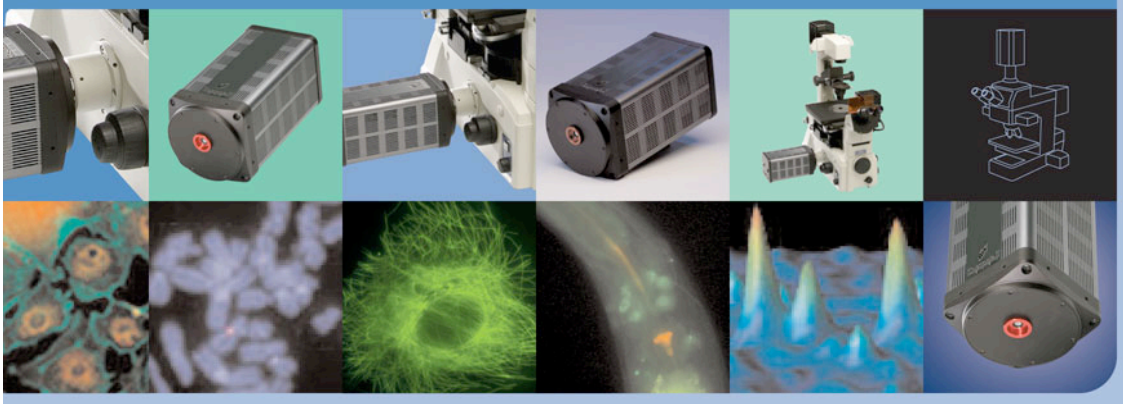
Photometrics®

Cascade® II

USER MANUAL Cascade II:512 and 1024



PHOTOMETRICS®

User Manual for Cascade II:512 & 1024 Cameras

PHOTOMETRICS®

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Customer Service

If you have any questions about your camera system, please contact Photometrics Customer Service. When you call, please have your Photometrics part number or equipment serial numbers available.

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LIMITED WARRANTY

Photometrics, a division of Roper Scientific, Inc., ("Photometrics," 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

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

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

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

Normal Wear Item Disclaimer

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

Shutter Warranty

Photometrics warrants the standard, factory-installed shutter of all our products that incorporate an integrated shutter for a period of twelve (12) months. This warranty applies to the standard shutter installed in the camera system at the time of manufacture. Non-standard shutters, SPR (special product request) shutters, and third-party shutter drive equipment carry no warranty expressed or implied. Photometrics will supply, at no cost to the customer, up to one (1) replacement shutter during the warranty period. Photometrics will, at Photometrics option, either ship a ready-to-install shutter to the customer site for installation by the customer according to the instructions in the product User Manual or arrange with the customer to return the camera system (or portion of the camera system) to the factory (or factory authorized service center) for shutter replacement by a factory-authorized agent. Responsibility for transportation and insurance charges is described above.

Cascade® II Sealed Chamber Integrity Limited Lifetime Warranty

Photometrics warrants that the cooling performance of the system will meet our specifications over the lifetime of the Cascade II detector or Photometrics 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.

Vacuum Integrity Limited 24 Month Warranty

Photometrics warrants the vacuum integrity of all our products for a period of up to twenty-four (24) months from the date of shipment. We warrant that the detector head will maintain the factory-set operating temperature without the requirement for customer pumping. Should the detector experience a Vacuum Integrity failure at anytime within twenty-four (24) months from the date of delivery all parts and labor needed to restore the vacuum integrity will be covered by us. Responsibility for shipping charges is as described above under our Basic Limited One (1) Year Warranty.

X-Ray Detector Limited One Year Warranty

Photometrics warrants the vacuum integrity of all our products for a period of up to twenty-four (24) months from the date of shipment. We warrant that the detector head will maintain the factory-set operating temperature without the requirement for customer pumping. Should the detector experience a Vacuum Integrity failure at anytime within twenty-four (24) months from the date of delivery all parts and labor needed to restore the vacuum integrity will be covered by us. Responsibility for shipping charges is as described above under our Basic Limited One (1) Year Warranty.

Software Limited Warranty

Photometrics 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. Photometrics 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 Photometrics 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 Photometrics 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 Photometrics.
2. You must notify the Photometrics 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 Photometrics factory or, at our option, an authorized service center.
4. Before products or parts can be returned for service you must contact the Photometrics 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 Photometrics factory or one of our authorized manufacturer's representatives or distributors.
6. Unless specified in the original purchase agreement, Photometrics 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 Photometrics.

8. After the warranty period has expired, you may contact the Photometrics factory or a Photometrics-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 Photometrics' 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 Photometrics factory of purchase, contact your authorized Photometrics representative or reseller, or visit our technical support page at www.photomet.com.

Declaration of Conformity

We,

Roper Bioscience, Inc. declares on its sole responsibility that the product,

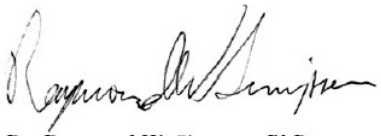
Product Description:	Digital Camera
Models:	Cascade II: 512BE
	Cascade II: 1024B
Manufacturer:	Roper Bioscience, Inc.

To which this equipment relates is in conformity with general safety requirements 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 61326-4-2, 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)



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

CE

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Chapter 1

Overview

Introduction

The new Cascade® II cameras feature on-chip, deeply cooled 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.

Currently the Cascade II line consists of the following camera models:

- Cascade II:512
  - Uses a 512x512 Back-illuminated CCD with 16x16 μm pixels.
  - Has two readout amplifiers – one that offers charge multiplication gain and another for traditional readout.
- Cascade II:1024
  - Uses a 1024x1024 Back-illuminated CCD with 13x13 μm pixels.
  - Has two readout amplifiers – one that offers charge multiplication gain and another for traditional readout.

The Cascade II: 512, the first in the series, features square, 16 x 16 μm pixels in a 512 x 512, frame-transfer format. The back-illuminated CCD with dual amplifiers ensures 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 image visualization or more slowly for high-precision photometry. Supravideo frame rates are achievable via subregion readout.

Technology Information

On-Chip Multiplication Gain

On-chip multiplication gain, also known as electron multiplication, multiplies 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. *See Figure 1* on the next page for a graphic illustration.

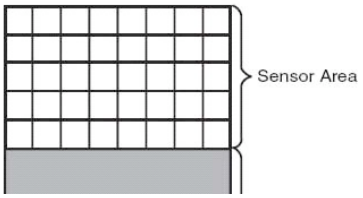


Figure 1. Cascade II CCD

Integrated Controller

The operation of the Cascade II cameras is regulated by their 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 Cascade II cameras with the rest of your experiment. The controlling electronics also collect the analog signal returned by the CCD, digitize it, and send it to the computer.

The Cascade II controller section allows you to specify read rate, binning parameters (m x n), 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.

System Components

A Cascade II camera is packaged with the power supply, a power cable, a data cable, a PCI card for your computer, the user manual (CD ROM), and a certificate of performance (*see Figure 2*).

Component descriptions and other information are detailed in the next section *Camera Information*.

Figure 2. Cascade II components & documentation

Camera Information

CCD Array

The Cascade II camera uses only scientific-grade devices 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.

Cooling

Dark current is reduced in the Cascade II camera system through thermoelectric cooling of the CCD array. Cooling by this method uses a four-stage Peltier cooler in combination with air-circulation. See the system data sheet for cooling performance.

Connectors

There are three connectors for the Cascade II camera:

- DATA (lower right): 20-pin, high-density connector for data transfer.
- I/O (lower left): DB26, high-density connector for input/output control signals.
- POWER (upper left): 5-pin, LEMO connector for camera power.

All connectors are plugged in to the camera backplate (*see Figure 3*).

Figure 3. Camera backplate

Fan

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

Data Cable

The Data cable has 20-pin, high-density (MDR-20) connectors for interconnecting the camera and the host computer. This cable is the data transfer link between these two system components (*see Figure 2*).

Certificate of Performance

Each Cascade II camera has a Certificate of Performance (*see Figure 2*). This certificate states that the camera system was assembled and tested according to approved Photometrics procedures. It documents the camera performance data as measured during the testing of your Cascade II and lists the Sales Order and Cascade II Camera Serial number (useful if you ever need to contact Photometrics Customer Support).

Software Components

The following software components are included with the camera.

PVCAM®

PVCAM includes drivers that allow for operating system compatibility, and libraries that provide for full access and control of Photometrics cameras when a custom application is being written.

QED Capture

QED Capture is an imaging acquisition package that utilizes the PVCAM libraries for camera control and data acquisition.

Grounding and Safety

Before turning on the power supply, the ground prong of the power-cord plug must be properly connected to the ground connector of the wall outlet. The wall outlet must have a third prong, or must be properly connected to an adapter that complies with these safety requirements.

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

Warning! Replacement power cords 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:

- 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.
- Never open the camera. There are no user-serviceable parts inside the Cascade camera. Opening the camera voids the warranty.
- Use only the PCI card, cables, and power supply designated for this camera system. Using non-Cascade II cables, PCI cards, or power supplies may result in permanent damage to your system.
- Do not use a C-mount lens that has optics that extend behind the lens flange.

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 Maintenance

Although there is no periodic maintenance that needs to be performed on a Cascade II 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.

Repairs

Because the Cascade II camera system contains no user-serviceable parts, repairs must be performed by Photometrics®. Should your system need repair, contact Photometrics customer support for instructions. See “Photometrics Customer Service” below.

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

About This Manual

The Cascade II:512 and 1024 User Manual is divided into five chapters. It is suggested that you read the entire manual before operating the camera in order to ensure proper use. The chapter contents are briefly described below.

- **Overview -** This is a basic overview of the Cascade II cameras that includes warnings, general maintenance/equipment information and a system component overview.
- **Camera Setup** - This chapter discusses hardware and software setup for the Cascade II cameras.
- **Operating Features** - This chapter discusses Cascade II camera features such as on-chip multiplication gain, readout, and trigger modes. Provides additional information on dual-readout mode feature available.
- **Troubleshooting** - This chapter provides answers to camera system problems.
- **Basic Specifications** - This chapter provides specifications for Cascade II camera components including dimensions, connector information and line drawings.

Storage Requirements

Store the Cascade II camera in its original containers. To protect the system from excessive heat, cold, and moisture, store at an ambient temperature between -20°C and 60°C with a relative humidity of 0% to 90%, noncondensing.

Microscopes, Lenses, and Tripods

The camera has a standard threaded video mount and can be mounted to any microscope that accepts a standard C-mount adapter. The camera also allows you to install any lens that is compatible with a standard threaded video mount as long as its optics does not extend behind the flange of the lens. Both Cascade II cameras can be mounted to a tripod using the tripod mounting attachment located on the bottom of the camera.

Cascade II cameras C-mount adapter is designed so it can be screwed in or out to change the focal depth. Once the focal depth as been changed, the adapter is secured by two setscrews. See Adjusting the C Mount Adapter (Chapter 2) for more information.

Chapter 2

Camera Setup

Carefully review the Precautions section in the previous chapter before performing any of the procedures outlined here. Again, use a Cascade II compatible data cable and PCI interface card. Using a different cable or interface card may result in permanent damage to your system.

In addition, to minimize risk to users or to system equipment, turn off the camera before connecting or disconnecting cables.

Introduction

Your Cascade II camera has the following hardware components:

- Camera head
- Power supply with power cord
- PCI Card
- Cables: Data and Power

All of the components and cables required for your configuration should be included with your shipment. Your Cascade II system has been specially configured and calibrated to match the camera and readout rate options specified at the time of purchase.

Keep all the original packing materials so you can safely ship the Cascade II system to another location or return it for service if necessary. If you have any difficulty with any step of the instructions, call Photometrics Customer Support. See "Photometrics Customer Service" on page 4.

To install the hardware, you must take these steps:

- Install a PCI interface card.
- Attach a lens to the C-mount on the camera or to a C-mount adapter.
- Connect the camera to external equipment, if required.
- Mount the camera to a microscope.

Software installation depends on the application software you will be using to run the system. PVCAM drivers must be installed, if not provided by third-party software.

Unpacking the System

When unpacking, check the camera components for possible signs of shipping damage. If there are any, notify Photometrics and file a claim with the carrier. If damage is not apparent but camera specifications cannot be achieved, internal damage may have occurred in shipment. Please save the original packing materials in the event your camera system must be shipped to another location or returned to Photometrics for repairs.

Checking Equipment and Parts Inventory

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

- Camera
- Power Supply
- Host Computer: Provided by the user.
- Data cable: 15 foot cable is standard.
- Photometrics CD-ROM containing PVCAM software and manual.
- QED CD-ROM with software key.

System Requirements

Temperature & Humidity

The camera should be operated in a clean, dry environment. Both cameras have an ambient operating temperature of 0ºC to 30ºC ambient

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

The relative humidity is 0% to 80%; non-condensing.

Note: For TE-cooled cameras, the cooling performance may degrade if the room temperature is above +23°C.

Camera Ventilation

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

Camera Power

The Cascade II camera receives its power from the supplied power supply, 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.

- Maximum Power Output: 96 W
- Input: 100-240 VAC, 47-63 Hz, 3 A
- Output: 12 VDC at 8 A maximum

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

Host Computer PC

Note that 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.

The PC host computer for your Cascade II must have the following:

- Windows® 2000 (Service pack 4), or Windows® XP (Service pack 2) or later operating system
- 1 GHz Pentium® 4 (or greater)

- 512 MB RAM (or greater)
- CD-ROM drive
- At least one unused PCI card slot
- Super VGA monitor and graphics card supporting at least 256 colors with at least 1 MB of memory. Memory requirement is dependent on desired display resolution.
- Hard disk with a minimum of 1 GB available. Disk level compression programs are not recommended.
- Mouse or other pointing device

Host Computer MAC

The Mac host computer for your Cascade II camera must have the following:

- Mac OS X operating system (Version. 10.3 or greater)
- G4/G5 computer
- 512 MB RAM (or greater)
- CD-ROM drive
- At least one unused PCI or PCI-X card slot
- Video adapter that supports 24-bit color (millions of colors)
- Hard disk with a minimum of 1 GB available. Disk level compression programs are not recommended.
- Mouse or other pointing device

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

Software Compatibility Requirements

The Cascade II package includes the PVCAM drivers and the QED Capture software program designed for use with your Cascade II camera.

All other imaging software must also be PVCAM-compatible. For full access to Cascade II hardware functions, the current version of PVCAM must be used.

Multiple Cameras

PVCAM supports multiple open cameras. In order to use this function, it must also be supported by your imaging software.

If your imaging software supports multiple cameras, there must be a separate PCI card for each camera.

Software Installation

An Installation Guide appropriate to your system is included on a CD-ROM. This guide provides step-by-step instructions for installing the camera interface software and the application software for Windows-based computers. Additional instructions are included for installing a PCI card in your computer and capturing images.

The Photometrics CD-ROM contains the following files:

- Linux directory -this directory contains the files for installing on a Linux PC.
- MacOS directory - this directory contains the files required for installing on a Macintosh computer.
- Manuals directory - this directory contains user manuals in PDF format.
- WinOS directory - this directory contains the files for installing on a Windows PC.

Installing the PCI Card

PCI card installation instructions are included on the CD-ROM. Refer to the Readme text files on the CD-ROM and to the Software Installation insert. The insert instructions will step you through the PCI card installation.

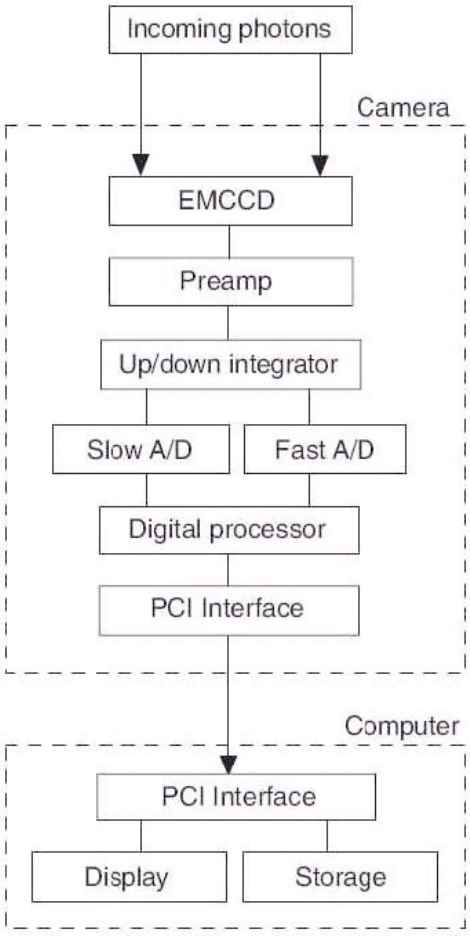
Chapter 3

Operating Features

Introduction

Once the Cascade II 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, 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 read out 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 4*.



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. 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 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. This mode is particularly convenient for familiarization and setting up. For ease in focusing, the screen refresh rate should be as rapid as possible.
- In Acquire mode, every frame of data collected can be automatically stored (the completed dataset may include multiple frames). This mode would ordinarily be selected during actual data collection.

The remainder of this chapter discusses factors that affect exposure, readout, and digitalization of the incoming signal. By understanding the exposure, readout, and digitalization factors and making adjustments to software settings you can maximize the signal-to-noise ratio. For information about synchronizing data acquisition with external devices, see *External Shutter Operation* later in this chapter.

First Light (Imaging)

When you set up the camera for the first time, use this procedure to help you gain basic familiarity with the operation of your system and to show that it is functioning properly. Once you have established a basic familiarity you can perform operations with other operating configurations. Follow these steps:

1. Place a test target in front of the camera.
2. Power ON the camera (the power switch is on the back of the camera).
3. Turn on the computer power.
4. Start the application software.
5. Block light from the lens.

Setting the Parameters

For most high-speed applications, the following software settings will yield the best results:

- Readout Speed: 10 MHz
- Readout Mode: Frame-Transfer
- Clearing Mode: Pre-sequence
- Number of Clears: 2

Applications that do not require high speed may benefit from these software settings:

- Readout Speed: 5 MHz
- Readout Mode: Frame-Transfer
- Clearing Mode: Pre-sequence
- Number of Clears: 2

Note: Not using circular buffers may affect the focus operation mode.

Detector Temperature

The default temperature setting is read from the camera. When the array temperature reaches the set point, the detector temperature will lock. 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 set point is established, the temperature will be stable to within ±0.05°C.

Note: Some initial overshoot may occur, which could cause the temperature lock to be briefly lost and then quickly reestablished.

Preparing to Acquire Data

If you are using the computer monitor for focusing, successive images will be sent to the monitor as quickly as they are acquired.

Adjust for parfocality, intensity scaling, and focus for the best image as viewed on the computer monitor. For example:

- Make sure there is a suitable target in front of the camera lens. An object with text or graphics works best.
- Adjust the intensity scaling and focal distance until a suitable setting is found. Once you've determined that the image is present, select a lower intensity 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 exposure time as needed until the brightest regions are below 65535.
- Set the focal adjustments for maximum sharpness in the viewed image.

After you have focused the camera and adjusted intensity, and the operating temperature set point has been reached, you can begin to acquire data.

Exposure and Signal

The principal difference between a charge-multiplying CCD (EMCCD) and a traditional CCD is the presence of an extended serial register in the EMCCD device. 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 Cascade II cameras excellent choices for experiments where fast frame rates and low light sensitivity are required. See *Figure 5* for a graphic comparison of the traditional CCD and Cascade II CCD array structures.

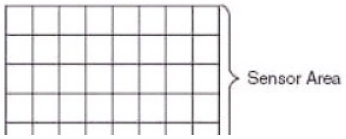


Figure 5. Comparison of traditional CCD and Cascade CCD array structures

Exposure Time

Exposure time is the time between start and stop acquisition commands that the application software sends to the camera. In combination with triggers, these commands control when continuous clearing of the CCD stops and when the signal is read out. The continuous clearing 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 read out and clearing 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
If this mode is active, 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
If this mode is active, the effective exposure time is the set exposure time.

For detailed information on these modes, see *Exposure-Readout Modes* later in this chapter.

Electron Multiplication Gain

The Cascade II 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 using the Multiplication Gain port, a Gain (DAC) setting can be entered. A Gain setting of zero (0) refers to a no-gain state where the camera behaves like a standard high speed CCD. 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 Cascade II can offer a multiplication gain factor in 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 electron multiplication gain for your camera is measured at various Gain (DAC) settings and the data are provided on the Certificate of Performance. An approximate relationship between the Gain (DAC) setting and charge multiplication factor for the Cascade II:512 and 1024 is shown in the graph below (see *Figure 6*).

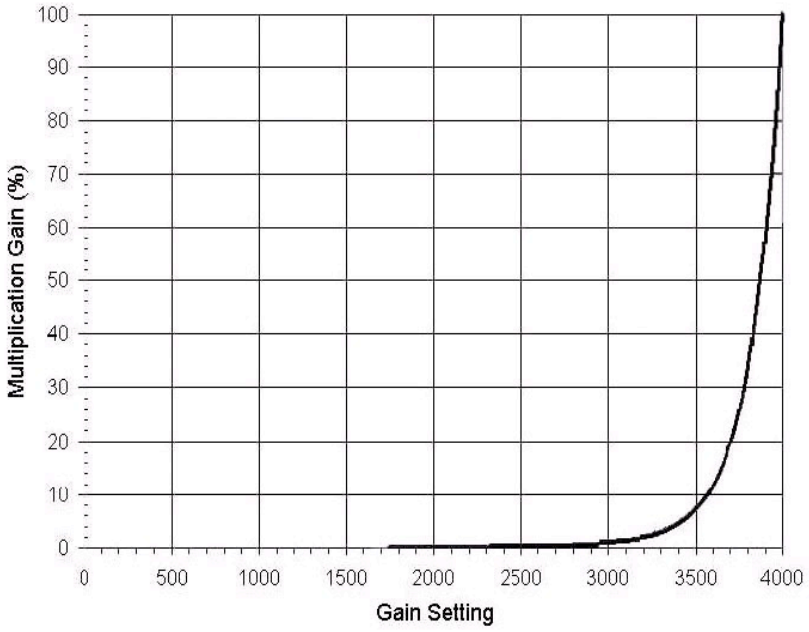


Figure 6. Gain setting vs. Charge multiplication gain

CCD Temperature

Lowering the temperature of the CCD generally enhances the quality of longer exposures by lowering the dark current. 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.

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, and so on. 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 the Cascade II is -65°C.

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 exponentially temperature dependent. In the case of cameras with MPP type arrays, the average dark charge is extremely small. However, the dark-charge distribution is such that a significant number of pixels may exhibit a much higher dark charge, limiting the maximum practical exposure. Dark charge effect is more pronounced in the case of cameras having a non-MPP array (such as deep-depletion devices).

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 dark-charge level of this background. What you see is not noise, but 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 and the camera temperature is not stable, turn off the camera and contact Photometrics Customer Support.

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 is subtracted from the sample image for quantitative measurement. Because the offset can change based on several factors such as multiplication gain, speed, etc., it is recommended that a new bias image be taken with the same settings as the sample image and then be subtracted from the sample image.

Clearing Modes

Clearing 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 clear mode determines when to clear the CCD array. Not all clearing modes are available for all cameras. The clear modes are:

Clear Never
The CCD is never cleared. This mode is useful for performing a readout after an exposure has been aborted.

Clear Pre-Exposure
Before each exposure, this mode clears the CCD by the number of clears 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, this mode clears the CCD the number of times specified by the number of clears selected. If no sequence is set up, this mode behaves as if the sequence has one exposure. The result is the same as using Clear Pre-Exposure. For

the Cascade II, this is the most useful method of clearing.

Clear Post-Sequence
This mode clears continuously after the data acquisition sequence ends. The camera continues clearing 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-Exposure and Post-Sequence
This mode clears the number of clears selected times before each exposure and clears continuously after the sequence ends. The camera continues clearing until a new exposure is set up or started, the abort command is sent, or the camera is reset.

Readout

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

Dual-Readout Port Operation

The Cascade II is configured with software-selectable dual-readout amplifiers (ports), as shown in *Figure 7*.

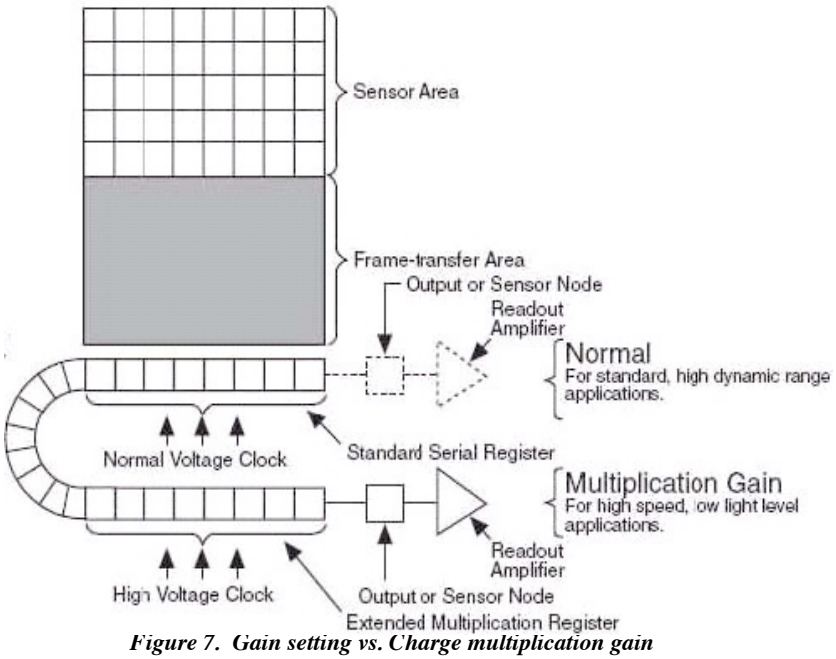


Figure 7. Gain setting vs. Charge multiplication gain

The two amplifiers are:

- Port #1: Multiplication Gain amplifier
- Port #2: Normal amplifier

The software automatically allows you to select one of these amplifiers. User interfaces differ. Refer to your software manual for specific information on readout amplifier/port selection.

Multiplication Gain

When this port is selected, a gain value can be entered. 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 (for example, single molecule fluorescence, ion imaging, and so on).

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.

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 (for example, bright field, fixed cell fluorescence, and so on).

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.

System Gain

System gain (a function of the preamplifier) is software-selectable and is used to change the relationship between the number of electrons acquired on the CCD and the Analog-to-Digital Units (ADUs or counts) generated.

The choices are **1 (Low), 2 (Medium)**, and **3 (High)**. Users who measure high-level signals may wish to select Low to allow digitalization 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.

Readout Amplifier (Port)	Readout Speeds	Conversion Gain (e^- /ADU)
Multiplication Gain	5 MHz 10 MHz	#1: 12e^- /ADU #2: 6e^- /ADU #3: 3e^- /ADU
Normal	1 MHz 5 MHz	#1: 4e^- /ADU #2: 2e^- /ADU #3: 1e^- /ADU

Table 1. 512 Readout Speeds and Typical Conversion Gains

Readout Rates

The Cascade II has two readout rates available on each of the two ports. 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, see the product data sheet.

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 Cascade II 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.

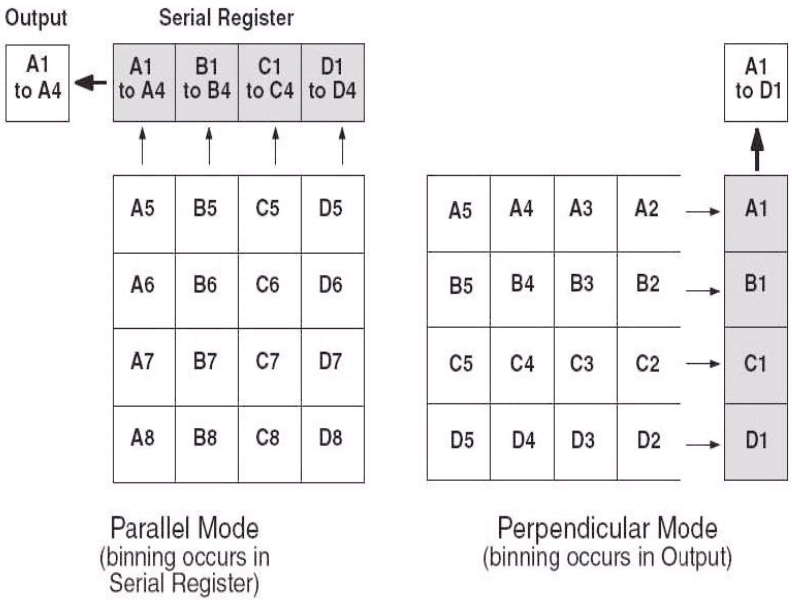


Figure 8. Binning and array orientation

Exposure Readout Modes

The frame transfer CCDs used by the Cascade II support Overlap and Non-Overlap exposure - readout modes. If you are planning to use Overlap mode, be aware that the set exposure time 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.

Program this sequence by setting:

- the Number of Images to some number greater than one;
- the Readout mode to "Frame Transfer";
- the Clearing mode to "Clear Pre-Sequence" with one or more Clears.

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

The simultaneous exposure-readout mechanism is illustrated with two examples (see next page).

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 × 34.8 ms + 10 ms), equivalent to a frame rate of 26.2 fps (3 frames ÷ 0.114 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:

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

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

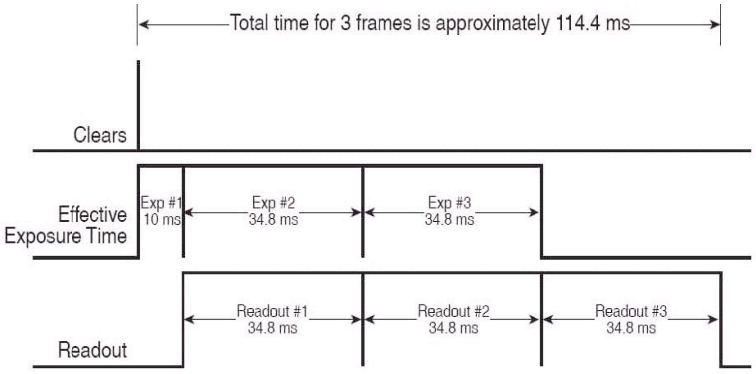


Figure 9. Timing Diagram for Overlap Mode when Exposure Time < Readout Time

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 × 50 ms + 34.8 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:

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

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 (*Figure 10*), 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 10. Timing diagram for Overlap Mode when exposure time > readout time

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.

Program this sequence by setting:

- the Readout mode to "Frame Transfer";
- the Clearing mode to "Clear Pre-Exposure" with one or more Clears.

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 x 10 ms + 3 x 34.8 ms), equivalent to a frame rate of 22.3 fps (3 frames ÷ 0.134 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.

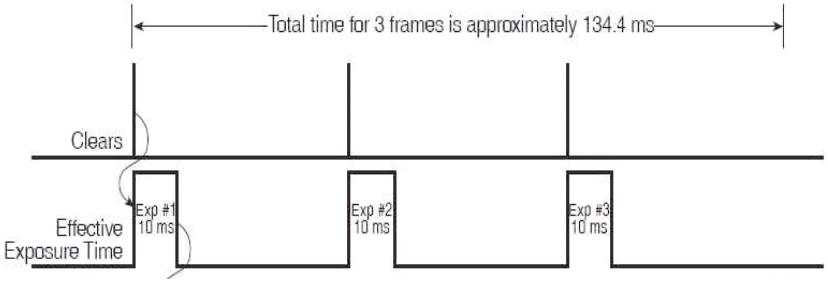


Figure 11. Timing diagram for Non-Overlap Mode

External Shutter Operation

Because the Cascade II camera uses frame-transfer CCDs, it does not incorporate an internal shutter. 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}).

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

The following figure 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.

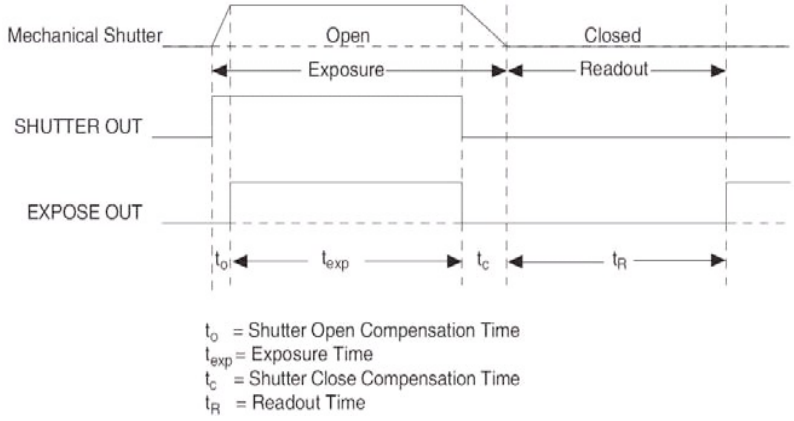


Figure 12. External Shutter timing diagram

Because most shutters behave like an iris, the opening and closing of the shutter causes 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.

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 Cascade II timing modes are Timed, Strobe, Bulb, and Trigger-First. These modes are combined with the Shutter options to provide the widest variety of modes for precision experiment synchronization.

Cascade II cameras offer several methods of integration with external trigger sources, such as delay generators or laser pre-triggers. Each camera has a 26pin, high-density I/O connector on the back for trigger-in/out and various TTL input and output operations (“I/O Connector” on page 35 for pinouts).

This I/O port 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. Cascade II cameras support the timing modes described in the next sections.

Timed Mode

In Timed 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 13*).

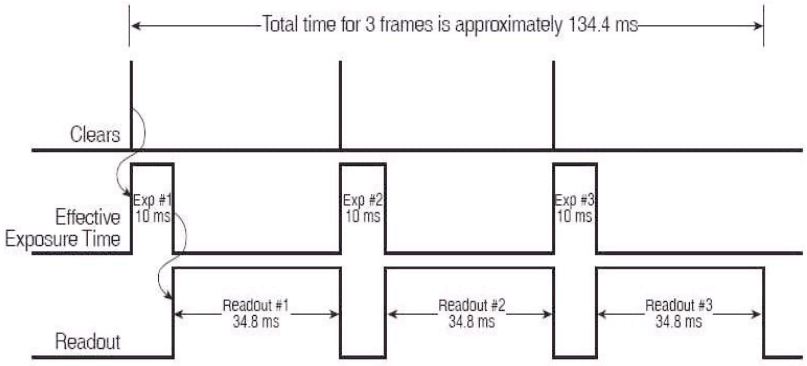


Figure 13. Timed Mode timing diagram: Non-overlap mode

When running in Overlap mode, the effective exposure time is the frame readout time unless the set exposure time is greater than the frame readout time, as shown in *Figure 14*.

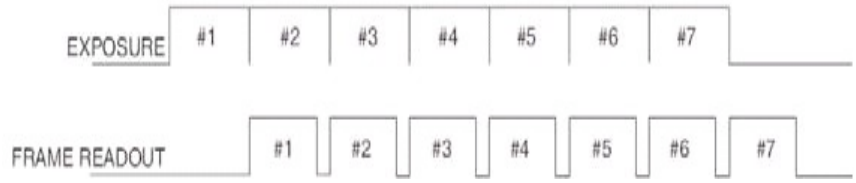


Figure 14. Timed Mode timing diagram: Overlap mode(t_{exp}>t_R)

Strobe Mode

Strobe mode operates *only* in Non-Overlap mode. In Strobe 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, as shown in the following figure. For a sequence of one frame, strobe mode and trigger-first mode are the same. The shaded areas (*see Figure 15*) denote the idle time between exposures.

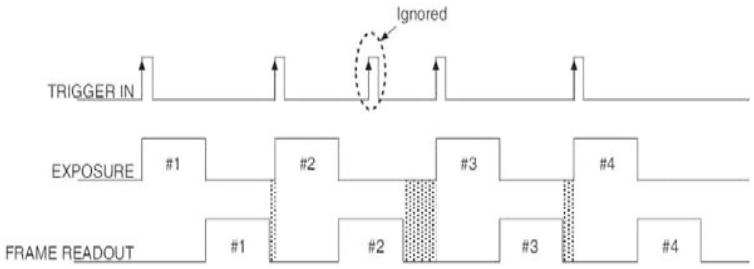


Figure 15. Strobe Mode timing diagram: Non-overlap mode

Bulb Mode

In Bulb mode, exposure time for each frame is determined by the trigger pulse width. Exposure time entered into the software is ignored in this mode, as shown in the following figure. If a trigger arrives during the readout of the previous frame, it is ignored. The shaded areas denote the idle time between exposures.

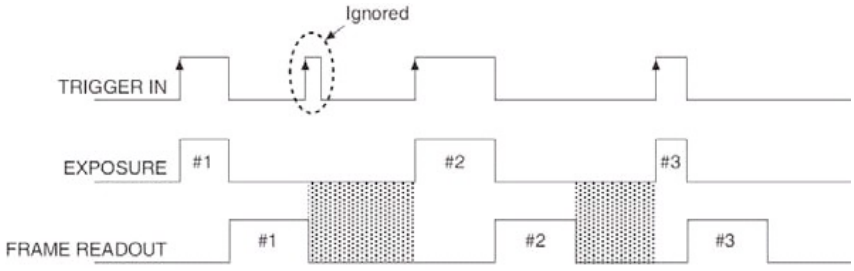


Figure 16. Bulb Mode timing diagram: Non-overlap mode

Trigger-First Mode

In Trigger-First 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. *Figures 17 and 18* shows a three-frame sequence.

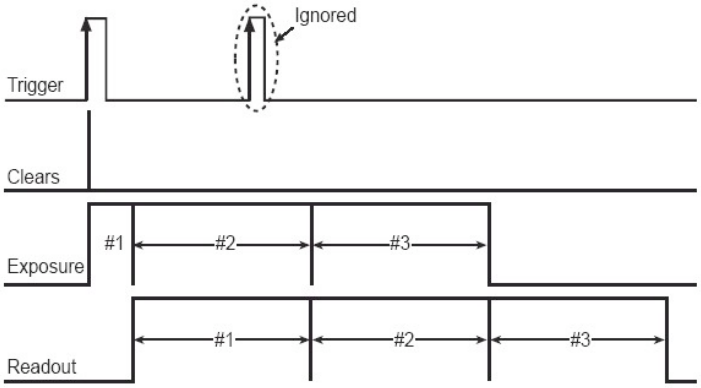


Figure 17. Trigger-first Mode timing diagram: Overlap mode

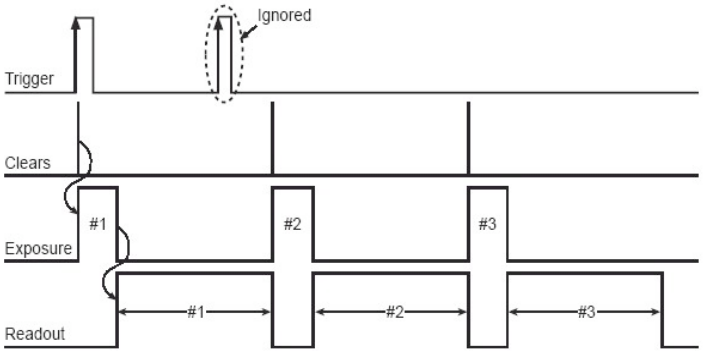


Figure 18. Trigger-first Mode timing diagram: Non-overlap mode

Fast and Slow Speed Modes

The Cascade II has been designed to allow the greatest possible flexibility when synchronizing data collection with an experiment. The fundamental difference between the Fast and Slow speed modes is how often the acquisition start and acquisition stop commands are sent by the computer for a data collection sequence. With Slow mode, the computer sends a start and a stop command for each frame of a data collection sequence. With Fast mode, the computer sends only one start and one stop command for each data collection 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.

The flowcharts on the next page (*Figure 19*) show the differences between the two modes.

Figure 19. Flow charts of Slow and Fast mode operation

Fast Mode
(Circular Buffers On)

In Fast operation, the Cascade II runs according to the timing of the Buffers On) 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 Cascade II 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.

Slow Mode
(Circular Buffers Off)

In Slow operation, the computer processes each frame as it is received: the Cascade II cannot collect the next frame until the previous frame has been completely processed. Slow 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. In Slow 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 Slow mode is that events may be missed during the experiment, since the Cascade II is disabled for a short time after each frame.

TTL Status Signals

The I/O (Input/Output Status) connector on the rear of the Cascade II provides information about trigger function, DAC, and TTL signals. (For details of pinouts, see “I/O Connector” on page 35.)

Inputs must be at least 3.15 V for a high and less than 0.9 V for a low. The signals **EXPOSE OUT**, **FRAME READOUT**, and **SHUTTER OUT** are provided by the camera and can be used to control external devices.

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.

See *Figure 20* for a graphic comparison of signal levels.

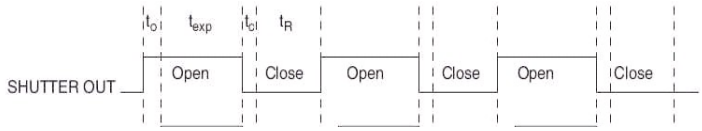


Figure 20. Comparison of signal levels

Chapter 4

Troubleshooting

If you have any difficulty while troubleshooting, or do not see your camera system's symptoms listed here, please contact Photometrics Customer Service.

General Troubleshooting

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 a potential cooling-related issue. Turn off the camera and contact Photometrics Customer Support.

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

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

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

Camera is Not Responding
If this happens, 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.

- If the camera is ON, the problem may be with the PCI card, its driver, or the cable connections. Check the LED lights on the PCI card for communication.
- 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.

Cooling Troubleshooting

Temperature Lock Cannot be Achieved, Maintained, or is Lost.

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

- Ambient temperature greater than +23°C. This condition affects Thermo Electric (TE) cooled cameras. If ambient is greater than +23°C, you will need to cool the camera environment or raise the set temperature.
- Airflow through the camera is blocked.
- The vacuum has deteriorated and needs to be refreshed.
- 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. Cascade II 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 Cascade II camera (guaranteed permanent vacuum for the life of the camera), if you see a gradual deterioration of the cooling capability, there may be a gradual deterioration of the camera's vacuum. This can affect temperature performance such that it may be impossible to achieve temperature lock at the lowest temperatures. In the kind of applications for which cooled CCD cameras are so well suited, it is highly desirable to maintain the system's lowest temperature performance because lower temperatures result in lower thermal noise and better signal-to-noise ratio.

If you observe a gradual loss of cooling capacity, contact the factory to make arrangements for returning the camera to the support facility.

Result Troubleshooting

Smeared Images

Cascade II uses a frame-transfer CCD which allows simultaneous exposure-readout operations (see “Exposure-Readout Modes” on page 21 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:

- Use a longer exposure time, or:
- 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.

Chapter 5

Basic Specifications

Introduction

This chapter provides some of the basic specifications for Cascade II cameras. If the information you are looking for is not here, it may be available in the appropriate data sheet. Contact Photometrics Customer Service if additional information is needed.

Cascade II Outline Drawings

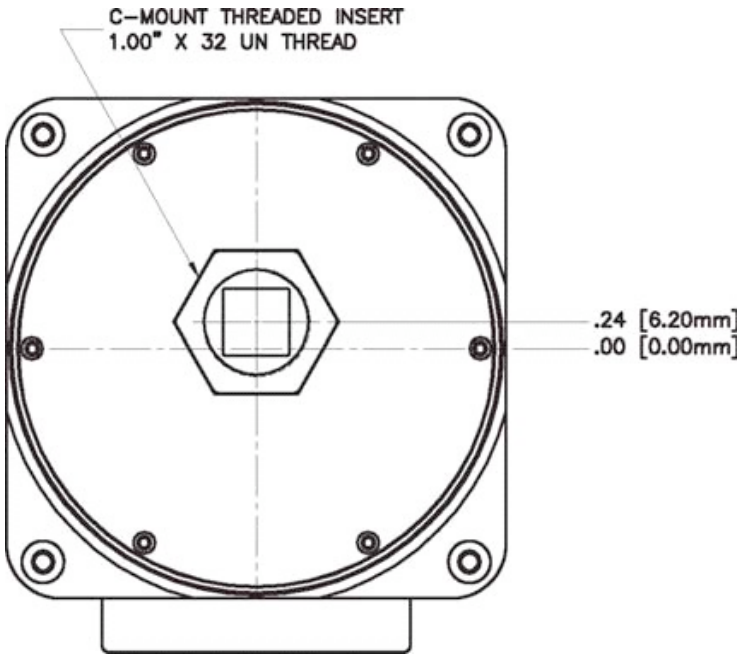
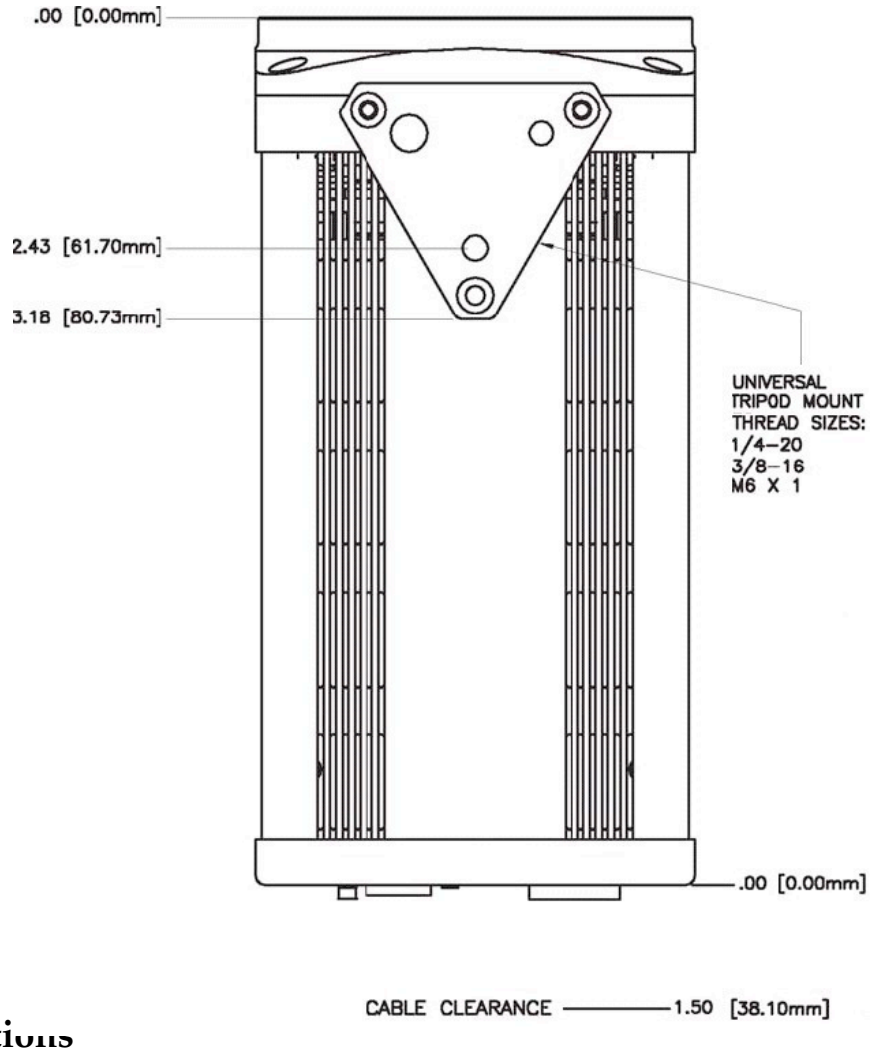


Figure 21. Cascade II Front camera view

Figure 22. Cascade II Back camera view



Basic Specifications Table

Table 2 lists and defines the basic specifications for the Cascade II:512 and 1024.

CASCADE II SPECIFICATIONS TABLE	
Window	SI-UV fused-silica quartz
CCD Arrays	
CCD	**512-** e2v CCD97B **1024-** e2v 201
Image Type	Monochrome
Imaging Format (Resolution)	**512**- 512 x 512 pixels **1024**- 1024 x 1024 pixels
Pixel Size	512- 16 x 16 _m pixels 1024- 13 x 13 _m pixels
Readout Amplifiers (Ports)	2
Digitalization (Readout) Rate	**512**- 10 MHz, 5 MHz, 1 Mhz **1024**- Same as above
Mounts	C-mount: Standard threaded video mount
Focal Distance (Optical)	C-mount, Front Surface to Focal Plane: "0.690" (17.53mm)
Camera	
Cooling	Thermoelectric (air)
Gain	Software-selectable (high, medium, low)
Dimensions	See line drawings in chapter.
Connectors	
Data Connector	20-pin, high density connector for data transfer
Power Connector	5-pin, LEMO connector for camera
I/O Connector	DB26, high-density connector for input/output control signals.
Cooling	
Fan	24 CFM fan capacity at full power.
Cooling (general)	Thermoelectric (air)
Imaging	
Imaging Format	**512-** 512 x 512 pixels **1024**- 1024 x 1024 pixels
Temperature	
Deepest Operating Temperature	-65°C
Temperature Stability	±0.05°C; closed-loop stabilized-temperature control
Power	
Power Input	100-240 VAC; 47 to 63Hz, 3 A. DC power to camera is provided by the self-switching power supply.

Table 2. Basic specifications

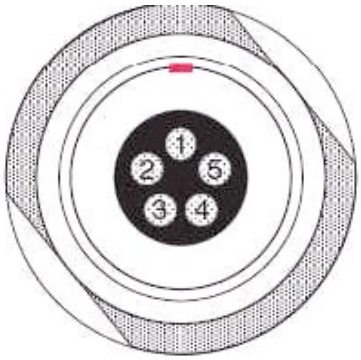
Connectors

The connectors are located on the back of the camera as shown.

Figure 24. Camera backplate connectors

POWER Connector

The POWER connector is a 5-pin LEMO connector as shown below.



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

Figure 25. Power connector pinouts

I/O Connector

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 I/O connector is a female, DB26, high-density connector. An I/O cable is provided with the Cascade II camera 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).

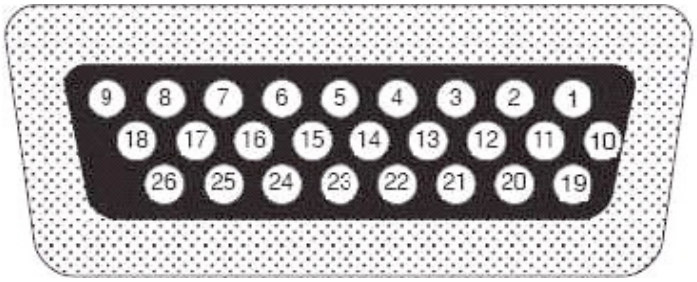


Figure 26. I/O connector pinouts

The numbers on the I/O connector diagram correspond to the numbered definition of each pin detailed in *Table 3*.

I/O Connector Pinouts

I/O PORTS, PIN NUMBERS & SIGNAL DESCRIPTIONS		
PORT #	**PIN #**	**Signal Description**
	1	Trigger Input: This input is internally tied high through a 4.7kW 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 4.7kW 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 50W 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 11	TTL I/O data bit 0: TTL level programmable input or output TTL I/O data bit 1: TTL level programmable input or output
Port 1	12 13	TTL I/O data bit 0: TTL level programmable input or output TTL I/O data bit 1: TTL level programmable input or output
Port 2	14 15	TTL I/O data bit 0: TTL level programmable input or output TTL I/O data bit 1: TTL level programmable input or output
Port 3	16 17	TTL I/O data bit 0: TTL level programmable input or output 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.
	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.

Table 3. I/O pinouts

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