltage applied to multiplication register clocks. For convenience, a 12-bit DAC (digital-to-analog converter) is provided to adjust the multiplication factor in 4096 steps. The digital value is proportional to the clock voltages, which in turn has a complex relationship (approximated to an exponential) with the level of multiplication.

When the Multiplication Gain port is selected (**Experiment Setup|ADC** tab page), the Avalanche Gain can be set by entering a digital (DAC) value on the **Experiment Setup|Main** tab page. A Gain setting of zero (0) refers to a no-gain state where the camera behaves like a standard high speed CCD (with rather high read noise). Values 1 to 4095 are mapped linearly to the internal serial clock voltages that vary the multiplication gain in a complex exponential fashion. Typically at a Gain setting of 4095, the PhotonMAX can offer a multiplication gain factor in the excess of 1000x. Even though the camera is capable of delivering large multiplication gain factors, multiplication gain should be used only as needed to preserve as much dynamic range as possible.

The avalanche gain for your camera is measured at various Gain (DAC) settings and the data are provided on the Certificate of Performance. A typical relationship between the DAC setting and charge multiplication factor for the PhotonMAX:512B or the PhotonMAX:1024B is shown in the graph below.

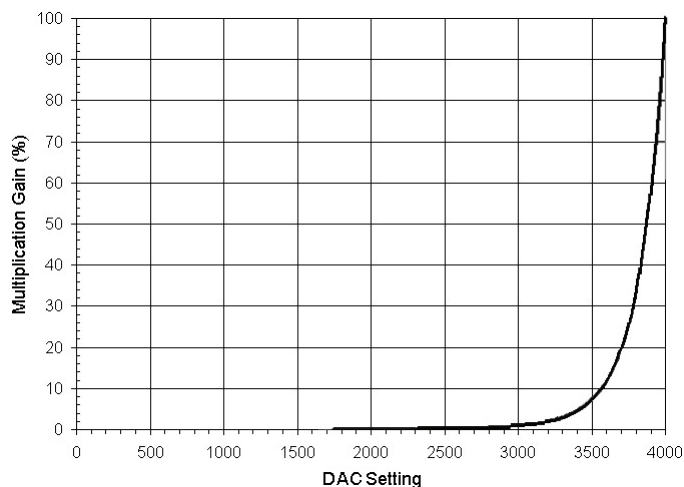


Figure 25. DAC Setting vs. Charge Multiplication Gain

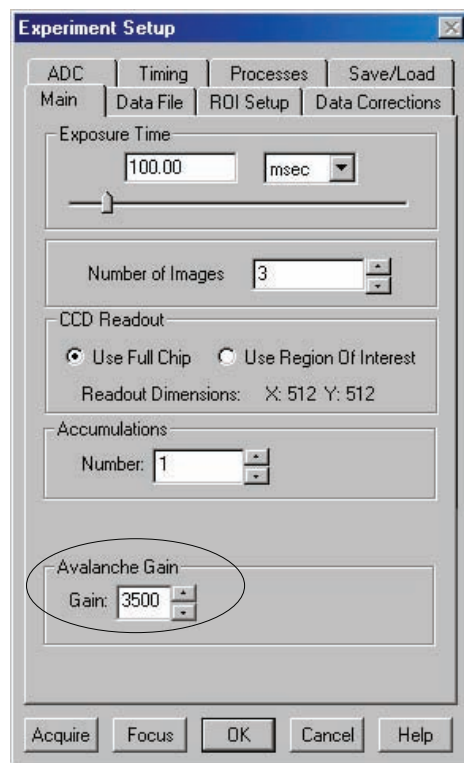


Figure 24. Setting the Avalanche Gain (Experiment Setup|Main tab page)

Note: As the on-chip multiplication introduces additional noise, it is recommended that the multiplication be used only as required. For more information, refer to the "On-Chip Multiplication Gain" technical note. This technical note can be accessed by going to the Princeton Instruments web site at www.princetoninstruments.com.

CCD Temperature

As stated before, lowering the temperature of the CCD will generally enhance the quality of the acquired signal. In EMCCD cameras, lower temperatures result in lower dark current and higher avalanche gain (multiplication gain). When WinView or WinSpec is the controlling software, temperature control is done via the **Detector**

Temperature dialog box (see Figure 26) accessed from the **Setup** menu. Initially, the dialogue shows default temperature appropriate for your specific model. Once the target array temperature has been set, the software controls the camera's cooling circuits to reach set array temperature. On reaching that temperature, the control loop locks to that temperature for stable and reproducible performance. When temperature lock has been reached (temperature within 0.05°C of set value) the Detector Temperature dialog box reports that the current temperature is **Locked**. The on-screen indication allows easy verification of temperature lock.

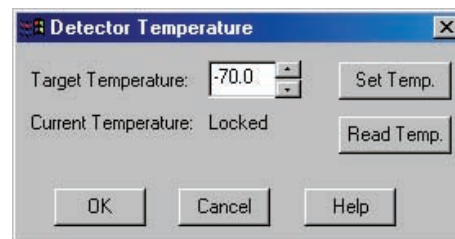


Figure 26. Setting the Temperature (Detector Temperature dialog box)

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 3, on page 79, for default cooling temperatures.

Note: If the CCD is cooled to low temperatures (below -50°C), exposure to ambient light will over-saturate it. This may increase dark charge significantly. If the camera remains saturated after all light sources are removed, you may have to bring the camera back to room temperature to restore dark charge to its original level.

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 temperature dependent.

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

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 S/N (Signal-to-Noise ratio) accomplished through the software.

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

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

Caution If 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 Princeton Instruments Customer Support. See page 94 for contact information.

Offset (Bias)

CCD cameras are typically designed to produce a certain level of offset (also known as bias) when no light is present and the exposure time is set to zero (0). Typically, the offset (bias) is subtracted from the sample image for quantitative measurement. Since the offset can change based on several factors such as multiplication gain, speed, etc., it is recommended that a fresh offset (bias) image be taken with the same settings as the sample image and then be subtracted from the sample image.

Cleaning

Cleaning removes charge from the CCD by clocking the charge to the serial register and then directly to ground. This process is much faster than a readout, because the charge does not go through the readout node or the amplifier. The selected clean mode determines when to clean the CCD array. Not all cleaning modes are available for all cameras.

The clean modes are described below:

- **Clear Never:** Never clean the CCD. Useful for performing a readout after an exposure has been aborted.
- **Clear Pre-Exposure:** Before each exposure, cleans the CCD by the number of cleans selected. This mode can be used in a sequence. It is most useful when there is a considerable amount of time between exposures.
- **Clear Pre-Sequence:** Before each data acquisition sequence, cleans the CCD the number of times specified by the number of cleans selected. If no sequence is set up, this mode behaves as if the sequence has one exposure. The result is the same as

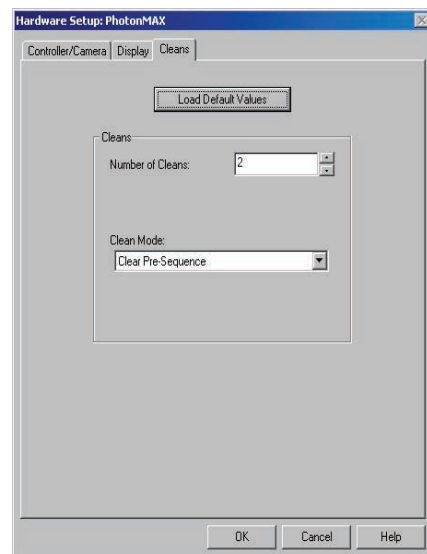


Figure 27. Selecting the Clean Mode (Hardware Setup/Cleans tab page)

using Clear Pre-Exposure. For the PhotonMAX, this is the most useful method of cleaning.

- **Clear Post-Sequence:** Cleans continuously after the data acquisition sequence ends. The camera continues cleaning until a new exposure is set up or started, the abort command is sent, the speed entry number is changed, or the camera is reset.
- **Clear Pre- and Post-Sequence:** Cleans the number of cleans selected times before each sequence and cleans continuously after the sequence ends. The camera continues cleaning until a new exposure is set up or started, the abort command is sent, or the camera is reset.
- **Clear Pre-Exposure and Post-Sequence:** Cleans the number of cleans selected times before each exposure and cleans continuously after the sequence ends. The camera continues cleaning until a new exposure is set up or started, the abort command is sent, or the camera is reset.

Readout

Introduction

The PhotonMAX:512B and 1024B models use frame transfer CCDs with 512x512 and 1024x1024 active pixels, respectively. These frame transfer CCDs also have an equivalent number of “frame transfer or masked” pixels as shown in Figure 28. (Note: typically there are additional rows and columns for internal reference).

In standard frame transfer mode, the sensor area is exposed for certain time, typically milliseconds to seconds. The acquired image data is then transferred to frame transfer area before reading it out via extended multiplication gain register or standard serial register. Region of Interest (ROI) and/or binning can be used to improve the time resolution, limited to a millisecond regime. For more information on the CCD exposure-readout operations, see "*Exposure - Readout Modes*", page 48.

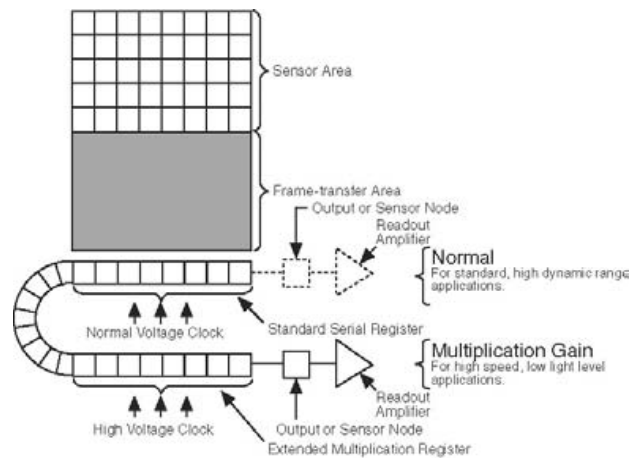


Figure 28. EMCCD Array Structure

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

Dual-Readout Port Operation

The PhotonMAX: 512B and 1024B models are configured with software-selectable dual-readout amplifiers, also referred to as "ports", shown in Figure 28. The two amplifiers are listed below.

Port #1: Multiplication Gain amplifier

Port #2: Normal amplifier

If your camera is configured with two readout amplifiers (ports), the software automatically allows port selection (Multiplication Gain or Normal). An example of a software dialogue to select the ports is shown in Figure 29.

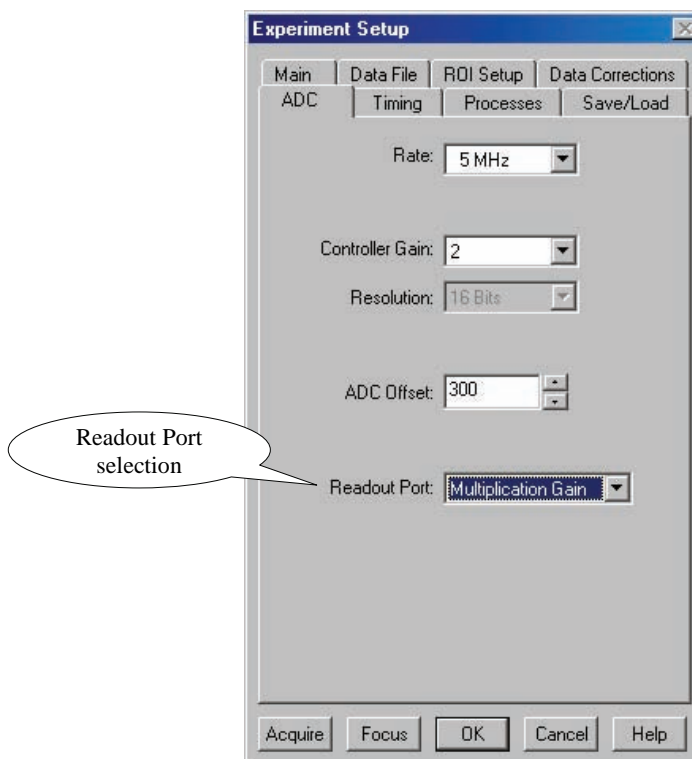


Figure 29. Selecting the Readout Port (Experiment Setup|Main tab page)

Note: As the user interface may be different, please refer to your software manual for specific information on readout amplifier/port selection.

1. **Multiplication Gain:** When this port is selected, the gain value can be entered on the **Experiment Setup|Main** tab page. A setting of 0 (zero) results in unity gain and the subsequent DAC settings are exponentially related to the multiplication gain. Since the multiplication gain can be used to overcome the read noise of the fast amplifier, this mode is most useful in applications requiring low-light sensitivity at high frame rates (e.g., Single molecule fluorescence, ion imaging, etc.).

Note: When used with a standard lens, the Multiplication Gain port produces an image in the correct orientation. The first pixel is read out at the bottom left of the array.

2. **Normal:** When the camera is using this amplifier, electrons (signal) generated in

pixels are clocked through the standard serial register. The amplifier is designed to take advantage of the dynamic range of the CCD and is most useful when the frame rate is not critical. (e.g., bright field, fixed cell fluorescence, etc.)

Note: Since the first pixel to be read out from the Normal port is at the bottom right (closest to the Normal port), the resulting image is a mirror image of the same image if it were read out of the Multiplication Gain port. Some software packages do a "horizontal-flip" in the software when the Normal port is selected to ensure the correct orientation for all ports. In WinView and WinSpec, you can specify a horizontal-flip on the **Hardware Setup|Display** tab page.

Controller Gain

Controller gain (a function of the preamplifier and analog electronics) 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. In WinView and WinSpec, gain selection is made on the **Acquisition|Experiment Setup...|ADC** tab page (Figure 30). The choices are **1 (Low)**, **2 (Medium)**, and **3 (High)**. Users who measure high-level signals may wish to select **Low** to allow digitization of larger signals. **Medium** is suitable for experiments within the mid-level intensity range. 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.

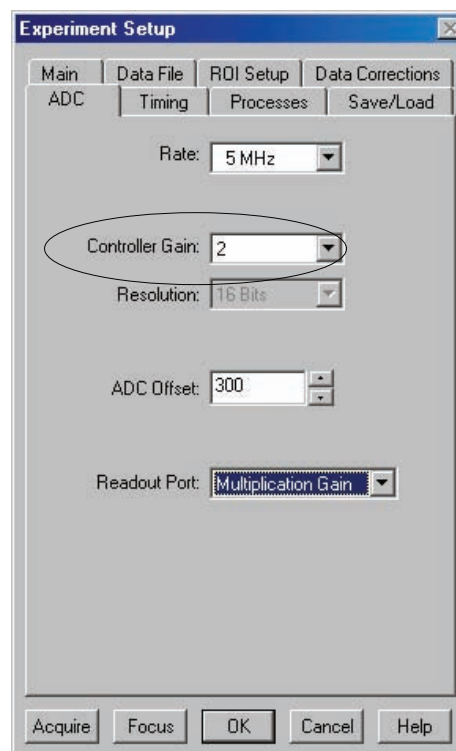


Figure 30. Selecting the Controller Gain (Experiment Setup/ADC tab page)

| Readout Amplifier (Port) | Readout Rates | Typical Controller Gain for 512B (e^- /ADU) | Typical Controller Gain for 1024B (e^- /ADU) |
|--------------------------|---------------|--|---|
| Multiplication Gain | 5 MHz | #1: $12e^-$ /ADU | #1: $12e^-$ /ADU |
| | 10 MHz | #2: $6e^-$ /ADU #3: $3e^-$ /ADU | #2: $6e^-$ /ADU #3: $3e^-$ /ADU |
| Normal | 1 MHz | #1: $4e^-$ /ADU | #1: $3e^-$ /ADU |
| | 5 MHz | #2: $2e^-$ /ADU #3: $1e^-$ /ADU | #2: $1.5e^-$ /ADU #3: $0.7e^-$ /ADU |

Table 2. Typical Controller Gains

Readout Rate

PhotonMAX has two readout rates available on each of the two ports. Selected on the **Acquisition|Experiment Setup...|ADC** tab page, a slower readout rate can be used when better noise performance is needed at the expense of frame rate. On the other hand, increased frame readout rate can be achieved by one or more of the following

- higher readout speed,
- sub-region selection,
- binning.

For more information on frame rate, please refer to the product data sheet.

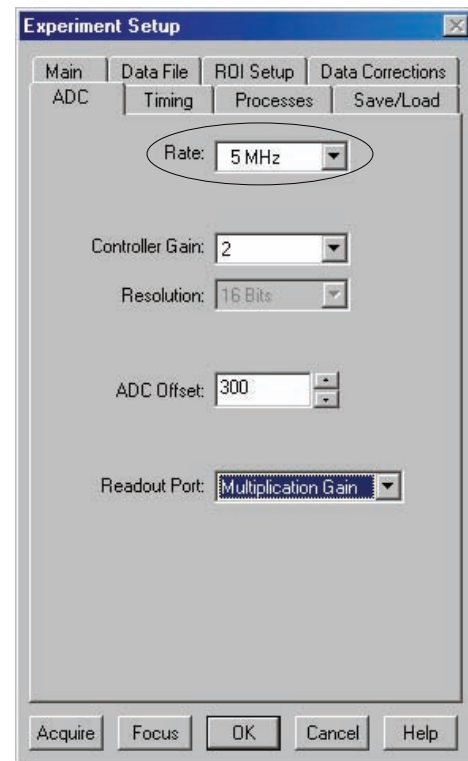


Figure 31. Selecting the Readout Rate (Experiment Setup|ADC tab page)

Binning

Binning (combining pixels into one super pixel) allows you to increase the sensitivity and frame rate. On the other hand, binning reduces spatial resolution. The PhotonMAX allows binning of 1, 2, 3, 4, 5, and 6 in the serial (horizontal) direction and arbitrary binning in the parallel (vertical) direction.

Array Orientation

For square format CCDs (for example, 512×512 or 1024×1024) you may orient the CCD to achieve binning along either direction of the CCD.

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

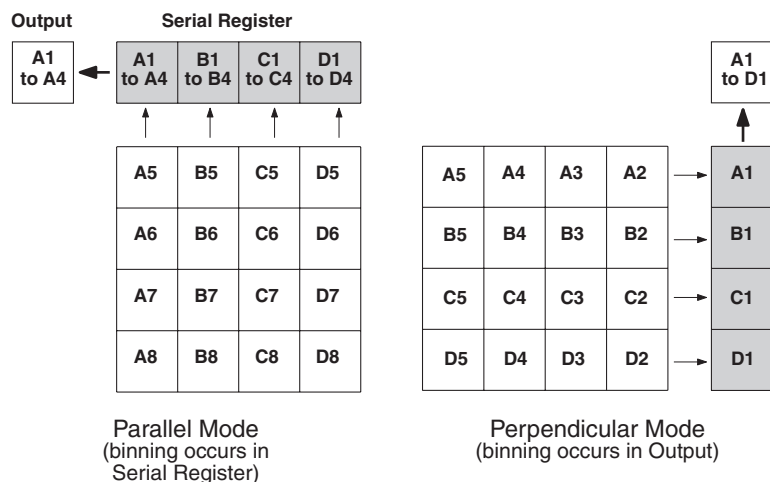


Figure 32. Binning and Array Orientation

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

Exposure - Readout Modes

The frame transfer CCDs used by the PhotonMAX support Overlap and Non-Overlap exposure - readout modes. If you are planning to use Overlap mode, be aware that the set exposure time (**Experiment Setup|Main** tab page) may not be the effective exposure time: the frame readout time is the determining factor in this mode.

Overlap Mode (Simultaneous Exposure-Readout)

Overlap mode is extremely useful in applications requiring continuous imaging (100% duty cycle). Once a frame is exposed and transferred into the frame transfer area, the next exposure immediately starts and continues until the previous frame is read out of the frame transfer area or until the exposure time is finished, whichever is longer (so the minimum effective exposure time in this mode is the readout time). This mode of operation allows you to continuously image a specimen to obtain better kinetic information about a process.

In WinView and WinSpec, this sequence is programmed by simply setting:

- the Number of Images (or Spectra) to some number greater than one (settable on the **Experiment Setup|Main** tab page),
- the Slow Mode vs. Fast Mode to "Fast Mode" (selectable on the **Experiment Setup|Timing** tab page),
- the Readout mode to "Frame Transfer" (selectable on the **Hardware Setup|Controller/Camera** tab page), and
- the Cleaning mode to "Clear Pre-Sequence" with one or more Cleans (selectable on the **Hardware Setup|Cleans** tab page).

Figure 33 shows the required selections for overlap mode.

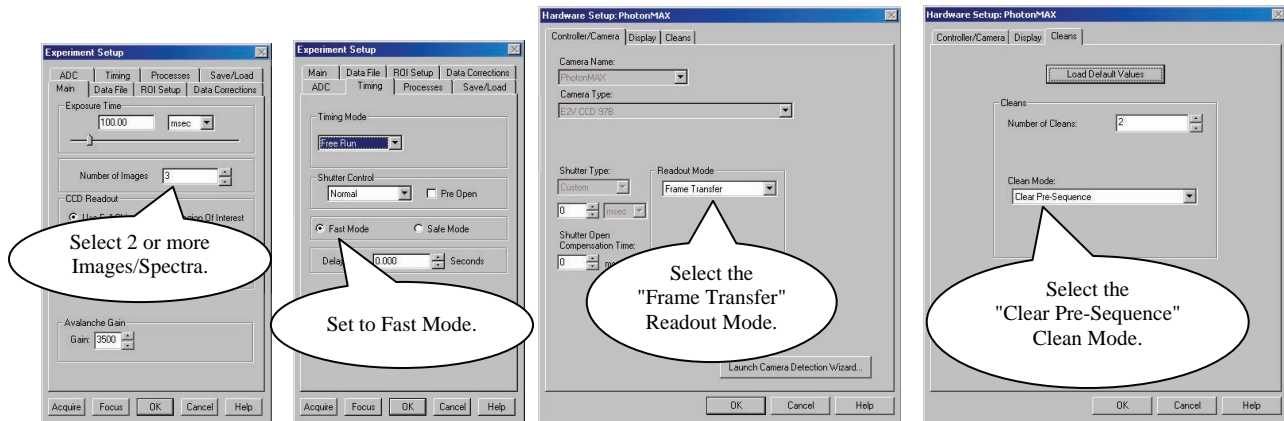


Figure 33. Required Selections for Overlap Mode Operation

Note: In Overlap mode, the minimum effective exposure time is the readout time.

The simultaneous exposure-readout mechanism is illustrated with two examples for the 512B model. This mechanism applies to the 1024B as well but with a larger readout time.

Example 1: Overlap Mode when Exposure Time < Readout Time

Consider a situation where full frame readout is 34.8 ms, the exposure time is 10 ms, and three frames are taken in overlap mode. The first frame is exposed precisely for the length of time entered into the software (10 ms) and all subsequent frames are exposed for the readout time. The total time to acquire 3 frames is then 114.4 ms ($3 \times 34.8 \text{ ms} + 10 \text{ ms}$), equivalent to a frame rate of 26.2 fps ($3 \text{ frames} \div 0.114 \text{ seconds}$).

Note: Because the first frame is exposed for 10 ms and the others for 34.8 ms, the first frame may look less bright compared to all other frames.

In Overlap mode when exposure time < readout time, the total time (T_N) taken to capture N frames is given by:

$$T_N = (t_R \times N) + t_{\text{exp}}$$

Where

T_N = Total time taken to capture a sequence of N frames

t_R = readout time for one frame

N = total number of frames in a sequence

t_{exp} = exposure time

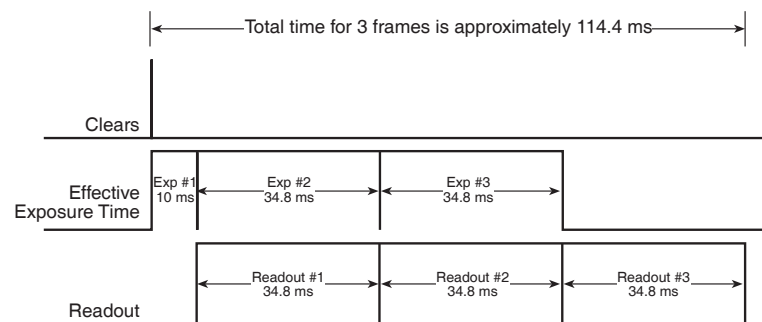


Figure 34. Timing Diagram for Overlap Mode when Exposure Time < Readout Time. Timing information shown is for illustration purpose only. Specific readout times vary depending on the model.

Example 2: Overlap Mode when Exposure Time > Readout Time

If the exposure time is set to 50 ms with the readout time remaining at 34.8 ms, the time taken to acquire 3 frames will be 184.8 ms ($3 \times 50 \text{ ms} + 34.8 \text{ ms}$), which is equivalent to a frame rate of 16.2 fps.

In Overlap mode when exposure time > readout time, the total time (T_N) taken to capture N frames is expressed as:

$$T_N = (t_{\text{exp}} \times N) + t_R$$

Where

T_N = Total time taken to capture a sequence of N frames

t_{exp} = exposure time

N = total number of frames in a sequence

t_R = readout time for one frame

From the timing diagram, you can see that because the exposure time is greater than the readout time, all frames are precisely exposed for the duration entered into the software and have similar intensities.

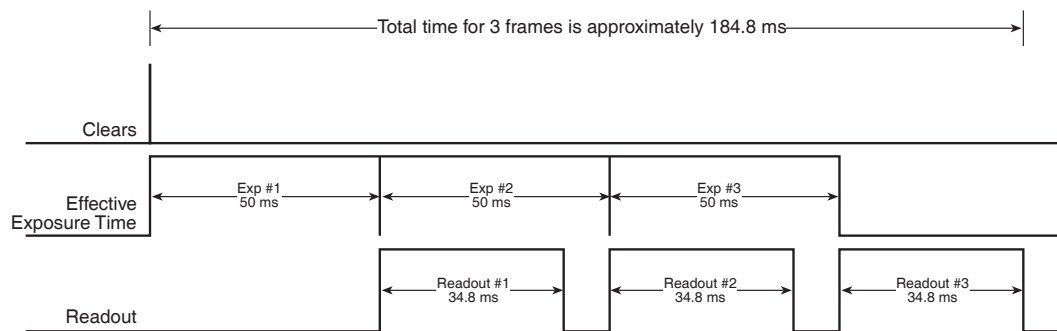


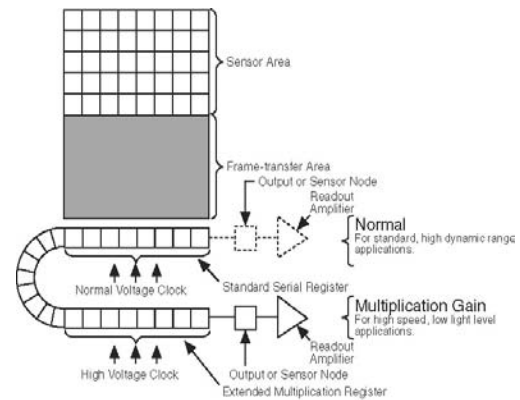
Figure 35. Timing Diagram for Overlap Mode when Exposure Time > Readout Time. Timing information shown is for illustration purpose only. Specific readout times vary depending on the model.

Non-Overlap Mode

The Non-Overlap mode allows you to expose the array for the exposure time specified in the software and is similar in performance to a normal, full-frame device.

The operational sequence for this mode is:

1. Clearing the CCD,
2. Exposing for the specified exposure time,
3. Shifting the image from the sensor area to the frame-transfer area, and
4. Reading out the CCD.



Steps 1-4 are repeated for each frame in a sequence. Steps 1 and 3, clearing the CCD and shifting the image, are usually very short and do not impact the frame rate.

In WinView and WinSpec, this sequence is programmed by simply setting:

- the Slow Mode vs. Fast Mode to "Fast Mode" (selectable on the **Experiment Setup|Timing** tab page),
- the Readout mode to "Frame Transfer" (selectable on the **Hardware Setup|Controller/Camera** tab page) and
- the Cleaning mode to "Clear Pre-Exposure" with one or more Cleans (selectable on the **Hardware Setup|Cleans** tab page).

Figure 36 shows these selections.

Note: Since the software you are using may show the settings differently, you should refer to the software documentation for accurate information.

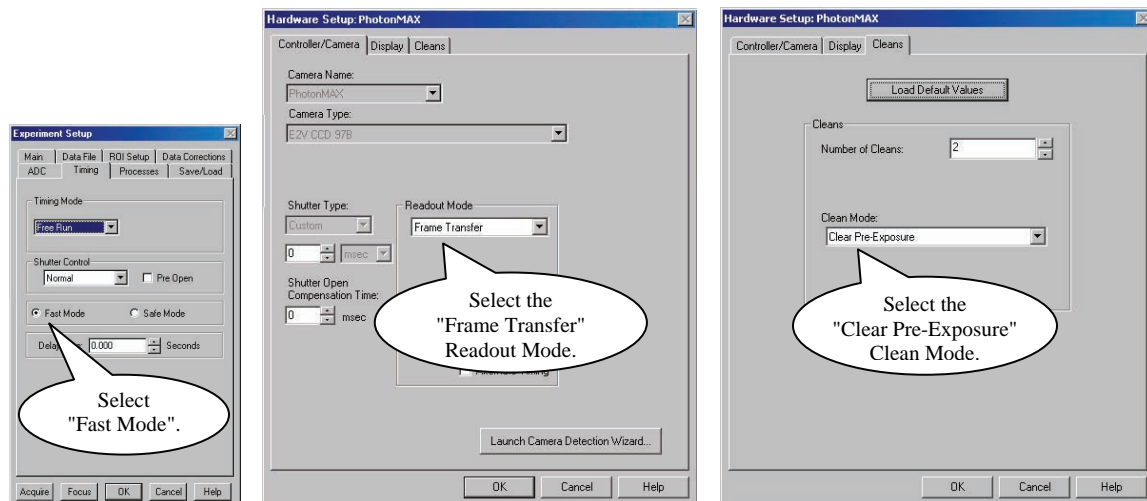


Figure 36. Required Selections for Non-Overlap Mode Operation

Example: Non-Overlap Mode

Operation in Non-Overlap mode is illustrated in the timing diagram below. In this example, the exposure time is 10 ms and the readout time is 34.8 ms. The total time to take 3 frames is 134.4 ms ($3 \times 10 \text{ ms} + 3 \times 34.8 \text{ ms}$), equivalent to a frame rate of 22.3 fps ($3 \text{ frames} \div 0.134 \text{ seconds}$).

Note: The exposure and readout times listed are for illustration purpose only. Actual values may vary. Refer to the product data sheet for the actual readout times.

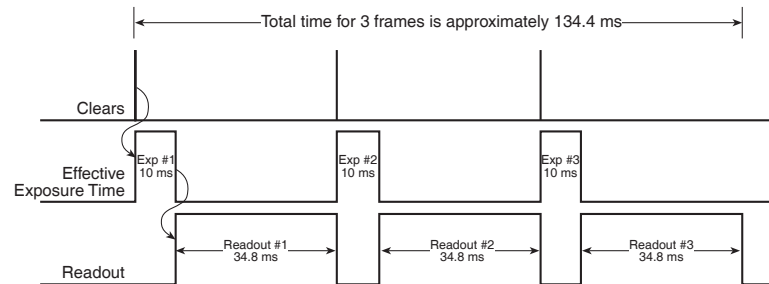


Figure 37. Timing Diagram for Non-Overlap Mode. Timing information shown is for illustration purpose only. Specific readout times vary depending on the model.

Referring to Figure 37, it can be seen that exposure and readout are carried out in non-overlapped fashion. As a result, each frame in the sequence is precisely exposed for the time specified (i.e., 10 ms).

Advanced Topics

Introduction

Previous chapters have discussed setting up the hardware and the software for basic operation. This chapter discusses topics associated with experiment synchronization (set up on the **Experiment Setup|Timing** tab page in WinView and WinSpec). With the exception of Edge Trigger, the topics are addressed in order of their appearance on the Timing tab page (see Figure 38).

"External Shutter Operation", the first topic covers some issues with regard to using an external shutter with a PhotonMAX system.

"Timing Modes", the second topic, discusses Timing Modes, and Shutter Control. Also included under this topic is a discussion of the **TRIGGER IN** connector that is the input connector for a trigger pulse: this connector is part of the I/O cable connected to the rear panel of the PhotonMAX.

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

"TTL Status Signals", discusses the input/output connectors on the I/O cable connected to the rear of the PhotonMAX. The levels at these connectors can be used to monitor camera operation or synchronize external equipment.

"Kinetics Mode", the final topic, discusses the Kinetics mode option. This form of data acquisition relies on mechanical or optical masking of the CCD array for acquiring time-resolved images.

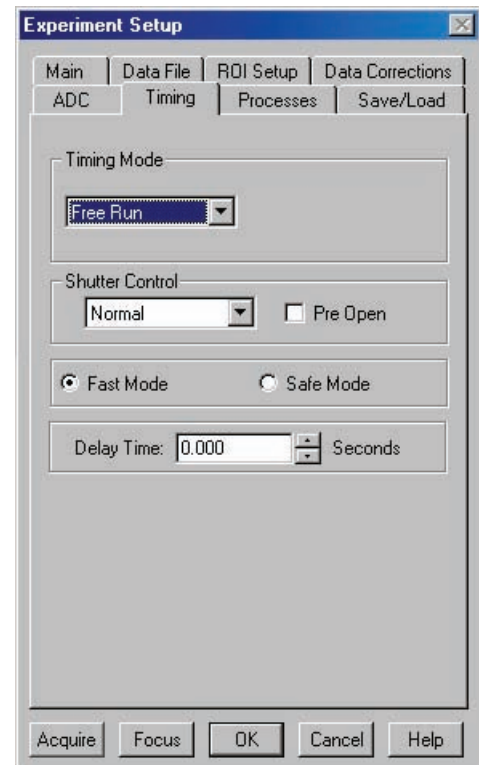


Figure 38. Timing tab page

External Shutter Operation

Because PhotonMAX cameras use frame-transfer CCDs, they do not incorporate internal shutters. However, there may be cases when you need an external shutter to control the exposure of the CCD. The **Shutter Out** connector on the **I/O** cable can be used to

provide TTL output for the timing of an external shutter driver. This signal is high during Shutter Open Compensation Time (t_o) and the Exposure Time (t_{exp}).

The Shutter Output connector does not provide power to drive the shutter directly, so an external shutter drive controller is required.

Figure 39 shows the relationships between the action of a mechanical shutter and the **Shutter Out** and **Expose Out** levels. The values of t_o and t_c are shutter-type dependent.

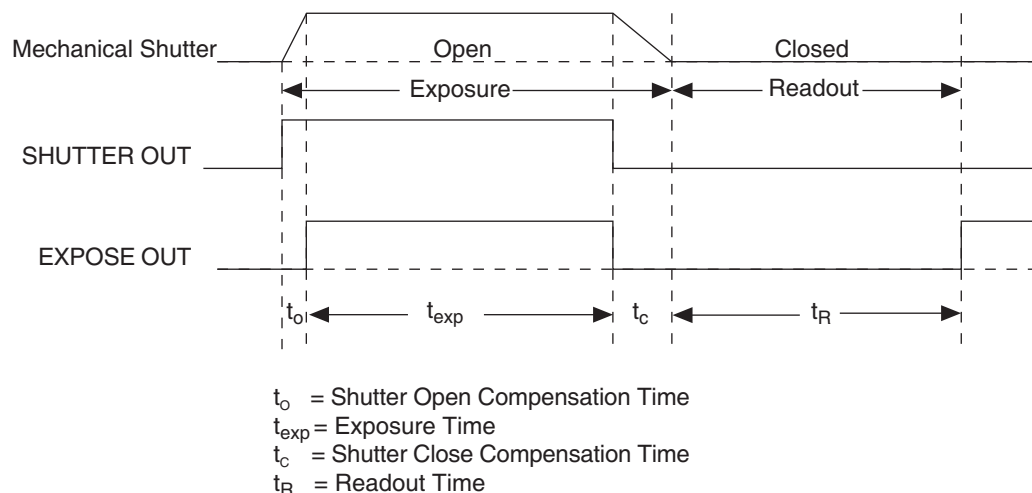


Figure 39. External Shutter Timing Diagram

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

The shutter signal options available in WinView and WinSpec include Normal, Disable Opened or Disable Closed. Disable simply means that the shutter will not operate during the experiment. Disable closed is useful for making dark charge measurements, or when no shutter is present in the camera.

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

Timing Modes

The basic PhotonMAX timing modes are Free Run, External Sync, Bulb Trigger, and Single Trigger. These modes are combined with the Shutter options (*see previous topic*) to provide the widest variety of modes for precision experiment synchronization.

PhotonMAX cameras offer several methods of integration with external trigger sources, such as delay generators or laser pre-triggers. Each camera has a 26-pin, high-density I/O connector (pinout functions are described on page 80) on the back for trigger-in/out and various TTL input and output operations. The I/O cable supplied with the PhotonMAX provides access to primary signals such as "Trigger-in," "Trigger-invert," "Expose out," "Frame readout," and "Shutter out." In the default mode, the camera triggers on the rising edge of a TTL signal. To invert the triggering polarity, the "Trigger-invert" must be grounded, which can be done with a 50-ohm terminator. PhotonMAX cameras support the timing modes described in the next sections.

Free Run

In Free Run mode, there is no external triggering and all settings are read from the setup parameters, making the duration of each exposure time constant and the interval times between exposures constant (see Figure 40).

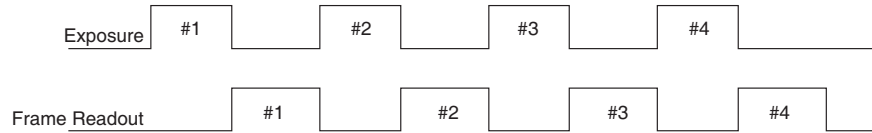


Figure 40. Free Run Timing Diagram: Non-Overlap Mode

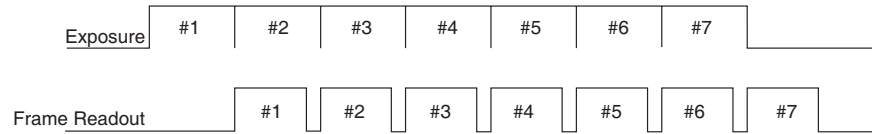



Figure 41. Free Run Timing Diagram: Overlap Mode ($t_{exp} > t_R$)

Note: When running in Overlap mode, the effective exposure time will be the frame readout time unless the set exposure time is greater than the frame readout time (as in Figure 41).

External Sync

External Sync mode only operates in Non-Overlap mode. In External Sync mode, each frame in a sequence requires a trigger. Each frame is exposed for the length of time entered into the software and is then read out. If a trigger arrives during the exposure-readout of the previous frame, it is ignored (see Figure 42). For a sequence of one frame, strobe mode and trigger-first mode are the same. The shaded areas  denote the idle time between exposures.

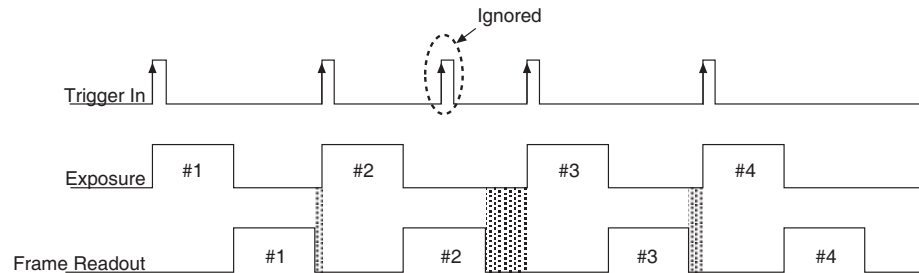



Figure 42. External Sync Timing Diagram: Non-Overlap Mode

Bulb Trigger

In Bulb Trigger mode, exposure time for each frame is determined by the trigger pulse width. Exposure time entered into the software is ignored in this mode (see Figure 43). If a trigger arrives during the readout of the previous frame, it is ignored. The shaded areas  denote the idle time between exposures.

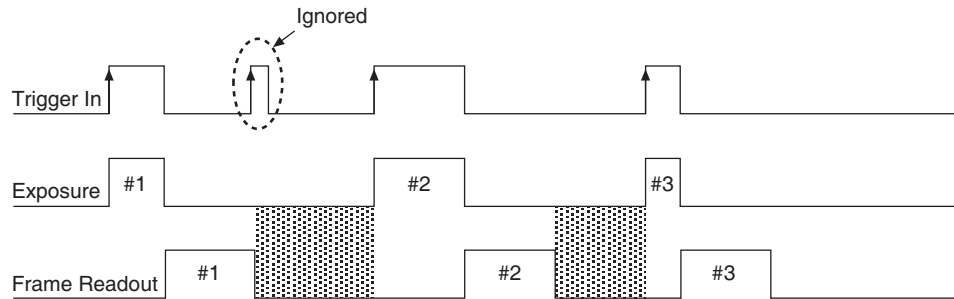


Figure 43. Bulb Mode Timing Diagram: Non-Overlap Mode

Single Trigger

In this mode, the camera requires only one trigger to acquire a sequence of frames. Once the initial trigger is received, the camera ignores any further triggers until the entire exposure/readout sequence is completed (see Figure 44 and Figure 45, which show a three-frame sequence).

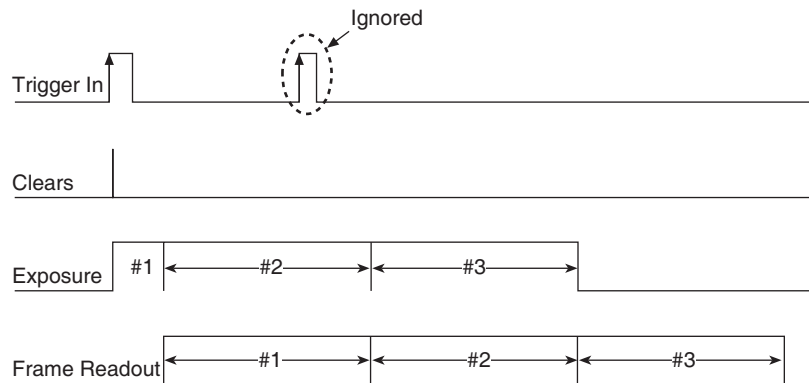


Figure 44. Single Trigger Mode Timing Diagram: Overlap Mode

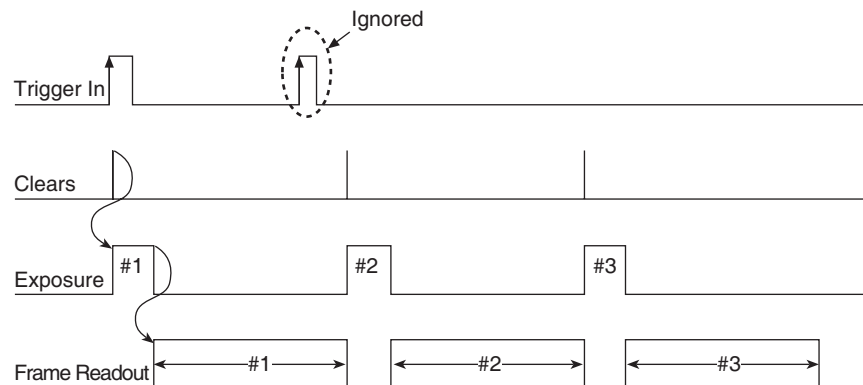


Figure 45. Single Trigger Mode Timing Diagram: Non-Overlap Mode

Fast and Safe Modes

Introduction

The PhotonMAX 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 computer for a data collection sequence. With Safe Mode, the computer sends a start and a stop command for **each frame** of a data sequence. With Fast Mode, the computer sends only one start and one stop command for **each data sequence**. Once the start command is sent, the selected timing mode and the shutter condition determine when charge will be allowed to fall on the CCD array.

In WinView/32 and WinSpec/32, the choice of **Fast** or the **Safe** data collection is made on the **Experiment Setup|Timing** tab page. The flowcharts in Figure 46 show the differences between the two modes.

Fast Mode

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

Safe Mode

In Safe Mode operation, the computer processes each frame as it is received: the PhotonMAX cannot collect the next frame until the previous frame has been completely processed. Safe Mode operation is useful when the camera is operated from a slower computer that cannot process the 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 seen in Figure 46, in Safe Mode operation, the computer controls when each frame is taken. After each frame is received, the camera sends the stop command to the camera, instructing it to stop acquisition. Once that frame is completely processed and displayed, another start command is sent from the computer to the camera, allowing it to take the next frame. Display is therefore, at most, only one frame behind the actual data collection. One disadvantage of the Safe mode is that events may be missed during the experiment, since the camera is disabled for a short time after each frame.

Note: Safe Mode must be used whenever the system is set up for the optional Kinetics Readout Mode. See "*Kinetics Mode (Option)*", page 60, for more information about this type of image acquisition and readout.

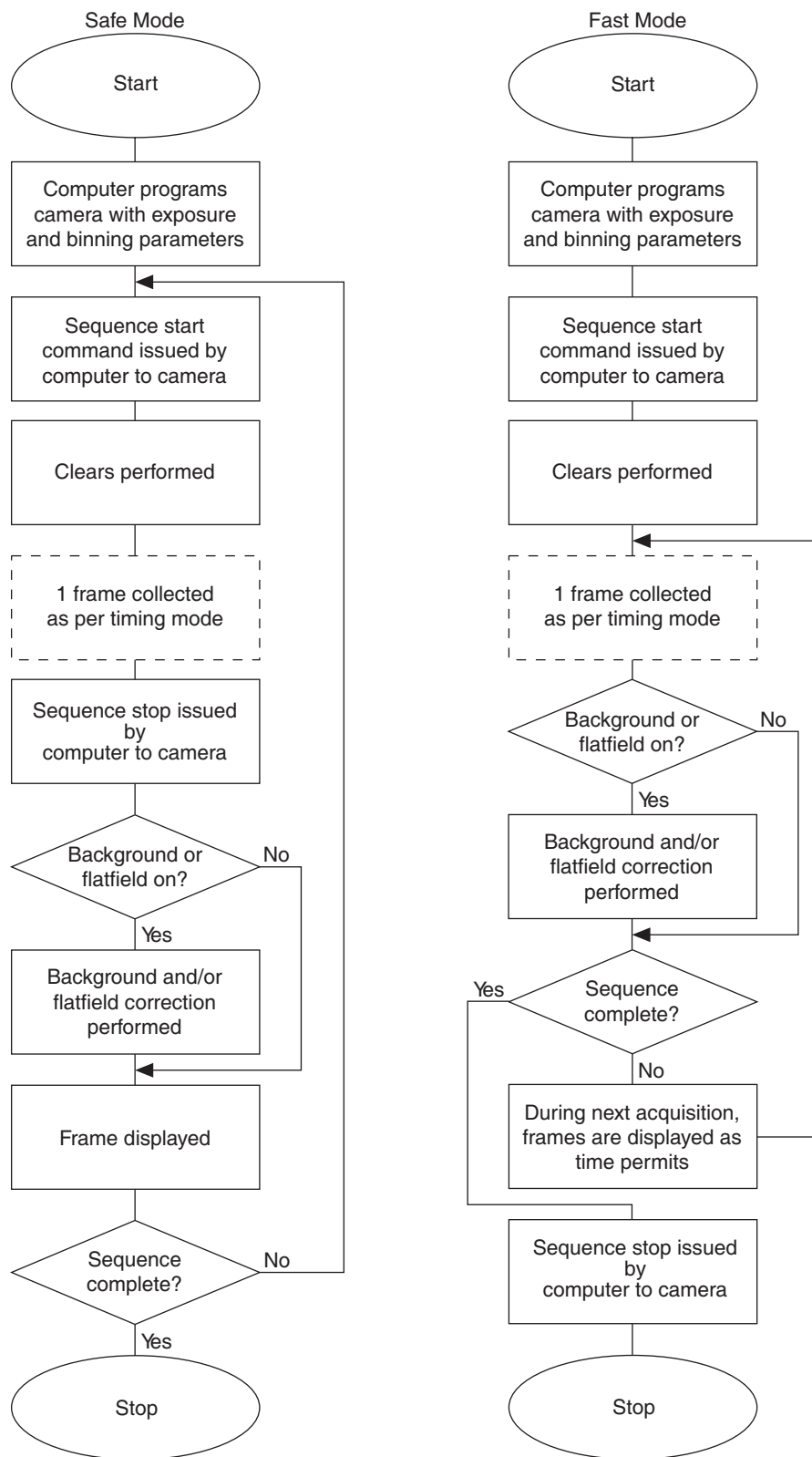


Figure 46. Flowcharts of Safe and Fast Mode Operation

TTL Status Signals

The I/O (Input/Output Status) connector on the rear of the PhotonMAX provides information about trigger function, DAC, and TTL signals. Inputs must be at least 3.15 V for a high and less than 0.9 V for a low. This section will describe the functions of the **EXPOSE OUT**, **FRAME READOUT**, and **SHUTTER OUT** signals that are provided by the camera and can be used to control external devices. For more information about the I/O connector, refer to "*I/O Connector Pinout*", starting on page 80.



Figure 47. PhotonMAX Rear Panel and I/O Cable

- **Shutter Out:** TTL output for timing of external shutter driver. Signal is high during Shutter Open Compensation Time and exposure time. The pin does not provide power to drive the shutter directly, so an external shutter drive controller is required.
- **Expose Out:** A high level on this output indicates that the camera is exposing (integrating).
- **Frame Readout:** Active high. A high level on this output indicates that data is being transferred.

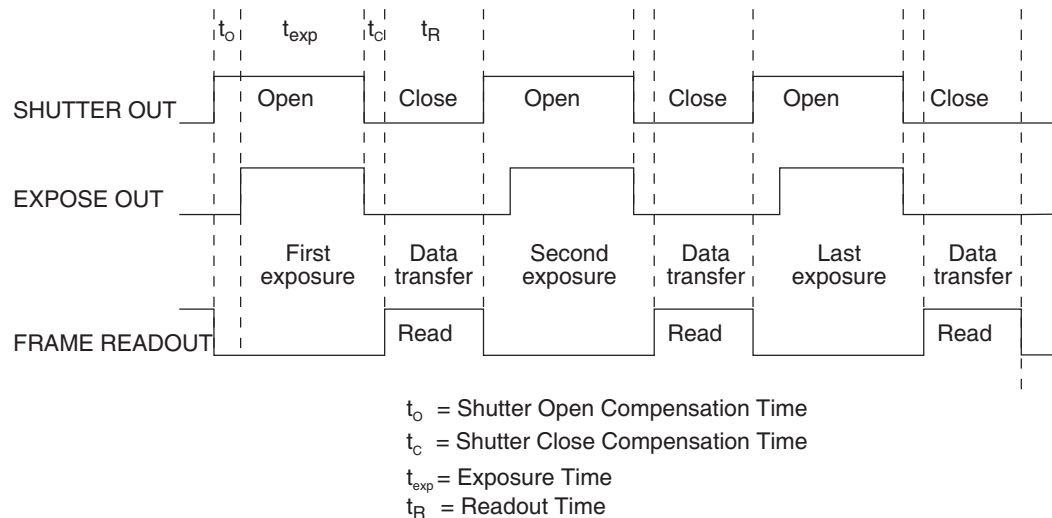


Figure 48. Comparison of SHUTTER OUT, EXPOSE OUT, and FRAME READOUT Levels

Kinetics Mode (Option)

Introduction

“Kinetics” refers to a special readout mode in which a portion of the CCD is illuminated while the rest of the active area is used to store a series of frames. At the end of the exposure-shift sequence, the entire CCD is readout to give a series of subframes (kinetic frames) separated in time. In order to support this special mode of operation, it is essential that the camera architecture be made flexible with special access to underlying CCD control functions. Aided by the back illumination technology for high QE and multiplication gain for sub-electron read noise, the kinetics mode (as implemented in WinView and WinSpec software packages ver. 2.5.19.4 or later) provides the powerful combination of speed and sensitivity.

Kinetics Readout

Kinetics readout allows a burst of subframes be captured with μsec resolution. This is accomplished by shifting each subframe exposure under the mask before reading it out. Since there is no overhead of readout time between each exposure, faster time resolution is achieved. At the end of a series “exposure-shift” cycles, the entire frame is typically read out at a slower readout speed, which does not affect the time resolution. The use of multiplication gain (EM Gain) in PhotonMAX further improves the SNR when the signal is below the read noise.

In kinetics mode, a portion of the CCD image is optically masked in order to minimize the cross-talk between subframes. Typically, in imaging applications, this is accomplished by placing a “knife edge” or an optical mask in the collimated beam path. Whereas, in spectroscopy, this is best achieved by limiting the height of the entrance slit of the spectrograph. In most of the applications, ability to mask as few rows as possible sets the ultimate limit on the temporal resolution. The operation is illustrated with examples in Figure 50 using an optical test target image.

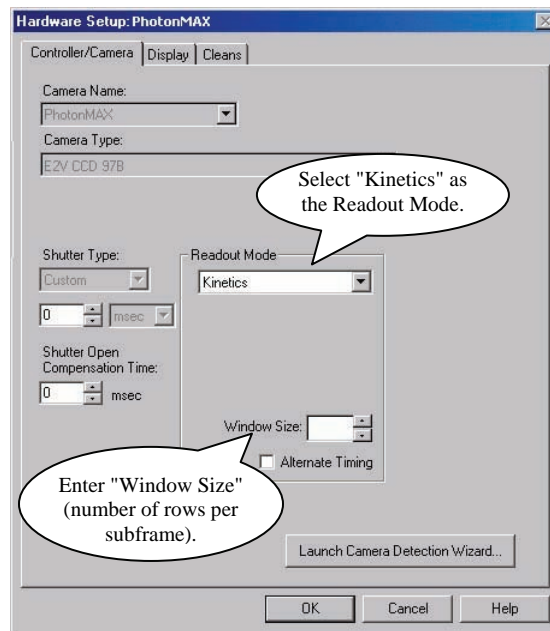


Figure 49. Hardware Setup Dialog Box:
Kinetics Readout Mode

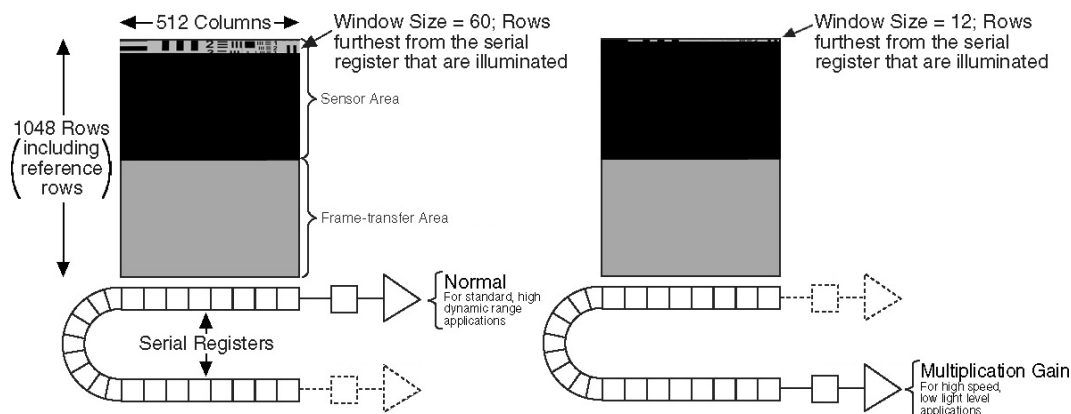
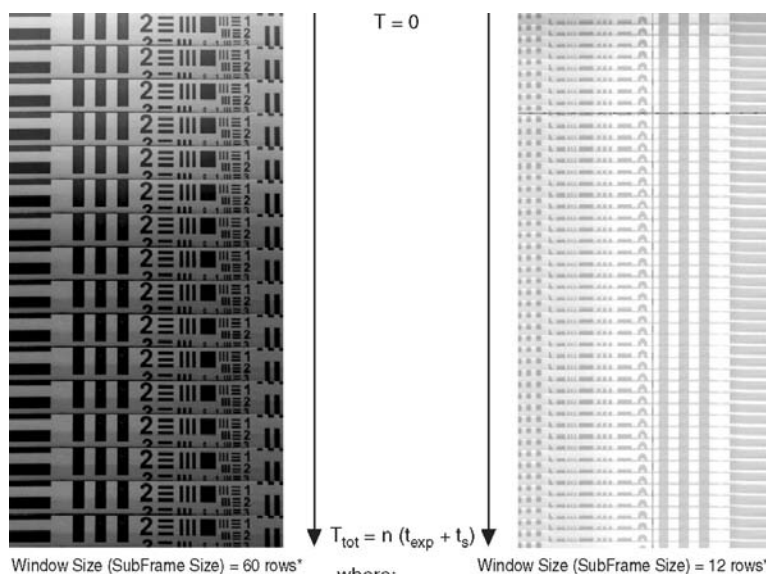


Figure 50. Two Examples illustrating Partial Illumination of CCD for Kinetics Mode in PhotonMAX: 512B

Note: The illuminated area is the furthest from the serial register.

- The left image shows an illuminated area of 60 rows. Window Size is 60 rows high.
- The right image shows an illuminated area of 12 rows. Window Size is 12 rows high.



Window Size (SubFrame Size) = 60 rows*

Window Size (SubFrame Size) = 12 rows*

where:
 T_{tot} = time to expose-shift subframes
 n = number of subframes (~ 1024 rows/window size)
 t_{exp} = Exposure time/subframe
 t_s = Vertical shift time/subframe

* Only partial series of subframes are shown here for clarity.

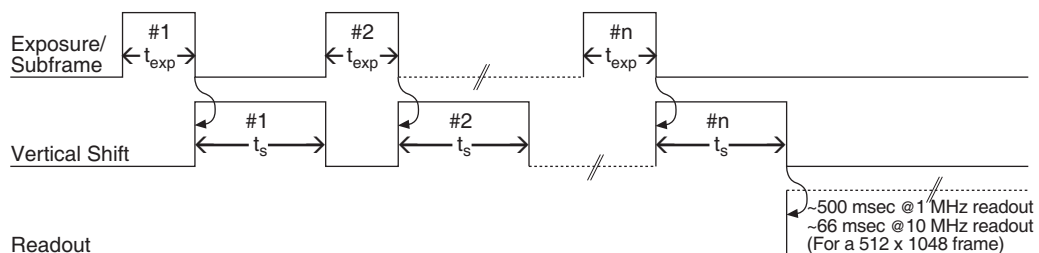


Figure 51. Kinetics Data acquired based on Masked Images shown in Figure 50. (For more information, see Notes on next page.)

Notes:

1. The timing diagram represents the exposure-readout sequence. Time resolution between subframes is given by $t_{exp} + t_s$.
2. A reduced number of rows in the right image illustrate a way to achieve better time resolution between subframes.

Triggered Operation

The PhotonMAX supports three different readout modes for kinetics mode data acquisition: free run, single trigger, and multiple trigger. Free run mode is used for experiments that do not require any synchronization with the experiments. The other two modes (single trigger and multiple trigger) require that an external TTL pulse be applied to the camera via the Trigger In connector on the I/O cable. The camera can be triggered either on +ve or -ve edge of the incoming TTL pulse.

Note: The I/O cable supplied with the PhotonMAX provides access to primary signals such as "Trigger In," "Trigger Invert," "Expose Out," "Frame Readout," and "Shutter Out." In the default mode, the camera triggers on the rising edge of a TTL signal. To change the trigger action to the falling edge, you must pull the Trigger Invert connector low by grounding it via a 50Ω terminator.

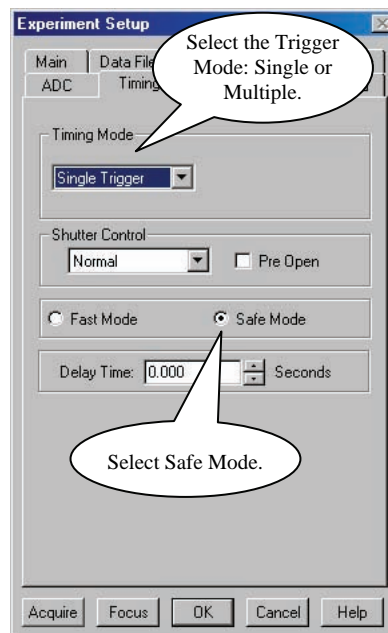


Figure 52. Experiment Setup/ Timing tab page

In single trigger mode, the camera requires only one trigger to initiate an entire series of “exposure-shift” cycles as shown in the timing diagram below. Here, the camera uses the exposure time as entered into the software.

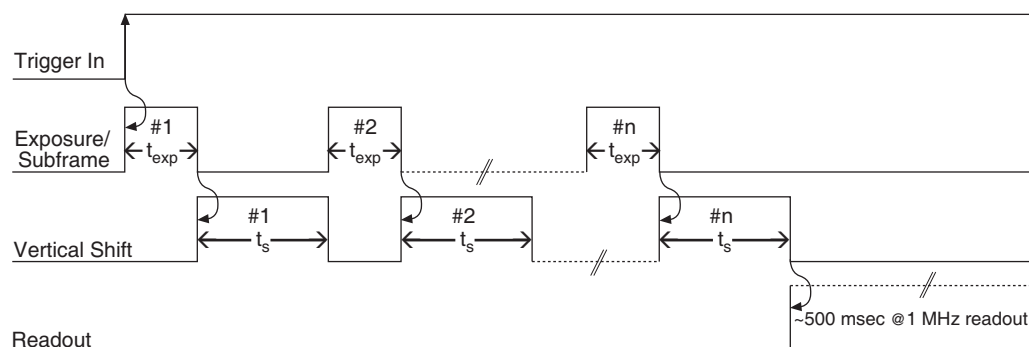


Figure 53. Example showing Kinetics Operation using "Single Trigger"

In multiple trigger mode, each “exposure-shift” cycle is triggered independently. This mode is useful when each subframe needs to be synchronized with a pulsed external light source such as a laser.

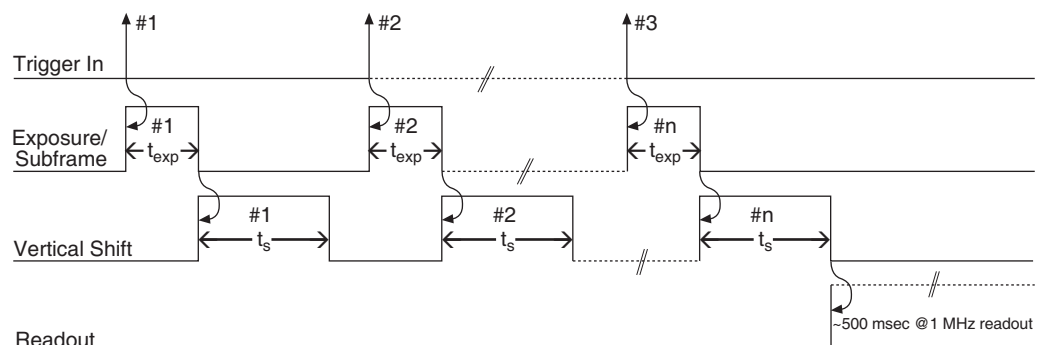


Figure 54. Example showing Kinetics Operation using “Multiple Trigger”

Note: It is particularly important to keep ambient light to a minimum while multiple trigger mode is used. In the case of this mode, automatic cleaning of the CCD only occurs until the first trigger arrives. Once the series of “exposure-shift” cycles begins, cleaning does not occur and, at the end of a cycle, ambient light will be collected through the window until the next trigger arrives. Depending on the time between triggers and the amount of ambient light, some subframes may appear brighter than others.

Cleaning the CCD

Since kinetics is most often used in asynchronous, single-shot experiments, it is important that CCD be cleared of accumulating background or dark charge while it is waiting for an external trigger. To take care of this, PhotonMAX automatically cleans the CCD “one row at a time” before the arrival of the first trigger. This keeps the charge buildup on the CCD to a minimum at the same time minimizing the timing jitter (determined by vertical shift time of a single row). If desired, the number of cleans can be set to zero for the best jitter performance. However, the camera must be in dark environment to minimize the background.

Setting up a Kinetics Experiment

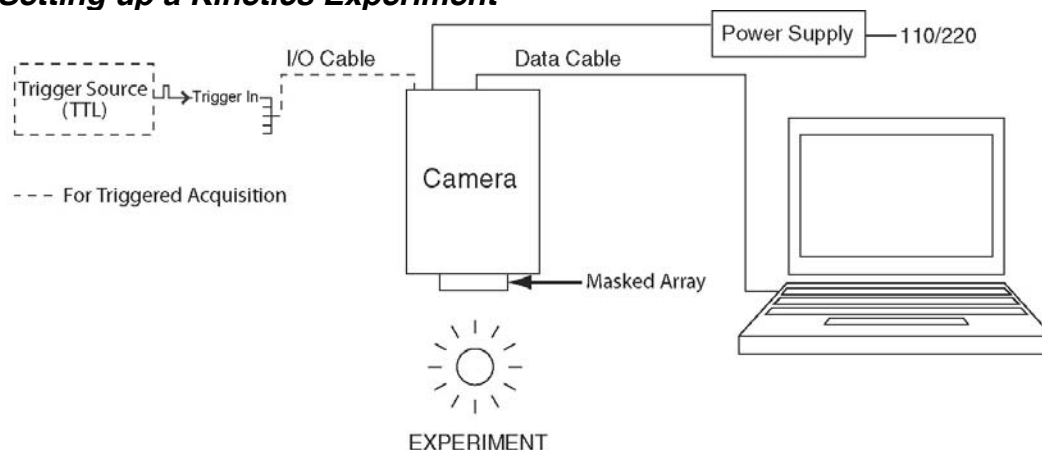


Figure 55. Typical Kinetics Experiment Layout

This procedure assumes that:

1. You have already set up your system in accordance with the instructions in the previous chapters.
2. You have read the previous sections of this chapter.
3. You are familiar with the application software.
4. The system is being operated in imaging mode.
5. The target is a sharp image, text, or a drawing that can be used to verify that the camera is "seeing" and can be used to maximize focus.
6. You are only illuminating a portion of the CCD as shown in Figure 50.

Setting the Software Parameters:

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

Set the software parameters as follows:

Controller/Camera tab page (Setup|Hardware): These parameters should be set automatically to the proper values for your system.

- **Use PVCAM:** Verify that this box is checked.

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

- **Controller type:** This information is read from the camera.
- **Camera type:** This information is read from the camera.
- **Shutter type:** Custom (System dependent).
- **Readout mode:** Available modes are read from the camera. Select **Kinetics**.
- **Window Size:** Enter the number of exposed rows.

Cleans tab page (Setup|Hardware): Automatically set.

Detector Temperature (Setup|Detector Temperature...): The default temperature setting is read from the camera. When the array temperature reaches the set temperature, the **Detector Temperature** dialog box will report that the temperature is **LOCKED**.

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

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

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

Use this function to define the region of interest (ROI).

- **Imaging Mode:** Select this mode if you are running WinSpec.
- Clicking on **Full** loads the full size of the chip into the edit boxes.

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

- **Timing Mode:** Free Run, Single Trigger, or Multiple Trigger
- **Shutter Control:** Normal
- **Safe Mode vs. Fast Mode:** Safe Mode must be selected for Kinetics mode operation.

Summary

The kinetics is a powerful feature that allows a burst of subframes to be captured with microsecond time resolution. However, careful attention must be paid to the optical and timing considerations, namely

- The rows furthest from the serial register need to be illuminated.
- The rest of the active area must be optically masked.
- Kinetics mode is supported under WinView and WinSpec versions 2.5.19.4 or later.
- Single trigger mode allows capture the burst of frame with just one trigger.
- In multiple trigger mode, the camera requires a trigger for each "exposure-shift" cycle.
- The highest time resolution between kinetic frames is determined by the window (subframe) size.
- Acquisition must be in Safe Mode.
- Binning and ROI selections are supported as in the standard operation.

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Chapter 7

Troubleshooting

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

Introduction

The following issues have corresponding troubleshooting sections in this chapter.

| | |
|--|---------|
| Baseline Signal Suddenly Changes | Page 68 |
| Camera Stops Working | Page 68 |
| Camera1 (or similar name) in Camera Name field | Page 68 |
| Controller Is Not Responding | Page 69 |
| Cooling Troubleshooting | Page 70 |
| Data Overrun Due to Hardware Conflict message | Page 71 |
| Demo is only Choice on Hardware Wizard:Interface dialog (Versions 2.5.19.0 and earlier) | Page 72 |
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| Detector Temperature, Acquire, and Focus are Grayed Out (Versions 2.5.19.0 and earlier) | Page 74 |
| Editing the PVCAM.INI File | Page 75 |
| Error Creating Controller message | Page 76 |
| Program Error message | Page 76 |
| Serial violations have occurred. Check interface cable. | Page 77 |
| Smeared Images | Page 77 |

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 Princeton Instruments Customer Support. See page 94 for contact information.

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 Princeton Instruments Customer Support.

Camera1 (or similar name) in Camera Name field



Figure 56. Camera1 in Camera Name Field

When a PVCAM-based camera is detected/selected during the Camera Detection wizard (formerly the Hardware Setup wizard), a default name such as Camera1 will be shown in the Detected Hardware table and will be entered in the **Camera Name** field on the **Setup|Hardware|Controller/CCD** tab page and in the Hardware Setup title bar. Because this name is not particularly descriptive, you may want to change it. Such a change is made by editing the PVCAM.INI file that is generated by Camera Detection wizard (or by the RSConfig.exe if you have a software version 2.5.19.0 or earlier).

To change the default Camera Name:

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

```
[Camera_1]
Type=0
Name=Camera1
Driver=pmwdm2k.sys
Port=0
```

2. Change the "Name=" entry to something more meaningful for you (for example, PhotonMAX-spec- to indicate that this is a PVCAM-based system using a PhotonMAX camera for spectroscopy). Then save the edited file.

```
[Camera_1]
Type=0
Name=PhotonMAX-spec
Driver=pmwdm2k.sys
Port=0
```

3. The new camera name will now appear in the **Camera Name** field and in the title bar for the Hardware Setup dialog box.

Controller Is Not Responding

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

- Verify that the **Use PVCAM** checkbox is checked Use PVCAM. This checkbox is located on the **Controller/Camera** tab page, accessed by selecting **Hardware...** from the **Setup** menu. Data transfer is disabled when this box is left unchecked Use PVCAM.
- If the camera is ON, the problem may be with the PCI card, its driver, or the cable connections.
- If the interface card is not installed, close the application program (WinView/32 or WinSpec/32) and turn the camera OFF. Follow the interface card installation instructions in provided with your interface card, and cable the card to the DATA port on the rear of the camera. Then do a "Custom" installation of WinView/32 or WinSpec/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 DATA 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 the application program was installed, close the application program and do a "Custom" installation of WinView/32 or WinSpec/32 with the appropriate interface component selected. Be sure to deselect the interface component that does not apply to your system.

Cooling Troubleshooting

Temperature Lock Cannot be Achieved or Maintained.

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

- Ambient temperature greater than +20°C. This condition affects TE-cooled cameras. If ambient is greater than +20°C, you will need to cool the camera environment or raise the set temperature.
- Airflow through the camera and/or circulator is obstructed. The camera needs to have approximately two (2) inches (50 mm) clearance around the vented covers. If there is an enclosure involved, the enclosure needs to have unrestricted flow to an open environment. The camera vents its heat out the vents near the nose. The air intake is near the rear of the camera.
- A hose is kinked. Unkink the hose.
- Coolant level is low. Add coolant.
 1. With hoses connected, place the camera and CoolCUBE circulator at the same level.
 2. Turn on the circulator.
 3. Using the supplied hex tool, open the fill port.
 4. Add a 50:50 mix of ethylene glycol and water (only a few cc's are needed).
 5. Using the supplied hex tool, close the fill port. **DO NOT OVERTIGHTEN.**
- There may be air in the hoses. Add coolant.

WARNING!

If more than two (2) inches of the coolant line is filled with air, the pump will stop working and may be damaged. If the flow stops while the pump is on, turn off the circulator and add fluid.

1. With hoses connected, place the camera and CoolCUBE circulator at the same level.
 2. Turn on the circulator.
 3. Using the supplied hex tool, open the fill port.
 4. Add a 50:50 mix of ethylene glycol and water (only a few cc's are needed).
 5. Using the supplied hex tool, close the fill port. **DO NOT OVERTIGHTEN.**
- Circulator pump is not working. If you do not hear the pump running when the circulator is powered on, turn off the circulator and contact Customer Support.
 - The circulator is higher than the camera. Reposition the circulator so that it is 6 inches (150 mm) or more below the camera. The vertical distance should not exceed 10 feet (3 m). Typically, the camera is at table height and the circulator is on the floor.
 - The vacuum has deteriorated and needs to be refreshed. Contact Customer Support.
 - The target array temperature is not appropriate for your particular camera and CCD array.

- The camera's internal temperature may be too high, such as might occur if the operating environment is particularly warm or if you are attempting to operate at a temperature colder than the specified limit. TE cameras are equipped with a thermal-protection switch that shuts the cooler circuits down if the internal temperature exceeds a preset limit. Typically, camera operation is restored automatically in about ten minutes. Although the thermo-protection switch will protect the camera, you are nevertheless advised to power down and correct the operating conditions that caused the thermal-overload to occur.

Gradual Deterioration of Cooling Capability

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

Data Overrun Due to Hardware Conflict message

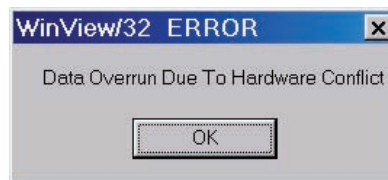


Figure 57. Data Overrun Due to Hardware Conflict dialog box

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

To change the DMA buffer setting:

1. Note the array size (on the **Setup|Hardware|Controller/CCD** tab page or the **Acquisition|Experiment Setup|Main** tab page Full Chip dimensions).
2. Open **Setup|Environment|Environment** dialog box.
3. Increase the DMA buffer size to a minimum of 32 Mb (64 Mb if it is currently 32 Mb or 128 Mb if it is currently 64 Mb), click on **OK**, and close the WinX application (WinView or WinSpec).
4. Reboot your computer.
5. Restart the WinX application and begin acquiring data or focusing. If you see the message again, increase the DMA buffer size.

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

If RSConfig.exe has not been run, the Hardware Wizard will only present the choice "Demo" in the Interface dialog box (Figure 58). Clicking on **Next** presents an "Error Creating Controller. Error=129." message, clicking on **OK** presents "The Wizard Can Not Continue Without a Valid Selection!" message, clicking on **OK** presents the Interface dialog box again.

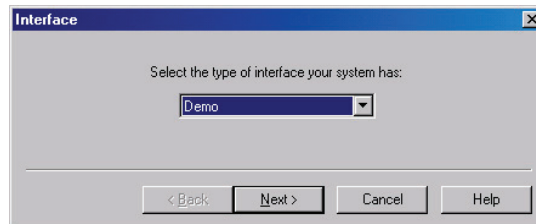


Figure 58. Hardware Wizard: Interface dialog box

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

1. If you have not already done so, close WinView/32 or WinSpec/32.
2. Make sure the PhotonMAX is connected to the host computer and that it is powered on.
3. Run RSConfig from the **Windows|Start|Programs|Roper Scientific** menu or from the directory where you installed WinView.
4. When the RSConfig dialog box (Figure 59) appears, you can change the camera name to one that is more specific or you can keep the default name "Camera1". When you have finished, click on the **Done** button.

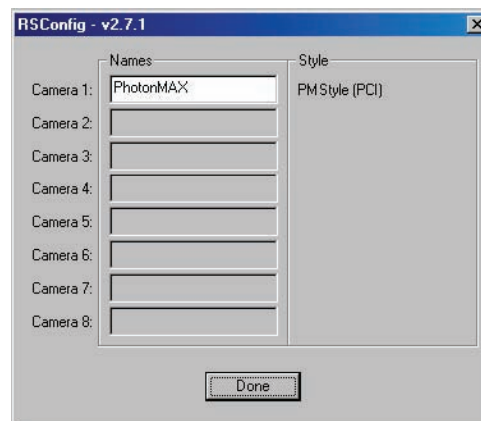


Figure 59. RSConfig dialog box

5. You should now be able to open WinView and, from **Setup|Hardware...**, run the Hardware Wizard.
6. When the PVCAM dialog box (Figure 60) is displayed, click in the **Yes** radio button, click on **Next** and continue through the Wizard. After the Wizard is finished, the **Controller/Camera** tab page will be displayed with the **Use**

PVCAM checkbox selected. You should now be able to set up experiments and acquire data.

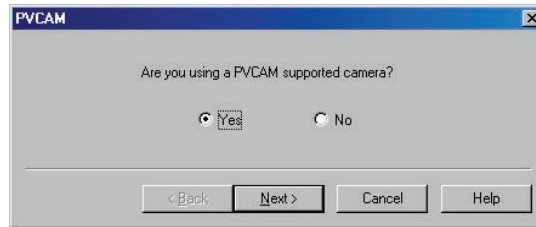


Figure 60. Hardware Wizard: PVCAM dialog box

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

If there is an installed Princeton Instruments (RSPI) high speed card in the host computer and you want to operate a PhotonMAX camera, the PVCAM.INI file (created by RSConfig.exe) must exist and the PhotonMAX camera (PM Style) must be [Camera_1]. PVCAM.INI, which contains information required to identify the interface/camera, is referenced by the Hardware Wizard when you are setting up WinView/32 with the PhotonMAX for the first time. If the Wizard did not find a PVCAM.INI file or if RSConfig.exe was run but the PhotonMAX (PM Style) is [Camera_2] in the PVCAM.INI file, "Demo", "High Speed PCI", and "PCI(Timer)" will be selectable from the Wizard's Interface dialog box.

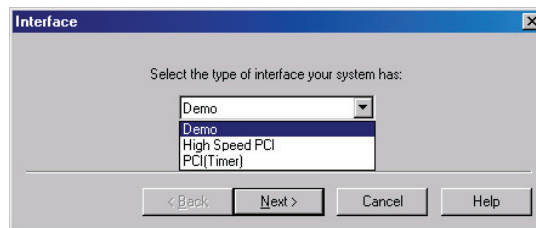


Figure 61. Hardware Wizard: Interface dialog box

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

1. If you have not already done so, close WinView/32 or WinSpec/32.
2. Make sure the PhotonMAX is connected to the host computer and that it is powered on.
3. Run RSConfig from the **Windows|Start|Programs|Roper Scientific** menu or from the directory where you installed WinView.
4. When the RSConfig dialog box (Figure 62) appears, you can change the camera name to one that is more specific or you can keep the default name "Camera2". When you have finished, click on the **Done** button.

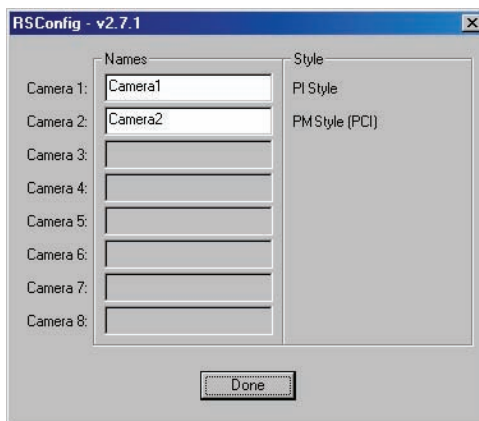


Figure 62. RSConfig dialog box: Two Camera Styles

5. Because the PhotonMAX camera is second in the list (PM Style), you will now have to edit the PVCAM.INI file created by RSConfig.exe. Refer to *"Editing the PVCAM.INI File"*, page 75, for instructions.

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

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

1. Check to see if the PhotonMAX is connected to the host computer and is powered on. If it is not connected or is connected but not powered on, go to Step 2. If it is connected and on, go to Step 3.
2. Close WinView, verify that the PhotonMAX is connected to the host computer, power the PhotonMAX on, and reopen WinView. The formerly grayed out functions should now be available.
3. If the PhotonMAX camera (PM Style) is connected and powered on, it may not be listed as Camera 1 in the PVCAM.INI file.
4. Run RSConfig.exe (accessible from the **Windows|Start|Programs|Roper Scientific** menu). If the PhotonMAX camera is listed as Camera 2 (PM Style) in Figure 63, you will have to edit the PVCAM.INI file. Refer to *"Editing the PVCAM.INI File"*, page 75, for instructions.

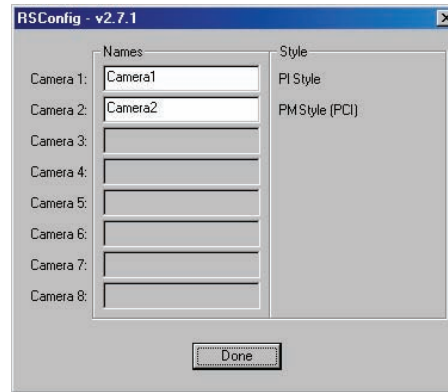


Figure 63. RSConfig dialog box: Two Camera Styles

Editing the PVCAM.INI File

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

| If the contents of the file look like: | Change the headings so the contents now look like: |
|---|---|
| <pre>[Camera_1] Type=1 Name=Camera1 Driver=rspipci.sys Port=0</pre> | <pre>[Camera_2] Type=1 Name=Camera1 Driver=rspipci.sys Port=0</pre> |
| <pre>[Camera_2] Type=0 Name=Camera2 Driver=pmwdm2k.sys Port=0</pre> | <pre>[Camera_1] Type=0 Name=Camera2 Driver=pmwdm2k.sys Port=0</pre> |

Note: The [Camera_#] must be changed so the PhotonMAX will be recognized (its driver is "pmwdm2k.sys"). For consistency, you may also want to change the camera names.

- Save the file. With the PhotonMAX powered and on, open WinView/32.
- Run the Hardware Wizard.
- When the PVCAM dialog box (Figure 64) is displayed, click in the **Yes** radio button, click on **Next** and continue through the Wizard. After the Wizard is finished, the **Controller/Camera** tab page will be displayed with the **Use PVCAM** checkbox selected. You should now be able to acquire data.

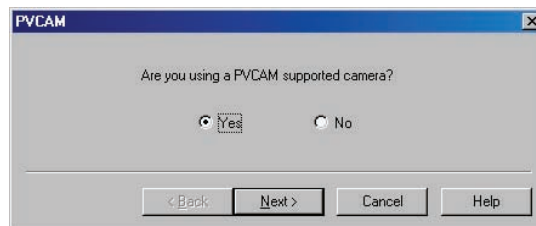


Figure 64. Hardware Wizard: PVCAM dialog box

Error Creating Controller message

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

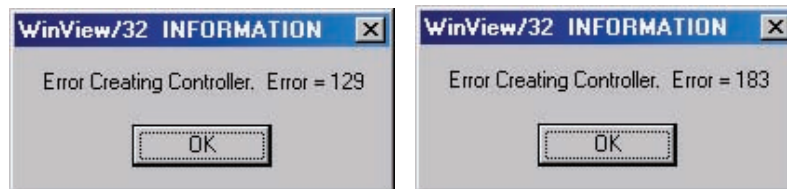


Figure 65. Error Creating Controller dialog box

Error 129: Indicates that the problem is with the PVCAM.INI file. Close WinView/32 or WinSpec/32, run RSConfig, verify that the PhotonMAX is the first camera, make sure the PhotonMAX is powered on, reopen WinView, and begin running the Hardware Wizard.

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

Program Error message



Figure 66. Program Error dialog box

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

To correct the problem:

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

6. Reboot your computer.
7. Restart WinView and begin acquiring data or focusing. If you see the message again, increase the DMA buffer size.

Serial violations have occurred. Check interface cable.



Figure 67. Serial Violations Have Occurred dialog box

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

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

To correct the problem:

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

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

Smearred Images

PhotonMAX uses a frame-transfer CCD which allows simultaneous exposure-readout operations (see pages 48-52 for more information). However, when the exposure time is small compared to the frame-transfer time, smearing may appear in the images. To alleviate this problem:

1. Use a longer exposure time, or
2. Use the SHUTTER signal from the camera to control a fast external shutter (such as an LCD shutter) to block light during the frame-transfer readout cycle.

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Appendix A

Basic Specifications

Note: This appendix provides some of the basic specifications of a PhotonMAX™ system. If the information you are looking for is not here, it may be available in *Appendix B, "Outline Drawings"* or on the appropriate data sheet. Data sheets can be downloaded from the Princeton Instruments website (www.princetoninstruments.com).

Window

SI-UV fused-silica quartz

CCD Arrays

| | <u>PhotonMAX:512B</u> | <u>PhotonMAX:1024B</u> |
|-------------------------------------|-----------------------|------------------------|
| <i>CCD:</i> | e2v CCD97B | e2v CCD201B |
| <i>Image Type:</i> | Monochrome | Monochrome |
| <i>Resolution:</i> | 512 x 512 | 1024 x 1024 |
| <i>Pixel Size:</i> | 16 μm x 16 μm | 13 μm x 13 μm |
| <i>Readout Amplifiers (Ports):</i> | 2 | 2 |
| <i>Digitization (Readout) Rate:</i> | 10 MHz, 5 MHz, 1 MHz | 10 MHz, 5 MHz, 1 MHz |

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

Mounts

C-mount: Standard threaded video mount. Optional C- to Spectroscopy-mount adapter.

Focal Distance (Optical)

C-mount, Front Surface to Focal Plane: 0.690" (17.53 mm)

Camera

Cooling: Thermoelectric; air or circulating coolant

CCD Operating Temperature:

| CCD Size | Default |
|-----------|---------|
| 512x512 | -70°C |
| 1024x1024 | -55°C |

Table 3. Default Operating Temperature

Temperature Stability: $\pm 0.05^{\circ}\text{C}$; closed-loop stabilized-temperature control

Gain: Software-selectable [1 (low), 2 (medium), 3 (high)]

Dimensions: See *Appendix B, "Outline Drawings"*, pages 83 and 84.

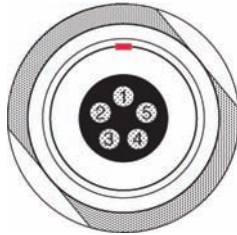
Connectors:

Data: 20-pin, high-density connector (MDR-20) for data transfer.

I/O: 26-pin, high-density connector (DB26) for TTL status signals).

Connector Pinouts:

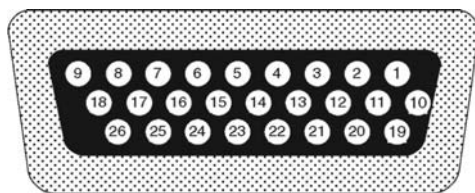
POWER Connector Pinout



1. +12V
2. +12V
3. GND
4. GND
5. GND



I/O Connector Pinout



The I/O (Input/Output Status) connector provides information about trigger function, DAC, and TTL signals. Inputs must be at least 3.15 V for a high and less than 0.9 V for a low.

The numbers on the I/O connector diagram correspond to the numbers given to the definition of each of the pins. The I/O connector is a female, DB26, high-density connector. The I/O cable (6050-0546) to access Trigger Input (Pin 1), Trigger Invert Input (Pin 2), Frame Readout (Pin 7), Camera Exposing Output (Pin 8), and Shutter Output (Pin 23) is provided with the PhotonMAX camera.

| PORT # | PIN # | SIGNAL Description |
|---------------|--------------|---|
| | 1 | Trigger Input: This input is internally tied high through a 4.7k Ω resistor. With Trigger Invert Input open or tied high, a rising edge of the Trigger Input signal initiates the trigger. The trigger source would normally hold this input low, then drive it high to initiate the trigger. To change the state of this input see Trigger Invert Input. |
| | 2 | Trigger Invert Input: This input is internally tied high through a 4.7k Ω resistor. With this input open or tied high, a rising edge on Trigger Input will initiate the trigger. With this input pulled low, a falling edge on Trigger Input will initiate the trigger. It can be pulled low by grounding it via a 50 Ω terminator. |
| | 3 | GND: System digital ground. Any external circuitry intended to interface with the trigger control signals must reference this ground connection. |
| Port 4 | 4 | DAC 1: 8-bit programmable output (0-5 V) |
| Port 5 | 5 | DAC 2: 8-bit programmable output (0-5 V) |
| | 6 | GND: System digital ground. Any external circuitry intended to interface with the trigger control signals must reference this ground connection. |
| | 7 | Frame Readout: Active high. A high level on this output indicates that data is being transferred. |
| | 8 | Camera Exposing Output: Active high. A high level on this output indicates that the camera is exposing (integrating). |
| | 9 | (not used) |
| Port 0 | 10 | TTL I/O data bit 0: TTL level programmable input or output |
| | 11 | TTL I/O data bit 1: TTL level programmable input or output |
| Port 1 | 12 | TTL I/O data bit 0: TTL level programmable input or output |
| | 13 | TTL I/O data bit 1: TTL level programmable input or output |
| Port 2 | 14 | TTL I/O data bit 0: TTL level programmable input or output |
| | 15 | TTL I/O data bit 1: TTL level programmable input or output |
| Port 3 | 16 | TTL I/O data bit 0: TTL level programmable input or output |
| | 17 | TTL I/O data bit 1: TTL level programmable input or output |
| | 18 | GND: System digital ground. Any external circuitry intended to interface with the trigger control signals must reference this ground connection. |
| | 19 | Power Status: A high level on this output indicates that the camera power is switched on (+5 V = on, 0 V = off). |
| | 20 | GND: System digital ground. Any external circuitry intended to interface with the trigger control signals must reference this ground connection. |

| <i>PORT #</i> | <i>PIN #</i> | <i>SIGNAL Description</i> |
|---------------|--------------|---|
| | 21 | (not used) |
| | 22 | (not used) |
| | 23 | Shutter Output: TTL output for timing of external shutter driver. Signal is high during Shutter Open Compensation Time and exposure time. The pin does not provide power to drive the shutter directly, so an external shutter drive controller is required. |
| | 24 | (not used) |
| | 25 | GND: System digital ground. Any external circuitry intended to interface with the trigger control signals must reference this ground connection. |
| | 26 | GND: System digital ground. Any external circuitry intended to interface with the trigger control signals must reference this ground connection. |

Power Input: 100-240 VAC; 47 to 63 Hz, 3 A. DC power to camera is provided by the self-switching power supply.

Fan: 24 CFM fan capacity at full power.

CoolCUBE Circulator

Closed loop system

Hoses: 3/8" ID, with no-drip quick disconnects at the circulator ends and CPC quick disconnects at the camera ends

Coolant: 50:50 ethylene glycol and water at 25°C

Dimensions: Refer to *Appendix B, "Outline Drawings"*, page 85

Circulator Weight (Filled): 6.0 lbs (2.7 kg)

Hose Weight (Filled): 3.0 lbs (1.4 kg) per hose

Options

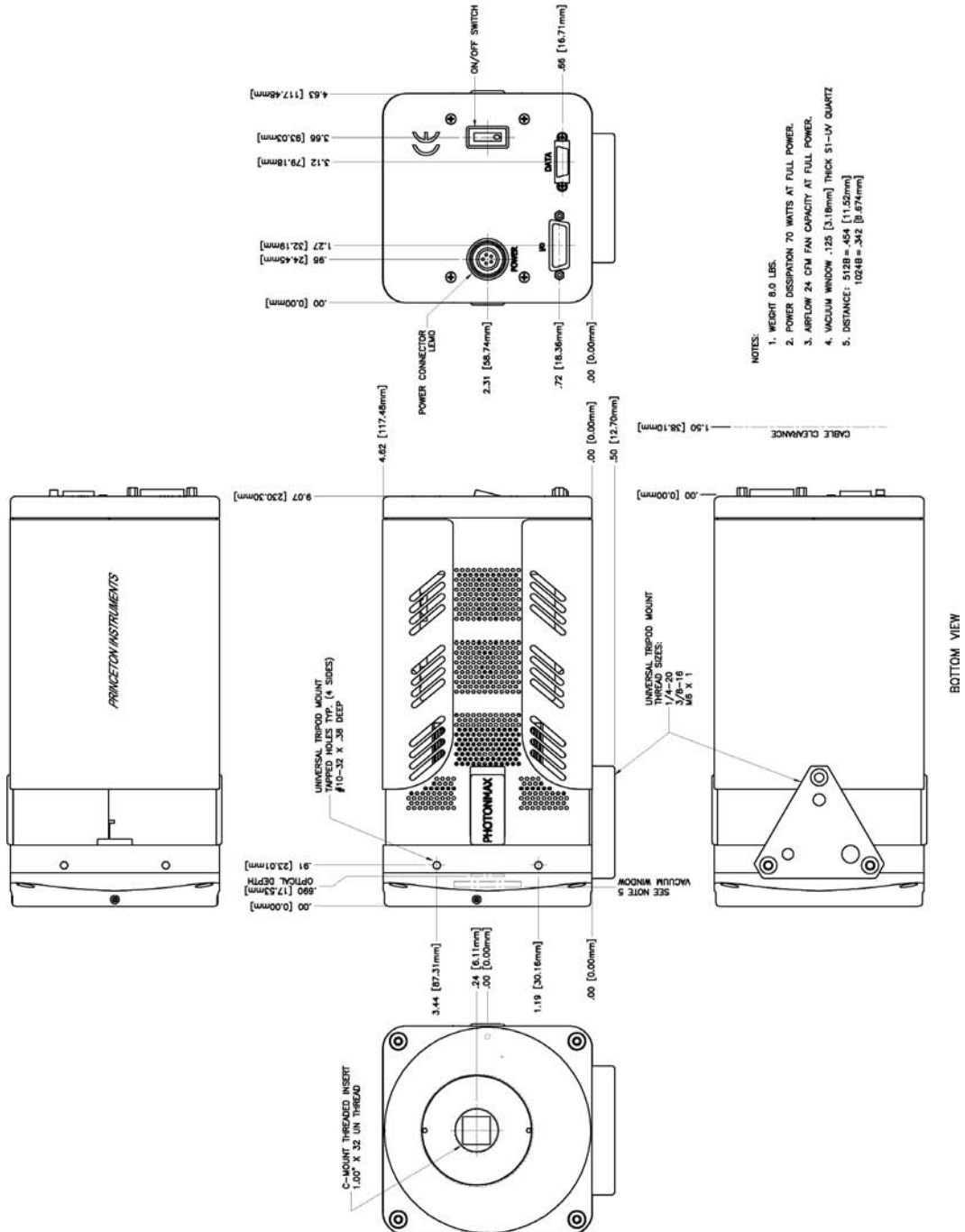
A partial listing of options includes the WinView/WinSpec application software and manual, Scientific Imaging ToolKit™ (SITK™) for LabVIEW®, fiber optic interface, and fiber optic cables. Contact the factory for more information regarding options available for your system.

Appendix B

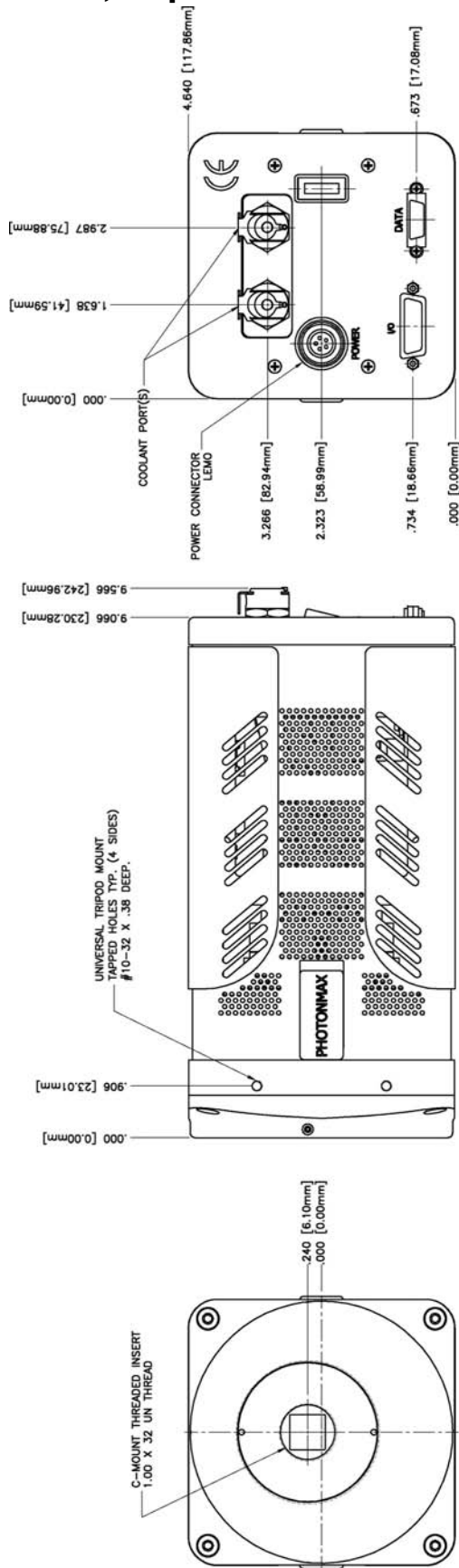
Outline Drawings

Note: Dimensions are in inches [mm].

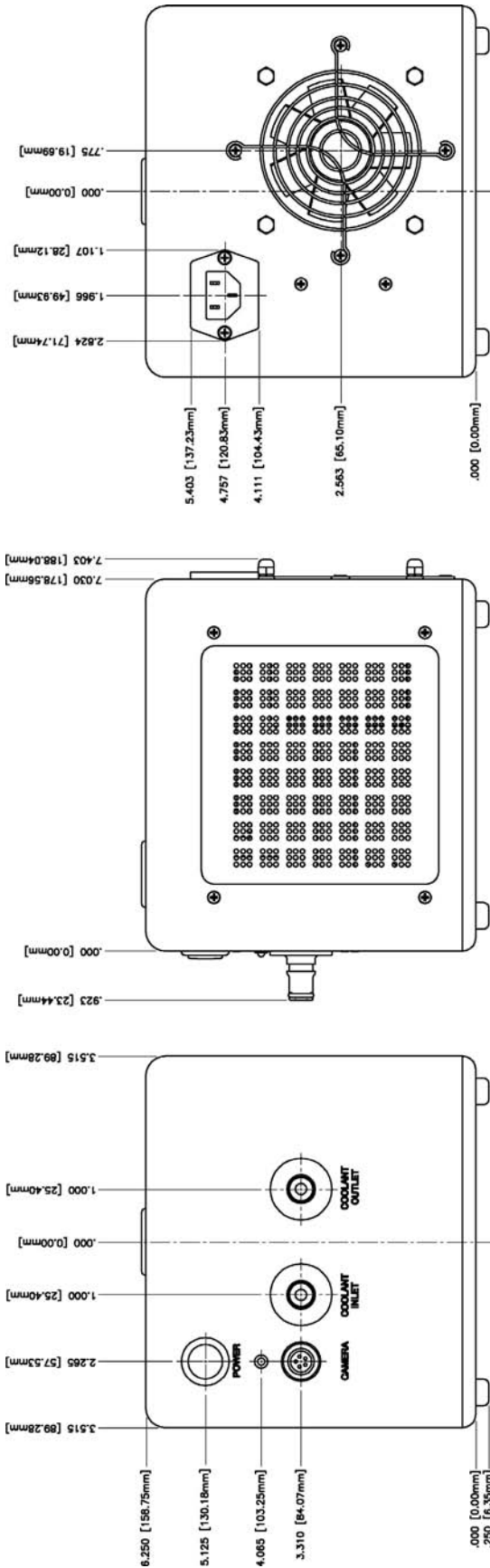
PhotonMAX Camera: C-mount, Air-Cooled



PhotonMAX Camera: C-mount, Liquid-Cooled



CoolCUBE Circulator



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Declaration of Conformity

This section of the PhotonMAX system manual contains the declaration(s) of conformity for PhotonMAX systems.

DECLARATION OF CONFORMITY

We,

ROPER SCIENTIFIC
(PRINCETON INSTRUMENTS)
3660 QUAKERBRIDGE ROAD
TRENTON, NJ 08619

Declare under our sole responsibility, that the product,

PhotonMAX CAMERA,

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

**IEC 1010-1:1990, EN 61010-1:1993/A2:1995,
EN 61326 for Class A, 1997/A1:1998/A2:2001,
(EN 61000-4-2, EN 61000-4-3, EN 61000-4-4, EN 61000-4-5,
EN 61000-4-6, EN 61000-4-11), EN 61000-3-2:2000, and
EN 61000-3-3:1995/A1:2001,**

Which follow the provisions of the

CE LOW VOLTAGE DIRECTIVE 73/23/EEC

And

**EMC DIRECTIVE 89/336/EEC
(Amending Directive 93/68/EEC, et al (CE Marking)).**

Date: March 10, 2005

TRENTON, NJ



(Dr. Raymond W. Simpson, PhD)
Acting Engineering Manager

DECLARATION OF CONFORMITY

We,

ROPER SCIENTIFIC
(PRINCETON INSTRUMENTS)
3660 QUAKERBRIDGE ROAD
TRENTON, NJ 08619

Declare under our sole responsibility, that the product,

PhotonMAX CAMERA with CoolCUBE,

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

**IEC 1010-1:1990, EN 61010-1:1993/A2:1995,
EN 61326 for Class A, 1997/A1:1998/A2:2001,
(EN 61000-4-2, EN 61000-4-3, EN 61000-4-4, EN 61000-4-5,
EN 61000-4-6, EN 61000-4-11), EN 61000-3-2:2000, and
EN 61000-3-3:1995/A1:2001,**

Which follow the provisions of the

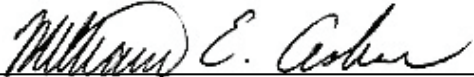
CE LOW VOLTAGE DIRECTIVE 73/23/EEC

And

**EMC DIRECTIVE 89/336/EEC
(Amending Directive 93/68/EEC, et al (CE Marking)).**

Date: March 9, 2006

TRENTON, NJ



William Asher
Vice President of New Product Development

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Warranty & Service

Limited Warranty

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

Basic Limited One (1) Year Warranty

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

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

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

XP Vacuum Chamber Limited Lifetime Warranty

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

Sealed Chamber Integrity Limited 12 Month Warranty

Princeton Instruments warrants the sealed chamber integrity of all our products for a period of twelve (12) months after shipment. If, at anytime within twelve (12) months from the date of delivery, the detector should experience a sealed chamber failure, all parts and labor needed to restore the chamber seal will be covered by us. *Open chamber products carry NO WARRANTY TO THE CCD IMAGING DEVICE, EXPRESSED OR IMPLIED.* Responsibility for shipping charges is as described above under our Basic Limited One (1) Year Warranty.

Vacuum Integrity Limited 12 Month Warranty

Princeton Instruments warrants the vacuum integrity of “Non-XP” style detectors (do not have all metal seals) for a period of up to twelve (12) months from the date of shipment. We warrant that the detector head will maintain the factory-set operating temperature without the requirement for customer pumping. Should the detector experience a Vacuum Integrity failure at anytime within twelve (12) months from the date of delivery all parts and labor needed to restore the vacuum integrity will be covered by us. Responsibility for shipping charges is as described above under our Basic Limited One (1) Year Warranty.

Image Intensifier Detector Limited One Year Warranty

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

X-Ray Detector Limited One Year Warranty

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

Software Limited Warranty

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

Owner's Manual and Troubleshooting

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

Your Responsibility

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

1. You must retain your bill of sale (invoice) and present it upon request for service and repairs or provide other proof of purchase satisfactory to Princeton Instruments.
2. You must notify the Princeton Instruments factory service center within (30) days after you have taken delivery of a product or part that you believe to be defective. With the exception of customers who claim a "technical issue" with the operation of the product or part, all invoices must be paid in full in accordance with the terms of sale. Failure to pay invoices when due may result in the interruption and/or cancellation of your one (1) year limited warranty and/or any other warranty, expressed or implied.
3. All warranty service must be made by the Princeton Instruments factory or, at our option, an authorized service center.
4. Before products or parts can be returned for service you must contact the Princeton Instruments factory and receive a return authorization number (RMA). Products or parts returned for service without a return authorization evidenced by an RMA will be sent back freight collect.
5. These warranties are effective only if purchased from the Princeton Instruments factory or one of our authorized manufacturer's representatives or distributors.
6. Unless specified in the original purchase agreement, Princeton Instruments is not responsible for installation, setup, or disassembly at the customer's location.
7. Warranties extend only to defects in materials or workmanship as limited above and do not extend to any product or part which has:
 - been lost or discarded by you;
 - been damaged as a result of misuse, improper installation, faulty or inadequate maintenance or failure to follow instructions furnished by us;
 - had serial numbers removed, altered, defaced, or rendered illegible;
 - been subjected to improper or unauthorized repair; or
 - been damaged due to fire, flood, radiation, or other "acts of God" or other contingencies beyond the control of Princeton Instruments.
8. After the warranty period has expired, you may contact the Princeton Instruments factory or a Princeton Instruments-authorized representative for repair information and/or extended warranty plans.
9. Physically damaged units or units that have been modified are not acceptable for repair in or out of warranty and will be returned as received.

10. All warranties implied by state law or non-U.S. laws, including the implied warranties of merchantability and fitness for a particular purpose, are expressly limited to the duration of the limited warranties set forth above. With the exception of any warranties implied by state law or non-U.S. laws, as hereby limited, the forgoing warranty is exclusive and in lieu of all other warranties, guarantees, agreements, and similar obligations of manufacturer or seller with respect to the repair or replacement of any parts. In no event shall Princeton Instruments' liability exceed the cost of the repair or replacement of the defective product or part.
11. This limited warranty gives you specific legal rights and you may also have other rights that may vary from state to state and from country to country. Some states and countries do not allow limitations on how long an implied warranty lasts, when an action may be brought, or the exclusion or limitation of incidental or consequential damages, so the above provisions may not apply to you.
12. When contacting us for technical support or service assistance, please refer to the Princeton Instruments factory of purchase, contact your authorized Princeton Instruments representative or reseller, or visit our technical support page at www.princetoninstruments.com.

Contact Information

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

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

Tel: 800.874.9789 / 609.587.9797

Fax: 609.587.1970

Customer Support E-mail: <mailto:techsupport@princetoninstruments>

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

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

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

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