THORLABS

CC Series Cameras
Cooled Scientific Digital Cameras

User Guide



Table of Contents

Chapter 1 Introduction 1
1.1 Intended Use 1
1.2 Explanation of Safety Warnings 1
1.3 Description 1
1.4 Technical Data 2
1.4.1 CC215MU Specifications 2
1.4.2 CC505MU Specifications 4
1.4.3 CC505MUP Specifications 6
1.4.4 CC895MU Specifications 9
1.4.5 CC126MU Specifications 11
1.4.6 General Specifications 13
1.4.7 Mechanical Drawings 14
1.5 Pin Diagrams 16
1.6 Components 17
1.6.1 CC215MU, CC505MU, CC895MU, and CC126MU Front Panel 17
1.6.2 CC505MUP Front Panel 17
1.6.3 Back Panel 18
1.7 Simplified Declaration of Conformity 18
1.8 FCC Designation 18
1.9 Auxiliary I/O Cable Requirements 19
Chapter 2 Safety 20
Chapter 3 Installation 21
3.1 Warranty Information 21
3.2 Packing List 21
3.2.1 Optional Items 21
3.3 Receiving and Unpacking 21
3.4 Installation Instructions 22
3.4.1 Pre-Installation - USB 3.0 22
3.4.2 Installing the Software 22
3.4.3 Connecting the Camera 23
3.4.4 Multiple Camera Operation 24
3.4.5 Optical and Mechanical Mounting Considerations 24
3.4.6 Optical Front End Procedures 27
3.4.7 Auxiliary Connector 28
Chapter 4 Operation 30
4.1 Starting the Camera 30
4.2 Camera Timing Diagrams 31
4.3 Camera-Specific Timing Considerations 33
4.4 Equal-Exposure Pulse (CC215MU Quantalux® Only) 33
4.5 Hot Pixel Correction 35

4.6 Frame-Rate Control 36

Chapter 5 Maintenance and Cleaning 37

Chapter 6 Troubleshooting and Repair 40

6.1 Interface 40

6.2 Optical 40

6.3 Operational 41

6.4 Software 42

Chapter 7 Disposal 43

Chapter 8 Thorlabs Worldwide Contacts 44

Chapter 1 Introduction

1.1 Intended Use

The products outlined in this manual are intended to be used as scientific imaging cameras, working best for applications with low light levels and longer exposure times. These are designed to be used within a laboratory environment only and powered from an auxiliary AC-DC power supply. These are controlled by connecting to a PC using the listed software through the provided USB cable. These are intended to be used at room temperature and protected from rapid variation in temperature and high humidity.

While these cameras are easily adapted for custom interfaces, they should only be used with accessories provided by Thorlabs to achieve the listed specifications. These are not certified for medical applications, including but not limited to life support situations.

The products may only be used in accordance with the instructions described in this manual. Any other use will invalidate the warranty.

1.2 Explanation of Safety Warnings

⚠CAUTION Caution indicates a hazard with a low level of risk that, if not avoided, could result in minor or moderate injury.

NOTICE Indicates information considered important, but not hazard-related, such as possible damage to the product.


Shock Warning


The CE/UKCA markings on the product are the manufacturer's declaration that the product complies with the essential requirements of the relevant European health, safety, and environmental protection legislation.


The wheelie bin symbol on the product, the accessories or packaging indicates that this device must not be treated as unsorted municipal waste but must be collected separately.

1.3 Description

The CC215MU is a 2.1 MP monochrome sCMOS camera, the CC505MU is a 5.0 MP monochrome CMOS camera, the CC505MUP is a 5.0 MP monochrome CMOS camera with an on-chip wire grid polarizer array, the CC895MU is an 8.9 MP monochrome CMOS camera, and the CC126MU is a 12.3 MP monochrome CMOS camera. All are USB 3.0, actively cooled scientific cameras. All are compatible with many related Thorlabs products, including C-mount lenses and our 60 mm cage system. They are supported by our ThorImage®CAM camera application as well as the free Micro-Manager software. They are also supported in LabVIEW and MATLAB through our .NET interfaces for each. The CC215MU is an extension of our Quantalux® CS2100M-USB sCMOS Compact Scientific camera and the CC505MU, CC505MUP, CC895MU, and CC126MU are extensions of our Kiralux® CMOS Compact Scientific camera family for active thermoelectric cooling of the sensor to reduce the dark shot noise.

The cameras include the full complement of downloadable Thorlabs imaging software. For end-users, the ThorImageCAM software application provides full control of the camera through an intuitive user interface, and it allows the user to acquire, pan, zoom, analyze, and save images and metadata. ThorImageCAM is only supported by 64-bit versions of Windows. For those operating 32-bit versions of Windows, use the legacy software ThorCam™.

For developers, Thorlabs also offers a Software Developer's Kit (SDK), which includes a comprehensive Application Programming Interface (API) to streamline the integration of any Thorlabs camera into your system. After software

installation, the SDK can be found in a sub-folder under C:\Program Files\Thorlabs. The same directory is used for 32- and 64-bit distributions.

This manual is a functional overview of these cameras, and it is meant to be a companion to the Camera Quick Start Guide, the ThorImage®CAM User Guide, and the Thorlabs Application Programming Interface Guide. All support documentation is available at **http://www.thorlabs.com/manuals**.

1.4 Technical Data

1.4.1 CC215MU Specifications

CC215MU sCMOS Sensor Specifications	
Sensor Type	sCMOS Monochrome
Number of Active Pixels	1920 (H) x 1080 (V) (~2.07 MP)
Pixel Size	5.04 µm x 5.04 µm
Optical Format	2/3" Format (9.68 mm x 5.44 mm)
Peak Quantum Efficiency	61% at 600 nm
Dynamic Range	Up to 87 dB
Full Well Capacity	≥23,000 e^-
Shutter Type	Rolling

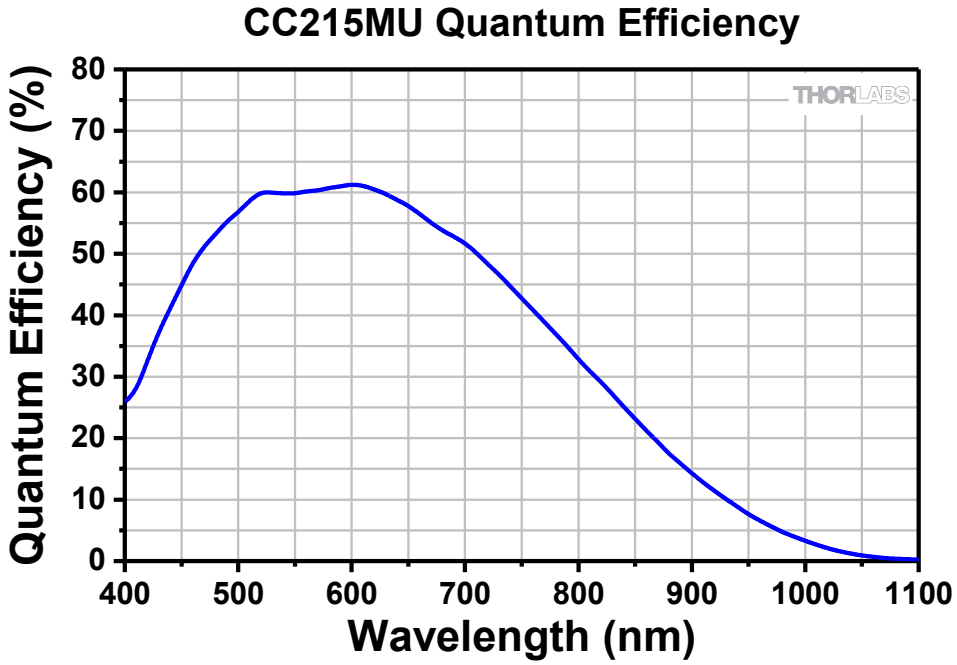


Figure 1 CC215MU Quantum Efficiency

CC215MU Imaging Specifications	
Exposure Time	0.029 to 7767.2 ms in ~0.03 ms Increments
Pixel Clock Speed	74.25 MHz and 148.5 MHz
Analog-to-Digital Converter (ADC) Resolution	16 Bits
Vertical and Horizontal Digital Binning	1 x 1 to 16 x 16
Region of Interest (Width x Height) (For Binning at 1 x 1)	8 x 2 Pixels to 1920 x 1080 Pixels, Rectangular
Read Noise	<1 e^- Median RMS[a] / <1.5 e^- RMS

a. Per Sensor Manufacturer's Specification

CC215MU Example Frame Rates[b]		
ROI	**Frame Rate[c]**	
	L.R.N.[d]	**H.F.R.[d]**
Full Sensor (1920 x 1080)	30 fps	50 fps
Half Sensor (960 x 540)	60 fps	100 fps
1/10th Sensor (192 x 108)	30 fps	500 fps

b. ~1 ms Exposure Time, 1 x 1 Binning, Frames per Trigger = Continuous

c. Frame rate is determined by frame valid (FVAL) frequency.

d. L.R.N. is Low Read Noise and H.F.R. is High Frame Rate. Both are optimization modes.

1.4.2 CC505MU Specifications

CC505MU CMOS Sensor Specifications	
Sensor Type	CMOS Monochrome
Number of Active Pixels	2448 (H) x 2048 (V) (~5.01 MP)
Pixel Size	3.45 µm x 3.45 µm
Optical Format	2/3" Format (8.45 mm x 7.07 mm)
Peak Quantum Efficiency	72% Over 525 to 580 nm (Typical)
Dynamic Range	Up to 71 dB
Full Well Capacity	≥10 000 e^-
Shutter Type	Global

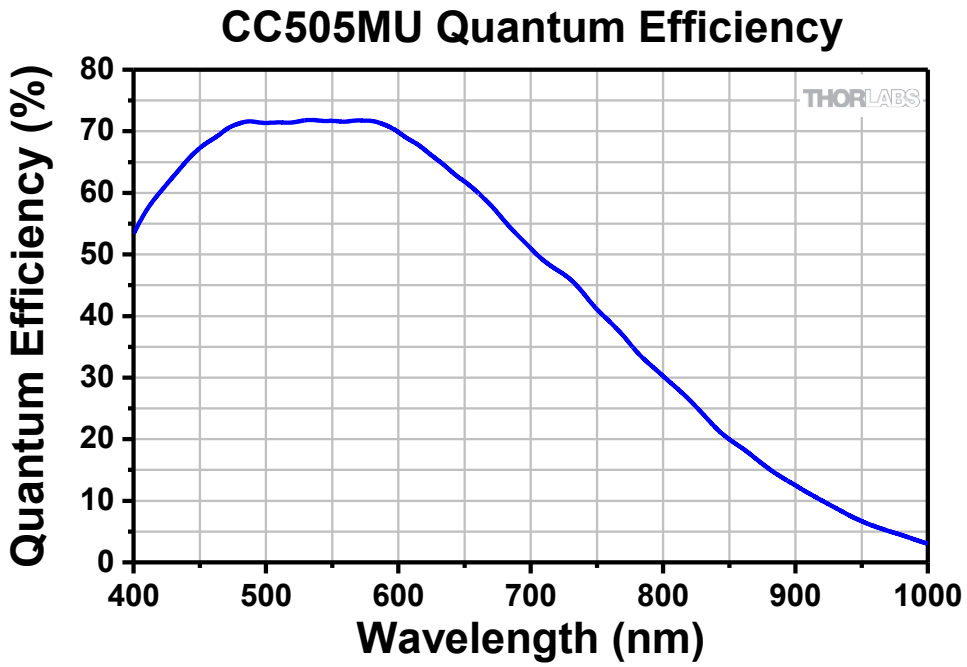


Figure 2 CC505MU Quantum Efficiency

CC505MU Imaging Specifications	
Exposure Time	0.027 to 14235 ms in ~0.013 ms Increments
ADC Resolution	12 Bits
Vertical and Horizontal Digital Binning	1 x 1 to 16 x 16
Region of Interest (Width x Height) (For Binning at 1 x 1)	260 x 4 Pixels to 2448 x 2048 Pixels, Rectangular
Read Noise	<2.5 e^- RMS
Dark Current[a]	<0.066 e^-/pixel/s
Overlapped Exposures	Frames per Trigger = Continuous Only

a. Dark current is measured with an ROI of 256 x 256 located at the center of the sensor. Dark current will be higher at the periphery due to glow from integrated active circuitry adjacent to the pixel array. Variation from camera to camera should be expected due to sensor manufacturing variability. All measurements were performed in an environmental chamber at 20 °C ambient.

CC505MU Example Frame Rates[b]	
ROI	**Frame Rate[c,d]**
Full Sensor (2448 x 2048)	35 fps
Half Sensor (1224 x 1024)	68 fps
~1/10th Sensor (260 x 208)	290 fps
Min ROI (260 x 4)	887.6 fps

b. ~1 ms Exposure Time, 1 x 1 Binning, Frames per Trigger = Continuous

c. Frame rate is determined by frame valid (FVAL) frequency.

d. Frame rate is directly dependent on the capabilities of the host computer. Results may vary. See also Section 4.6: Frame-Rate Control.

1.4.3 CC505MUP Specifications

CC505MUP CMOS Polarization Sensor Specifications	
Sensor Type	CMOS Monochrome With Micropolarizer Array
Number of Active Pixels	2448 (H) x 2048 (V) (~5.01 MP)
Pixel Size	3.45 µm x 3.45 µm
Optical Format	2/3" Format (8.45 mm x 7.07 mm)
Peak Quantum Efficiency	72% Over 525 to 580 nm (Typical)
Dynamic Range	Up to 71 dB
Full Well Capacity	≥10,000 e^-
Shutter Type	Global

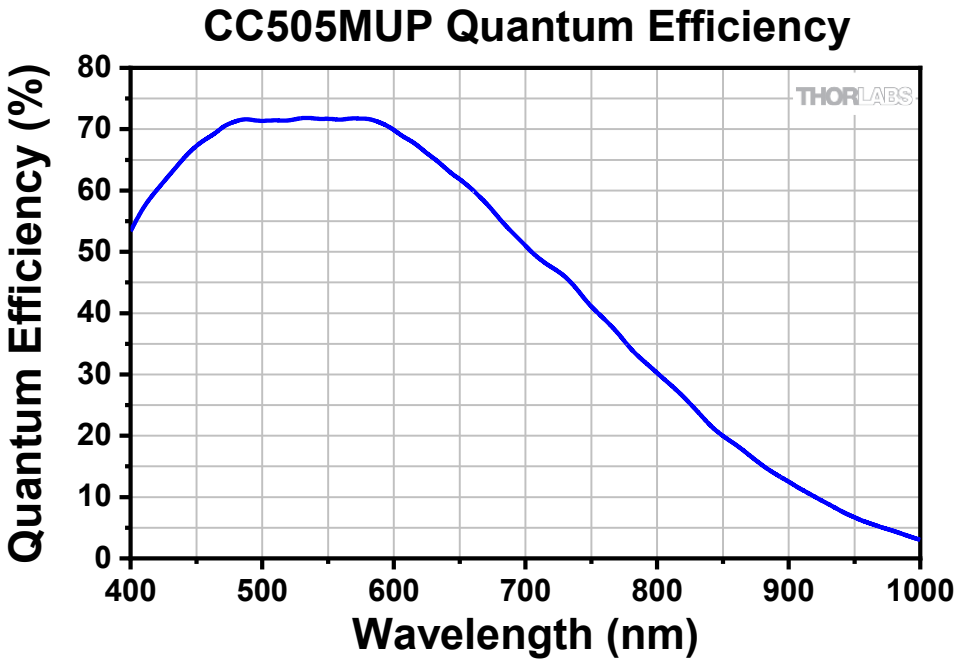


Figure 3 CC505MUP Quantum Efficiency

CC505MUP Imaging Specifications	
Exposure Time	0.027 to 14235 ms in ~0.013 ms Increments
ADC Resolution	12 Bits
Vertical and Horizontal Digital Binning	1 x 1 to 16 x 16
Region of Interest (Width x Height) (For Binning at 1 x 1)	260 x 4 Pixels to 2448 x 2048 Pixels, Rectangular
Read Noise	<2.5 e^- RMS
Dark Current[a]	<0.066 e^-/pixel/s
Overlapped Exposures	Frames per Trigger = Continuous Only

a. Dark current is measured with an ROI of 256 x 256 located at the center of the sensor. Dark current will be higher at the periphery due to glow from integrated active circuitry adjacent to the pixel array. Variation from camera to camera should be expected due to sensor manufacturing variability. All measurements were performed in an environmental chamber at 20 °C ambient.

CC505MUP Example Frame Rates[b]	
ROI	**Frame Rate[c,d]**
Full Sensor (2448 x 2048)	35 fps
Half Sensor (1224 x 1024)	68 fps
~1/10th Sensor (260 x 208)	290 fps
Min ROI (260 x 4)	887.6 fps

b. ~1 ms Exposure Time, 1 x 1 Binning, Frames per Trigger = Continuous

c. Frame rate is determined by frame valid (FVAL) frequency.

d. Frame rate is directly dependent on the capabilities of the host computer. Results may vary. See also Section 4.6: Frame-Rate Control.

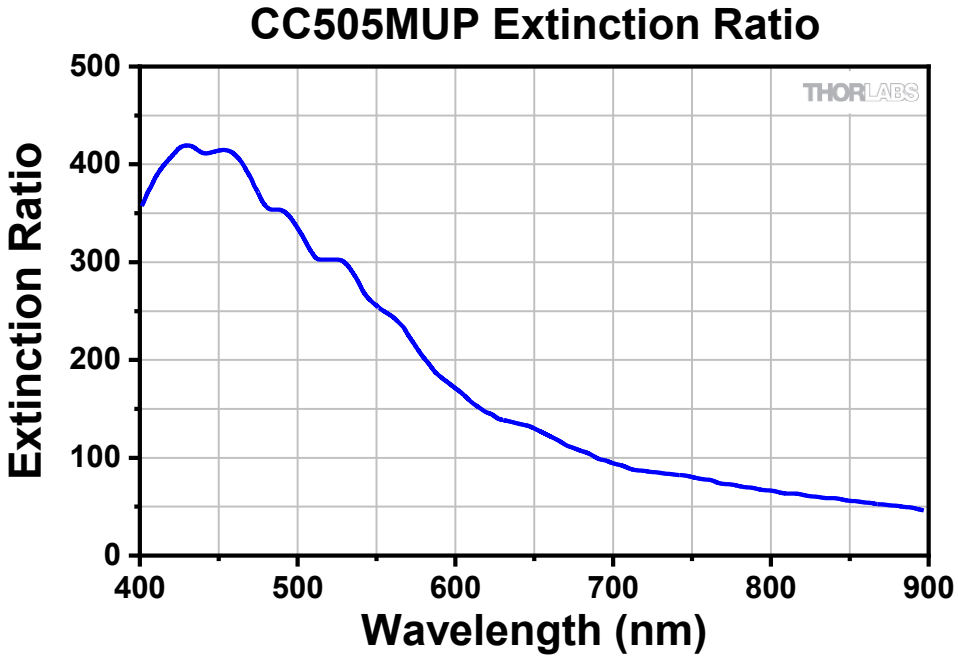


Figure 4 CC505MUP Extinction Ratio

Micropolarizer Array (Item # CC505MUP Only)

The CC505MUP image sensor incorporates an integral, linear micropolarizer array to detect the linear polarization states within the image. The micropolarizer array is fabricated directly on the sensor and arranged in a mosaic pattern, as shown in Figure 5. Each pixel is covered with one of four linear polarizers with orientations of -45°, 0°, 45°, or 90°. These pixel values are then used to compute the three polarization parameters for the light incident at every pixel: intensity, degree of linear polarization, and azimuth. Refer to the ThorImageCAM user guide for more information on operating the polarization camera and interacting with polarization images.

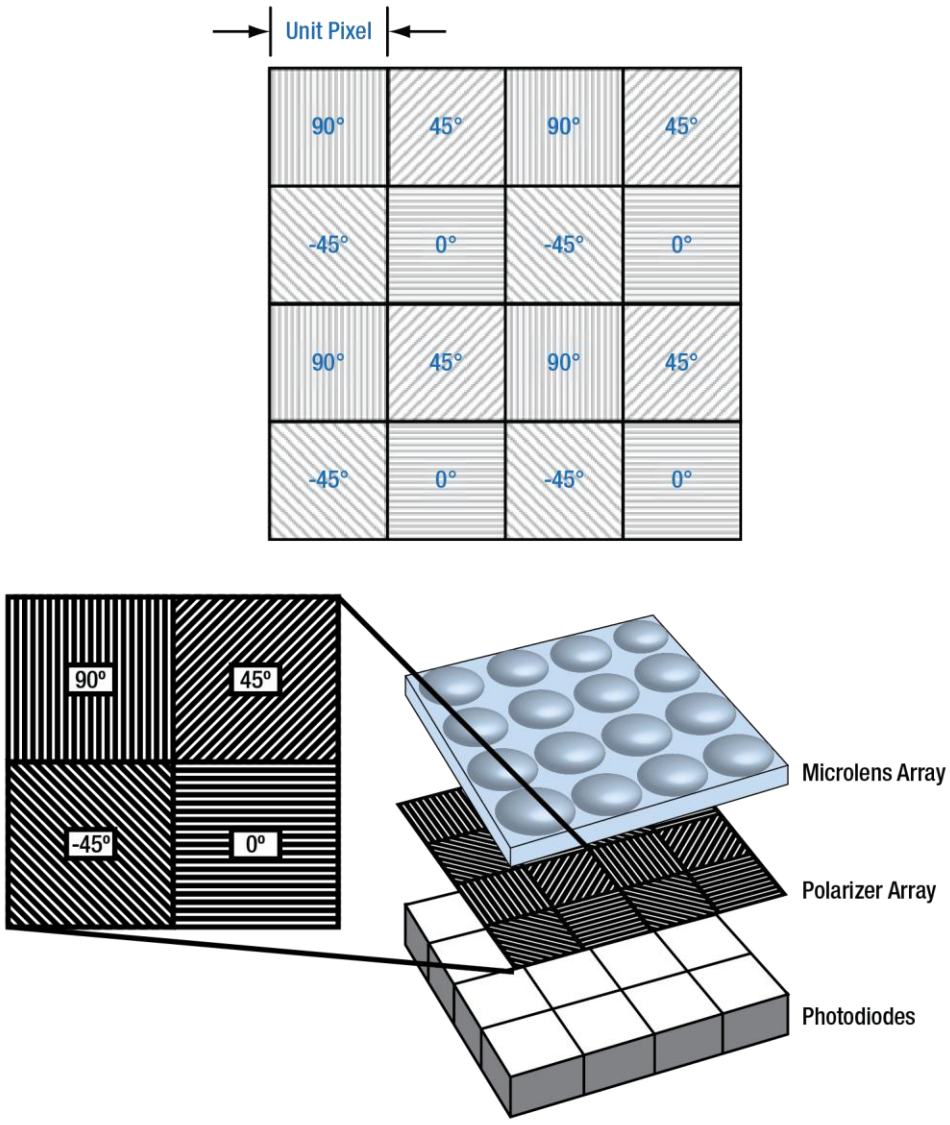


Figure 5 ***The four-directional wire grid polarizer array is present on the sensor chip between the microlens array and the photodiodes.***

Polarization Azimuth Marking

Each CC505MUP comes with front plate markings that indicate the orientation of the incident polarization azimuth as interpreted by the software, as shown in Figure 12.

Software Compatibility

The CC505MUP camera will only work with ThorImage®CAM or ThorCam™ V3.3.0 or higher.

1.4.4 CC895MU Specifications

CC895MU CMOS Sensor Specifications	
Sensor Type	CMOS Monochrome
Number of Active Pixels	4096 (H) x 2160 (V) (~8.9 MP)
Pixel Size	3.45 µm x 3.45 µm
Optical Format	1" Format (14.13 mm x 7.45 mm)
Peak Quantum Efficiency	72% Over 525 to 580 nm (Typical)
Dynamic Range	Up to 71 dB
Full Well Capacity	≥10,650 e^-
Shutter Type	Global

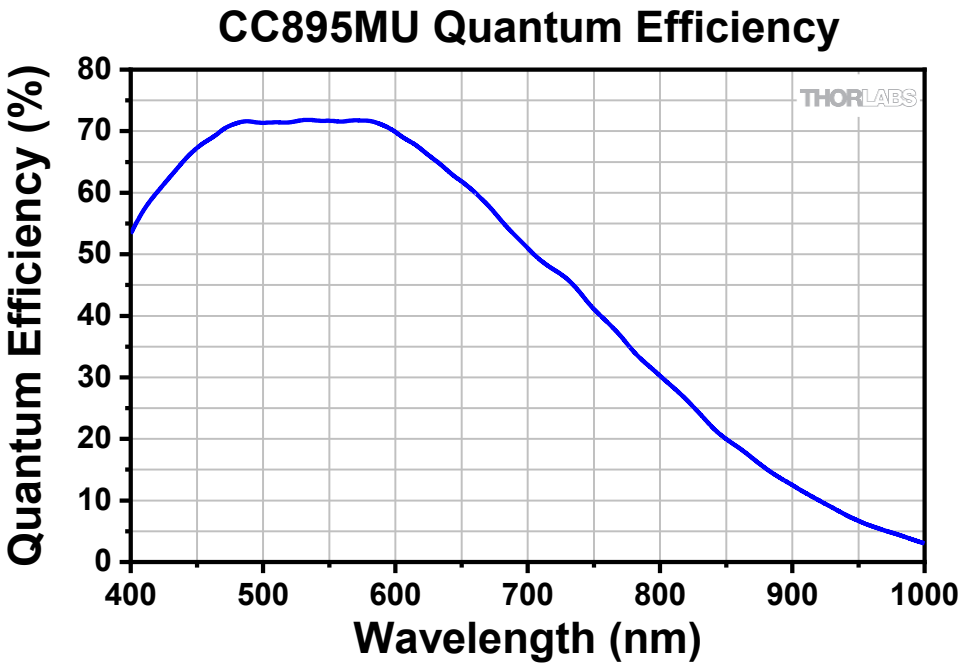


Figure 6 CC895MU Quantum Efficiency

CC895MU Imaging Specifications	
Exposure Time	0.036 to 22795 ms in ~0.022 ms Increments
ADC Resolution	12 Bits
Vertical and Horizontal Digital Binning	1 x 1 to 16 x 16
Region of Interest (Width x Height) (For Binning at 1 x 1)	260 x 4 Pixels to 4096 x 2160 Pixels, Rectangular
Read Noise	<2.5 e^- RMS
Dark Current[a]	<0.04 e^-/pixel/s
Overlapped Exposures	Frames per Trigger = Continuous Only

a. Dark current is measured with an ROI of 256 x 256 located at the center of the sensor. Dark current will be higher at the periphery due to glow from integrated active circuitry adjacent to the pixel array. Variation from camera to camera should be expected due to sensor manufacturing variability. All measurements were performed in an environmental chamber at 20 °C ambient.

CC895MU Example Frame Rates[b]	
ROI	**Frame Rate[c,d]**
Full Sensor (4096 x 2160)	20.8 fps
Half Sensor (2048 x 1080)	40.8 fps
~1/10th Sensor (410 x 216)	175.4 fps
Min ROI (260 x 4)	922 fps

b. ~1 ms Exposure Time, 1 x 1 Binning, Frames per Trigger = Continuous

c. Frame rate is determined by frame valid (FVAL) frequency

d. Frame rate is directly dependent on the capabilities of the host computer. Results may vary. See also Section 4.6: Frame-Rate Control.

1.4.5 CC126MU Specifications

CC126MU CMOS Sensor Specifications	
Sensor Type	CMOS Monochrome
Number of Active Pixels	4096 (H) x 3000 (V) (~12.3 MP)
Pixel Size	3.45 µm x 3.45 µm
Optical Format	1.1" Format (14.13 mm x 10.35 mm)
Peak Quantum Efficiency	72% Over 525 to 580 nm (Typical)
Dynamic Range	Up to 71 dB
Full Well Capacity	≥10,650 e^-
Shutter Type	Global

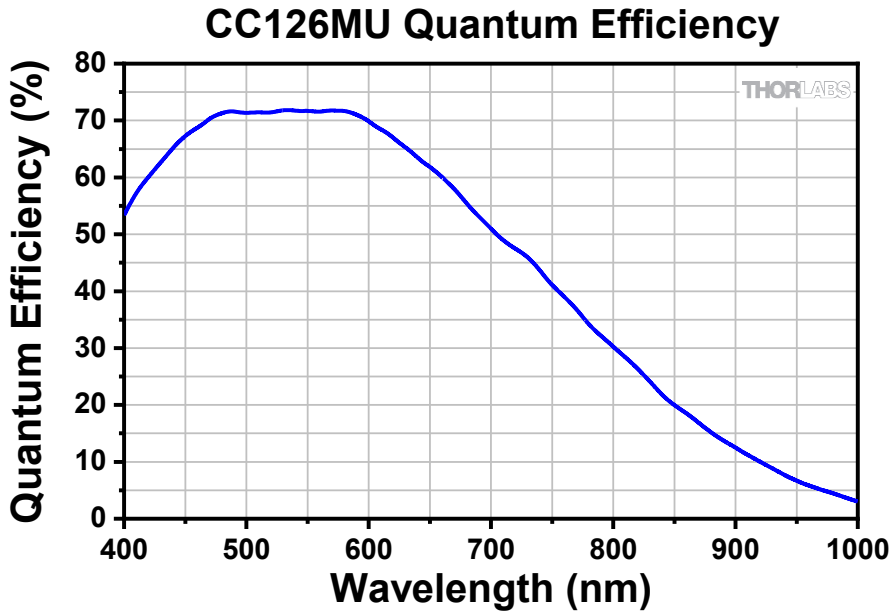


Figure 7 CC126MU Quantum Efficiency

CC126MU Imaging Specifications	
Exposure Time	0.028 to 14700.9 ms in ~0.014 ms Increments
ADC Resolution	12 Bits
Vertical and Horizontal Digital Binning	1 x 1 to 16 x 16
Region of Interest (Width x Height) (For Binning at 1 x 1)	260 x 4 Pixels to 4096 x 3000 Pixels, Rectangular
Read Noise	<2.5 e^- RMS
Dark Current[a]	<0.035 e^-/pixel/s
Overlapped Exposures	Frames per Trigger = Continuous Only

a. Dark current is measured with an ROI of 256 x 256 located at the center of the sensor. Dark current will be higher at the periphery due to glow from integrated active circuitry adjacent to the pixel array. Variation from camera to camera should be expected due to sensor manufacturing variability. All measurements were performed in an environmental chamber at 20 °C ambient.

CC126MU Example Frame Rates[b]	
ROI	**Frame Rate[c,d]**
Full Sensor (4096 x 3000)	15.1 fps
Half Sensor (2048 x 1500)	29.8 fps
~1/10th Sensor (410 x 300)	132.9 fps
Min ROI (260 x 4)	869.6 fps

b. ~1 ms Exposure Time, 1 x 1 Binning, Frames per Trigger = Continuous

c. Frame rate is determined by frame valid (FVAL) frequency

d. Frame rate is directly dependent on the capabilities of the host computer. Results may vary. See also Section 4.6: Frame-Rate Control.

1.4.6 General Specifications

Item #	CC215MU	CC505MU	CC505MUP	CC895MU	CC126MU
General Specifications					
AR-Coated Window Reflectivity	R_{avg} < 0.5% per Surface (400 - 700 nm)				
AR-Coated Window Glass	N-BK7				
Max Filter Thickness When Using C-Mount Adapter	0.08" (2.0 mm)				
USB Power Consumption (Full Sensor ROI, Camera Only, Powered from Host Computer)	3.7 W Max @ 30 fps 4.3 W Max @ 50 fps	3.6 W Max @ 35 fps		3.7 W Max @ 20.8 fps	3.7 W Max @ 15.1 fps
Cooling Power Consumption	10.0 W Max, Cooler Power Only (Using Provided Power Supply, 100 - 240 VAC @ 50 - 60 Hz.)				
Operating Ambient Temperature	10 °C to 40 °C (Non-Condensing)				
Storage Temperature	0 °C to 55 °C				
Sensor Temperatures in Cooling Mode (at Operating Temperature)	-10 °C to 20 °C			-5 °C to 25 °C	

1.4.7 Mechanical Drawings

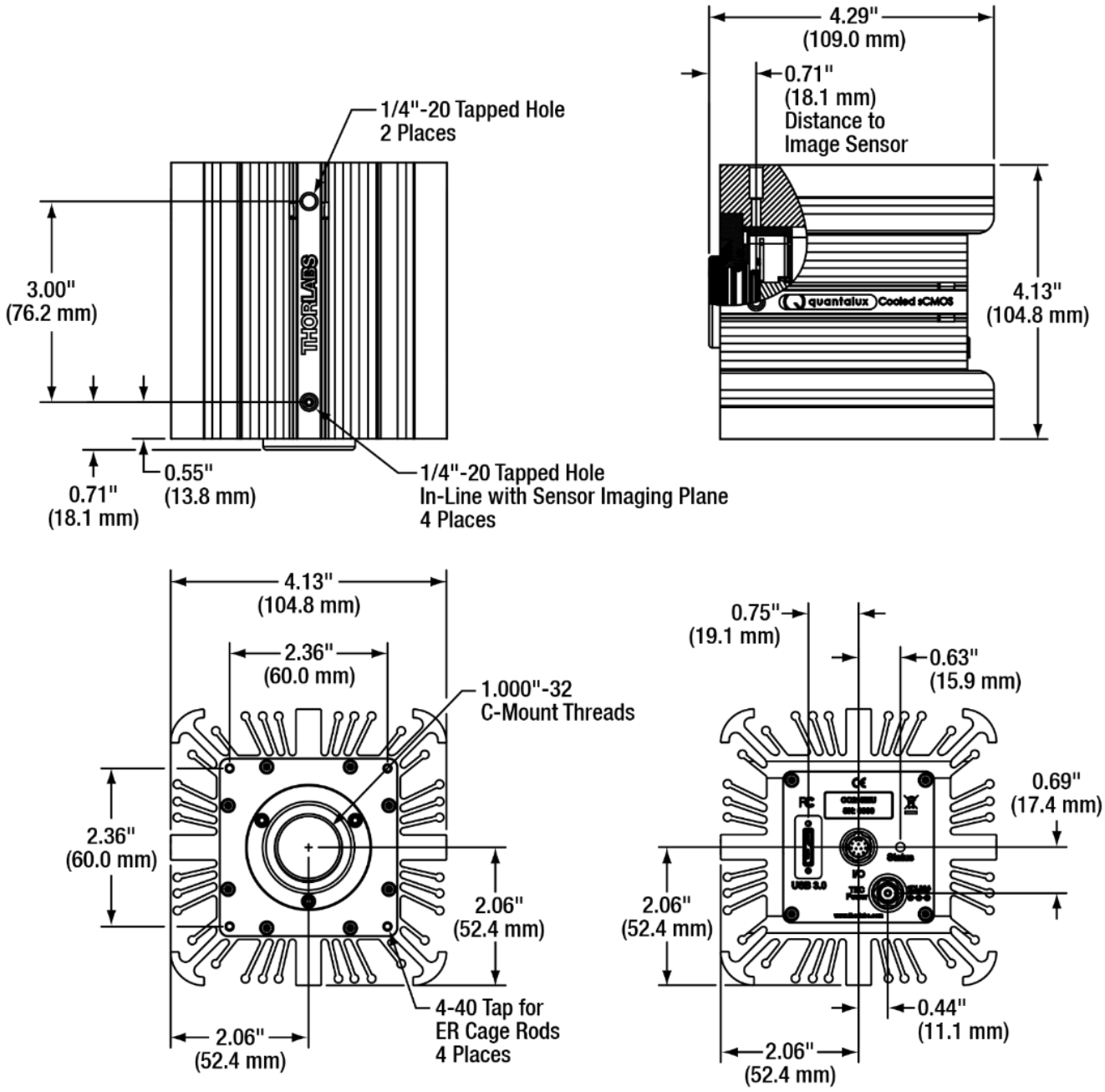


Figure 8 ***Cooled Scientific Camera Mechanical Drawing (Markings Vary Across the CC Camera Series)***

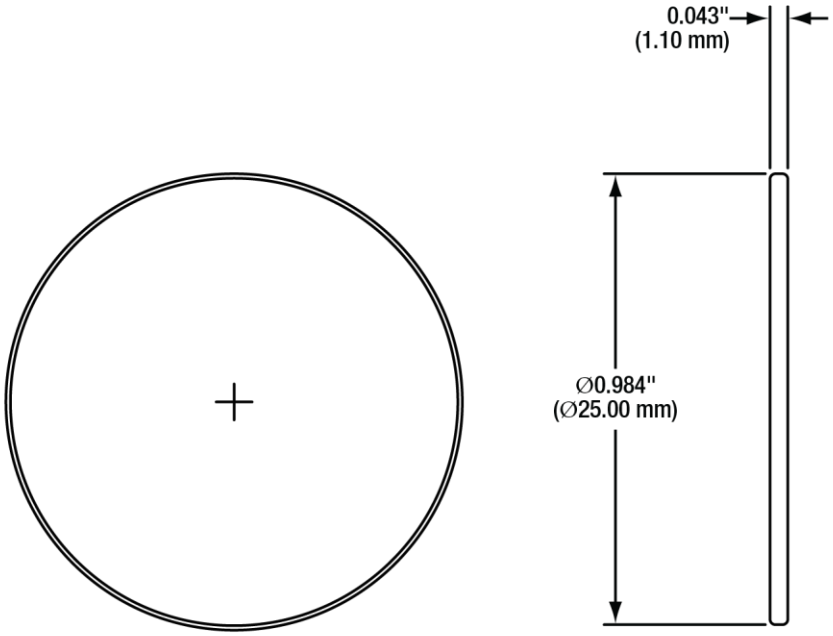


Figure 9 Protective Glass Window Mechanical Drawing

1.5 Pin Diagrams

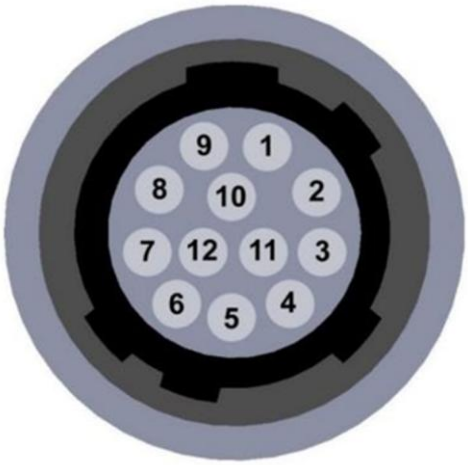


Figure 10 Illustration of the Auxiliary Connector on the Rear of the Camera

Pin Descriptions	
Pin #	**Signal**
1	Ground
2	Ground
3	Ground
4	LVTTL STROBE_OUT / EEP
5	LVTTL TRIGGER_IN
6	LVTTL LVAL_OUT
7	OPTO I/O_OUT STROBE
8	OPTO I/O_ RTN
9	OPTO I/O_IN
10	Ground
11	Ground
12	LVTTL FVAL_OUT

1.6 Components

1.6.1 CC215MU, CC505MU, CC895MU, and CC126MU Front Panel

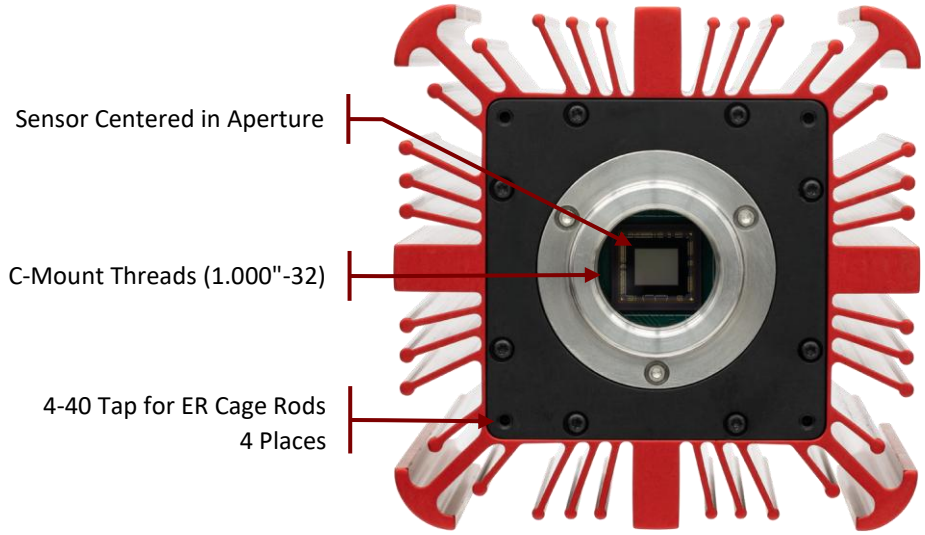


Figure 11 CC215MU, CC505MU, CC895MU, and CC126MU Front Panel

1.6.2 CC505MUP Front Panel

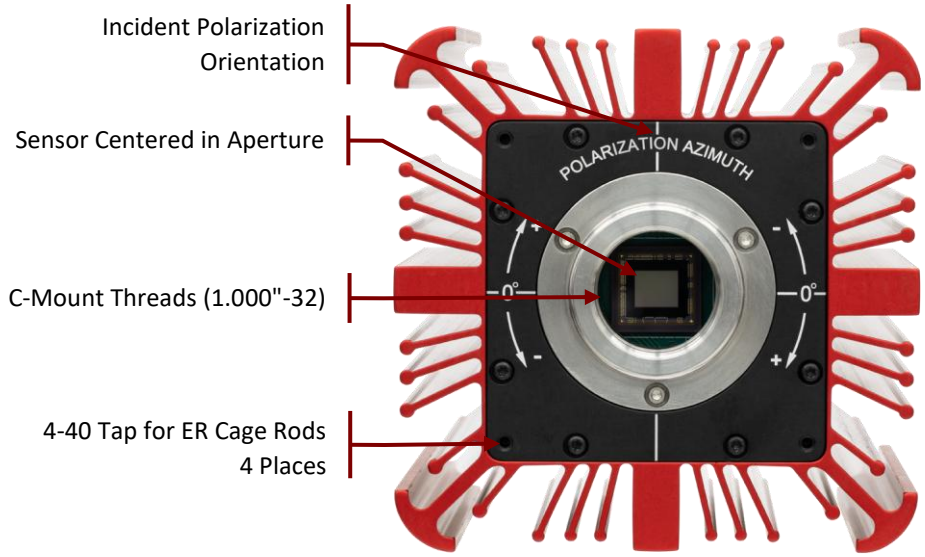


Figure 12 CC505MUP Front Panel

1.6.3 Back Panel



Figure 13 Back Panel

1.7 Simplified Declaration of Conformity

The full text of the EU declaration of conformity is available at the following internet addresses:

https://www.thorlabs.com/f317187

https://www.thorlabs.com/f334942

https://www.thorlabs.com/f313271

1.8 FCC Designation

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules, and meets all requirements of the Canadian Interference Causing Equipment Standard ICES-003 for digital apparatus. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Thorlabs is not responsible for any radio television interference caused by modifications of this equipment or the substitution or attachment of connecting cables and equipment other than those specified by Thorlabs. The correction of interference caused by such unauthorized modification, substitution or attachment will be the responsibility of the user. The use of shielded I/O cables is required when connecting this equipment to any and all optional peripheral or host devices. Failure to do so may violate FCC and ICES rules.

1.9 Auxiliary I/O Cable Requirements

The Digital Camera is not supplied with a cable for connecting to the AUX I/O port of the camera. This cable is application-specific in all cases due to varying lengths and functions that are used. If an auxiliary I/O cable is to be used with this camera, it must be constructed with the requirements shown in Section 3.4.7 in order for the camera to adhere to CE and FCC compliance.

Chapter 2 Safety

Please read the instruction manual carefully before operating your digital camera. All statements regarding safety and technical specifications will only apply when the unit is operated correctly.

NOTICE

Notice

This equipment is intended for laboratory use only and is not certified for medical applications, including but not limited to, life support situations.

NOTICE

Warranty Notice

Do not open the digital camera. There are no user-serviceable parts in this product. Opening the device will void your warranty. Any modification or servicing of this system by unqualified personnel renders Thorlabs free of any liability. This device can only be returned when packed into the complete original packaging, including all foam packing inserts. If necessary, ask for replacement packaging. Please contact Thorlabs' Technical Support at **techsupport@thorlabs.com,** and a member of our team will be happy to assist you.

NOTICE

Transportation and delivery may cause the digital camera to be warm or cool upon receipt. Please wait for the device to reach room temperature before attempting to operate.



Caution

This product is powered directly from the USB 3.0 port of a host computer (not included), and from an auxiliary AC-DC power supply (included). To ensure optimal performance and the safety of the user, the host computer must use a properly grounded UL Listed or Recognized AC-DC power supply (or comparable regulatory approvals).

Dangerous voltage exists within the power supplies. Do not tamper with or open the supplies under any circumstances. Doing so may expose personnel to lethal voltages and will void the warranty of the computer and the camera.

Chapter 3 Installation

3.1 Warranty Information

Thorlabs warrants that all products sold will be free from defects in material and workmanship and will conform to the published specifications under normal use, when correctly installed and maintained.

All specific warranty and repair information can be found in the general terms and conditions located at **https://www.thorlabs.com/legal**

This precision device is only serviceable if returned and properly packed into the complete original packaging including the complete shipment plus the cardboard insert that holds the enclosed devices. If necessary, ask for replacement packaging. Refer servicing to qualified personnel.

3.2 Packing List

- Cooled Scientific Digital Camera
- USB 3.0 Type Micro B to A Cable for PC Connection, 3 m Long[1]
- Hex Key - 5/64" (for C-Mount Adapter Removal)
- Lens Dust Cap
- 5 V / 3 A AC-DC Converter, 2 m Long (Region-Specific Adapter Included, for TEC Cooling Power Only)
- Quick Start Guide

3.2.1 Optional Items

- Auxiliary I/O Patch cable – The auxiliary connector on the camera allows the user to access optional camera control and internal status signals (see Section 3.4.7). Order Item # Thorlabs 8050-CAB1 and either Item # TSI-IOBOB or Item # TSI-IOBOB2 (for use with an Arduino board).
- Region-Specific Mains Power Plug Adapters[2] (See Figure 14)

3.3 Receiving and Unpacking

Your camera was thoroughly tested and carefully packed at the factory. Once the camera shipment is accepted for delivery, the carrier assumes full responsibility for its safe arrival. Should you receive your shipment with any damage—concealed or apparent—please contact the carrier at once. The carrier will instruct you on how to initiate a damage claim. If a visual inspection reveals damage upon receipt, it must be noted on the freight bill or express receipt and the notation signed by the carrier's agent. Failure to do so can result in the carrier refusing to honor the claim.

To return your camera to Thorlabs for service, you must first contact your local Thorlabs office or distributor and request a Return Material Authorization (RMA). Returns will not be accepted without an RMA. See Section 3.1: Warranty Information for details.

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[1] All cameras are supplied with one USB 3.0 cable. These cables are constructed to provide reliable data throughput at a length of 3 m. Do not replace this cable with a 3 m cable from a different vendor. The use of a shorter cable (1 m or 2 m) may be acceptable but is not guaranteed. Never use any cable that is longer than 3 m on a USB 3.0 system.

*[2] Each camera is shipped with a region-specific power adapter based on the country where the order was placed. The adapters are only available for individual purchase by contacting **Tech Sales**.*

3.4 Installation Instructions

3.4.1 Pre-Installation - USB 3.0

Your camera will only operate when connected to a USB 3.0 "SS" (SuperSpeed) port on your PC. USB 2.0 ports are not supported at this time. A USB 3.0 compatible port is typically blue - but not always. Look for this symbol above the port to be sure it is USB 3.0:



If your computer does not have a USB 3.0 port, it is likely an indication that it is an older machine. If you must use that machine, Thorlabs recommends our PCIe USB 3.0 card (Thorlabs' Item # USB3-PCIE).

Recommended Installation Sequence:

1. Run the software installer following the steps outlined in the next section.
2. Connect the camera to the controlling PC. Power will be applied when connected to a USB 3.0 port. See Section 3.4.3.
3. Your PC should discover the new USB device and install the necessary drivers. This may take a minute or so for the first instance.
4. Run the ThorImage®CAM application software.

3.4.2 Installing the Software

ThorImageCAM runs on Windows 10 (64-bit) and Windows 11 operating systems ONLY. For those operating Windows 7, use the legacy software, ThorCam™, which is available for download at the same URL.

Download and Run the Installation File

You may download the latest version of the software from our webpage **ThorImageCAM Software for Scientific and Compact USB Cameras**. Download the file to your host computer, double-click the file to run the installation, and follow the on-screen prompts.

Software Designer Kits (SDKs) for Windows and Linux are also available at the same download page.

Once setup is complete, you may now proceed to the next section that will describe how to connect and power on your camera. When the camera is connected and powered up, you can navigate to the ThorImageCAM Imaging Software as shown below:

"Start"→"All Programs"→"Thorlabs" → "ThorImageCAM"

Or simply double-click on the ThorImageCAM shortcut icon that was placed on your desktop during installation of the software:



Installing 3rd Party Software Application Support

After installation of Thorlabs components is complete, you have access to interfaces for select 3rd-party image analysis packages you may already have installed on your computer, such as MATLAB®*.

*MATLAB® is a registered trademark of The MathWorks, Inc.

3rd-party application software interfaces are located in Zip files in the following directory:

`C:\Program Files\Thorlabs\Scientific Imaging\Scientific Camera Support`

Important: Do not develop 3rd-party solutions in this directory, as they will be deleted if you update your ThorImage®

CAM software.

To use the MATLAB and LabVIEW interfaces, extract the files from the Zip archive and place them in the appropriate directory on your system.

Special note for users of Micro-Manager (µManager) software: support for Thorlabs scientific cameras (excluding the CS505MUP polarization camera) is included when you run versions 2.0 and later. If you wish to download or update your Micro-Manager software, please visit

https://micro-manager.org/wiki/Micro-Manager_Open_Source_Microscopy_Software

Before using your camera within Micro-Manager, first make sure that your camera is properly installed and powered on. You may run a session of ThorImage®CAM to confirm that the camera, software, and drivers are properly installed. Then, shut down your ThorImageCAM session and start a Micro-Manager session.

3.4.3 Connecting the Camera

To connect the camera, follow the steps below, referring to Figure 13 for the back panel connections.

1. Connect the provided USB 3.0 cable[3] into the mating **USB 3.0** port on the back of the camera. The camera end of the cable will have two thumb screws. Make sure the connector is fully inserted, and then tighten the thumbscrews by hand into the camera housing.
2. Connect the provided +5 V / 3 A power supply to the TEC Power port by threading the mating connector onto the camera's connector.
3. Connect the other end of the USB 3.0 cable to a USB 3.0 port (USB SS) on the host computer. Note: The camera will turn on at this point.
4. If external I/O signaling is required, connect an 8050-CAB1 cable (not included) to the I/O port. See Section 3.4.7
5. Confirm that the appropriate AC mains adapter is installed on the +5 V / 3 A power supply, then plug it into a suitable AC Mains power source of 100 - 240 VAC @ 50 - 60 Hz. See Section 3.2.



Figure 14 TEC Power Supply and Region-Specific Mains Adapters

[3] All cameras are supplied with one USB 3.0 cable. These cables are constructed to provide reliable data throughput at a length of 3 m. Do not replace this cable with a 3 m cable from a different vendor. The use of a shorter cable (1 m or 2 m) may be acceptable but is not guaranteed. Never use any cable that is longer than 3 m on a USB 3.0 system.

3.4.4 Multiple Camera Operation

If multiple cameras need to be controlled by the same computer, it is recommended that each camera use a dedicated USB 3.0 port. Do not use a USB 3.0 hub.

3.4.5 Optical and Mechanical Mounting Considerations

Using a C-Mount Lens

For the best results, the use of a C-mount lens that matches the optical format of the sensor's imaging area is recommended (refer to the sensor specifications for your camera in Section 1.4). For more information on Thorlabs C-Mount lenses, please visit **https://www.thorlabs.com/g441523**.

C-mount lenses are specified with a flange focal distance of 17.5 mm in free air. However, there can be considerable variation in the flange focal distance among commercially available lenses, as well as effects due to inline optics.

To accommodate these variations, the camera has a fixed flange distance of 18.0 mm to allow you to bring objects at infinity in focus before the infinity stop on the lens is reached.

Mounting the Camera

On most commercial microscopes, the use of a suitable adapter is recommended in order to match the optical format of the imaging area. Please note that some commercial 1X adapters may underfill the imaging area, leading to vignetting of the image.

Six 1/4"-20 tapped holes are provided, one or two on each side of the camera housing. These holes may be used with tripods or other optical mounting devices. The 1/4"-20 tapped holes are compatible with Thorlabs Ø1" posts. For more information on Thorlabs Ø1" posts, please visit **https://www.thorlabs.com/g441282.**

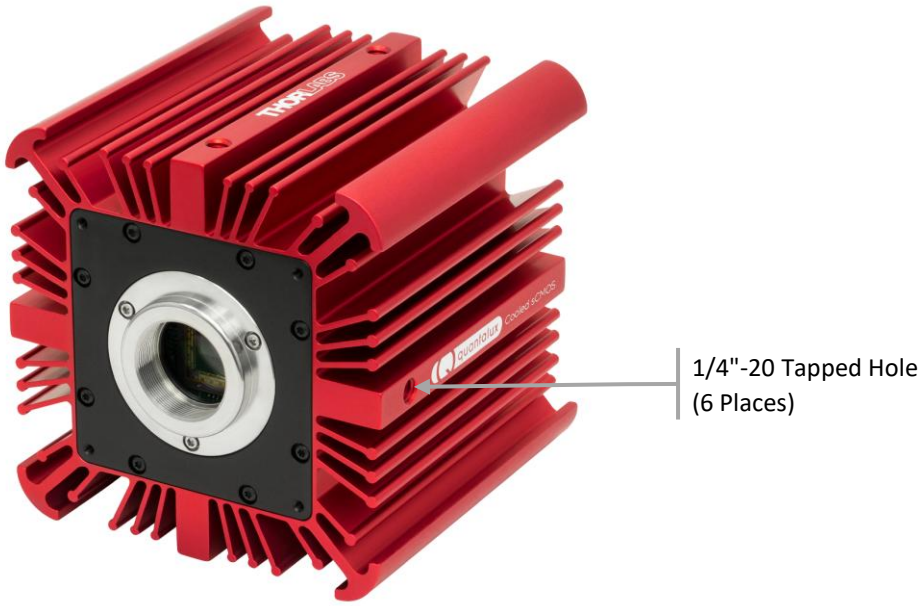


Figure 15 Arrow Indicates One of the Six 1/4"-20 Tapped Holes on Camera (Markings Vary Across the CC Camera Series)

Using the Camera with a Cage System

The cameras have 4-40 tapped holes on the front face for compatibility with Thorlabs' 60 mm Cage systems.

For more information on Thorlabs' 60 mm Cage system components, please visit **https://www.thorlabs.com/g441341**.

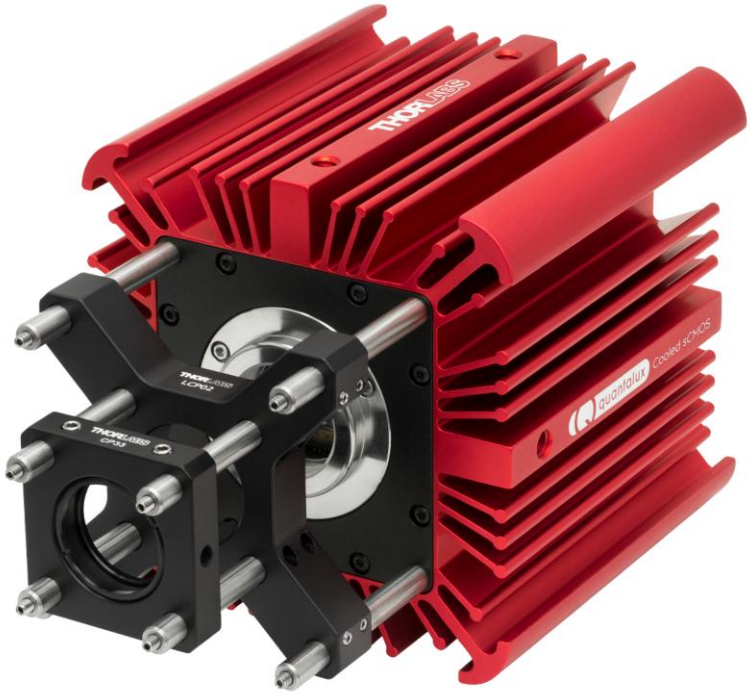


Figure 16 ***Camera Shown as Part of a 60 mm Thorlabs Cage System with Adaptor Plate to 30 mm Cage System (Markings Vary Across the CC Camera Series)***

Optical Front End

The images below show the components located on the front end of the camera.

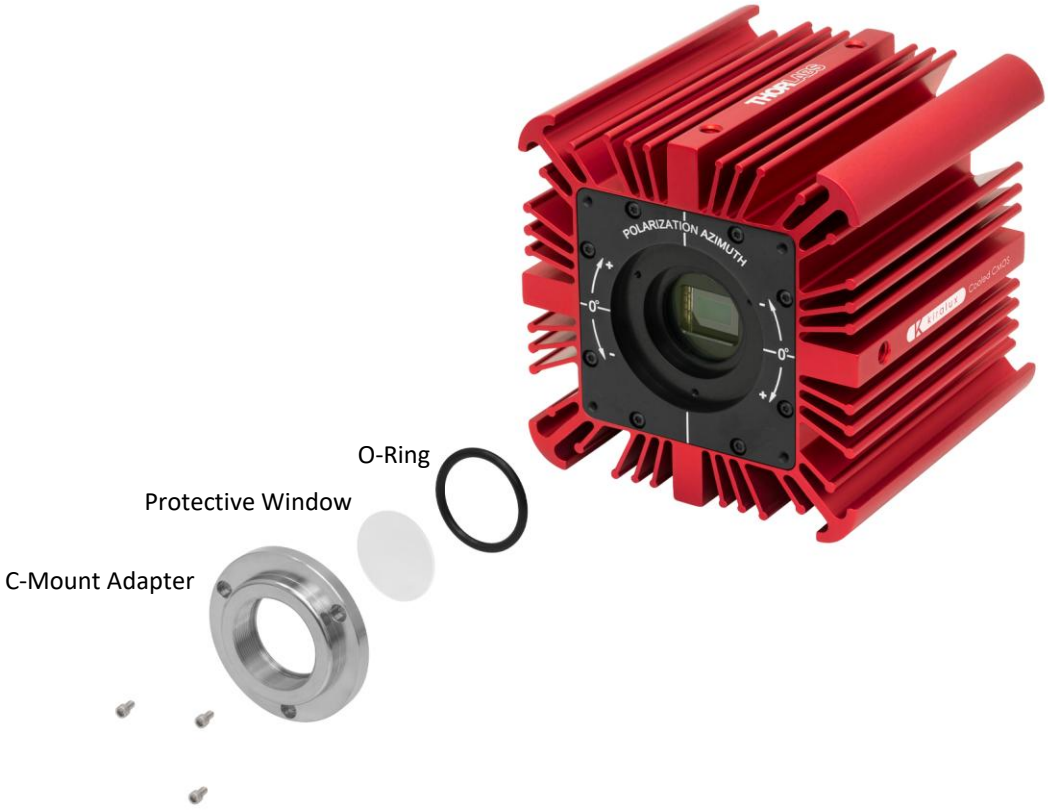


Figure 17 Exploded View of Optical and Mechanical Components (Markings Vary Across the CC Camera Series)

Description of Components

- **C-Mount Adapter:** Allows the camera to be optically coupled with standard C-mount optics, including lenses and microscope adapters.
- **Lens Dust Cap (Not Shown):** A protective cover that should always be installed during movement or shipment, and when the camera is not in use. The lens cap threads into the C-mount adapter.
- **Protective Window:** Unless otherwise requested, an AR (anti-reflective) coated protective glass window is installed and held in place by an **O-ring**.
    - Users may, at their discretion, remove the protective glass window or replace it with a custom optical filter. When using the C-mount adapter, the maximum filter thickness is 0.08" (2.0 mm) with Ø1" (25 mm).
    - All monochrome cooled scientific cameras are configured with a clear, broadband, AR-coated protective window to preserve the entire sensor spectral response. If the image spectrum must be limited, for example, to eliminate unwanted near-infrared light, Thorlabs offers a wide range of high-quality interference and colored-glass filters compatible with the camera.

See Sections 1.4.6 and 1.4.7 for specifications for and drawings of the clear glass window. See Section 3.4.6 for instructions on removing and replacing the glass window.

3.4.6 Optical Front End Procedures

Window Removal and Replacement Procedure

Thorlabs cooled scientific cameras have a protective clear glass window installed (see Figure 17). The window has a broadband anti-reflection coating that is easily scratched or smudged by oil from fingers. Use soft, clean cotton, latex, or nitrile gloves and handle the window by the edges.

The optical front end is designed to accommodate standard Ø1" windows. Users can, at their discretion, operate the camera without any glass installed or install custom filters in front of the sensor. The maximum filter thickness when using the C-mount adapter is 0.079" (2.0 mm). See Figure 9 for more information.

Note: If no glass is installed, dust and debris may collect on the hermetic chamber window. Care must be taken when cleaning this window to avoid scratching or other damage to the glass. Please use every precaution to avoid contact with the hermetic chamber window, and to keep the camera securely mounted to the optical system or capped when not in use.

Removal of the Protective Window from the Camera:

1. Using the hex key provided, remove the three socket head screws from the C-mount adapter.
2. You can now lift the C-mount adapter out of the camera housing.
3. Locate the pry slot along the perimeter of the rubber O-ring that is holding the protective window in the adapter. Using a non-metallic tool (optic safe tweezers or equivalent) pry the O-ring out of the C-mount adapter. Use caution to prevent the glass window from falling out of the adapter.
4. Carefully remove the window from the C-mount adapter and place it in a safe location.

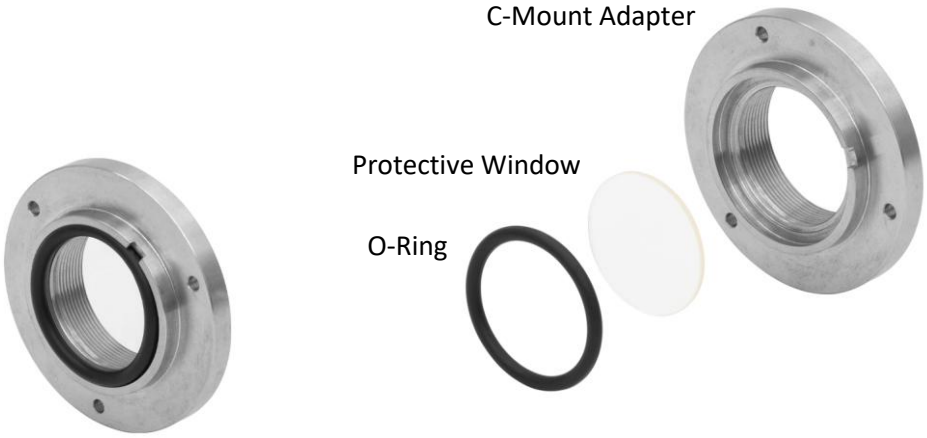


Figure 18 Removing the Window

Re-Assembly of the Window and C-Mount Adapter and Flange Focus Adjustment:

1. Replacement of the window and C-mount adapter is done in the reverse order of removal, as described above. **Care must be taken when handling the window.**
2. The O-ring used to secure the window in the adapter must be pressed firmly into the mating groove in the adapter until both the O-ring and the window are held securely in place.
3. Clean the window prior to reinstalling the C-mount adapter into the camera.

4. Install a compatible lens. There is no further adjustment required as the C-mount adapter has a fixed flange focal distance.

3.4.7 Auxiliary Connector

The auxiliary connector on the camera allows the user to access optional camera control and internal status signals. See Section 1.5 for the pin diagram.

- **Pins 1, 2, 3, 10, 11:** Ground. This is the electrical ground for the camera TTL signals.
- **Pin 4, STROBE_OUT (Output):** STROBE_OUT is an LVTTL output that is high during the actual sensor exposure time when in continuous, overlapped exposure mode. STROBE_OUT is typically used to synchronize an external flash lamp or other device with the camera.
- **Pin 4 EEP Alternate Function (Output – CC215MU Only):** EEP - Equal-Exposure Pulse is available when Equal-Exposure Pulse is selected in the ThorImage®CAM Trigger Control settings window. This signal is active from the time when the rolling reset is complete to the time when rolling readout commences. The Equal Exposure Pulse is typically used to synchronize an external flash lamp or other device with the camera in order to produce uniform exposures across the entire ROI. See Section 4.4 .
- **Pin 5 TRIGGER_IN (Input):** TRIGGER_IN is an LVTTL input used to trigger exposures on the camera. Transitions can occur from the HIGH to LOW states or LOW to HIGH, as selected using the ThorImageCAM interface. Default is Low to High. Minimum Trigger Pulse-width is 100 µs. This input is +5 V tolerant (5.5 V Max).
- **Pin 6, LVAL_OUT (Output):** LVAL_OUT refers to “Line Valid Output.” It is an active-HIGH LVTTL signal and is asserted during the valid pixel period on each line. It returns low during the inter-line period between each line and during the inter-frame period between each frame.
- **Pin 7, OPTO I/O_OUT (Output):** The OPTO I/O_OUT signal is an optically isolated output signal. The user must provide a pull-up resistor to an external voltage source of 2.5 V to 20 V. The pull-up resistor must limit the current into this pin to <40 mA. The default signal present on Pin 7 is the STROBE_OUT signal, which is effectively the Trigger Out signal as well. Note: The value of the user-supplied pull-up resistor affects the rise and fall time of this output.
- **Pin 8, OPTO I/O_RTN:** This is the return connection for the OPTO I/O_OUT output and the OPTO I/O_IN input connections. This must be connected to the pull-up source for OPTO I/O_OUT or the driving source for the OPTO I/O_IN signals.
- **Pin 9, OPTO I/O_IN (Input):** The OPTO I/O_IN signal is an optically isolated input signal used to trigger an exposure event. The user must provide a driving source from 3.3 V to 10 V. An internal series resistor limits the current into this pin to <50 mA @ 10 V. Minimum Trigger Pulse-width is 100 µs.
- **Pin 12, FVAL_OUT (Output):** FVAL_OUT refers to “Frame Valid Output” and is an LVTTL output that is HIGH during active readout lines. FVAL_OUT remains high throughout the active readout and returns low between frames.

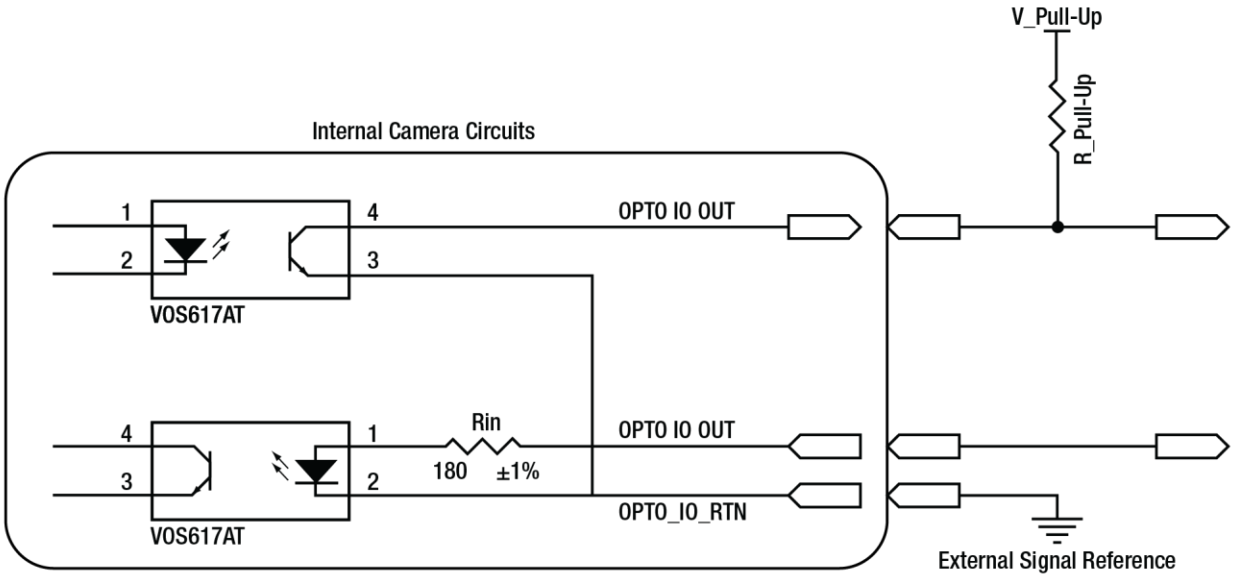


Figure 19 Internal Opto-Isolated I/O Circuits

Auxiliary I/O Cable Requirements

An auxiliary I/O cable may be fabricated in order to connect to the AUX I/O port of the camera. This cable is application-specific in all cases due to varying lengths and functions that are used. If an auxiliary I/O cable is to be used with this camera, it must be constructed using shielded cabling for the camera to adhere to CE and FCC compliance. Lengths greater than 10 feet (3 m) have not been evaluated for EMC compliance. The mating connector for the rear panel connector is HIROSE HR10-10P-12P (73).

A 10-foot-long (3 m) auxiliary I/O cable and interconnect break-out board are available from Thorlabs, allowing access to some of the I/O control functions (LVTTL_Trigger_In, LVTTL_LVAL_Out, LVTTL_FVAL_Out, and LVTTL_Strobe_Out). OPTO I/O_OUT, OPTO I/O_RTN, and OPTO I/O_IN are not supported. Order Item # 8050-CAB1, and TSI-IOBOB or TSI-IOBOB2, as well as the required number and style of SMA patch cables for your specific application. Order the CA28xx SMA-to-BNC series cable (e.g. CA2848 for 48” cable) or the CA29xx SMA-to-SMA series cable (CA2948 for 48” cable), as needed.

Chapter 4 Operation

The cooled scientific cameras can be operated using the ThorImage®CAM Imaging Software. For more details on using the software, please consult the ThorImageCAM User Manual, available on the **ThorImageCAM software page**.

4.1 Starting the Camera

With the camera software installed and the camera connected as instructed (Refer to Section 3.4), the Status LED should light up solid yellow, turning to solid blue several seconds after power is applied. Table 1 details the conditions represented by the status indicator.

If you are using the ThorImage®CAM Image Acquisition Software please refer to the ThorImageCAM User Guide, which can be accessed in the Documentation selection under the Start menu / All Programs listing for Thorlabs' products, see Figure 20.

Status LED Color and State	Condition
Flashing	The USB port cannot provide sufficient power to the camera.
Solid Blue	The camera is connected to a USB 3.0 port.
Solid Green	The camera is connected to a USB 2.0 port.
Solid Yellow	The camera has an internal problem. The status LED will be yellow momentarily during initialization of the camera.
Solid Cyan	The TEC power supply is not connected or turned on.
Off	There is no USB connection providing power to the camera.

Table 1 Status LED Conditions

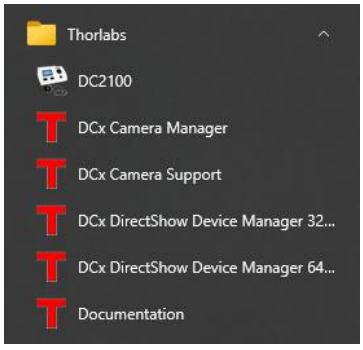


Figure 20 Start Menu All Programs Listing for Thorlabs' Products

4.2 Camera Timing Diagrams

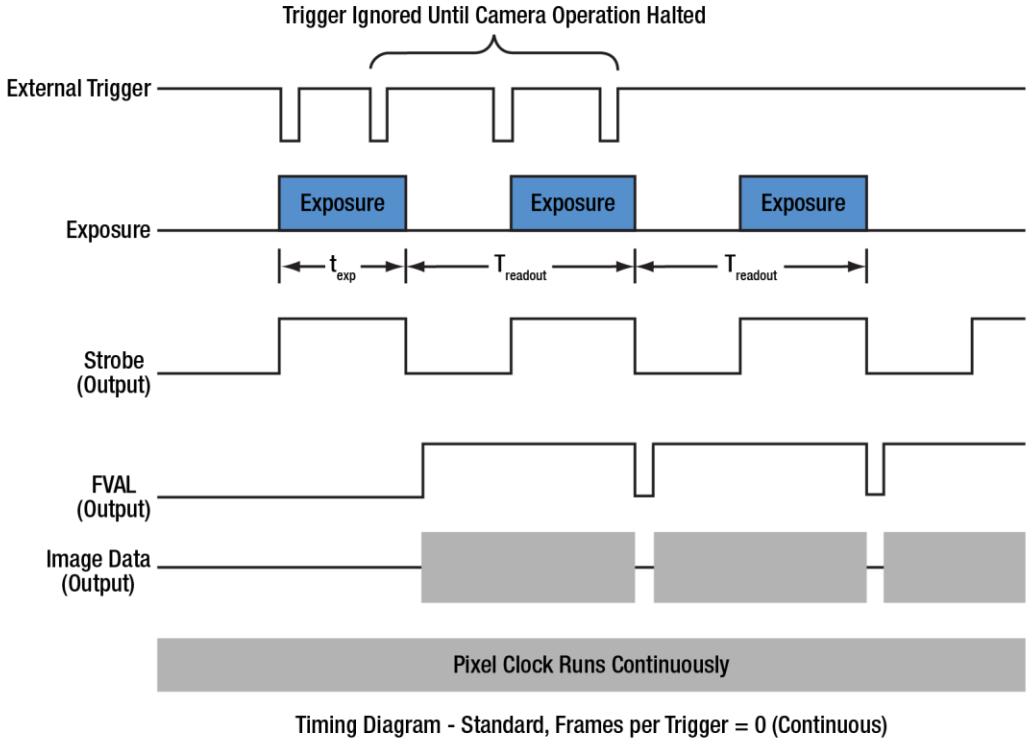


Figure 21 Timing Diagram – Standard Trigger with Overlapped Exposures
Trigger Mode: Hardware Trigger First;
Frames per Trigger: Kiralux® = 0 (Continuous), Quantalux® = 0 or > 1; Exposure Set in Camera Control

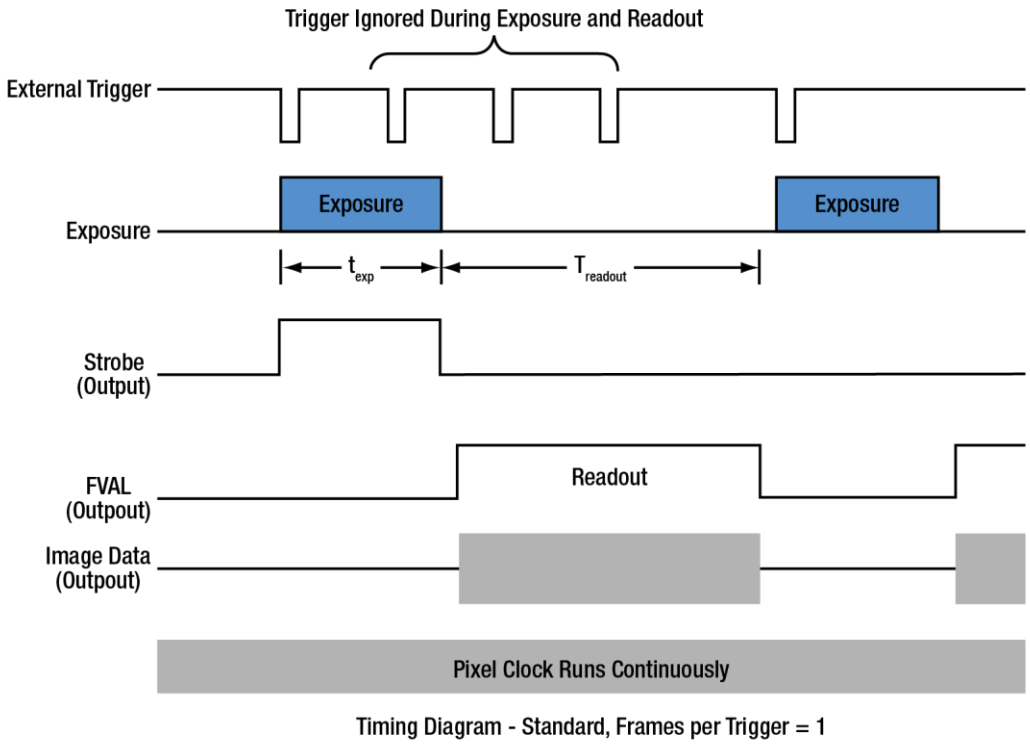


Figure 22 Timing Diagram – Standard Trigger
Trigger Mode: Hardware Trigger Each;
Frames per Trigger: Kiralux® > 0, Quantalux® = 1, Exposure Set in Camera Control

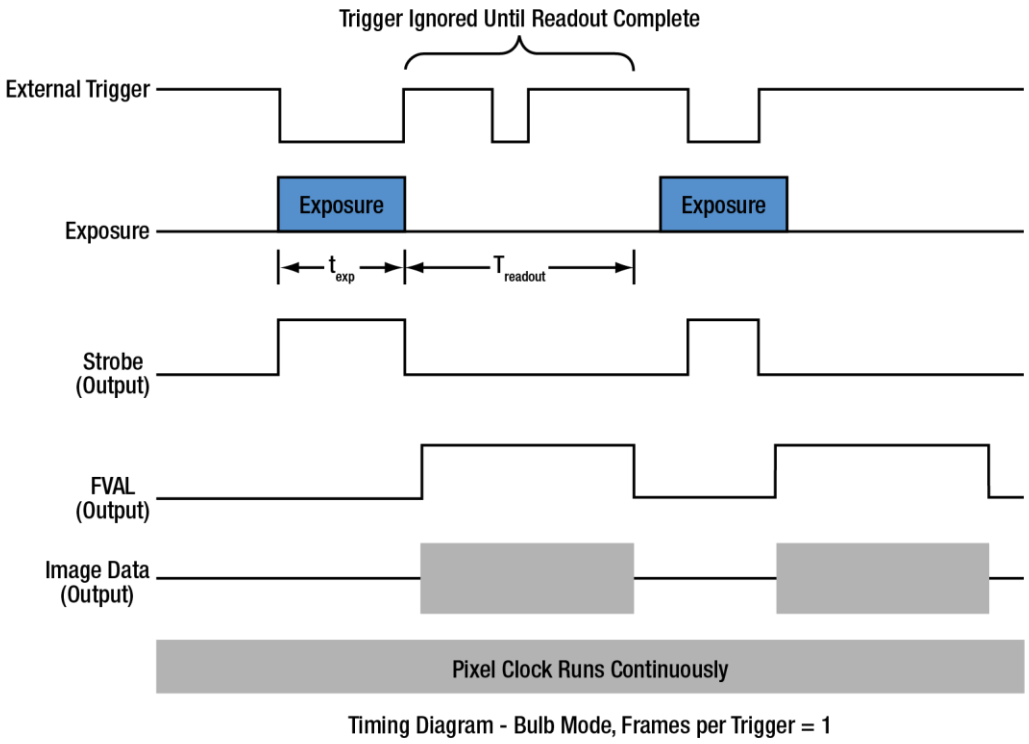


Figure 23 Timing Diagram – Bulb Mode of Kiralux® and Quantalux®
Trigger Mode: Hardware Trigger Each; Frames Per Trigger: 1; Exposure Determined by Trigger Input

Note: The default Frames per Trigger setting is 0 (Continuous).

4.3 Camera-Specific Timing Considerations

Due to the general operation of our Kiralux® CMOS sensor cameras, as well as typical system propagation delays, the timing relationships shown above are subject to the following considerations:

1) The delay from the external trigger to the start of the exposure and strobe signals is typically 270 ns for all triggered modes (standard and Pulse Driven Exposure (PDX) / Bulb) for the CC505MU, CC505MUP, CC895MU, and CC126MU cameras.

2) For PDX/Bulb mode triggered exposures, in addition to the start delay discussed above, there is also a fixed exposure time error AFTER the falling edge of the external trigger. This is inherent in the Kiralux sensor operation. This error is 13.72 µs on the CC505MU and CC505MUP, and 14.26 µs on the CC895MU and CC126MU.

It is important to note that the Strobe_Out signal includes the additional fixed exposure time error and is therefore a better representation of the actual exposure time. Our suggestion is to use the Strobe_Out signal to measure your exposure time and adjust your PDX mode trigger pulse accordingly.

4.4 Equal-Exposure Pulse (CC215MU Quantalux® Only)

The Equal-Exposure Pulse (EEP) is an output signal available on the Quantalux Cooled sCMOS camera's I/O connector (Refer to Section 3.4.7). When operated from the ThorImageCAM acquisition software, checking the Equal Exposure Pulse box in the Trigger Control window will reconfigure the Strobe_Out signal on the I/O connector to be active only after the sensor's "rolling reset" function has completed. The signal will remain active (logical high) until the sensor's "rolling readout" function begins. This means that the EEP signal is high only

between the “rolling reset” and “rolling readout” intervals, when all the sensor’s pixels are simultaneously integrating. If the illumination source is active only within this interval, when the EEP signal is high, the resulting image will not show an exposure gradient typical of rolling shutter sensors.

The EEP can only be produced when the exposure time is greater than the rolling reset period, defined as the reciprocal of the frame rate. Exposure time, optimization rate, and ROI all determine the final frame rate, so varying combinations of all will determine when the signal can be produced.

For example, a CC215MU at full-frame ROI and a Data Rate setting of 30 fps requires an exposure setting greater than ~33.3 ms for EEP to be active. Changing the ROI to 50% also changes the minimum exposure setting for an active EEP to ~16 ms.

The EEP is primarily meant to be used to control a light source that will expose a scene for a precise duration only when all pixels are integrating charge. The user must keep in mind that the exposure setting will not be the effective exposure produced from the external light source. A rule of thumb would be to subtract the rolling reset period from the exposure setting to arrive at an approximate effective exposure time.

Using the example above, a CC215MU at full frame ROI, with a Data Rate setting of 30 fps requires an exposure setting greater than ~33.3 ms for EEP to be active. If you set the exposure time in the Setting window to 43.3 ms, your effective exposure as a result of using an external light source driven from the EEP would be ~10 ms.

The ThorImageCAM acquisition software provides an intuitive interface for setting your desired exposure pulse time without having to worry about the impact of the other parameters, including the overall exposure time. ThorImageCAM allows a minimum pulse width of 1 ms, with increments of 0.1 ms.

Be aware that the EEP has no bearing on continuously illuminated scenes, and the resulting exposure and timing relationship will be that of a normal acquisition.

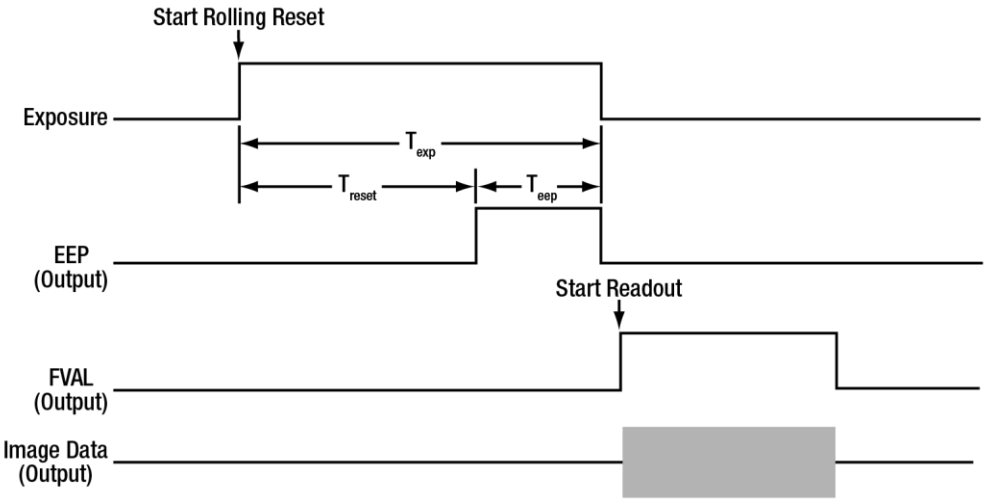


Figure 24 Timing Diagram – Equal-Exposure Pulse, Quantalux® Only (Item # CC215MU)

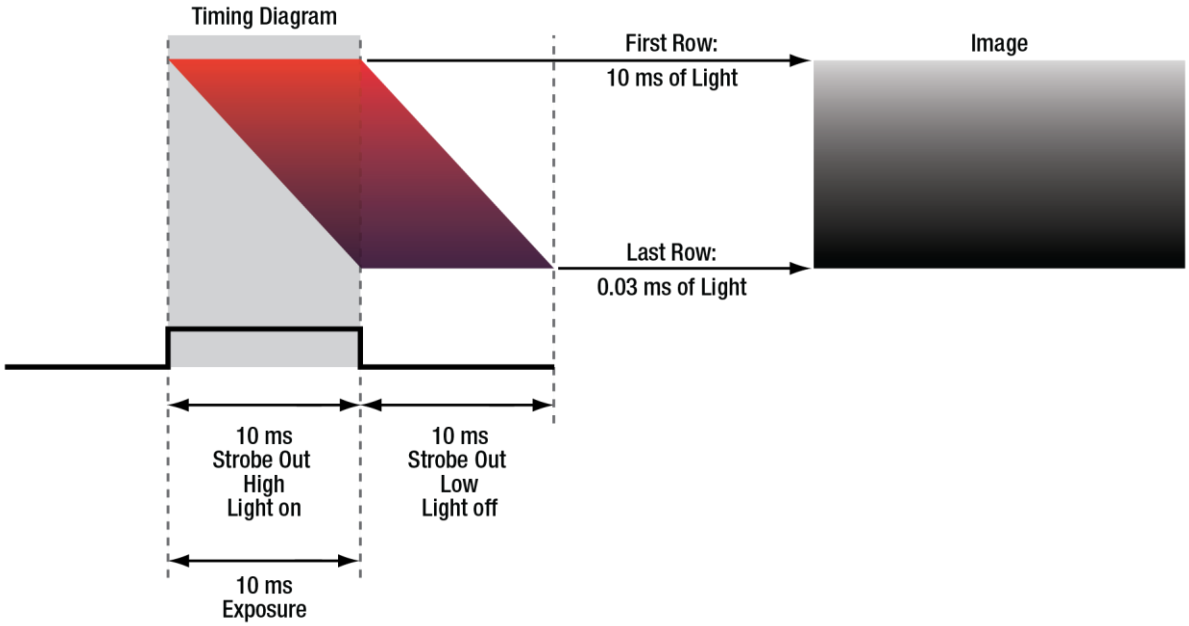


Figure 25 Timing Diagram – Strobe Driven Exposure, Quantalux® Only (Item # CC215MU)
A timing example for an exposure using STROBE_OUT to trigger an external light source during exposure. A gradient is formed across the image since the sensor rows are not integrating charge for the same length of time the light source is on.

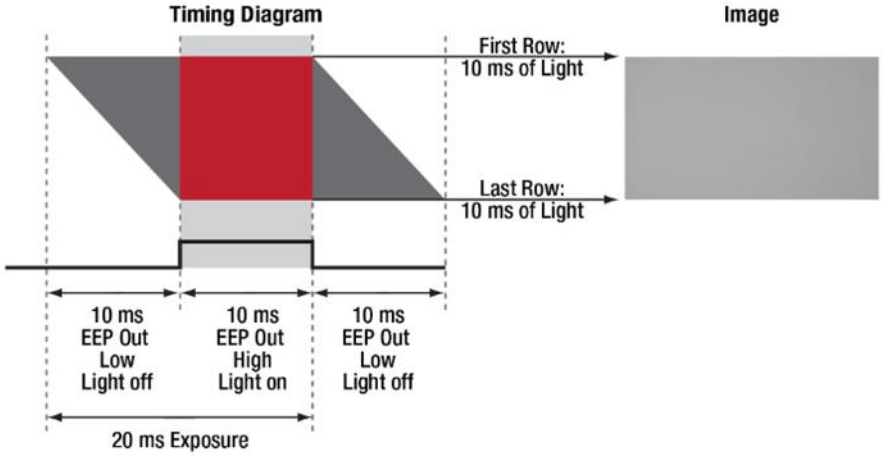


Figure 26 Timing Diagram – EEP Driven Exposure, Quantalux® Only (Item # CC215MU)
A timing example for an exposure using EEP. The image is free of gradients, since the EEP signal triggers the light source only while all sensor rows are integrating charge.

4.5 Hot Pixel Correction

Hot Pixel Correction is a firmware function that identifies and corrects pixels that are much brighter than their surrounding pixels. Typically visible as very bright pixels regardless of the scene being imaged, these are unavoidable by-products of the CMOS and sCMOS sensor manufacturing process.

This feature can be activated by checking the Hot Pixel Threshold check box in the ThorImageCAM acquisition software Camera Settings window. The threshold can then be adjusted using the numeric input box. The Hot Pixel Threshold check box can only be checked or unchecked when the camera is stopped. Once it is checked, however, the threshold adjustment can be made on a live image.

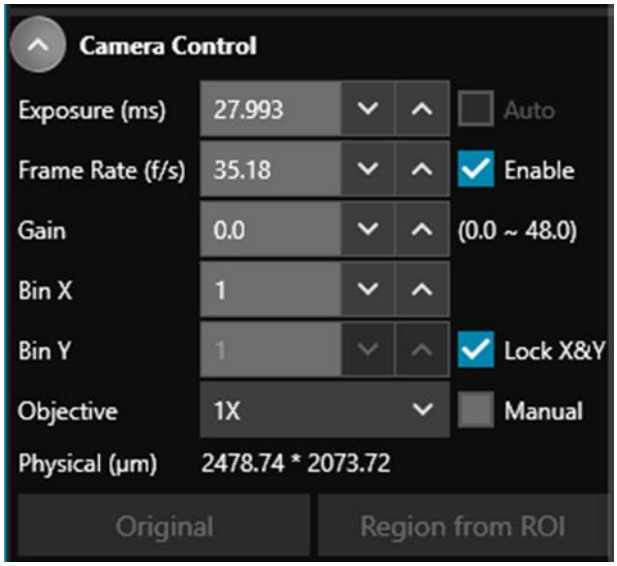
A hot pixel is identified by comparing a pixel's value with the mean value of the surrounding eight pixels in a 3x3 neighborhood centered on the pixel. If the difference between the pixel value and the mean of the surrounding pixels is larger than a specified threshold value, then this pixel is considered a hot pixel and will be replaced with the median value of those pixels in the neighborhood. As the slider is moved towards "Aggressive," the threshold is reduced in a linear fashion. The minimum threshold value, corresponding to the upper limit, has been selected to provide users with the ability to correct hot pixels having a deviation of only a few hundred counts. At this most aggressive value, it is quite likely that image signal near the maximum pixel values (full scale) will be altered by the Hot Pixel Correction algorithm, so care must be taken at the most aggressive levels. This correction is done in hardware, and any images saved by the host application will only have the corrected data.

This feature is available on all models.

4.6 Frame-Rate Control

All models in the Kiralux® family of Cooled CMOS Scientific cameras employ a unique feature in the ThorImage®CAM software environment and SDK that allows a user to adjust the frame rate in frames per second (FPS) to reduce or eliminate the number of dropped frames that may occur due to limitations in the host computer.

The Frame-Rate Control is accessed in the Camera Control settings window of ThorImageCAM. When the Frame Rate Enable box is unchecked the camera will operate at its maximum FPS for the given settings of Exposure, ROI and Binning. When the box is checked, the numeric input field and increment/decrement arrows are enabled.



Please refer to the ThorImageCAM User Guide for more details, which can be accessed in the Documentation selection under the Start menu / All Programs listing for Thorlabs' products once the software package has been installed.

Note: If the Frame-Rate Control feature is not visible when operating your Kiralux camera, please visit:

https://www.thorlabs.com/software-pages/thorcam/

for the latest ThorImageCAM software and camera firmware updates.

Chapter 5 Maintenance and Cleaning

There are no user-serviceable parts inside the camera. Removing the rear cover of the camera without express authorization from Thorlabs will void the camera warranty.

Thorlabs' scientific-grade cameras are manufactured in a clean environment. Before shipping, each camera is tested to ensure that it meets stringent specifications for cleanliness and quality.

Cleaning Guidelines

Frequent lens changes, especially without careful attention to contaminants, can allow debris to accumulate on the infrared blocking filter and lens surfaces. Therefore, Thorlabs provides the following guidelines for cleaning those components.

To minimize the need to clean the optical surfaces, do not remove the protective lens mount cap shipped with the camera until you are ready to mount the camera to the optical system.

For an informative tutorial, refer to the "Handling and Cleaning Procedures for Optical Components". The following guidelines, specific to Thorlabs cameras, are meant to be used in conjunction with the procedures described in the tutorial.

Cleaning the Lens of the Optical Assembly

Please follow the lens manufacturer's recommendations for cleaning. Thorlabs is not responsible for any damage caused to a lens or optical assembly caused by customer cleaning or misuse.

To ensure optimum image quality with any Thorlabs camera, do not remove the protective lens-mount cap until ready to mount the camera on the application. If the camera is removed from the application, immediately replace the cap. Doing so will keep dust and other contaminants from accumulating on the optical surfaces. In addition, please note the following model-specific guidelines.

Cooled Camera Precautions

Complete removal of the C-mount adapter and Ø1" protective window will expose the hermetic chamber's sealed window and will likely cause debris to accumulate on its surface.

NOTICE

Extreme care should be taken to avoid completely removing the Ø1" window and exposing the chamber window unless absolutely necessary. Scratches or other evidence of contact with the chamber window may void the warranty.

Cleaning the Ø1" AR-Coated Protective Window

The Ø1" window is visible when the lens is removed, mounted inside the C-mount adapter.

- ***What must I do before cleaning the AR-Coated Window?***

  Do not remove the window from the camera.

  First, remove the lens, if one is installed, and carefully examine the window in a clean location under a strong, direct light. Try to determine if the contaminants are a few dust particles, oily smudge (such as fingerprints), or both.

- ***What if the contamination is only a few dust particles?***

  Use a CLEAN, DRY (preferably brand-new), camel hair lens cleaning brush (such as those used by photographers) to gently wipe the particles off the filter.

- ***What if the contamination includes a smudge?***

1. Remove the camera from the optical assembly and bring the camera to a clean, dry location where it is safe to use flammable solvents (please see “Caution” below)
2. Refer to Section 3.4.6. for details on removing the C-mount adapter and Ø1" protective window.
3. Place the camera face down on a clean, dry surface to prevent particles from accumulating on the chamber’s hermetic window.
4. Once the window is removed, use a CLEAN, DRY (preferably brand-new), camel hair lens cleaning brush (such as those used by photographers) to gently wipe the particles off the Ø1" window.
5. Re-examine the window after removing the dust. If a smudge is still visible, proceed by dipping a clean, lint-free cotton swab (such as Item # CTA10) in ethyl or isopropyl alcohol. DO NOT USE ACETONE. The swab should be saturated, but not dripping.
6. Carefully draw the swab once across the surface, then rotate the swab 180 degrees to expose the fresh surface and draw it across the window surface again. Be careful not to pool alcohol on the glass surface.
7. Re-examine once again and repeat the process once, if necessary.

If contamination continues to be a problem, please call Thorlabs for assistance.

Cleaning the Hermetic Chamber’s Protective Window

The hermetic chamber’s protective window is visible when the lens, C-mount adapter, and Ø1" protective window are removed. This window forms an integral part of the hermetic seal of the chamber. It cannot be removed and should never be touched. In the case of accidental contamination or smudging, please use the following guidelines.

- ***What must I do before cleaning the Hermetic Chamber’s Protective Window?***

  First, remove the lens and the Ø1" protective window. Carefully examine the chamber window in a clean location under a strong, direct light. Try to determine if the contaminants are a few dust particles, oily smudge (such as fingerprints), or both. Refer to Section 3.4.6 for details on removing the C-mount adapter and Ø1" protective window.

- ***What if the contamination is only a few dust particles?***

  Use a CLEAN, DRY (preferably brand-new), camel hair lens cleaning brush (such as those used by photographers) to gently wipe the particles off the filter.

- ***What if the contamination includes a smudge?***

1. Remove the camera from the optical assembly and bring the camera to a clean, dry location where it is safe to use flammable solvents (please see “Caution” below).
2. Refer to Section 3.4.6 for details on removing the C-mount adapter and the Ø1" protective window.
3. Place the camera face down on a clean, dry surface to prevent particles from accumulating on the chamber’s hermetic window until you are ready to perform the cleaning.
4. Use a CLEAN, DRY (preferably brand-new), camel hair lens cleaning brush (such as those used by photographers) to gently wipe the particles off the chamber window.
5. Re-examine the window after removing the dust. If a smudge is still visible, proceed by dipping a clean, lint-free cotton swab (such as Item # CTA10) in ethyl or isopropyl alcohol. DO NOT USE ACETONE. The swab should be saturated, but not dripping.

6. Carefully draw the swab once across the surface, then rotate the swab 180 degrees to expose the fresh surface and draw it across the window surface again. Be careful not to pool alcohol on the glass surface.
7. Re-examine once again and repeat the process once, if necessary.

If contamination continues to be a problem, please call Thorlabs for assistance.

⚠CAUTION

Ethyl and isopropyl alcohols are highly flammable! Do not use near extreme heat, arcing electrical equipment (such as space heaters) or open flame! Use only with proper ventilation. Follow all safety instructions provided by the manufacturer of the alcohol product.

Chapter 6 Troubleshooting and Repair

6.1 Interface

Problem	Symptoms	Possible Cause	Remedy
Software Cannot Find a Connected Camera	• Software does not display a connected camera. • Software does not display an image.	No power to the camera.	Connect the camera to the USB 3.0 Port.
		The camera has yet to complete “enumeration”.	Restart/refresh the software after the camera has been powered on and connected to the host PC for at least 30 seconds.
		USB 3.0 camera not connected to the USB 3.0 Port or has not enumerated properly.	See Section 3.4.3. Disconnect the USB 3.0 cable and then reconnect. First-time connections to a PC may take longer to enumerate and load drivers.

6.2 Optical

Problem	Symptoms	Possible Cause	Remedy
When Using a Standard C-Mount Lens (Not Included), Image Is Not in Focus	The displayed image is not in focus.	The lens is not to spec.	Replace the lens.
Displayed Image Has Spots or Has Debris in Image	There is debris in the displayed image.	The protective window has particulates on it.	Carefully clean the window. See Section 3.4.6 and Chapter 5.

6.3 Operational

Problem	Symptoms	Possible Cause	Remedy
Camera Excessively Warm (Too Hot to Safely Hold with Ungloved Hand)	• The camera is too hot to hold with an ungloved hand. • Poor image quality.	The camera is not properly ventilated.	Remove any obstructions or provide adequate ventilation around the camera.
		Electronics failure.	Disconnect the camera from the USB 3.0 port and contact **Tech Support**.
Imaging Software "Times Out" Without Acquiring Image	• The imaging software indicates a timeout. • No images are acquired – no frame count is provided.	The camera is not powered.	See Section 6.1 for interface troubleshooting information.
		The camera is not connected to a computer.	See Section 6.1 for interface troubleshooting information.
		The imaging software is not configured to the camera.	Consult the ThorImage®CAM User Guide.
		The camera is not "armed" and "started" properly.	Refer to Section 4.1.
Low Bandwidth USB 3.0 Connection	• Excessive dropped frames. • Inconsistent operation.	Low bandwidth USB 3.0 port.	Use a PCIe high bandwidth USB 3.0 card, such as: Thorlabs' USB3-PCIE card.
		The USB 3.0 cable is too long or poor quality.	• Use the 3 m long cable supplied with the camera. • Use a 3 m long (max) cable with 28AWG signal wires - or a 1 m long cable.
Yellow Status LED	The camera does not connect to the host.	Windows power saving settings.	Turn off all USB 3.0 power saving settings in the Device Manager.
Cooler Not Working	• The Status LED is Cyan. • ThorImageCAM shows a status error.	The TEC power supply is not connected to the camera.	Connect the power supply to the camera. See Section 3.4.3
		TEC power supply is not plugged into the AC source.	Plug the power supply into an appropriate AC mains outlet.

6.4 Software

Problem	Symptoms	Possible Cause	Remedy
Camera Not Found	Error message, or camera does not show up in Hardware Connections.	Power not on.	Make sure the camera is connected to a USB 3.0 Port.
		Not plugged in.	Make sure the camera is connected to a USB 3.0 Port.
		Bad USB cable or connection.	Try a different cable. Refer to Section 4.1 for information on the camera's status indicators.
Insufficient Illumination	The images are all black.	The exposure time is too low.	Make sure that the exposure time is greater than 0; if the exposure is already greater than 0, try increasing the exposure time or gain gradually.
		No light is going to the camera.	Make sure that the light source is turned on, and that the aperture of the lens (or other optics) is not shut.
		The lens cap is installed.	Remove the lens cap.

Chapter 7 Disposal



Thorlabs verifies our compliance with the WEEE (Waste Electrical and Electronic Equipment) directive of the European Community and the corresponding national laws. Accordingly, all end users in the EC may return “end of life” Annex I category electrical and electronic equipment sold after August 13, 2005 to Thorlabs, without incurring disposal charges. Eligible units are marked with the crossed out “wheelie bin” logo (see right), were sold to and are currently owned by a company or institute within the EC and are not dissembled or contaminated. Contact Thorlabs for more information. Waste treatment is your own responsibility. “End of life” units must be returned to Thorlabs or handed to a company specializing in waste recovery. Do not dispose of the unit in a litter bin or at a public waste disposal site. It is the user’s responsibility to delete all private data stored on the device prior to disposal.

Chapter 8 Thorlabs Worldwide Contacts

For technical support or sales inquiries, please visit us at www.thorlabs.com/contact for our most up-to-date contact information.



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