



Compact Scientific Digital Cameras

User Guide

CS165 Series CMOS Scientific Cameras



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Chapter 1 Safety

1.1. Precautions

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.

Refer to this User's Guide whenever the following symbols are encountered on the Digital Camera and Power Supply.



ATTENTION



This symbol indicates that additional information is available in this user guide.

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

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.



WARRANTY WARNING



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.



CAUTION



















This product is powered directly from the USB 3.0 port of a host computer (not 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 supply. Do not tamper with or open the supply under any circumstances. Doing so may expose lethal voltage to personnel and will void the warranty of the computer.

1.2. Warning Symbol Definitions

Below is a list of warning symbols you may encounter in this manual or on your device.

Symbol	Description
	Direct Current
	Alternating Current
	Both Direct and Alternating Current
	Earth Ground Terminal
	Protective Conductor Terminal
	Frame or Chassis Terminal
	Equipotentiality
	On (Supply)
	Off (Supply)
	In Position of a Bi-Stable Push Control
	Out Position of a Bi-Stable Push Control
	Caution: Risk of Electric Shock
	Caution: Hot Surface
	Caution: Risk of Danger
	Warning: Laser Radiation
	Caution: Spinning Blades May Cause Harm

1.3. Product Care

Handle the system with care during transportation and unpacking. Bumping or dropping the system can damage the unit or lower system performance. If the system is mishandled during shipment, the optical components may become misaligned, which could lead to a decrease in the image quality. If this happens, the system will need to be realigned by qualified personnel. To ensure proper care and operation of your Compact Scientific Digital Camera, please follow the handling instructions below.

- Do not store or operate in a damp, closed environment.
- Do not use solvents on or near the equipment.
- Keep away from dust, dirt, and air-borne pollutants (including cigarette smoke). The system is not designed for outdoor use. Protect the equipment from rain, snow, and humidity.
- Do not expose to mechanical or thermal extremes. Protect the equipment from rapid variation in temperature.
- Handle all connectors with care. Do not use unnecessary force as this may damage the connectors.
- Clean using a soft, lint free cloth. Use of isopropyl alcohol is permitted, however do not immerse in any liquid or solvent.
- Clean any accessible optical surfaces with an appropriate optics grade tissue or cloth.

1.3.1. Service

Only trained and approved Thorlabs' personnel should service the system. Please contact Thorlabs' Technical Support at techsupport@thorlabs.com and a member of our team will be happy to assist you.

1.3.2. Accessories and Customization

Although the system is easily adapted for custom interfaces, to achieve the listed specifications, this system should only be used with accessories provided by Thorlabs. Any modification or servicing by unqualified personnel renders the warranty null and void, leaving Thorlabs free of liability. Please contact Thorlabs for questions on customization.

All cameras are supplied with one USB3-MBA-118 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) might be acceptable but is not guaranteed. Never use any cable that is longer than 3 m on a USB 3.0 system.

The safety of any system incorporating this camera is the responsibility of the system integrator. If the camera is used in a manner not specified by Thorlabs, Inc., the protection provided by the equipment may be impaired.

Chapter 2 Description

2.1. Introduction

This Compact Scientific camera series consists of various monochrome and color models with USB 3.0 interfaces. All models are compatible with many Thorlabs supporting products, including CS-mount and C-mount lenses, our 30 mm cage system, and SM1 tubes and accessories. They are designed specifically to work “out of the box” in conjunction with our ThorCam software tool, and can also be operated with a variety of other imaging tools, as well as from a USB 2.0 port.

The model format for the **Zelux** series  is CSxxy{M/C}U{1}{/M} where:

xx is the number of pixels, where “xx” is the multiplier and “y” is the exponent of 10. A value of “505” is then 50 x 10⁵ indicating 5 megapixels, **M/C** denotes **monochrome** or **color**, **U** indicates a USB2.0/3.0 interface, **1** indicates I/O capable, and **/M** indicates a metric M-6 mounting option, as opposed to an Imperial ¼”-20 thread.

The cameras are bundled with the full complement of Thorlabs Scientific Imaging (TSI) software. For end-users, the ThorCam 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.

For developers, TSI also offers a Software Developer’s Kit (SDK), which includes a comprehensive Application Programming Interface (API) to streamline the integration of any TSI camera into your system. After software installation, the SDK can be found in a sub-folder under C:\Program Files\Thorlabs. This is the same directory for 32- and 64-bit distributions.

This manual is a functional overview of the camera, and it is meant to be a companion to the Camera Quick Start Guide, ThorCam User Guide, and the TSI Application Programming Interface Guide. All support documentation is available at www.thorlabs.com as well as in the C:\Program Files\Thorlabs folder following the installation of ThorCam.

The current list of CS165 series digital cameras consists of:

CS165MU, CS165CU monochrome or color 1.6 MP camera with imperial ¼”-20 mounting threads

CS165MU/M, CS165CU/M monochrome or color 1.6 MP camera with metric M6 mounting threads

CS165MU1, CS165CU1 monochrome or color 1.6 MP camera with ¼”-20 threads and I/O.

CS165MU1/M, CS165CU1/M monochrome or color 1.6 MP camera with M6 threads and I/O.

2.2. 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 TSI 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 Chapter 12, titled “Warranty” for details.

2.3. Supplied Equipment

The following is a list of equipment that is supplied with your camera

Supplied Equipment	
Interface Accessories	3 Meter USB 3.0 Cable ¹
Accessories	SM1 Compatible Lens Cap CA3339 BNC-to-MMCX Coax Cable (QTY 2) ²
Software	Thorlabs Camera Software and SDK Available for Download from www.thorlabs.com/software

Note 1 - All cameras are supplied with one USB3-MBA-118 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.

Note 2 – Included with CS165xU1 and CS165xU1/M models.

2.3.1. Optional Items

- Auxiliary I/O Patch cable – The optional I/O connectors on CS165xU1 and CS165xU1/M models allows the user to access Trigger Input and Strobe Output functions (see Section 3.7).
Thorlabs CA3339 BNC-to-MMCX cables are included, or order Thorlabs CA3439 for the SMA-to-MMCX version, which is compatible with the Thorlabs IOBOB2 Arduino Shield.

Chapter 3 Setup & Installation

3.1. Pre-Installation – USB 2.0 and USB 3.0

Your camera will operate when connected to a USB 3.0 “SS” (Super Speed) port on your PC (preferred), as well as a USB 2.0 port. A USB 3.0 compatible port is typically blue - but not always. Look for this symbol above the port to be sure:



If your computer does not have a USB 3.0 port, it is likely an indication that it is an older machine. The camera will function normally, but the frame rate will be slower than on a USB 3.0 port. Thorlabs recommends our PCIe USB 3.0 card (Thorlabs' part number USB3-PCIE) if you wish to get the full frame rate capability of your camera.

Recommended Installation Sequence

1. Run the software installer, follow the steps outlined in the next section.
2. Connect the camera, power will be applied when connected to a USB port.
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 ThorCam application software.

3.2. Installing the Software

The Thorlabs camera software runs on Windows 7 and 10 operating systems ONLY.

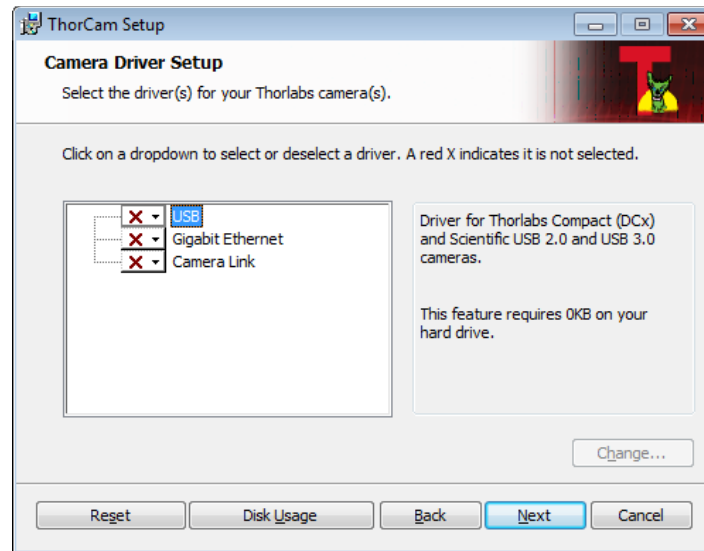
3.2.1. Run the Installation file

3.2.2. You may download the latest version of software from our webpage [ThorCam™ Software for Scientific and Compact USB Cameras](#). Choose the appropriate installation format, 32-bit or 64-bit and download the file to your host computer. Double-click the file to run the installation.

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

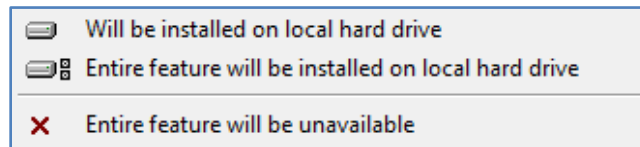
3.2.3. Driver Selection

Your camera requires a driver to be installed on your computer. After the welcome screen, acceptance of the license agreement, and entering your user information, you will be presented with a choice of drivers. Select the driver that matches the interface on your camera, in this case USB. Thorlabs offers various cameras with Gigabit Ethernet or Camera Link interfaces. If you have more than one camera, and they have different interfaces, select all that apply. If you're unsure, select them all.

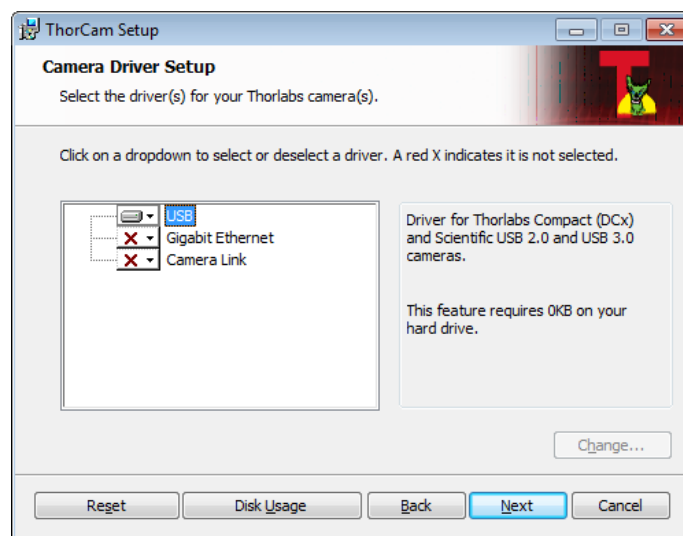


Select a driver for installation by clicking on the dropdown arrow and selecting either of the two choices; “This feature will be installed on local hard drive,” or “This feature, and all sub-features, will be installed on local hard drive.” There are no sub-features, so both choices do the same thing.

ALL compact series cameras must have the USB driver selected.

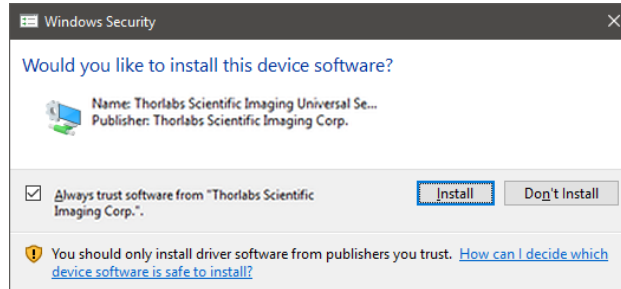


Once a driver is selected, the red X will be replaced with a hard drive icon as shown in the USB selection below.

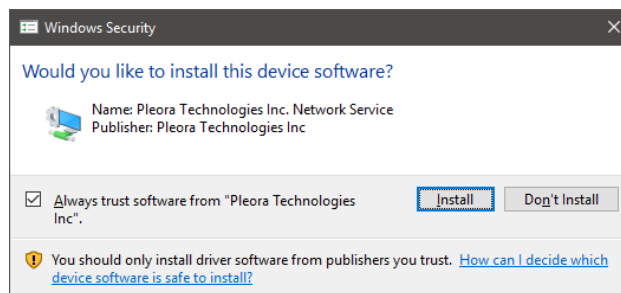


Click Next to proceed with the driver installation. Depending on your PC's configuration and the drivers you selected, you might encounter the additional Windows security dialogs below. Be sure to click "install" to complete the operation, otherwise the installer will "roll back" and exit.

USB Driver Installation. Click "Install". This is required for compact series cameras.

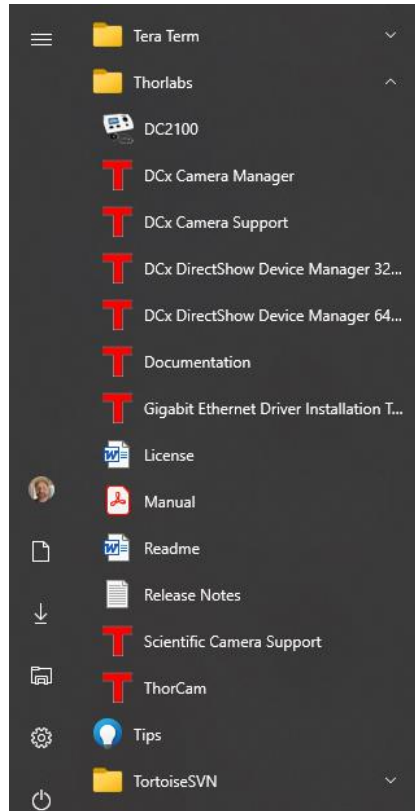


Gigabit Ethernet Driver Installation (if selected - not required for Compact Scientific cameras). Click "Install".



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 ThorCam Imaging Software as shown below:

“Start” → “All Programs” → “Thorlabs” → “ThorCam”



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



3.2.4. 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®.

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 ThorCam software.

To use the MATLAB and LabVIEW interfaces, extract from the Zip file and place 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 ThorCam to confirm that the camera, software and drivers are properly installed. Then, shut down your ThorCam session and start a Micro-Manager session.

3.3. Connecting the Camera

To connect the camera, follow the steps below.

1. Connect the provided USB 3.0 cable¹ into the mating connector on the side of the camera. The camera end of the cable will have two thumb screws. Make sure the connector is fully inserted, and then hand tighten the thumbscrews into the camera housing.
2. Connect the other end of the USB 3.0 cable into a USB 3.0 port (USB SS) or USB 2.0 port on the host computer.

Note 1 - All cameras are supplied with one USB3-MBA-118 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.

3.3.1. Multiple Camera Operation

If multiple camera operation is required on the same computer, it is recommended that each camera uses a dedicated USB port. Do not use a USB hub.

3.4. Optical and Mechanical Mounting Considerations

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 starting at Chapter 5). For more information on Thorlabs C-Mount lenses, please visit www.thorlabs.com.

3.4.1. Using a C-Mount Lens

C-mount lenses are specified with a flange focal distance of 17.5 mm. The Zelux cameras come with a standard SM1 threaded bore. Thorlabs offers a fixed depth SM1 to C-mount adapter, catalog number SM1A10Z that can be purchased on our web site.



Figure 1 Camera Shown with C-Mount Lens Adapter SM1A10Z (Not Supplied)

3.4.2. Using a CS-Mount Lens

CS-mount lenses are specified with a flange focal distance of 12.5 mm. The Zelux cameras come with a standard SM1 threaded bore. Thorlabs offers a fixed depth SM1 to CS-mount adapter, catalog number SM1A10 that can be purchased on our web site.



Figure 2 Camera Shown with CS-Mount Lens Adapter SM1A10 (Not Supplied)

3.4.3. Mounting the Camera

Two 1/4"-20 or M6 tapped holes are provided, one on the bottom and one on the side of the housing. These may be used with tripods or other optical mounting devices. These tapped holes are compatible with Thorlabs posts. For more information on Thorlabs posts, please visit www.thorlabs.com.

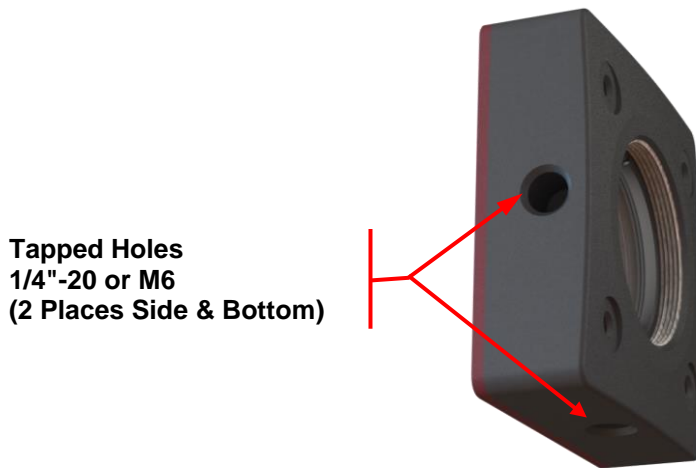


Figure 3 Arrow Indicates One of the Tapped Holes on Camera

3.4.4. Using the Camera with a Cage System

The cameras have 4-40 tapped holes for compatibility with Thorlabs' 30 mm Cage systems.

For more information on Thorlabs' 30 mm Cage system components, please visit www.thorlabs.com.



Figure 4 Camera Shown as Part of a 30 mm Thorlabs Cage System

3.4.5. SM1 Compatible Threads

The main sensor access bore has an internal SM1 (1.035"-40) thread that is directly compatible with Thorlabs Ø1" Lens Tubes.



Figure 5 Camera Shown Using Ø1" Lens Tube

3.5. Optical Front End

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



Figure 6 Exploded View of Optical and Mechanical Components

3.5.1. Description of Components

- **Lens Cap:** A protective cover that should always be installed during movement or shipment, and also when the camera is not in use. Included but not shown here.
- **Protective Window:** Unless otherwise requested, a protective glass window is installed and held in place by a retaining ring.
 - Users may, at their discretion, remove the protective glass window, or replace it with a custom optical filter. When using a CS-mount or C-mount adapter the maximum filter thickness is 0.050" (1.270 mm) with Ø1", otherwise the maximum filter thickness is 0.173" (4.4 mm) with Ø1".
 - CMOS imagers have responsivity that extends beyond the visible range, into the NIR spectral range. When installed, an NIR blocking filter cuts off light at higher wavelengths.
 - All monochrome Compact Scientific cameras are configured with an AR-coated protective window. For imaging that is limited to the visible region, users may install an NIR blocking filter in its place.
 - All color models are configured with an NIR blocking filter as the protective window. The NIR blocking filter is installed in order to achieve realistic colors in white light.
 - See Chapter 7 for more information on both types of windows. See Section 3.6.1 for instructions related to removing and replacing the glass window.

3.6. Optical Front End Procedures

3.6.1. Window Removal and Replacement Procedure

TSI Compact Scientific cameras are provided with a protective glass window installed (See Chapter 7).

The optical front end is designed to accommodate standard Ø1" windows. Users may, 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 a CS-mount or C-mount adapter is 0.050" (1.270 mm). With the adapter removed the maximum filter thickness is 0.173" (4.4 mm). See Chapter 7 for more information on both types of windows.

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

Removal of the Window from the Camera

1. If installed, remove any CS-mount or C-mount adapters.
2. Using an SPW606 spanner wrench or equivalent tool carefully remove the SM1 retaining ring and window as shown below.



Figure 7 Removing the Window

3.6.2. Re-Assembly of the Window

Replacement of the window is done in the reverse order as shown in Section 3.6.1.

Care must be taken when handling the filter. Do NOT over-tighten the retaining ring.

3.7. Auxiliary I/O Connectors

Two auxiliary I/O connectors on the CS165xU1 and CS165xU1/M cameras allow the user to access optional camera control and internal status signals. The connectors are coax MMCX connectors.



Figure 8 **I/O Ports**

3.7.1. I/O Port Descriptions

- **STROBE OUT (Output):** STROBE OUT is an LVTTTL output (0 to 3.3 V) that is high during the actual sensor exposure time. STROBE OUT is typically used to synchronize an external flash lamp or other device with the camera.
- **TRIGGER IN (Input):** TRIGGER IN is an LVTTTL input (0 to 3.3 V) used to trigger exposures on the camera. Transitions can occur from the HIGH to LOW states or LOW to HIGH, as selected using the ThorCam interface. Default is Low to High. Minimum Trigger Pulse-width is 100 μ s. Maximum trigger voltage may not exceed +5 V or go below -0.7 V.

3.7.2. Auxiliary Cable

Two Thorlabs CA3339 BNC-to-MMCX 1m cables are supplied with each CS165xU1 and CS165xU1/M camera.

Chapter 4 Operation

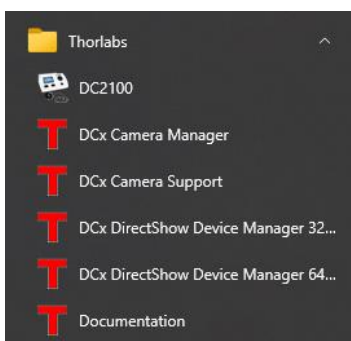
The Compact Scientific series cameras can be operated using the ThorCam Imaging Software. For more details on using ThorCam please consult the ThorCam User Manual.

4.1. Starting the Camera

With the camera software installed and the camera connected as instructed (Refer to Section 3.3), the Status LED should light up solid Yellow, turning to solid Blue several seconds after power is applied. The table below details the conditions represented by the status indicator.

LED	If LED is Flashing	If LED is On	If LED is Off
Status	USB port cannot provide sufficient power to the camera	Blue: Connected to a USB 3.0 Port Green: Connected to a USB 2.0 Port Yellow: Camera has internal problem or the USB port is malfunctioning	There is no USB Connection providing power to the camera

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



4.2. Camera Timing Diagrams

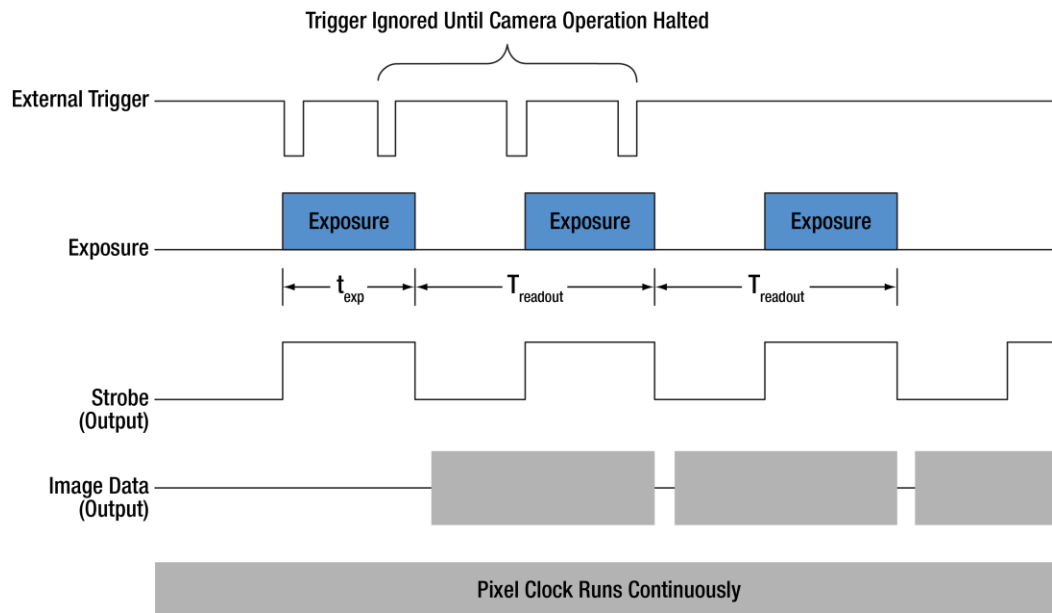


Figure 9 Timing Diagram – Standard, Frames per Trigger = 0 or > 1

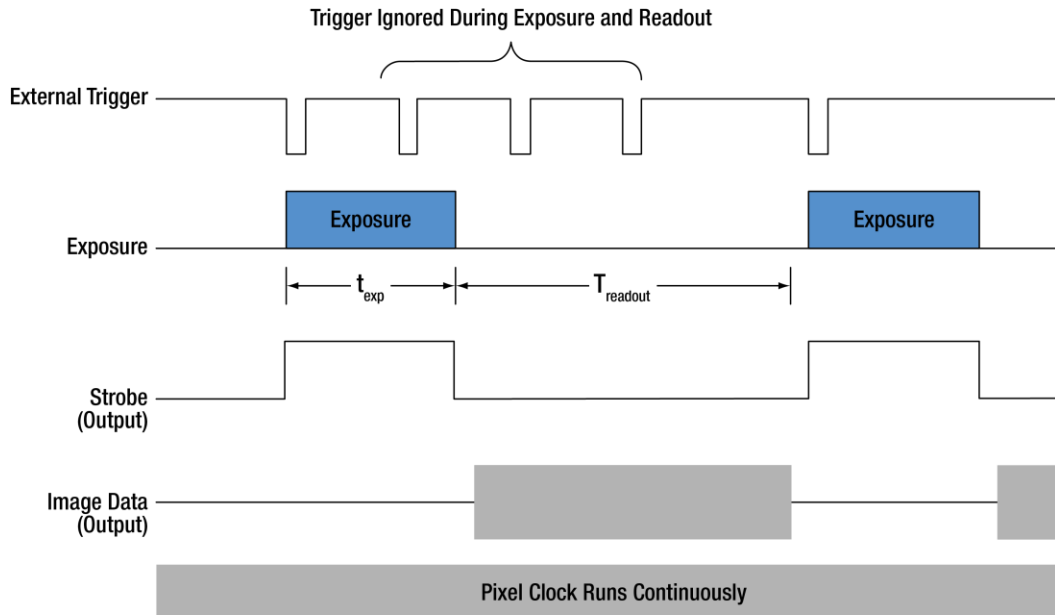


Figure 10 Timing Diagram – Standard, Frames per Trigger = 1

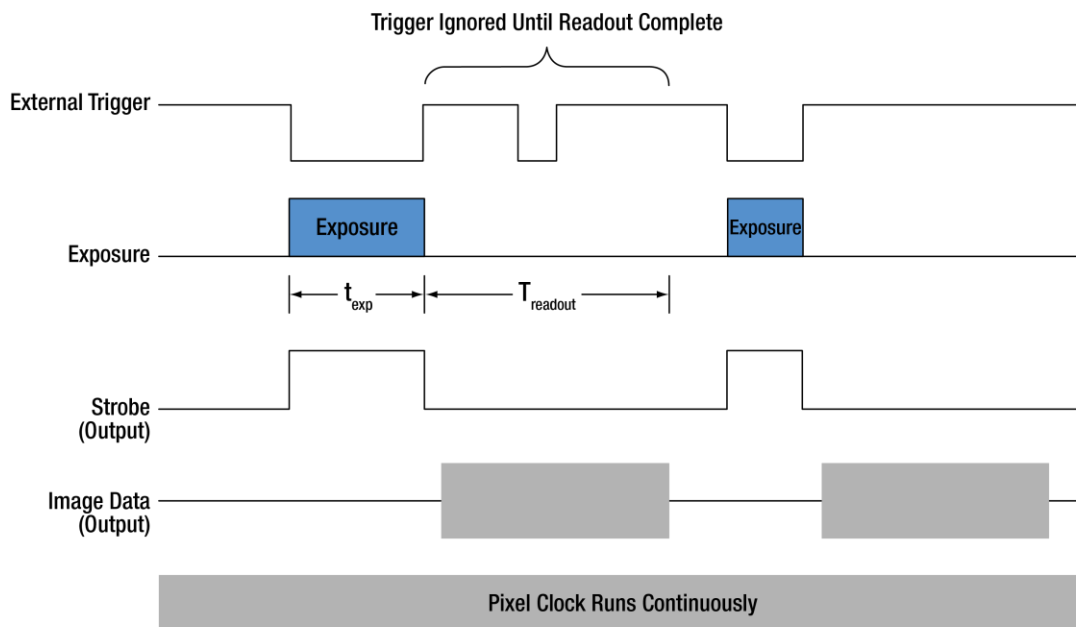


Figure 11 **Timing Diagram – Bulb Mode**

4.2.1. Camera-Specific Timing Considerations

Due to the general operation of our Zelux 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 12 μ s to 15.5 μ s for all triggered modes (standard and PDX/Bulb).
- 2) For PDX/Bulb mode triggered exposures, in addition to the 12 μ s to 15.5 μ s delay at the start of the exposure, there is also a fixed exposure time period¹ AFTER the falling edge of the external trigger. This is inherent in the sensor operation.

It is important to note that the Strobe_Out signal includes the additional fixed exposure time period and therefore is 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.

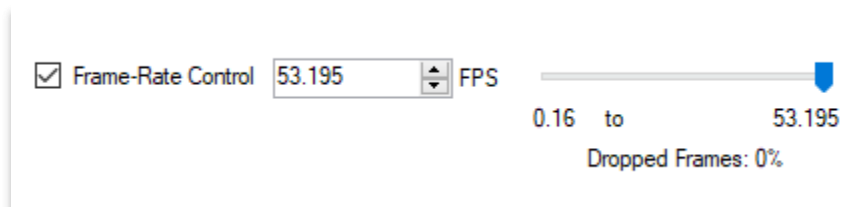
Note 1 – The fixed exposure time period for the CS165 models is 14.26 μ s.

4.3. Frame-Rate Control

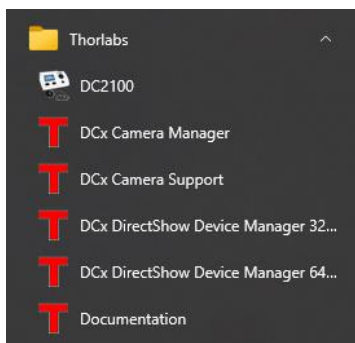
The Zelux family of Compact Scientific cameras employ a unique feature in the ThorCam software environment and SDK that allows a user to adjust the frame rate in frames per second (FPS) to reduce or eliminate the number of dropped frames that may occur due to limitations in the host computer.

The Frame-Rate Control is accessed in the Camera Settings window of ThorCam. When the Frame-Rate Control 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 adjustment slider is enabled, as is the numeric input field and increment/decrement arrows.

Adjust the FPS until the Dropped Frames percentage reduces to 0%.



Please refer to the ThorCam User Guide for more details, which can be accessed in the Documentation selection under the Start menu / All Programs listing for Thorlabs' products.



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

https://www.thorlabs.com/software_pages/ViewSoftwarePage.cfm?Code=ThorCam

for the latest ThorCam software and camera firmware updates.

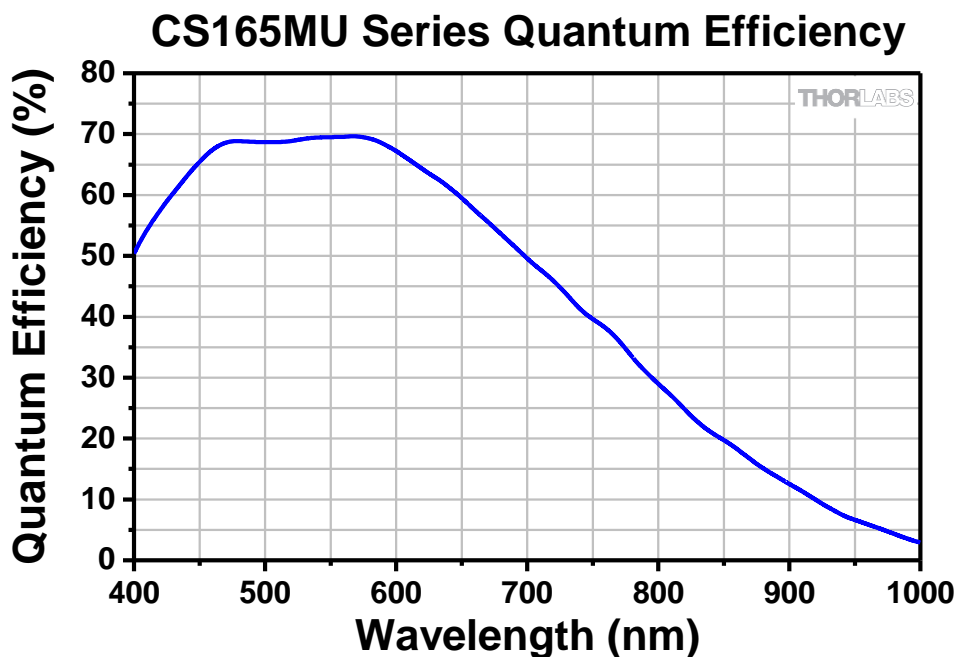
Chapter 5 CS165MU Specifications

The following specifications are valid for CS165MU, CS165MU1, CS165MU/M, and CS165MU1/M cameras.

5.1. CMOS Sensor Specifications

Sensor Specifications	
Sensor Type	CMOS Monochrome
Number of Active Pixels	1440 (H) x 1080 (V) (~1.6 MP)
Pixel Size	3.45 μm x 3.45 μm
Optical Format	1 / 2.9 Format (4968 μm x 3726 μm)
Peak Quantum Efficiency	69% at 575 nm
Dynamic Range	Up to 69 dB
Full Well Capacity	$\geq 11,000 e^-$
Shutter Type	Global

5.2. Quantum Efficiency



5.3. Imaging Specifications

Imaging Specifications	
Exposure Time	0.040 to 26843 ms in ~0.025 ms Increments
ADC Resolution	10 Bits
Vertical and Horizontal Digital Binning	1 x 1 to 16 x 16
Region of Interest (Width x Height)	80 x 4 Pixels ¹ to 1440 x 1080 Pixels, Rectangular
Read Noise	<4.0 e^- RMS
Overlapped Exposures	When Frames per Trigger = Continuous

¹ For Binning at 1 x 1.

5.4. Example Frame Rates (USB 3.0)

ROI	Frame Rate
Full Sensor (1440 x 1080)	34.8 fps
Half Sensor (720 x 540)	67.0 fps
1/10th Sensor (144 x 108)	260.0 fps
Min ROI (80 x 4)	>800 fps

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

Frame rate is directly dependent on the capabilities of the host computer. Results may vary.

See also Section 4.3 Frame-Rate Control

5.5. CS165MU Power Consumption

1.17 W Max @ 34.8 fps Full Sensor ROI

5.6. Operating/Storage Temperatures

Operating: 10 °C to 40 °C (Non-condensing)

Storage: 0 °C to 55 °C

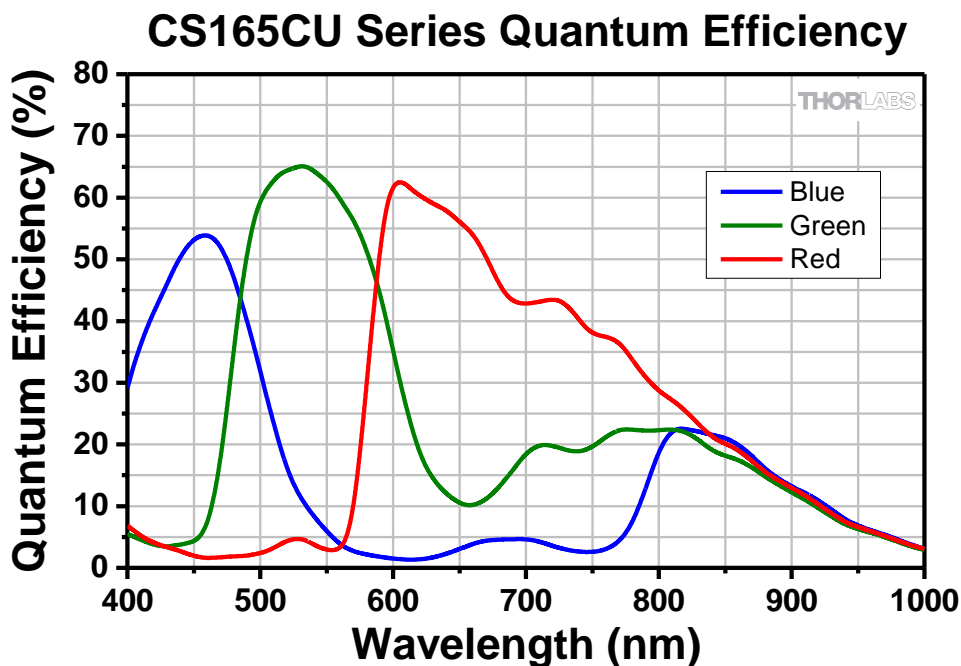
Chapter 6 CS165CU Specifications

The following specifications are valid for CS165CU, CS165CU1, CS165CU/M, and CS165CU1/M cameras.

6.1. CMOS Sensor Specifications

Sensor Specifications	
Sensor Type	CMOS Color
Number of Active Pixels	1440 (H) x 1080 (V) (~1.6 MP)
Pixel Size	3.45 μm x 3.45 μm
Optical Format	1 / 2.9 Format (4968 μm x 3726 μm)
Peak Quantum Efficiency	65% at 535 nm
Dynamic Range	Up to 69 dB
Full Well Capacity	$\geq 11,000 e^-$
Shutter Type	Global

6.2. Quantum Efficiency



An IR-blocking filter is typically installed. This filter may be removed if NIR responsivity is desired. See Chapter 7 for specifications related to the IR-blocking filter. The Responsivity plot above is without an IR-blocking filter.

6.3. Imaging Specifications

Imaging Specifications	
Exposure Time	0.040 to 26843 ms in ~0.025 ms Increments
ADC Resolution	10 Bits
Vertical and Horizontal Digital Binning ^a	1 x 1 to 16 x 16
Region of Interest (Width x Height)	80 x 4 Pixels to 1440 x 1080 Pixels, Rectangular
Read Noise	<4.0 e^- RMS
Overlapped Exposures	When Frames per Trigger = Continuous

a – Binning >1 x 1 only available when operating camera in unprocessed mode (monochrome).

6.4. Example Frame Rates (USB 3.0)

ROI	Frame Rate
Full Sensor (1440 x 1080)	34.8 fps
Half Sensor (720 x 540)	67.0 fps
1/10th Sensor (144 x 108)	260.0 fps
Min ROI (80 x 4)	>800 fps

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

Frame rate is directly dependent on the capabilities of the host computer. Results may vary.

See also Section 4.3 Frame-Rate Control

6.5. CS165CU Power Consumption

1.17 W Max @ 34.8 fps Full Sensor ROI

6.6. Operating/Storage Temperatures

Operating: 10 °C to 40 °C (Non-condensing)

Storage: 0 °C to 55 °C

Chapter 7 Protective Glass Windows

The protective glass window may be either an AR (anti-reflective) coated window for monochrome cameras, or an IR Filter for color cameras.

7.1. Protective Glass Window Dimensions

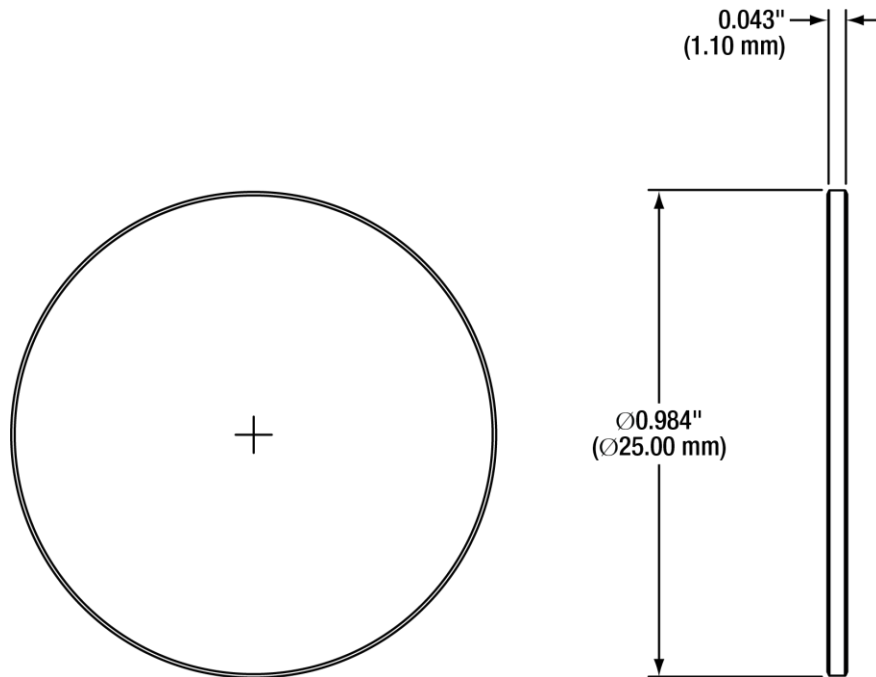


Figure 12 Protective Window Dimensions

7.2. AR-Coated Window Specifications

The AR coating has $R_{avg} < 0.5\%$ per surface over the 400 – 700 nm wavelength range.

7.3. IR Filter Transmission Curve

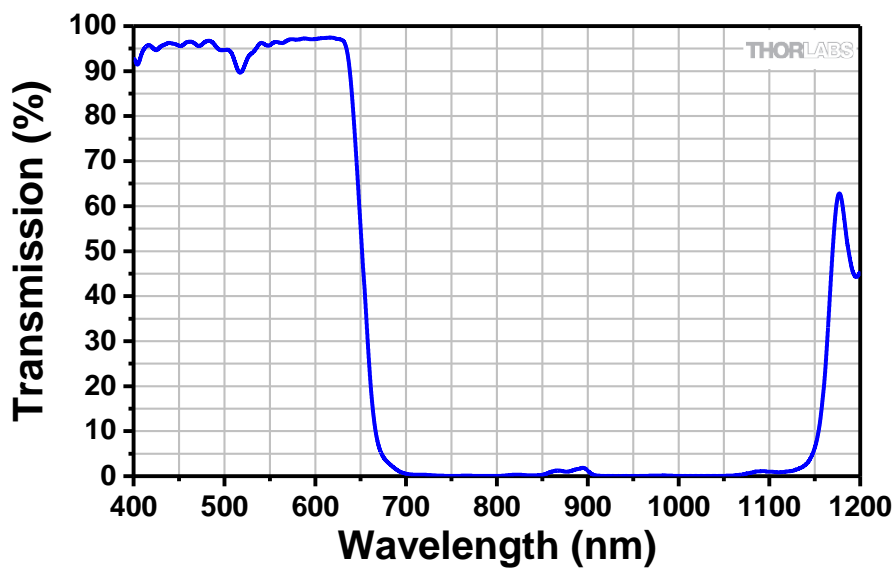
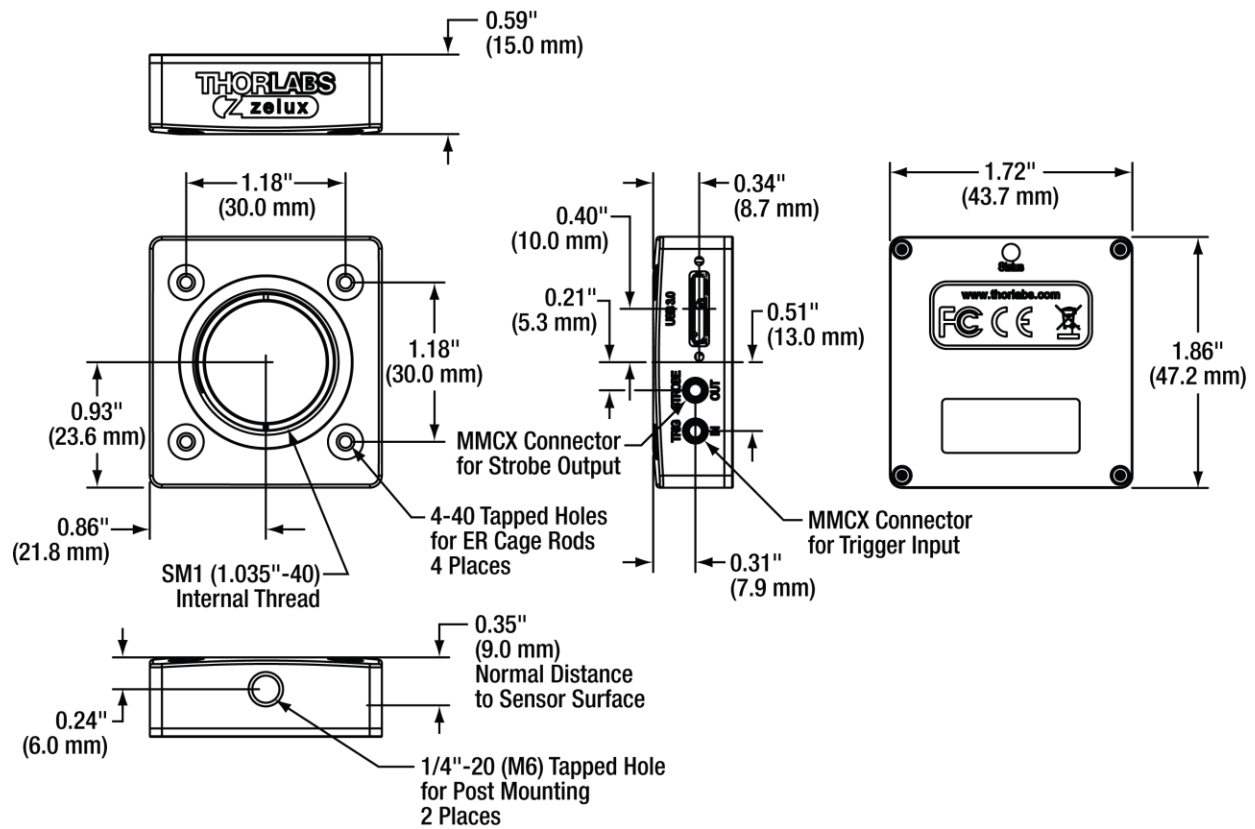


Figure 13 IR Blocking Filter Transmission Curve

Chapter 8 Mechanical Drawings



Dimensions of CS165xUx/M metric models are shown in parenthesis

Figure 14 Zelux Scientific Camera Dimensions

Chapter 9 Troubleshooting

9.1. Interface

Problem	Symptoms	Possible Cause	Remedy
Software cannot find a connected camera	<ul style="list-style-type: none"> Software does not display a connected camera. Software does not display an image. 	1. No power to camera.	1. Connect camera to USB 2.0 or 3.0 Port.
		2. Camera has yet to complete "enumeration".	2. Restart/refresh software after camera has been powered on and connected to host PC for at least 30 seconds.
		3. USB camera has not enumerated properly. (Amber LED stays on)	3. See Section 4.1. Disconnect USB 3.0 cable and then reconnect. First time connections to a PC may take longer to enumerate and load drivers. Problem may be with USB port. Reboot computer.

9.2. Optical

Problem	Symptoms	Possible Cause	Remedy
When using a standard C-mount lens (not included), image is not in focus	<ul style="list-style-type: none"> Displayed image is not in focus. 	Target image may be too close to the lens. Wrong lens adapter.	Select an appropriate lens for the distance of the target. C-mount lens must use Thorlabs SM1A10Z C-mount adapter.
When using a standard CS-mount lens (not included), image is not in focus	<ul style="list-style-type: none"> Displayed image is not in focus. 	Target image may be too close to the lens. Wrong lens adapter.	Select an appropriate lens for the distance of the target. C-mount lens must use Thorlabs SM1A10 CS-mount adapter.
Displayed image has spots or has debris in image	<ul style="list-style-type: none"> Debris in displayed image. 	Protective window has particulates on it.	Carefully clean the protective window. See Sections 3.6. and 10.1

9.3. Operational

Problem	Symptoms	Possible Cause	Remedy
Camera excessively warm (too hot to safely hold with ungloved hand)	<ul style="list-style-type: none"> Camera is too hot to hold with an ungloved hand. Poor image quality. 	1. Camera is not properly ventilated.	1. Remove any obstructions or provide adequate ventilation around camera.
		2. Electronics failure.	2. Disconnect camera from USB3 port and contact customer service.
Imaging Software “times out” without acquiring image	<ul style="list-style-type: none"> Imaging software indicates timeout. No images acquired – no frame count provided. 	1. Camera is not powered.	1. See Section 9.1 Troubleshooting above.
		2. Camera is not connected to computer.	2. See Section 9.1 Troubleshooting above.
		3. Imaging software is not configured to camera.	3. Consult the ThorCam User Guide.
		4. Camera is not “armed” and “started” properly.	4. Refer to Section 4.1.
Low Bandwidth USB 3.0 connection	<ul style="list-style-type: none"> Excessive dropped frames Inconsistent operation 	1. Low bandwidth USB 3.0 port.	1.a. Use a PCIe high bandwidth USB 3.0 Card, such as: Thorlabs' USB3-PCIE. 1.b. Reduce Frame Rate (See Section 4.3)
		2. USB 3.0 cable is too long or poor quality.	2. a. Use the 3 m cable supplied with the camera. 2. b. Use a 3 m (max) cable with 26AWG signal wires - or a 1m cable.
Yellow Indicator	<ul style="list-style-type: none"> Camera does not connect to Host 	1. Windows power saving settings.	1. Turn off all USB3.0 power saving settings in Device Manager.

9.4. Software

Problem	Symptoms	Possible Cause	Remedy
Camera not found	<ul style="list-style-type: none"> Error message, or camera does not show up in Hardware Connections. 	1. Power not on.	1. Make sure camera is connected to USB3 Port.
		2. Not plugged in.	2. Make sure camera is connected to USB3 Port.
		3. Bad USB cable, connection, or port	3. Try a different cable. Refer to Section 4.1 for information on the camera's status indicators. Reboot computer.
Insufficient illumination	<ul style="list-style-type: none"> Images are all black. 	1. Exposure time too low.	1. Make sure that exposure time is greater than 0; if the exposure is already greater than 0, try increasing the exposure time or gain gradually.
		2. No light going to the camera.	2. Make sure that the light source is turned on, and that the aperture of the lens (or other optics) is not shut.
		3. Lens Cap is Installed.	3. Remove Lens Cap.

Chapter 10 Maintenance

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

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

10.1. 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, TSI 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 TSI cameras, are meant to be used in conjunction with the procedures described in the tutorial.

Cleaning the Lens of Optical Assembly

Please follow the lens manufacturer’s recommendations for cleaning. TSI 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 TSI 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.

Standard Camera Precautions

While the lens mounting ring and locking flange allow the user some lens back-focus adjustment, complete removal of the ring will expose the sensor faceplate and will likely cause debris to accumulate on its surface. **Extreme care should be taken to avoid completely removing the lens mounting ring and exposing the sensor faceplate unless absolutely necessary. Fingerprints or other evidence of contact with the sensor faceplate may void the warranty.**

Cleaning the Infrared Filter or AR-Coated Window

The filter or window is visible when the lens is removed, mounted inside the lens mounting ring. This filter blocks invisible, near-infrared light from reaching the sensor. This filter is required for accurate color reproduction.

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

Do not remove the filter or window from the camera.

First, remove the lens and carefully examine the filter 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 of 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. Remove any CS-mount or C-mount lens adapters from camera.
3. Orient the camera so that the sensor is pointing downward and carefully unscrew the SM1 retaining ring and remove the window or filter. Refer to Section 3.6.1.
4. Place the camera face down on a clean, dry surface to prevent particles from accumulating on the sensor’s faceplate.
5. Once the filter 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 of the filter.
6. Re-examine the filter after removing the dust. If a smudge is still visible, proceed by dipping a clean, lint-free cotton swab in ethyl or isopropyl alcohol. The swab should be saturated, but not dripping.
7. Carefully draw the swab once across the surface, then rotate the swab 180 degrees to expose the fresh surface and draw it across the filter surface again. Be careful not to pool alcohol on the glass surface.
8. Re-examine once again and repeat the process once, if necessary.

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

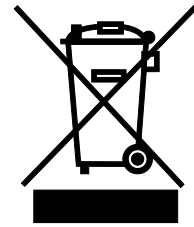
**CAUTION**

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 11 Regulatory

As required by the WEEE (Waste Electrical and Electronic Equipment Directive) of the European Community and the corresponding national laws, Thorlabs offers all end users in the EC the possibility to return “end of life” units without incurring disposal charges.

- This offer is valid for Thorlabs electrical and electronic equipment:
- Sold after August 13, 2005
- Marked correspondingly with the crossed out “wheelie bin” logo (see right)
- Sold to a company or institute within the EC
- Currently owned by a company or institute within the EC
- Still complete, not disassembled and not contaminated



Wheelie Bin Logo

As the WEEE directive applies to self-contained operational electrical and electronic products, this end of life take back service does not refer to other Thorlabs products, such as:

- Pure OEM products, that means assemblies to be built into a unit by the user (e. g. OEM laser driver cards)
- Components
- Mechanics and optics
- Left over parts of units disassembled by the user (PCB's, housings etc.).

If you wish to return a Thorlabs unit for waste recovery, please contact Thorlabs or your nearest dealer for further information.

Waste Treatment is Your Own Responsibility




If you do not return an “end of life” unit to Thorlabs, you must hand it to a company specialized in waste recovery. Do not dispose of the unit in a litter bin or at a public waste disposal site.

Ecological Background

It is well known that WEEE pollutes the environment by releasing toxic products during decomposition. The aim of the European RoHS directive is to reduce the content of toxic substances in electronic products in the future.

The intent of the WEEE directive is to enforce the recycling of WEEE. A controlled recycling of end of life products will thereby avoid negative impacts on the environment.

11.1. Certifications and Compliance – CE Declaration of Conformity

		THORLABS www.thorlabs.com	
EU Declaration of Conformity <i>in accordance with EN ISO 17050-1:2010</i>			
We:	Thorlabs Inc.		
Of:	56 Sparta Avenue, Newton, New Jersey, 07860, USA		
<i>in accordance with the following Directive(s):</i>			
2014/35/EU	Low Voltage Directive (LVD)		
2014/30/EU	Electromagnetic Compatibility (EMC) Directive		
2011/65/EU	Restriction of Use of Certain Hazardous Substances (RoHS)		
 <i>hereby declare that:</i>			
Model:	CS165; CS165MU, CS165MU1, CS165MU/M, CS165MU1/M, CS165CU, CS165CU1, CS165CU/M, CS165CU1/M		
Equipment:	ZELUX CMOS Scientific Camera, 1.6MP, with Ext. Trigger option		
<i>is in conformity with the applicable requirements of the following documents:</i>			
EN 61010-1	Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use.	2010	
EN 61326-1	Electrical Equipment for Measurement, Control and Laboratory Use - EMC Requirements	2013	
 <i>and which, issued under the sole responsibility of Thorlabs, is in conformity with Directive 2011/65/EU of the European Parliament and of the Council of 8th June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment, for the reason stated below:</i>			
does not contain substances in excess of the maximum concentration values tolerated by weight in homogenous materials as listed in Annex II of the Directive			
 <i>I hereby declare that the equipment named has been designed to comply with the relevant sections of the above referenced specifications, and complies with all applicable Essential Requirements of the Directives.</i>			
Signed:		On:	07 February 2020
Name:	Carmine Lencsak		
Position:	Chief Operating Officer	EDC - CS165; CS165MU, CS165MU1, CS16...	

11.2. FCC Statement

This device complies with part 15 of the FCC rules. Operation is subject to the following 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.

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. 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 their own expense.

Modifications not expressly approved by the manufacturer could void the user's authority to operate the equipment under FCC rules.

Chapter 12 Warranty

12.1. General Product Warranty

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.

12.2. Specific Warranties and Repairs

All specific warranty and repair information can be found in the general terms and conditions located at https://www.thorlabs.com/Images/PDF/LG-PO-001_Thorlabs_terms_and_%20agreements.pdf

Chapter 13 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.



THORLABS

www.thorlabs.com
