

# Piranha XL™ Camera User's Manual

PX-HM-16K12B-00-R and PX-HM-16K06B-00-R

sensors | **cameras** | frame grabbers | processors | software | vision solutions



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# The Piranha XL Camera

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## Highlights

Teledyne DALSA introduces the latest breakthrough multiline CMOS TDI camera with unprecedented speed and responsivity, and exceptional low noise. The Piranha XL™ camera has 16k pixel resolution and a 5 µm x 5 µm pixel size and is compatible with fast, high magnification lenses. The camera delivers a 125 kHz line rate, very low noise and high sensitivity through TDI on-chip summing of multiple image lines. Exposure control allows for seamless variable speed imaging down to stopped conditions.

The Piranha XL camera uses the Camera Link HS™ interface, which is the latest industry standard for very high speed camera interfaces with long transmission distances and cable flexing requirements. Teledyne DALSA's Piranha XL camera and XTNUM Camera Link HS frame grabber combine to offer a complete solution for the next generation of Automatic Optical Inspection systems.

The Piranha XL camera is ideal for detecting the smallest defects at high speeds and over a large field of view in LCD and OLED flat panel displays, printed circuit boards, film and large format web materials.

## Key Features

- Highly responsive multiline CMOS-TDI
- 16k pixel resolution
- Very low noise
- High dynamic LUT mode
- Bi-directionality with fixed optical center
- Binning
- Small form factor
- Low power
- Robust Camera Link HS interface
- Smart lens shading correction

## Programmability

- Adjustable responsivity
- Multiple areas of interest for data reduction
- Region of interest for easy calibration of lens and shading correction
- Test patterns & diagnostics
- 8 or 12 bit output

## Applications

- Flat-panel LCD and OLED display inspection
- Web inspection
- Printed circuit board inspection
- High throughput and high resolution applications

## Model

The camera is available in the following configurations:

*Table 1: Camera Models Comparison*

Piranha XL Multi Line Model Comparison			
Part Number	Resolution	Maximum Line Rates	Pixel Size
PX-HM-16K12B-00-R	16352 pixels x 12 rows	125 kHz ( 4 and 8 rows) 100 kHz (12 rows)	5.0 $\mu\text{m}$ x 5.0 $\mu\text{m}$
PX-HM-16K06A-00-R	16352 pixels x 12 rows	60 kHz ( 4 and 8 rows) 50 kHz (12 rows)	5.0 $\mu\text{m}$ x 5.0 $\mu\text{m}$

Note 1: See Exposure time requirement page 21

*Table 2: Software*

Software	Product Number / Version Number
Camera firmware	Embedded within camera
GenICam™ support (XML camera description file)	Embedded within camera
Sapera LT, including CamExpert GUI application and GenICam for Camera Link imaging driver	Version 7.40 or higher

## Performance Specifications

*Table 3: Camera Performance Specifications*

Specifications	Performance	
Imager Format	High speed CMOS multiline scan	
Resolution	16352 Active Pixels x 4, 8 & 12 Rows	
Pixel Size	5.0 μm x 5.0 μm	
Pixel Fill Factor	100%	
Line Rate	PX-HM-16K12B-00-R	PX-HM-16K06B-00-R
	14KHz <sup>1</sup> to 125 kHz (4 and 8 Rows)	0 to 60 kHz (4 and 8 Rows)
	14KHz <sup>1</sup> to 100 kHz (12 rows)	0 to 50 kHz (12 rows)
Exposure Time	2 μs to 3 ms	
Bit Depth	8 and 12 bit, selectable	
Connectors and Mechanicals		
Control & Data Interface	Camera Link HS	
Power Connector	Hirose 6-pin male circular	
Power Supply	+ 12 V to + 24 V DC (+11.4 V to +25.2 V maximum limits)	

Typical Power Dissipation	23 W
Size	97 mm (W) x 97 mm (H) x 61 mm (D)
Mass	685 grams
Operating Temp	+0 °C to +60°C, front plate temperature
<b>Optical Interface</b>	
Lens Mount	M90x 1 mm
Sensor to Camera Front Distance	12 mm
Sensor Alignment (aligned to sides of camera)	
$\Theta$ y (parallelism) x y z $\Theta$ z	100 $\mu$ m $\pm$ 100 $\mu$ m $\pm$ 100 $\mu$ m $\pm$ 250 $\mu$ m $\pm$ 0.2°
<b>Compliance</b>	
Regulatory	CE, FCC, and RoHS
Communications Standards	GenICam, Camera Link HS

Note 1: The camera will operate below 14KHz when using an external trigger but show global and pixel based increases in offset.

Operating Ranges	Performance			Notes
	Four Rows	Eight Rows	Twelve Rows	
Random Noise	6.4 DN* rms	9 DN rms	11 DN rms	
Peak Responsivity	733 DN/(nJ/cm <sup>2</sup> )	1467 DN/(nJ/cm <sup>2</sup> )	2200 DN/(nJ/cm <sup>2</sup> )	625 nm
Gain	0.67x to 2.5x	1x to 2.5x	0.67x to 2.5x	Normal Range
	0.67x to 5x	1x to 5x	0.67x to 5x	Extended Range
DC Offset	5 DN	5 DN	5 DN	Can be adjusted as required
PRNU	< $\pm$ 2%	< $\pm$ 2%	< $\pm$ 2%	50% of calibration target
FPN	< $\pm$ 2 DN	< $\pm$ 2 DN	< $\pm$ 2 DN	8 bit, 1x gain
SEE	5.6 nJ / cm <sup>2</sup>	2.8 nJ / cm <sup>2</sup>	1.9 nJ / cm <sup>2</sup>	
NEE	8.7 pJ / cm <sup>2</sup>	6.2 pJ / cm <sup>2</sup>	5 pJ / cm <sup>2</sup>	RN / Responsivity
Anti-blooming	> 100x Saturation	> 100x Saturation	> 100x Saturation	
Integral non-linearity	< 2%	< 2%	< 2%	

\*DN = digital number

Test Conditions unless otherwise specified:

- Values measured using 12 bit, 1x gain
- 50 kHz line rate
- Light source: green LED 560 nm
- Front plate temperature: 45° C



## Piranha XL's Physical Pixel Arrangement

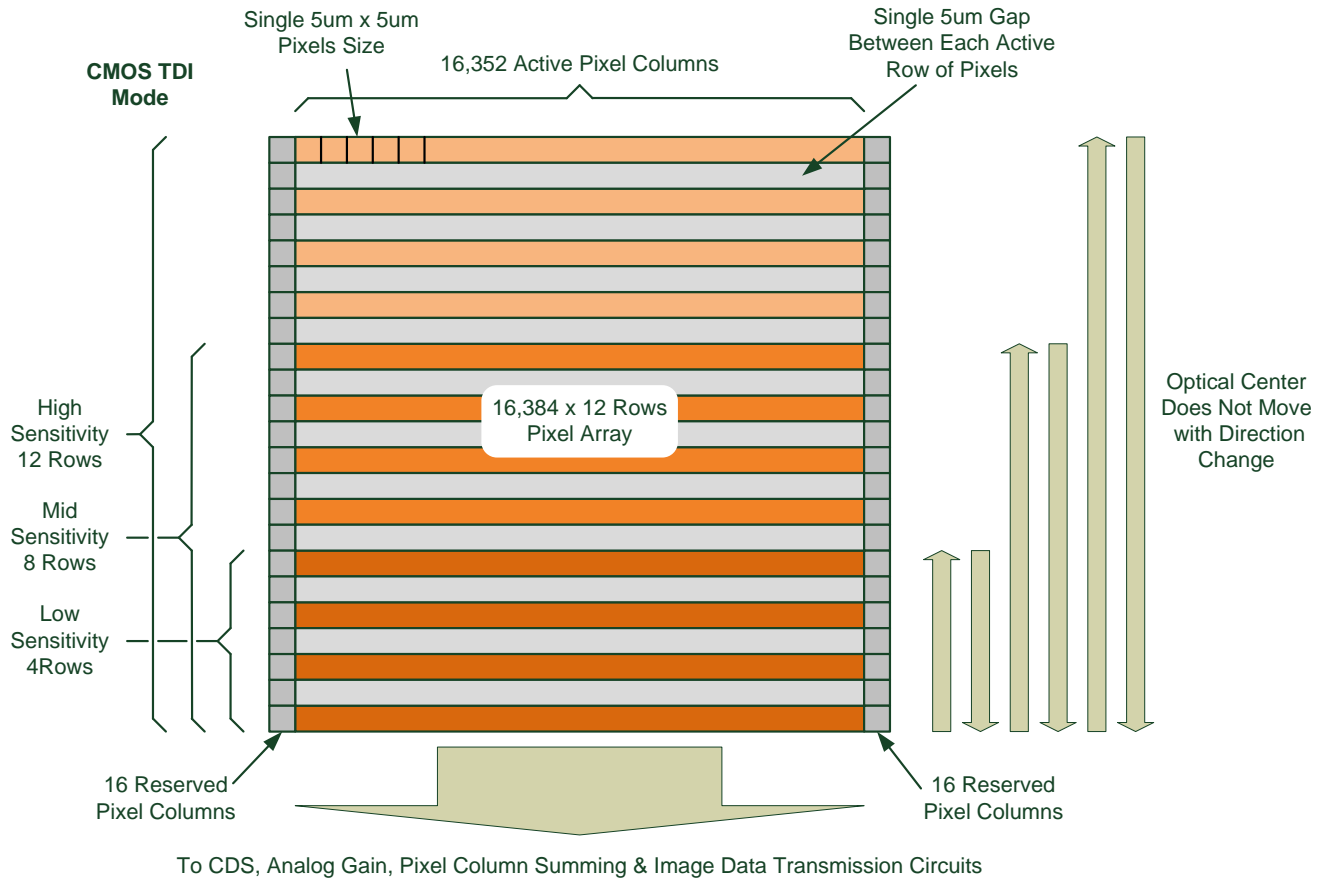


Figure 1: Piranha XL Camera CMOS-TDI Pixel Structure

The CMOS TDI sensor used in the Piranha XL camera is made up of a 16,384 x 12 line array of 5 µm x 5 µm pixels.

Each line of pixels is spaced 5 µm apart to accommodate pixel interface circuitry. 16 pixels at each edge of the array are reserved for special use by the camera, resulting in 16,352 pixels being available to the user. By default, 16,384 pixels are output by the camera where the 16 pixels at each edge are set to 1 DN. The Area of Interest feature (See section Using Area of Interest to Reduce Image Data & Enhance Performance) can be used to eliminate the 32 edge pixels if desired.

The 12 lines are grouped into three sets of four. The responsivity of the camera can be adjusted by summing 4, 8, or 12 lines to form the output image data (See Adjusting Responsivity). Forward and reverse imaging does not cause the optical center to change. Exposure control allows inspection speed to change without changing responsivity from maximum speed down to the stopped condition.

# Certification & Compliance

Compliance
EN 55011, FCC Part 15, CISPR 11, and ICES-003 Class A Radiated Emissions Requirements
EN 55024 and EN 61326-1 Immunity to Disturbance
RoHS per EU Directive 2011/65/EC and WEEE per EU Directive 2002/96/EC and China Electronic Industry Standard SJ/T11364-2006

## Supported Industry Standards

### GenICam™

The Piranha XL camera is GenICam compliant and implements a superset of the GenICam Standard Features Naming Convention specification V1.5.

This description takes the form of an XML device description file using the syntax defined by the GenApi module of the GenICam specification. The camera uses the GenICam Generic Control Protocol (GenCP V1.0) to communicate over the Camera Link HS command lane.

For more information see [www.genicam.org](http://www.genicam.org).

### Camera Link HS

The Piranha XL camera is Camera Link HS version 1.0 compliant. Camera Link HS is the next generation of high performance communications standards and is used where a digital industrial camera interfaces with single or multiple frame grabbers with data rates exceeding those supported by Camera Link. The Piranha XL camera includes two Camera Link HS compatible connectors, each capable of supporting data rates up to 2.1 Gbytes / sec per second. Each connector can also interface with standard 'CX4 Active Optical Cable' fiber modules where very long data transmission is required—up to 300 meters.

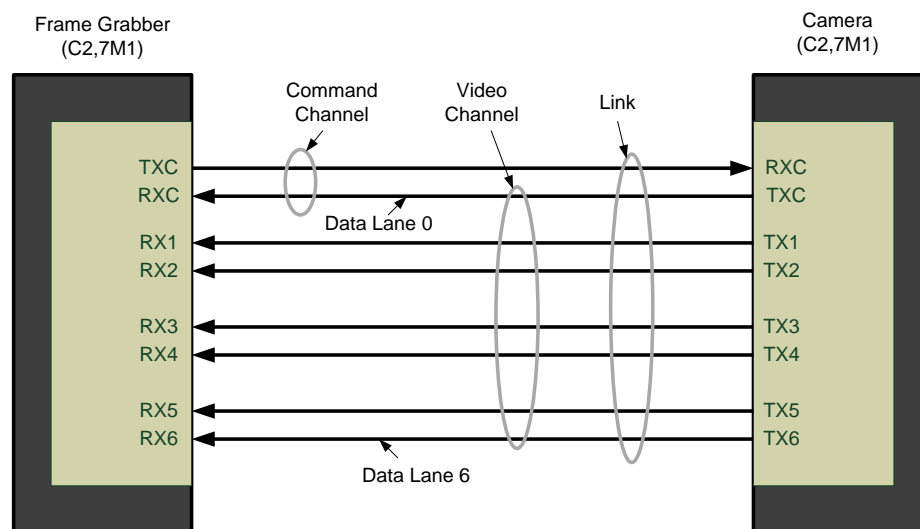


Figure 2. Piranha XL Single CLHS Connector Configuration

The command channel is used by the frame grabber to send command, configuration, and programming data to the camera and to receive command responses, status, and image data from the camera.

The designation C2,7M1 defines the use of a SFF-8470 connector (C2) and up to 7 lanes of data with 1 command channel using M-Protocol (8b/10b) at the default speed of 3.125Gb/sec.

When using a CX4 Active Optical Cable fiber module, only the command channel and data lanes 0, 1, 2 and 3 (C2,4M1) will be available, with an associated reduction in bandwidth. Use two fiber modules to retain the full performance of the camera.

The Piranha XL camera has two CLHS connectors that allow data to be routed to two separate frame grabbers installed in the same or separate PC's.

A feature of CLHS is that the initialization of the frame grabber automatically starts a discovery process that will identify the lane configuration of the camera. This process is transparent to the user and requires no action by the user to correctly configure the link.

## Camera Link HS Transmission Characteristics

The camera's data distribution supports two cables with single CLHS ROI capability. The single CLHS ROI is determined from the 1 to 4 areas of interest (AOI) entered by the user and transmitted across all seven data lanes. There is a minimum of 96 pixels per data lane used.

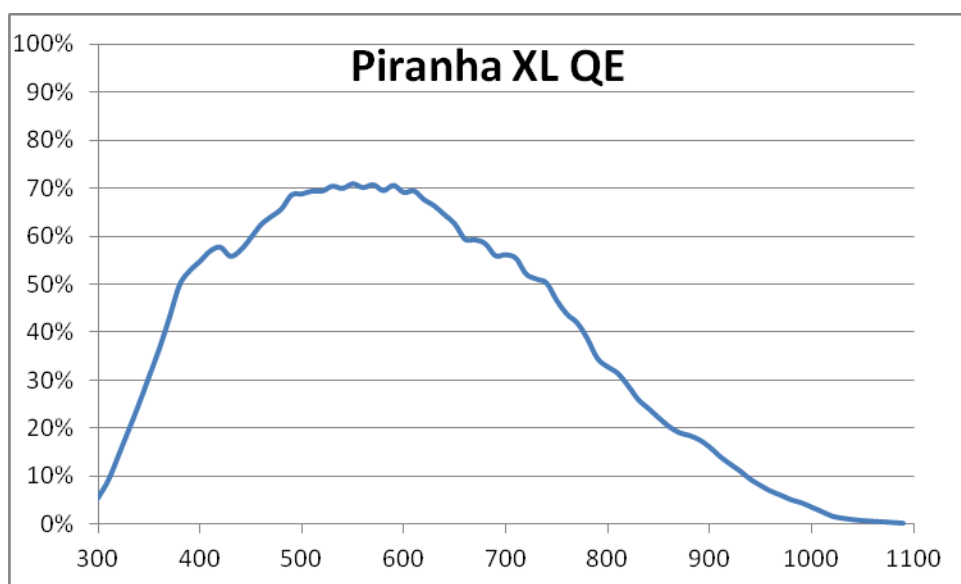
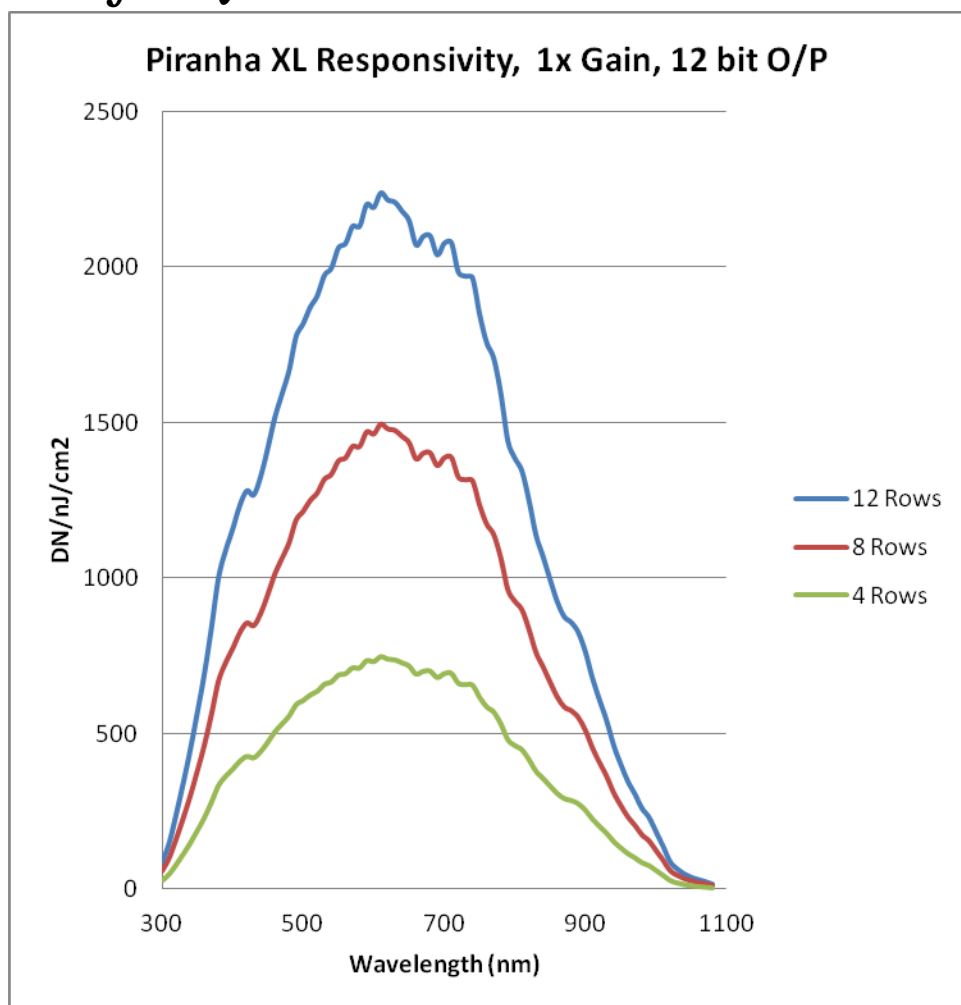
CLHS limits the start and stop location of the ROI to a multiples of 32 pixels. The maximum line rate is limited by the sensor when not limited by the CLHS cable or by the PCIe transfer. The sensor is limited to a 125 kHz maximum line rate.

The CLHS cable has approximately 2.1 GByte / sec bandwidth for seven lanes.  
The XTNUM frame grabber has about 1.6 GByte / sec across the PCIe bus.

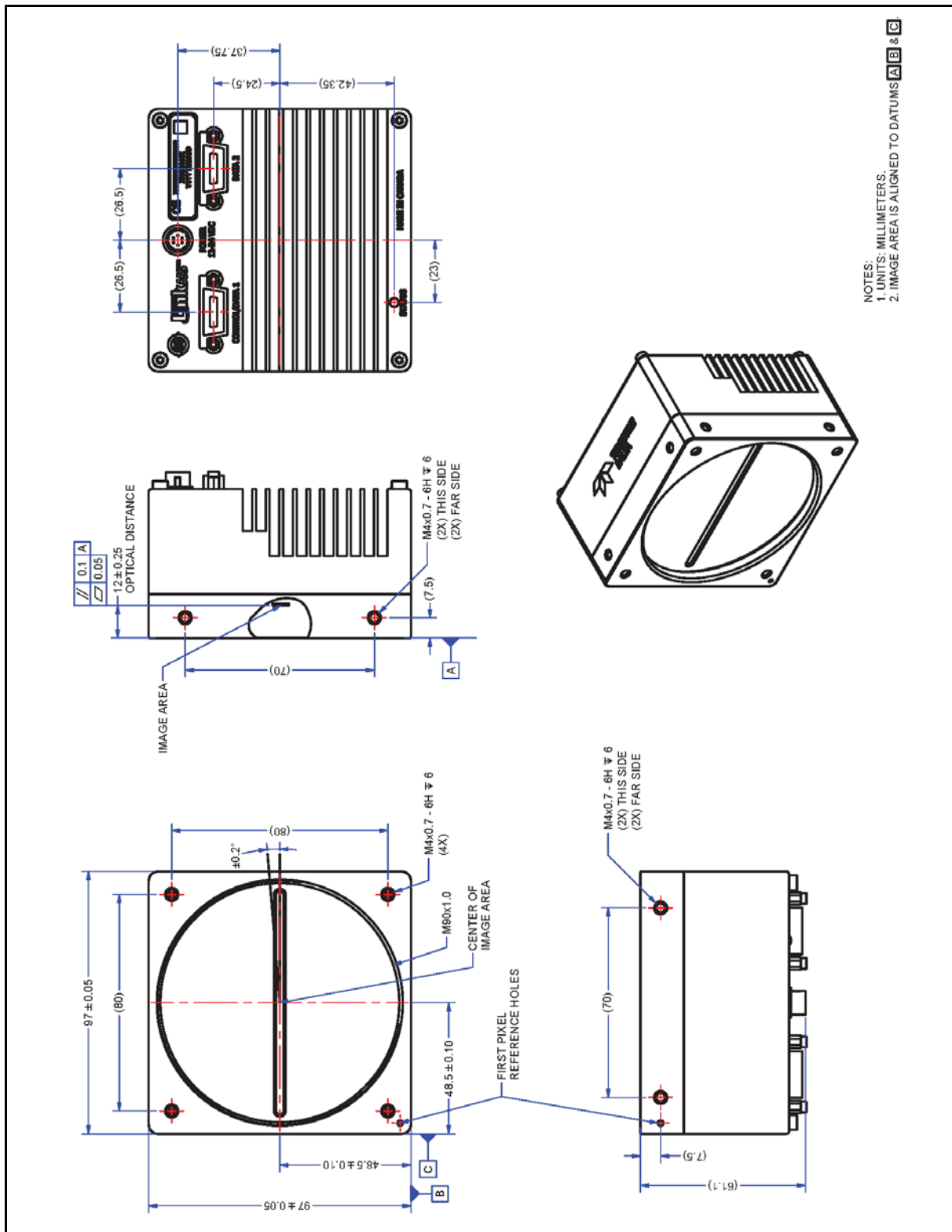
The Frame Grabber is able to store rows in order to perform a "burst-type" operation. CLHS packs the bits, while the frame grabber unpacks 12 bit data into 16 bit data across the PCIe bus. The table below shows a single cable with seven lane limits. When using 2 cables the performance is equivalent to using an 8k ROI and limited to the sensor's maximum data rates.

16 K ROI		12K ROI		8K ROI	
Burst	Continuous	Burst	Continuous	Burst	Continuous
8 bit					
125,000	97,600	125,000	125,000	125,000	125,000
12 bit					
86,000	48,800	114,000	65,000	125,000	97,000

## Responsivity & QE Plots



# Mechanical Drawings



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## Precautions

Read these precautions and this manual carefully before using the camera.

Confirm that the camera's packaging is undamaged before opening it. If the packaging is damaged please contact the related logistics personnel.

Do not open the housing of the camera. The warranty is voided if the housing is opened.

Keep the camera's front plate temperature in a range of 0 °C to 60 °C during operation. The camera has the ability to measure its internal temperature. Use this feature to record the internal temperature of the camera when it is mounted in your system and operating under the worst case conditions. The camera will stop outputting data if its internal temperature reaches 80 °C. Refer to section 0 for more information on the 'Temperature' feature.

Do not operate the camera in the vicinity of strong electromagnetic fields. In addition, avoid electrostatic discharging, violent vibration, and excess moisture.

To clean the device, avoid electrostatic charging by using a dry, clean absorbent cotton cloth dampened with a small quantity of pure alcohol. Do not use methylated alcohol. To clean the surface of the camera housing, use a soft, dry cloth. To remove severe stains use a soft cloth dampened with a small quantity of neutral detergent and then wipe dry. Do not use volatile solvents such as benzene and thinners, as they can damage the surface finish. Further cleaning instructions are below.

Though this camera supports hot plugging, it is recommended that you power down and disconnect power to the camera before you add or replace system components.

## Electrostatic Discharge and the CMOS Sensor

Image sensors and the camera's housing can be susceptible to damage from severe electrostatic discharge (ESD). Electrostatic charge introduced to the sensor window surface can induce charge buildup on the underside of the window. The charge normally dissipates within 24 hours and the sensor returns to normal operation.

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## Install & Configure Frame Grabber & Software

We recommend the Teledyne DALSA XTIUM frame grabber or equivalent, described in detail on the [teledynedalsa.com](http://teledynedalsa.com) site [here](#). Follow the manufacturer's installation instructions.

A GenICam compliant XML device description file is embedded within the camera firmware allowing for GenICam compliant applications to recognize the camera's capabilities immediately after connection. Installing Spera LT gives you access to the CamExpert GUI, a GenICam compliant application.


## Using Spera CamExpert

CamExpert is the camera interfacing tool supported by the Spera library. When used with a Piranha XL camera, CamExpert allows a user to test all camera operating modes. In addition, CamExpert can be used to save the camera's user settings configurations to the camera. Or saves multiple configurations as individual camera parameter files on the host system (\*.ccf). CamExpert can also be used to upgrade the camera's software.

An important component of CamExpert is its live acquisition display window. This window allows the user to immediately verify the timing or control parameters without needing to run a separate acquisition program.

To control the camera and frame grabber settings, the user must open two instances of CamExpert—one is used to control the frame grabber features and as a display window. The second instance is used to control the camera features.

For context sensitive help, click on the  button and then click on a camera configuration parameter.

A short description of the configuration parameter will be shown in a popup. Click on the  button to open the help file for more descriptive information on CamExpert.

The central section of CamExpert provides access to the camera features and parameters. **Note:** The availability of features depends on the CamExpert user setting. Not all features are available to all users.

A note on the CamExpert examples shown here: The examples shown for illustrative purposes and may not entirely reflect the features and parameters available from the camera model used in your application.

# CamExpert Panes

CamExpert, first instance: select Camera Link HS Mono using the Device drop-down menu.

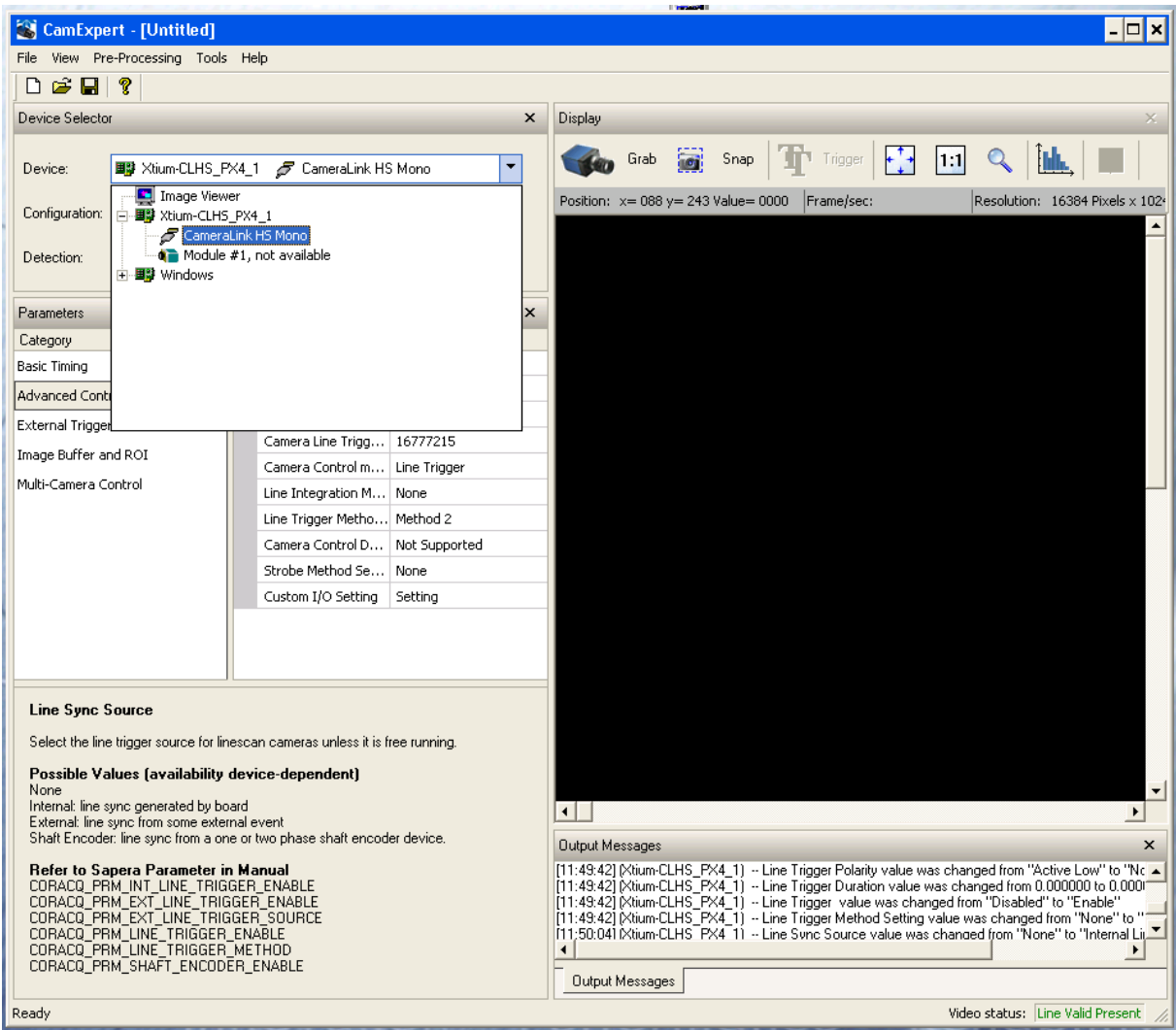


Figure 3. CamExpert Frame Grabber Control Window

CamExpert, second instance: select PX\_HM\_16k12A\_00\_R using the Device drop-down menu.



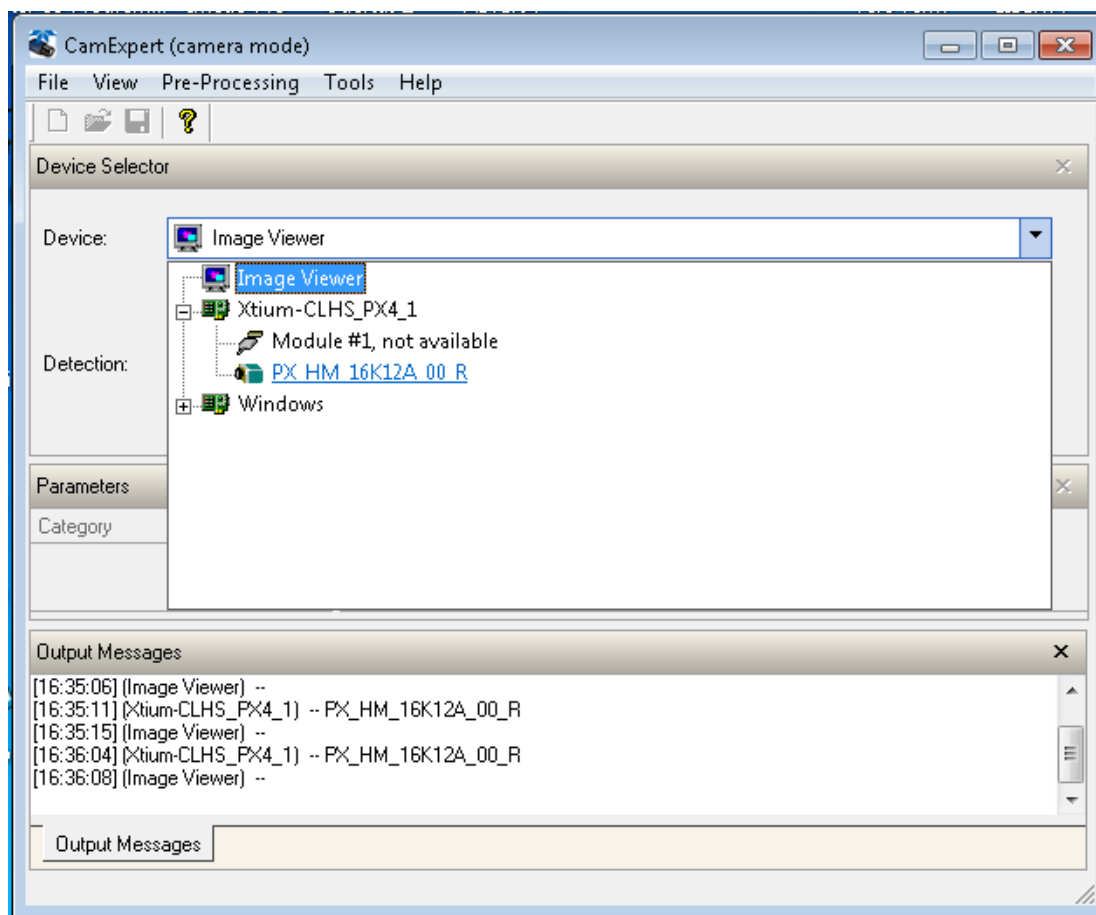


Figure 4. CamExpert Camera Control Window




The CamExpert application uses panes to organize the selecting and configuring of camera files or acquisition parameters.




**Device Selector pane:** View and select from any installed Sapera acquisition device. Once a device is selected, CamExpert will only show acquisition parameters related to that device. Optionally, select a camera file included with the Sapera installation or saved by the user.

**Parameters pane:** Allows the viewing or changing of all acquisition parameters supported by the acquisition device. CamExpert displays parameters only if those parameters are supported by the installed device. This avoids confusion by eliminating parameter choices when they do not apply to the hardware in use.

**Display pane:** Provides a live or single frame acquisition display. Frame buffer parameters are shown in an information bar above the image window.

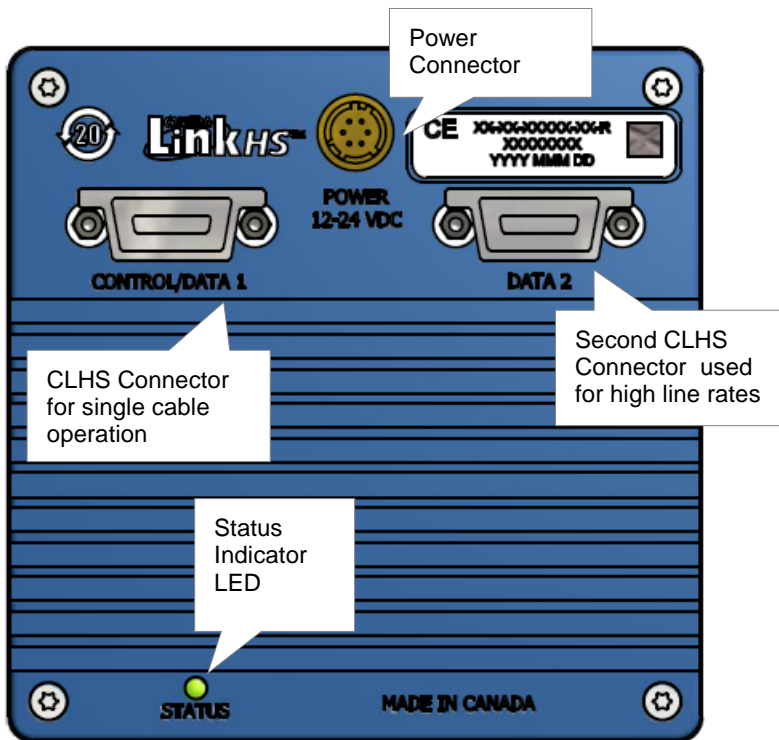
**Control Buttons:** The Display pane includes CamExpert control buttons. These are:

 Grab  Freeze	<b>Acquisition control button:</b> Click once to start live grab, click again to stop.
 Snap	<b>Single frame grab:</b> Click to acquire one frame from device.

	<b>Trigger button:</b> With the I/O control parameters set to Trigger Enabled, click to send a single trigger command.
	<b>CamExpert display controls:</b> (these do not modify the frame buffer data) Stretch image to fit, set image display to original size, or zoom the image to virtually any size and ratio.
	<b>Histogram / Profile tool:</b> Select to view a histogram or line/column profile during live acquisition or in a still image.

**Output Message pane:** Displays messages from CamExpert or the device driver.  
At this point you are ready to start operating the camera in order to acquire images, set camera functions, and save settings.

## Setting Up for Imaging



## Powering the Camera

**WARNING:** When setting up the camera's power supply follow these guidelines:

- Apply the appropriate voltages of between +12 Volt to +24 Volt. Incorrect voltages may damage the camera.
- Before connecting power to the camera, test all power supplies.
- Protect the camera with a 3 amp slow-blow fuse between the power supply and the camera.
- Do not use the shield on a multi-conductor cable for ground.
- Keep leads as short as possible in order to reduce voltage drop.

- Use high-quality supplies in order to minimize noise.

Note: If your power supply does not meet these requirements, then the camera performance specifications are not guaranteed.

The camera uses a Hirose 6-pin female connector for power. The Hirose male connector is part# HR10A-7P-6S and should have the following pin out.

Hirose 6-pin Circular Male



Mating Part: HIROSE  
HR10A-7P-6S

Table 4. Power Plug Pin Out

Pin	Description	Pin	Description
1	+12 V to +24 V DC	4	GND
2	+12 V to +24 V DC	5	GND
3	+12 V to +24 V DC	6	GND

The power cable wire gauge should be sufficient to accommodate a power-up surge of at least 3 amps with a minimum voltage drop between the power supply and camera. The camera can accept **any** voltage between 12 Volts and 24 Volts. If there is a voltage drop between the power supply and camera, ensure that the power supply voltage is at least 12 Volts plus this voltage drop. The camera input supply voltage can be read using CamExpert. Refer to the section Voltage & Temperature Measurement for details.

## Data Cables

The Camera Link HS cables are made to handle very high data rates. Cable length can be up to 15 meters. Camera Link HS cables can be bought from an OEM. OEM cables are also available for applications where flexing is present. Please see Teledyne DALSA's website ([www.teledynedalsa.com](http://www.teledynedalsa.com)) for a list of qualified vendors and part numbers.

If you want to fabricate your own cables, please refer to the Camera Link HS Specification Version1.0 for printout details and design guidelines. Each data cable is used for sending image data to and accepting command data from the frame grabber. Command data includes GenICam compliant messages, trigger timing, and general purpose I / O, such as direction control.

## Lens Selection & Setup

To ensure optimum optical performance for all 16k pixels, the lens image circle must be greater than 82 mm. This typically means using at least an 80 mm focal length lens. And longer focal length lenses may be required to achieve the minimum image circle requirement. Another significant consideration in selecting an appropriate lens is to ensure acceptable MTF performance over the entire sensor length. Also, this should be matched to the sensor pixel size of 5  $\mu\text{m}$  x 5  $\mu\text{m}$ . Lens and barrel edge roll off (vignetting) is another performance factor of the lens and is an element in determining the brightness variation between center and edge pixels. Further, ensure that the extension tube inner walls do not obstruct any part of the lens aperture with respect to the sensor. Illumination beam structure can also affect edge roll off. The more diffuse the light, the less edge roll off.

We recommend that the user talk to their lens provider for detailed help in selecting a suitable lens for the application and detailed lens setup design guidelines.

- Before starting to image, take the following steps to set up the lens to a state close to being focused:
- In the lens specification, find the distance from the lens mounting flange surface to its principle plane.
- Determine the magnification for your application = sensor pixel size (5  $\mu\text{m}$ ) / object pixel size in  $\mu\text{m}$ .
- Use the lens specification to find the actual lens focal length, F. Often this value varies slightly from the one advertised.
- Calculate the distance from the front face of the camera to the lens flange using the following formula:
- Camera Face to Flange =  $F (1 + 1 / m) - 12 \text{ mm} - \text{Principle Plane to Flange (From lens spec.)}$
- With the focusing helical in the center of its range, assemble your extension tubes such that their total length equals the Camera Face to Flange distance.
- Install the lens on the focusing helical and the lens assembly on to the camera.
- Calculate the distance from the object surface you intend to image to the front face of the camera using the following formula:
- Object Surface to Camera Face =  $F \times (2 + m + 1 / m) + \text{HH}' - 12 \text{ mm}$
- (Note: HH' is the distance between the two principle planes of the lens. You can get this from the lens specifications.)
- Adjust the camera squarely to the object surface with the Object Surface to Camera Face distance equal to the value determined above.
- The lens setup should now be good enough to use during camera evaluation. Fine adjustment of the focusing helical should be all that is required to get the image in focus at the desired magnification.

## Establishing Camera Communications

Power up the camera and observe the LED which indicates the following status conditions:

LED State	Description
Off	Camera is not powered up or is waiting for the software to start.
Constant Red	The camera BIST status is not good. See BIST status for diagnosis. CamExpert can be used to get the BIST value from the camera.
Blinking Red	The camera has shut down due to a temperature problem.
Blinking Orange	Powering Up. The microprocessor is loading code.
Blinking Green	Hardware is good but the CLHS connection has not been established or has recently been broken.
Constant Green	The CLHS Link has been established and data transfer may begin.

When the camera status indicator LED state is a constant green, the camera is ready to start the first instance of CamExpert.

1. CamExpert will search for installed Sopera devices.
2. In the Devices list area on the left side of the window, the connected frame grabber will be shown.
3. Select the frame grabber device by clicking on the name

Start the second instance of CamExpert.

1. CamExpert will again search for any installed Spera devices.
2. In the Devices list area on the left side, the connected camera will be shown.
3. Select the camera device by clicking on the name.
4. The XML is automatically read from the camera and CamExpert will use it to set up the panes detailing the configurable functionality of the camera.

The two CamExpert instances can now be used to set up the camera and frame grabber for capturing the first images. See Appendix O for a detailed description of the camera features available in each pane.

## Establishing Data Integrity

- Use the camera's internal Triggering. This will allow initial imaging with a static object and no encoder input will be required.
- Enable the camera to output a test pattern.
- Use a frame grabber CamExpert instance to capture, display, and analyze the test pattern image to verify the integrity of the connection. If the test pattern is not correct, check the cable connections and the frame grabber setup.
- Disable the test pattern output.

## Review of Camera Performance and Features

This section is intended to be a progressive introduction to the features of the Piranha XL camera and how to use them effectively.

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## Synchronizing to Object Motion

The Piranha XL camera supports two trigger modes: internal and external. Internal was used in the previous sections where synchronization to image motion was not required.

### External Trigger Mode

*See the section Digital I / O Control Feature Descriptions in Appendix A for GenICam features associated with this section and how to use them.*

*Relevant Feature: Trigger Source, Trigger Selector, Trigger Mode*

The Piranha XL sensor uses a multi-line CMOS TDI technology where the image is integrated over multiple adjacent lines as it moves over the sensor. All the lines are then summed to achieve a highly responsive output. To achieve correct summing, it is vital that the image motion across the sensor is synchronized to the integration timing of the sensor. The user must provide a synchronizing external trigger pulse derived from an encoder that generates one pulse for one object pixel of motion. The encoder signal must be connected to the encoder input of the frame grabber. See the XTNUM frame grabber user manual ([here](#)) for details on how to make this connection.

CamExpert can be used to configure the frame grabber for routing the encoder signal from the frame grabber input to the trigger input of the camera via the Camera Link HS data cable.

The continuous stream of encoder trigger pulses synchronized to the object motion establishes the line rate. The faster the object's motion, the higher the line rate. The Piranha XL camera can accommodate up to its specified maximum frequency. If the maximum frequency is exceeded, the

camera will continue to output image data at the maximum specified. The result will be that some trigger pulses will be missed and there will be an associated distortion of the image data. When the line rate returns to below the maximum specified, then normal imaging will be reestablished.

The Piranha XL camera can accommodate the full range of line rate frequency—from the maximum specified to a stopped condition. No line artifact is generated as the line rate approaches and reaches the stopped condition and starts up again in the same direction (PX-HM-16K06B-00-R model only). Care must be taken that at no time does the object go backwards, even for a single line, as it comes to a stop and starts up again. If this motion occurs, then a blurred image may occur for a few lines.

## **Internal Trigger Mode**

*See the section Camera Control Category in Appendix A for GenICam features associated with this section and how to use them.*

*Relevant Feature: Internal Line Rate*

The internal trigger mode does not have much use in the normal inspection system environment, as TDI imaging requires an accurate synchronization to the objects motion. However, the internal mode can be very useful when a stationary target is used for camera evaluation or debugging issues.

## **Measuring Line Rate**

*See Camera Control Category in Appendix A for GenICam features associated with this section and how to use them.*

*Relevant Feature: Measured Line Rate, Refresh Measured Line Rate*

The camera has the means to measure the line (trigger) rate that is currently being applied to the trigger input of the camera, or what is being internally generated. This is not a continuous reading but a one-time measurement that needs to be initiated by the user with the *Refresh Measured Line Rate* command.

## Maximum Trigger (Line) Rate

There are now two configurations of the Piranha XL camera.

- The high speed configuration PX-HM-16K12B-00-R has a useful operating range from 14 kHz up to 125 kHz. It will operate below 14 kHz but may experience increased offset associated with dark current, both on a pixel and global basis.
- The low speed configuration PX-HM-16K06B-00-R has a useful operating range from 0 kHz up to 60 kHz. It can achieve defect free stop / start imaging

Maximum Line Rates for a 16k Pixel Image, Single Cable				
Row Configuration	PX-HM-16K12B-00-R		PX-HM-16K06B-00-R	
	8Bits	12 bits	8 Bits	12 Bits
4 Rows				
7 Lanes	125kHz	87kHz	60kHz	60kHz
4 lanes	74kHz	50kHz	60kHz	50kHz
1 Lane	18kHz	12kHz	18kHz	12kHz
8 Rows				
7 Lanes	125kHz	87kHz	60kHz	60kHz
4 lanes	74kHz	50kHz	60kHz	50kHz
1 Lane	18kHz	12kHz	18kHz	12kHz
12 Rows				
7 Lanes	100kHz	87kHz	50kHz	50kHz
4 lanes	74kHz	50kHz	50kHz	50kHz
1 Lane	18kHz	12kHz	18kHz	12kHz

## Effect of Exposure Time on Maximum Line Rate

When 4 and 8 rows are selected, only certain exposure times can achieve the full 125 kHz line rate, as detailed below. This is a result of the process used by the camera's sensor to detect and synchronizing to a line trigger.

*To achieve the maximum line rate, the following exposure times in 8 and 4 rows must be selected:*

- 8 rows (µsec): 1.2, 1.84, 2.48, 3.12 3.84, 4.48, 5.12, 5.76
- 4 rows (µsec): 1.44, 2.48, 3.92

Exposure times between these values will result in slightly lower maximum line rates. Exposure times greater than the maximum values above will reduce line rate progressively as the times get larger and must remain within the line rate period limitation.

The maximum line rate for 12 rows is not sensitive to this synchronization limitation.

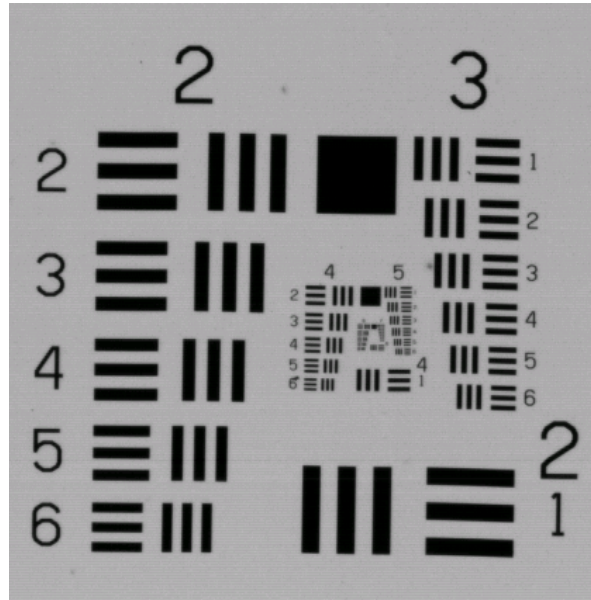
## Scan Direction

*See the section Camera Control Category in Appendix A for GenICam features associated with this section and how to use them*

*Relevant Features: Direction Source, Internal Direction*

The Piranha XL camera can accommodate a forward and reverse scan direction. The sensor timing must follow the image as it moves over its imaging area. If the direction is wrong then the image will look out of focus, as can be seen in the following figure.

Image scanned in direction where the TDI rows track the object motion



*Figure 5. Image with proper scan direction*

Image scanned in direction where the TDI rows track opposite to the object motion



*Figure 6. Image with incorrect scan direction*

Some AOI systems require the scan direction to change at regular intervals, such as those scanning a panel forwards, coming to a stop, and then scanning backward as the cameras field of view is



progressively indexed over the entire panel. Direction can be dynamically controlled by sending the appropriate direction command to the camera or via the CLHS GPIO (General Purpose Input / Output) control bits. The CLHS GPIO direction is controlled by writing Frame Grabber register #80524, bit 2. Set bit 2 to 0 for forward and 1 for reverse.

It is important to note that when the camera line rate comes to a stop and the direction is changed the correct imaging will not be achieved for several scan lines. Therefore, it is necessary for the system to over-scan the area being imaged, including the lines that are not valid as a result of the direction change. This will ensure that valid data will be generated on the return path, as the camera field of view reaches the area to be inspected. The number of invalid lines that result after the direction change are as follows:

Number of Rows	Number of Invalid Lines
4	7
8	15
12	23

The mechanical diagram shows which direction is designated as forward for the camera. However, due to the characteristics of the lens, the direction of the objects motion is opposite to the image motion direction.

Camera Orientation

The diagram below shows the definition of forward and reverse with respect to the camera body. Note that the diagram assumes the use of a lens which inverts the image.

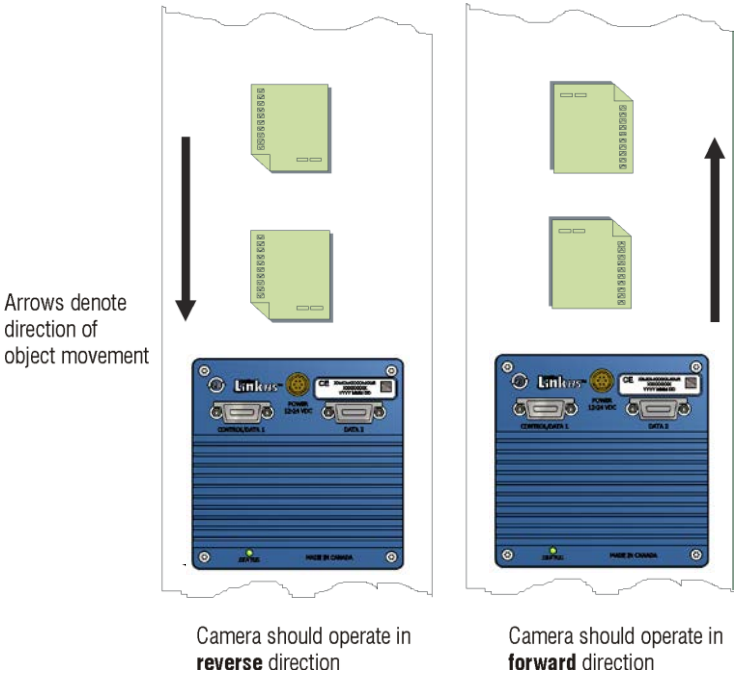


Figure 7: Object Movement and Camera Direction Example using a Lens

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## Establishing the Desired Response

One of the most important performance characteristics of the Piranha XL camera that will determine the camera's suitability for a specific application is its responsivity and the associated noise level at the system's maximum line rate and under the desired illumination conditions and lens configuration.

The Piranha XL camera has several features that directly affect response and noise performance, including exposure control, row selector, gain adjustment, and flat field calibration.

Responsivity and noise performance can be assessed using a stationary plain white bright target under bright field illumination; or by using no target for rear bright field illumination.

When evaluating the camera's responsivity and noise performance, it is important that the camera setup is representative of the system configuration. The setup should meet the following conditions:

- The camera is set up for TDI imaging.
- The lens is in focus, at the desired magnification, and with the desired aperture.
- The illumination intensity is equal to that of the Automatic Optical Inspection (AOI) system and is aligned with the camera field of view.
- The camera is operated with an exposure time that will allow the maximum line rate of the system to be achieved. The camera's internal line rate generator and exposure control can be used for a stationary target.

## Exposure Control

*See the section Camera Control Category in Appendix A for GenICam features associated with this section and how to use them.*

*Relevant Features: Exposure Time Source, Exposure Time Selector, Exposure Time*

Exposure time determines how long pixels collect photons and accumulate the electrons generated. The longer the exposure time, the more electrons are accumulated and the greater increase in response.

The exposure time for each line captured is initiated by the trigger pulse and must be completed before the next trigger pulse occurs. The camera also requires enough time at the end of the exposure time in order to transfer the image out of the pixels for analog-to-digital conversion. Therefore, the exposure time cannot be longer than the period between trigger pulses at the highest line rate minus 4  $\mu$ sec for 4 rows and 2  $\mu$ sec for 8 and 12 rows.

The Piranha XL camera uses the GenCP Exposure Time feature as the only means to adjust exposure time. This ensures that the exposure time period is very stable with respect to the camera's internal timing. Any variation will become line noise in the image.

When using internal trigger mode, the camera will only accept an exposure time that can be accommodated within the internal line rate that has been set. When using external trigger mode, the user must ensure that the exposure time can be accommodated within the maximum line rate period minus 4  $\mu$ sec for 4 rows and 2  $\mu$ sec for 8 and 12 rows. If the exposure time is longer than the line rate period, then some of the trigger pulses will be ignored and the image will appear compressed in the scan direction.

When evaluating the responsivity of the camera, set the exposure time to the maximum allowable for the system, minus any margin required for illumination degradation, if applicable. The line rate during evaluation is not critical and can be internal or externally triggered as long as its period does not violate the above rule.

Note that when adjusting the exposure time, a momentary loss of LVAL will occur. This will also happen when changing user sets that include exposure time.

## Measuring Exposure Time

*See the section Camera Control Category in Appendix A for GenICam features associated with this section and how to use them.*

*Relevant Feature: Measured Exposure Time, Refresh Measured Exposure Time*

The camera has the means to measure the exposure time that is currently being internally generated. This is not a continuous reading but a one-time measurement that needs to be initiated by the user through issuing a *Refresh Measured Exposure Time* command.

## Adjusting Responsivity

*See the section Camera Control Category in Appendix A for GenICam features associated with this section and how to use them.*

*Relevant Features: Row Selector, Gain Selector, Gain*

It is desirable for camera performance to always use the maximum exposure time possible based on the maximum line rate of the inspection system and any margin that may be required to accommodate illumination degradation. However, it will be necessary to adjust the responsivity to achieve the desired output from the camera. The camera has a row selector feature and a gain feature that can be used to make the necessary adjustment to the responsivity.

Three Row Selections are available: 4 rows, 8 rows, and 12 rows.

- 4 rows are useful when there is plenty of light and the inspection system needs to extract low contrast defects from bright image backgrounds. By only using four line rows a higher full well can be achieved (more electrons collected in a pixel for a given integration period) and an associated higher signal to noise performance (i.e. less shot noise).
- 8 rows offer the highest responsivity at the highest line rate. It is optimized for light starved inspection systems where low contrast defects must be extracted from dark images and where the dark noise level needs to be minimized (i.e. minimizes Noise Equivalent Exposure).
- 12 Rows are useful for light starved inspection systems but at a maximum line rate less than 8 Rows. This may be useful for lower performance or cost sensitive systems where less intense, lower cost, illumination is used.

A single gain adjustment is used for any of the row configurations. Gain can be adjusted from 0.65x to 5x (Extended Gain Range Enabled), depending on the number of rows selected. Using row selection and gain adjustment the camera's responsivity can be changed by a factor of 23x—from lowest to highest responsivity performance.

When evaluating responsivity, it is best to start with four rows and then move to a higher number of rows if the resulting responsivity does not meet your application's requirements.

Note that when adjusting the row selection, a momentary loss of LVAL will occur. This will also happen when changing user sets that include row selection.

## Image Response Uniformity

*See the section Flat Field Category in Appendix A for GenICam features associated with this section and how to use them*

*Relevant Features: Calibrate FPN, Calibrate PRNU, Calibration Algorithm, Calibration Target*

It is common to experience a lower response image at the edges of the camera's field of view compared to its center. This is typically a result of a combination of lens vignetting ( $\cos^4$ ) roll-off and the beam structure of the illumination source. A more diffused light may reduce this roll-off effect. However, if decreasing the lens aperture improves the edge roll-off, then barrel vignetting (a shadow cast on the sensor by the focus helical or extension tubes) may also be present.

The camera can compensate for edge roll-off and other optical non-uniformities through flat field calibration.

- When performing Flat Field (PRNU) calibration, the camera should be imaging a front illuminated white target or rear bright field illumination source. The optical setup should be as per the inspection system; including lens magnification, aperture, and illumination intensity, plus illuminator beam structure.
- Flat field calibration should be performed for each row selection that will be used by the system and saved as a distinct user set (see the Saving & Restoring Camera Setup Configurations section). Whenever a different number of rows are selected the camera setup will default to the factory settings. The user must select and load the associated user set for the number of rows in use that was previously saved in the user set
- Flat field calibration should be performed when the camera temperature has stabilized.
- When the camera is commanded to execute a flat field calibration it will adjust all pixels to have the same value as that of the peak pixel value or target level, as per the calibration mode selected.

On completion of a flat field calibration, all pixels should be at their un-calibrated peak value or target value. Subsequent changes in gain will allow the user to make refinements to the operating responsivity level.

Note that the best flat field calibration can be achieved by performing it at the mid DN level of the working range used in the operation. Any flat field error associated with residual non linearity in the pixel will be halved as compared to performing a calibration at the peak value of the operating range. A simple way of performing this is to reduce exposure time to half what is used in the operation in order to get the mid DN level for flat field calibration. Once complete, return the exposure time to its original setting.

Those areas of the image where high roll-off is present will show higher noise levels after flat field calibration due to the higher gain values of the correction coefficients. Flat field calibration can only compensate for up to an 8:1 variation. If the variation exceeds 8:1, then the line profile after calibration will include pixels that are below the un-calibrated peak level.

## Setting Custom PRNU Coefficients

There may also be circumstances when the user wants to upload their own PRNU coefficients. PRNU coefficients can be custom modified and uploaded to the camera. They can also be downloaded from the camera.

To download and upload PRNU coefficients, use *File Access Control Category > Upload / Download File > Settings* and select *Miscellaneous > Current PRNU* to download / upload a file. The file format is described in 03-084-20123 Piranha XL Binary File Format which can be obtained from Teledyne DALSA Technical Support. This document also includes Excel spread sheet examples.

Once the PRNU coefficients are uploaded, they are used immediately by the camera. To avoid loss at power up or changing row settings, they should be saved in one of the 8 available user sets.

## Flat Field Calibration Filter

*See the section Flat Field Category in Appendix A for GenICam features associated with this section and how to use them*

*Relevant Features: Calibration Algorithm*

If a sheet of material is being used as a white target, it must be completely free of blemishes and texture. Any dirt or texture present will generate a variation in the image that will be incorporated into the calibration coefficients of the camera. Once the target is removed, or moved, vertical stripes will be present in the scanned image. Dirt or texture that has dark characteristics will appear as bright vertical lines. And dirt or texture that has bright characteristics will appear as dark vertical lines. One way to minimize this affect is for the white target to be moving during the calibration process. This has the affect of averaging out any dirt or texture present. If this is not possible, the camera has a feature where a flat field calibration filter can be enabled when generating the flat field correction coefficients which can minimize the effects of dirt. Note that this filter is only capable of compensating for small, occasional contaminants.

## Flat Field Calibration Region of Interest

*See the section Flat Field Category in Appendix A for GenICam features associated with this section and how to use them*

*Relevant Features: ROI Offset X, ROI Width*

There are occasions when the camera's field of view includes areas that are beyond the material to be inspected. This may occur for cameras imaging off the edge of a panel or web. Another type of inspection system may be imaging multiple lanes of material. The edge of the material or between lanes may not be illuminated in the same way as the areas of inspection and, therefore, would cause problems with a flat field calibration. The camera can accommodate these "no inspection zones" by defining up to four Regions of Interest (ROI) where flat field calibration is performed. Image data outside the ROI is ignored by the flat field calibration algorithm. Each ROI is user selected with the pixel boundaries defined by the pixel start address and pixel width and then followed by initiating flat field calibration for that region. Once completed, the next ROI can be defined and flat field calibrated.

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## Achieving Faster Scan Speeds When Lower Image Resolution Is Acceptable (Binning)

See the section *Image Format Control Category* in Appendix A for GenICam features associated with this section and how to use them

*Relevant Features: Horizontal Binning, Vertical Binning*

In certain applications, lower image resolution may be acceptable if the desired defect detection can still be achieved. This accommodation can result in higher scan speeds, as the distance travelled per encoder pulse is increased due to the larger object pixel size. The Piranha XL camera has a binning feature that produces rapid adjustment to a lower object pixel resolution without having to change the optics, illumination intensity, or encoder pulse resolution.

Binning is a process whereby adjacent pixels are summed. The Piranha XL camera can support 1 x 2, 2 x 1, and 2 x 2 binning (vertical x horizontal). Vertical Binning is achieved by the camera ignoring every other encoder pulse. Horizontal binning is achieved by averaging adjacent pixels in the same line. Therefore, 2x binning results in the object pixel doubling in size vertically, horizontally, or in both axes, as selected by the Binning feature. When selecting binning, the current exposure time is retained so no change in light level is required. As every other encoder pulse is dropped with 2x vertical binning, scan speed can double without exceeding the maximum specified line rate, or the maximum line rate as dictated by the selected exposure time. Horizontal 2x binning will halve the amount of image data out of the camera. This can be used to save processing bandwidth in the host and storage space by creating smaller image file sizes.

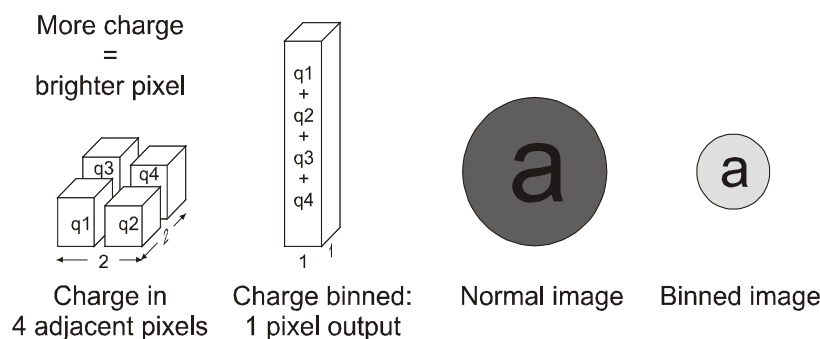


Figure 8: 2x2 Binning

For the Piranha XL camera, the default binning value is 1 x 1.

## Using Area of Interest to Reduce Image Data & Enhance Performance

See the section *Image Format Control Category* in Appendix A for GenICam features associated with this section and how to use them

*Relevant Features: AOI Port Selector, AOI Count, AOI Selector, AOI Offset, AOI Width*

If the camera's field of view includes areas that are not needed for inspection (also refer to the description in the 0 Flat Field Calibration Region of Interest), then the user may want to ignore this superfluous image data. Eliminating unwanted image data that is present in the camera's field of view reduces the amount of information the host computer needs to process. It may also result in an increase to the maximum allowable line rate when using 12 bit output data.

Different Areas of Interest can also be selected to be output on the Master and Slave ports. This would allow the camera to be connected to a dual port frame grabber or two frame grabbers, possibly in two PC's. Using this configuration may eliminate frame grabber and/or PC bandwidth issues allowing the camera to achieve its maximum line rate.

The Piranha XL camera can accommodate up to four Areas of Interest (AOI) for each of the Master & Slave ports. Image data outside the AOI are discarded. Each AOI is user selected and its pixel boundaries defined. The camera will assemble all individual AOI into one contiguous image line with a width equal to the sum of the individual AOI('s). The frame grabber will need to be adjusted to accommodate the smaller overall image width. As the host computer defined the size of each individual AOI, it will be able to extract and process each individual AOI from the one larger image.

## Steps to Setup Area of Interest

1. Plan your AOI's
2. Stop acquisition
3. Select the Master or Slave port
4. Set the number of AOI's
5. Select the first AOI and set the offset and width
6. If the other AOI's are large you may need to select them first and reduce their width's
7. Repeat for each AOI in turn
8. Start acquisition

## The Rules for Setting Areas of Interest

Notes:

- The rules are dictated by how image data is organized for transmission over the available CLHS data lanes.
  - The camera/XML will enforce these rules truncating entered values where necessary.
1. Acquisition must be stopped to change the AOI configuration
  2. 1-4 AOI's can be selected
  3. Minimum width is 96 pixels per AOI
    - a. Minimum total of all AOI widths summed together must be at least = Number of CLHS lanes x 96 pixels
      - i. 7 lanes: 672 pixels (Normal Use)
      - ii. 4 lanes: 384 pixels (When using CX4 fiber cable modules)
  4. Maximum width of all AOI widths summed together must be no more than  $= 16,384 + (3 \times 96) = 16,672$ 
    - a. There can be maximum 8k bytes per CLHS lane when using only 4 lanes, such as with a CX4 fiber module. i.e.
      - i. 8192 pixels per lane can be supported when using 8 bit pixels
      - ii. 5,461 pixels per lane can be supported when using 12 bit pixels
  5. AOI width step size is 32 pixels
  6. The offset of each AOI may be 0 to  $(16,384 - 96 = 16,288)$ 
    - a. Therefore overlapping AOI's are allowed
  7. Offset and width for individual AOI's will "push" one another
    - a. e.g. if AOI has offset 0, width 16,384, and the offset is changed to 4096, then the width will be "pushed" to 12,288.
    - b. AOI's only effect one another by limiting the maximum width
  8. AOI's are concatenated together in numerical order and sent to the frame grabber starting at column zero

9. "Extreme" differences in AOI width's will reduce the maximum line rate
  - a. e.g. If AOI #1 is 16,384 x 12 bit pixels and the other three AOI's are just 96 pixels then with a seven lane CLHS cable the maximum line rate will be ~50.8 kHz
10. If the AOI count is reduced to less than the current AOI count, the AOI selector will be changed to the largest of the new AOI count available

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## Increasing Dynamic Range

*See the section Camera Control Category in Appendix A for GenICam features associated with this section and how to use them*

*Relevant Features: Output LUT Mode, HDR Gamma Correction*

To enhance the camera's ability to detect defects from the dark and bright areas of an image, a high dynamic range HDR LUT is available.

When the LUT is enabled, 12 bit image data within the camera is compressed into an 8 bit output from the camera using a conversion table that can be internally generated using a 'gamma' type algorithm or a conversion table that is downloaded by the user. The gamma correction value can be adjusted by the user at any time.

The algorithm used by the camera to convert 12bit linear data to 8bit 'gamma type' encoded data is as follows:

$8\text{bit\_gamma} = 255.0 * ((\text{RGB\_12bit\_linear}/4095.0) ^ (1.0/\text{gamma}))$ , where gamma = 1.0 to 3.0

When the LUT is enabled, there is no change in maximum line rate or amount of data output from the camera. The LUT can be used with any mode of the camera.

To upload a LUT, use *File Access Control Category > Upload / Download File > Settings* and select *Look Up Table* to upload a file. The file format is described in 03-084-20123 Piranha XL Binary File Format which can be obtained from Teledyne DALSA Technical Support. This document also includes Excel spread sheet examples.

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## Contrast Enhancement

*See the section Camera Control Category in Appendix A for GenICam features associated with this section and how to use them*

*Relevant Features: Offset, Gain*

When the image does not contain useful dark image data below a particular threshold, it may be beneficial to increase the contrast of the image. The Piranha XL camera has an offset feature that allows a selectable level to be subtracted from the image data. The gain feature can then be used to return the peak image data to near output saturation with the result being increased image contrast.

First, determine the offset value you need to subtract from the image with the current gain setting you are using. Then set this negative offset value and apply additional gain to achieve the desired peak image data values.



Note: A positive offset value is not useful for contrast enhancement. However, it can be used while measuring the dark noise level of the camera to ensure zero clipping is not present.

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## Help with Lens Focusing & Camera Alignment

See the section *Camera Control Category* in *Appendix A* for GenICam features associated with this section and how to use them

Before evaluating the cameras imaging performance, it is important to ensure that the image is properly focused and that the camera's 16k pixel axis is perpendicular to the motion of the object.

### Establish Optimum focus

The target being used for focus adjustment should have sharp black-to-white transitions and as much fine detail as possible. Ideally, black and white features of approximately 10 pixels or less wide will be in the image. A back illuminated USAF 1951 target may be suitable.

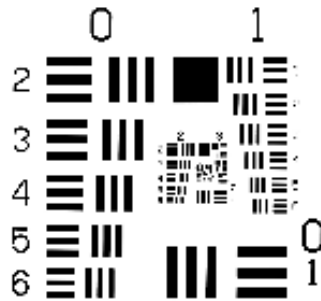
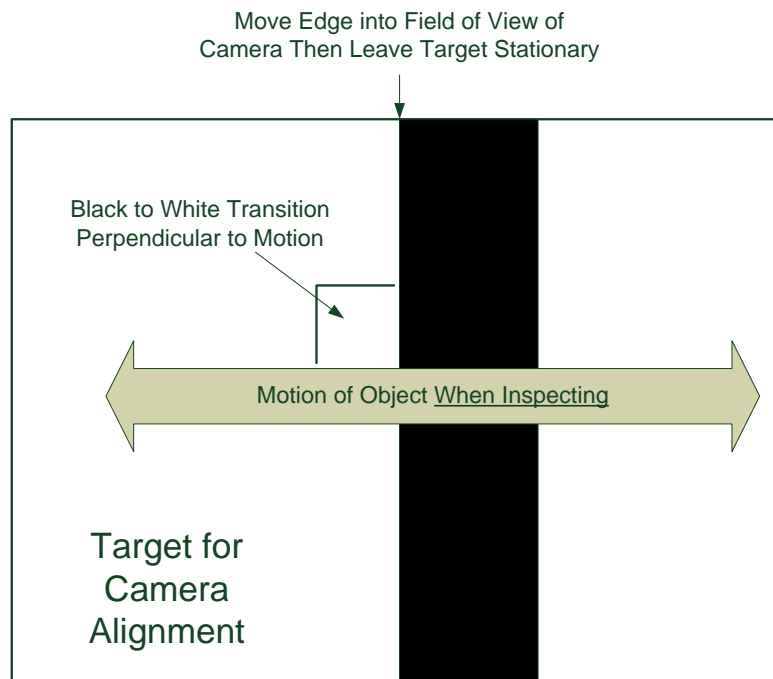


Figure 9 USAF 1951 'Positive'

- Ensure that the lens aperture is fully open.
- Select the cameras 12 row mode.
- Select the low gain range and 1x gain.
- Select a slow internal line rate of 5 kHz.
- Set exposure time to 100  $\mu$ sec.
- Use the factory calibration settings.
- Adjust the target so that the fine details appear in the camera's field of view. Adjust the camera's gain so that the white parts of the image are at high values, but not saturated. If the response is too high at 1x gain, then reduce the exposure time to 25  $\mu$ sec or lower. Use CamExpert to capture, display, and analyze the image. If insufficient response is achieved at high gain, use the next highest gain range
- Select the CamExpert histogram analysis tool.
- Using the mouse, drag a box over the image area with lots of fine detail you want to use for focusing. The target should be stationary.
- Adjust the lens' focus helical or the camera's working distance to the object until the histogram shows a maximum of dark and light peaks with the largest separation and the lowest level of grey peaks.
- Optimum focus should now be achieved.

## Ensuring Rows are Aligned to the Object Motion

To achieve the best image quality, it is important that the object motion tracks across the CMOS TDI rows without any up or down movement. One method of achieving this is to align the CMOS TDI rows to the object motion by using a stationary target located at the object plane, which has a black-to-white single, sharp transition perpendicular to the direction of motion, and is in focus. The black to white transition should be located at the point where all the cameras are to be optically aligned.



Note: It is assumed that the camera mounting system has the ability to rotationally adjust the camera about its central axis and in the scan direction to perform the desired alignment.

- Select the CamExpert line profile analysis tool.
- Continue using the camera setup in 12 row mode and continuous imaging.
- Align the camera such that only the white, fully illuminated portion is being imaged. This can be determined when rotational and scan direction adjustments of the camera do not result in changes in the image line profile.
- Adjust the illumination, exposure time and/or gain to achieve a peak value of approximately 200 DN.
- Perform a Flat Field calibration with a target of 200 DN.
- Adjust the camera in the scan direction such that the center of the image is 100 DN. This will align the black-to-white transition at the center of the FOV to the center rows of the camera.
- While watching the line profile, rotate the camera and make both ends of the sensor equal to the center value. The line transition at the center of the image should not move. If it does, it means that the camera is not being rotated around its center axis. Adjust the camera in the scan direction until the center value again reaches 100 DN.

- When both end of the line profile are equal to the center, then the camera will be aligned both in the scan direction and rotationally with the black-to-white transition.
- The accuracy of the adjustment can be increased by using 8 rows or even 4 rows. However, this will be associated with an increase in sensitivity to camera adjustments. Start with 12 rows to get close and then move to 8 and then 4 rows. Ensure 4 and 8 rows are also Flat Fielded to the same target as 12 rows.

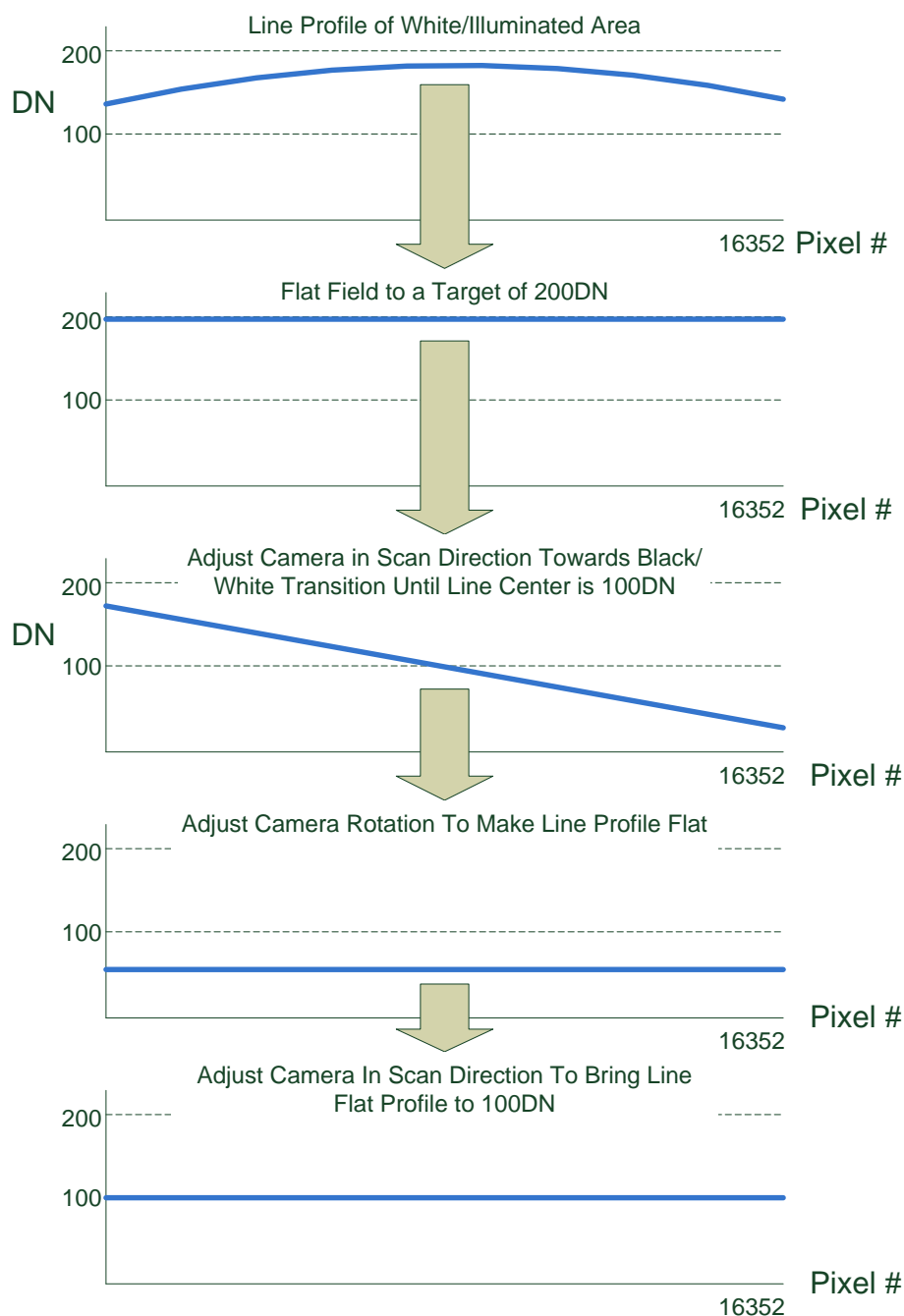


Figure 10 Alignment Method

This method is not effective for CCD TDI cameras with many stages as there is insufficient sensitivity. Area mode imaging is required. Single line cameras would be too sensitive. However, the Piranha XL camera has the right number of rows to make this simple alignment method practical.

---

## Changing Output Configuration

### Bit Resolution

*See the section Image Format Control Category in Appendix A for GenICam features associated with this section and how to use them*

*Relevant Features: Pixel Format*

The Piranha XL camera can output video data as 8-bit or 12-bit format. 8-bit output allows for the maximum specified line rate to be achieved. 12-bit data limits the maximum line rate to approximately  $2/3^{\text{rd}}$  of the maximum specified line rate, when using a single Camera Link HS cable. The maximum line rate can be restored if the image data is split equally across two Camera Link HS cables.

### Camera Link HS Lane Selection

*See the section Image Format Control Category in Appendix A for GenICam features associated with this section and how to use them*

*Relevant Features: Next CLHS Devise Configuration*

Each Camera Link HS cable includes 8 lanes. One lane is used to send command data from the frame grabber to the camera. Seven lanes are used to send camera data to the frame grabber, one of which carries both image and command response data. The camera can also support the use of only 4 lanes, which allows standard fiber modules to be plugged into the camera, or 1 lane which may be useful for diagnostic purposes.

Use the 'Next CLHS Devise Configuration' to select the desired lane configuration. Ensure that the acquisition is stopped when performing lane configuration selection. The frame grabber must also have the same lane selection.

Note that this feature also controls the cable selection.

### Using Two CLHS Cables

*See the section Image Format Control Category in Appendix A for GenICam features associated with this section and how to use them*

*Relevant Features: Next CLHS Devise Configuration*

The camera has two CLHS compliant connectors. Control / Data1 is typically assigned as the master with Data 2 connector as the slave. Use the 'Next CLHS Devise Configuration' to select the desired number of cables.

Note that this feature also controls lane selection.

## Using Fiber Modules

The Piranha XL camera is capable of supporting one or two “CX4 Active Optical” fiber modules, which can have cable lengths up to 300 meters. The fiber module plugs directly into the camera connectors, which provide both communication and power to the module. CX4 fiber modules support four receiver lines, which results in only four image data lanes with one also carrying command response data and being available from the camera to the frame grabber. CX4 also has four transmit lines. One of which is used for the command channel from the frame grabber to the camera. This results in reduced image data bandwidth when using fiber modules. See section Camera Link HS for line rate performance with and without fiber modules.

Note that CX4 fiber modules must have jack screws to secure the module to the camera.

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## Saving & Restoring Camera Setup Configurations

*See the section Camera Information Category in Appendix A for GenICam features associated with this section and how to use them*

*Relevant Features: Power-up Configuration Selector, UserSet1 thru UserSet8, User Set Selector, Power-on User Set, Current User Set*

An inspection system may require several different illumination, resolution, and responsivity configurations in order to cover the different types of inspection it is expected to perform. The Piranha XL camera includes 8 user sets where camera setup information can be saved to and restored from—either at power up, or dynamically during inspection. The camera’s active settings can be derived from one of four settings:

1. Set by GenICam command from host.
2. User setting.
3. Factory setting (read-only).
4. Default setting.

The settings active during the current operation can be saved (and thereby become the user setting) using the user set save parameter.

A previously saved user setting (User Set 1 to 8) or the factory settings can be restored using the user set selector and user set load parameters.

Either the factory setting or one of the user settings can be saved as the default setting, by selecting the set in the user set default selector. The set selected automatically saves as the default setting and is the set that is loaded and that becomes active when the camera is reset or powered up.

The relationship between these four settings is illustrated in Figure 11. Relationship between the Camera Settings:

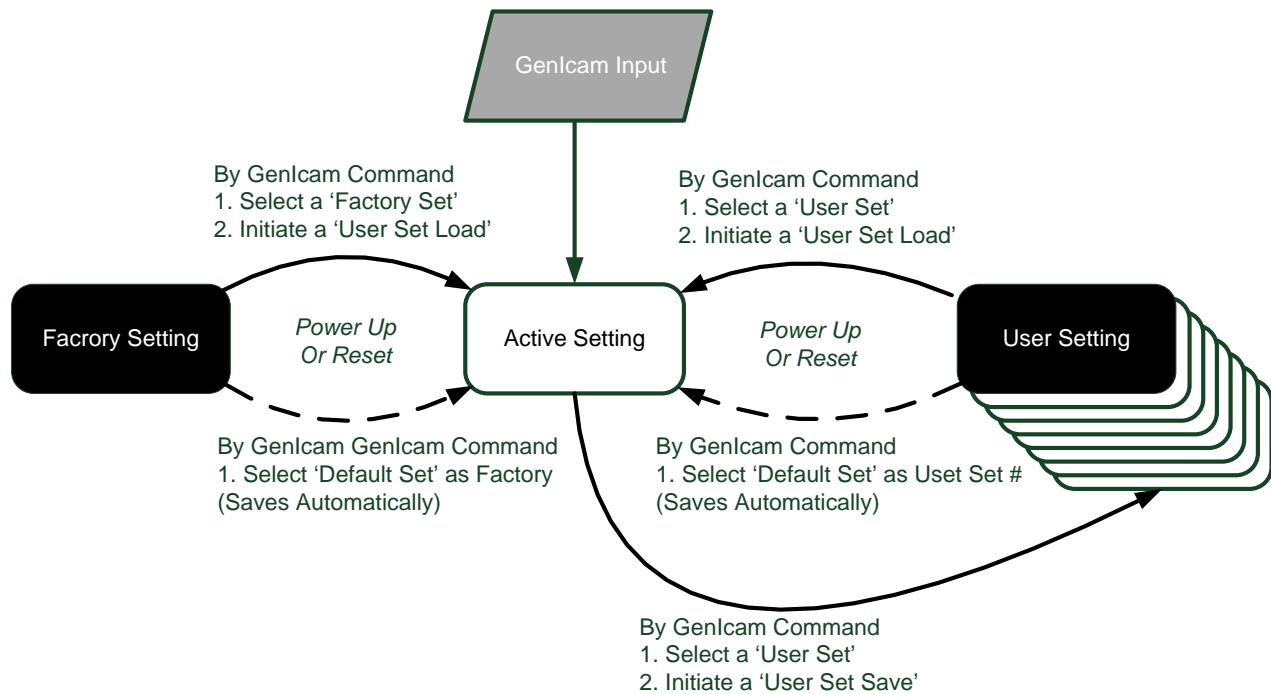


Figure 11. Relationship between the Camera Settings

## Active Settings for Current Operation

Active settings are those settings used while the camera is running. And include all unsaved changes made by GenIcam input to the settings.

These active settings are stored in the camera's *volatile* memory and will be lost and cannot be restored if the camera resets, is powered down, or loses power during operation.

To save these settings so that they can be restored next time you power up the camera, or to protect against losing them in the case of power loss, you must save the current settings using the user set save parameter. Once saved, the current settings become the selected user set.

## User Setting

The user setting is the saved set of camera configurations that you can customize, resave, and restore. By default, the user settings are shipped with the same settings as the factory set.

The command user set save saves the current settings to non-volatile memory as a user set. The camera automatically restores the last saved user settings when it powers up.

To restore the last saved user settings, select the user set parameter you want to restore and then select the user set load parameter.

## Factory Settings

The factory setting is the camera settings that were shipped with the camera and which loaded during the camera's first power-up. To load or restore the original factory settings, at any time, select the factory setting parameter and then select the user set load parameter.

Note: By default, the user settings are set to the factory settings.

## Default Setting

Either the factory or one of the user settings can be used as the default setting, by selecting the set to use in the user set default selector. The chosen set automatically becomes the default setting and is the set loaded when the camera is reset or powered up.

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## Appendix A: GenICam Commands

This appendix lists the available GenICam camera features. The user accesses these features using the CamExpert interface.

Features listed in the description table but tagged as *Invisible* are typically reserved for Teledyne DALSA Support or third party software usage, and not typically required by end user applications.

The following feature tables describe these parameters along with their view attributes and in which version of the device the feature was introduced. Additionally the Device Version column will indicate which parameter is a member of the DALSA Features Naming Convention (using the tag **DFNC**), versus the GenICam Standard Features Naming Convention (SFNC tag not shown).

In the CamExpert Panes, parameters in gray are read only, either always or due to another parameter being disabled. Parameters in black are user set in CamExpert or programmable via an imaging application

The Device Version number represents the camera software functional group, not a firmware revision number.

A note on the CamExpert examples shown here: The examples shown for illustrative purposes and may not entirely reflect the features and parameters available from the camera model used in your application.

## Camera Information Category

Camera information can be retrieved via a controlling application. Parameters such as camera model, firmware version, etc. are read to uniquely identify the connected Piranha XL camera. These features are typically read-only.

The Camera Information Category groups information specific to the individual camera. In this category the number of features shown is identical whether the view is Beginner, Expert, or Guru.

Parameters - Visibility: Guru		
Category	Parameter	Value
Camera Information	Model	PX-HM-16K12B-00-R
Camera Control	Vendor	Teledyne_DALSA
Digital IO Control	Serial Number	CAM_29
Flat Field	Microcode Version	03-081-20341-01
Image Format	XML Version	03-119-20047-02
File Access Control	FPGA Version	03-056-20464-02
Transport Layer	Script Version	03-110-20344-01
Acquisition and Transfer Cont...	Power-on Status	Good
	Refresh BIST	Press...
	LED Color	Green
	Temperature	43.5
	Refresh Temperature	Press...
	Input Voltage	19.5
	Refresh Voltage	Press...
	Power-up Configuration	Setting...
	<< Less	

Figure 12 CamExpert Camera Information Panel



## Camera Information Feature Descriptions

Display Name	Feature	Description	Device Version & View
Model Name	DeviceModelName	Displays the device model name. (RO)	1.00 Beginner
Vendor Name	DeviceVendorName	Displays the device vendor name. (RO)	1.00 Beginner
Device Version	DeviceVersion	Displays the device version. This tag will also highlight if the firmware is a beta or custom design. (RO)	1.00 Beginner
Manufacturer Info	DeviceManufacturerInfo	This feature provides extended manufacturer information about the device. (RO)	1.00 Beginner
Firmware Version	DeviceFirmwareVersion	Displays the currently loaded firmware version number. Firmware files have a unique number and have the .cbf file extension. (RO)	1.00 Beginner
Serial Number	DeviceID	Displays the device's factory set camera serial number. (RO)	1.00 Beginner
Device User ID	DeviceUserID	Feature to store user-programmable identifier of up to 15 characters. The default factory setting is the camera serial number. (RW)	1.00 Beginner
Power-up Configuration Selector	UserSetDefaultSelector	Selects the camera configuration set to load and make active on camera power-up or reset. The camera configuration sets are stored in camera non-volatile memory. (RW)	1.00 Beginner
Factory Setting	Default	Load factory default feature settings	
UserSet1	UserSet1	Select the user defined configuration UserSet 1 as the Power-up Configuration.	
UserSet2	UserSet2	Select the user defined configuration UserSet 2 as the Power-up Configuration	
UserSet3	UserSet3	Select the user defined configuration UserSet 3 as the Power-up Configuration	
UserSet4	UserSet4	Select the user defined configuration UserSet 4 as the Power-up Configuration.	
UserSet5	UserSet5	Select the user defined configuration UserSet 5 as the Power-up Configuration.	
UserSet6	UserSet6	Select the user defined configuration UserSet 6 as the Power-up Configuration.	
UserSet7	UserSet7	Select the user defined configuration UserSet 7 as the Power-up Configuration.	
UserSet8	UserSet8	Select the user defined configuration UserSet 8 as the Power-up Configuration.	
Load & Save Configuration	UserSetSelector	Selects the camera configuration set to load feature settings from or save current feature settings to. The Factory set contains default camera feature settings. (RW)	1.00 Beginner
Factory Setting	Default	Select the default camera feature settings saved by the factory	

Display Name	Feature	Description	Device Version & View
UserSet 1	UserSet1	Select the User-defined Configuration space UserSet1 to save to or load from features settings previously saved by the user.	
UserSet 2	UserSet2	Select the User-defined Configuration space UserSet2 to save to or load from features settings previously saved by the user.	
UserSet3	UserSet3	Select the User-defined Configuration space UserSet3 to save to or load from features settings previously saved by the user.	
UserSet4	UserSet4	Select the User-defined Configuration space UserSet4 to save to or load from features settings previously saved by the user.	
UserSet5	UserSet5	Select the User-defined Configuration space UserSet5 to save to or load from features settings previously saved by the user.	
UserSet6	UserSet6	Select the User-defined Configuration space UserSet6 to save to or load from features settings previously saved by the user.	
UserSet7	UserSet7	Select the User-defined Configuration space UserSet7 to save to or load from features settings previously saved by the user.	
UserSet8	UserSet8	Select the User-defined Configuration space UserSet8 to save to or load from features settings previously saved by the user.	
Power-on User Set	UserSetDefaultSelector	Allows the user to select between the factory set and 1 to 8 user sets to be loaded at power up	1.00 Beginner
Current User Set	UserSetSelector	Points to which user set (1-8) or factory set that is loaded or saved when the UserSetLoad or UserSetSave command is used	1.00 Beginner
Load Configuration	UserSetLoad	Loads the camera configuration set specified by the User Set Selector feature, to the camera and makes it active. (W)	1.00 Beginner
Save Configuration	UserSetSave	Saves the current camera configuration to the user set specified by the User Set Selector feature. The user sets are located on the camera in non-volatile memory. (W)	1.00 Beginner
Device Built-In Self Test Status	deviceBISTStatus	Determine the status of the device using the 'Built-In Self Test'. Possible return values are device-specific. (RO)  See Built In Self Test Codes for status code details	1.00 DFNC Beginner
LED Color	deviceLEDCOLORControl	Displays the status of the LED on the back of the camera. (RO)	1.00 DFNC Beginner
Temperature	deviceTemperature	Displays the internal operating temperature of the camera. (RO)	1.00 DFNC Beginner

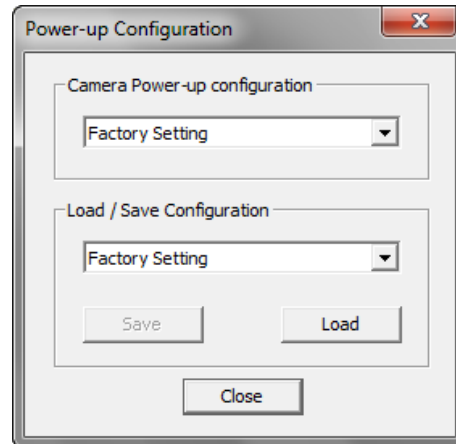
Display Name	Feature	Description	Device Version & View
Refresh Temperature	refreshTemperature	Press to display the current internal operating temperature of the camera.	1.00 DFNC Beginner
Input Voltage	deviceInputVoltage	Displays the input voltage to the camera at the power connector (RO)	1.00 DFNC Beginner
Refresh Voltage	refreshVoltage	Press to display the current input voltage of the camera at the power connector	1.00 DFNC Beginner
License Key	securityUpgrade	TBD	1.00 DFNC Guru

## Built In Self Test Codes

In the Camera Information screen shot example above, the Power-On Status is showing the 23 status flags where '1' is signaling an issue. When there are no issues, the Power-On status will indicated "Good".

Details of the Built in Self Test (BIST) codes can be found in the Trouble Shooting Guide in Appendix B.

## Camera Power-Up Configuration Selection Dialog



CamExpert provides a dialog box which combines the menu option used to select the camera's power-up state and the options for the user to save or load a camera state as a specific user set that is retained in the camera's non-volatile memory.

## Camera Power-up Configuration

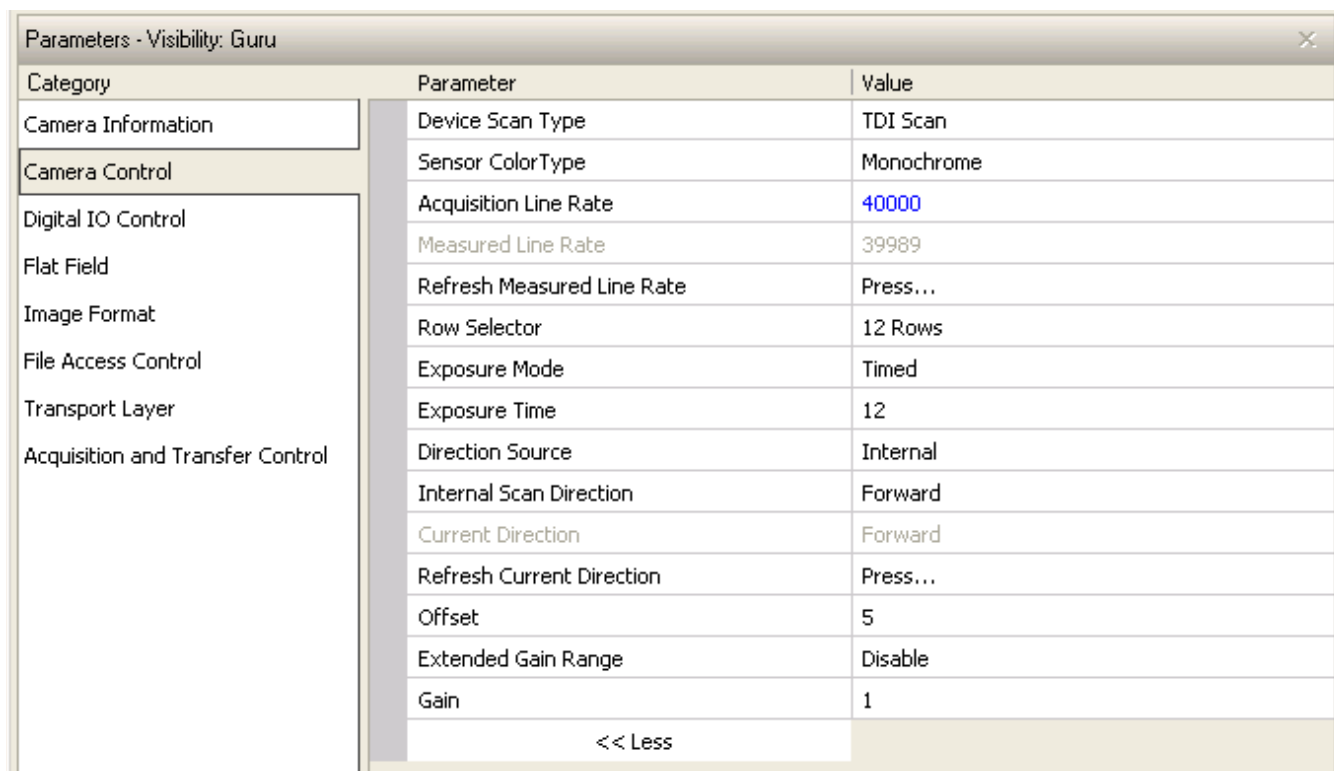
The first drop list selects the camera configuration state to load on power-up (see feature *UserSetDefaultSelector*). The user chooses from one factory data set or from one of eight available user-saved states.

## User Set Configuration Management

The second drop list allows the user to change the camera configuration anytime after a power-up (see feature *UserSetSelector*). To reset the camera to the factory configuration, select *Factory Setting* and click Load. To save a current camera configuration, select User Set 1 to 8 and click Save. Select a saved user set and click Load to restore a saved configuration.

## Camera Control Category

The Piranha XL camera control category, as shown by CamExpert, groups control parameters such as line rate, exposure time, scan direction, and gain.



Category	Parameter	Value
Camera Information	Device Scan Type	TDI Scan
Camera Control	Sensor ColorType	Monochrome
	Acquisition Line Rate	40000
	Measured Line Rate	39989
	Refresh Measured Line Rate	Press...
Digital IO Control	Row Selector	12 Rows
Flat Field	Exposure Mode	Timed
Image Format	Exposure Time	12
File Access Control	Direction Source	Internal
Transport Layer	Internal Scan Direction	Forward
Acquisition and Transfer Control	Current Direction	Forward
	Refresh Current Direction	Press...
	Offset	5
	Extended Gain Range	Disable
	Gain	1
	<< Less	

Figure 13: Camera Control Panel

## Camera Control Feature Descriptions

Display Name	Feature	Description	Device Version & View
Device Scan Type	DeviceScanType	Used to set the camera scanning mode. Only standard TDI mode is available.	1.00 Beginner SNFC
Standard			
Internal Line Rate	AcquisitionLineRate	Specifies the camera internal line rate, in Hz when Trigger mode set to internal. Note that any user entered value is automatically adjusted to a valid camera value.	1.00 Beginner
Measured Line Rate	measureLineRate	Specifies the line rate provided to the camera by either internal or external source (RO)	1.00 Beginner
Refresh Measured Line Rate	refreshMeasureLineRate	Press to show the current line rate provided to the camera by either internal or external sources	1.00 Beginner
Exposure Time Source	ExposureMode	Sets the operation mode for the camera's exposure (or shutter). (RO)	1.00 Beginner
Timed	Timed	The exposure duration time is set using the Exposure Time feature and the exposure starts with a LineStart event.	
Exposure Time	ExposureTime	Sets the exposure time (in microseconds) when the Exposure Mode feature is set to Timed.	1.00 Beginner
Measured Exposure Time	measureExposureTime	Specifies the exposure time provided to the camera by either internal or external source (RO)	1.00 Beginner
Refreshed measured exposure time	refreshMeasureExposureTime	Press to display the current exposure time provided to the camera.	1.00 Beginner
Direction Source	sensorScanDirectionSource		1.00 Beginner
	Internal	Direction determined by value of SensorScanDirection	
	External	Direction control determined by value on CLHS GPIO bit 2, Frame grabber register #80524	
Internal Direction	sensorScanDirection	When ScanDirectionSource set to Internal, determines the direction of the scan	1.00 Beginner
	Forward		
	Reverse		
Row Selector	TDIStagesSelector	Selects the number of rows that will be used	1.00 Beginner
4 Rows			
8 Rows			
12 Rows		Adjusts the sensor characteristics to optimize for noise performance where the 4 rows would be selected first with the maximum available light. If there is insufficient response, add more rows.	
Extended Gain Range	gainExtended	Increase the maximum allowable gain.	1.00 Guru
Gain	Gain	Sets the gain as per the gain selector setting	1.00 Beginner

Display Name	Feature	Description	Device Version & View
Offset	BlackLevel	Controls the black level as an absolute physical value. This represents a DC offset applied to the video signal, in DN (digital number) units.	1.00 Beginner

## Digital I / O Control Feature Descriptions

The camera's Digital I / O Control category is used to determine the source of the line sync generator. The line synchronization can be internally generated by the camera or from the frame grabber over the CLHS cable. CamExpert for the frame grabber can be used to then determine the line sync source such as from the shaft encoder input.

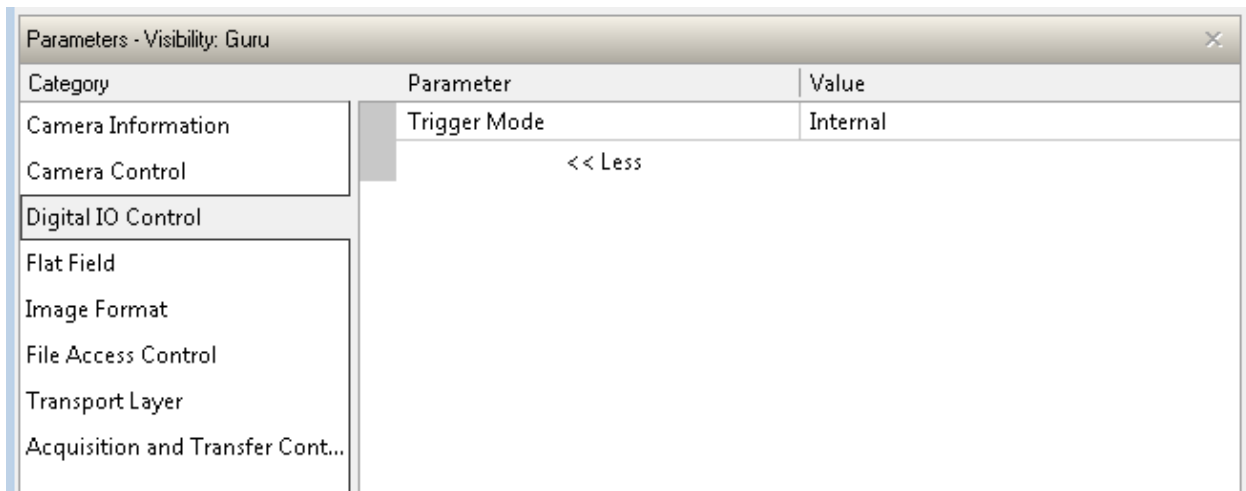
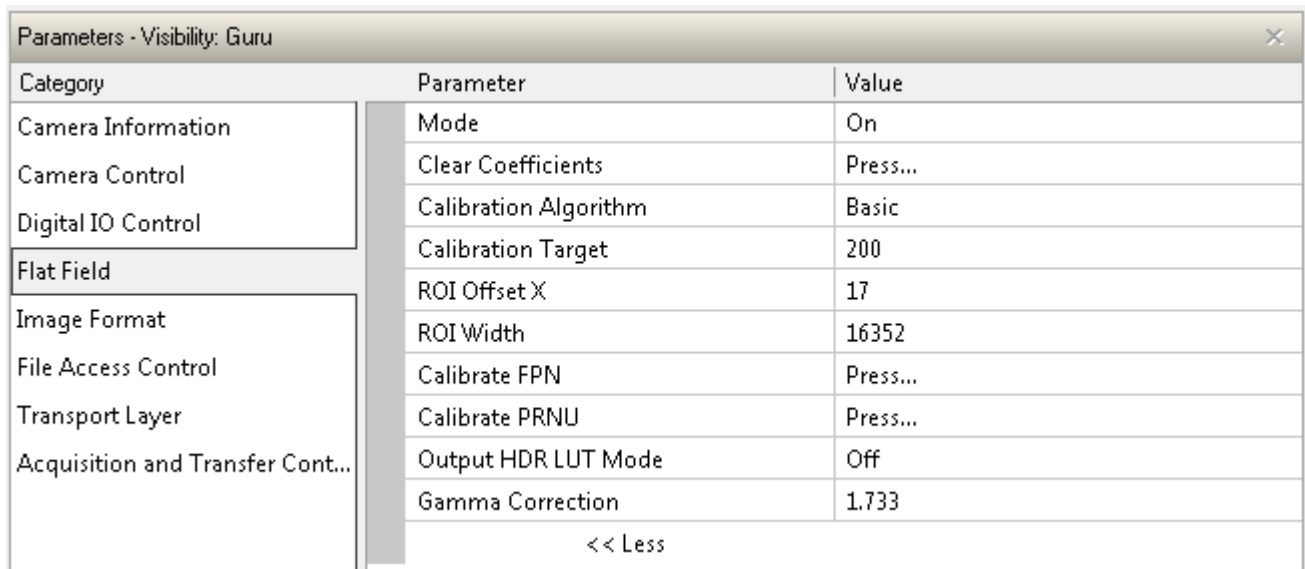


Figure 14 Digital I/O Control Panel

Display Name	Feature	Description	Device Version & View
Trigger Mode	Trigger Mode	Determines the source of trigger to the camera, internal or external	1.00 DFNC Beginner

## Flat Field Category

The Piranha XL Flat Field controls, as shown by CamExpert, group parameters used to control the FPN and PRNU calibration process.



Category	Parameter	Value
Camera Information	Mode	On
Camera Control	Clear Coefficients	Press...
Digital IO Control	Calibration Algorithm	Basic
Flat Field	Calibration Target	200
Image Format	ROI Offset X	17
File Access Control	ROI Width	16352
Transport Layer	Calibrate FPN	Press...
Acquisition and Transfer Cont...	Calibrate PRNU	Press...
	Output HDR LUT Mode	Off
	Gamma Correction	1.733
	<< Less	

Figure 15: Flat Field Panel

## Flat Field Control Feature Description

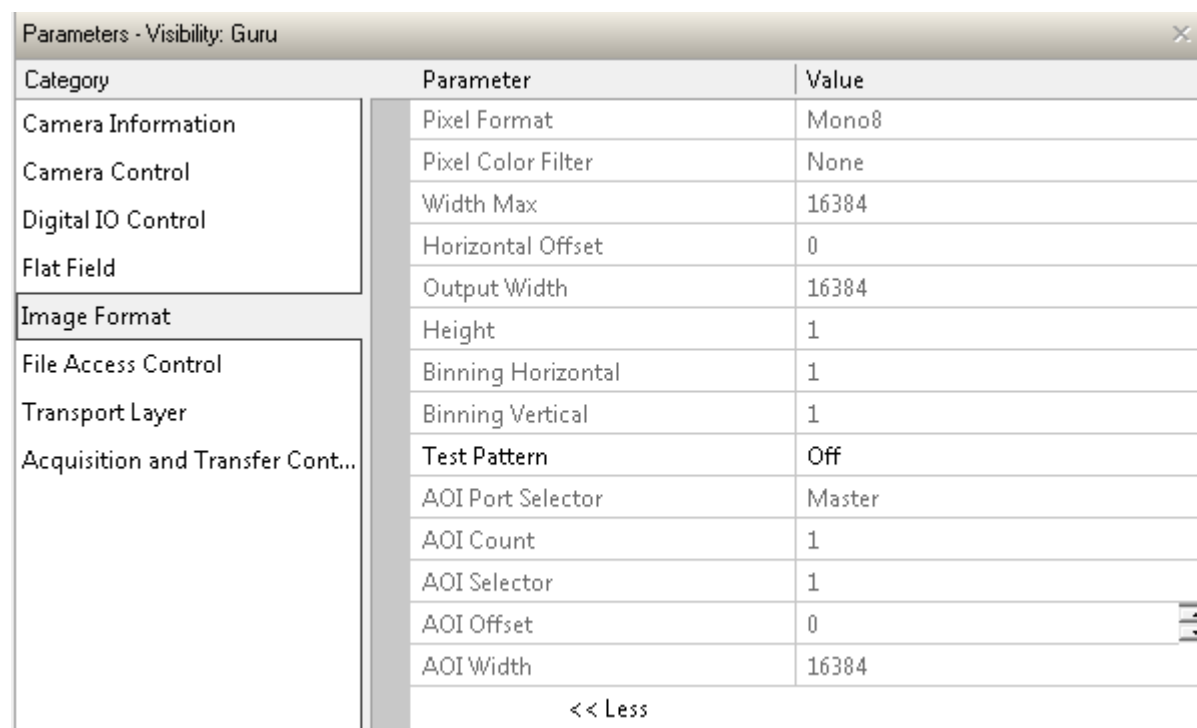
Display Name	Feature	Description	Device Version & View
Mode	flatfieldCorrectionMode		1.00
Off	Off	FPN and flat field coefficients disabled.	Beginner
On	On	FPN and flat field coefficients enabled.	DFNC
Clear Coefficients	Initialize	Reset all FPN to 0 and all flat field coefficients to 1.	
Calibration Algorithm	flatfieldCorrectionAlgorithm		1.00
Basic	Basic	Selection between two different flat field algorithms. Direct calculation of coefficients based on average line values and target. First each color is flat fielded to its peak value and then the color gains are used to achieve the target.	Beginner DFNC

Display Name	Feature	Description	Device Version & View
LowPass	LowPass	A low pass filter is first applied to the average line values before calculating the coefficients. Use this algorithm if the calibration target is not uniformly white or it is not possible to defocus the image. Because of the low pass filter this algorithm is not able to correct pixel-to-pixel variations and so it is preferable to use the "Basic" algorithm.	
ROI Offset X	flatfieldCalibrationROIOffsetX	Set the starting point of a region of interest where a flat field calibration will be performed	1.00 Beginner DFNC
ROI Width	flatfieldCalibrationROIWidth	Sets the width of the region on interest where a flat field calibration will be performed	1.00 Beginner DFNC
Calibrate FPN	flatfieldCalibrationFPN	Initiates the FPN calibration process	1.00 Beginner DFNC
Calibrate PRNU	flatfieldCalibrationPRNU	Initiates the Flat Field (PRNU) process	1.00 Beginner DFNC
Auto Calibration	flatfieldAutoCalibrationDark	Allows the customer to initiate an auto calibration cycle.	1.00 Beginner DFNC
Output HDR LUT Mode	lutMode	Allows the output LUT to be selected	1.00 Beginner DFNC
Off	Off	The output LUT is disabled and linear data is output	
Gamma Correction User Defined	Gamma Correction User Defined	Gamma correction table is used LUT download by the user is used.	
Gamma Correction	gammaCorrection	Sets the output LUT gamma correction factor	.00 Beginner DFNC



## Image Format Control Category

The Piranha XL Image Format controls, as shown by CamExpert, groups parameters used to configure camera pixel format, image cropping, binning and test pattern generation features.



Parameters - Visibility: Guru		
Category	Parameter	Value
Camera Information	Pixel Format	Mono8
Camera Control	Pixel Color Filter	None
Digital IO Control	Width Max	16384
Flat Field	Horizontal Offset	0
Image Format	Output Width	16384
File Access Control	Height	1
Transport Layer	Binning Horizontal	1
Acquisition and Transfer Cont...	Binning Vertical	1
	Test Pattern	Off
	AOI Port Selector	Master
	AOI Count	1
	AOI Selector	1
	AOI Offset	0
	AOI Width	16384
	<< Less	

Figure 16: Image Format Panel

## Image Format Control Feature Description

Display Name	Feature	Description	Device Version & View
Test Pattern	TestImageSelector	Selects the type of test image that is sent by the camera. Choices are either as defined by SNFC and/or as provided by the device manufacturer.	1.00 Beginner DFNC
Off	Off	Selects sensor video to be output from sensor	
Each Tap Fixed	Each Tap Fixed	Selects a grey scale for each tap of the sensor	1.00 Beginner DFNC
Grey Horizontal Ramp	Grey Horizontal Ramp	Select a grey scale ramp for each tap of the sensor	
Pixel Format	Pixel Format	Output image pixel coding format of the sensor. For Piranha XL, this currently is 8,12 for normal TDI operation and 16 bits for high dynamic range 'Fusion' mode	1.00 Invisible DFNC
Mono8			
Mono12			
Mono16			
Vertical Binning	BinningVertical	Number of vertically adjacent pixels to sum together. This increases the intensity of the pixels and reduces the vertical resolution of the image	1.00 Beginner SFNC
Horizontal Binning	BinningHorizontal	Number of horizontally adjacent pixels to sum together. This increases the intensity of the pixels and reduces the horizontal resolution of the image	1.00 Beginner SFNC
AOI Count	multipleROICount	Specified the number of AOI's in an acquired image	1.00 Beginner SFNC
AOI Selector	multipleROISelector	Select 1 of up to 4 AOI's when setting the AOI Offset & AOI Width	1.00 Beginner SFNC
AOI Offset	multipleROIOffsetX	Location of the start of a single Area of a Interest to be output on the cable specified by CLHS Port AOI Selector feature	1.00 Beginner
AOI Width	multipleROIWidth	Width of the start of a single Area of a Interest to be output on the cable specified by CLHS Port AOI Selector feature	1.00 Beginner
AOI Port Selector	PortRoiSelector	Used to select which cable the AOI values are applied.	1.00 Beginner
Master	Master	Selects Master (Control/Data1) data port	
Slave	Slave	Selects Slave (Data2) data port	
Max Width	WidthMax	The maximum image horizontal dimension of the image. (RO)	1.00 Beginner
Height	Height	Height of the Image provided by the device (in lines). (RO)	1.00 Beginner
Input Pixel Size	pixelSizeInput	Size of the image input pixels, in bits per pixel. (RO)	1.00 DFNC Invisible

10 Bits/Pixel  
12 Bits/Pixel  
16 Bits/Pixel

Bpp10  
Bpp12  
Bpp 16

Senor input data path is 8, 12 or 16 bits per pixel.

## Transport Layer Control Category

Note: All features shown in Guru visibility.

Parameters - Visibility: Guru		
Category	Parameter	Value
Camera Information	XML Major Version	47
	XML Minor Version	2
Camera Control	CLHS Discovery	Discovery Disabled
	Next CLHS Device Configuration	One Cable Seven Lanes
Digital IO Control	CLHS 8b/10b Receive Error Count...	Control / Data 1 Receive Error Count
	CLHS 8b/10b Receive Error Count	255
Flat Field	Refresh CLHS 8b/10b Receive Err...	Press...
	Reset Receive Error Count	Press...
Image Format	Refresh GenCP Status	Press...
	Last GenCP Status	Good
<< Less		

Figure 17: Transport Layer Panel

## Transport Layer Feature Descriptions

Display Name	Feature	Description	Device Version & View
XML Major Version	DeviceManifestXMLMajorVersion	Together with DeviceManifestXMLMinorVersion specifies the GenICam™ feature description XML file version (RO)	1.00 Beginner DFNC
XML Minor Version	DeviceManifestXMLMinorVersion	Together with DeviceManifestXMLMajorVersion specifies the GenICam™ feature description XML file version (RO)	1.00 Beginner DFNC
Refresh GenCP Status	refreshGenCPStatus	Press to return the current status of the GenCP	1.00 Beginner
Last GenCP Status	genCPStatus	If a feature read or write fails then Samera only returns that it fails – read this feature to get the actual reason for the failure Returns the last error Reading this feature clears it	1.00 Beginner DFNC
CLHS Discovery	clhsDiscovery	Selects between CLHS discovery mode which automatically determines the configuration of the CLHS interface when enabled. When disabled, the frame grabber needs to have the configuration set by the user  CLHS transmitters are enabled immediately on power up  CLHS transmitters enable after sending Acquisition start	1.00 Guru DFNC
Discovery Disabled			
Discovery Enabled			
Next CLHS Device Configuration	clhsNext DeviceConfig	When the camera is next powered up, the specified CLHS lane configuration will be set for the camera.	1.00 Guru DFNC
One cable seven lanes			
One cable four lanes			
One cable one lanes			
Two cable seven lanes			
Two cable four lanes			
Two cable one lanes			

CLHS 8b/10b Receive Error Count selector	clhsErrorCountSelector	Selects the error count that the following three features apply to	1.00 Guru DFNC
Data 2 Receive Error Count			
Control/Data1 Receive Error Count			
CLHS 8b/10b Receive Error Count	clhsError Count	CLHS error count value for the selected data/control lanes (RO)	1.00 Guru DFNC
Refresh CLHS 8b/10b Receive Error Count	clhsError CountRefresh	When pressed, the error count is updated	1.00 Guru DFNC
Reset Receive Error Count	clhsErrorCountReset	When pressed, the error count is rest to zero	1.00 Guru DFNC

## Acquisition and Transfer Control Category

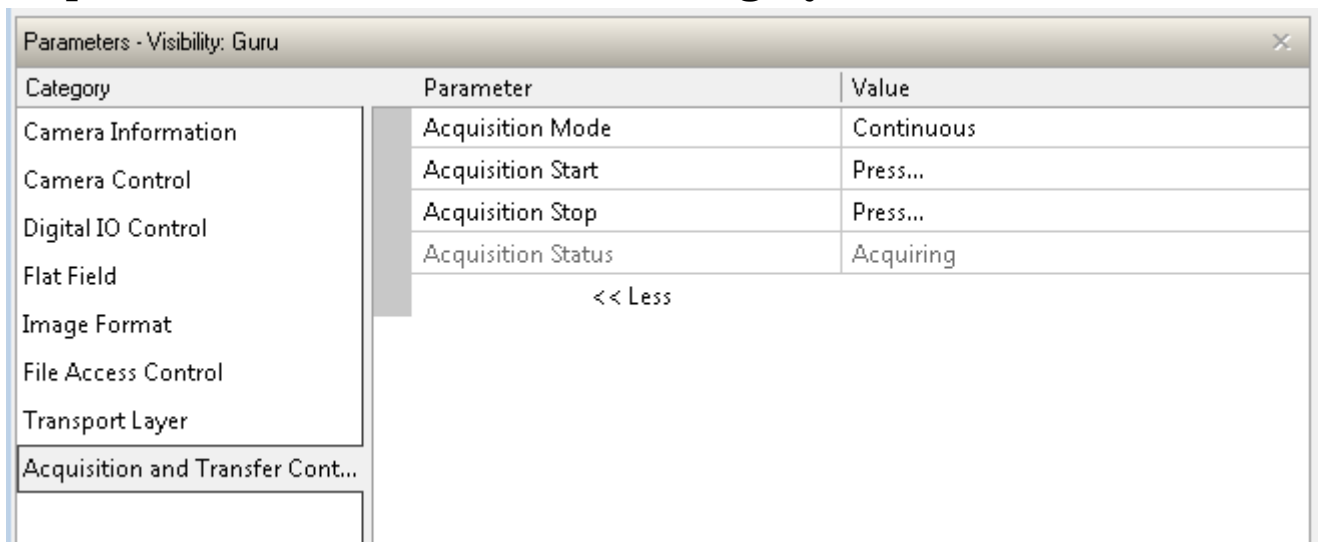


Figure 18: Acquisition & Transfer Control Panel

## Acquisition and Transfer Control Feature Descriptions

Display Name	Feature	Description	Device Version & View
Acquisition Mode	AquisitionMode	The device acquisition mode defines the number of frames to capture during an acquisition and the way it stops Only continuous mode is currently available	1.00 Beginner DFNC
Continuous			
Acquisition Start	AquisitionStart	Starts the acquisition of image data. The number of frames captured is defined by the Acquisition Mode. (WO)	1.00 Beginner DFNC

Acquisition Stop	AquisitionStop	Stops the acquisition of image data at the end of the next frame(s) sequence (WO)	1.00 Beginner DFNC
Acquisition Status	AquisitionStatus	Indicates whether the camera has been commanded to stop or to send image data.	1.00 Beginner DFNC

## File Access Control Category

The File Access control in CamExpert allows the user to quickly upload and download of various data files to the connected Piranha XL camera. The supported data files for the Piranha XL camera include firmware updates and Flat Field coefficients.

Note that the communication performance when reading and writing large files can be improved by stopping image acquisition during the transfer.

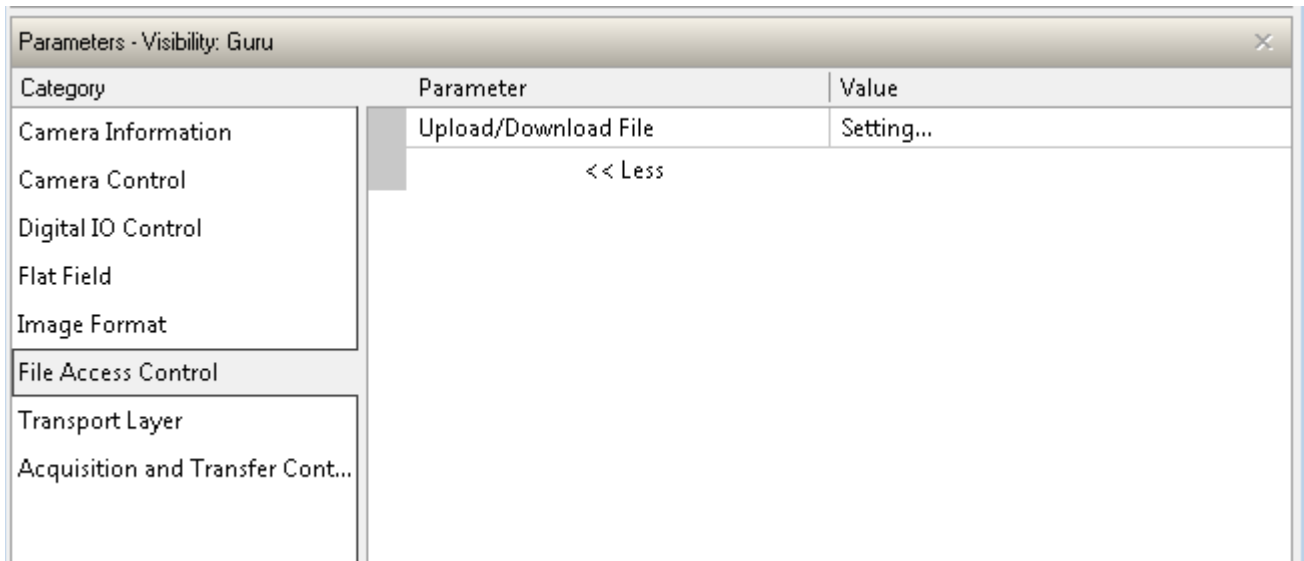


Figure 19: File Access Control Panel

## File Access Control Feature Descriptions

Display Name	Feature	Description	View
File Selector	FileSelector	Selects the file to access. The file types which are accessible are device-dependent.	1.00 Beginner
All Firmware		Upload micro code, FPGA code & XML as a single file to the camera which will execute on the next camera reboot cycle.	DFNC
Microcode		Upload micro to the camera which will execute on the next camera reboot cycle.	
XML		Upload XML to the camera which will execute on the next camera reboot cycle	
User Set		Use UserSetSelector to specify which user set to access.	
User FlatField coefficients		Use UserSetSelector to specify which user flatfield to access.	
User FPN		Use UserSetSelector to specify which user FPN to access.	

Display Name	Feature	Description	View
CameraData		Download camera information and send for customer support.	
File Operation Selector	FileOperationSelector	Selects the target operation for the selected file in the device. This operation is executed when the File Operation Execute feature is called.	1.00 Guru
Open	Open	Select the Open operation - executed by FileOperationExecute.	
Close	Close	Select the Close operation - executed by FileOperationExecute.	
Read	Read	Select the Read operation - executed by FileOperationExecute.	
Write	Write	Select the Write operation - executed by FileOperationExecute.	
Delete	Delete	Select the Delete operation - executed by FileOperationExecute.	
File Operation Execute	FileOperationExecute	Executes the operation selected by File Operation Selector on the selected file.	1.00 Guru
File Open Mode	FileOpenMode	Selects the access mode used to open a file on the device.	1.00 Guru
Read	Read	Select READ only open mode	
Write	Write	Select WRITE only open mode	
File Access Buffer	FileAccessBuffer	Defines the intermediate access buffer that allows the exchange of data between the device file storage and the application.	1.00 Guru
File Access Offset	FileAccessOffset	Controls the mapping offset between the device file storage and the file access buffer.	1.00 Guru
File Access Length	FileAccessLength	Controls the mapping length between the device file storage and the file access buffer.	1.00 Guru
File Operation Status	FileOperationStatus	Displays the file operation execution status. (RO).	1.00 Guru
Success	Success	The last file operation has completed successfully.	
Failure	Failure	The last file operation has completed unsuccessfully for an unknown reason.	
File Unavailable	FileUnavailable	The last file operation has completed unsuccessfully because the file is currently unavailable.	
File Invalid	FileInvalid	The last file operation has completed unsuccessfully because the selected file is not present in this camera model.	
File Operation Result	FileOperationResult	Displays the file operation result. For Read or Write operations, the number of successfully read/written bytes is returned. (RO)	1.00 Guru
File Size	FileSize	Represents the size of the selected file in bytes.	1.00 Guru

## File Access via the CamExpert Tool

1. Click on the “Setting...” button to show the file selection menu.

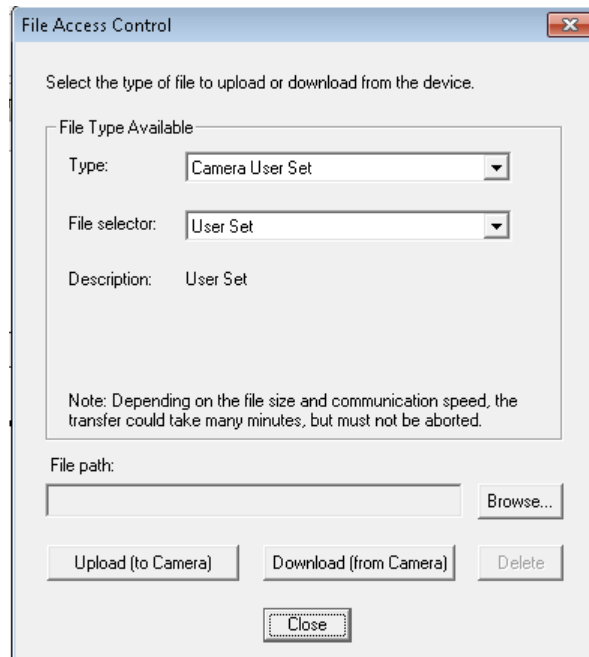


Figure 20: File Access Control Tool

2. From the Type drop menu, select the file type that will be uploaded to the camera.
3. From the File Selector drop menu, select the data to be uploaded.
4. Click the Browse button to open a typical Windows Explorer window.
5. Select the specific file from the system drive or from a network location.
6. Click the Upload button to execute the file transfer to the camera.
7. Note that firmware changes require that the camera be powered down and then back up. Additionally, CamExpert should be shutdown and restarted following a reset.

## Download a List of Camera Parameters

For diagnostic purposes you may want to download a list of all the parameters and values associated with the camera.

1. Go to File Access Control
2. Click on Settings
3. In the “Type” drop down box select “Miscellaneous.”
4. In the “File selector” drop down box select “CameraData.”
5. Hit “Download”
6. Save the text file and send the file to Teledyne DALSA customer support.



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# Appendix B: Trouble Shooting Guide

## Diagnostic Tools

### Camera Data File

The Camera Data file includes the operational configuration and status of the camera plus a record of recent commands sent to the camera along with status responses. This text file can be downloaded from the camera and forwarded to Teledyne DALSA Technical Customer support team to aid in diagnosis of any reported issues. See Saving & Restoring Camera Setup Configurations of the Piranha XL User Manual for details on downloading the Camera Data file.

### Voltage & Temperature Measurement

The camera has the ability to measure the input supply voltage at the power connector and to measure the internal temperature. Both of these features can be accessed using the Camera CamExpertGUI > Camera Information tab. Press the associated refresh button to receive a real-time measurement.

### Test Patterns – What can they indicate

The camera can generate fixed test patterns that may be used to determine the integrity of the CLHS communications beyond the Lock status. The test patterns give the user the ability to detect bit errors using an appropriate host application. This error detection would be difficult, if not impossible, using normal image data.

There are five test patterns that can be selected via the Cameras CamExpertGUI > Image Format tab. They have the following format when using 8-bit data.

- Each Tap Fixed
  - Starting at 08H increases in by 10H steps every 1K pixels ending in F8H except first and last 16 pixels are 01H
- Grey Horizontal Ramp
  - 64 horizontal ramps starting at 00H increases in by 01H every pixel ending in FFH except first and last 16 pixels are 01H
- Grey Vertical Ramp
- Grey Diagonal Ramp
- User Pattern
  - When selected, the camera will first output all pixels values to be half full scale. The user can then generate a custom test pattern by uploading PRNU coefficients that appropriately manipulate the half scale data to achieve the desired pattern. See section *Setting Custom PRNU Coefficients* for details.

### Built-In Self-Test Codes

The Built-In Self-test (BIST) codes are located in the Camera Information pane.

*Note. Items in italics are specific to the internal hardware of the camera and will only be useful to the User when communicating potential issues with Teledyne DALSA technical support team.*

What each flag signifies:

BIST Error Description	Status Code (Bit Set)	Potential Cause
SUCCESS	0x00000000	No errors detected
I2C Error	0x00000001	Camera internal hardware
FPGA_NO_INIT	0x00000002	Camera internal hardware
FPGA_NO_DONE	0x00000004	Camera internal hardware
EXT_SRAM_ERROR	0x00000008	Camera internal hardware
ECHO_BACK_ERROR	0x00000010	Camera internal hardware
FLASH_TIMEOUT	0x00000020	Camera internal hardware
FLASH_ERROR	0x00000040	Camera internal hardware
NO_FPGA_CODE	0x00000080	Camera internal hardware
NO_COMMON_SETTINGS	0x00000100	Camera internal hardware
NO_FACTORY_SETTINGS	0x00000200	Camera internal hardware
OVER_TEMPERATURE	0x00000400	The camera has detected excessive internal temperatures and has partially shut down for protection. Remove power to recover and improve airflow over the camera fins
(reserved)	0x00000800	-
NO_USER_FPN	0x00001000	The user has yet to save any FPN calibration data to a User Set. (Note. Default values should have been set by the factory)
NO_USER_PRNU	0x00002000	The user has yet to save any PRNU calibration data to a User Set. (Note. Default values should have been set by the factory)
CLHS_TXRDY_RETRY	0x00004000	The camera cannot establish CLHS communications with the frame grabber. Check the CLHS connection integrity.
INVALID_UPGRADE	0x00008000	An invalid file format or type was used when trying to upgrade software or coefficients.
NO_USER_SETTINGS	0x00010000	The User has yet to save a User Set (Note. Default values should have been set by the factory)
NO_ADC_COEFFICIENTS	0x00020000	Camera internal hardware
NO_SCRIPT	0x00040000	Camera internal hardware

## Status LED

A single red/green LED is located on the back of the camera to indicate status.

LED State	Description
Off	Camera not power up or waiting for the software to start
Constant Red	The camera BIST status is not good. See BIST status for diagnosis.
Blinking Red	The camera has shut down due to an over temperature condition.
Blinking Orange	Powering Up. The microprocessor is loading code.
Blinking Green	Hardware is good, but the CLHS connection has not been established or has recently been broken.
Constant Green	The CLHS Link has been established and data transfer may begin

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# Resolving Camera Issues

## Communications

### ***No Camera Features when Starting CamExpert***

If the camera's CamExpert GUI is opened and no features are listed, then the camera may be experiencing lane lock issues.

While using the frame grabber CamExpert GUI you should be able to see a row of status indicators below the image area that indicates the status of the CLHS communications. These indicators include seven lane lock status and a line valid (LVAL) status.

If the status for one or more lane locks is red, then there is likely an issue with the CLHS connectors at the camera and / or frame grabber. Ensure that the connectors are fully engaged and that the jack screws are tightened. Ensure that you are also using the recommended cables.

### ***No LVAL***

If the LVAL status is red and all lane locks are green, then there may be an issue with the camera receiving the encoder pulses.

1. From the Camera CamExpert > Digital I/O Control tab, select Internal Trigger Mode and set the CamExpert > Camera Control tab Acquisition Line Rate to the maximum that will be used.
2. The trigger signal from the frame grabber will not be used and the LVAL status should now be green. This will confirm the integrity of the image data portion of the CLHS cabling and connectors.
3. From the Camera CamExpert > Digital I/O Control tab, select External Trigger Mode.
4. From the Frame Grabber CamExpert > Advanced tab, select the Line Sync Source to be Internal Line Trigger and the Internal Line Trigger frequency to the maximum that will be used.
5. The trigger source is now being generated by the frame grabber and the LVAL status should be green. This will confirm the integrity of the General Purpose I / O portion of the CLHS cabling and connectors.
6. From the Frame Grabber CamExpert > Advanced tab, select the Line Sync Source to be External Line Trigger and select the Line Trigger Method to Method 2 under the same tab.
7. From the Frame Grabber CamExpert > External Trigger tab, select External Trigger to be enabled. If LVAL status turns red, check the following:
  - a. Is the transport system moving such that encoder pulses are being generated?
  - b. Has the encoder signal been connected to the correct pins of the I / O connector of the frame grabber? See the XTNUM frame grabber user manual for details.
  - c. Do the encoder signal levels conform to the requirements outlined in the XTNUM frame grabber user manual?

## Image Quality Issues

### ***Vertical Lines Appear in Image after Calibration***

The purpose of flat field calibration is to compensate for the lens edge roll-off and imperfections in the illumination profiles by creating a uniform response. When performing a flat field calibration, the camera must be imaging a flat white target that is illuminated by the actual lighting used in the application. Though the camera compensates for illumination imperfection, it will also compensate for imperfections such as dust, scratches, paper grain, etc. in the white reference. Once the white reference is removed and the camera images the material to be inspected, any white reference

imperfections will appear as vertical stripes in the image. If the white reference had imperfections that caused dark features, there will be a bright vertical line during normal imaging. Similarly, bright features will cause dark lines. It can be very difficult to achieve a perfectly uniform, defect-free white reference. The following two approaches can help in minimizing the effects of white reference defects:

1. Move the white reference closer to or further away from the object plane such that it is out of focus. This can be effective if the illumination profile changes minimally when relocating the white reference.
2. If the white reference must be located at the object plane, then move the white reference in the scan direction or sideways when flat field calibration is being performed. The camera averages several thousand lines when capturing calibration reference images so any small imperfections are averaged out.
3. Use the camera's flat field calibration filter feature, as detailed in the user manual Flat Field Calibration Filter section. This algorithm implements a low pass moving average that covers several adjacent pixels. This filter can help minimize the effects of minor imperfections in the white reference. Note: this filter is NOT USED in normal imaging.

### ***Over Time, Some Pixels Develop Low Response***

When flat field calibration is performed with a white reference as per the guidelines in the user manual, all pixels should achieve the same response. However, over time, dust within the lens extension tube may migrate to the sensor surface thereby reducing the response of certain pixels. If the dust particles are very small, they may have only a minor effect on responsivity, but still produce vertical dark lines that interfere with defect detection and need to be corrected.

Repeating the flat field calibration with a white reference may not be practical with the camera installed in the system. The camera has a feature where the flat field coefficients can be downloaded to the host PC and adjusted using a suitable application, such as Microsoft Excel. (See section *Setting Custom PRNU Coefficients* for details. If the pixel location that has a low response can be identified from the image, then the correction coefficient of that pixel can be adjusted, saved as a new file, and then uploaded to the camera, thereby correcting the image without performing flat field calibration.

See the user manual for details on downloading and uploading camera files using CamExpert.

Note that dust accumulation on the lens will not cause vertical lines. However, heavy accumulation of dust on the lens will eventually degrade camera responsivity and focus quality.

### ***Smeared & Distorted Images***

The camera achieves its high responsivity by accumulating 4, 8 or 12 lines in the sensor. To achieve a well-defined image, the multiple lines are summed together in a manner that matches the motion of the image across the sensor. This synchronization is achieved by the user providing an external synchronization (EXSYNC) signal to the camera, where one pulse is generated when the object moves by the size of one object pixel. See 'External Trigger Mode' in the user manual.

Any transport motion that is not correctly reflected in the EXSYNC pulses will cause image distortion in the scan direction. For standard line scan cameras, this type of image distortion may not greatly affect edge sharpness and small defect contrast, thereby having minimal impact on defect detection. However, TDI image quality is more sensitive to object motion synchronization errors. The following subsections discuss various causes for poor image quality as a result of EXSYNC not accurately reflecting object motion.

### ***Continuously Smeared, Compressed or Stretched Images***

When accurate synchronization is not achieved, the image will appear smeared in the scan direction. If the EXSYNC pulses are coming too fast, then the image will appear smeared and stretched in the machine direction. If the pulses are too slow, then the image will appear smeared and compressed. Check the resolution of the encoder used to generate the EXSYNC pulses along with the size of the rollers, pulleys, gearing, etc. to ensure that one pulse is generated for one pixel size of travel of the object.

It is also important that the direction of image travel across the sensor is per the camera's scan direction set by the user. See 'Scan Direction' in the user manual for more information. If the scan direction is incorrect, then the image will have a significant smear in the scan direction. Changing the scan direction to the opposite direction should resolve this problem. Refer to 'Camera Orientation' in the user manual to determine the correct direction orientation for the camera. Note that the lens has a reversing effect on motion. That is, if an object passes the lens-outfitted camera from left to right, the image on the sensor will pass from right to left. The diagrams in the user manual take the lens effect into account.

### ***Randomly Compressed Images***

It is possible that when the scan speed nears the maximum allowed, based on the exposure time used, the image will be randomly compressed and possibly smeared for small periods in the scan direction. This is indicative of the inspection systems transport mechanism dynamics causing momentary over-speed conditions. The camera can tolerate very short durations of over-speed but if it lasts too long, then the camera can only maintain its maximum line rate and some EXSYNC pulses will be ignored, resulting in the occasional compressed image.

The over-speeding may be due to inertia and / or backlash in the mechanical drive mechanism causing variations around the target speed. The greater the speed variation, the lower the target speed needs to be to avoid over-speed conditions. If the speed variation can be reduced by eliminating the backlash in the transport mechanism and / or optimizing the motor controller characteristics, then a higher target speed will be achievable.

### ***Distorted Image when Stopping and Starting***

The camera has a stop / start capability unique to TDI imaging and one that customers may not be familiar with. It may expose motion issues in a system that were not apparent previously. The camera is sensitive to any mismatch in object motion with respect to EXSYNC, as this will cause a smeared, distorted image. When the user is using the camera in a stop / start condition, great care must be taken to ensure that the EXSYNC pulses accurately reflect the object motion when stopping and starting occurs and that there is no momentary backwards motion. Any backlash in the transport mechanism could cause these types of problems due to acceleration transients when stopping and starting.

Below is an example of the precautions necessary to achieve a smooth start to imaging from a stopped condition using a non-ideal transport mechanism.

The test bench transport mechanism discussed here has an encoder which is an integrated part of the servo drive motor. There is a gear reduction and screw mechanism that attaches the motor / encoder to a slide that supports the object to be imaged. This setup includes some backlash between the slide and motor / encoder which creates an object motion to EXSYNC mismatch at the start and stop of travel. The whole test setup also vibrates for some time after it stops due to the acceleration transient. To achieve the best possible start up image quality with this non-ideal transport mechanism, the following precautions had to be taken with the transport control:

1. Before imaging was triggered, the transport was moved forward a few millimetres at a very slow speed and stopped to take up the slack.
2. The transport was then stopped for a sufficient time for the vibrations to die out.
3. Image capture could then be enabled and the transport ramped up to the target speed
4. S-Curve acceleration profiles were used to minimize rapid velocity changes.

Even with these precautions, some image distortion could still be seen. It is assumed that the user will have much better transport system than this demonstration test bench. However, users may still experience similar issues, especially when they working with very high object resolutions.

### ***Distorted Image when Changing Direction***

The camera achieves its high responsivity by accumulating 4, 8 or 12 rows within in the sensor in a fashion that accurately follows the object motion. When the scan direction changes the multiple line TDI accumulation process must reverse to match the reversed image motion across the sensor. Only when all rows being accumulated have received the same image will the output be correct. Prior to this some lines have been exposed to one direction and other lines exposed to the opposite direction in the accumulated output. The camera will output a number of invalid rows immediately after a direction change as follows:

Number of Rows Selected	Number of Invalid Rows After Direction Change
4	7
8	15
12	23

That is, when changing direction the first  $2 \times \text{\#Rows} - 1$  should be ignored.

Notes:

1. The camera has a single line gap between each light sensitive row, thus the  $2 \times \text{\#Rows} - 1$  invalid rows.
2. The camera does not drop invalid rows as some applications have issues when the number of EXSYNC pulses sent to the camera does not match the number of lines output from the camera.

### ***Optical Misalignment Issues***

As with all TDI cameras, image quality is sensitive to how accurate the image movement is aligned to the pixels as it tracks over each row of the sensor. The greater the number of rows, the more sensitive image quality will be to misalignment. The camera's maximum number of selectable rows is 12, which is far less than some CCD TDI cameras. However, maintaining accurate alignment should still be a priority.

The following sections detail the causes of possible image quality problems with respect to optical misalignment and how to identify them.

### ***Image Will Not Focus Well over the Entire FOV***

If the image is skewed with respect to the sensor pixel array, then a sharp image perpendicular to object travel will not be achievable regardless of attempts to adjust focus. This is due to a component of the image motion traveling in the long axis of the sensing array.

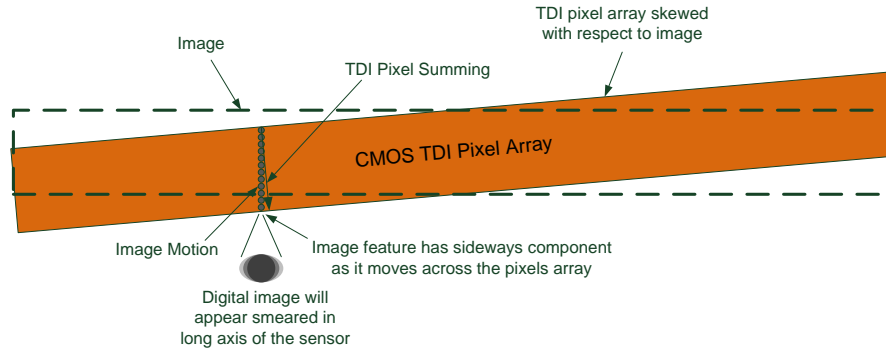


Figure 21 Effects of Camera Skew

The camera mounting assembly should have a mechanism to minimize any skew between the image motion and TDI summing direction.

For example, for 12 rows and no more than  $\frac{1}{4}$  pixel movement along the long axis, skew will need to be less than  $\tan^{-1} (0.25\text{pixel}/12\text{rows} + 11\text{spaces}) = 0.6^\circ$ .

### ***Image Will Not Focus at Edges of Field of View.***

If sharp focus can be achieved at the centre of the image but not at the edges, this may be due to the camera's optical axis not being perpendicular to the material surface in the scan direction. If the optical axis is not perpendicular, then this will cause a parallax issue at the edges of the field of view resulting in a component of image motion traveling in the long axis of the sensing array.

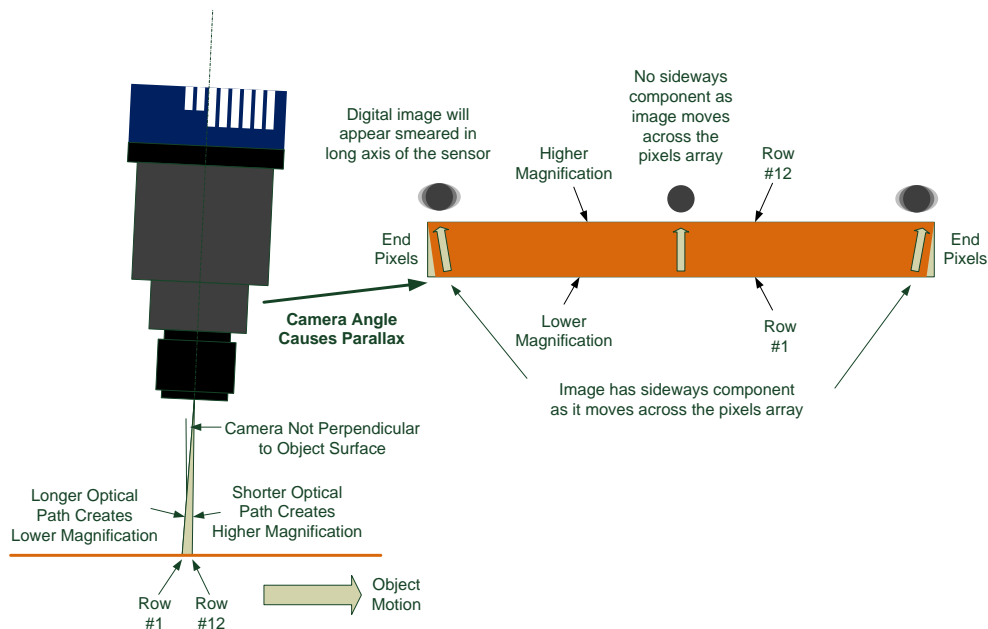


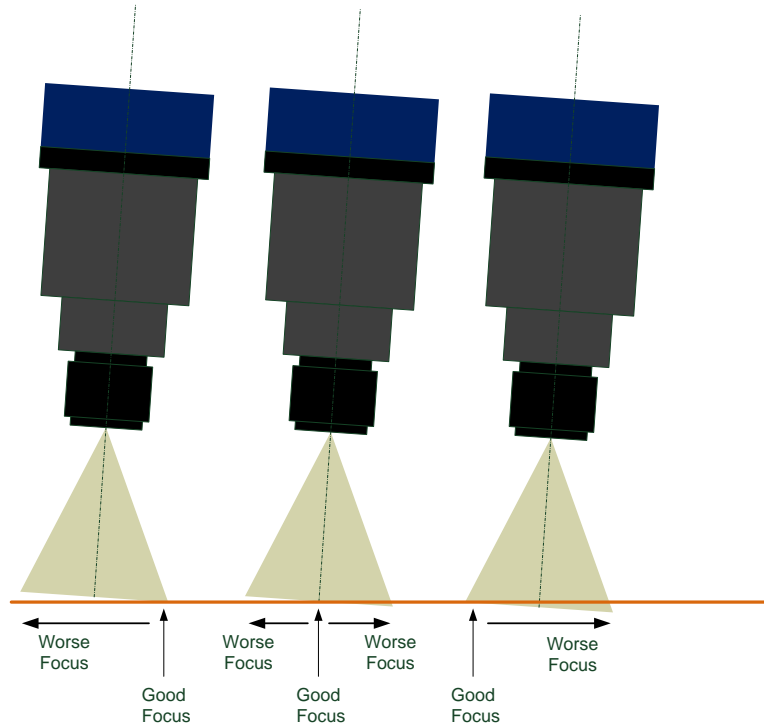
Figure 22 Effects of Camera Tilt in Scan Direction

Though the Piranha camera only has a maximum of 12 rows, the tolerable angle that does not cause a parallax issue is still quite small. For example, assume that a satisfactory image quality can be achieved with  $\frac{1}{4}$  pixel sideways motion at the end pixels and a 120 mm lens with magnification of 0.5. This would require that the camera's optical axis to be within  $\pm 3.5^\circ$  from perpendicular.

Note: If you have confirmed that the camera's optical axis is perpendicular to the material surface and you still have difficulty focusing at the edges, then check that the lens specification for MTF characteristics over the entire field of view. The MTF of lenses typically reduces at the edges of the field of view.

### ***Image Will Focus Well on One Side but Not the Other at the Same Time***

If sharp focus can be achieved at only one location of the sensor's field of view and progressively gets worse from that point, then the camera may not be perpendicular to the object surface with respect to the long axis of the sensor.



*Figure 23 Effects of Camera Tilt In the Long Sensor Axis*

A mechanical means to adjust this angle may need to be incorporated into the camera mount. This becomes a finer, more precise adjustment as the magnification increases, especially above 1x, as the depth of field becomes progressively smaller. The two examples below demonstrate this characteristic.

Assume the use of a 120 mm lens set at f5.6 and Circle of Confusion = 2 pixels.

Example A: Magnification of 0.5X

Depth of Field = 1.34mm

Field of View =  $16352 \times 10\mu\text{m} = 163.52\text{mm}$

Requires the camera optical axis to be within  $\pm 0.94^\circ$  from perpendicular

Example B: Magnification of 2X

Depth of Field = 0.042mm

Field of View =  $16352 \times 2.5\mu\text{m} = 40.88\text{mm}$

Requires the camera optical axis to be within  $\pm 0.12^\circ$  from perpendicular



## Power Supply Issues

For reliable operation the camera input supply must be within +12 V to + 24 V.

The power supply to the camera should be suitably current limited as per the applied input voltage of between +12 V to +24 V. Assume a worst case power consumption of 24 W and a 150% current rating for the breaker or fuse. Note that the camera will not start to draw current until the input supply is above approximately 10.5 V and 200 msec has elapsed. If the power supply stabilizes in less than 200 msec, then inrush current will not exceed normal operating current.

It is important to consider how much voltage loss occurs in the power supply cabling to the camera, particularly if the power cable is long and the supply is operating at 12V where the current draw is highest. Reading the input supply voltage as measured by the camera will give an indication of the supply drop being experienced.

The camera tolerates "hot" unplugging and plugging.

The camera has been designed to protect against accidental application of an incorrect input supply, up to reasonable limits. With the following input power issues, the status LED will be OFF.

- The camera will protect against the application of voltages above approximately +28 V. If the overvoltage protection threshold is exceeded, then power is turned off to the camera's internal circuitry. The power supply must be recycled to recover camera operation. The input protection circuitry is rated up to an absolute maximum of +30 V. Beyond this voltage, the camera may be damaged.
- The camera will also protect against the accidental application of a reverse input supply up to a maximum of -30 V. Beyond this voltage, the camera may be damaged

## Causes for Overheating & Power Shut Down

For reliable operation, the camera's face plate temperature should be kept below 65°C and the internal temperature kept below 70°C.

Many applications, such as in clean rooms, cannot tolerate the use of forced air cooling (fans) and therefore must rely on convection. The camera's body has been designed with integrated heat fins to assist with convection cooling. The fins are sufficient to keep the camera at an acceptable temperature if convection flow is unimpeded. The camera also benefits by conducting heat away via the face plate into the lens extension tubes and camera mount. It is therefore important not to restrict convection airflow around the camera body, especially the fins and the lens assembly and camera mount. Lowering the ambient temperature will equally lower the camera's temperature.

If the camera's internal temperature exceeds 80 °C, then the camera will partially shut down to protect against damage.

Commands can still be sent to the camera to read the temperature, but the image sensor will not be operational and LVAL in response to line triggers will not be generated. Additionally, the camera's power will reduce by approximately 70% of normal operation. If the camera's temperature continues to rise, at 90°C the camera will further reduce its power to approximately 30% of normal operation and any communication with the camera will not be possible. The only means to recover from a thermal shutdown is to turn the camera's power off. Once the camera has cooled down, the camera data can be restored by re-applying power to the camera.

# Declaration Of Conformity



## EC & FCC DECLARATION OF CONFORMITY

We :  
Teledyne DALSA inc.  
605McMurray Road,  
Waterloo, Ontario, Canada,  
N2V 2E9

Declare under sole legal responsibility that the following products conform to the protection requirements of council directive 2004/108/EC (2014/30/EU after April 2016) on the approximation of the laws of member states relating to electromagnetic compatibility and are CE-marked accordingly:

Piranha XL, PX-HM-16K12B-00-R, PX-HM-16K06B-00-R

The products to which this declaration relates are in conformity with the following relevant harmonized standards, the reference numbers of which have been published in the Official Journal of the European Communities:

EN55032 (2012)	Electromagnetic compatibility of multimedia equipment — Emission requirements
EN55011 (2009) with A1(2010)	Industrial, scientific and medical equipment — Radio-frequency disturbance characteristics — Limits and methods of measurement
EN 61326-1 (2013)	Electrical equipment for measurement, control and laboratory use — EMC requirements — Part 1: General requirements
EN 55024 (2010)	Information technology equipment — Immunity characteristics — Limits and methods of measurement


Further declare under our sole legal responsibility that the product listed also conforms to the following international standards:

CFR 47	part 15 (2008), subpart B, for a class A product. Limits for digital devices
ICES-003	Information Technology Equipment (ITE) — Limits and Methods of Measurement
CISPR 11	Industrial, scientific and medical equipment - Radio-frequency disturbance characteristics - Limits and methods of measurement
CISPR 32	Electromagnetic compatibility of multimedia equipment - Emission requirements

Note: this product is intended to be a component of a larger system.

Waterloo, Canada  
Location

2015-08-25  
Date

  
Hank Helmond.  
Director, Quality Assurance

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