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## Finger Lakes Instrumentation Information Guide

Finger Lakes Instrumentation is a company based in Lima, NY and Binghamton, NY. We specialize in scientific imagers and the accessories that are paired with scientific image capture. We offer four families of cameras: MicroLine, ProLine, Hyperion, and Kepler. Kepler, being the newest addition, is the focus of many sections of this digital guide. Please regard the [MicroLine User's Guide](#), [ProLine User's Guide](#), and [Hyperion User's Guide](#) for specifications, installation, and operation specific to those imagers.

This information guide has a wide span of information including, but not limited to the following: Focuser, Filter Wheels, FLI Pilot, Lens and Sensor Selection, and information regarding sCMOS and CCD operation and readout structures. The contents of this website are subject to be changed, added to, and removed with no notification. Many aspects of this website will grow, and many aspects may change completely.

Use the search bar at the top of the screen to locate information relevant to your needs. Use the navigation menu below the search bar to navigate the website. Words underlined with blue text are links to relevant information. Follow these links to learn more about the subject discussed.

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## Welcome

Thank you for purchasing an FLI camera. We know that your new camera will bring you years of enjoyment and excellent imaging results.

This User Guide is intended as a reference tool for you to use with the Kepler Imaging System. Please read it and follow the procedures to ensure trouble-free installation of your hardware and software.

If you have any questions about your purchase, please [contact](#) us.

## Conventions

*The following standard conventions are used in this Guide. Review all cautions and dangers prior to operating the system.*

Note: To emphasize or clarify information or instructions.

**WARNING:** To prevent damage to or from the System.

## Additional Information

For additional information about the Kepler Imaging System, refer to the following information:

- FLI Software/FLI Pilot User Guide
- [www.flicamera.com](http://www.flicamera.com)

## Accessories and Ordering Options

FLI provides a variety of accessories including [color filter wheels](#), high-speed filter wheels, research grade filters, [digital focusers](#), adapters and other products to meet your needs. Refer to [www.flicamera.com](http://www.flicamera.com) for the most recent products and information.

For information regarding accessories and options for the Kepler Imaging System, refer to the FLI website ([flicamera.com](http://flicamera.com)).

## Warranty and Return Procedure Information

The FLI web site ([flicamera.com](http://flicamera.com)) contains current information regarding the product warranty and if required, return of the product to FLI. The website's Support tab contains links for Warranty, Returns and the RMA (Return Materials Authorization) form with instructions.

## Contact Information

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## FLI Yahoo Group

FLI Yahoo Group is an active forum for members wishing to discuss FLI imaging systems, share imaging experiences, techniques, results, and discuss imaging solutions and problem solving. The forum is accessible online at [http://groups.yahoo.com/neo/groups/FLI\\_Imaging\\_Systems/info](http://groups.yahoo.com/neo/groups/FLI_Imaging_Systems/info).

## Corporate Information

This product is designed and manufactured in Lima, NY (USA) by Finger Lakes Instrumentation LLC

Information in this document is subject to change without notice and does not represent a commitment on the part of Finger Lakes Instrumentation LLC (FLI). Although every effort has been made to ensure the accuracy of this documentation, FLI cannot be held liable for any errors. No part of this manual may be reproduced or transmitted in any form or by any means, electronic, or mechanical, including photocopying and recording, for any purpose other than the purchaser's personal use without written permission from FLI.

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KL400



KL4040

## Kepler

Kepler is FLI's new series of cooled cameras, providing higher throughput, more channels, and a variety of new sensors, including scientific CMOS.

The official Kepler documentation, including specifications for each camera and sensor available in the Kepler family is available at [flicamera.com/kepler/kepler.html](http://flicamera.com/kepler/kepler.html).

An overview of the Kepler family is available at [flicamera.com/pdf/KeplerOV.pdf](http://flicamera.com/pdf/KeplerOV.pdf).

A setup guide for the Kepler family cameras can be accessed [on the Set Up Page](#).

An overview of the auxiliary connector on the Kepler cameras and the modes of indication of exposure processes can be accessed [on the Connectors Page](#).

## KL400

The KL400's back-illuminated sensor has a peak quantum efficient of 95%, making it one of the most sensitive sensors on the market. The camera can reach video rates at full resolution with as little as 1.6 electrons RMS noise.

[For KL 400 operation features click here](#)

[For a KL400 spec. sheet, click here](#)

### Table 1. KL 400 Specifications

These specifications are subject to change without notice.

Shutter	Rolling
Sensor Type	Front and Back Illuminated
Resolution	2048x2048
Pixel size	11 microns
Imaging area	22.5mm x 22.5mm
Linear full well capacity (e-)	120000 (FI) / 90000 (BI)
Read noise (RMS)	1.5 e- (FI) / 1.6 e- (BI)
Maximum Frame Rate	48fps (24 fps HDR)
Interface	USB 3.0, optional QSFP fiber
Peak QE	58% (FI) / 95% (BI)
Dynamic Range (HDR)	96 dB (FI) / 93 dB (BI)
Dark Current @ -20C	0.2 eps (FI) / 0.6 eps (BI)
Regulatory Certifications and Standards	
Software / OS Requirements	FLIPilot
Operating Temperature	
Operating Humidity	Non-condensing
Physical Dimensions	See <a href="#">Mechanical Drawing</a>
Weight	2.65 lbs (1.2 kg)
Electrical Requirements	110-240V AC, 50-60 Hz, 2 Amp max draw
System Power	
IP Classification	

## KL4040

The KL4040 scientific CMOS camera has the same pixel size and imaging area as the popular KAF-16803 CCD, but with 1/3 the noise and 40% higher quantum efficiency. Kepler cooled sCMOS cameras provide ultra-high sensitivity, ultra-low noise, and high frame rates, all at game-changing price to performance ratio.

[For a KL4040 spec. sheet, click here](#)

### Table 1. KL 4040 Specifications

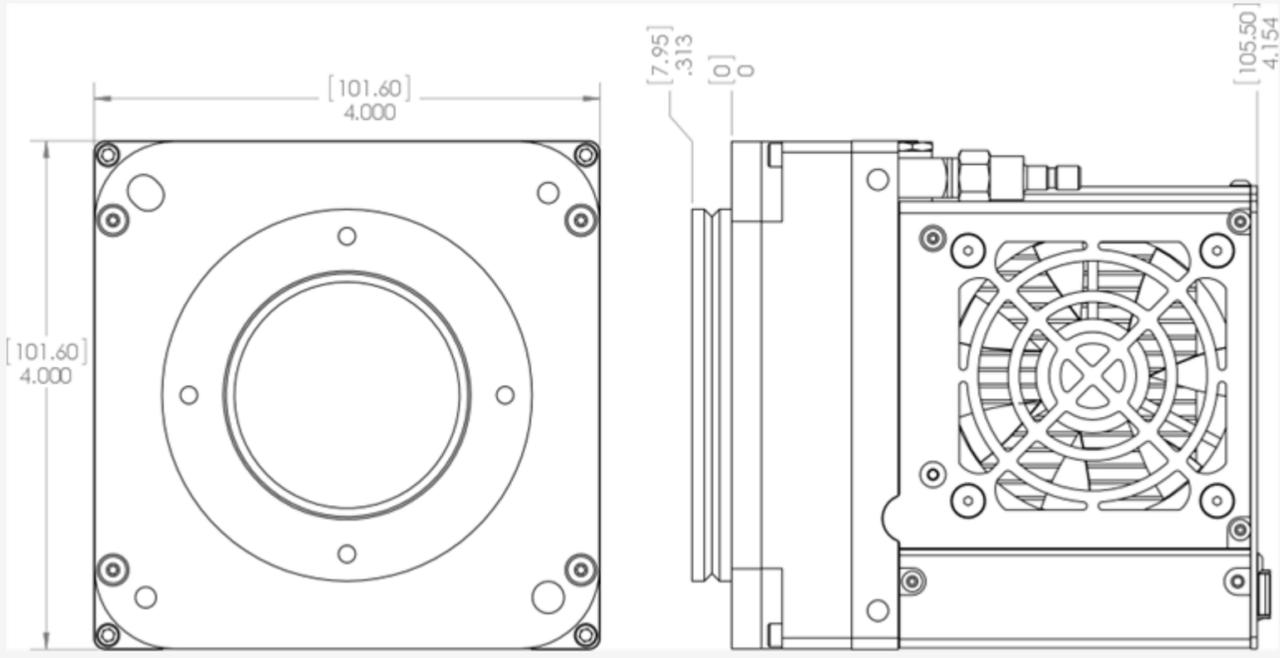
These specifications are subject to change without notice.

Shutter	Rolling
Sensor Type	Front Illuminated
Resolution	4096 x 4096
Pixel size	9 microns
Imaging area	36.9mm x 36.9mm
Linear full well capacity (e-)	70000 electrons
Read noise (RMS)	3.7e-
Maximum Frame Rate	24FPS
Interface	USB 3.0, optional QSFP fiber

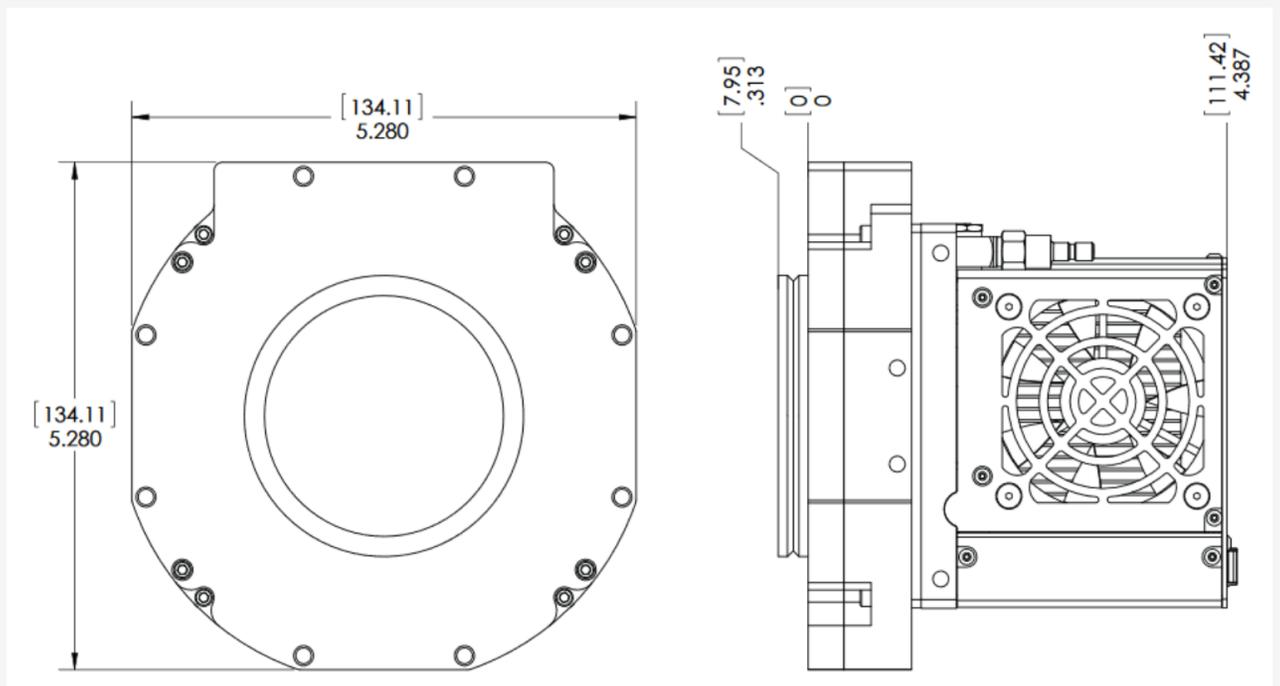
Peak QE	74%
Dynamic Range (HDR)	86dB
Dark Current @ -20C	0.15 eps
Regulatory Certifications and Standards	
Software / OS Requirements	FLIPilot
Operating Temperature	
Operating Humidity	Non-condensing
Physical Dimensions	See <u>Mechanical Drawing</u>
Weight	2.65 lbs (1.2 kg)
Electrical Requirements	110-240V AC, 50-60 Hz, 2 Amp max draw
System Power	
IP Classification	

## Mechanical Drawings

Model: KL 400



Model: KL 4040



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## Assumptions

This User Guide is written with the assumption that you are familiar with cameras, computers (PCs), and image enhancement software. This Guide provides information on the use of the Kepler Imaging System.

This Guide describes the standard System components. If you have received custom or optional items, they are not described in the main sections of this Guide. Information for special items may be provided in an Appendix or as separate documentation.

## Check your Shipment

Ensure that all the components have arrived safely and that all the items you ordered were properly delivered to you. In the unlikely event of a missing or damaged component, immediately notify your FLI dealer or FLI.

**Note:** Save the shipping materials that minimize shock and vibration in the event that you need to return the camera.

A camera order should include the following items:

- Camera with shutter cover installed (save this cover)
- Camera Test Report / FLI Quality Assurance Test Summary
- USB cable
- 12 volt power supply
- Packing list
- FLI Software Installation and Documentation (one page)
- User Guide (also available at <http://www.flicamera.com/software/index.html>)

## Camera Care and Safety

**WARNING:** Kepler Imaging System is shipped with a 12-volt grounded power supply. Do not use any other power supply with this System or use the power supply in a way other than described in this Guide as it may cause damage to the camera that will not be covered under the warranty.

**WARNING:** If any liquid spills into the camera, immediately remove the power cord from the wall outlet and remove the power supply cable from the camera. Use a dry cloth to absorb the liquid. DO NOT USE the camera as it may cause personal HARM or damage the camera. Contact FLI for further information and instructions.

Review the information below. Failure to heed these suggestions may damage to the camera or may adversely affect its operation.

- The camera contains no user serviceable components.
- As a general safety precaution, remove liquids and all unnecessary items from the area in which the camera will be used.
- Provide adequate clearance (2.5 inches (6 cm)) on the camera's intake and exhaust sides for air flow.
- For USB 3 Systems, directly connect the computer and camera power supply to standard grounded electrical power outlets (the same service).
- **Plug the power cord into the camera first, then plug the power cord into the power outlet.**
- When not in use eliminate damage to the camera from electrical surges (for example, lightning strikes) by unplugging both the camera power supply from power and the camera USB cable from the computer.
- Before connecting and disconnecting any cables, shut down the computer. Failure to do so may result in damage to the camera.
- The site should not have excessive dust. Use a dust cover to protect the camera when not in use.
- If the fins of the camera's fan contain debris, use a cotton swab to remove debris.
- The room temperature and humidity should provide adequate operator comfort. High or low temperatures and humidity may adversely affect the camera.
- Dispose of the camera according to national guidelines.

## Installing FLI Software

**Note:** If your system contains an earlier version of the FLI Software, uninstall / remove it by following the onscreen prompts. Then install the most current version. Overwriting an old file is not recommended.

Your computer must run Windows XP/Vista/7/8/8.1/10 32-bit or 64-bit. (If you do not know your system type, it is typically available from the Control Panel / System and Security / System menu.)

As noted in the camera shipping box, go to the "Support" tab of the [FLI website](#). Select the FLI Software Installation Kit corresponding to your computer type. The Installation Kit installs FLI's applications and USB device drivers. Also, download the ASCOM driver for the focuser products if appropriate. Follow the onscreen prompts for the installation instructions.

After installing FLIPilot, click on the FLIPilot icon to launch it and ensure it has been installed.

## Confirming Driver Installation

You can determine if the camera drivers have been properly installed after connecting and powering the camera. The procedure below is typical of most operating systems; however, it may be slightly different on your computer.

1. Choose the Control Panel from the start menu.
2. Choose System Properties.
3. Select the Hardware tab and select Device Manager.
4. Click the (+) next to Universal Serial Bus Controllers.
5. If the FLI Camera is displayed, the drivers are correctly installed.
6. Right Click on FLI Camera, choose Properties to view the driver status, driver date, etc. If the driver does not show up, uninstall FLIPilot then re-install it.

## Third Party Software

Kepler cameras are supported by a robust SDK (Windows, LINUX) free of charge. Also included is [FLI Pilot](#) software. MATLAB®, LabVIEW®, ASCOM and µManager are fully supported.

Input-output TTL signals via an eight pin AUX port are provided making it easy to synchronize the camera's operation with external events or light sources.

Before acquiring software to control your camera we strongly advise you to check with the software vendor and contact FLI. New releases of software may differ in functionality from previous versions of the same software and not operate as expected.

Image capture and analysis software includes:

- SkyX from Software Bisque ([www.bisque.com](http://www.bisque.com))
- MaximDL from Diffraction Ltd ([www.cyanogen.com](http://www.cyanogen.com))
- Astroart from MSB software that has a multi-lingual interface ([www.msb-astroart.com](http://www.msb-astroart.com))

## Setting up and Powering Your System

Assemble all system components in one area before beginning this set up procedure.

**Note:** Run the FLI Software Installation Kit before you set up and power your system to ensure the system recognizes and correctly initializes the camera.

Figure 2 shows the camera with the appropriate connections made.

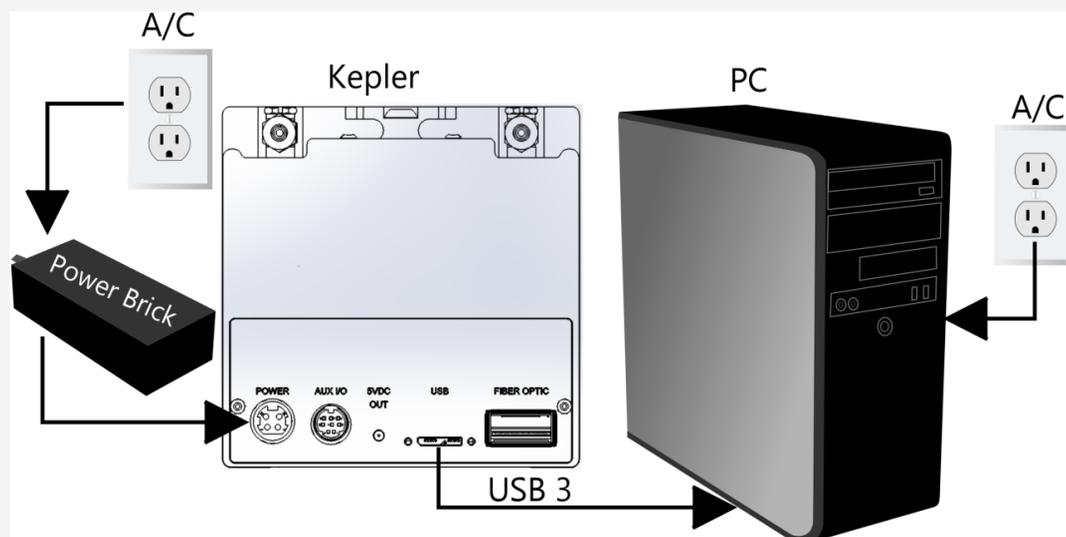


Figure 2. Kepler Camera with System Connections

Set up the system as described in the steps below.

1. Run the FLI Installation Kit to install the software as described previously.
2. Attach the USB cable between the camera and your computer.
3. Connect the 12-volt power supply between the camera's 4-pin "DC Power Jack" connector and a wall socket or switched AC power strip. The camera's fans will start running. Your computer should display a screen indicating that the system has found new hardware. If it has not, refer to "[Confirming Driver Configuration](#)" earlier in this Guide.

The option to electrically isolate your Kepler is available. [See System Isolation](#)

## Sensor Temperature / Cooling Information

The standard Kepler camera configuration provides for sensor air cooling (un-cooled). Depending on your application, your camera sensor may require cooling with air or with liquid coolant.

The Kepler family of cameras, like all FLI cameras, have a built-in TEC (Peltier) and a fan that enables the camera to cool the sensor. Removing excess heat from the camera's electronics and keeping the sensor cool keeps the dark current to an acceptable minimum and reduces drift when capturing multiple frames. Provide clearance on the air intake/output faces of the camera.

The fan power is set at the factory. Refer to the [FLIPilot documentation](#) for information on controlling the fan.

Two heater strips on the outside of the camera window keep the window just above ambient temperature to reduce condensation on the window. Refer to the FLIPilot documentation for information on controlling the heater.

If your application requires liquid cooling, refer to Table 1 for connectors for the ports on the camera. The actual cooling for any given camera will depend on the sensor size and ambient temperatures. The Liquid Cooler can accept a flow rate up to 0.5 gallon/minute (1.91 liter/ min).

**Note:** The Maximum Liquid Cooler inlet pressure is 50 psig. Ensure the tubing has the proper pressure rating. To avoid undesired pressure build up in Liquid Cooler shut off flow on the inlet side before detaching or closing outlet connections.

Connector	Standard User Interface	Additional Information
1/8" ID Hose Barb	1/8" ID Tubing	FLI recommends use of hose clamps. User supplies tubing and clamps with appropriate pressure rating for their application.
Quick Connect Double Shutoff	#10-32 UNC male coupling	FLI supplies both female and male connectors. User supplies the interface.
Quick Connect Dry Break	#10-32 UNC male coupling	FLI supplies both female and male connectors. User supplies the interface.
Custom	Per Customer	FLI is able to plumb to interfaces not listed. Please contact FLI Requirements with your connection requests.

Table 1. Connectors

## External Triggering and/or Exposure Control

**WARNING:** Using liquid cooling flow rates above the recommended flow rates may cause the liquid cooling system to leak and will void the warranty.

Externally trigger the camera using FLI Pilot as described in the steps below.

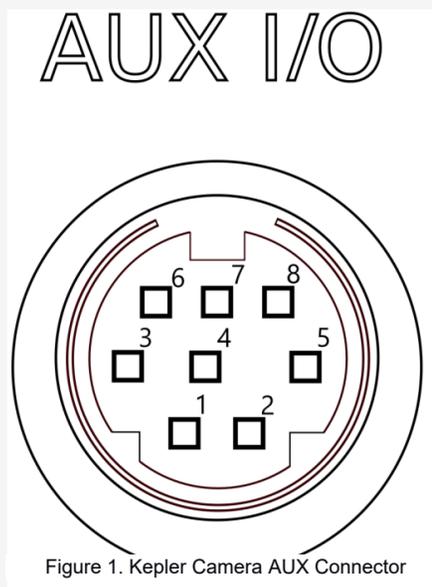
1. In FLI Pilot select the Shutter Control.
2. Select how the triggering is setup on the pull down menu:
  - "External trigger on LOW" for low edge triggering (transition from +3.3V to 0V or equivalent LVTTTL signal ) on AUX pin 5.
  - "External trigger on HIGH" for high edge triggering (transition from 0V to +3.3V or equivalent LVTTTL signal ) on AUX pin 5
3. Select "Done".
4. Open the Grab Control.
5. Select desired frame and exposure settings.
6. Click the Grab button. The camera will now wait for an external trigger.



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## 8-Pin Connector

The Kepler Imaging Systems have an eight pin AUX connector as shown in **Figure 3** with each pin described below.



The tables below summarize the pins on the 8-pin connector by pin number and by description in alphabetical order.

Pin	Description
1	<b>Aux2_InOut</b>
2	<b>Aux1_InOut</b>
3	<b>External Trigger</b>
4	<b>Aux3_InOut</b>
5	<b>Shutter Open</b>
6	<b>Ground Reference</b>
7	<b>Aux4_InOut</b>
8	<b>Exposure Active</b>

Description	Pin
<b>Aux1_InOut</b>	2
<b>Aux2_InOut</b>	1
<b>Aux3_InOut</b>	4
<b>Aux4_InOut</b>	7
<b>Exposure Active</b>	8
<b>External Trigger</b>	3
<b>Ground Reference</b>	6
<b>Shutter Open</b>	5

### Pin 1 - Aux2\_InOut

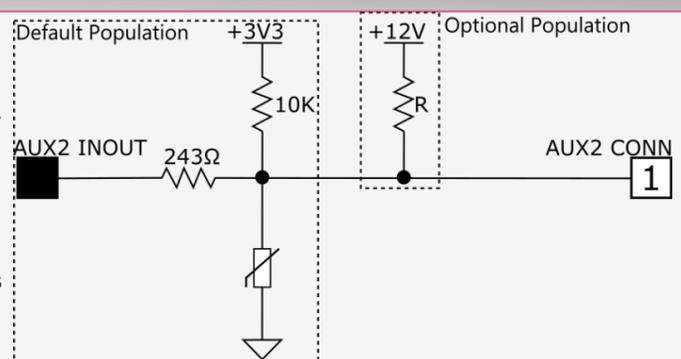
Pin 1 of the 8 Pin connector is a 12V supply.

By default, there is a 243 Ohm series pullup resistor to 12V. This configuration allows use of the [Kepler Image Time Stamp \(KITS\)](#) module which requires 12V for operation.

An optional configuration is available to use pin 1 as an auxiliary IO connection. With the optional configuration, there is a 243 Ohm series resistor between the connector pin and the input/output driver. There is also a pullup of 10K to 3.3V.

Note: Installation of this configuration adds an additional aux IO, but removes the ability to use the KITS module.

The optional configuration can be assembled by FLI upon ordering. Contact FLI for information.

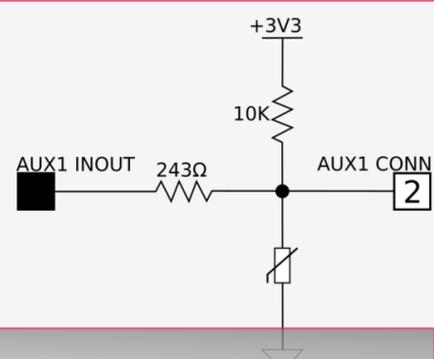


### Pin 2 - Aux1\_InOut

Pin 2 of the 8 Pin connector is auxiliary Input/Output 1.

There is a 243 Ohm series resistor between the connector pin and the input/output driver. There is also a pullup of 10K to 3.3V.

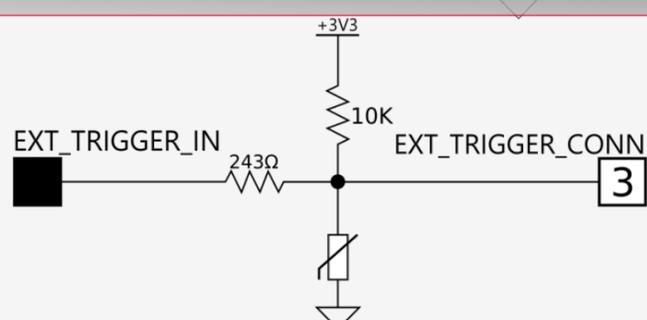
This input/output driver is 3.3V LVCMOS compatible. The direction is controlled via the API. The state is controlled by the user or the API, depending on the direction.



### Pin 3 - External Trigger

Pin 3 of the 8 Pin connector is the external trigger input signal.

There is a 243 Ohm series resistor between the connector pin and the input driver. There is a 10K Ohm pullup resistor to 3.3V. The state is controlled by the user.



See [External Triggering](#).

## Pin 4 - Aux3\_InOut

Pin 4 of the 8 Pin connector is auxiliary Input/Output 3.

There is a 243 Ohm series resistor between the connector pin and the input/output driver. This input/output driver is 3.3V LVCMOS compatible. The direction is controlled via the API. The state is controlled by the user or the API, depending on the direction.

This pin can be programmed as a general purpose I/O or as UART in which case this pin becomes the RX for the UART.

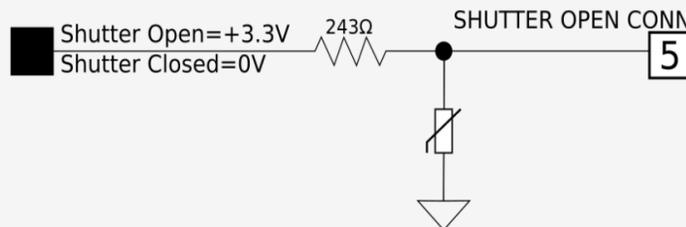
Default configuration operates as a UART, however, can be configured to operate as an IO upon request.

## Pin 5 - Shutter Open

Pin 5 of the 8 Pin connector is the shutter\_open output signal.

There is a 243 Ohm series resistor between the connector pin and the output driver. The output driver is 3.3V LVCMOS compatible.

Default state is shutter closed, 0V.



## Pin 6 - Ground Reference

Pin 6 of the 8 Pin connector is camera ground. All other pins on this connector are referenced to this pin.

## Pin 7 - Aux4\_InOut

Pin 7 of the 8 Pin connector is auxiliary Input/Output 4.

There is a 243 Ohm series resistor between the connector pin and the input/output driver. This input/output driver is 3.3V LVCMOS compatible. Direction is controlled via the API. The state is controlled by the user or the API, depending on the direction.

This pin can be programmed as a general purpose I/O or as UART, in which case the pin becomes the TX for the UART.

## Pin 8 - Exposure Active

Pin 8 of the 8 Pin connector is the exposure active output signal.

There is a 243 Ohm pullup resistor to 3.3V. There is a FET switch to ground. The state is controlled by the camera controller. The default state is low.

This pin is configured to be either a logic output or a driver for optocouplers. Possible optocoupler setups are shown in the figures to the right.

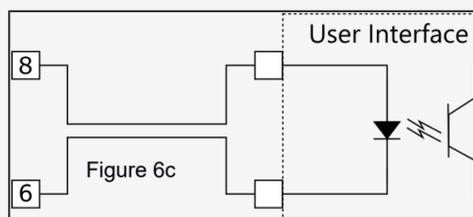
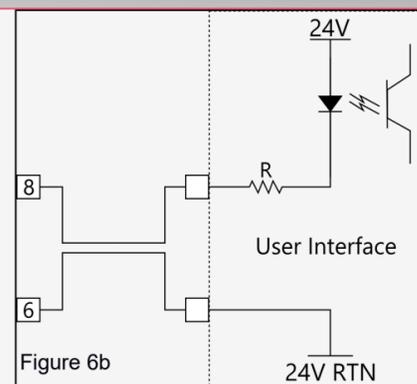
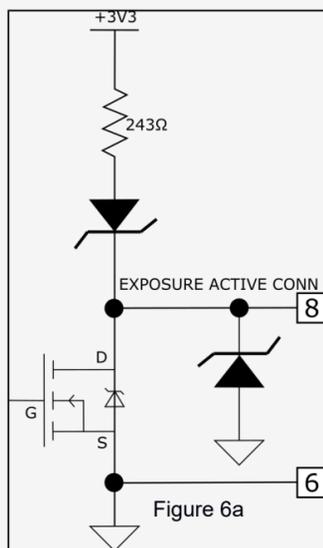


Figure 6a. The internal configuration of pin 8.

Figure 6b. A possible configuration that uses a 24V supplied by the user to drive an optocoupler.

Figure 6c. Another possible usage for pin 8 to use an optocoupler driven by the 3.3V supplied by the camera.

## Exposure Indicator

From pin 8, an exposure active signal can be detected. High indicates active, while low indicates inactive. This indicator can be used for timing instruments properly, and can be configured in the following modes to vary the output based on specific moments in the sensors process.

### First Row Active:

In First Row Active mode, the output signal is high during the first rows' exposure in a single frame. (**Figure 7**)

The length of the signal is dependent on the first rows exposure time. The exposure time can be set in the software by the user.

This mode maximizes frame rates, but results in overlap of frames due to the rolling shutter effect.

### Exposure Active:

In Exposure Active mode, the output signal is high when any row in a single frame is exposing. (**Figure 7**)

The length of the signal is dependent on the time between the start of the first rows' exposure and the end of the last rows' exposure.

It is not possible to achieve maximum frame rates in this mode, but frame overlap is avoided.

### Global Exposure Active:

In Global Exposure Active mode, the output signal is high when all rows are simultaneously exposing.

The length of the signal is dependent on the time between the start of the last rows' exposure and the end of the first rows' exposure.

This mode takes advantage of the speed and low noise capabilities of the rolling shutter but eliminates motion artifacts. (**Figure 7**)

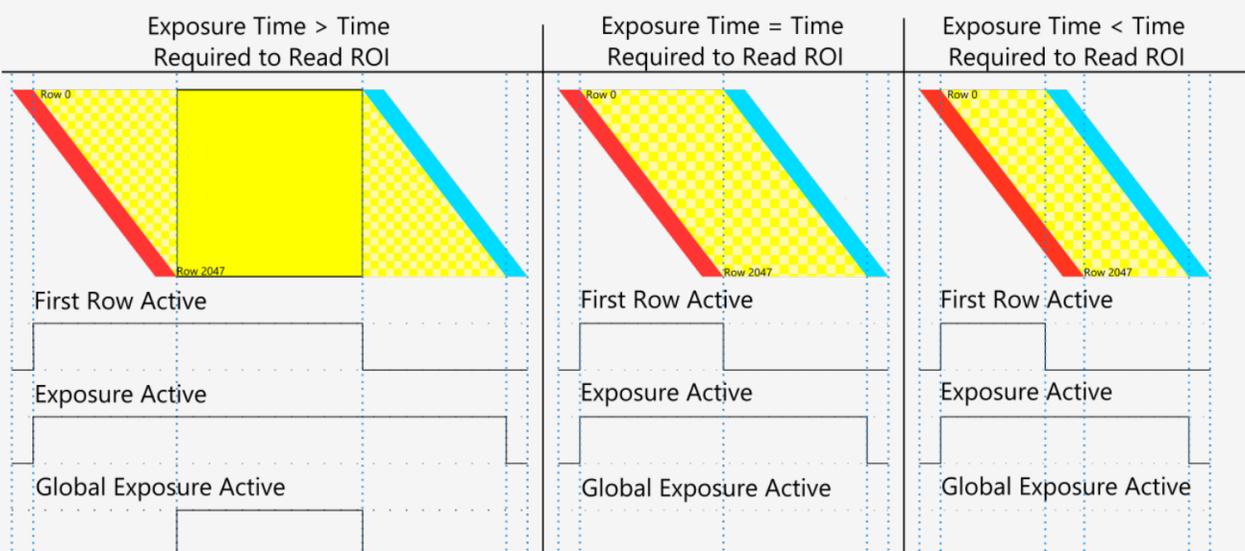


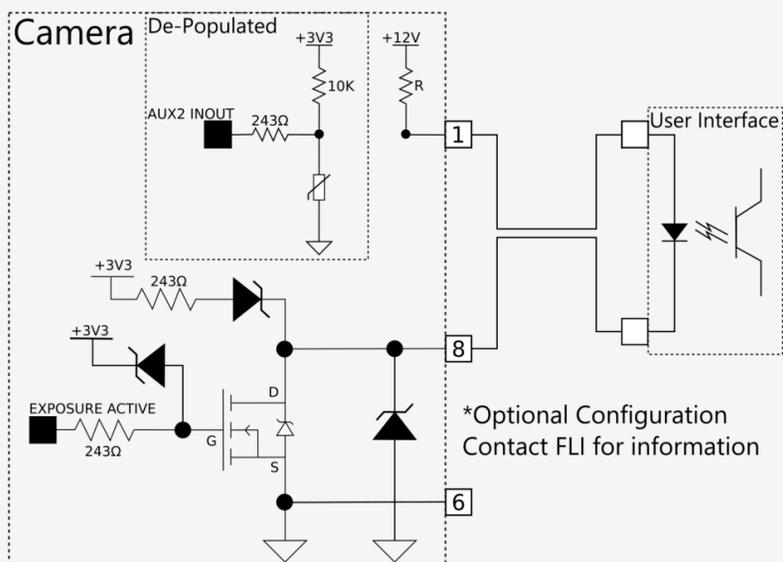
Figure 7. Exposure Control

First Row Active is the default configuration for pin 8's output. To change this option, one may use LibFLIPro, the SDK behind FLI Pilot, to program the exposure active signal type. The function `FPROAuxIO_SetExposureActiveType(iHandle, eType)` is used for this operation and discussed in greater detail in the SDK documentation. The SDK and SDK documentation is available at [flicamera.com](http://flicamera.com). The most up-to-date information can be requested through FLI.

## Pin 1 and 8 - Optional Optocoupler Configuration

This configuration uses a 12V source provided by pin 1 to drive an optocoupler.

For more information see [Pin 1](#) and [Pin 8](#). Contact FLI for more details.



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## KL400 Rolling Shutter Overview

The KL400 sensor is a rolling shutter imager.  
The pixels in the array are always exposed to light.

A single row within the sensor consists of a three step sequence.

The sequence starts with discarding built up charge, known as a reset or flush, to bring each pixels charge back to the reference level. When a reset is finished, the pixels in that row begin absorbing light (exposing) which accumulates charge. Finally, after the row is done exposing, the built up charge is read, known as readout. (**Figure 1**)

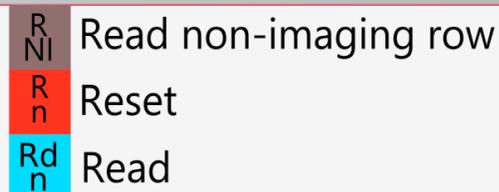


Figure 1. Single Row Sequence

More information regarding rolling shutter imaging [can be viewed here](#).

## KL400 Triggering

The KL400 supports internal and external ways of triggering (commencing exposure) an image. When an image frame is required, the user interface can command a trigger. All trigger commands are executed after the Exposure Delay time has expired. This approach makes computer control of when an image is captured easy.

The triggering options can be modified in [FLI Pilot](#) under [Trigger](#).

### Trigger Options:

**Internal:** This method uses the software application to issue a trigger request immediately when a capture is requested. This internal trigger is communicated over the USB 3.0 connection or Optical Fiber connection ([See System Isolation](#)). These connections introduce a small amount of variable delay. There is also a fixed delay in the camera for the internal trigger to be communicated to the sensor controller.

**External Low to High and External High to Low:** This method configures the sensor to respond to an external trigger. This input is found on the 8-pin connector, [Pin 3](#). When an external trigger is selected and image capture is requested, the camera waits for the transition of the external trigger pin to start the exposure. With Low to High selected, the camera waits from the signal on Pin 3 to transition from Low to High. With High to Low, the camera waits for a High to Low transition.

**External Control High to Low and External Control Low to High:** In these modes of operation, the level of the externally supplied trigger signal (provided through [Pin 3](#)) controls the start of the image exposure and the end of the exposure. For control high to low, the image exposure starts when the external trigger input transitions from high state to low state and ends when the external trigger input transitions from low state to high state. For control low to high the external trigger states are the reverse. The exposure value entered in the software acts as a maximum exposure. If the external trigger state is still active when the entered maximum exposure is reached the exposure is halted and readout begins. Therefore, ensure the entered exposure setting value is larger than the maximum expected externally controlled exposure time.

## KL400 Exposure Start Options

The Exposure start options are controlled in [FLI Pilot](#) under [Trigger](#).

### First Row Exposure (Default Exposure Setting)

In first row exposure mode, the trigger may be received at any time during the sensor's idling, however, the sensor will always finish its active cycle of flushing before beginning exposure. Where in this process the trigger was received is unknown, thus, there is a variable delay of between 0ms and 21ms.

When an exposure starts, the camera resets the start row and commences exposure as soon as the trigger is received. In this case, no charge that was accumulated in the exposure prior to the trigger is kept since all image rows are reset after the trigger. This results in a start of exposure time difference for each image row. For most imaging applications this is acceptable.

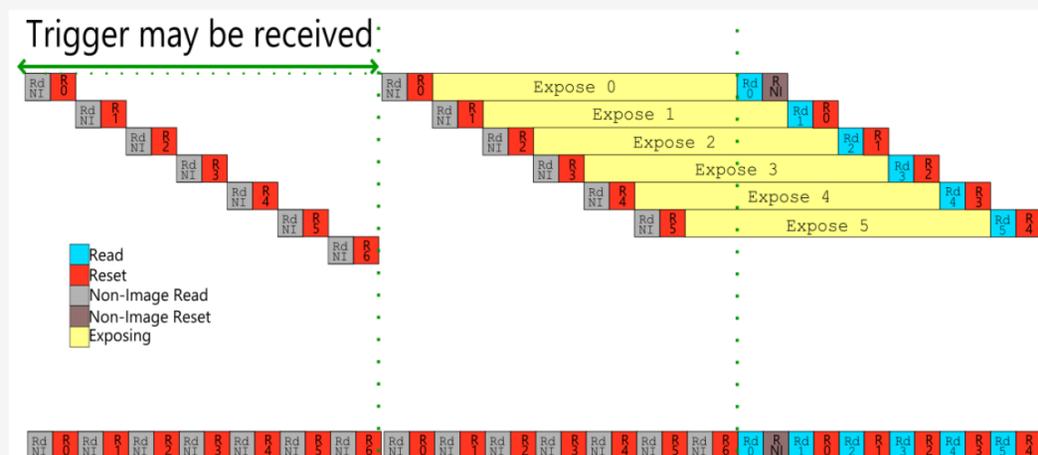


Figure 2: First Row Exposure. Six row example.

### Immediate Global Exposure

In immediate global exposure mode, the trigger is received and all row resets cease immediately and all rows are exposing. Therefore, all rows are exposing at the same time without read and reset interruptions.

This prevents a 21/42ms variability that the first row exposure has. However, there are rows with up to 21/42 msec of exposure which has already occurred due to rows that had not been reset since the previous flush procedure. This is only an issue if the sensor has been exposed to light during the time immediately prior to the trigger. A well functioning shutter or a dark scene with a flash allow this mode to function best.

When the start row has reached the desired exposure duration, image row readout commences and continues

for 21/42 msec. In **Figure 3**, for example, row 6 is read first due to the timing of the received trigger. When it reaches row 11, readout loops back to row 0 and continues until row 5, which is the last row to be read. This results in all rows having slightly different exposures, but this is not deemed a problem due to the nature of the image being captured.

This exposure mode is useful for applications such as bioluminescence.

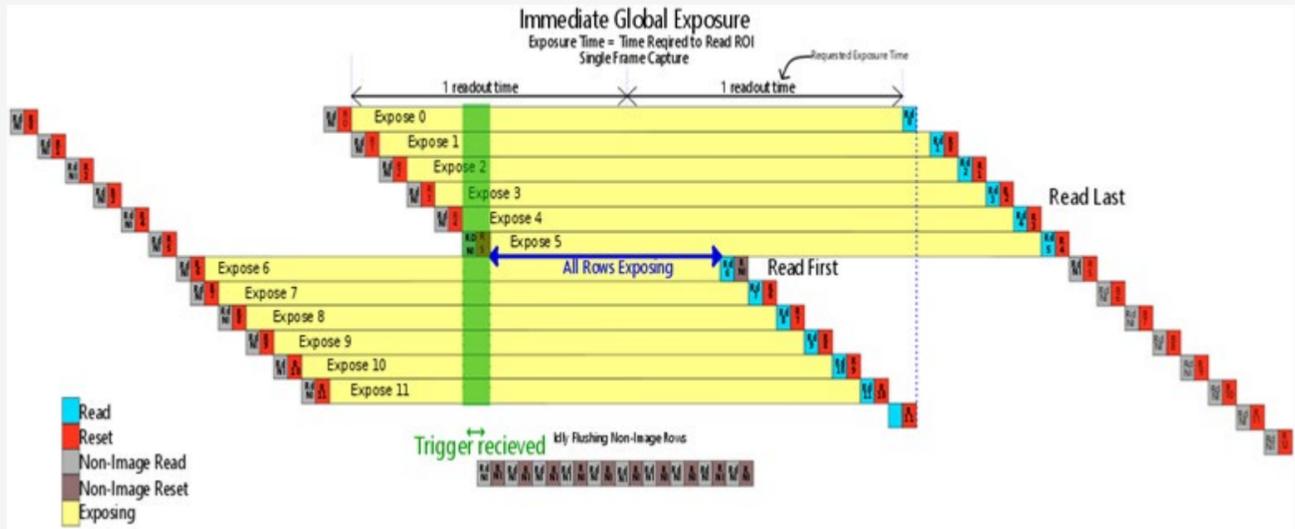


Figure 3. Immediate Global Exposure

## KL400 Image to Image Timing

The KL400 Image to Image timing can be controlled when you are running multiple images or continuous images. Image to Image time consists of exposure time and delay between end of exposure and start of next exposure. The KL400 camera lets you set exposure time and image to image time.

The FLI Pilot interface allows you to define any two parameters and automatically calculates the third parameter of the equation:

$$\text{Image to Image Time} = \text{Exposure Time} + \text{Delay Time}$$

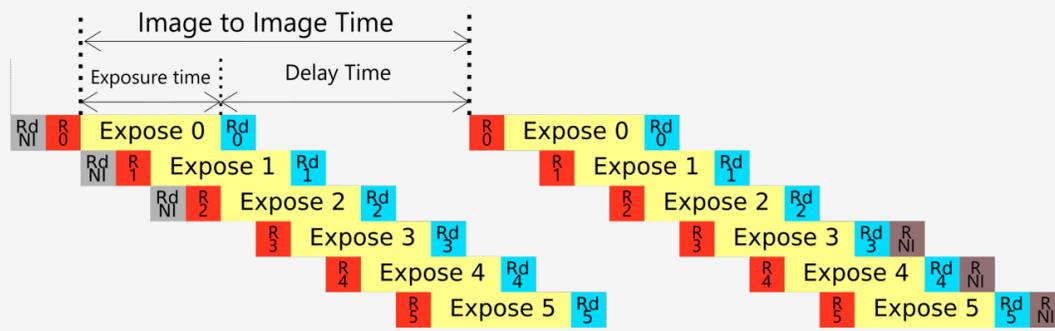


Figure 4. Image to Image Timing

## KL400 Camera Modes

The KL400 has four camera modes:

- Rolling LDR
- Rolling LDR-LDC
- Rolling HDR
- Rolling HDR-LDC

### Rolling LDR:

LDR (Low Dynamic Range) mode captures a single 12 bit image. This mode consists of 0 to 4,095 counts, but offers high frame rates compared to HDR. LDR mode is useful for short and bright exposures.

### Rolling LDR-LDC:

LDR-LDC (Low Dynamic Range-Low Dark Current) mode is similar to LDR mode. The difference is that LDC leads to less electrons accumulating in pixels when not exposed to light. This results to a smaller full well capacity, but allows for less dark current growth in long exposure images.

### Rolling HDR:

HDR (High Dynamic Range) mode captures two images, a high gain and low gain image. In this mode you can view either gain image, or a merged image of the two, which creates a 16 bit image. HDR has slower frame rates than LDR, but is more sensitive and detailed with 0 to 65,535 counts.

### Rolling HDR-LDC:

HDR-LDC (High Dynamic Range-Low Dark Current) mode is similar to HDR mode. The difference is that LDC leads to less electrons accumulating in pixels when not exposed to light. This results to a smaller full well capacity, but allows for less dark current growth in long exposure images.

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## **Installation**

The basic installation procedure and requirements for FLI Pilot are found here.

## **Quick Start**

This page contains the basics you need to know for capturing an image and performing post-image analysis.

## **Display Customization**

FLI Pilot provides a very modular and customizable interface. This page discusses the various ways one can alter the interface.

## **Pilot Overview**

This page goes through each part of the FLI Pilot program to familiarize the user with the various components of the interface.

## **Control Panel**

This page reviews every element of the rightmost control panel, from Grab Control to Tester Routines.

## **FPN Correction**

The problem of Fixed Pattern Noise is discussed here, as well as the technique required to remove FPN from an image.

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## FLI Pilot Installation

The installation files for FLI Pilot can be found on our main website under the [Support Tab](#). The FLI Pilot software download files are labeled [FLI Pilot Software for Kepler Cameras: Windows 7/8/10 \(32-bit/64-bit\)](#).

- 1) Download the correct version (32-bit or 64-bit) for your computer. It is our recommendation that this software be run on a Windows 10, 64-bit computer.
- 2) Unzip the FLIPilot folder that was downloaded.
- 3) Find and open the FliPilotSetup
- 4) Follow the program prompts to finish the install.
- 5) Pilot should now be loaded onto your computer. It can be started by clicking on the desktop icon or navigating to Start FLIPilot.

## FLI Accessory Drivers Installation

If you have purchased any accessories like our Filter Wheel then you will need additional drivers to connect these devices to your computer. These files can be found in the [FLI Software Installation Kit](#) under the [Support Tab](#). The download files are labeled [Windows XP/Vista/7/8/8.1/10 \(32-bit/64-bit\)](#)

- 1) Download the correct version (32-bit or 64-bit) for your computer. It is our recommendation that this software be run on a Windows 10, 64-bit computer.
- 2) Unzip the FLISetup folder that was downloaded.
- 3) Ensure that all FLI programs like FLIPilot are not running, if they are close the program.
- 4) Find the and open the FLISetup windows installer file.
- 5) Follow the program prompts to finish the install.
- 6) Your drivers should now be installed and your filter wheel should automatically be detected by Pilot now.

## FLI Pilot Updates

As Pilot is updated, the newest released version will be added to the website. Updating your current version of Pilot is as simple as downloading the new install file and completing the steps above. Once the installer has completed, please restart your computer. Once your computer has rebooted, your existing shortcuts for Pilot will function with the new version.

## Beta Versions of Software

As we are updating and modifying our software we may post beta versions on our website, under the software page. These versions of the software programs may have new features however they may also have bugs in the code. While we encourage you to try them, we ask that if you do find an error in the program that you email us with the details. We ask that if you have any problems that you follow our [troubleshooting](#) guide.

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## Quick Start Guide

This Quick Start Procedure provides information to grab the first image. Once you have an image, you can experiment with the settings to optimize the image quality.

You should have already downloaded FLIPilot. See the [Set Up](#) page.

With your computer running, insert the camera's interface cable into your computer and insert the camera's power cable into AC. The camera fan will run.

Launch FLI Pilot

### Set Image Capture Controls

1. Expand the [Grab Control](#) pane.
2. Click the Grab Modes drop-down list to display the type of grab you want to obtain.
3. Click "[Exposure](#)". On the displayed Exposure pane enter the Exposure time and if appropriate, either the Frame Delay or the Frame Interval.
4. Click "[Cooler Temp](#)". On the displayed Camera pane turn on Cooler Temp and enter a temperature value.
5. Click "[Camera Mode](#)". On the displayed Sensor pane select the camera mode you want to use. If you selected an HDR mode, enter different LDR and HDR gain values on this same pane.
6. Click the term "[Binning](#)" if binning is available on your camera. (The KL400 does not allow binning.) On the displayed [Sensor](#) pane, select horizontal and vertical binning values. (Omit this step when using the KL400).
7. To save the grabbed image as a file, navigate to [File](#) under Imaging Parameters. On the displayed File pane, select the file type(s) and enter or browse to identify a file path. If you are capturing an HDR image, choose to save the High Gain and/or Merged Images. (The Low Gain image is automatically saved).
8. To use a trigger, click the Imaging Parameters "[Trigger](#)" tab and select the type of triggering.
9. To Initiate the Exposure Sequence, click "[Grab](#)".

### Review the Image

Consider the following when reviewing the image:

- Magnification of image (slider to left of image)
- Rotation of image (under [Display Control](#))
- Change display scaling by moving the red squares under the histogram to the left of the image
- Perform image analysis on column/row, region, single line (under [Image Analysis](#))
- Check the values on the [Merge tab](#) under Imaging Parameters
- Display metadata (under [Display](#) on the menu bar)

### Optimizing Acquisition

After capturing and reviewing the first image, consider modifying the following features/settings:

- Recapture only the region of interest (ROI) rather than the full image (under [Imaging Parameters / Frame](#))
- Vary exposure time, frame delay/interval (under [Imaging Parameters / Exposure](#))
- Consider immediate start option (under [Imaging Parameters / Trigger](#))
- Capture reference and post-reference data (under [Imaging Parameters / Frame](#))
- Use High Frame Rate settings (under [Imaging Parameters / Sensor](#))
- Black level sun/black adjust values (under [Imaging Parameters / Sensor](#))
- Save to an alternate file format (under [Imaging Parameters / File](#))

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## Display Customization

### Customize the Display

Ways to alter the display:

- [Switch control panel display layout](#)
- [Switch control panel side](#)
- [Change width of display areas](#)
- [Swap the image in the image areas](#)
- [Rotate or flip the displayed image](#)
- [View reference data with image](#)
- [Display one window rather than three windows](#)

### Control Panel Customization

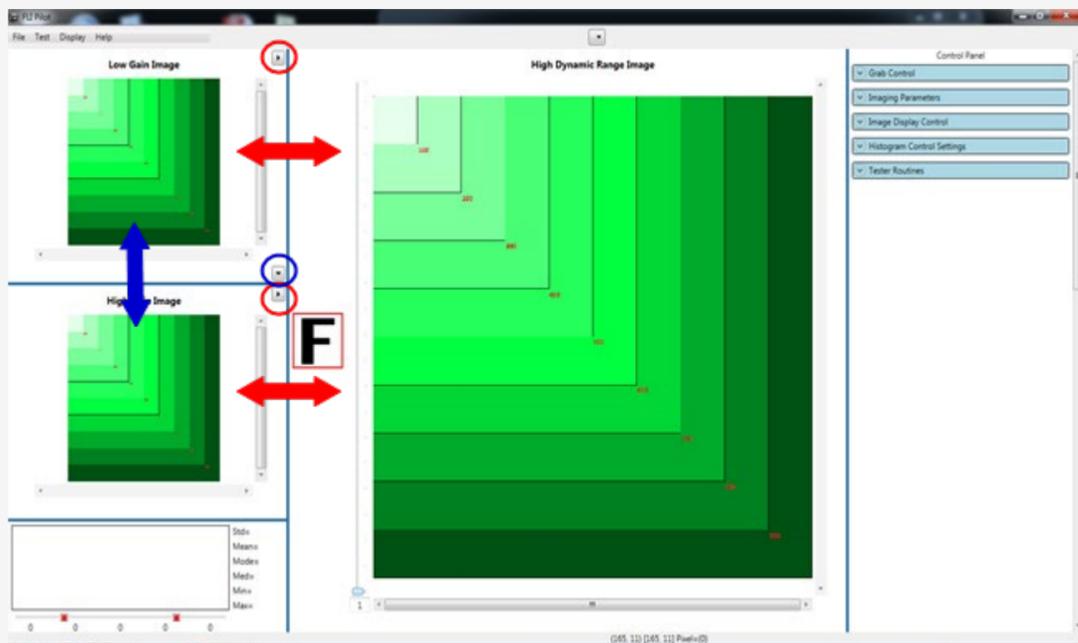
The control panel can be customized by changing its layout, swapping which side the panel resides, and toggling buttons vs. drop down menus. More information is provided under [Control Panel Customization](#).

### Switch Image Positions

You can change which images are displayed in the three image panels.

By default the Kepler High Dynamic Range Image is displayed in the Main Image Panel, however, any of the three images can become the larger sized image.

- Use the Top Image Panel's right-facing arrowhead to swap the Top Image Panel's small image with the large image in the Main Image Panel.
- Use the Bottom Image Panel's right facing arrowhead to swap images in the same way.
- Use the Top Image Panel's down-facing arrowhead to swap the vertical position of the two small images (Top Image Panel and Bottom Image Panel).



### Change Panel Widths

You can change the width of the panels relative to one another. Drag either of the two vertical blue lines that separate the panels or either of the horizontal lines that separate the Top and Bottom Image Panels and the Histogram Panel. The display below identifies the blue lines to use to modify the panel widths. To reset the panels to the default widths, use the Display menu and select Reset.

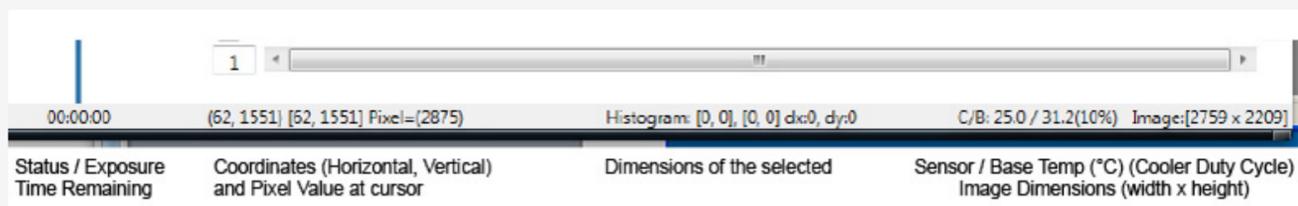
Additionally, you can remove a panel from the display by dragging the vertical or horizontal line to the edge of the display. If a panel was removed, simply use the blue line to pull the area back into view or use Display/Reset. You can also opt to display only a single image and the histogram rather than three images. Refer to "[Display Single/Three Windows Only](#)."

### Review Status Bar Data

The FLIPilot Status Bar is located at the bottom of the screen is continuously updated. If connected, the status bar displays camera information. When an image is opened or captured image and histogram information is displayed.

The Status bar shows:

- Status/ Exposure Duration
- Coordinates (horizontal, vertical) and Value of pixel at mouse cursor
- Dimensions of the selected histogram
- MOS Base: Ambient / Base Temp. (°C) (Cooler duty cycle in %)
- Image Dimensions (width x height)



### Use Image Zoom/Magnify Slider

An image with no magnification/zoom is identified as such by a "1" located in the numeric field just outside the bottom left corner of the image. When zoomed, the orientation device is surrounded by a large red box to represent the whole captured image is displayed.

Zoom in on the information in an image in three ways:

Place the mouse cursor in the image at the area you want to zoom, and scroll the mouse wheel. The image zooms around the cursor.

Move the slide bar located on the left of the image. The image zooms around the center of the original image.

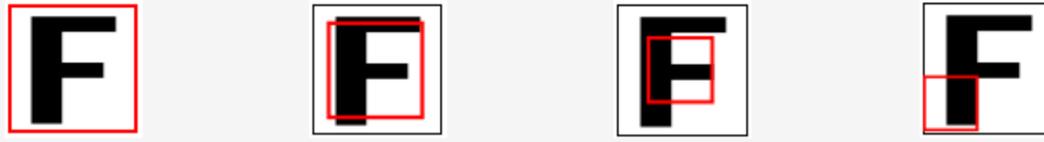
Enter a numeric zoom value in the field on the lower left of the image. The image zooms around the center of the original image. The zoom values are integers from 1 (default normal display) to 100. You can unzoom the image using any one or a combination of the three ways used to zoom the image.

Once zoomed, you can reposition the zoomed image in one of two ways:

Use the vertical scroll bar on the right of the image and the horizontal scroll bar below the image to translate the image up/down or right/left, respectively.

Press the left mouse button on the zoomed image to grab it then move the mouse in any direction.

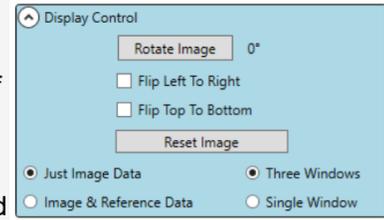
The location of your zoomed view can quickly be determined by looking to the left of your main image at the F indicator. The F represents your image while the red outline represents your field of view. Please see the images below for representations of different zoom states.



### Display Control Functions

The Display Control panel gives the user further access to customization of the FLIPilot display.

There is an option to rotate, flip, or reset the captured image, as well as utilize reference data, and change the display type to single window instead of three window.



To the left of the main image, a box with an F is displayed. This F shows the orientation of the image, as well as the position of the image in relation to the field of view displayed.

A proper explanation of the display control panel is under [Control Panel Overview](#).

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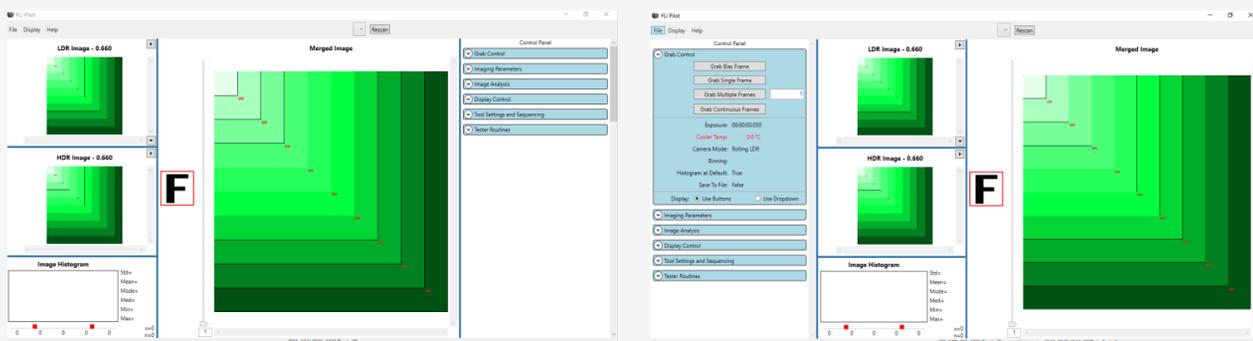
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## Control Panel Customization

### Switch Control Panel Side

The Control Panel can reside on the right or the left side of the images. To switch The Control Panel's position use the [display menu](#) to select Switch Control Panel.

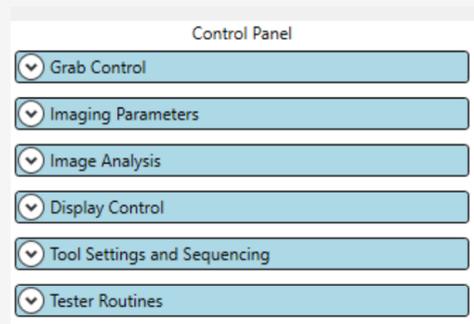
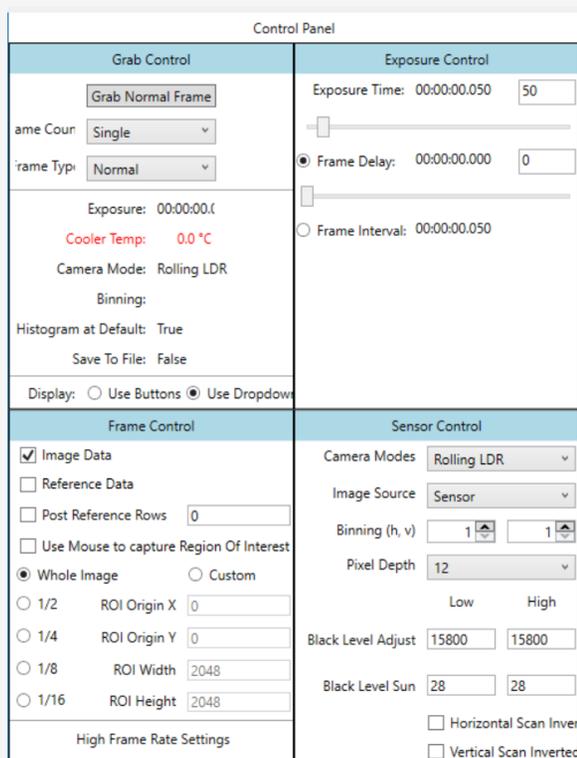


### Switch Control Panel Types

You can display the content of the Control Panel in two different ways, although the settings and their location on the images is the same. These options can be toggled under *Display* in the Menu Bar.

**Flat control panes:** There are 10 different panes all open at once. Use the right-side gray slider to scroll through the other open panes. Use the vertical blue line between Panels to increase or decrease the width of the Control Panel.

**Collapsible control panes:** There are five panes, two of which (Imaging Parameters and Image Analysis) have multiple tabs. Use the down arrowheads to the left of the control pane title to expand or collapse the pane. If not all the open panes are visible, use the right side gray slider to scroll down the expanded control panes.

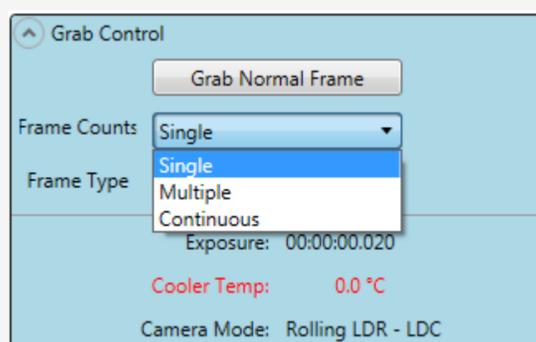


### Change Grab Control Panel Display

There are two ways to display the selections on the [Grab Control Panel](#):

**Use Buttons** shows the four most frequently used (but not all) Grab Control options as buttons for quick access.

**Use Dropdown** identifies the currently selected Grab mode in the button name and provides a complete dropdown list with all available Grab modes.





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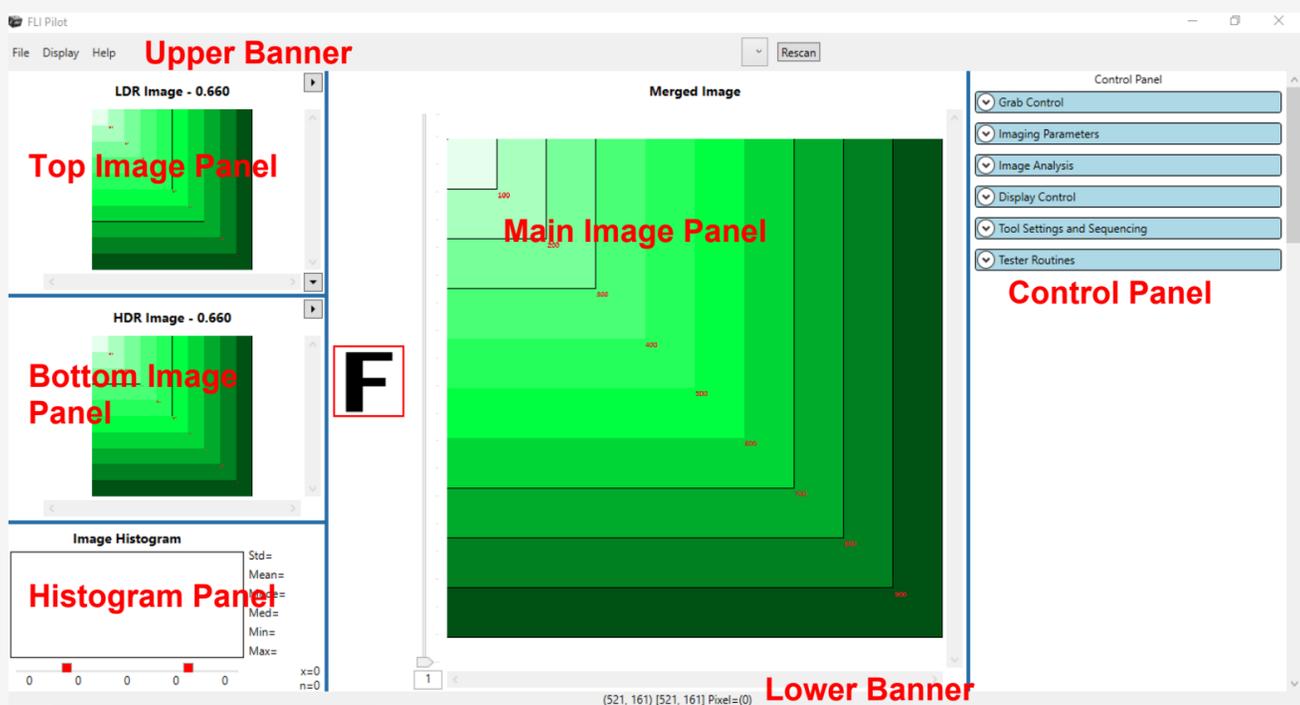
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## FLI Pilot Display

FLIPilot allows you yo customize the location of the panels in the display as well as the relative sizes of the panels to make your imaging more efficient and convenient.



### Upper Banner

Upper banner contains the Menu Bar with drop down controls. These controls are also provided in the Control Panel. The center of the upper banner also identifies the name of the current camera along with open image files. See Menu Bar for more information.

### Top Image Panel

Top Image Panel with a Kepler camera is typically the Low Gain Image.

### Bottom Image Panel

Bottom Image Panel with a Kepler camera is typically the High Gain Image.

### Histogram Panel

Histogram Panel contains the image histogram. The two red blocks at the bottom set the main image's minimum and maximum pixel brightness. Pixels above the limit will be fully white, pixels below will be fully black.

### Main Image Panel

Main Image Panel contains a large image and the Orientation device (F). With a Kepler camera, this panel typically displays the High Dynamic Range Image. You can display a High Gain or Low Gain image in this panel. If a High Dynamic Range Image is not captured, the Low Gain image is displayed in the Main Image Panel. This panel also contains the horizontal slider control to adjust the image position and a vertical Zoom/Magnify slider. See "Switch Image Position" and "Use Image Zoom/Magnify Slider" for additional information.

### Lower Banner

Lower banner contains the Status Bar with data about the image. See Review Status Bar Data for more information.

### Control Panel

Control Panel contains multiple panes with controls to make selections that affect image capture and image review. See "Switch Control Panel Types" and "Control Panel" for more information on customizing the display.

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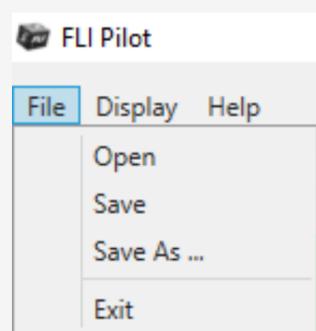
## Menu Bar

The menu bar is located in the upper banner of FLIPilot.



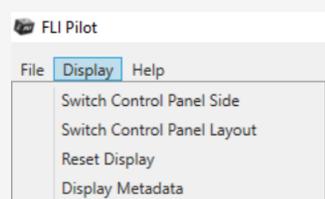
### File Menu

- Open** - Displays an Open window for you to select files by moving through the directory structure. Once selected, FLIPilot loads the file and displays it.
- Save** - Saves the currently opened image to disk. The same file name that was used to open the file will be used with the Save command.
- Save As** - Displays a Save As dialog for you to save the currently opened image in a different file format or with a different name.
- Exit** - Closes FLIPilot.



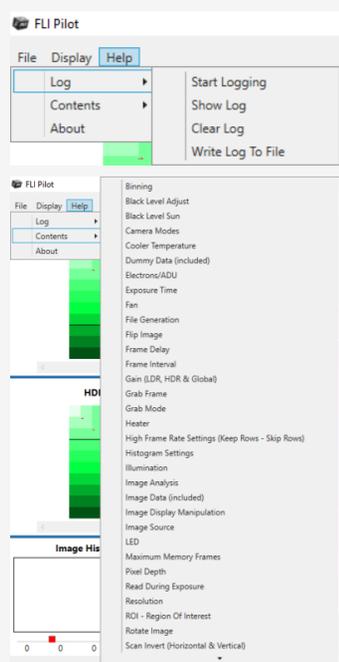
### Display Menu

- Switch Control Side** - Changes the location of the Control Panel from the left side to the right side or the right side to left side of the display.
- Switch Control Panel** - Changes the appearance of the Control Panel from one with control panes all open at the same time to one that allows for expanding and collapsing of various control panes. See [Control Panel Customization](#).
- Reset** - Returns the display to the default orientation with the control panel on the right, and adjusts the three panes to their default proportions on the display.
- Display Metadata** - Displays a Meta Data window with values for each of the settings used to obtain the currently displayed image. You can save a metadata file by enabling the "Save Metadata to file" feature (displayed on the File pane).



### Help Menu

- Log** - If enabled, saves a file that logs communication between the camera and the computer. If you have a PC crash or camera issues, FLI may request you send the log file for investigation. The submenus allow you to start logging, show the log, clear the log and write the log to a file.
- Contents** - Displays a drop down list of key terms in FLIPilot. Selecting a term displays the pane contain that term.
- About** - Provides version information.





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## Control Panel

### **Grab Control**

The Grab Control Panel is your direct connection to the camera. Important information regarding the device is displayed, and commands for image capture are initiated here.

### **Imaging Parameters**

The Imaging Parameters Panel contains almost every setting you would set before image capture is located here. From the camera, to the sensor, to the filter wheel, any pre-photo setting is found within the tabs placed in this panel.

### **Image Analysis**

The Image Analysis Panel contains settings for post-capture procedures. Primarily: viewing images, and viewing histograms and profiles of images.

### **Display Control**

The Display Control Panel provides options for customizing the display of FLI Pilot, including orientations and panel options. For small tweaks in FLI Pilot, head here.

### **Tool Settings and Sequencing**

Tool Settings and Sequencing essentially allows you to setup and run a batch file. You are able to setup various settings like different gains etc. to take successive images while you change the settings between images. Execute uses the settings, then does a grab. Then it uses the next set of settings and does another grab.

### **Tester Routines**

The Tester Routines tab includes a number of useful subroutines for the camera. These include the ability to stack frames, run frame subtractions, and more.

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## Grab Control

The two ways to display the Grab Modes on this panel are selectable at the bottom of the panel. The "Use Buttons" option displays the most frequently used modes for easy access. The "Use Dropdown" option displays a single mode with the option to switch between that mode and others. "Use Dropdown" also gives access to more grab modes that "Use Buttons" provides.

### Grab Modes

#### Single Frame

Takes a single image with the defined exposure length (entered in the [Exposure Control panel](#)). When selected, the button changes to **Stop Grab** to abort the capture.

This is a standard frame that exposes light to the sensor by opening and closing the shutter.

#### Multiple Frames

Captures the number of images entered in the field to the right of this button. Each capture will have the defined exposure length (entered in the [Exposure Control panel](#)). When selected, the button changes to **Stop Grab** to abort the capture.

#### Continuous Frames

Captures continuous images, each with the displayed exposure length (entered in the [Exposure Control panel](#)). When selected, the button changes to **Stop Grab** to abort the capture.

#### Dark Frame

If your camera has a mechanical shutter, this mode may help calibrate the pixels by obtaining an image (data) with the shutter closed (essentially no light (dark)) that is same length as your desired image. However, even when the camera is completely blocked by a closed shutter, the array collects a dark charge pattern dependent on exposure time and camera temp. By collecting a dark frame, this information can then be subtracted from the intended image to reduce dark charge artifacts. The longer the exposure and warmer the camera, the larger the dark current growth and noise accumulation may be.

#### Flood Frame

This mode is applicable for full frame sensors but not sCMOS sensors. It is useful to fill sensor traps that cause ghosting. Enable the LED to flood the image with light. This is sometimes called "Flash."

#### RBI\_Flush

This mode fires the pre-flash with the shutter closed, then reads out the sensor (essentially pre-flash plus bias). the length of the pre-flash is therefore defined by the same bar as the exposure. If you do a long pre-flash, you may want to add one or more additional bias or dark frames (for clearing purposes) to see their effect. Longer dark frames will allow more trapped charge to migrate. The highest uniformity is achieved with a pre-flash that fills all the wells to capacity, but that also adds more noise to the image.

This mode is applicable for full frame sensors, but not sCMOS sensors. It is useful to fill sensor traps that cause ghosting.

During long exposures, images being read do not extract full charge, thus artifacts of the previous image may emerge on the next image (as a ghost). This is a defect in the pixels ability to completely reset. Ghosting is more prevalent at lower operating temperatures.

#### Bias Frame

A bias frame is a frame captured with the shortest exposure time possible. The outcome of such is that any flaws or discontinuities in the image caused by minute differences between pixels can be subtracted out to produce an image with very little influence from internal imperfections.

### Exposure

Displays the currently entered exposure time. If the Control Panel layout is collapsible, click "Exposure" to open [Exposure under Imaging Parameters](#) to change the time.

### Cooler Temp

Displays the current temperature of the sensor. If the Control Panel is collapsible, click "Cooler Temp" to open [Camera under Imaging Parameters](#) to change the desired operating temperature. If the current temperature does not match the desired operating temperature, the sensor will cool at a rate of approximately 5°C per minute. This is to ensure the sensor does not receive a thermal shock.

### Camera Mode

Displays the current camera mode. If the Control Panel is collapsible, click "Camera Mode" to open [Sensor under Imaging Parameters](#) to change the mode.

### Binning

Displays the current binning value. If the Control Panel is collapsible, click "Binning" to open [Sensor under Imaging Parameters](#) to change the value.

### Save to File

Save to File will display True if the captured data will be saved automatically. If it displays False, the file will not be saved automatically. Save to File will only display true if, within **File**, a file type is selected, a image to be saved is selected, and a file path is selected. If the Control Panel is collapsible, click "Save To File" to open [File under Imaging Parameters](#) to change the settings.

### Display

The screenshot shows the 'Grab Control' panel with the following elements:

- A 'Grab Normal Frame' button at the top.
- 'Frame Counts' dropdown menu set to 'Single'.
- 'Frame Type' dropdown menu set to 'Normal'.
- Exposure: 00:00:00.050
- Cooler Temp: 0.0 °C
- Camera Mode: Rolling LDR - LDC
- Binning: (no value shown)
- Histogram at Default: True
- Save To File: False
- Display:  Use Buttons  Use Dropdown

This setting toggles the Grab Control Panel display mode between button and drop down. This differences of which are described under [Change Grab Control Panel Display](#).

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## Imaging Parameters

### **Exposure**

Exposure controls the exposure and frame time for image capture.

### **Frame**

Frame controls what information is included in a frame capture.

### **Sensor**

Sensor controls the options associated with the imaging sensor's operation.

### **Filter Wheel**

Filter Wheel controls the options regarding an optional filter wheel assembly.

### **Trigger**

Trigger controls when an exposure is to start depending on an input via the auxiliary connector.

### **Camera**

Camera controls the operation of the camera during the image capture, as well as the shutter.

### **Merge**

Merge controls the merge of the high gain and low gain images into one HDR image.

### **File**

File defines where and with what title the images captured will be saved on the PC running the software.

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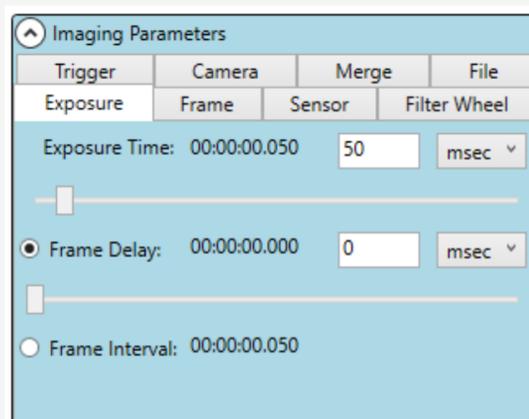
## Exposure Settings

### Exposure Time

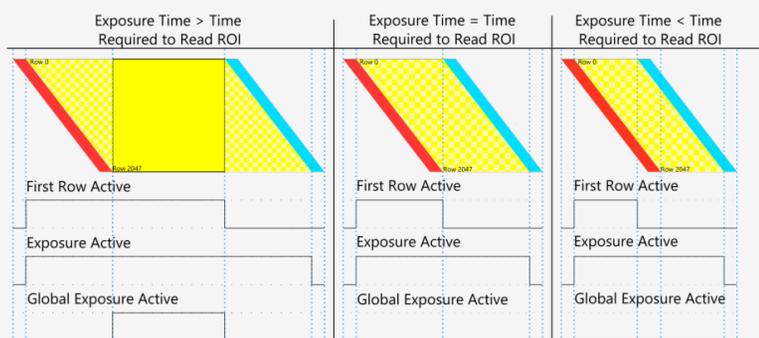
Exposure is the duration of time that each row will collect light. Enter a numeric value or use the slider to adjust the exposure time and select the units.

The exposure status signal is output on Pin 8 (Exposure\_Active output) of the 8 pin AUX connector. There are three exposure active options that are user selectable in FLIPilot described and illustrated below.

**Note:** Refer to [Connectors](#) for additional information on the 8-Pin AUX connector.



- **First Row Active** signal is high when the first row of the image is exposing, otherwise, it is low. If **Immediate Global Exposure** is enabled, the first row is not the physical first row of the image, but rather the row immediately after the last reset row. Other rows will still be integrating after this signal goes low.
- **Exposure Active** signal is high when any row is exposing.
- **Global Exposure Active** signal is high when all rows of the sensor are exposing. If any row has not started integrating, or finished integrating, the signal is low.



### Frame Delay Time

Frame Delay is applicable for multiple and continuous grabs. It is the duration of time between the end of an exposure and the start of the subsequent exposure. This delay may be useful to allow for controlling external items such as illumination.

Enter a numeric value or use the slider to adjust the delay time and select the units. Enter 0 to disable.

### Frame Interval

Frame interval is applicable for multiple and continuous grabs. It is the duration of time between the start of consecutive exposures.

Enter a numeric value or use the slider to adjust the frame interval and select the units. Enter 0 to disable.

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## Merge Settings

The high dynamic range (HDR) image is created by combining the low gain and high gain images. Both images are the same, but read out of the sensor at two different gain settings.

FLI Pilot creates the HDR image by combining these two Low and High gain images into one. The high gain images allow for improved resolution in the darker regions of the image, while the low gain provides better resolution in your bright areas. The resulting HDR image is 16 bits/pixel instead of the 12 bits/pixel that the low and high gain images contain. The user interface provides the ability to input a variety of Merge Variables to modify how the image is merged. Please see below for more information on the Merge Variables. The user interface may also display the default values calculated by the program if the user does not wish to provide custom data.

Exposure	Frame	Sensor	Filter Wheel
Trigger	Camera	Merge	File
<input type="checkbox"/> Override			
	1	2	3
Temperature:	-10	5	20
Slope Offset:	1700	1750	1800
Gain Ratio:	0		
ADU/Electrons:	0.1316		
Threshold:	3800		Apply
Default Merge Settings:	Read	Save	
Restore Merge Settings From Factor Defaults			

Generally, the best merged image results when the exposure is adjusted such that the low gain image has pixel values spanning the range of values from 0 to 4095. Under these conditions, the high gain image will be saturated in most image areas.

### Automatic vs Fixed Merge Calculation (Override)

Automatic: To use automatic merge calculations uncheck the Override box.

The automatic merge calculates new variables for each image that is captured. This means that each merge image may have different parameters on how it was created. If the camera is not able to determine new variables for an image due to a lack of useable pixel values it will use the last calculated merge variables. It is recommended that you use the fixed merge calculation.

unless the camera is being operated outside of its default configuration. If you are operating the camera in an unusual manner please see [Merge Calculate](#) to automatically have the camera determine the optimum merge variables for your settings.

Fixed: To use fixed merge calculations check the Override box.

The fixed merge uses the Merge Variables set in the variable boxes to merge each image. This standardizes each merge image if you are capturing multiple images. Many cameras will already have Factory Default Merge Variables for the default Gain Pair and Black Level settings. These were calculated for each camera to deliver the best merged images for the default settings. If you are operating outside of the default parameters you can run [Merge Calculate](#), in the Tester Routines tab, to have the camera determine the optimum Merge Variables for your settings.

## Merge Variables

### Temperature

By providing sensor temperature values at three points, as well as Line Offset values at the corresponding temperatures, FLI Pilot can calculate an effective Line Offset value for each image at various temperatures, using linear interpolation. If you operate the camera at a different temperature and would like more direct control, that temperature can be used instead of the defaults (KL4040 -10, 5, 20 or KL400 -20, 0, 20). Please see [Merge Calculate](#) for determining the best settings at your unique settings.

### Line Offset

The Line Offset value is used to ensure there is a smooth transition for pixels around the threshold value. This ensures that the last pixel used from the high gain image and the first pixel from the low gain image will have the same pixel value, ensuring that there is not gap in pixel values in your image.

### Gain Ratio

The Gain Ratio is used to ensure that the low gain and high gain pixels mapped to the merged image have an equivalent photon response, which unless otherwise changed is 1 ADU/electron. A higher Gain Ratio will increase the Low Gain photon response compared to that of the High Gain, conversely a lower Gain Ratio will decrease the Low Gain photon response compared to that of the High Gain.

### ADU/Electrons

On some Low/High gain pair choices it is possible that the combined image calculation may result in pixel values greater than can be expressed in 16bits. These pixels will result in saturated pixels (value of 65535). Exposure time could be reduced to correct for this, however a new image capture would be required. An alternative is to modify this parameter and apply it to update the merged image, using the [Merge Frames](#) Tester Routine. This parameter adjusts the photon response slope of the merged image. This can be used to avoid saturation of pixels in the merged image, or to express all images at a certain photon response (1:1, 2:1 etc.).

### Threshold

The threshold value is used to determine whether a pixel in the merged HDR image is taken from the high gain image or the low gain image. When a pixel has a high gain value less than or equal to the threshold value, then the high gain pixel value is used in the HDR merged image. Otherwise, the modified low gain image pixel is used. The threshold value is set based on the sensors characteristics from the sensor manufacturer and thus should not need to be modified from its factory default.

### Custom Merge Variables

Custom Merge Variables may be used by overwriting the individual boxes and clicking the Apply Button.

### User/Factory Saved Settings

Merge Variables may be saved and recalled by the user at any time. For the default Gain Pair, the factory default Merge Variables may be recalled by pressing the Restore Merge Settings from Factory Defaults button. If custom settings are preferred, the user may save one set of Merge Variables for each Gain Pair by pressing the Save button. Similarly, to recall the user saved Merge Variables for the selected Gain Pair press the Read button, this will recall the User saved Merge Variables. It is possible to store around 40 Merge Variable sets. After you have reached maximum capacity the Pilot will not allow you to save any more sets without first deleting existing sets. If you would like to delete one set of Merge Variables pick the Gain pair you no longer use and press the Delete button. If you would like to delete ALL user saved Merge Variable sets press the Clear All button.

**Note:** Changing Black Level Adjust settings, under the Sensor tab, will impact the merged image. It is recommended that if you modify the Black Level Adjust that you then rerun the Merge Calculate to get new Merge Variables.

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**Available Filter Wheels**

**Color Filter Wheel**

**Description:**

The FLI Color Filter Wheel is designed with astrophotography in mind. Our traditional Color Filter Wheel line has six different body styles that hold either round or square filters in various sizes.. The Color Filter Wheel product number identifies the body type and the number of filter cups.



CFW4-5 with a ProLine16803

**Documentation:**

[Color Filter Wheel User's Guide](#)

**Additional Information:**

[Color Filter Wheel](#)

**CenterLine Filter Wheel**

**Description:**

The CenterLine Filter Wheel is designed with astrophotography in mind. Our filter wheels feature a centrally located aperture that presents a symmetrical mass distribution, eliminating the offset weight problems associated with virtually every other color filter wheel on the market. It is also ideal for prime focus installations where a zero or symmetric shading of the primary mirror is critical. The CenterLine Filter Wheel holds filters in two independently operated wheels. Mechanical attachment of the CenterLine Filter Wheel is realized through the robust Zero-Tilt Adapter™ mechanism, which is incorporated into both the housing and cover side of the filter wheel and operated using easily accessible set screws.



CenterLine Dual Color Filter Wheel

**Documentation:**

[CenterLine Filter Wheel User's Guide](#)

**Additional Information:**

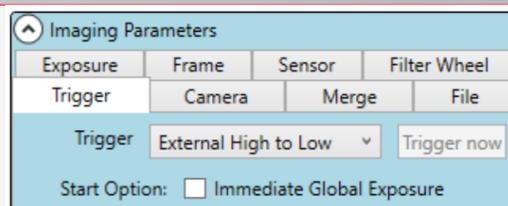
[CenterLine Filter Wheel](#)



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## Trigger Settings

Several types of trigger control commands are available. All trigger commands are executed after the Exposure Delay Time has expired, if a non-zero value was entered.



### Internal

This method uses the software application to issue a trigger request immediately when a capture is requested. This internal trigger is communicated over the USB 3.0 connection or Adnaco Optical Fiber connection. These connections introduce a small amount of delay. There is also a fixed delay in the camera for the internal trigger to be communicated to the sensor controller.

### External High to Low and External Low to High

This method configures the sensor to respond to an external trigger. This input is delivered via the 8-pin connector, on pin 3. When an external trigger is selected and image capture is requested, the camera waits for the transition of the external pin to start the exposure. If "External High to Low" is selected, the exposure will begin when the voltage on pin 3 transitions from high to low. If "External Low to High" is selected, the exposure will begin when pin 3 transitions from low to high.

### External Control H to L and External Control L to H

In these modes of operation, the level of the externally supplied trigger signal controls the start of the image exposure and the end of the exposure. For Control H (high) to L (low), the image exposure starts when the external trigger input transitions from a high state to a low state and ends when the external trigger input transitions from a low state to a high state. For Control L (low) to H (high), the image exposure starts when the external trigger transitions from low to high, and the exposure ends when the input transitions from high to low.

The exposure value set in Exposure is the maximum allowed exposure, so, even if the external trigger signal is still active, the exposure will end when the set exposure time is reached. Therefore, ensure that the exposure time set in Exposure is greater than the exposure duration you intend to conduct.

### Start Option

When a trigger is commanded (internally or externally) the sensor may be at any point in its continuous loop of resetting rows in the image row space. The image row space is defined as a row in the whole image (row 0-2047) or a row in a defined region of interest (ROI).

The default start option begins exposure at the same spot in the image, that is, the lowest row in the image row space. The trigger is held until the first row (lowest row) in the image space is reset, at which point the image exposure begins. Exposure ends at the highest row in the row space.

With the Immediate Global Exposure start option, the row reset ends immediately and the requested exposure readout begins with the row following the last row reset. The first row of imagery exposed by the sensor can be any row in the image row space. The last row of imagery similarly can be any row.

Total Integration Time			
Standard Start (Row 0)		Immediate Global Exposure Start (Anywhere in row space)	
LDR	HDR	LDR	HDR
(0 - 21msec) + Exposure Time	(0 - 42msec) + Exposure Time	(0 - 10.26 usec) + Exposure Time + [21msec*(#rows/2048)]	(0 - 20.52 usec) + Exposure Time + [42msec*(#rows/2048)]

The drawback to the standard start, at row 0, is the variable amount of time between the trigger command and exposure start. If you are taking short exposure images, this variable amount of time from trigger to exposure start can, relatively speaking, have a large impact on the image.

The advantage of the Immediate Global Exposure start option is the reduction of variability in the time between trigger and exposure compared to the default trigger option. The drawback to Immediate start is that the imagery starts at any row, and due to the characteristics of a rolling shutter imager, any motion during exposure will produce a discontinuity in the image. This flaw is produced by a large gap in time between the initial rows exposure beginning and the final rows exposure beginning. As the beginning and end meet somewhere in the middle of the image, the time differential between the first and last row read will produce an unpleasing image. This mode is best used when the scene is dark, allowing as little incident light in prior to the event as possible. The goal of this is to make the exposure before and after the event insignificant to the final image.

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## Sensor Settings

### Camera Modes

CMOS cameras allow four camera modes for selection: Rolling LDR, Rolling HDR, Rolling LDR - LDC, and Rolling HDR - LDC.

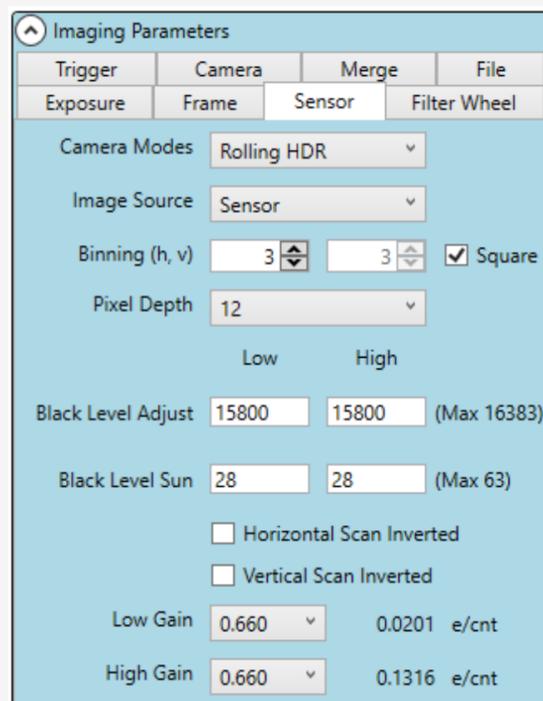
These modes operate the camera with [rolling shutter operation](#).

LDR and HDR define the [dynamic range](#) of the mode of operation.

LDC denotes Low Dark Current mode which decreases the full well capacity of the photosensors, decreasing the number of electrons that accumulate when the pixels are not exposed to light. As a result, the dark current accumulated is decreased, allowing better long exposure images.

### Image Source

Typically, the sensor is the image source. "Row Test Pattern" and "Col Test Pattern" are useful for camera diagnostics and are not typically used for any purpose other than such.



### Binning

Binning is the process of combining adjacent pixels into a large pixel. The combining occurs either as part of the charge transfer process in CCD sensors or via Pilot post image readout.

#### Hardware Binning

While the KL400 sCMOS sensor does not allow binning, some CMOS sensors do but the binning must be the same in each direction. For CMOS sensors that allow binning, enable the **Square** checkbox to bin horizontally and vertically equally. CCD sensors permit unequal binning, so the Square checkbox is not required for such cameras.

The two primary benefits of hardware binning are a decrease in transmitted data which leads to a potential increase in FPS and the ability to have a larger well size.

#### Software Binning

It is also possible to run Binning after the image is captured using software in Pilot. By using the software to accomplish the binning you are not limited to a square bin and can instead accomplish a rectangular binning. Any image can thus go through the binning process.

The primary benefit of software binning is an increase in the Signal to Noise Ratio however this comes at the cost of Sampling Density and therefore Resolution.

To set binning options, first, check Square if required or desired. Then, type or use the up/down buttons to adjust the values. On the left is horizontal (h) and on the right is vertical (v). These options are displayed on the [Grab Control Pane](#).

### Pixel Depth

Pixel depth describes the number of bits used to represent the sensor. It is used to represent a sensor pixel and is determined by the sensor. Typical output is 16 bit. Using a lower number truncates the data in the camera for faster transmission.

The KL400 sensor does not allow for changing the bits per pixel.

For cameras with sensors that offer pixel depth modifications (Interline and Full Frame), the available selections are displayed.

### Black Level Adjust

Black level is a measure of a reference voltage. This number is normally defined by non-imaging pixel areas of the sensor, however, the black level adjust option allows a secondary influence on this reference voltage. Black level adjust can be increased to increase the pixel values within your image. If you take a 10msec dark and look at the minimum pixel value, you can adjust it up or down by increasing or decreasing the black level adjust. This can be useful to ensure that you are not clipping your darkest pixels.

### Black Level Sun

Very bright areas in an image can cause saturation of the pixel well and "overflow" resulting in that area looking dark. This option allows for mitigation of that effect. Enabling this feature increases noise. Increasing black level sun reduces the black sun effect, while increasing noise.

A maximum value of 63 can be selected which will produce quite a lot of noise while correcting the black sun as best it can. If a level this high is required to correct your image, it is recommended to correct the capture rather than this value specifically. adjusting the cameras aperture and exposure, and removing the intense bright light from the sensors FOV will all improve the black sun effect without significantly impacting image quality.

### Horizontal Scan Inverted

The scan direction reflects the movement of the rolling shutter. The default horizontal direction is left to right. When "Horizontal Scan Inverted" is enabled, the read direction is right to left. This changes the pixel order in the data file.

### Vertical Scan Inverted

The scan direction reflects the movement of the rolling shutter. The default vertical direction is from top to bottom. When "Vertical Scan Inverted" is enabled, the read direction is from bottom to top. This

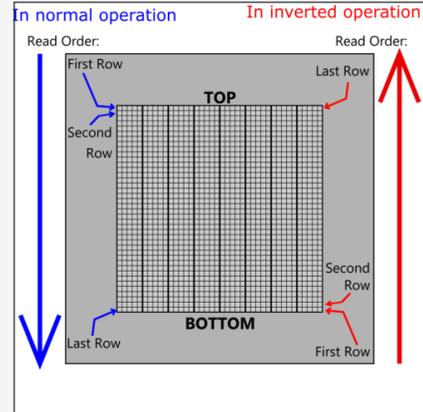
changes the pixel order in the data file.

### LDR and HDR Gain

Dynamic range can be assigned for both the high and low gain images. LDR images are often captured with a low gain of 1.85. HDR images are often captured with a low gain of 1.29 and a high gain of 7.2.

### Global Gain

the global gain option allows the user to define the gain setting for both low and high gain images.



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## Dynamic Range

Dynamic range is a ratio of the largest signal a system can process, above the noise floor of that system. As the noise floor is essentially constant, the gain values are directly related to the maximum signal strength that can be reported. This has the effect of reporting brighter images with high gain, at a lower quality.

Low gain images are high quality with average lighting.  
High gain images are lower quality with brighter lighting.

The goal of taking both a low and high gain image is to combine them post-process to give better detail to images with a wide range of lighting. High Dynamic Range describes the intention of achieving a wide range of varying luminance.

### LDR and HDR Imaging Modes

In LDR mode, the low gain and high gain settings are the same value corresponding to even and odd rows. Each "line" time of the sensor contains two row reads and two row resets that results in a single image.

In HDR mode, the low and high gain settings are different values. Every pixel has both the low gain and high gain applied to it. Each "line" time of the sensor contains one row read and one row reset. The sensor reads out both the low gain image and the high gain image. In addition, the software displays the calculated (merged or combined) high dynamic range image to increase the accuracy at the low light level without sacrificing resolution of higher light levels.

The time between reset commands (and likewise between read commands) depends if the array is using the Low Dynamic Range (LDR) mode or the High Dynamic Range (HDR). The time between the start of exposure of the first row and the last row are mode dependent as shown below.

Mode	Gain Setting	Minimum Time Between Reset Commands or Read Commands	Time Between Start Exposure of Row 0 to Start Exposure of Row 2047
LDR	Low == High	10.26us	21ms
HDR	Low != High	20.52us	42ms

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## Frame Settings

### Image Data

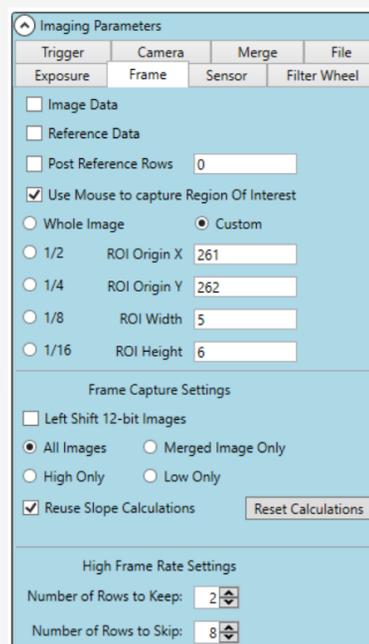
The image data describes the full size or region of interest. This checkbox must be selected to obtain image data.

### Reference Data and Post Reference Rows

The imaging sensor can capture sensor non-illuminated pixel data that may be useful to review changes that might have occurred between the beginning and the end of a long exposure (drift) or through the image (full image). This information can then be used to improve image quality. You can display the captured images with or without the reference or post reference data overlaid on the image.

The sensor can output reference pixels at the end of every imaging data row. One pixel is generated for each column (of 256 pixels) on the sensor, so the reference data is eight pixels wide. The reference data appears as a black band on the right side of the image.

You can also enable the readout of an entered number of rows of data after the exposure. This post-reference data is shown at the bottom of the image.



### Use Mouse to Capture Region of Interest and Whole Image

You can capture or view a subregion of the full image. Capturing a region of interest (ROI) has the benefits of reducing trigger variability, increasing frame rate, and reducing image file size. This feature is very useful for small objects such as plants and small galaxies that do not require the full field of view. Decreasing the number of rows in the ROI increases the frame rate, however, decreasing the number of columns does not affect the frame rate. It does, however, reduce the amount of data, thus reducing processing time.

A captured image has no magnification/zoom and is identified as such by a "1" located in the numeric field just outside the bottom left corner of the image. In addition, the large red box around the letter "F" represents the whole captured image that is displayed in the window.

Define a region of interest in one of two ways using the controls on the Imaging Parameters' Frame tab:

- When the "Use Mouse to capture Region Of Interest" checkbox is enabled (on Frame Control panel), place the mouse cursor in the image, press the right mouse button and drag and draw a rectangle. The thin red box on the image identifies the ROI and the Frame tab displays the coordinates and dimensions of the ROI.
- Enter integers into the Origin X and Y fields and into the Width and Height fields. The system displays a thin red box on the image that correlates with the entered values.

After selecting or modifying an ROI, the software automatically recalculates the histogram to reflect the change.

To remove the ROI display and redisplay the whole image, select **Whole Image** on the Frame tab.

For precise region setting, one can either use the text boxes corresponding with origin x and y and width and height.

For those looking for precision scaling or simply looking to reduce unused sensor area, select one of the fractions. This option generates a ROI with that fraction of the whole imaging sensors pixels and centers the region about the center point of the image.

### High Frame Rate Settings

Frame rate is in part determined by the amount of data that is read. By reducing the number of rows read, the overall frame rate is increased. High frame rate mode gives users the option to "skip" rows. Small skips are often insignificant in a final image and can reduce the data captured significantly.

Due to the behavior of sCMOS sensors, rows must be selected in pairs, or powers of two (2, 4, 6, 8, etc...). As examples, the system could be set to read every other pair of lines (keep two lines, skip two lines) or read 20 lines, skip 4 lines.

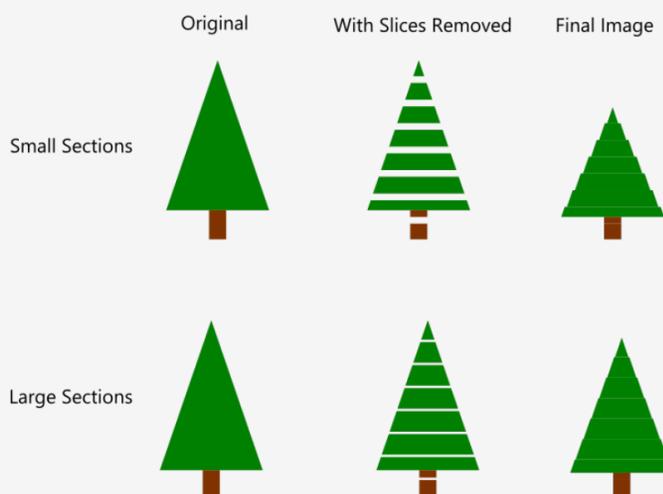
To use this feature, enter the number of rows to capture per block and the number of rows to skip between capture blocks in Frame Settings.

The figure to the right displays an example of high frame rate mode. The top image has larger skipped areas and smaller captured areas, resulting in the final image having minor issues. The bottom image has smaller skips and larger captured areas, resulting in the final image looking proper, while still reducing image size and increasing frame rate.

The default values of 0 will disable this mode.

### High Frame Rate Mode

Achieve an increased frame rate by only reading selected sections of an image. Larger sections are less noticeable.





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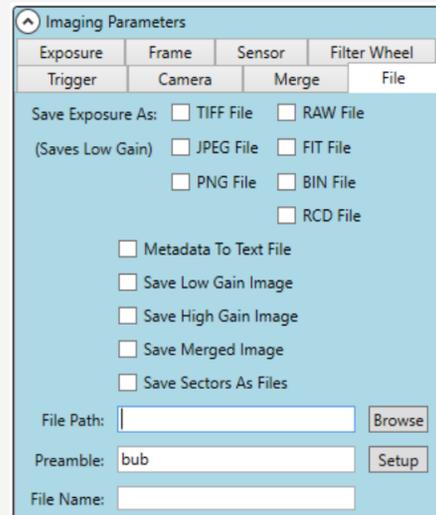
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## File Settings

The Grab Control pane displays the "Save to File" status as True or False. If False is displayed, captured and displayed images are not automatically saved. If True is displayed, the captured images are saved automatically according to the user preferences selected such as file type and which of the high, low, and merged images you would like saved. For the program to automatically save, show True, you must select at least one file type, one image or metadata, and the file path. Other options that can be selected are a Preamble and an automatically generated file name. If you would like to have an automatically generated filename for each image, select setup.

Each image may be saved manually as well. The Menu bar at the top of FLIPilot contains a File menu with the Save and Save as controls to allow you to save the currently displayed image.



### Save Exposure As

Make a selection to specify the type(s) of data file to save. The file types in alphabetical order are:

BIN File is a binary file format that contains the image data as it was received from the board. The file contains the metadata then the image data with the low and high gain images together (interlaced).

FIT (Flexible Images Transport System) is a 16-bit image defined by NASA/Science Office of Standards and Technology (NOST).

JPEG (Joint Photographic Experts Group) uses lossy compression for images and allows for a selectable degree of compression, storage size and image quality.

Metadata to Text File saves the values for each of the settings used to obtain the displayed image in a text file that may be useful for review. You can display metadata for the currently displayed image using File/Display Metadata.

PNG (Portable Network Graphics) is a raster graphics file that supports lossless data compression.

RAW File is Finger Lakes Instruments' format, that contains the metadata bytes followed by the image data bytes. You can save the image as more than one type of file; however, the files may be quite large.

RCD proprietary format that can be opened by pcAnywhere software and some other applications

TIFF (Tag Image File Format). Version 6.0 is a 16-bit monochrome and color image format.

### Metadata to Text File

When enabled, the system saves the metadata information as an independent .txt file.

### Save Low Gain Image

When enabled, the system saves the Low Gain image.

### Save High Gain Image

When enabled, the system saves the High Gain image.

### Save Merged Image

When enabled, the system saves the High Dynamic Range information (merged image).

### Save Sectors As Files

When enabled, the system saves the 8 channels that make up the image as 8 separate files.

### File Path and Browse

The File Path identifies the location and directory into which files will be saved. Click Browse to display a window to locate and select a different file path and directory for file saving.

### Preamble

The Preamble will be added to the front of each file name. This is useful if you are using the automatically generated file names and want to tag the sequence with a unique identifier to keep them grouped together.

### File Name and Setup

The File Name identifies the files saved. Click Setup to customize the file name to be saved. Select the options you wish to include in the file name. Under **Order**, the option to rearrange the texts in the file name with 1 representing the first, and 11 representing the final. The file name is composed next to "File Name:" with the selected options. Press "Reset Defaults" to reset selected texts and order to default values.

The following are the available texts:

Preamble: A prefix to the file name, custom text can be placed here to identify files.

Frame Type: Displays the Frame Type selected in [Grab Control](#).

Camera Model: Displays the model of the camera connected to FLIPilot.

Mode: Displays the camera mode set in [Sensor under Imaging Parameters](#).

Gain: Displays the LDR and HDR Gain set in [Sensor under Imaging Parameters](#).

Frame Number: Displays the number the images frame is in that set of images.

Diag Routine Name: Displays the Routine name selected in Tester Routines.

Serial Number: Displays the serial number of the connected camera.

Sensor Temperature: Displays the temperature of the sensor at the time of capture.

Binning: Displays the binning setting set in [Sensor under Imaging Parameters](#).

Exposure Time: Displays the exposure time set in [Exposure under Imaging Parameters](#).

Date: Displays the date of image capture.

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## Camera Control Settings

### Manual Shutter Control Enabled

CMOS cameras do not require an electromechanical shutter for exposure gating. The optional shutter is used for acquiring calibration bias and dark images. For light exposures, enable manual control of the shutter and leave it open until you want to acquire the calibration images.

**Note:** If the mechanical shutter is an "iris type" opening, it may expose the center of the sensor slightly longer than its edges.

### Illumination

This feature provides control for an external illumination source connected to the 8-pin auxiliary I/O port. Enable this operation and enter a delay time. The On delay is the time the system waits before turning on the output/illumination. the Off delay is the time the system waits before turning off the output/illumination.

### LED

Control the operation of the internal LED. Enable the operation.

### Heater

Some cameras have optional heaters. If the camera has heaters they are two heater strips on the outside of the camera window. These strips keep the window just above ambient temperature the reduce condensation on the window. FLIPilot allows you to turn the heater strips on and off and enter a value that represents the duty cycle. FLI recommends you keep the heater on as a means of preventing condensation/frosting.

### Fan

The fan power is set at the factory. You can enable or disable the fan operation.

### Cooler Temp

Removing excess heat from the camera's electronics and keeping the sensor cool keeps the dark current to a minimum and reduces drift when capturing multiple frames. To accomplish this, the camera housing includes a Thermoelectric Cool (TEC) System, cold finger, and a fan. Provide adequate clearance (2.5 inches(6cm)) on the camera's intake and exhaust sides for airflow.

When Cooler Temp is enabled on the Camera Control panel the software will attempt to maintain the entered temperature setpoint. The current temperature is displayed on the Grab Control panel. If the temperature is displayed in a red color, the actual temperature and the set point temperature are different. If the temperatures are different the camera will attempt to rectify the difference.

### Read During Exposure

The software displays the current temperature of the Cold Finger base in the status bar at the bottom of the screen. The temperature is sampled every three to five seconds. During an exposure, the temperature is sampled, but it is typically not updated in the status bar.

### Thumbnail Capture

Thumbnails can be generated to provide small format images to accompany the full images for use in icons

### Max Frames Kept in Memory

FLIPilot will store the last images taken within its memory. This allows the user to go back to a previous image if they forgot to save it or if they would like to see a number of images in a row. Depending on the computers capabilities you may change the number of stored images. Fifty is the maximum number of frames FLIPilot will store in memory. When the entered value is reached, FLIPilot will automatically discard the oldest frames. This value defines the number of frames available in [Frame Slide Show](#).

Imaging Parameters			
Exposure	Frame	Sensor	Filter Wheel
Trigger	Camera	Merge	File
Delay			
<input type="checkbox"/> Manual Shutter Control Enabled	<input type="radio"/> Open	<input type="text" value="0"/>	ms
	<input checked="" type="radio"/> Close	<input type="text" value="0"/>	ms
Illumination:	<input type="radio"/> On	<input type="text" value="0"/>	ms
	<input checked="" type="radio"/> Off	<input type="text" value="0"/>	ms
LED	<input type="radio"/> On	<input checked="" type="radio"/> Off	
Heater	<input type="radio"/> On	<input checked="" type="radio"/> Off	<input type="text" value="0"/> %
Fan	<input checked="" type="radio"/> On	<input type="radio"/> Off	<input type="text" value="85"/> %
Cooler Temp	<input checked="" type="radio"/> On	<input type="radio"/> Off	<input type="text" value="-15"/> °C
Cooler Dty Cycle	<input type="radio"/> On	<input checked="" type="radio"/> Off	<input type="text" value="0"/> %
Read During Exposure	<input type="radio"/> On	<input checked="" type="radio"/> Off	<input type="text" value="0"/> ms
Thumbnail Capture	<input type="radio"/> On	<input checked="" type="radio"/> Off	
Max Frames Kept in Memory (50 max)			<input type="text" value="10"/>



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## **Data Analysis**

Data Analysis controls how the image data is displayed. High and Low gain images can be replaced by either a profile analysis tool or a histogram analysis tool.

## **Histogram Settings**

Histogram Settings controls how the histogram and a captured image are displayed. This allows you to change the default settings for the histogram.

## **Frame Slideshow**

The Frame Slide Show feature allows you to review captured frames in order as if they were in a slide show.

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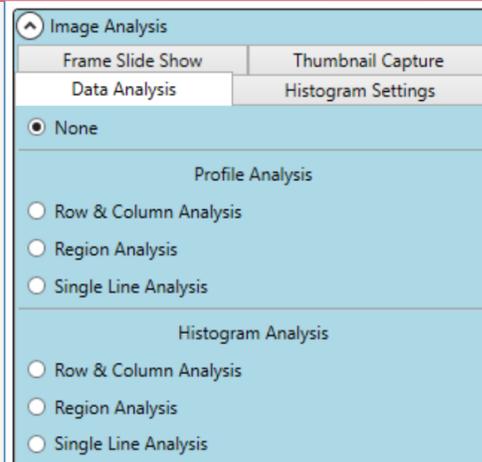
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Data Analysis

This menu controls how data regarding the image is displayed. Depending on your selection, the High and Low gain images will be replaced by either a profile analysis tool or a histogram analysis tool.

There are multiple options for data analysis using this menu. There are two formats and three area selection tools for each. One can also decide to not use any of those and only display the full image histogram.

Selecting None will do just that, all other analysis panels will be removed and only the histogram representing the full image will be displayed on the left side of the screen. To retrieve high and low gain images on the left panel, see "Three Windows" under Display Control.



Under Profile Analysis are the options for displaying data in a profile view.

"Row & Column Analysis" allows selection of a row and a column of the image and their profiles are displayed on the right.

"Region Analysis" allows selection of a rectangular region for analysis.

"Single Line Analysis" allows the user to draw a single line from any two points and view the profile of that selection.

Under Histogram Analysis are similar options.

"Row & Column Analysis" produces histograms for a selected row and column.

"Region Analysis" produces a histogram for a selected area of the image.

"Single Line Analysis" provides a histogram for a line connecting any two selected points in an image.

To select the rows, columns, areas or lines for any of the previously mentioned operations, right click on the image and move the cursor. The selection will appear as a red line.

For "Row & Column," two perpendicular red lines intersecting at the cursor represent the row and column that will be analyzed.

For "Region," a red rectangle will be displayed and the section of the image inside the rectangle is that which will be analyzed.

For "Single Line," a red line will be drawn from the point where you first right click, to the location where you release. This line will be the section analyzed.

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## Histogram Settings

When you capture an image, the system will automatically display a histogram that measures and graphs the brightness and contrast characteristics of the image. The histogram is displayed in the [Histogram Panel](#). You can view and analyze the histogram and manipulate it to enhance the image. To change the size of the histogram, you can change the size of the panel in which it resides. See [Display Customization](#).

You can move the red histogram pointers to adjust the image's screen display settings. The red points represent minimum and maximum brightness for the displayed image. This panel displays parameters that influence the histogram display and the calculations it provides (std, mean, mode, median). After making changes to Histogram Settings, click **Apply** to update the histogram.

The screenshot shows the 'Image Analysis' window with the 'Histogram Settings' tab selected. The settings are as follows:

Parameter	Value
Dimmest Data Threshold	0.1
Brightest Data Threshold	0.1
Use Absolutes	<input type="checkbox"/>
Dim	0
Bright	0
Discard Edge Pixels	<input checked="" type="checkbox"/> 10
Use Log Scale	<input checked="" type="checkbox"/>
Histogram Origin X	0
Histogram Origin Y	0
Histogram Width	1
Histogram Height	1

Buttons: Apply, Reset To Defaults

### Dimmest Data Threshold

This parameter accepts a percentage as input. The X% of the dimmest pixels will be discarded from the histogram display and calculations.

### Brightest Data Threshold

This parameter accepts a percentage as input. The X% of the brightest pixels will be discarded from the histogram display and calculations.

### Use Absolutes

Use the given absolute Bright and Dim values as fixed thresholds to draw the histogram. When not active, values will be calculated based on the percentages given above.

### Dim

The absolute dimmest pixel value used to draw the histogram.

### Bright

The absolute brightest pixel value used to draw the histogram.

### Discard Edge Pixels

When enabled, the histogram discards the entered number of pixels on the left and right edges of the image from the histogram display and calculations.

### Use Log Scale

The histogram's x-axis can be displayed in two different scales. A linear histogram is a representation of how the camera sees the data. A logarithmic histogram is a representation of how our eyes see the data. If the checkbox is enabled, the logarithmic scale is used.

### Histogram Origin X, Y, Width, Height

These parameters allow manual selection for the region displayed in the histogram. One can enter an x and y coordinate and a width and height, or one can use the right mouse button to click and drag over an area to select the intended region. Remember to click apply after either input to update the histogram.

### Apply

Pressing this button applies the settings to the image displayed.

### Reset To Defaults

If erroneous changes occur due to Histogram Settings, press reset to default to start over with the values preset by the system.

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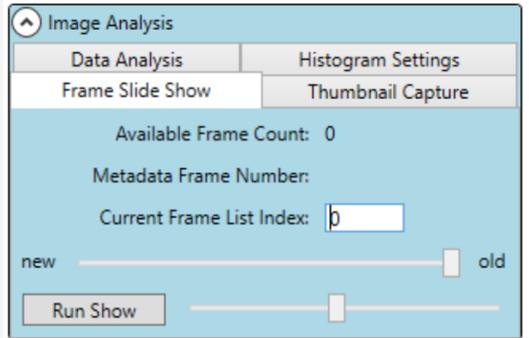
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## Frame Slide Show

The Frame Slide Show feature allows you to review captured frames in order as if they were in a slide show. You can view the frames in either newest-to-oldest or oldest-to-newest order using the keyboard arrow keys or clicking the cursor on the new-old scroll bar. The currently displayed frame is identified by the numeric in the list index field, which also allows you to enter a value to display a specific frame.

The maximum Available Frame Count is defined by the "Max Frames Kept in Memory (50 Max) value on the [Camera Control panel](#). Hence, capturing 10 frames with a value of 5 in the "Max Frames Kept in Memory" field will result in only five available frames in the slide show.



### Available Frame Count

The number of frames currently held in memory as set in Max Frames Kept.

### Metadata Frame Number

The frame number stored in the metadata of the current frame.

### Current Frame List Index

The index in the list of frames.

### New - Old

From newest to oldest, the list of frames held in memory.

### Run Show and Slider

Run Show controls which frame will be displayed from the list of frames in memory. The slider determines the rate at which the frames are present. Left is quicker, right is slower.

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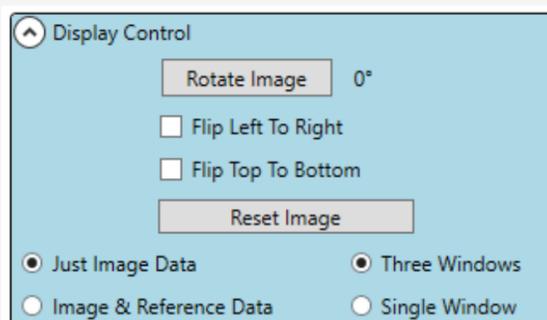
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## Display Control Panel

### Rotate Images

You can rotate all three images (High Gain, Low Gain and High Dynamic Range) in 90° increments together. Rotate the images using the Display Control Panel's **Rotate Image** button. The current rotation is displayed to the right of the Rotate Image button and represented by the orientation device. Click **Reset Image** to return the image to its original orientation.



### Flip Image Left To Right, Flip Top To Bottom

You can flip all the images (High Gain, Low Gain and High Dynamic Range) together horizontally and vertically. Use the checkboxes on the Image Display Control to rotate the images. The current rotation is represented by the orientation device (F). Deselect the selected checkbox or click **Reset Image** button to return the image to the original orientation.

Orientation Device	Rotate Position
	0° / Default
	90°
	180°
	270°

Orientation Device	Flip Position (with 0° Rotation)
	Standard Orientation
	Flip Left To Right
	Flip Top To Bottom
	Flip Left To Right & Top to Bottom

### Reset Image

Returns the image to the original orientation (top/bottom (rotation) and left/right (flip)).

### Display Just Image Data / Image & Dummy Data

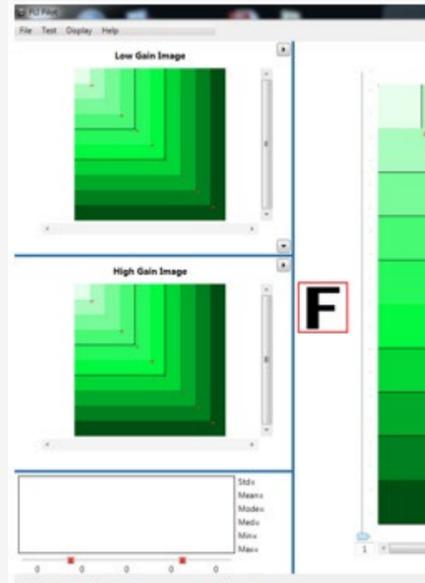
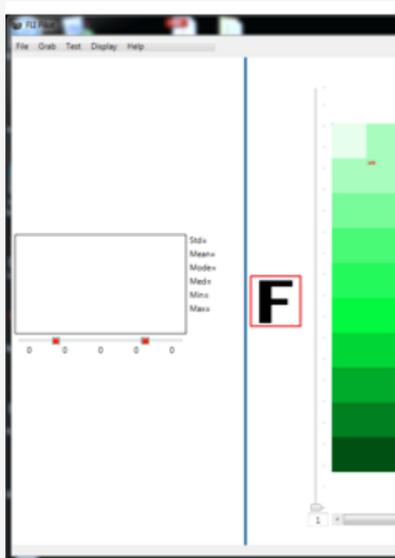
Use these two radio buttons to select which set of data to display on the screen. Refer to "[Frame Control Settings](#)" for more information on capturing reference data.

### Three Windows / Single Window

If you captured only a low gain image (entered a value for the LDR Gain), it is displayed in the Main Image panel and its corresponding histogram is displayed in the Histogram panel.

If you set two different gains, you will obtain and can view the Low Gain, High Gain and the merged High Dynamic Range (HDR) images. The default image in the Main Image panel is the High Dynamic Range image with the Low Gain image in the Top Image panel and the High Gain image in the Bottom Image panel. This default with three images in the three Image panels and the histogram in the Histogram Panel is referred to as the Three Windows layout. You can change which image is displayed in which Panel using the arrowheads in the panel borders as described earlier. The displayed histogram corresponds to the image in the Main Image Panel.

You can change the display so only a single image (Low Gain, High Gain or the merged High Dynamic Range (HDR) Image) appears in the Main Image panel and its corresponding histogram is displayed. This layout is referred to as the Single Window layout. Change the layout using the **Single Window** or **Three Windows** radio buttons located on the Image Display Control panel.





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## Tool Settings and Sequencing

If, while experimenting with various settings you find a setup that you like, you can easily save them as a set, for future recall. You can save multiple sets, each customized for particular a use. You can save one set of settings as the “default” settings that are automatically loaded when you open FLIPilot. The default settings can be the factory default settings or any set that you have saved. You can easily change which set is the default and repopulate (load) the default set if needed. In addition, you can change which set is currently active, modify (update/overwrite) a set, rename a set or delete a set.

After defining sets, you can combine the saved sets into sequences that allow you to automate image capture. You can save, modify, rename and delete sets to meet your needs.

### Save Current Settings As Default

Button saves the current imaging parameters settings as the “default” set.

### Repopulate with Default Settings

Button loads the saved default set to make it the current set.

### Save Settings As

Enter a name for the current set (a unique name for a new set or an existing set name to overwrite) then click this button to save the current set with the entered name.

### Restore Settings

Use the drop-down list to select the name of the set you want to restore then click this button to make the selected set current.

### Sequencing

After defining sets, you can combine the saved sets into sequences (routines) that allow to automate image capture. You can save, modify, rename and delete sets to meet your needs.

### Current Sequence

List displays the sets in the order in which they would be executed. If you add a continuous capture to the sequence, the sequence will continue until you manually stop the continuous capture.

### Move Up, Move Down

Buttons move the selected set up or down, respectively, in the Current Sequence list.

### Delete

Button removes the selected set(s) from the Current Sequence list.

### Add Settings and drop-down list

Drop-down list displays the saved sets that can be added to a sequence. Select the set to add to the bottom of the Current Sequence list, then click this button.

### Save Sequence As

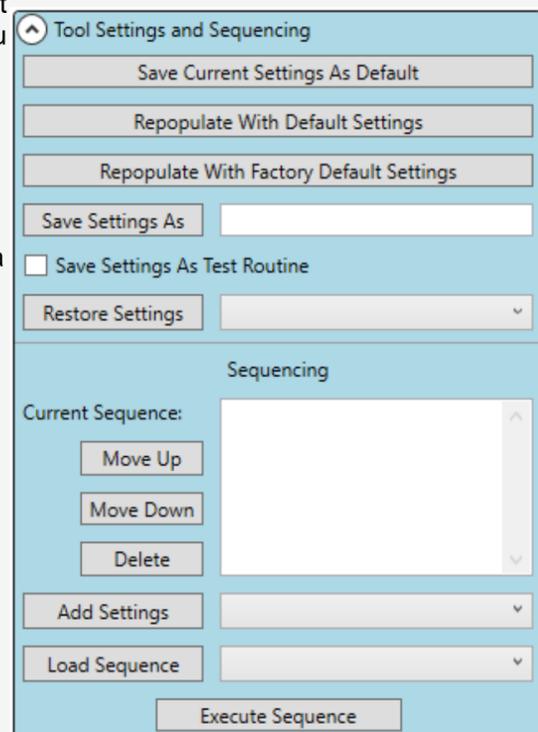
Enter a name for the active sequence defined in the Current Sequence list (a unique name for a new sequence or an existing sequence name to overwrite) then click this button to save the sequence with the entered name.

### Load Sequence

Use the drop-down list to select the name of the sequence you want to make active then click this button. The sets in the loaded sequence appear in the Current Sequence list.

### Execute Sequence

Executes the capture command beginning with the topmost set shown in the Current Sequence list.



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## Tester Routines

### Dark Frame Uniformity (Figure 1)

The Dark Frame Uniformity function is designed to quantify Dark Current Growth across the sensor by taking two dark exposures of differing times and determining the difference in the pixel values in user controlled regions.

#### Exposure

Set the two exposure times for Exposure A and Exposure B either numerically or using the slider bar.

#### Size of Analysis Square

Size of Analysis Square determines the size of the square region that will be used to calculate the Mode values throughout the image.

#### Size of Analysis Offset Shift

Size of Analysis Offset Shift is the distance that each region will be shifted when calculating subsequent Mode values throughout the image.

#### Output Path

The output path, selected by clicking on Browse, is the location the .csv file will be saved to once the images statistical data has been processed.

#### Manual or Automatic Image Processing

While the default of this function is to capture images at the time of clicking start, it is also possible to manually tell this function what images to use. If you would like to analyze two images that have already been captured and saved, enter their locations into Image File A and Image File B using the browse buttons. If both File locations are populated, Pilot will analyze those images using the above settings. If the File locations are not populated, Pilot will proceed to automatically capture two images and analyze them with the above settings.

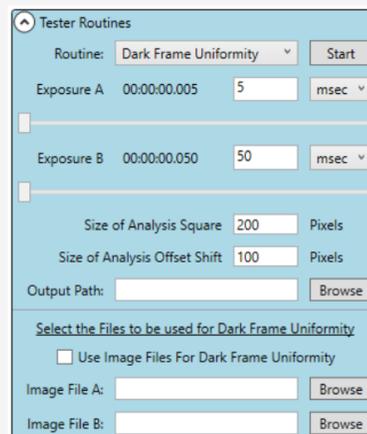


Figure 1.

### Flash Sequence (Figure 2)

This function is designed to run through an exposure sequence containing preflash, dark exposure, and normal exposures. The function is designed to control ghosting due to a bright flash from your illumination equipment.

#### Cycles Count

The Cycles Count controls how many time the function loops through the Flash Sequence. This can be changed by using the slider or numeric control.

#### Preliminary Preflashes

If Preliminary Preflashes is enabled, the number of times the light will flash can be manually controlled. If Preliminary Preflash is disabled then the light will flash once.

#### Cycle Pattern

The following Cycle Patterns are programmed with the following image/flash routines.

Primary Sequence: Preflash, Dark Exposure, 2 Normal Exposures

Cached Darks Sequence: Preflash, 2 Normal Exposures, Pause

Live Darks Sequence: Preflash, Dark Exposure, 2 Normal Exposures, Dark Exposure, Pause

#### Preflash Time

The length of time of the preflash can be controlled numerically or with the slider bar.

Frequency:

None: Omits any preflash and replaces it with a Dark Exposure with a duration equal to the Preflash Time

# Of Cycles: This allows you to only run the Preflash for the set number of cycles entered, then it runs a Dark Exposure for the remaining cycles.

Skip Cycles: This runs the Preflash Exposure then skips (replaces the Preflash with a Dark Exposure) for the set number of cycles before running it again.

#### Exposure

Exposure length for the Normal and Dark images may be set here either numerically or with the slider bar.

#### Pause

Pause controls the pause during every cycle in which it is included. This can be set numerically or with the slider bar.

#### User Fields

Output Path: The output path can be set using the browse button. This is where the images taken will be stored.

Region File: If you would like to only sample a subframe, a Region File may be selected using the browse button.

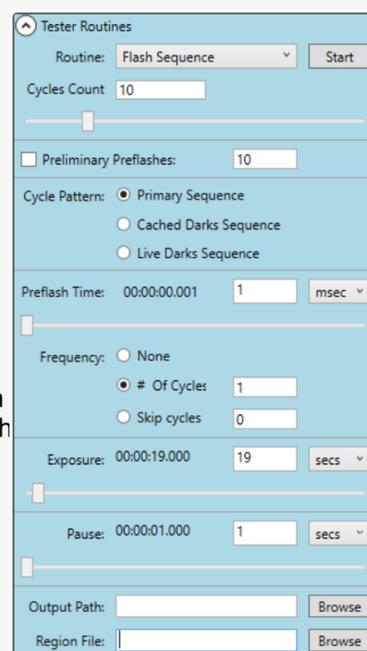


Figure 2.

### Force Training (Figure 3)

Force Training ensures that the camera is reading the sensor output during the correct time. If the camera starts reading the output during the transition from one byte of data to another the signal/image will be will show irregularities. If there is an image defect it is always recommended that you run a Force Training first to see if that solves the problem.

Auto Force Training: When enabled automatically force trains as the camera changes temperature by the value entered.

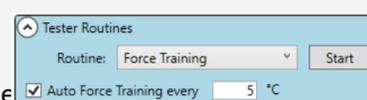


Figure 3.

## LED Control (Figure 4)

The LED Control allows you to manually control the onboard camera LED as well as set parameters to control the LED during an exposure.

In order to manually control the LED, use the On/Off buttons.

In order to automatically have the camera flash the LED during exposures select the LED On during Exposure for 'LED on Time' toggle, then set the amount of time you wish the LED to stay on for using the LED On Time by either entering a numeric value or using the slider.

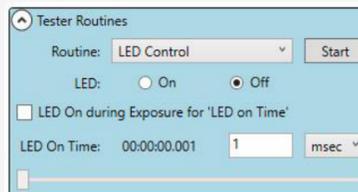


Figure 4.

## Merge Frames (Figure 5)

Merge Frames allows you to manually merge two image files together. First select which Low Gain and High Gain image files you wish to merge by selecting the Browse buttons. The program will use the settings in the Imaging Parameters - Merge tab to control the merge function. Please ensure that the settings there are adequate and then press Start. The program will create the merged image which you can then save.

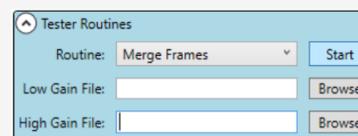


Figure 5.

## Frames Difference (Figure 6)

Frames Difference allows you to subtract one images pixel values from another. This is primarily used to subtract a dark stacked frame from an image to remove the pattern noise.

The image file should be added to the Source File line using the Browse button while the reference image that will be subtracted should be added to the Reference File line using the Browse button.

Subtract Reference Files from Displayed Image: allows you to subtract the reference frame from the currently captured image displayed from the camera that may or may not have been saved to a file yet.

Use Histogram Cutoffs to Remove Outlying Pixels: This uses the settings for the Dimmest Data Threshold and Brightest Data Threshold found in Histogram Settings (LINK) to remove the outlying pixels.

Use Difference Factors in Calculations: This function allows you to shift every pixel in each image by the amount entered. This function is useful if the image pixel values are being clipped at 0.

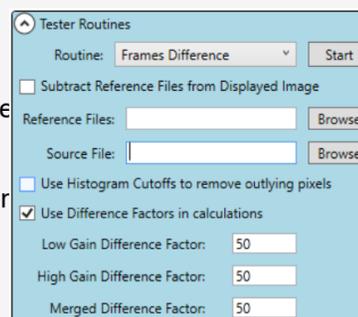


Figure 6.

## Stack Frames (Figure 7)

Stack Frames takes a number of images equal to the Frame Count and averages the images pixel values to create a single Stacked Image. This allows you to gain an image showing the pattern noise of the sensor while minimizing the impact of noise.

Frame Count: Is the number of images that will be taken and averaged together.

Exposure: Is the exposure time for the images that will be captured.

LED On Time: Is the amount of time the LED will flash for each image. The LED can be enabled or disabled with the LED Lights dropdown list.

Pixel Averaging: Creates a Stacked image where the Pixels value is an average of the respective pixels in each of the reference images.

Pixel Summing: Creates a Stacked image where the Pixels value is a summation of the respective pixels in each of the reference images minus the bias pixel times the Frame Count. In order to specify the Bias Image you must fill out the Reference File by selecting Browse. If more than one bias image is selected they will be averaged together before proceeding with the correction.  $(Image1Pixel1 + Image2Pixel1 + \dots + ImageNPixel1) - (N * BiasPixel1) = StackedPixel1$

Use Shifted Averaging: Shifted Averaging is used to minimize truncation errors by using a 16bit value for each pixel instead of a 12bit value. Essentially this means each pixel is multiplied by 16 before averaging.

Use Difference Factors in Calculations: If there is concern about clipping negative values you can enable Use Difference Factors in Calculations. This raises each pixels value by the amount entered to ensure that no values are clipped.

Stack Images Manually: It is possible to stack images that have already been saved. In order to manually stack images, select Use Image Files For Stacking, then select the Image Files using the Browse button and the program will stack the images using the above factors.

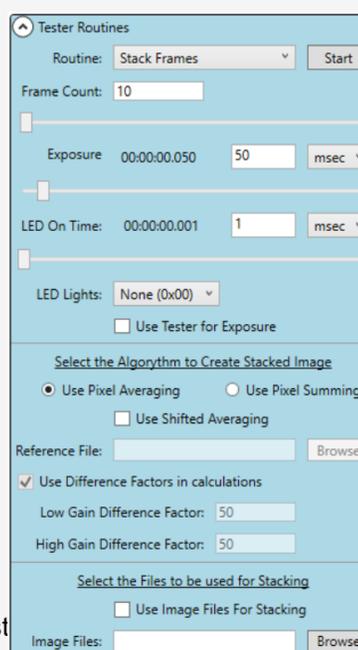


Figure 7.

## Merge Calculate (Figure 8)

In order to create a linear response across the range of a merged image, Pilot requires a number of Merge Variables. Merge Calculate is designed to find the best Merge Variables for the current settings of the camera. In order to better understand the Merge Variables please review the [Merge](#) page.

The Merge Variables are based on the Gain Pair you are using. So a low gain of 1 and high gain of 5 will have different Merge Variables then a low gain of 1 and a high gain of 10.

Merge Calculate is designed to automatically find the optimum settings for a given set of image parameters. If you are operating the camera with unique settings, running this routine will provide you with the Merge Variables needed to produce good merge images for those settings.

To understand the variables that go into creating a merged image please see the [Merge](#) page.

### Before Initiating the Routine

Select which of the three Temperature/Line Offset settings you would like to change. If you are not running the camera at one of the three predesignated temperatures please select the one closest to the current temperature.

The temperature of the camera should be set under the [Camera](#) Tab under Imaging Parameters. Merge Calculate will fill in the Temperature the camera is running at when the program is initiated, therefore the camera temperature should be changed far enough in advance for the temperature of the sensor to stabilize. If you are taking long exposures we recommend allowing the sensor to sit for 10-15 minutes, or longer, for the sensor and thermal mass of the camera to stabilize.

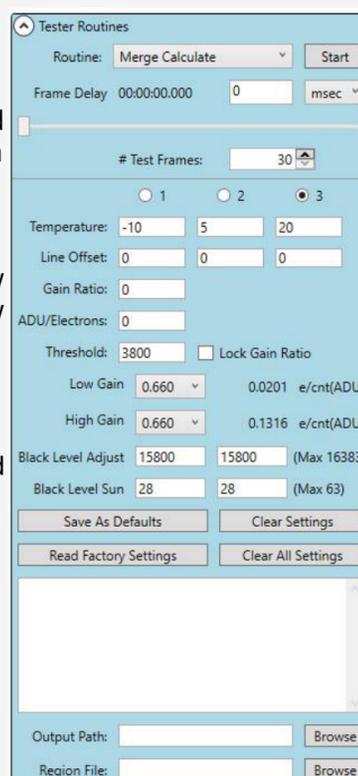


Figure 8.

Select the Gain Pair that you wish to use.

Select the [MergeCalculateRegionFile.csv](#) that was included in the installation zip folder from the [Software](#) page. This can be selected by pressing the Browse button next to Region File: at the bottom of the Merge Calculate tab.

Prevent exterior light from entering the camera. If your camera has a built in shutter, it will automatically close for this routine, you should not need to take any special precautions. If you do not have a shutter, you can place the camera on a flat table in a dark room or on a black mat in a dark room. To test if it is dark, take a 0 sec image and a 20 msec image. If it is dark the mean of these two images should be the same or very close (1 count difference). If the camera does not have a dark environment, Merge Calculate may not produce reasonable values.

If you are concerned about ghosting effects, you can enter a frame delay between images. Adding a frame delay can substantially increase the run time of this routine but if you will have a long delay between image captures it may be worth adding a frame delay to the test. If however you will be running the camera in continuous mode or with little to no delay between image captures it is not recommended that you set a frame delay here.

#### **Initiating the Routine and Expectations**

In order to start the routine, once the above has been completed, press the Start Button. The routine should complete in less than 10 minutes, unless a frame delay has been set. As the program runs you should see sdiff and idiff values appear after each step, these values should approach 0. If these after a few minutes these values are still increasing toward larger numbers then you should recheck the above settings and restart the test. You can cancel the test by pressing the Abort button, where the Start button was.

#### **Requirements to run Merge Calculate**

FLI Pilot 1.2.10 or later

KL400: Revision 4 of the FPGA Code (6 and 9 do not work)

KL4040: Revision D of the FPGA Code or later

A way of blocking light to the camera (Shutters if installed will close automatically) If you do not have a shutter you will need to manually block light for this process.

**Note:** This program should calculate the new Merge Variables in less than 10 minutes. If you find this program does not complete after this time please check that you have blocked all light from entering the camera with its shutter or some form of light block and restart the process.

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## FPN Correction

Fixed-pattern Noise (FPN) is a term given to a noise pattern often generated during long exposures. This noise is generated when particular pixels are susceptible to producing brighter signals than the background noise.

FPN is visible when one takes an image with no noise correction, as seen below. (**Figure 1**)

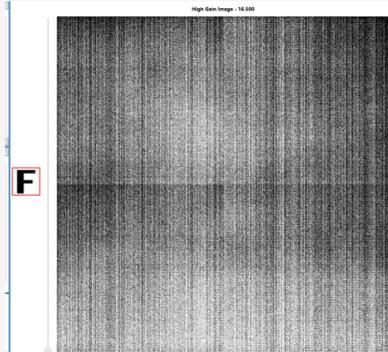


Figure 1: Uncorrected Image

The correction of this noise is quite easy with the FLI Pilot application.

First, one should open the **Stack Frames** menu of Tester Routines. (**Figure 2**)

Enter the desired quantity of frames you wish to produce. 20 is generally an acceptable number.

Select your desired exposure. The generated set of stack frames can only be used to correct images with the same exposure as the stack, so one will likely want to produce multiple stacks in the case of multiple exposure durations being used.

The Tester Routine page is a great resource for the subsequent information you may input in this panel.

When the user is ready, press start to begin capture and production of a stacked frame. (**Figure 3**)

Save the stacked frame with **File** → **Save As ...**

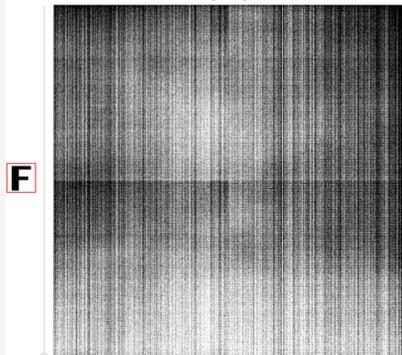


Figure 3: Stacked Frames

When the stacked frame is saved, enter the **Frames Difference** menu of Tester Routines. (**Figure 4**)

First, use **Browse** to select a reference file. This will be the image previously saved as a result of the stacked frame generation.

Select a source file, which will be the image you wish to remove FPN from.

Set the subsequent settings as required.

Select **Start** to generate the final image (**Figure 5**), which can then be saved.



Figure 5: Final Image

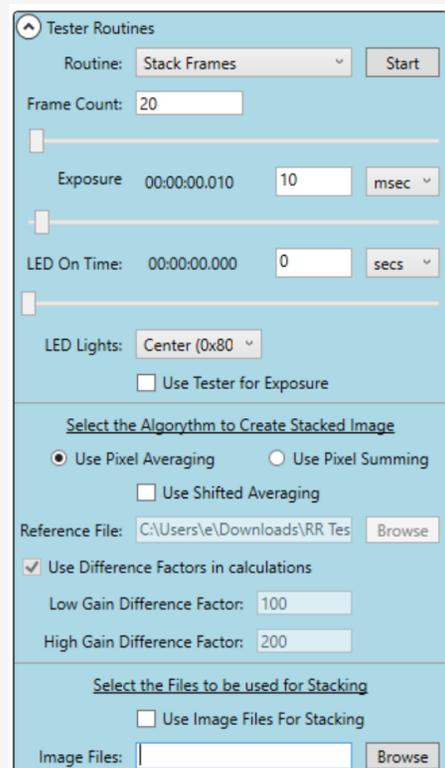


Figure 2: Stack Frames

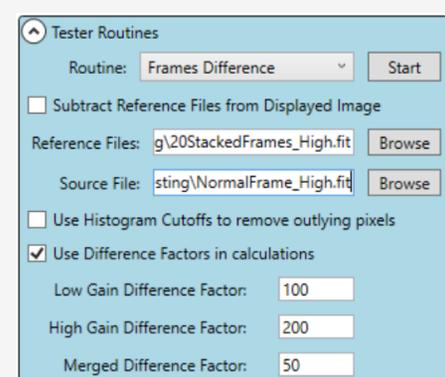


Figure 4: Frames Difference

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## Sensor Selection

The selection of the appropriate sensor for your purposes is defined primarily by your intended use. FLI cameras are available with sensors optimized for every corner of the scientific world. Variables such as sensor type, size, and shape, alongside pixel size and density will help define which sensor is appropriate for its intended use.

A list of all available sensors alongside information regarding each sensors qualities is available on this chart: [Sensors Supported in FLI Cameras](#)

## Sensor Size

Sensor size influences the field of view of the image. A sensor with a large area can capture a larger area of light, resulting in a larger field of view. A sensor with a small area cannot capture the same area of light, resulting in a narrower field of view. Each sensors area, in mm<sup>2</sup>, is displayed in the chart referenced above.

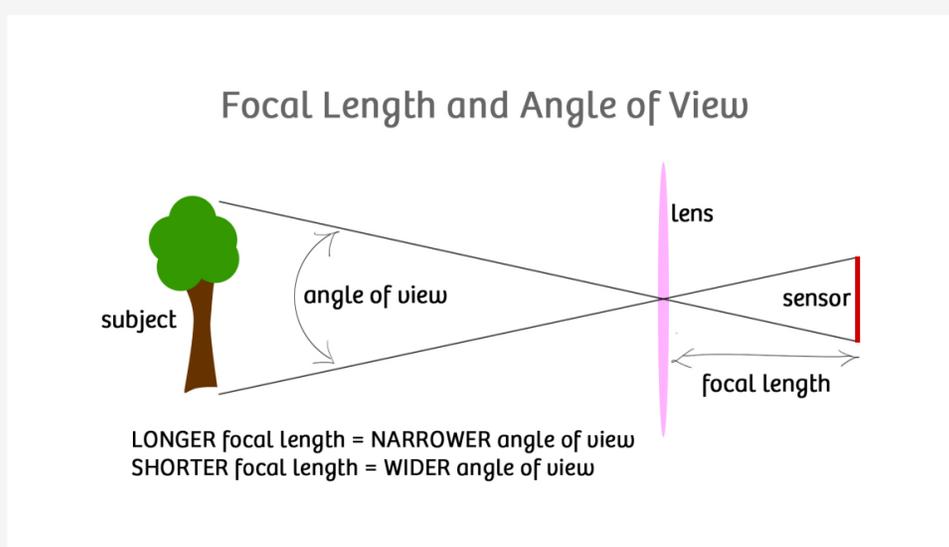


Figure 1: Sensor Size and Field of View Soon to be animated  
Image Credit: Jack Hollingsworth, [snapsnapshots.com](https://www.snapsnapshots.com)

If one can imagine the size of the sensor in the **Figure 1** modulating between larger and smaller, with the lines drawn from its edges intersecting at the same location, one may note that the angle of view increases as sensor size increases, thus capturing a larger portion of the scene.

## Sensor Shape

The FLI cameras come with two available shapes. While the shapes are not explicitly stated on the chart referenced above, one can deduce from the array size (X and Y) that some sensors are square and nearly square, and others are much wider than they are tall.

The most common is square and rectangular with similar height and width dimensions (**Figure 2**). These sensors are applicable for nearly every use for a camera.

The second available option is the Hamamatsu horizontally stretched sensors, which are significantly wider than they are tall (**Figure 3**). These sensors are well designed for applications such as spectrophotometry, but are not well designed for most applications.

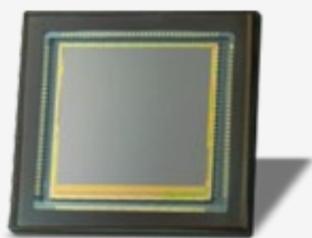


Figure 2: GSense400  
Image Credit: GPixel, [gpixelinc.com](https://www.gpixelinc.com)



Figure 3: S9979  
Image Credit: Hamamatsu, [hamamatsu.com](https://www.hamamatsu.com)

## Pixel Size

Pixel size is very important to quality imaging. A pixel with a large area will collect more light, however it will result in a decreased resolution, as the pixels precision is lost when it collects light over a large area. A pixel with a smaller area will collect less light, but it will hold more precision by better identifying the location of where photons impacted the sensor. On the chart referenced above, pixel size is shown as a measure of microns, another name for which is micrometers.

As displayed in **Figure 4**, the wide pixel bucket has capacity to not only store more light information, but collect light from a greater area.

The decision of what size a sensor's pixels needs to be is often concluded with a balance between resolution and sensitivity. A system intended for low light situations should prefer larger pixels, while a system intended for well lit scenes should prefer smaller pixels.

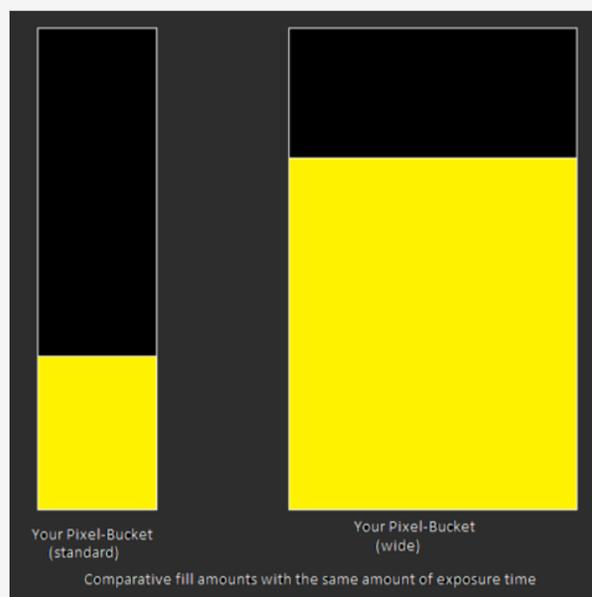


Figure 4: Effect of Pixel Size  
Image Credit: Jon Minnick, [cloudbreakoptics.com](https://www.cloudbreakoptics.com)

## Pixel Density

High density pixel arrangements collect less light with more precision, while low density pixel arrangements

collect more light with less precision. On the chart referenced above, there is no given measure of pixel density; however, you can get a good idea of how each sensor compares by taking the number of pixels and dividing it by the sensor area. For example, the KAF-4301 has a pixel density of approximately 1700pixels/mm<sup>2</sup>, while the KAF-50100 has a pixel density of approximately 28,000pixels/mm<sup>2</sup>. The KAF-50100 is clearly much more dense than the KAF-4301 because it has almost 16 times more pixels the amount of pixels per mm<sup>2</sup>.

Pixel density goes hand in hand with pixel size. As pixel density increases, the size of the pixels must decrease. High density sensors have a greater number of pixels, and thus have greater precision when identifying where light came from, producing higher resolution images. Low density sensors, however, include larger pixels more capable of collecting light when there is not a lot of light in the scene.

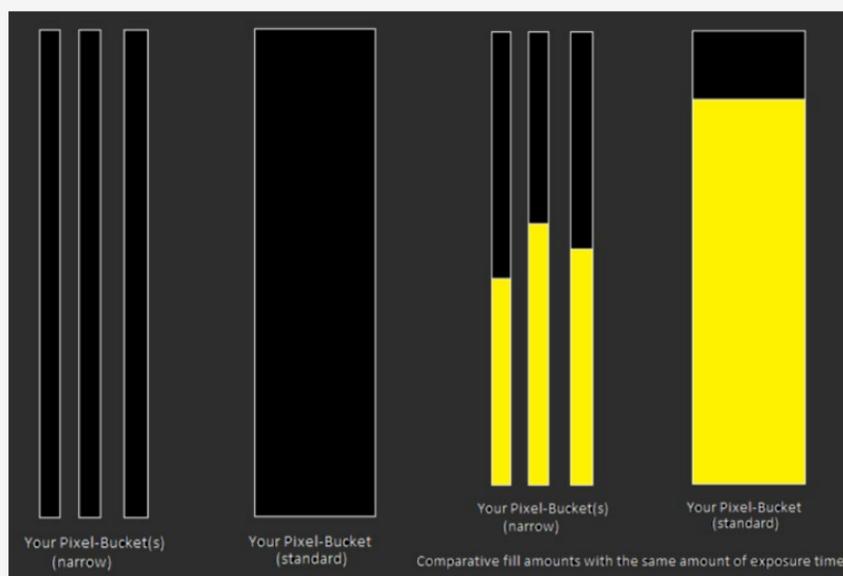


Figure 5: Effect of Pixel Density  
Image Credit: Jon Minnick, [cloudbreakoptics.com](http://cloudbreakoptics.com)

## Sensor Type

There are two primary sensor types to choose from: CCD and sCMOS. On the chart referenced above, any GPixel sensor is a sCMOS sensor, and any of the other sensors are CCD.

CCD sensors provide low dark current images at the cost of higher frame rate availability. These sensors are ideal for long exposure imaging. CCD sensors are discussed further [here](#).

sCMOS sensors provide images with very low noise, significantly higher frame rates, and a large field of view. sCMOS sensors are ideal for imaging requiring quick image capture and low noise. sCMOS sensors are discussed further [here](#).

## Sensor Illumination

Two options exist with sensor illumination, backside and frontside. The root of this option sprouts from a pixel's architecture. **Figure 6** shows how front illuminated sensors require light to first pass through a layer of circuitry on the front side of the photodiode. Inversely, back illuminated sensors place the circuitry on the backside of the photodiode. Back illuminated sensors require a significantly more challenging procedure to produce. Thus, back-illuminated sensors are more expensive than front illuminated sensors.

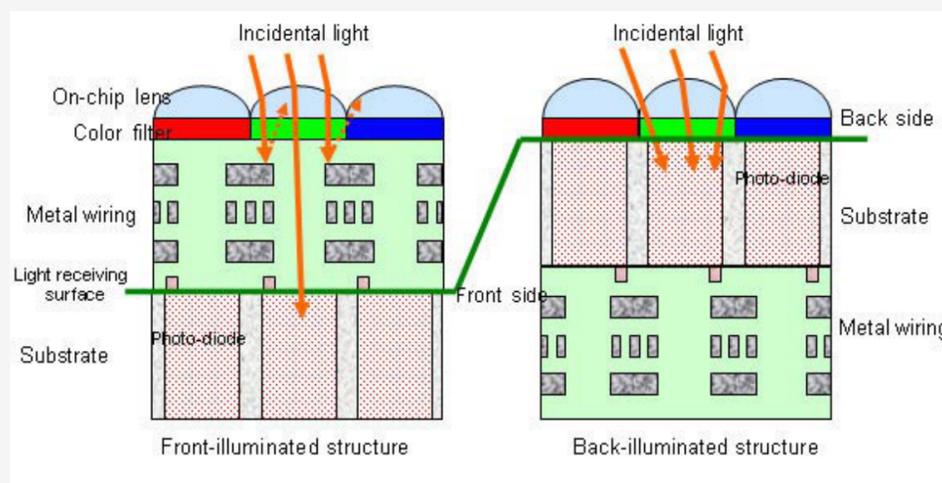


Figure 6: Pixel Illumination  
Image Credit: Sony, [Sony.net](http://Sony.net)

The chart referenced above shows front illuminated sensors with a red font, and the back illuminated sensors with a blue font. Sensors shown in neither a red nor blue font are interline transfer CCD sensors, which are discussed in further detail on the CCD Sensors page.

interline transfer sensors are a type of CCD sensor that do not provide a choice between front/back illuminated, thus earn their own category. Interline transfer sensors are less sensitive to light due to their architectures, however, they avoid smear and are capable of higher image capturing rates than other CCD architectures.

Back illuminated sensors allow more light into the photodiode, because less light is blocked, reflected, or absorbed by the circuitry in a frontside illuminated sensor. With this increased light, the low-light capabilities of the sensor are enhanced, and digital noise is reduced.

Back illuminated sensors are ideal for low light imaging, due to its ability to capture more light.

Front illuminated sensors are ideal for imaging devices not expected to be used in low light situations.

Interline transfer sensors are ideal for high rates of frame captures, but not very low light situations.

## Quantum Efficiency

Quantum efficiency (QE) is provided as a percentage and is a measure of efficiency a sensor can measure incident photons. We know light to be composed of photons, objects which we can then measure with photodiodes. With a sensor capable of 100% QE, the photodiodes of the sensor would translate one incident photon into one measurable electron. As QE decreased towards 90%, 50%, etc, the amount of photons recorded by the sensor decreases, subsequently resulting in decreased sensitivity to light.

High QE sensors capture the most light, and thus are more sensitive imaging devices. Devices with low QE may suffer from dark images, and will not operate optimally in low light situations.

The image to the right shows an example of a pixel with decreased QE (on the right). As light enters the pixel well, some is reflected, some is absorbed,

and some gets to the sensing area. The more in the way of the lights path, the lower the QE is due to less light being read.

The pixel to the right would be an example of a front illuminated sensor, with various objects blocking the lights path.

QE is not shown on the chart referenced above, however, a simple internet search of the sensor ID, example: KAF-50100, will return the sensor specifications from the manufacturer and will

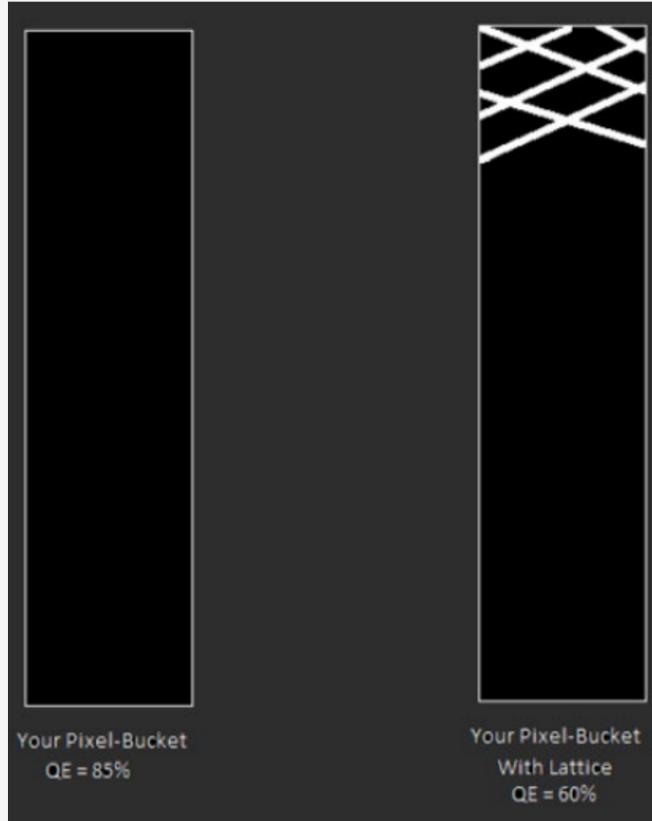


Figure 7: Quantum Efficiency Example  
Image Credit: Jon Minnick, [cloudbreakoptics.com](http://cloudbreakoptics.com)

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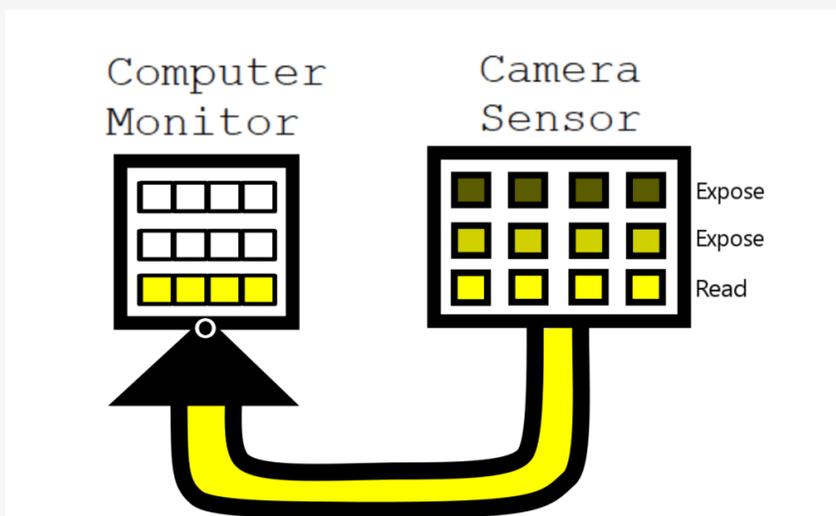
## Scientific Complementary Metal Oxide Semiconductor

Scientific Complementary Metal Oxide Semiconductor (sCMOS) Sensors provide high frame rate imaging with a variety of imaging options to create a modular system valuable to a wide array of applications. sCMOS sensors operate with a Rolling Shutter, allowing high frame rate while maintaining low noise operation and high resolution images. [More information on rolling shutter imaging can be found here.](#)

Potential applications of a camera with a sCMOS sensor installed may include the following implementations.

- Orbital Debris Detection
- Occultations
- Solar Astronomy
- TEM
- Photometry
- Near Earth Object (NEO)
- Super Resolution Microscopy
- Wavefront Sensing
- Speckle Imaging
- Forensic Imaging
- Photocell Inspection

## Animation



As displayed in the animation above, there are three states a row of pixels can be in: read, reset, expose. The exposure time of this example is the minimum. With longer exposure times, there are periods where all rows are exposing, known as [Global Exposure](#).

The arrow and the "Computer Monitor" represent the flow of information during each read row process. during each read process, the entire rows data is sent to the PC for interpretation.

## Pertinent Pro's and Con's

One can see that while every row is always actively performing a function, each row begins exposure at a slightly different time. The severity of the timing variance is dependent on whether the camera is operating in [HDR or LDR mode](#).

This lag between exposure starts only begins to cause problems when a subject is moving at very high speeds. This problem is discussed fully in [Rolling Shutter](#). For this reason, very high speed subjects are often better captured with [CCD Sensors](#).

Despite the problems endured with high speed subjects, sCMOS sensors are very efficient. Due to the constant progress in each row, time is not wasted as it is in CCD sensors. This results in faster readout and thus, a faster frame rate.

## Available Products

As of September, 2018, The only sCMOS sensors Finger Lakes Instrumentation offers are the GPixel GSense 400, 2020, 4040, and 6060, all of which are only available in the Kepler family of cameras. The 400, 2020, and 6060 are available as Back Illuminated Sensors, benefits of which are discussed under [Sensor Selection](#).

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## Rolling Shutter Overview

In a rolling shutter imager, the pixels in the array are always exposed to light unless physically blocked by a shutter mechanism.

A single row within the sensor consists of a three step sequence, as shown in **Figure 1**.

Exposure causes charge to accumulate at each pixel in proportion to the incident light. The pixels' accumulated charge must be removed prior to exposure to assure the user-defined exposure start time and duration are met.

The accumulated charge is removed when a reset occurs (also referred to as a flush or a clear). Pixels are reset and read one row at a time, not individually or globally.

After requesting an image capture, the camera waits, if set for a delay time, then resets the first row of the image. Immediately following each row's reset, exposure begins for that row, for the requested length of time. When the exposure has completed, the camera issues a read command for that row.

Once the first row's exposure begins, the following row begins its process. The result is a staggering of the start of exposure for the rows in the array. This staggered reset and read timing is referred to as a "rolling shutter exposure," or simply "rolling exposure," as there is no associated physical shutter. The graphic below depicts this concept. (**Figure 2**)

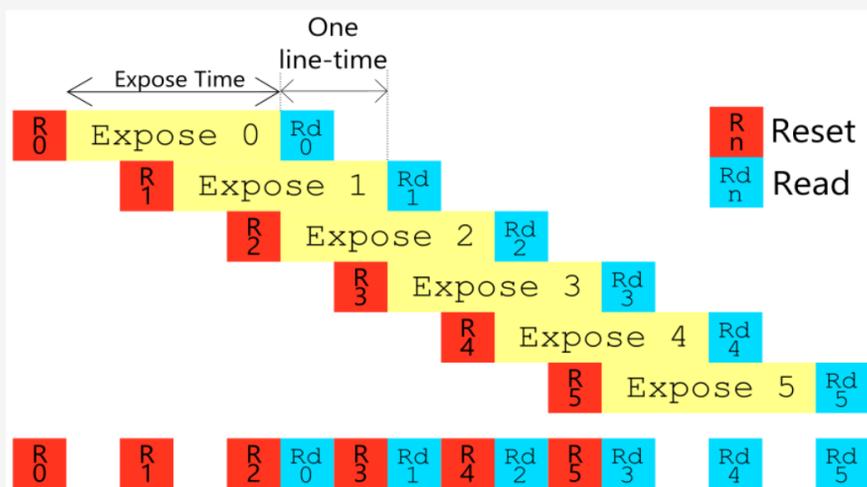


Figure 2. Rolling Shutter Sequence

Since the time between read commands is the same as the time between reset commands one is able to expose all rows of the imager for the same amount of time, however, the time of the exposure is shifted from the first row for each subsequent row. A more comprehensive depiction of the sensor's activity is shown below with each row resetting, exposing and reading.

One line time consist of a read and reset. In LDR mode it is 10.26 usec and in HDR mode it is 20.52 usec. Thus, there is a time delay every 10.26 usec or 20.52 usec due to the overlap of the row sequences.

When the sensor is not actively collecting information from the rows, such as in an idle mode, the sensor continues its process of reading and resetting. However, it reads a "non-imaging row" for each row it resets. This process keeps the sensor ready to capture an image with minimal delay while not wasting resources collecting unwanted row data. This action is referred to as flushing.

An unfortunate consequence of rolling shutter photography is that it often fails to accurately capture objects moving quickly due to the difference in start time of each row's exposure. An effect may occur where the moving object may look oblong, or, in the case of this spinning colour wheel (**Figure 3**), the object may distort into odd patterns.

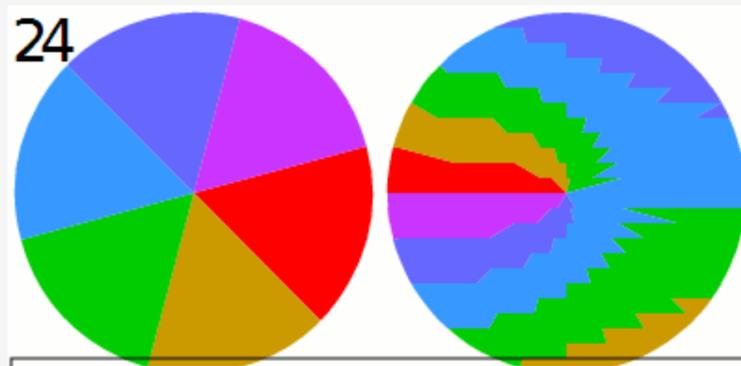


Figure 3: Rolling Shutter Color Wheel  
Image Credit: Cmglee, [wikimedia.org](https://commons.wikimedia.org/wiki/File:Rolling_shutter_color_wheel.jpg)

This unfortunate sideeffect only appears when the object moves fast enough as to move a significant distance in the time it takes for the sensor to complete a single exposure-read-reset cycle. Results like this disc are uncommon, unless the object moves very quick like a propeller.

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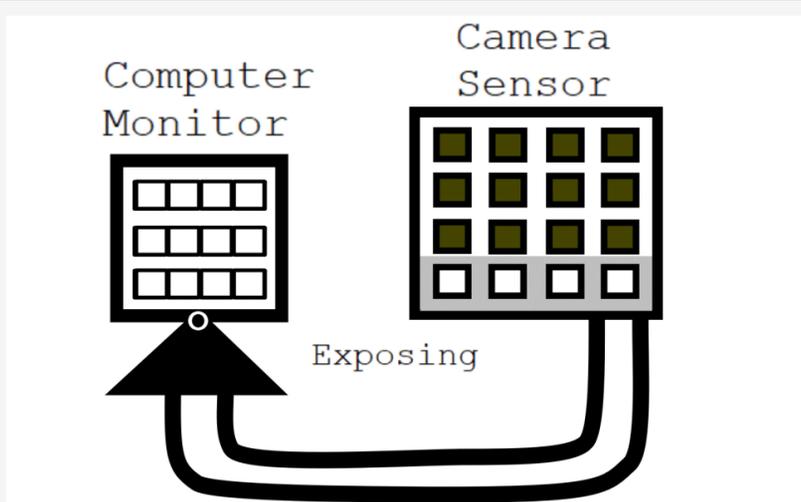
## Charge Coupled Device Sensor

Charge Couple Device (CCD) sensors provide low-noise, high quality images. CCD sensors are capable of long duration exposures while effectively collecting a large portion of the available light. Alongside its ability to capture low noise images with long exposures, CCD sensors operate with a Global Shutter. A global shutter begins exposure of the whole sensor at the same time, preventing motion blur associated with rolling shutter imaging sensors.

Potential applications of a camera with a CCD sensor installed may include the following implementations.

- X-ray Applications
- Fluorescence
- Bioluminescence
- Chemiluminescence
- Solar Panel Inspection
- Gel Documentation
- Astronomical Imaging
- Digital Radiography
- Forensic Imaging

## Animation



Above is an animation that displays a frame cycle of a CCD interline sensor. One should note that during readout, rows are read into a bus, then sent to the computer. Also note that each row begins exposure at the same time.

## CCD Architecture

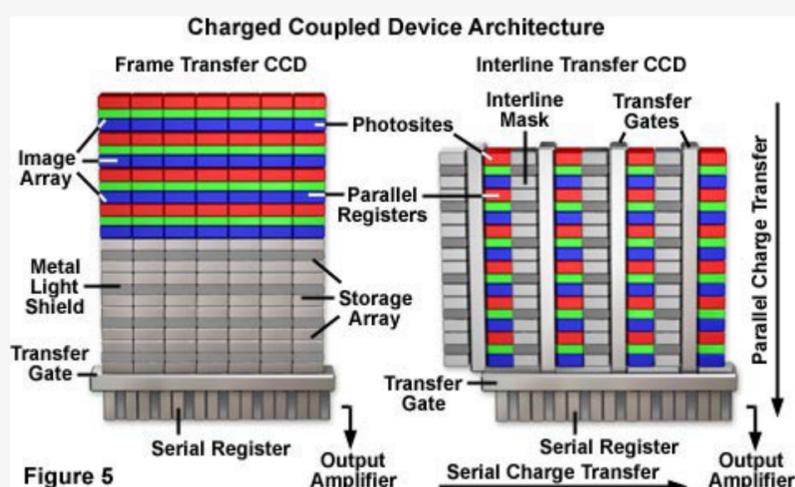


Figure 5: Charged Coupled Device Architecture  
Image Credit: Olympus, [Olympus-LifeScience.com](http://Olympus-LifeScience.com)

### Interline CCD

Interline CCDs use part of each pixel to collect light, and part of each pixel to store and move charge. The storage area has a metal mask to prevent corruption of the image during readout. New CCDs have a microlens over each pixel to focus incoming light onto the photodiode portion of the pixel so that light is not lost landing on the metal masks. Because only part of the pixel is used to collect light, the full well capacity of interline CCDs is typically lower than comparably sized full frame pixels.

Interline transfer CCDs shutter the image by moving the charge from the photodiode to the storage diode side of the pixel. As a result, interline frame times can potentially be very short. For FLI cameras, interline frame times can be as low as 30 microseconds (as opposed to about 30 milliseconds for an electromechanical shutter). Usually interline CCDs are used without electromechanical shutters. However, it is complicated to take a dark image without a shutter unless you have some way of keeping the camera in a 100% dark environment.

### Full Frame CCD

Full frame CCD's use 100% of each pixel to collect, store, and transfer charge. The readout procedure begins with each row flushed, then each row begins exposure simultaneously with the aid of a physical shutter. After the requested exposure time, the physical shutter closes and readout begins. Individual rows are shifted into the readout area, with each shift adding one row to the readout area and subtracting one row from the photosensitive area. As each row leaves the photosensitive area, its row is reset in preparation for the following image. Once every row is in the readout area, information begins to be transferred to the computer and a new image begins exposing.

Due to the operation of a full frame CCD, they require an electromechanical shutter unless the camera is going to be used in a 100% dark environment. Full frame devices typically have higher full well capacities and higher quantum efficiencies than interline sensors.

The primary benefit of CCD sensors is their ability to grab very low noise, long exposure images. The design of the sensor produces very little noise and with an effective use of the sensor area. Additionally, CCD sensors do not suffer from the row offset that CMOS sensors produce.

Unlike CMOS sensors, however, CCD sensors suffer from smear, a side effect of the readout procedure that produces bands of light in columns with extremely bright light. Additionally, full frame CCD sensors are a much larger profile, and interline transfer CCD's do not provide an option concerning back/front illumination.

## Available Products

As of October, 2018, CCD sensors are provided by Finger Lakes Instrumentation in every family of cameras except the Kepler Family. The Hyperion, MicroLine, and ProLine families only use CCD sensors. The Kepler family contains no CCD sensor imagers.

There are too many CCD sensors to discuss individually. Refer to [Sensor Selection](#) to analyze what aspects are important for you. You can also contact FLI directly for more information of the selection.

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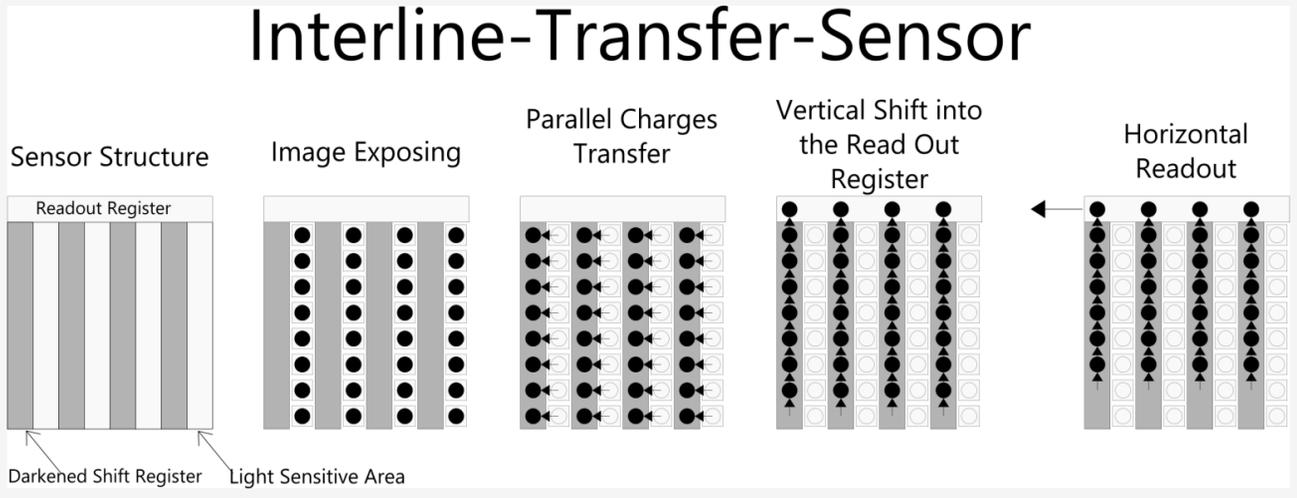
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**Smear**

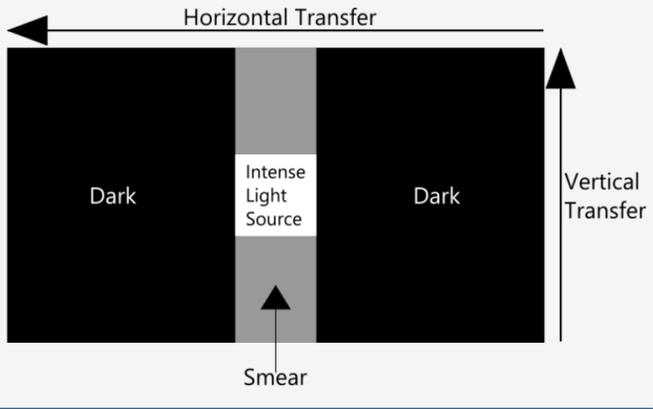
**Interline Transfer Sensor**

The sensor is divided into alternating vertical columns of light sensitive and light blocking areas. the light sensitive area is the image sensor where light is collected and transformed into charges. the light blocking area is the vertical shift register, where those charges are stored and shifted into the read out register. When the image sensor area recieves the requested duration of exposure, the charges are transferred to the vertical shift register directly beside the image sensor area. Once the charges enter the vertical shift register, the charges begin to shift vertically towards the read out register. The read out register reads the charges row by row until all the stored charges have been moved into the read out register and read.



**Smear**

Smear is an excess signal that becomes visible when an interline sensor is exposed to an intense light source during its readout period. Smear results from light leaking into the vertical shift registers as charges are being moved towards the readout register to be read out. As the charges move, light from intense sources can penetrate the vertical shift register, brightening the image above and below where the source should expose the image. This causes unattractive bands of brightness in the image.





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## **Filter Wheels**

Two families of filter wheels are sold by FLI. The Color Filter Wheel family offers 8 filter wheel options with various quantities of filters. The CenterLine Filter Wheel family offers a unique design, two filter wheels are used together to balance the system and reduce any unnecessary motion and destabilization.

FLI produces filter wheels for any of your imaging needs.

## **Kepler Image Time Stamp**

The Kepler Image Time Stamp (KITS) is a product sold with the Kepler imaging system to provide precise time logs. the KITS can allow the Kepler imaging system to log exposure times extremely accurately because the duration is based of satellite feed rather than a local computer, which may have inaccuracies.

KITS reduces variability in time logging that may occur, and results in logging precision of +-1 microsecond.

## **Adnaco Fiber Optics**

With the use of two Adnaco products, it is possible to completely electrically isolate your imager and your computer. An added benefit of which is the ability to use a fiber optic connection, which is capable of longer distances and higher speeds that USB 3.0.

System isolation is important when the camera is placed in an electrically unsafe place, such as high altitude observatories susceptible to lightning. The fiber optics connection protects computers operating the camera from electrical damage the camera may endure.

## **Camera Lenses**

There are thousands of camera lenses for sale. Each lens has important characteristics such as f/number and focal length. As well as lens mounting and modularity, the choice of which lens is best is often quite complicated.

Fortunately, FLI has compiled the answers to many of the questions one may ask and explained important aspects in the hunt for a lens, here.

## **USB 3.0 Extension Cables**

If you are in the market for a longer USB Cable, we have some third party products that might be right for you.

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## Color Filter Wheel

### Mechanical Connection to Camera

The default front flange of FLI cameras is the FLI dovetail. This mates to the back of CFWs with a 2.93inch pocket in the Frame Connection column on the following chart:  
[Color Filter Wheel Specifications](#)

As shown, the CFW9 and CFW10 filter wheels require the camera to have a special front flange with the mating bolt pattern.

Additional parts are sold by FLI, contact an FLI sales representative at [sales@flicamera.com](mailto:sales@flicamera.com)

### Mechanical Connection to Telescope

Our adapters page includes several adapters, however, our customers often require a custom length to cooperate with their back focal distance. Custom adapters are available from [preciseparts.com](http://preciseparts.com). The necessary numbers to calculate the back focal distance is in the following chart:  
[Color Filter Wheel Specifications](#)

### Filter Size

The most important aspect of color filter wheel selection is assuring the filter wheel uses filters that cooperate with your sensor. If the filter is too small, vignette will appear at certain f/ ratios. A chart of all sensor FLI currently handles is available here:  
[Sensors Supported in FLI Cameras](#)

A sensors diagonal measurement is most important in this situation. We recommend selecting a filter wheel capable of handling filters with diameters greater than the sensor's diagonal, or, if the filter is square, select filters with horizontal and vertical measurements greater than that of the sensor. Filter wheel sizes and shapes are displayed on the following chart:  
[Color Filter Wheel Specifications](#)

Another important aspect is the quantity of filters the filter wheel can handle. Depending on the model, between 5 and 20 filters can be stored. The number of filters a wheel stores is indicated by the final number in its model identification. Select a filter wheel with appropriate filter dimensions and quantity of filters.

### Quick Setup

1. Install [FLI Software Installation Kit](#) (Includes FLI Filter).
2. Plug the power supply cable into the Color Filter Wheel.
3. Attach the USB cable between the Color Filter Wheel and your computer.
4. Plug the power supply cable into a wall socket or switched AC power strip.
5. Run FLI Filter to initialize the Color Filter Wheel and make control selections.

Complete Setup Procedure, including filter installation and homing procedure, is available in the online manual found [here](#).

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## CenterLine Filter Wheel

CenterLine Filter Wheels are chosen because of its center aperture with balanced weight. This prevents destabilization when the filter wheel rotates.

Three general difficulties arise when a filter wheel is introduced to a system. These are discussed below, as well as information valuable to purchasing.

### Mechanical Connection to Camera

CenterLine Filter Wheels require either a front flange with a CenterLine ZTA dovetail (so the filter wheel is flush to the camera), or an adapter that threads into the default FLI dovetail. The adapter adds approximately 8mm of offset.

Utilizing the adapter provides easy switching between the FLI dovetail flange and the CenterLine ZTA flange if it is desirable to do so.

Additional parts are sold by FLI, contact an FLI sales representative at [sales@flicamera.com](mailto:sales@flicamera.com)

### Mechanical Connection to Telescope

Our adapters page includes several adapters, however, our customers often require a custom length to cooperate with their back focal distance. Custom adapters are available from [preciseparts.com](http://preciseparts.com). The necessary numbers to calculate the back focal distance is in the following chart:

[Color Filter Wheel Specifications](#)

### Filter Size

The most important aspect of color filter wheel selection is assuring the filter wheel uses filters that cooperate with your sensor. If the filter is too small, vignette will appear at certain f/ ratios. A chart of all sensor FLI currently handles is available here:

[Sensors Supported in FLI Cameras](#)

A sensors diagonal measurement is important in this situation. We recommend selecting a filter wheel capable of handling filters with diameters greater than the sensor's diagonal, or, if the filter is square, select filters with horizontal and vertical measurements greater than that of the sensor. Filter wheel sizes and shapes are displayed on the following chart:

[Color Filter Wheel Specifications](#)

Another important aspect is the quantity of filters the filter wheel can handle. Depending on the model, between 10 and 20 filters can be stored. However, due to the double carousel design of the CenterLine wheels, one position on each wheel is left empty. The number of filters a wheel stores is indicated by the final number in its model identification, minus two. For example, the CL-1-10 has 10 empty positions, 8 of which are usable.

Select a filter wheel with appropriate filter dimensions and quantity of filters.

### Quick Setup

1. Install [FLI Software Installation Kit](#) (Includes FLI Filter).
2. Plug the power supply cable into the CenterLine Filter Wheel.
3. Attach the USB cable between the CenterLine Filter Wheel and your computer.
4. Plug the power supply cable into a wall socket or switched AC power strip.
5. Run FLI Filter to initialize the CenterLine Filter Wheel and make control selections.

Complete Setup Procedure, including filter installation and homing procedure, is available in the online manual found [here](#).

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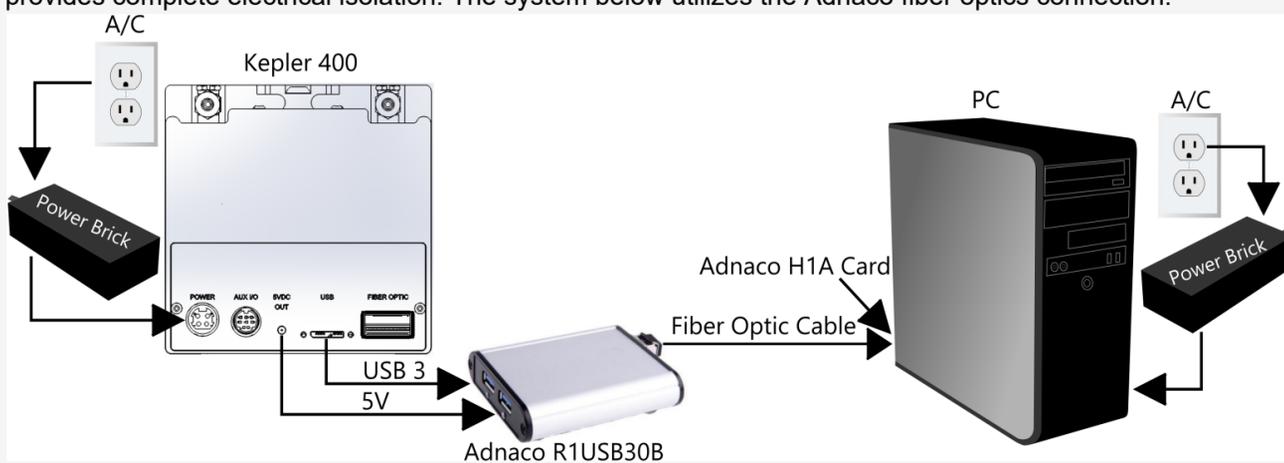
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## FLI Fiber Optics

FLI offers options to utilize fiber optics to transmit information from computer to camera and from camera to computer. The primary benefit of fiber optics is the significantly extended range compared to USB 3. USB 3 is limited to 3 meters of cable before the cable will fail to successfully transfer data. Fiber optics, on the other hand, can reach over 100 meters without issue.

A secondary, and equally important benefit of fiber optics is that fiber optics does not conduct electricity. With a fiber optical connection, there is protection from a power surge in one location damaging a second location. This is a very beneficial feature for situations where the camera is located off site from the operating computer. If, for example, a lightning strike occurs and damages the camera, the surge of electricity from the lightning would not have a path to the operating camera. Thus, this type of connection can add a secondary layer of protection to important equipment.

Below is a drawing to represent how the fiber optics protects and extends the connection. The camera and the computer can be on completely separate electrical circuits and the use of non-conductive fiber optics cable provides complete electrical isolation. The system below utilizes the Adnaco fiber optics connection.



There are two necessary products for the setup above to operate: the Adnaco R1USB30B, and the Adnaco H1A Card. The R1 is an external device that accepts USB 3 input and outputs a fiber optic signal. The H1A is a PCIe card that must be installed into ones PC. Instructions on operation and setup for these products are available via Adnaco documentation. Visit [Adnaco.com](http://Adnaco.com) for more information.

Beyond product setup and installation on the computer, the FLI camera will operate with the computer exactly as it had prior to the injection of the Adnaco products.

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## Lens Selection

An important aspect of lens selection is the intended use. Low light situations require large aperture lenses, while day time or well illuminated scenes do not require large aperture. In these conditions it is more likely to use smaller apertures than the maximum size.

For astrophotography, it is important to get a lens that supports a quite large aperture. This quality can be noted by a reported f-ratio around or below  $f/2$ . So, the closer to  $f/1$  a lens can operate, the more light and more information can be recorded.

A lens' ability to magnify is significant to an image as well. Prime lenses lack dynamic magnification, however the image is often better than dynamic zoom lenses due to the internal mechanisms of the dynamic lens reducing the possible light capture.

Some lenses, such as fisheye, will increase the field of view of the lens, at the cost of distortion in the image.

It is also important to locate a lens that works with the sensor you need. If the lens is meant for sensors smaller than the sensor its used with, vignette will appear because the lens can't fill the sensor's area.

The best advice for lenses is to research what other members of your community use for the use you intend. Try lenses, if possible, and understand what qualities are important to you, such as autofocus, fixed-focus, telephoto, fisheye, or macro lenses.

There exists a large range of lenses with many possibilities. Chose a lens that works best for your needs and your sensor needs, then focus on connecting it to your camera. The following sections discusses FLI supported mounts, with which you can connect most modern lenses on the market.

## C Mount

Merely to say that a lens is "C-mount" says very little about the lens' intended use. C-mount lenses have been made for many different formats.

C-mount is a system heavily used in the photograph industry, and thus, its applications spread a very wide span. Lens types from macro to telephoto are applicable, with a large range of apertures, focal lengths, and options. The ability to use lenses with mounts beyond what is seen here can come through c-mount connectors, as the range of use C-mount gets has introduced interest in making it even more universal.

## 50mm

50mm lenses refers to the focal length of the device. The focal length influences the field of view of the images captured inversely. Thus, the 50mm lenses will produce a narrower field of view than the 35mm. With a 50mm focal length, these lenses are capable of producing images with a field of view very similar to the human eye.

50mm lenses are prime lenses, meaning they have a roughly fixed focal length. Most lenses will have a small range for focusing the image properly, but often not more than  $\pm 3$ mm.

## 35mm

35 mm lens refers to the focal length of the device. The focal length influences the field of view of the images captured inversely. Thus, the 35mm lenses will produce a wider field of view than the 50mm.

The 35mm lens is also a prime lens, meaning the focal length is only adjustable in small increments to correct focus. The benefit of this is that the image quality is significantly higher than in adjustable focus lenses because the design is simple and doesn't block light with unnecessary parts.

## 4/3

Four Thirds was an initiative by multiple optics companies in the early 2000's to produce universally cooperating products. With this, came a large selection of Four Thirds cameras and lenses. The lenses are similar to c-mount in that Four Thirds doesn't really describe anything specific about the lens. Four Thirds lenses are available in as many different optical configurations as exist, including macro, telephoto, fisheye and prime.

The Four Thirds lens mount is specified to be a bayonet type with a flange focal distance of 38.67 mm.

The important quality of Four Thirds lenses is that they are first and foremost designed for operation with Four Thirds systems. Particularly, this means that the lenses maximum sensor dimensions are  $4/3$ " with a 4:3 aspect ratio. A Four Thirds lens will not work properly on a full frame sensor, or any sensor larger than  $4/3$ ".

## Micro 4/3

Micro Four Thirds (MFT) refers to the brand name for this family of lens. "Four thirds" also refers to the sensor format the lens is designed for ( $4/3$ " with a 4:3 aspect ratio).

MFT shares the original image sensor size and specification with the Four Thirds system, designed for DSLRs. Unlike Four Thirds, the MFT system design specification does not provide space for a mirror box and a pentaprism, which facilitates smaller body designs and a shorter flange focal distance, and hence smaller lenses. The MFT system design specifies a bayonet type lens mount with a flange focal distance of 19.25 mm.

Micro 4/3 cameras can still use older Four Thirds lenses, but an adapter is needed to extend the length from rear element to the sensor.

Like Four Thirds and C-mount, Micro Four Thirds is title for the adapter which is used. No specification of the lens type is defined by its name. Zoom, fixed focal, macro, fisheye, prime, 3D and pinhole lens varieties are produced.



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## Kepler Image Time Stamp (KITS)

Kepler systems allow the use of the Kepler Image Time Stamp device, which is capable of very precise timing information, as well as positional information. KITS is a 32-channel receiver that yields 10 Hz update rates. When enabled, this option provides accurate timing, longitude, and latitude information by using GPS and GLONASS satellite data. This device is designed to log exposure times with better precision than the clock of a standalone computer is capable of. Extremely accurate exposure duration information is important when captures need to be reproduced or in an event where time is an important factor. If KITS is not in use, timing information will come from the computer which is controlling the camera.

KITS has an accuracy of 1 microsecond, and can be configured to have an accuracy of 100 nanoseconds upon request to FLI. In comparison, a typical PC clock has an accuracy of approximately 1 milliseconds.

The Kepler Image Time Stamp (KITS) is connected to the Kepler system via [pin 1](#), [pin 4](#), [pin 6](#), and [pin 7](#). Pin 1 operates as a 12V power supply for the KITS module. Pins 4 and 7 operate a UART connection, where pin 4 is the RX, and pin 7 is the TX. Pin 6 is ground, and connects into the cameras ground.

The Kepler Image Time Stamp specifications are available [here](#).

To enable the KITS option, just plug the KITS connector into the auxiliary port of your Kepler Camera. There is a delayed connection of up to two minutes. Once the KITS is connected and operational, a small green lock symbol will activate in the lower right hand corner of Pilot, if it has not yet connected, it will show a small red unlocked symbol. Please note that the KITS device must be in visual contact of the sky and the GPS satellites for successful connection.

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## Focuser

Finger Lakes Instrumentation offers three focusers for use with our imaging systems. These focusers are designed to operate with FLI cameras to precisely focus an image.

The three focusers we offer are the DF-2, PDF, and Atlas. The DF-2 is a small digital focuser. The PDF is a digital focuser with a large aperture with support for high resolution imaging. The Atlas focuser is designed for a critical focus with heavy loads.

FLI's website pertaining to the focuser systems can be found [here](#).

A well detailed users guide for the Focusers we offer can be found [here](#).

A data sheet for the Atlas focuser can be found [here](#).

Below is a specifications table pertaining to the DF-2, PDF, and Atlas focusers.

Focuser Specification	DF-2	PDF	Atlas
Minimum Travel	0.20"	0.35"	0.35"
Dimensions	5.0" x 6.5"	8.0" diameter	7.0" x 7.0"
Thickness in Closed Position (Factory Set)	1.05"	1.05"	1.26"
Weight	1.6lbs	2.4lbs	3.0lbs
PC Interface	USB	USB	USB
Telescope Side Threads	2.005"-24 UNS-2B	3.750"24 UNS-2B	*
Number of Steps	2,000	7,000	105,000
Resolution per Step	2.5 micron	1.25 micron	0.083 micron
Clear Aperature	50 mm	89 mm	89 mm

\*The Atlas is not threaded. use a Zero Tilt Adapter™ to interface with a telescope.

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## USB Extension Cables

If you are in need of a USB Extension Cable please see the products listed below. There are traditional copper USB cables for shorter runs as well as some fiber optic systems for longer requirements.

### Copper USB Extension

Manufacturer: [StarTech](#)  
Length: 3m  
PN: USB3AAEXT3M  
Link: [StarTech.com](#)

Length: 5m  
PN: USB3AAEXT5M  
Link: [StarTech.com](#)

Length: 10m  
PN: USB3AAEXT10M  
Link: [StarTech.com](#)



### Fiber Optic USB Extension

Manufacturer: [Corning](#)  
Length: 10m  
PN: AOC-ACS2CVA010M20  
Link: [Amazon.com](#)

Length: 15m  
PN: AOC-ACS2CVA015M20  
Link: [Amazon.com](#)

Length: 30m  
PN: AOC-ACS2CVA030M20  
Link: [Amazon.com](#)

Length: 50m  
PN: AOC-ACS2CVA050M20  
Link: [Amazon.com](#)



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## Troubleshooting

Issue	Remedy
The fan on the camera does not turn.	Check that the camera is plugged into a suitable power supply and that power is available.
The fan turns but when I use FLIPilot, the camera does not work or works erratically.	Make certain that all cables are well seated and are not stretched.
FLIPilot runs, the camera fan turns but FLIPilot cannot locate the camera.	Turn off your computer and camera and leave them switched off for two to three minutes, this will flash the USB chips. Try again.
I get a Windows "Communication" error.	Turn off your computer and camera and leave them switched off for two to three minutes, this will flash the USB chips. Try again.
Everything is connected and FLIPilot has been installed but the software cannot locate the camera.	Make certain that you have installed the software and drivers as described in this documentation. Letting Windows locate the camera during installation is likely to create problems.
I captured an image but the image appears as a flat black or white frame.	You are over exposing or under exposing. Check the settings in the FLIPilot.

The following are problems and steps that may fix them. We ask that if you are experiencing a problem listed below that you follow these steps first. If that does not eliminate your error please follow the instructions on the [Reporting Issues](#) page.

### Image Defect

Please note that certain sensors have inherent defects that are a result of the manufacturing process. These row and column defects tend to show up as a single row or column that does not output realistic pixel values, ie a line in the image. Incorrect image defects may be random length horizontal lines scattered about the image, 1/8th or more of the image missing, or a completely random distribution of pixel values where there should be order.

In the event of an image defect please do the following.

- 1) Run [Force Training](#). Retake image, was the problem solved? If yes, then you have a slight imbalance in the timing sequence of your camera at the current operating condition. If the problem reappears in the future please rerun Force Training.
- 2) Is the image defect in every image? If the image defect is only in the Merged image but does not exist in the High or Low image, then you may have an issue with your [Merge Settings](#).
- 3) If the image defect was only in the High or Low image please change the gain setting for that image or change the Mode you are operating in. If the defect goes away switch back to the previous mode/gain. Without changing any other settings take an image, if the image does not reappear then it may be a setting you changed. Changing the mode resets some settings back to their factory defaults.
- 4) If the defect did not go away in step 3, please note what temperature you are currently operating the camera at. If you are operating it warm, please cool the camera off. If you are operating the camera cold, please warm it up. As the temperature changes, perhaps every 5 deg or so take an image. Does the defect go away at any point?
- 5) If you were not using Pilot up until this point, please rerun the above tests using Pilot. This will help eliminate a software issue. If Pilot does not show the defect under the same operating conditions/settings please contact us.
- 6) What is the physical conditions your camera is operating in? While our sensors are designed to operate at below freezing temperatures, our cameras are not. If your camera is in an extreme environment, please run a test of the camera once it comes closer to standard indoor temperatures. If the defect goes away you are trying to operate the camera too far outside of its design window.
- 7) If at this point you still have your defect or if you need further guidance please see the [Reporting Issues](#) page.

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**Shutter Assembly**

If you need to service your shutter assembly or replace the shutter assembly please see the following schematic (Figure 1) to assist you. Please note that the shutter assemblies are very fragile.

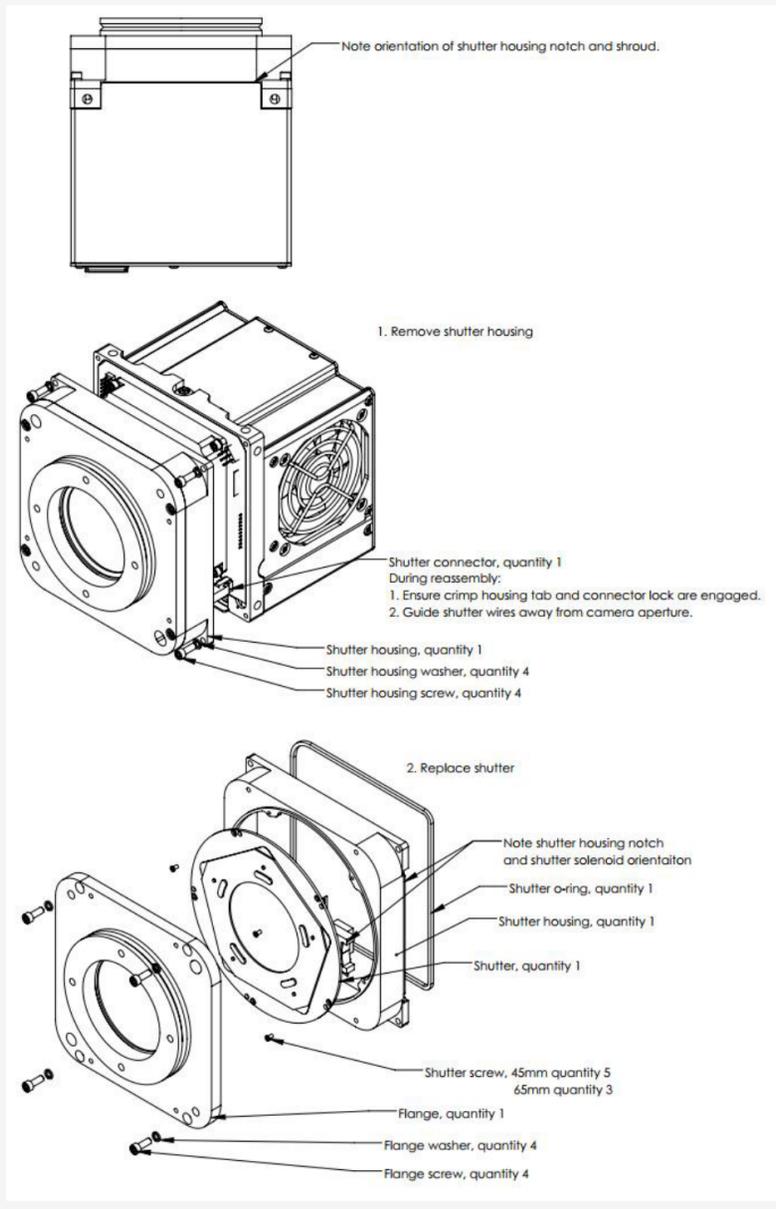


Figure 1. Shutter Assembly



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## Reporting an Issue

Before reporting an issue, please see if our troubleshooting guide may be able to help. If you are still stuck please send us an email at [sales@flicamera.com](mailto:sales@flicamera.com).

In order to best help you solve your problem please include the following information. As a general rule of thumb the more information you can provide us about the issue you are having the quicker we can determine the root cause and get you back in operation.

What camera model do you have?

What is the serial number of the Camera?

What programs are you running when the issue occurs? Pilot or ASCOM? If you are using ASCOM what third party software are you using as an interface?

What versions of software are you using? In pilot these can be found under Help-About. With the camera connected, there should be 4 software versions listed, please include all 4. In ASCOM please provide the ASCOM drivers version number.

Please provide a description of the issue you are having. If it is a new issue, please provide details about possible changes that may have occurred leading to this error. What mode are you in, what gain settings are you using, etc.

If you are encountering an image issue/defect. Please provide a .raw file of both the high and low gain image (hdr) single image (ldr). If you would like to provide screenshots in addition to (not a replacement of) the .raw file to help explain the issue please do so.

If there is any other information you believe might be relevant to the issue please include that as well.

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