

Kestrel

Model: KE60V-BV-CL



USER MANUAL

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1. INTRODUCTION

This document provides detailed instructions for the operation of the Kestrel, Scientific EMCCD camera. Raptor Photonics Limited reserves the right to change this document at any time without notice and disclaims liability for editorial, pictorial or typographical errors.

1.1 Scope

This manual covers the Kestrel digital camera and all applicable components. Raptor recommends that this manual be used to optimize camera operation. Details of the camera's mechanical and electrical interfaces are provided, as well as information on setting the camera up with liquid cooling. Important precautions to be taken when using the camera are also stated.

Detailed information is also provided on each of the camera's control parameters. Each camera control is discussed and explained with the use of XCAP Imaging software, which is the core plug and play software package that is offered with Raptor cameras. An image of the camera is shown in Figure 1.



Figure 1: Complete Camera Module.

2. CAMERA CARE

2.1 Cleaning the Sensor Window

Raptor cameras require no regular maintenance except occasional external cleaning of the sensor window (the glass window between the camera sensor and the microscope or lens). Use optical grade isopropyl to clean this window. A cotton swab can be used, but may leave some fibres on the window, so be careful. To avoid this, you could also use a lens tissue or a cleaning swab such as a Texwipe Swab. Forced air can be applied to remove any loose particles. Should any other issues occur please contact your local agent.

CAUTION — The camera's sensor and circuits are sensitive to static discharge. Ensure that you are using a static strap or completely grounded at all times to release any static energy before you clean the window.

CAUTION — Do not use acetone.

3. SPECIFICATION

3.1 Camera Overview

The Kestrel is designed for applications that require high sensitivity and speed. The camera uses the CCD 60 sensor from e2v with a resolution of 128 x 128. High-speed low-noise electronics provide linear response and sensitivity for rapid image capture.

The Camera Link digital interface provides the most stable platform for data transfer and the camera will work on any Camera Link standard frame grabber.

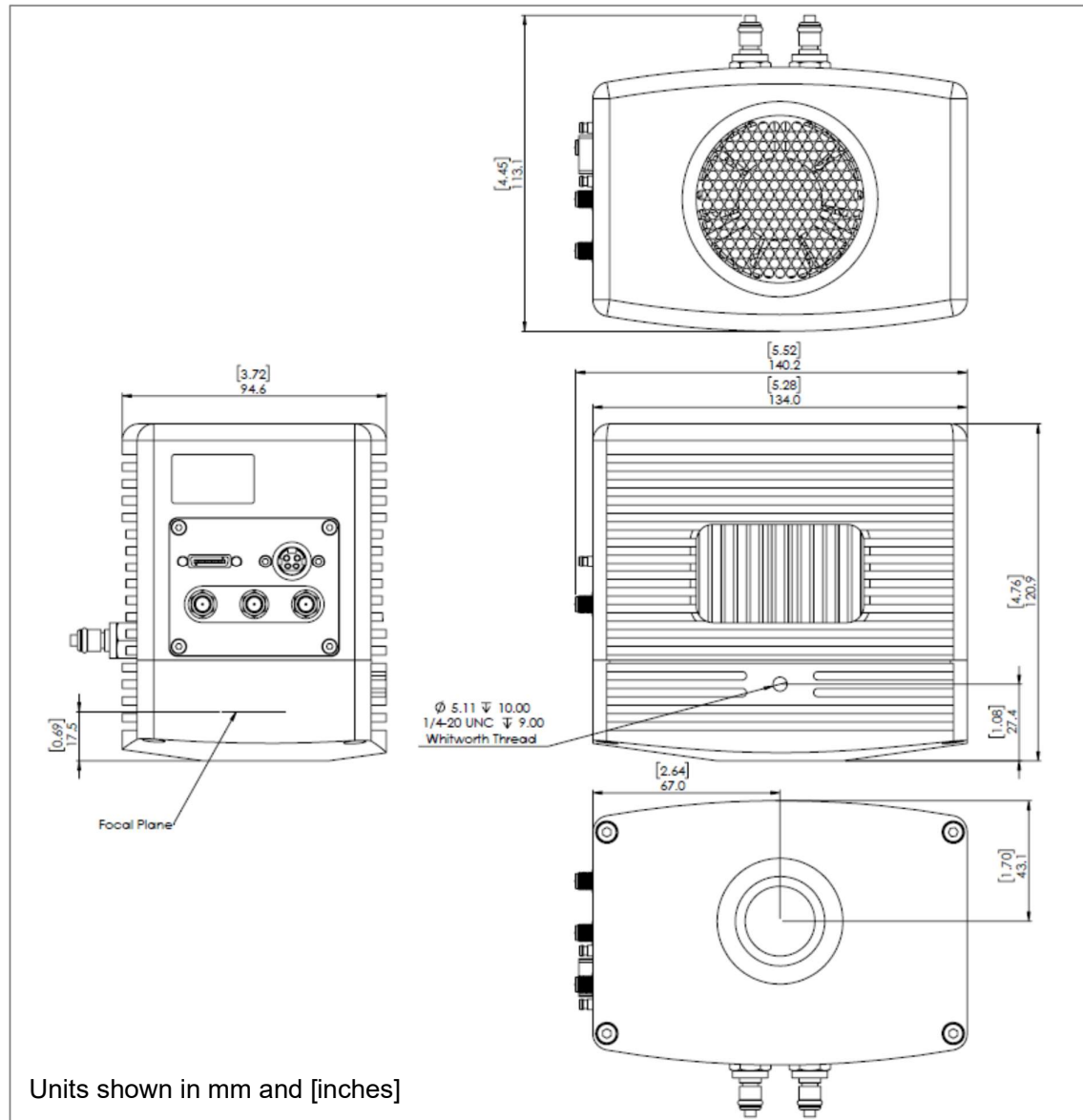
3.2 Datasheet

For the full specification of the Kestrel, the datasheet for the camera can be downloaded from the Raptor Photonics website:

<https://www.raptorphotonics.com/products/kestrel-emccd/>

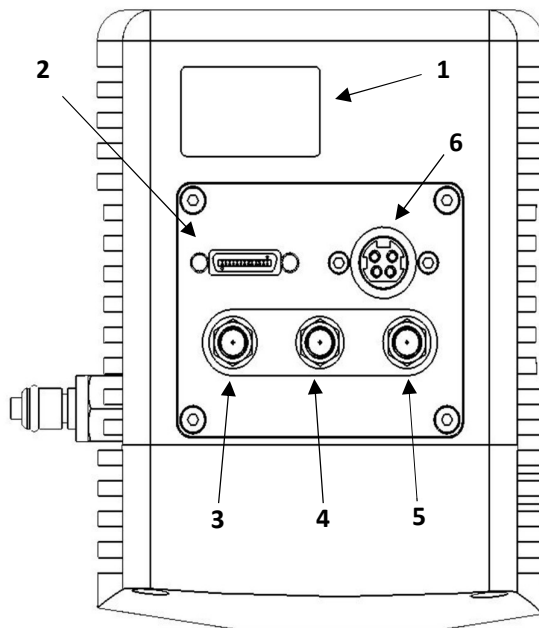
4. DESIGN OVERVIEW

4.1 Mechanical Model



PDF of mechanical model available from our website:
<https://www.raptorphotonics.com/products/kestrel-emccd/>

4.2 Physical Interface



1. **Label Recess**
2. **3M Camera Link connector**
Part #: 12226-1150-00FR
3. **SMA connector: Trigger Out (Frame).**
Single ended, source impedance = $51\ \Omega$, capable of sinking and sourcing 32mA and will have an output voltage of 3.3v i.e. TTL compatible.
4. **SMA connector: Trigger In.**
Single ended, termination impedance = $510\ \Omega$, capacitive load = 200 pF, TTL compatible.
5. **SMA connector: Trigger Out (Exp).**
Single ended, source impedance = $51\ \Omega$, capable of sinking and sourcing 32mA and will have an output voltage of 3.3v i.e. TTL compatible.
6. **4 Pin KYCON Power Connector**
Part#: KPJX-PM-4S
7. **Water taps**
Part#: CPC; MCD2402

4.3 Power Consumption

The camera input power specification is 12V +/- 10% with a maximum of 10 Watts power dissipation with the TEC cooler switched off. Additional current is required when the cooler power is switched from low to high. The total, maximum steady state, unit power dissipation is < 30W.

4.4 Mounting to Microscope

The camera has a standard C-mount that should easily screw onto any microscope port.

4.5 Mounting to a Tripod or Optical Table

The camera has a 1/4-20 BSW (Whitworth), threaded hole to mount to a tripod or an optical table.

5. SOFTWARE COMPATIBILITY

This section outlines the options relating to software that are available for the Kestrel camera.

5.1 XCAP Compatibility

Raptor works closely with EPIX who integrate all the Raptor camera models into their XCAP Imaging Software package. XCAP is the core plug and play software package that is offered with Raptor cameras.

5.2 LabView Compatibility

Upon request, Raptor can create a LabView .icd file which can be used to control the camera on National Instruments imaging tool NI MAX. The file may also be useful if attempting to create your own LabView VI.

5.3 Custom Software Interfacing

Raptor works closely with EPIX Inc, who integrates all of our cameras into their software package, XCAP. The EPIX frame grabbers are the models that we offer with our cameras. We offer their Software Development Kit (SDK) for interfacing with custom software (XCLIB). If using a frame grabber from a different company, you will have to obtain their SDK to implement a custom solution.

6. CAMERA AND CHILLER SETUP

This section will give instruction on setting up the camera and other components, including connecting to the frame grabber and chiller (if applicable).

6.1 Connecting Camera to Frame Grabber

The camera has the shrunk SDR port on the interface. The main frame grabber that Raptor offer with this camera has the normal MDR port (EPIX EB1). Therefore, one MDR – SDR Camera Link cable is required to connect the camera to this frame grabber.

If demoing the camera with the Mini PC system that Raptor provides, you should connect to the left port of the frame grabber in the Mini PC. This should be stated on the Mini PC.

6.2 Connecting Camera to Chiller

Raptor use a Chiller from Thermotek, the T257P Precision Chiller. For the datasheet and full user manual from Thermotek, please contact Raptor and we will provide this. The instructions to set up the chiller are as follows:

1. Connect the T257P chiller to the Kestrel using the tubing provided. You will hear a click which indicates a solid connection. The polarity of the tubing connections does not matter.
2. Keep the chiller horizontal and on a level surface.
3. Make sure there is a minimum 12" clearance and free path for flow of air entry and exit at the left side and right side of the T257P chiller prior to operation.
4. Remove the reservoir cap and add coolant to the reservoir until the fluid reaches the bottom of the neck. Please refer to section 6.3 for recommended coolants.
5. Close the cap securely to the reservoir. Make sure not to overfill the reservoir.
6. Install the appropriate end of the power cord into the unit and connect to the mains electricity.

If using another chiller model, please refer to it's manual for start-up instructions.

6.3 Recommended Coolants for Chiller

The recommended coolants are:

Option 1: Distilled Water

Option 2: 95% distilled water and 5% isopropyl alcohol mixture prevents bio growth.

Option 3: 80% distilled water and 20% inhibited glycol mixture for set temperatures below 5C.

Raptor recommends using option 3. If purchasing the Thermotek model from Raptor or using a demo kit provided by Raptor, there will be inhibited glycol mixture provided to mix with water.

6.4 Setting the Coolant Temperature for Re-circulation

When powering up the chiller, the screen will immediately give the option to set the temperature of the coolant. It is recommended to set a 20 °C set point. After the set point has been configured, selecting start will initiate the coolant re-circulation. For more detailed information on all the operating modes of the T257P Precision Chiller, please refer to the

Thermotek user manual.

WARNING: Please ensure the temperature set point of the chiller is above your ambient dew point, otherwise condensation can form around the sensor package and cause damage.

6.5 Draining the Chiller, Camera and Tubing

If using the Thermotek T257P Precision Chiller, it is recommended that a coolant change be implemented at a minimum, every six months, to keep the system in working order. Based on the amount of use, you may need to perform this more frequently. For more detailed information, please refer to the Thermotek user manual. If using another model of chiller, please refer to its user manual for the recommended time frame for coolant changes.

If finishing the testing of a demo kit, please disconnect the tubing and drain all of the camera, chiller and tubing before sending the equipment back to Raptor. Shorter draining tubes will be supplied with the demo kit. Two draining tubes (with the appropriate mating connectors) need to be connected to both connectors on each of the camera, chiller and tubing to drain each individually.

7. FRAME GRABBER AND SYSTEM REQUIREMENTS

7.1 Computer/Laptop System Requirements

The basic requirement is that the PCIe bus of the system must provide sufficient bandwidth to handle video rate transfers. The amount of bandwidth required depends on the camera in-hand. The Kestrel uses a Base Camera Link interface which can be handled with a x1 PCIe bus and PIXCI EB1, providing roughly 200MB/sec maximum bandwidth. Contact EPIX Inc. for further information regarding minimum computer/laptop specification requirements to run the XCAP Imaging Software. <http://www.epixinc.com/products/xcap.htm>

7.2 Frame Grabber Requirements

If using a computer, it is a minimum requirement to use an PIXCI EB1 frame grabber. If using a frame grabber from another company, the specification requirements of this frame grabber must meet those supplied by the PIXCI EB1 model.

If using a laptop, EPIX offers base Camera Link frame grabbers for a laptop system, such as the ECB1/ECB1-34.

8. XCAP IMAGING SOFTWARE

This section will discuss downloading and installing XCAP, as well as acquiring an initial image using the software package.

8.1 Downloading and Installing XCAP

The latest version of XCAP can be downloaded from the link below:

<http://www.epixinc.com/support/files.php>

please select the appropriate version of XCAP for your computer. Ensure that you download from the section labelled ***“Pre-release version with support for the latest cameras and latest PIXCI® imaging boards”***. Open the downloaded file when complete and follow the onscreen instructions in the installation wizard. If a pop-up message appears asking whether to install the PIXCI driver, ensure that you click yes.

8.2 Opening the Camera Configuration

After opening XCAP, select ***“PIXCI Open/Close”*** from the ***“PIXCI”*** tab from the top menu bar in the main window. A PIXCI Open/Close pop-up box will open as shown in Figure 2.

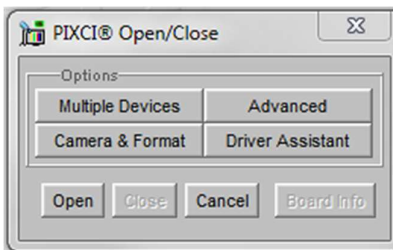


Figure 2: PIXCI Open/Close.

Click on ***“Camera & Format”*** that is highlighted in Figure 2 and a ***“PIXCI Open Camera & Format”*** box will appear, as shown in Figure 3.

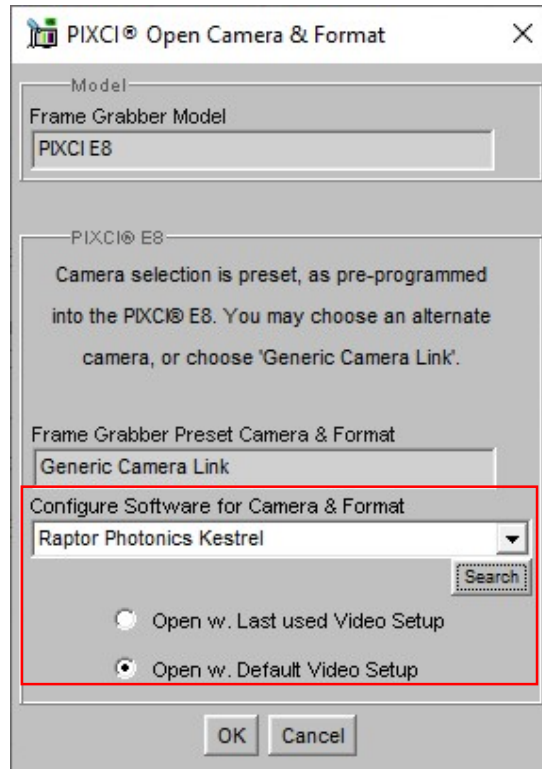


Figure 3: PIXCI Open Camera & Format.

Using the dropdown menu highlighted, search for “*Raptor Photonics Kestrel*”. Alternatively, you can use the search button and typing Kestrel will bring up the correct configuration. Selecting “*Open w. Default Video Setup*” will open the control panel with all control parameters set to the default states. “*Open w. Last used Video Setup*” will open the control panel with all parameters set at the last known state. Once this option between the two has been selected, click “*Ok*”. To open the camera control panel and imaging window, click “*Open*” in the “*PIXCI Open/Close*” window (Figure 2).

Two windows will now open in XCAP, and imaging window and control panel, as shown in Figure 4.

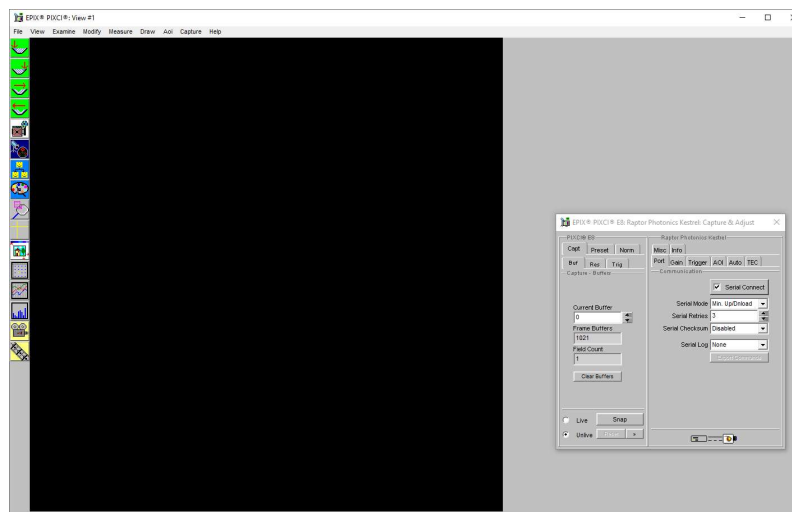


Figure 4: Imaging Window & Control Panel.

8.3 Acquiring a Live Image Sequence

There are two things to observe in the control panel that inform you that the camera is connected and ready to image.

The serial connect checkbox must be ticked in the control panel. This informs you that you have established a serial connection with the camera and can control the camera.

Secondly, the symbol near the bottom right of the control panel will have three moving dots. This indicates that you are obtaining video data from the camera. The imaging statistics displayed directly underneath the imaging window will also inform you if you are receiving a video feed from the camera.

Once you have established a serial connection with the camera and are receiving video data, you can now grab a live image feed. Clicking the “Live” button will grab a live image sequence which you will now see in the imaging window.

For the Kestrel, you will have to enable contrast modification after going live. For instruction on how to do this on XCAP, please refer to section 10.2.

The symbols in the control app discussed above are displayed in Figure 5.

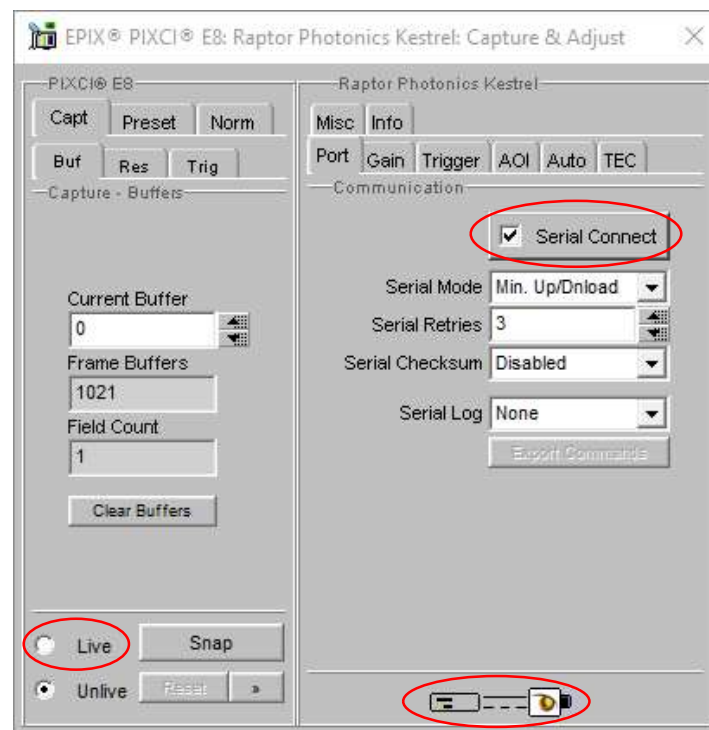


Figure 5: Port Tab – Checking Camera.

9. CONTROLLING THE CAMERA (XCAP)

The sections below will give information on using each control of the Kestrel, giving a description on how to use each control parameter and their effect on the camera's performance. The software used to illustrate the camera controls is XCAP.

9.1 EM Gain

The EM gain applied can be controlled from the “Gain” tab of the XCAP GUI, shown in Figure 6. The user can either manually input a value to apply EM Gain or use the slider bar provided. By default, the EM Gain slider bar is set to zero (Gain = 1).

The values in the EM Gain slider bar on XCAP are not real/linear gain values. More detailed information on why Raptor does not calibrate “real gain” controls can be seen from the “*Understanding Electron Multiplying Gain*” technical note from our website:

<https://www.raptorphotonics.com/products/kestrel-emccd/>

The values on XCAP are the DAC (Digital to Analog Converter) values. During the calibration of the camera, the DAC value vs EM Gain ratio is characterized and stored in memory locations of the camera. The slider is directly controlling the amount of voltage that the EM gain register in the camera is seeing. The relationship of gain to the DAC value is exponential, so up until around 3000 on the slider, there is a minimal gain being applied (roughly in the region of 1-10x). Once you go above 3000, as the gain ramps exponentially, small changes in the slider will equate to larger changes in the gain. A gain of X1000 should be achievable by setting a DAC value of roughly 3500, as long as the camera is water cooled to roughly -20°C. There isn't any real benefit to using a gain larger than this. For most applications, a gain in the region of X200 is sufficient.

Please note that EM gain should only ever be used when it is required and leaving the EM gain running indefinitely may cause irreparable damage to the camera. EM Gain should only be used during the experimental test. If the camera is in idle mode and not being used, EM Gain should be disabled. Extreme caution must be used when setting the DAC value for the EM Gain. As the relationship between the DAC value and gain is exponential, DAC values greater than 3000 result in large changes of real gain being applied. Using gains in the upper region (3500 – 4096) for longer lengths of time will cause the sensor to age and could cause damage to the camera.

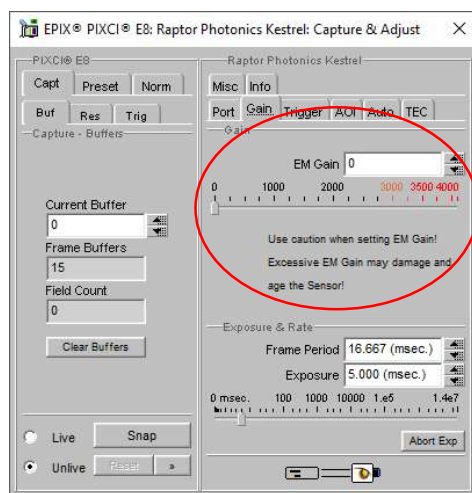


Figure 6: EM Gain.

9.2 Triggering Modes and Pixel Clock Rate

The camera's triggering mode can be toggled from the "Trigger" tab, shown in Figure 7. A summary of the triggering modes is below:

Live – ITR: This is the default mode of the camera, using the internal trigger, Integrate then Read. In this mode, the camera will run at the highest possible frame rate given the current exposure time set. The frame period will be:

$$\text{Frame period} = \text{Exposure time} + \text{Readout time}$$

Using an exposure time of 1.93ms with a 10MHz pixel readout speed, the maximum frame rate of 510.5Hz in full frame resolution can be achieved.

Live – FFR: This is fixed frame rate mode. In this mode, the user will be allowed to set a fixed frame period. If an exposure time set is greater than the maximum exposure time for the set frame period, the exposure time will dominate, and the frame period will be increased.

Ext Triggered: This mode sets the camera into external trigger mode. Enabling the external trigger will open the trigger polarity options (rising or falling edge).

There is a slight drop off in the maximum frame rate in external trigger mode. The maximum frame rate achievable in full frame resolution is roughly 510.5Hz.

In ITR mode, the camera is in full control of the trigger and is aware that repeated frames will be requested one after another as quickly as possible. Therefore, the vertical clear is skipped before the start of each acquisition. In external trigger mode, the camera has no knowledge of when the next trigger will arrive, and hence conducts the vertical clear before the beginning of the next exposure. This vertical clear accounts for the slight drop in frame rate in external trigger. The lack of the vertical clear in ITR mode also means that the effective exposure time in ITR mode is closer to exposure time + readout time.

Btn. Triggered: This mode enables the user to capture a single exposure. The "Single Exposure" button in the GUI will become active and clicking it will trigger an exposure time and capture.

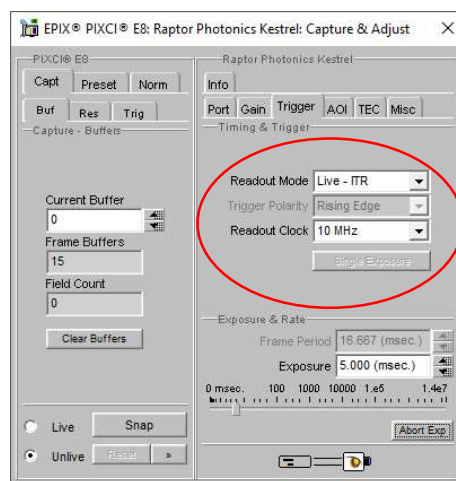


Figure 7: Trigger Tab.

9.3 Region of Interest and Binning

The region of interest and binning can be controlled from the “AOI” tab in the control panel.

A region of interest within the main active region of 128x128 may be defined. The ROI is setup using a bank of registers to control the X offset, the ROI width, the Y offset and the ROI height. These parameters are shown pictorially below in Figure 8.

The user must ensure that X offset + ROI width is ≤ 128 and similarly the Y offset + ROI height is ≤ 128 . Also, ROI width and ROI height must be > 0 .

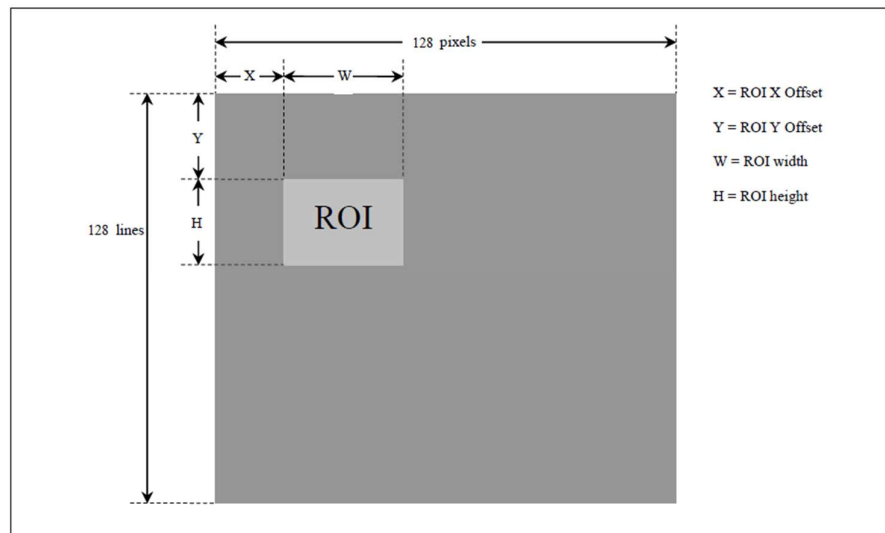


Figure 8: Region of Interest.

Binning can be set from 2x2 and 4x4.

9.4 Exposure Time and Frame Period

The exposure time and frame period controls are active in the control panel under all tabs, except the port and info tabs. Unless “Live – FFR” mode (discussed in section 7.6.2) is active, the frame period will set automatically to the maximum possible given the current exposure time set. The minimum exposure time in the internal trigger is 0 seconds.

If fixed frame rate mode is selected, then the user will now be able to set a fixed frame period. If the exposure time set exceeds the maximum possible under the given frame period, then exposure will dominate, and the frame period will be increased. The frame period and exposure time controls on XCAP are shown in Figure 9.

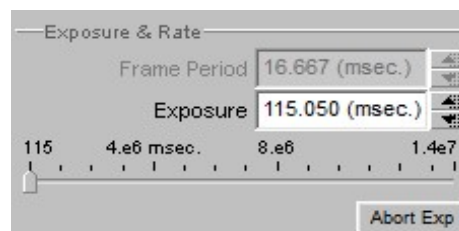


Figure 9: Exposure Time & Frame Period

9.5 Maximum Frame Rates

The maximum frame rates achievable with each binning level 128x128 resolution are shown in the two tables below. These frame rates were measured using internal trigger mode.

10MHz Pixel Clock	
Binning Factor	Frame Rate
1x1	508.9
2x2	928
4x4	1324

10MHz Pixel Clock	
ROI Factor	Frame Rate
Full Frame	508.9
64 ROI	940.9
32 ROI	1635.2

9.6 Thermoelectric Cooler (TEC)

The “TEC” tab in the GUI gives the user control over the TEC and fan. The minimum cooling temperature using both the fan and liquid cooling is -20°C. If only using the fan, the minimum cooling temperature is -20°C. For important information on using the liquid cooling with the chiller, please refer to sections 6.2 – 6.5.

The actual TEC set point of the camera should be within $\pm 2^{\circ}\text{C}$ of the TEC set point set by the user. The sensor temperature will then have a stability of $\pm 0.5^{\circ}\text{C}$ around the actual TEC set point.

The TEC controls in XCAP are shown in Figure 10.

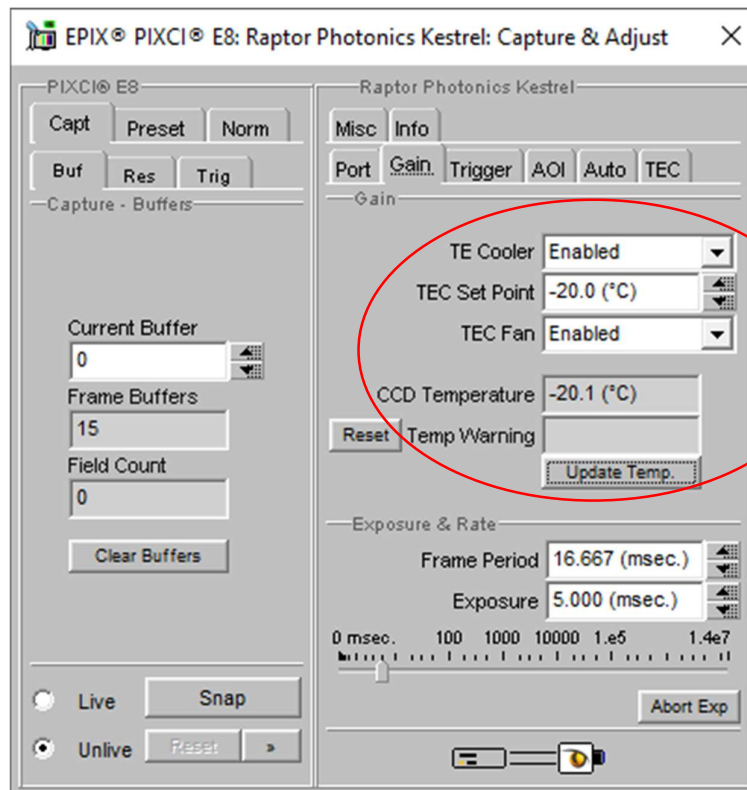


Figure 10: TEC Control Tab.

9.7 Information Tab

The “Info” tab displays the manufacturers data of the camera, such as the firmware version, serial number etc. The sensor and PCB temperature can also be read from this tab. The “Info” tab is shown in Figure 11.

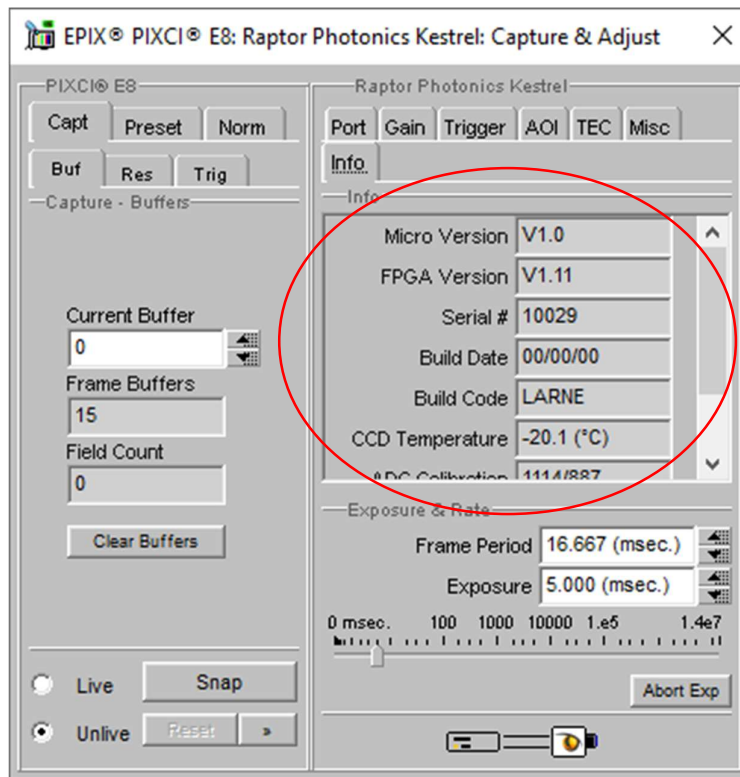


Figure 11: Info Tab.

10. XCAP CONTROL FEATURES

XCAP has many different control functions and analytical tools that can be used when imaging the camera. For the full XCAP user guide, please refer to the link below:

http://epixinc.com/manuals/pixci_e14el/index.htm

This section will discuss in detail a few features on XCAP that Raptor feel would be of immediate use when using the camera.

10.1 Saving Preset Settings

Different camera and frame grabber settings can be saved in the “*Preset*” tab under the PIXCI (relevant frame grabber model number) section of the GUI, as shown in Figure 12.

Up to three different presets can be saved per settings file. If the camera is set to a desired state outside of the default state, clicking “Save 1” will save all the current parameter states that have been set. This can be done a further two times. These camera states can be recalled at any time by using the recall buttons. The overall settings file can then be saved and loaded in this tab also. Three preset states is the maximum number that can be saved in a settings file.

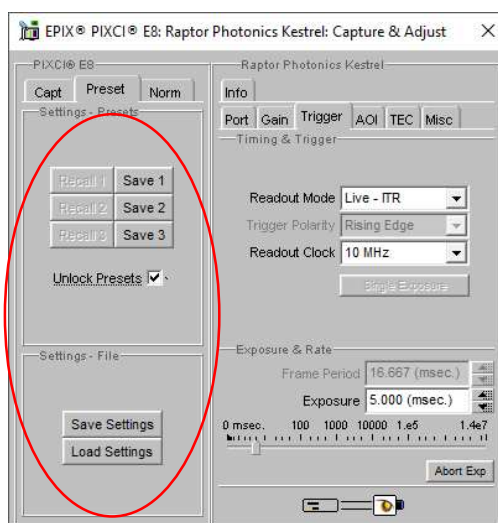


Figure 12: Preset Settings.

10.2 Contrast Modification (XCAP Std. Only)

The image contrast can be modified from the “*Contrast Modification*” section under the “*Modify*” tab in the XCAP imaging window. Where to find this control feature is shown in Figure 13. If wanting to view a useable image without any EM gain applied, contrast modification will have to be enabled. Raptor recommends having this enabled at all times when imaging the camera. If applying ROI or binning controls, the contrast modification will have to be re-enabled each time.

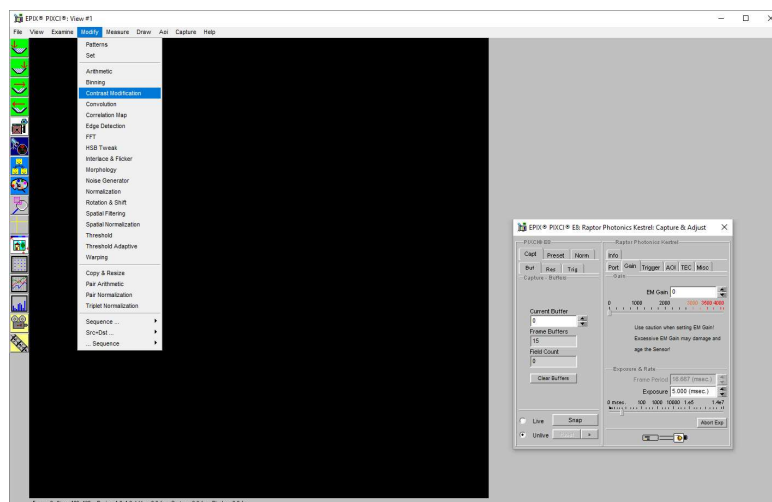


Figure 13: Contrast Modification Location on Toolbar.

In the contrast modification box, that can be seen from Figure 14, select “*Stretch Contrast, Histogram Percentile Endpoints*” and click “*preview*”. The contrast modification will now be applied over the live image feed. The contrast can be adjusted using the low and high end percentile point controls. The default settings are usually adequate for most applications.

NOTE: This control feature is only applicable with XCAP Std.

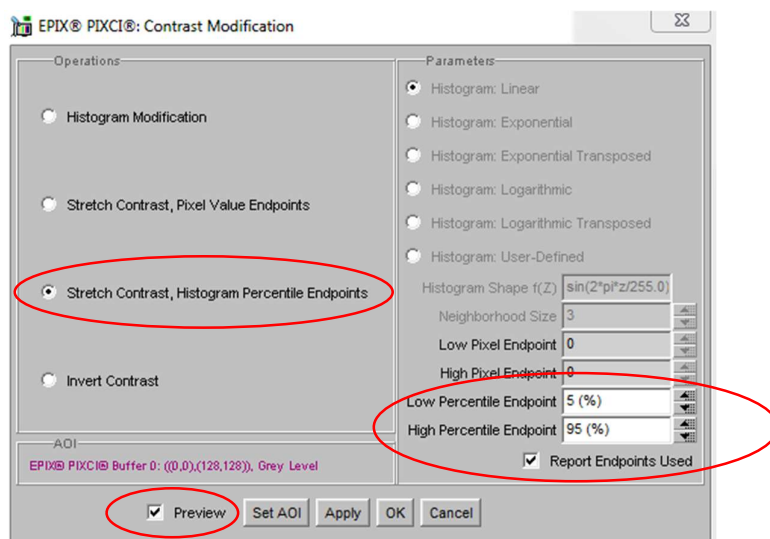


Figure 14: Contrast Modification.



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