Linea ML Multispectral Cameras

ML-FC-08K07N

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

03-032-20271-01

www.teledynedalsa.com

TELEDYNE DALSA
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Notice

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About Teledyne DALSA
Teledyne DALSA, a business unit of Teledyne Digital Imaging Inc., is an international high performance semiconductor and electronics company that designs, develops, manufactures, and markets digital imaging products and solutions, in addition to providing wafer foundry services.

Teledyne DALSA Digital Imaging offers the widest range of machine vision components in the world. From industry-leading image sensors through powerful and sophisticated cameras, frame grabbers, vision processors and software to easy-to-use vision appliances and custom vision modules.

This document does not contain information whose export/transfer/disclosure is restricted by the Canadian Export Control regulation.

Contents

The Linea ML Multispectral Camera

Description

Teledyne DALSA introduces a breakthrough multiline CMOS linescan camera format with unprecedented speed, responsivity and exceptional low noise. The Linea ML™ multispectral cameras have 8k or 16k pixel resolution, a 5 µm x 5 µm pixel size, either RGB or RGB + NIR outputs, and are compatible with fast, high magnification lenses.

The cameras have a maximum line rate up to 300 kHz. Exposure control can be used for seamless, variable speed imaging.

The camera uses the Camera Link HS™ interface, which is the industry standard for very highspeed camera interfaces with long transmission distances and cable flexing requirements (SFP+ or CX4, resolution dependent).

Teledyne DALSA's Linea ML color camera and compatible frame grabber combine to offer a complete solution for the next generation of automatic optical inspection (AOI) systems.

This camera is recommended for detecting small defects at high speeds and over a large field of view in LCD and OLED flat panel displays, printed circuit boards, film, printed material, and large format web materials.

Available Camera Models

Table 1: Camera Model Part Numbers

Part Number	Description
ML-FC-08K07N-00-R	8,192 x 4 pixels, maximum line rate of 70 kHz x 4 (280 kHz aggregated), 5 µm x 5 µm pixel size, RGB + NIR output. 300 kHz line rate achievable using AOI.

Camera Highlights

Key Features

- Highly responsive multiline CMOS
- Quadlinear RGB + NIR outputs
- 8K or 16K pixel resolution
- Up to 300 kHz aggregated line rates
- Very low noise
- Bi-directionality with fixed optical center
- Binning
- Small form factor
- Robust Camera Link HS interface
- LC fiber optic Camera Link HS control & data connector
- Smart lens shading correction
- High dynamic LUT mode

Programmability

- Adjustable responsivity and white balancing
- Spatial correction including sub pixel adjustment
- Parallax correction
- Multiple areas of interest for data reduction
- Region of interest for easy calibration of lens and shading correction
- Test patterns & diagnostics

Applications

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

Part Numbers and Software Requirements

The camera is available in the following configurations:

Table 2: Camera Models Comparison

Part Number	Resolution	Maximum Line Rates	Pixel Size
ML-FC-08K07N-00R	8,192 pixels x 4 (RGB + NIR)	70 KHz (280 kHz, aggregate)	5.0 µm x 5.0 µm

Table 3: Frame Grabber

Compatible Frame grabber	Product Number / Version Number
Teledyne DALSA	OR-A8S0-FX840 (8K camera)

Table 4: 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	Latest version on the TeledyneDALSA Website
Camera Link HS	V 1.0

Performance Specifications

Table 5: Camera Performance Specifications

Specifications	Performance
Imager Format	High speed CMOS multiline quadlinear scan
ML-FC-08K07N-00-R	8,192 pixels x 4 (red + green + blue + NIR)
Pixel Size	5.0 µm x 5.0 µm
Pixel Fill Factor	88 %
Line Rate	280 kHz aggregate: 70 kHz x 4 (RGB + NIR) 300 kHz aggregate achievable using AOI
Exposure Time	2.4 µs to 1,400 µs
Bit Depth	8 bit
Connectors and Mechanicals	
Control & Data Interface	Camera Link HS LC fiber optic
Power	+12 V to +24 V DC, Hirose 12-pin circular
Typical Power Dissipation[1]	16 W
Size	76 mm (W) x 76 mm (H) x 85 mm (D)
Mass	< 500 grams
Operating Temp	+0 °C to +65°C, front plate temperature[2]
Optical Interface	
Lens Mount	M58 x 0.75 mm

Sensor to Camera Front Distance	12 mm	
Sensor Alignment (aligned to sides of camera)		
Flatness Θ y (parallelism) x y z Θ z	50 µm 100 µm ± 100 µm ± 100 µm ± 250 µm ± 0.4°	
Operating Ranges	**Performance (All models)**	**Notes**
Random Noise*	< 9 DN rms	12bit
Peak Responsivity *Blue* *Green* *Red* *NIR*	 Blue: 85 ± 10% Green: 130 ± 10% Red: 190 ± 10% NIR: 105 ± 10%	12bit DN/(nJ/cm^2)
DC Offset	15 ± 10% DN	Can be adjusted as required
Full Well	7,200 e-	Typical, single row
PRNU	< 4% DN p-p	12bit @ 50% of calibration target
DSNU (FPN)	< 4.8 DN p-p	12 bit
SEE *Blue* *Green* *Red* *NIR*	 Blue: 46 ± 20% Green: 30 ± 20% Red: 21 ± 20% NIR: 37 ± 20%"	12bit nJ/cm^2
NEE *Blue* *Green* *Red* *NIR*	 Blue: < 106 Green: < 70 Red: < 48 NIR: < 86	RN / Responsivity 12bit pJ/cm^2
Anti-blooming	> 100x Saturation	
Integral non-linearity	< 2%	

Notes:

*DN = digital number

1. Power dissipation increases with temperature.
2. Camera will shut down when the internal temperature reaches +80 ºC.

Test Conditions unless otherwise specified:

- *Note: Specifications are under specified operating conditions and may degrade as temperature limits are approached.*
- Values measured using 8-bit (unless stated otherwise), 1x gain.
- 40 kHz line rate.
- Light source: White LED if wavelength not specified.
- Front plate temperature: 45º C.

Environmental Specifications	
Storage temperature range	-20 °C to +80 °C
Humidity (storage and operation)	15% to 85% relative, non-condensing
MTBF (mean time between failures)	> 100,000 hours, typical field operation

Flash Memory Size

Table 6: Camera Flash Memory Size

Camera	Flash memory size
All models	4 GByte

Certification & Compliance

Table 7: Camera 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

Camera Pixel Arrangement

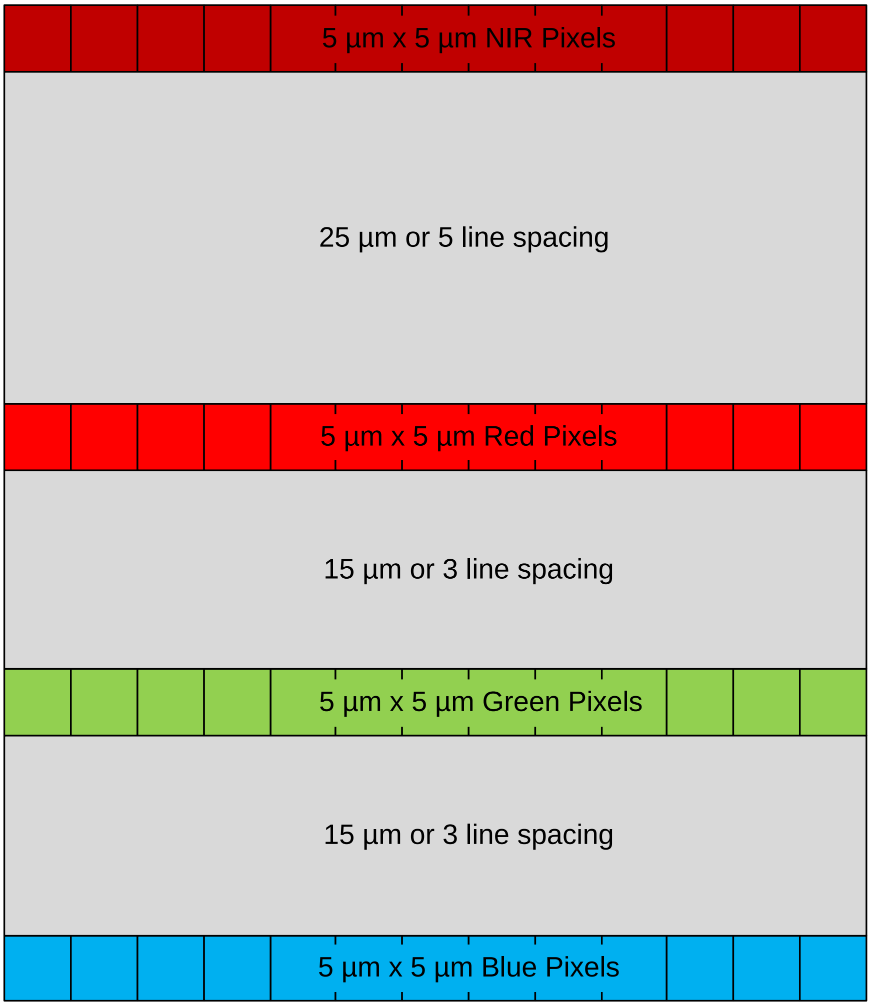


Figure 1 ML-FC-08K07N-00-R Color Pixel Structure

Forward and reverse imaging does not cause the optical center to change. Exposure control allows inspection speed to change without changing responsivity.

Camera Processing Chain

The diagram below details the sequence of arithmetic operations performed on the cameras sensor data, which the user can adjust to obtain an optimum image for their application. These adjustments are performed using camera features outlined in the 'Review of Camera Performance and Features' section.

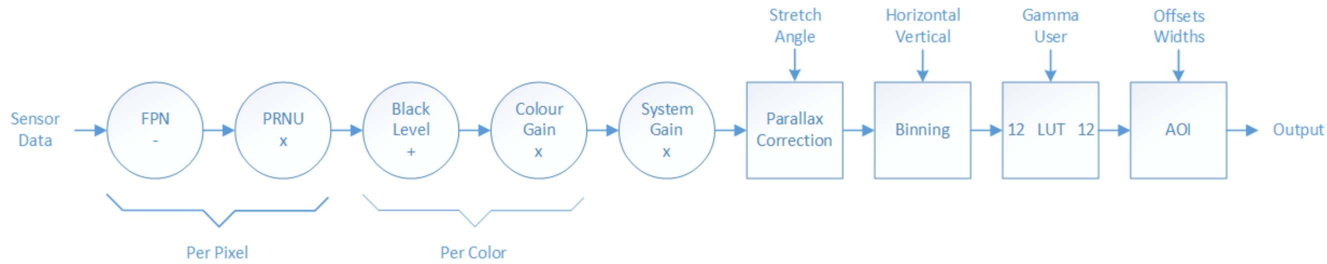


Figure 2: Sensor Data Processing Chain

Supported Industry Standards

GenICam™

The 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.

Camera Link HS

The camera is Camera Link HS (version 1.0) compliant. Camera Link HS is the next generation of high performance communications standards. It is used where an industrial digital camera interfaces with a single or multiple frame grabber and with data rates exceeding those supported by the standard Camera Link.

The cameras come with two different output mediums. For the 8K camera it uses two LC connectors for data output. These two LC connectors are part of the SFP+ standard but in the case of Linea ML 8K camera the SFP+ modules are built into the camera. Either one or both SFP+ modules can be used but using only one SFP+ / Fibre optic will sacrifice available bandwidth.

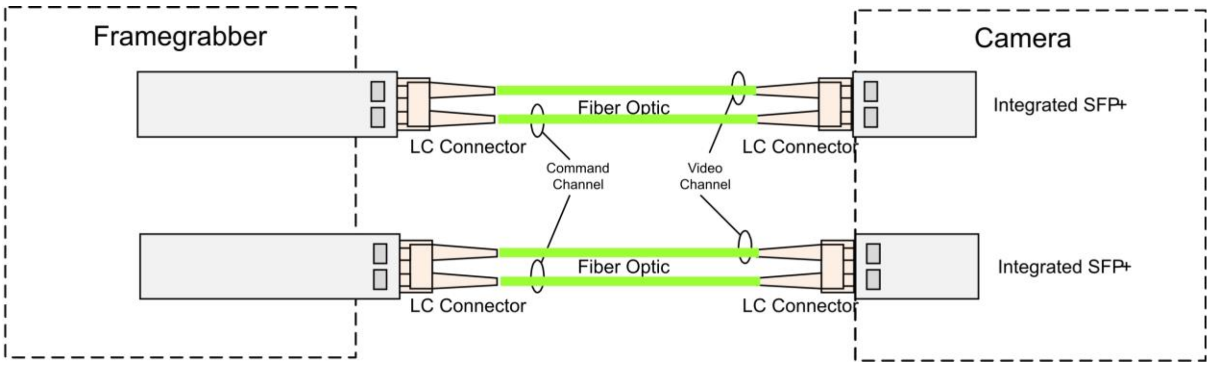


Figure 3: Linea HS 8K Dual LC/SFP+ Connector Configuration

The command channel is used by the frame grabber to send commands, configuration, and programming data to the camera and to receive command responses, status, and image data from the camera. With two SFP+ modules populated, the CLHS protocol will auto negotiate which one will be dedicated as the command channel. Data and command transmission is done with CLHS X protocol (64b / 66b) at the default speed of 10 Gbs.

Data Cables

The fiber optic cables for the 8K camera require LC connections on both ends of the cable. The frame grabber requires the LC connector to be plugged into a SFP+ transceiver module.

LC is a small-form factor fiber optic connector that uses a 1.25 mm ferrule, half the size of a standard connector. These cables are in wide use in the telecommunications industry and available in many lengths.

The distance through which the data can be transmitted depends on the type of fiber optic used.

Recommended fiber optic cables are types OM3 and OM4.

OM4 is used for distances > 300 m, but also requires SFP+ transceiver module changes.

Contact Teledyne DALSA Support for more information.

Table 8: LC Fiber Optic Cables

Category	Fiber Diameter	Mode	Max Distance
OM3	50 µm	Multimode	< 280 m
OM4	50 µm	Multimode	> 300 m

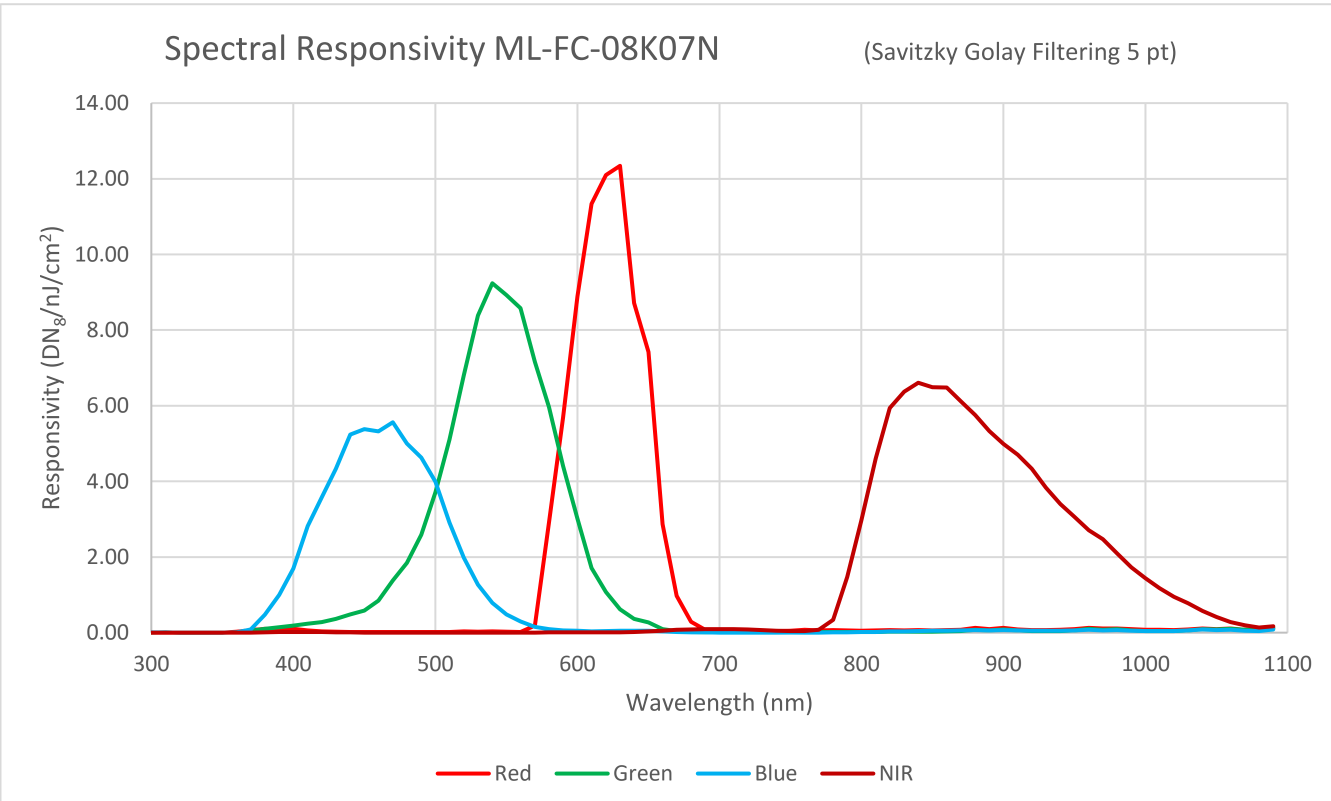
Camera Link HS cables can be bought from an OEM. OEM cables are also available for applications where flexing is present.

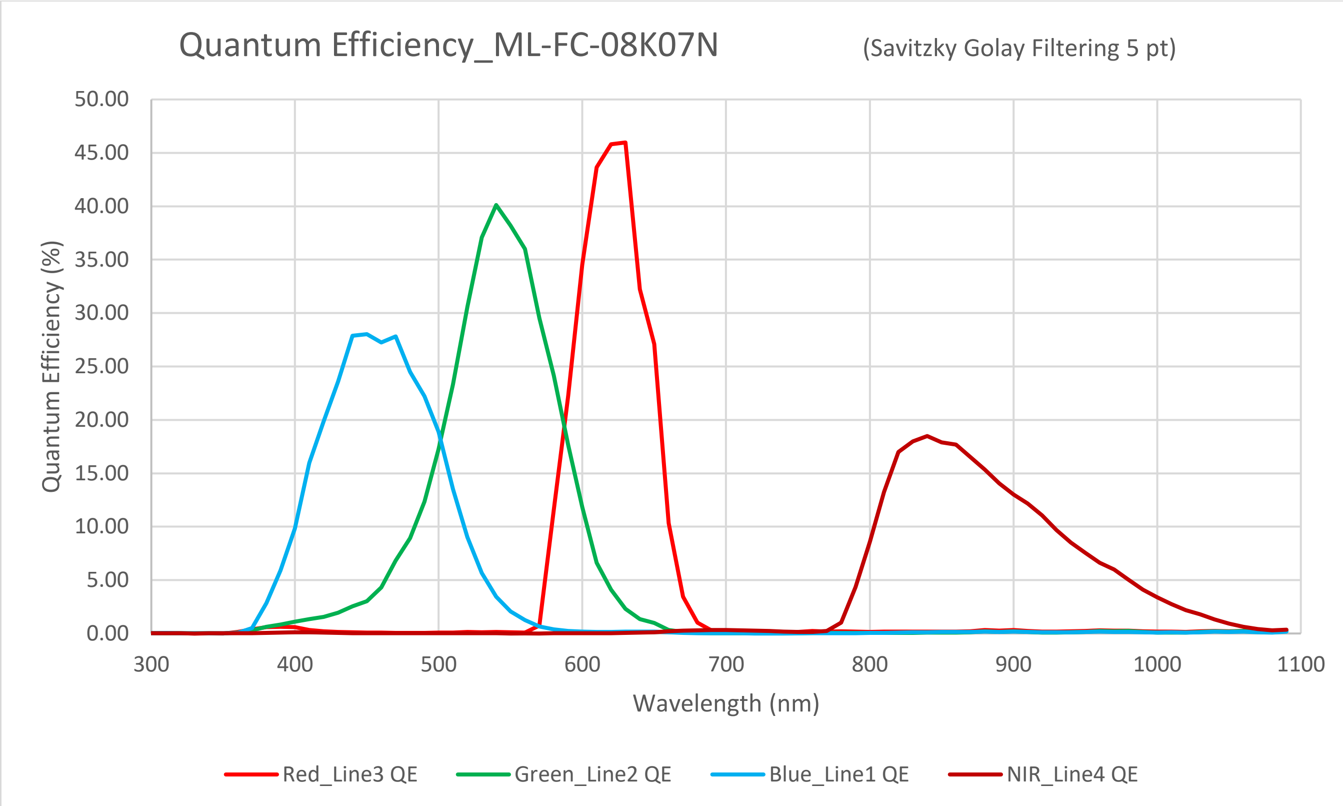
Please refer to Teledyne DALSA's website (www.teledynedalsa.com) for a list of recommended cable vendors and for part numbers.

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.

Please note: the data transmits at 10 Gbps which limits the effective distance of copper-based cables.

Responsivity & QE Plots

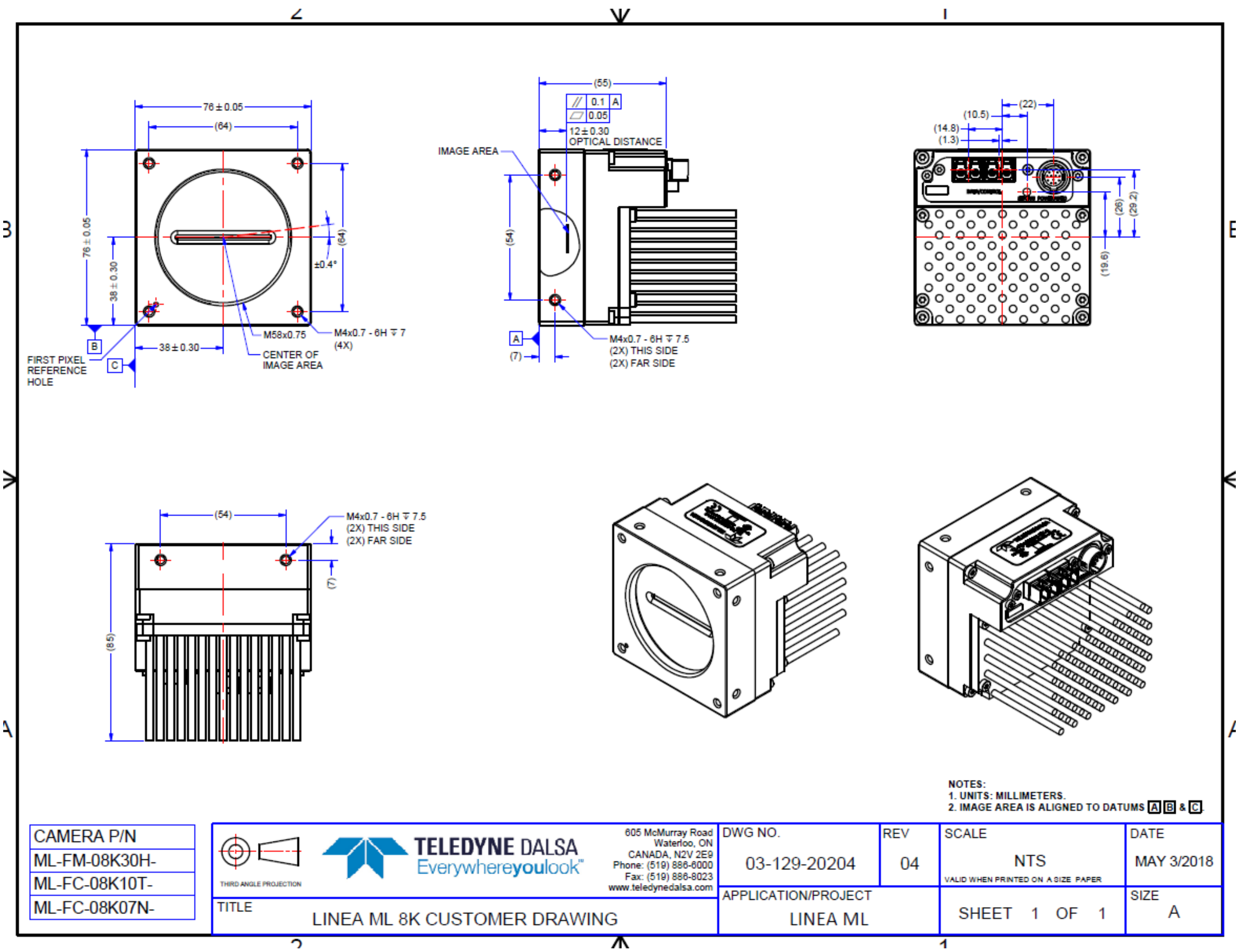




Quantum Efficiency_ML-FC-08K07N
(Savitzky Golay Filtering 5 pt)
Quantum Efficiency (%)
50.00
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
300
400
500
600
700
800
900
1000
1100
Wavelength (nm)
Red_Line3 QE
Green_Line2 QE
Blue_Line1 QE
NIR_Line4 QE

Mechanical Drawings

ML-FC-08K07N-00-R



Precautions

Read these precautions 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 +65 °C during operation. The camera can 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 shut down if its internal temperature reaches +80 °C.

Do not operate the camera near 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.

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.

Install & Configure Frame Grabber & Software

Because of the high bandwidth required by this camera, we recommend a compatible Teledyne DALSA frame grabber (OR-A8S0-FX840, or equivalent), described in detail on the teledynedalsa.com site here. Follow the manufacturer's installation instructions.

A GenICam compliant XML device description file is embedded within the camera firmware and allows GenICam compliant applications to recognize the camera's capabilities following connection. Installing Sapera LT gives you access to the CamExpert GUI, a GenICam compliant application.

Using Sapera CamExpert

CamExpert is the camera interfacing tool supported by the Sapera library. When used with the camera, CamExpert allows a user to access a camera's features and parameters, and to test the 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.

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.

	**Note:** The availability of features depends on the CamExpert user setting. Not all features are available to all users. The examples shown are 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 RGB using the Device drop-down menu.

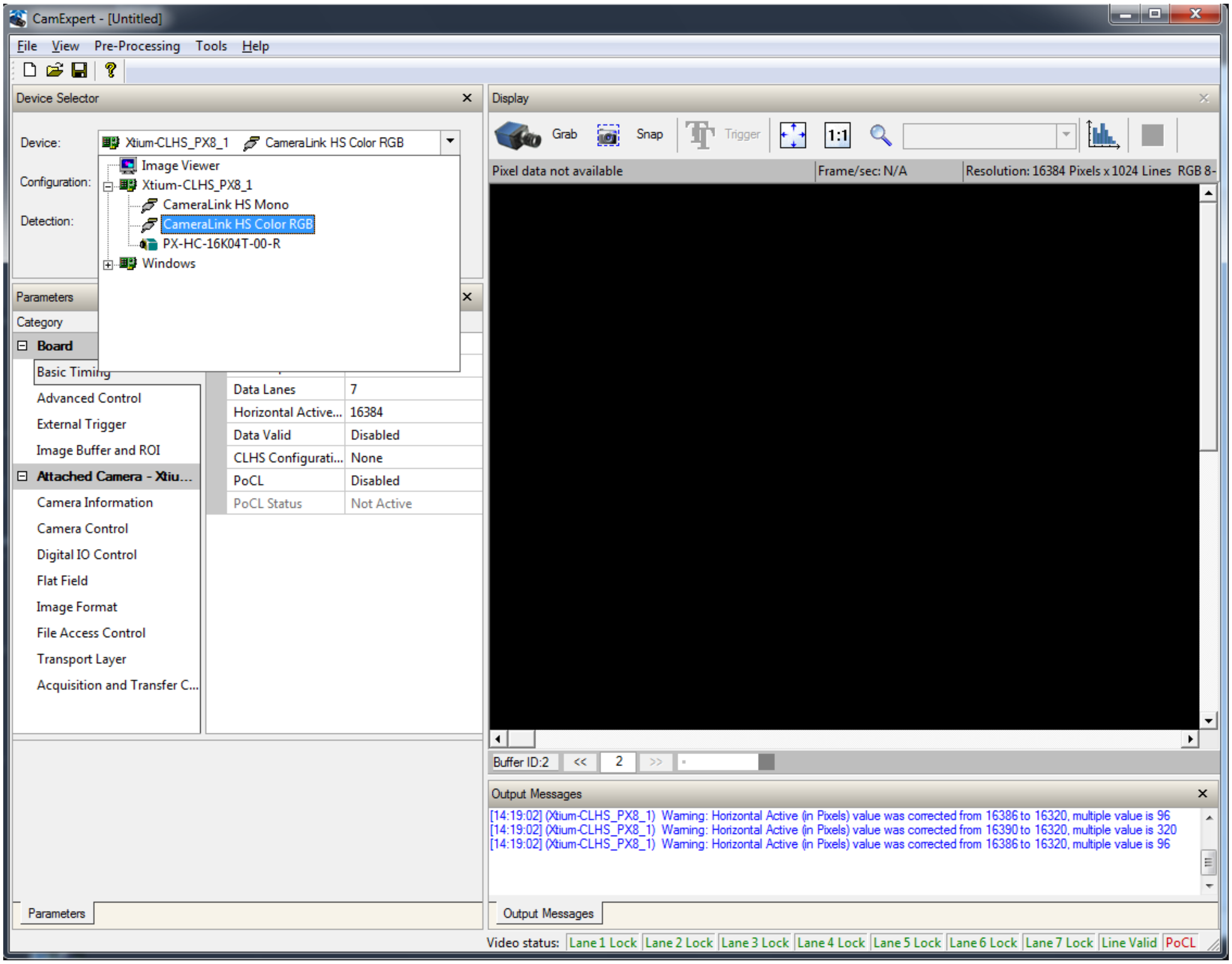


Figure 4. CamExpert Frame Grabber Control Window

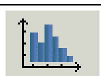
The CamExpert application uses panes to organize the selecting and configuring of camera files or acquisition parameters.

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.

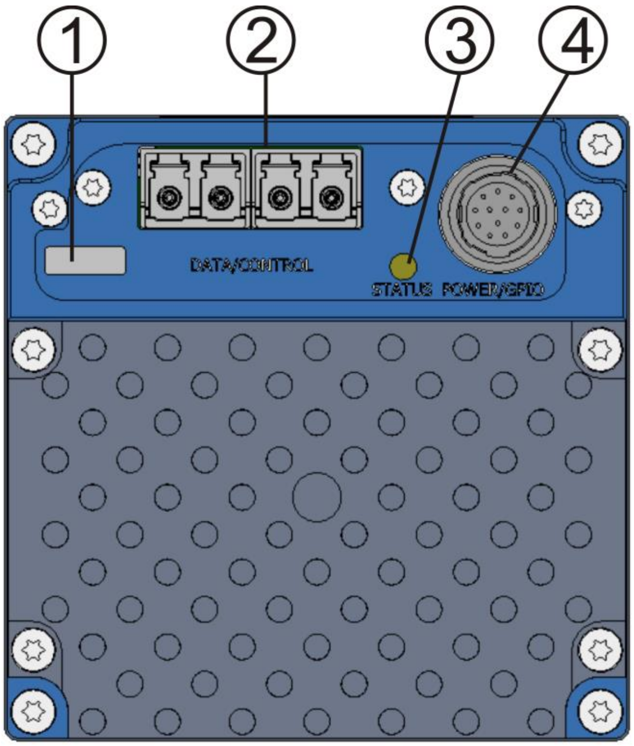
Display pane: Provides a live or single frame acquisition display. Frame buffer parameters are shown in an information bar above the image window.

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

	**Acquisition control button:** Click once to start live grab, click again to stop.
	**Single frame grab:** Click to acquire one frame from device.
	**Trigger button:** With the I/O control parameters set to Trigger Enabled, click to send a single trigger command.
	**CamExpert display controls:** (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.
	**Histogram / Profile tool:** 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



Camera I / O Connectors

1) Factory use only.

2) Data and control connectors: LC

3) LED status indicators.

4) Power and GPIO connectors: +12 V to +24 V DC, Hirose 12-pin circular.

Powering the Camera

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

- Apply the appropriate voltages of between +12 V to +24 V. 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 to reduce voltage drop.
- Use high quality supplies to minimize noise.

- When using a +12 V supply, voltage loss in the power cables will be greater due to the higher current. Use the Camera Information category to refresh and read the camera's input voltage measurement. Adjust the supply to ensure that it reads above or equal to +12 V.

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

Power and GPIO Connections

The camera uses a single 12-pin Hirose male connector for power, trigger, and strobe signals. The suggested female cable mating connector is the *Hirose model HR10A-10P-12S*.

12-Pin Hirose Connector Signal Details

The following figure shows the pinout identification when looking at the camera's 12-pin male Hirose connector. The table below lists the I/O signal connections.

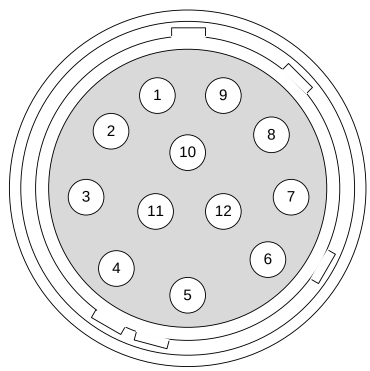


Figure 5. 12 Pin Hirose Connector

Table 9: Hirose Connector Pinout Signal Details

Pin Number	Input / Output	Signal Details	Notes
1		Power Ground*	
2		+12 V to +24 V power*	
3	Output	Line 3 Out	0 to 3.3V TTL
4	Output	Line 4 Out	0 to 3.3V TTL
5	Input	Line 1/ Trigger / Phase A	0 to 3.3V TTL
6	Input	Line 2 / Scan Direction/Phase B	0 to 3.3V TTL
7	Output	Line 5 Out	0 to 3.3V TTL
8	Output	Line 6 Out	0 to 3.3V TTL
9		Power Ground*	
10		+12 V to +24 V power*	
11		Signal Ground	Note: intended as a return path for GPIO signal and not intended as a power ground
12		Signal Ground	Note: intended as a return path for GPIO signal and not intended as a power ground

*Connect all power pins. Each pin is rated 2A.
The wire gauge of the power cable should be sufficient to accommodate a surge during power-up 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 on Voltage & Temperature Measurement for more details.

Mating GPIO Cable Assembly

Teledyne DALSA makes available for purchase an optional GPIO breakout cable (12-pin Female Hirose to 13-Pos Euro Block), as shown in the following drawing. Use accessory number #CR-GENC-IOP00 to order.

REVISION HISTORY				
ZONE	REV	DESCRIPTION	DATE	APPROVED
	A	Initial Drawing	04/06/2006	Artur Didyk

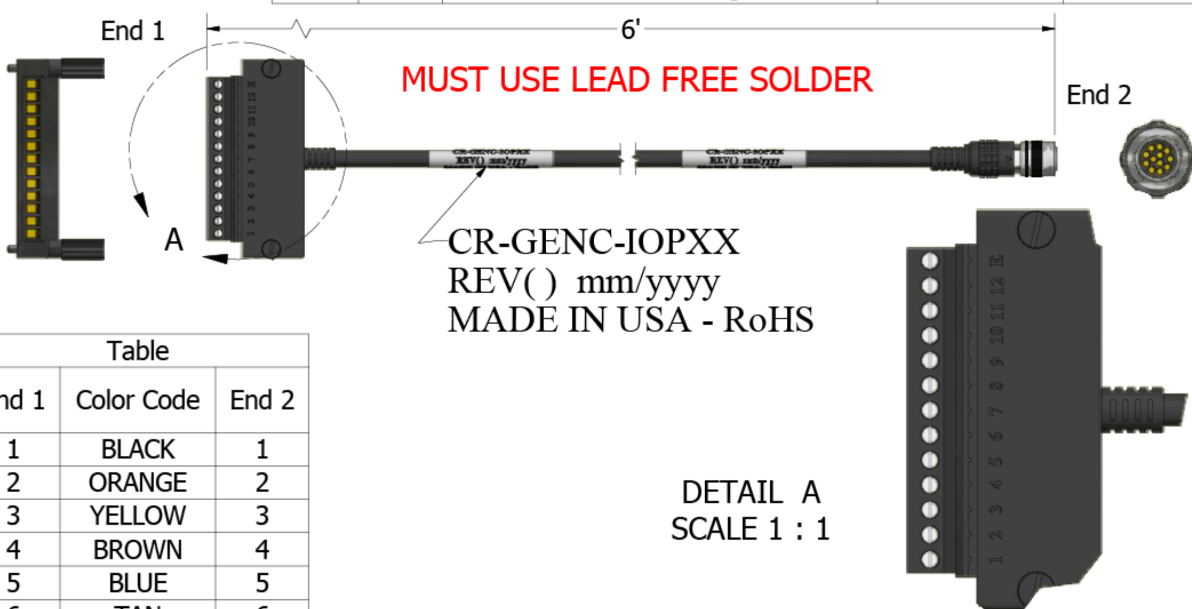


Table		
End 1	Color Code	End 2
1	BLACK	1
2	ORANGE	2
3	YELLOW	3
4	BROWN	4
5	BLUE	5
6	TAN	6
7	GREEN	7
8	PINK	8
9	VIOLET	9
10	WHITE	10
11	GRAY	11
12	RED	12
13	SHIELD	HSG

DRAWN Art Didyk	4/4/2006
CHECKED	
QA	
MFG	
APPROVED	

Components Express, Inc.

TITLE: BREAKOUT CABLE

SIZE: A | DWG NO: CR-GENC-IOPXX | REV: A

SCALE | SHEET 1 OF 1

External Input Electrical Characteristics

Table 10: External Input Electrical Characteristics

	Switching Voltage		
Input Level Standard	**Low to high**	**High to low**	**Input Impedance**
3.3 V TTL	2.1 V	1 V	10K Ω

External Input Timing Reference

Table 11: External Timing Reference

Input Level Standard	Maximum Input Frequency	Minimum Pulse Width	Input Current	Maximum Signal Propagation Delay @ 60ºC	
3.3 V TTL	20 MHz	25 ns	<250 µA	0 to 3.3 V	<100 ns
				3.3 V to 0	<100 ns

External Output Electrical Characteristics

Table 12: External Output Electrical Characteristics

Output Level Standard	V_{OL}	V_{OH}
3.3 V TTL	<0.4 V @ 10mA*	>3.1 V @ 10mA*

*See Linear Technology data sheet LTC2854

External Output Timing Reference

Table 13: External Output Timing Reference

Output Level Standard	Maximum Output Frequency	Minimum Pulse Width	Output Current	Maximum Signal Propagation Delay @ 60ºC	
3.3 V TTL	Line rate dependent	25 ns	<180 mA	0 to 3.3 V	<100 ns
				3.3 V to 0	<100 ns

To reduce the chance of stress and vibration on the cables, we recommend that you use cable clamps, placed close to the camera, when setting up your imaging system. Stress or vibration of the heavy CLHS AOC cables may damage the camera's connectors.

Establishing Camera Communications

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

Table 14: LED States

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 stopped output and has shut down some components 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 been broken.
Constant Green	The CLHS Link has been established and data transfer may begin

When the camera's LED state is a steady green, open the first instance of CamExpert.

1. CamExpert will search for installed Sapera 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

In a change from previous versions of the Sapera GUI, only one instance of CamExpert is required.

Selecting the Data Format

The camera can output data in the following formats:

RGB8 Planar

RGBY8 Planar

The camera always outputs data to the frame grabber in a 'planar' format—where the red, green and blue lines are sent separately, one after the other. Please consult the frame grabber user's manual for further details on selection input and output pixel formats.

Establishing Data Integrity

- Use the camera's internal triggering. This will allow for 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 camera, including explanations of how to use them effectively.

A detailed description of all features is found in Appendix A: GenICam Commands.

Synchronizing to Object Motion

Triggering the camera

Relevant Features: ExposureMode, TriggerMode, TriggerSource, TriggerActivation

There are several different methods that can be used to trigger image acquisition in the camera.

Internal Trigger

The simplest method is to set the Trigger Mode to off. As a result, the camera is triggered by an internal timer and can be adjusted by the Acquisition Line Rate feature.

External Triggers

When the Trigger Mode is set to External, the triggers to the camera can come from different sources which are set by the Trigger Source feature.

The available sources for the triggers are from pin 5 of the GPIO connector, from the Camera Link HS frame grabber, or from the rotary encoder feature (using pin 5 and pin 6 of the GPIO connector).

Use the Trigger Activation feature to select the edge or level that triggers the camera. The options are: Rising Edge, Falling Edge, or Either Edge.

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 is, the higher the line rate. The 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 (compression in the scan direction) of the image data. When the line rate returns to below the maximum specified, then normal imaging will be reestablished.

Measuring Line Rate (Trigger)

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

Relevant Feature: measuredLineRate

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.

Maximum Line Rate

The maximum line rate that the camera can achieve is determined by the number of CLHS lanes used and by the number of cables installed, as shown in the table below.

Table 15: Maximum Line Rates

Maximum Line Rate (KHz)		
Camera Model	**One Cable**	**Two Cables**
ML-FC-08K07N-00-R	36	70

Scan Direction

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

Relevant Feature: sensorScanDirectionSource, sensorScanDirection

Since the camera is a multiline model, the user needs to indicate to the camera the direction of travel of the object being imaged. The scan direction is set using the sensorScanDirectionSource command. The options are: Internal, Line 2 (pin 6 on the GPIO connector), the Camera Link HS frame grabber, or the rotary encoder feature (using pin 5 and pin 6 of the GPIO connector).

When set to internal, use the sensorScanDirection feature to set the direction.

Direction Change Time

The direction change time between forward and revers is < 1 ms.

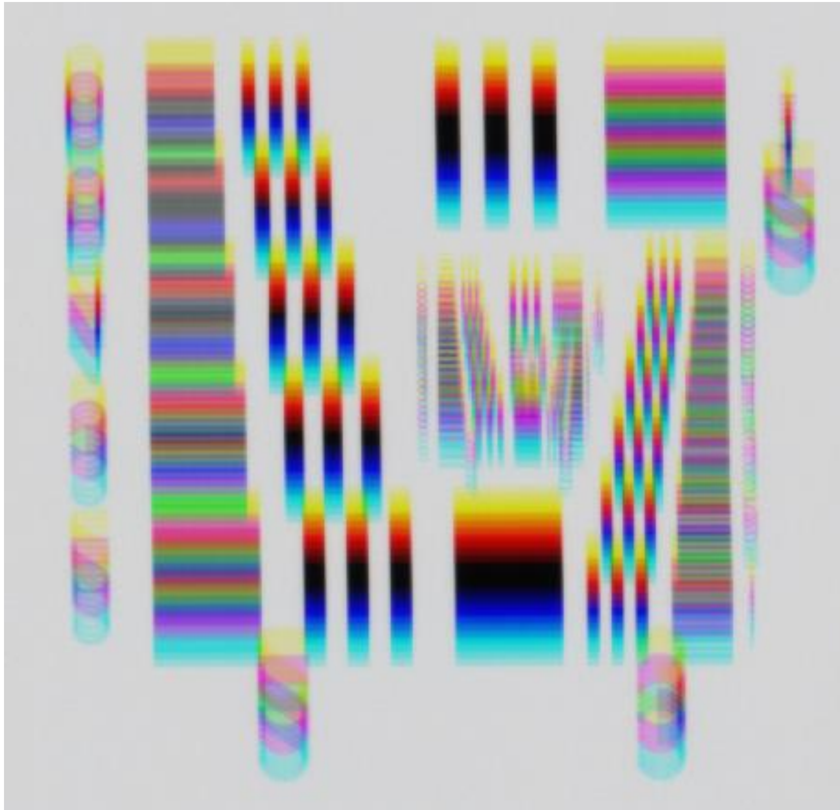


Figure 6. Image with incorrect scan direction

Camera Orientation

The diagram below shows the definition of forward and reverse with respect to a camera body.

Note that the diagram assumes the use of a lens, which inverts the image.

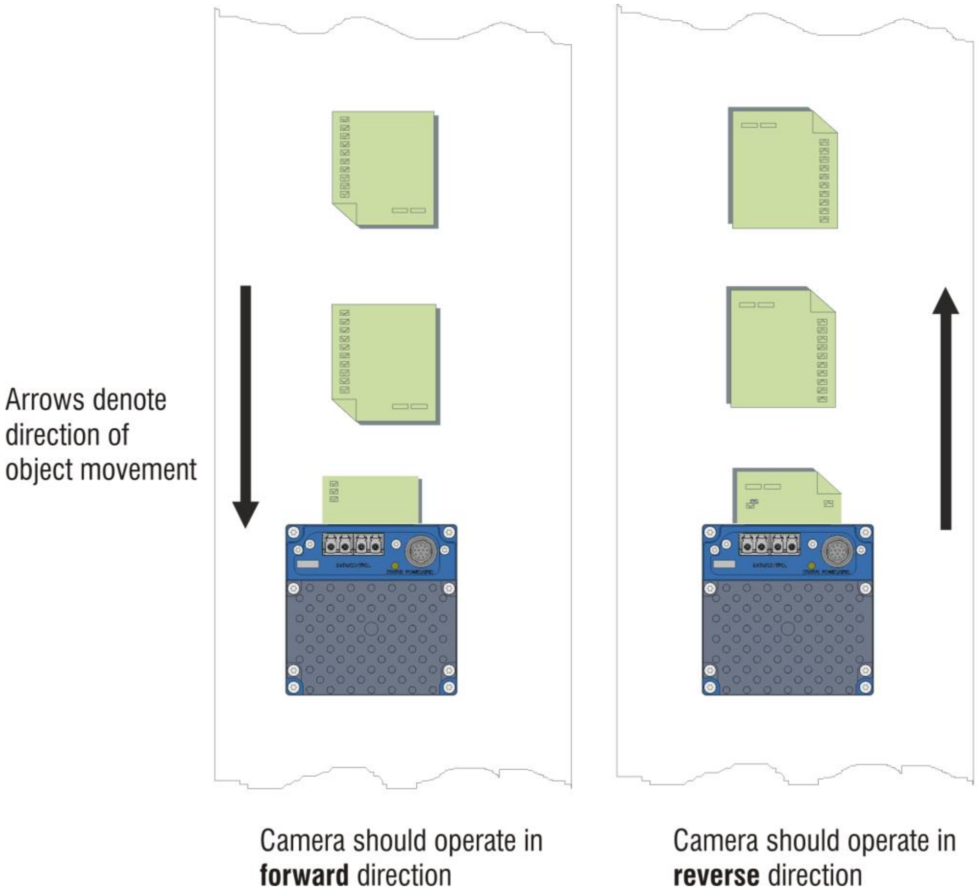


Figure 7: Example of Object Movement and Camera Direction with a Lens

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.

Some AOI systems require the scan direction to change at regular intervals. For example, 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 General Purpose Input / Output (GPIO) control bits.

It is necessary for the system to over-scan the area being imaged, including the lines that are not valid, because 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.

Spatial Correction

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

Relevant Features: *sensorLineSpatialCorrection*

The RGB+NIR camera has a quadlinear configuration—each set of color rows are spatially separated by three rows except for the NIR row which has 5 row spacing.

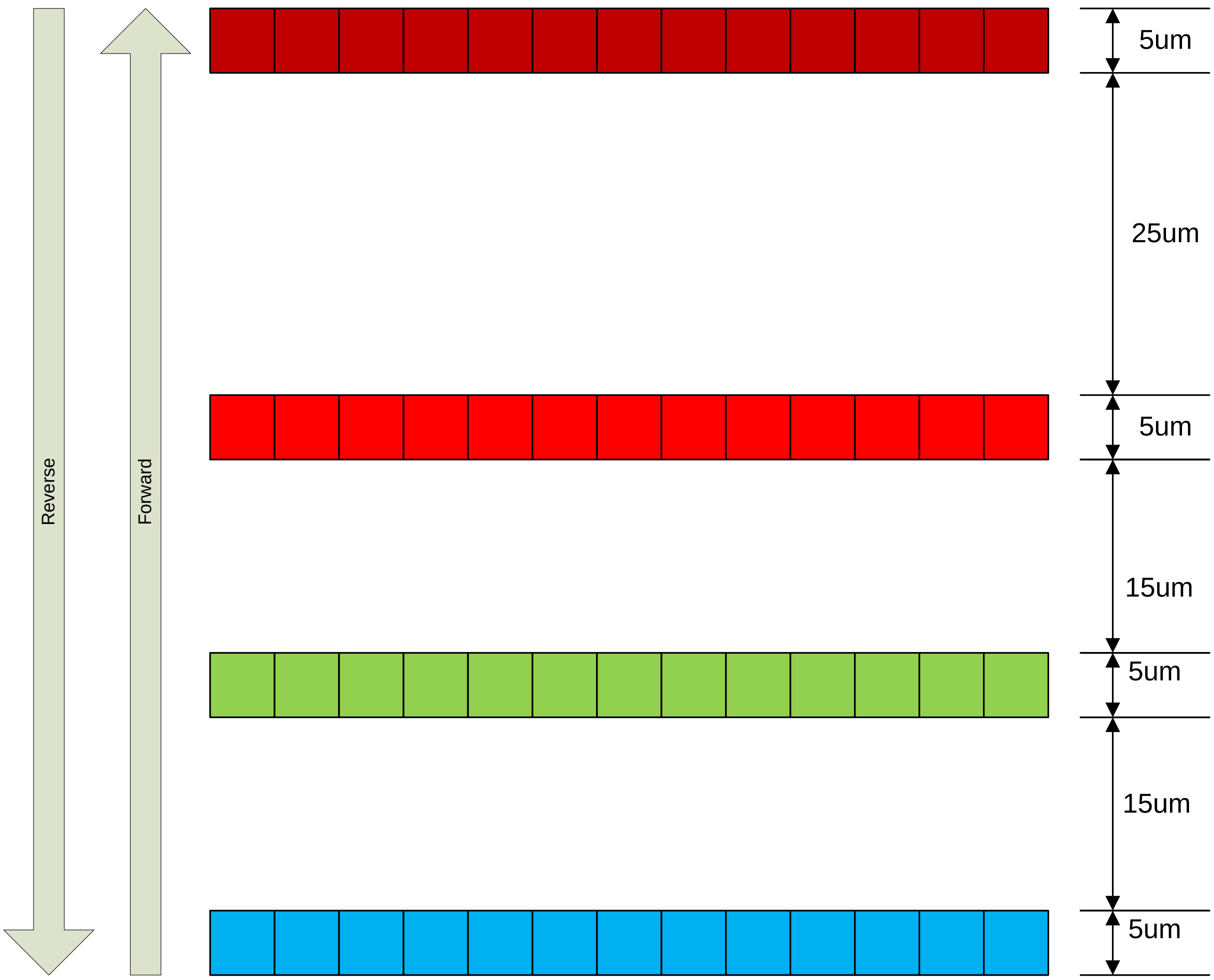


Figure 8 ML-FC-08K07N-00-R Line Spacing

The camera ensures the scan direction alignment of the three colors by delaying the image data for each color a set amount of time, as dictated by the scan direction.

If the encoder generates a pulse that is equal to the object pixel, the spatial correction value used by the camera will be 1. However, guaranteeing the encoder pulse accuracy may not always be possible. In addition, lens magnification may not be exact—which will introduce a similar error.

The camera has a Spatial Correction feature that can correct for these small encoder or magnification errors on a sub-pixel level. The user can enter a floating-point number from 0 to 15.996 in order to perform the spatial correction. The sub-pixel spatial correction resolution is

1/256th of a row. The feature accepts up to two decimal places and will adjust the entered sub-pixel adjustment component accordingly. This feature can only be adjusted when the acquisition is stopped.

Examples of color artifacts generated by a small encoder error:

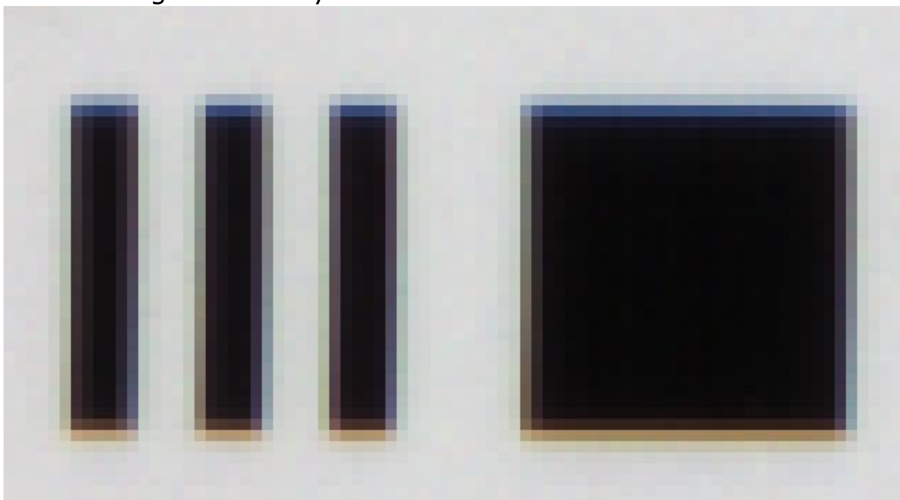


Figure 9: Color Artifacts Example (encoder 19 µm)

Image Details:

- Object Pixel Setup for 20 µm
- Encoder set at 19 µm
- Forward Scanning
- Can be corrected with 20 / 19 = 1.05 Spatial Correction

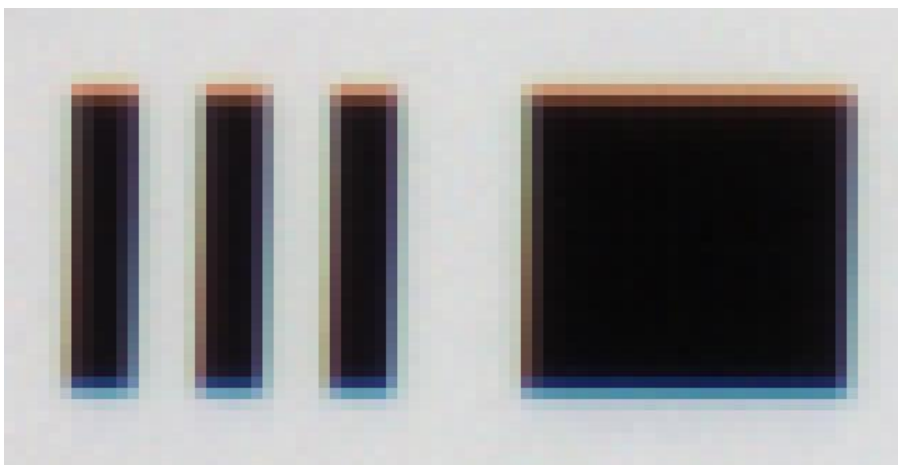


Figure 10: Color Artifacts Example (encoder 21µm)

Image Details:

- Object Pixel Setup for 20 µm
- Encoder set at 21 µm
- Forward Scanning
- Can be corrected with 20 / 21 = 0.95 Spatial Correction

If there are several different camera angles and associated illumination configurations in the inspection system, a single encoder pulse will not provide the correct timing for all the cameras.

For example, as the camera angle moves away from perpendicular, the image row spacing increases. If the encoder resolution remains at that for perpendicular operation, many encoder pulses will be too closely spaced, apparent row spacing will increase and the spatial correction will need to be increased.

The spatial correction feature can accommodate these potentially larger encoder errors where the spatial correction value has an adjustment range from 0 to 15.99.

Parallax Correction: Using the Camera at Non-Perpendicular Angles to the Object

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

Relevant Features: [imageDistortionCorrectionMode](), [imageDistortionCorrectionAlgorithm](), [imageDistortionCorrectionLineSelector](), [imageDistortionParallaxCorrectionPixelStretch]()

When using a camera at an angle to the objects surface, the object pixel size for the red, green and blue pixel arrays are slightly different. This is due to parallax. If the camera angle and the lens angular field of view are sufficiently large, this may cause color artifacts at the extremities of the image. The color camera includes a Parallax feature that can correct these color artifacts.

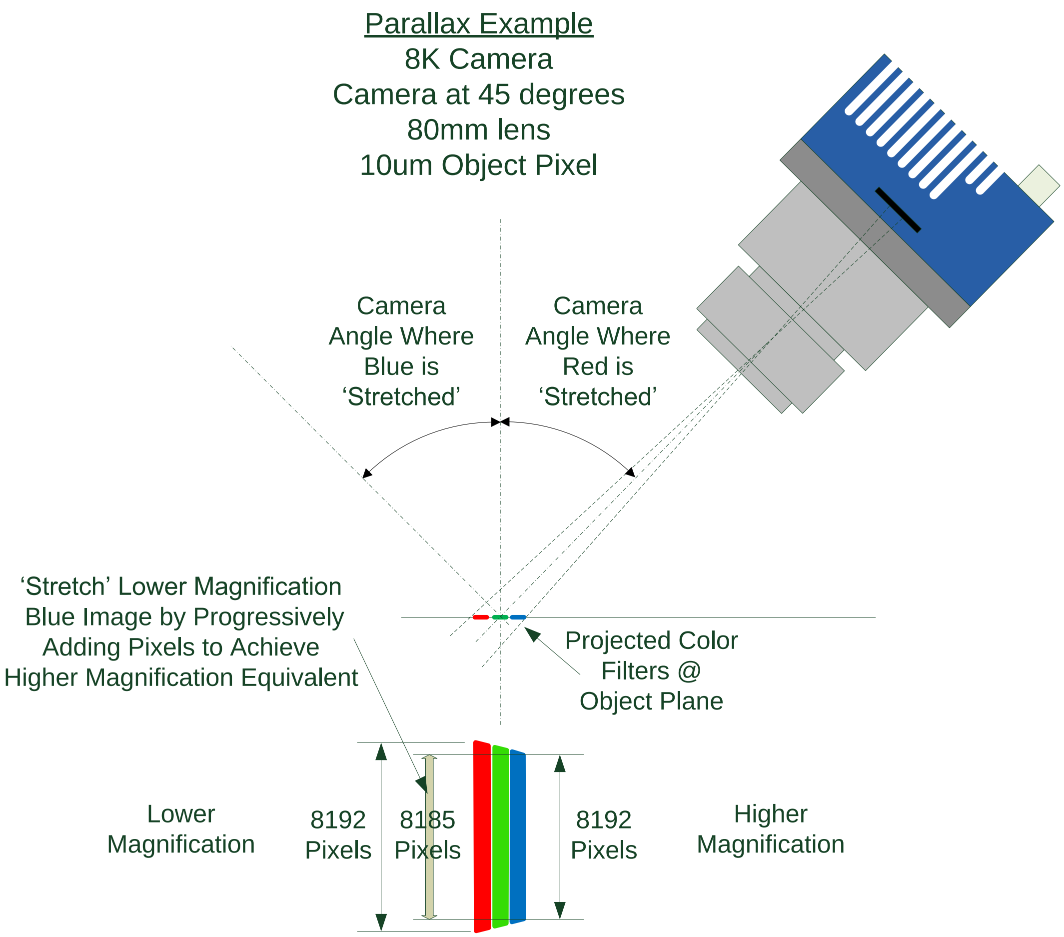


Figure 11: Camera Angle Creates Parallax

Notes:

- This feature will be most useful when processing RGB image formats using 8K cameras with long focal length lenses.
- Parallax correction of the individual colors cannot be performed due to the row summing in the sensor. Therefore, at high angles, a degradation in MTF at the end pixels may occur.
- Selection of the color to adjust is dependent on positive or negative angle. It is not sensitive to scan direction.
- The stretch value for green is always half that of the stretch value for blue or red.

Image example of color artifact induced by parallax at the image extremity

Figure 12:Parallax Image Example

Image Details:

- 30^{O} Camera Angle
- 20 µm Object Pixel
- 8k Camera
- Spatial Correction = 1.15
- 80 mm lens
- No Parallax Correction

Establishing the Desired Response

One of the important performance characteristics of the camera that will determine its suitability for an 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.

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

To accurately evaluate the camera's responsivity and noise performance it is important that the camera setup is representative of the system configuration.

The ideal test setup meets the following conditions:

- 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's 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 Mode

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

Related Features: ExposureMode (Timed)

ExposureMode: Timed. Timed is the standard exposure operation as found in Teledyne DALSA line scan cameras. See the Exposure Control Section.

Line Rate Jitter

If the exposure time is close to the line period there could be jitter in the line rate when it is synchronized to the sensor clock if ExposureMode = Timed. With Exposure mode off there is no jitter in the line rate. If trying to coordinate a LED strobe with the exposure of the sensor it is important to be away of this jitter and make sure the LED is on long enough to account for this.

Exposure Control

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

Relevant GenICam features: ExposureMode, exposureTimeSelector, ExposureTime

The camera has the following exposure mode(s):

- Timed: where the sensor rows are exposed at the same time.

Use exposureTimeSelector to select whether to set the exposure time of each row independently or all to the same value. Adjusting the exposure will result in a temporary loss of LVAL (8 lines) while the sensor is re-configured.

Timed Exposure Mode

Also called Global Reset Mode, the exposure begins when the line trigger occurs. If some rows have shorter exposure times, then they are held in reset longer such that all the rows finish exposing at the same time and read out begins.

The minimum exposure time depends on the number of rows being read out. The maximum time is 1,500 µs. The minimum line period is the largest exposure time + 0.83 µs. With internal trigger mode the line rate will be decreased as necessary if the exposure time is increased. Similarly, the exposure times will be decreased as necessary if the line rate is increased. If this happens the ratio between the different row exposure times will be maintained (for example, to maintain white balance). In external trigger mode the maximum line rate will be limited by the current exposure time.

Exposure Time Selector

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

Relevant Feature: ExposureTimeSelector

The Exposure Time Selector allows the user to set the exposure time of each line individually or all to the same exposure time.

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: GainSelector, 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 gain feature that can be used to make the necessary adjustment to the responsivity.

There are two gain adjustments available: color gains, which can be set independently for each color (range 1 to 4x); and the system gain, which is applied to all colors (range 1 to 10x).

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: flatfieldCalibrateFPN, flatfieldCalibrationPRNU, flatfieldCorrectionAlgorithm, flatfieldCalibrationTarget

It is common to find an image with lower response at the edges of the camera's field of view compared to its center. This is typically the result of a combination of lens vignetting ($\cos^{4th}$) 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, spectral content, plus illuminator beam structure.
- 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.
- If flat field calibration is being set to a target level that is lower than the peak value and the system gain is set to a low value, then it is possible that the sensor will maximize its output before the camera's output reaches 255 DN. This can be seen when a portion of the output stops increasing before reaching 255DN with increasing illumination and the PRNU deteriorates. This effect can be resolved by reducing the light level or exposure control time.

On completion of a flat field calibration, all pixels should be at their un-calibrated peak value or target value. Subsequent changes in gain 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 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.

	Note: The Linea ML camera has many different modes of operation. It is strongly recommended that the camera be flat fielded for the mode of operation that is intended.

White Balancing

Relevant Features: BalanceWhiteAuto

After performing PRNU calibration using the peak value as the target for each color, this may result in each color having a different level even though the target may be white. The difference is caused by the spectral content of the light source in combination with the spectral characteristics of the cameras color filters. The White Balance feature can be used to bring all colors to the same level as that of the highest color.

When performing white balance, the highest response color will be assigned the gain of 1x and the other two color-gains will be adjusted to establish white balance. If the user had higher gains applied, these will be over-written. If the user wants to subsequently increase the gain, they should use the Camera Control > Color Selector feature and select System Gain. The gain feature will then show the highest of the three color-gains being used. The user can then increase this gain and the other two color-gains will be proportionally adjusted to maintain white balance.

Note: running a PRNU calibration set to achieve a common target level for each color will produce the same result. However, this action will introduce additional gains into the PRNU coefficient and reduce their effective correction range and may result in a color imbalance when changing camera direction. Therefore, it is recommended to use the peak PRNU followed by white balance.

White Balance Region of Interest

Typically, a white or neutral gray target is put in front of the camera while performing a white balance. In some cases, this is not possible, or it may be desired that the white balance is performed while acquiring the targeted object.

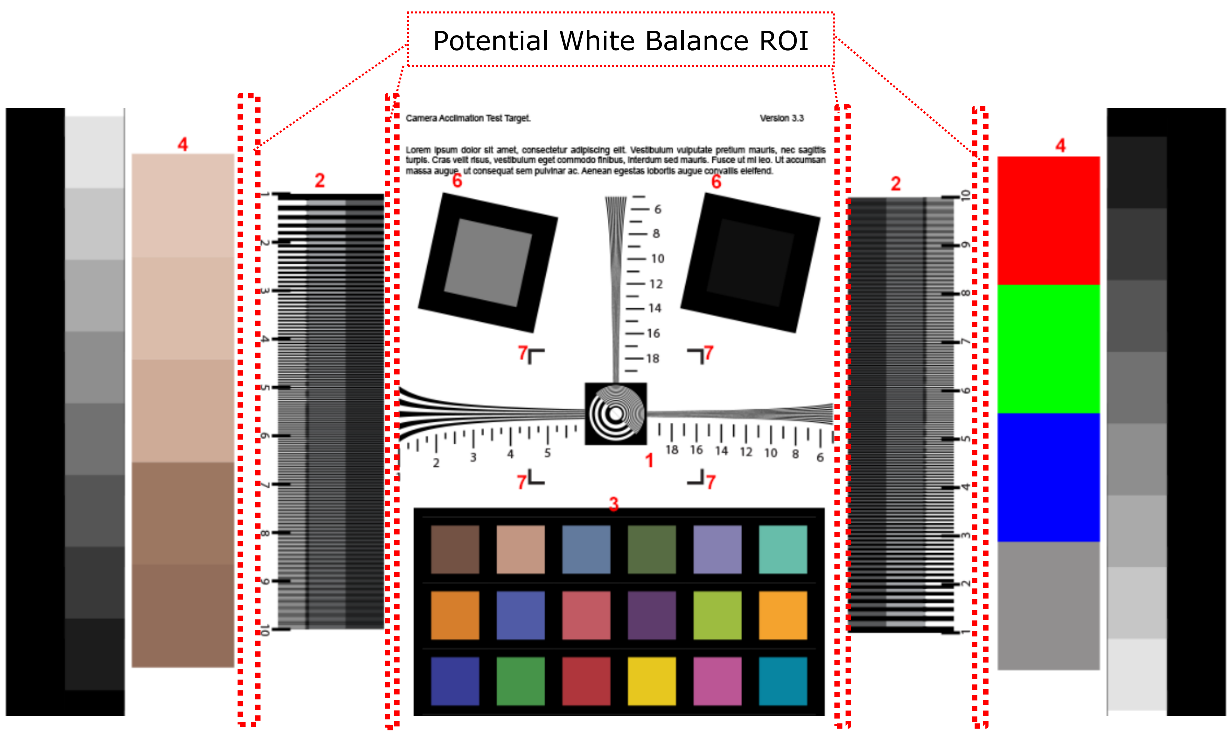


Figure 13. White Balance ROI Example

With a white balance ROI, the camera looks at a user-designated region of interested, performs the white balance calculations based on those regions, and applies the appropriate corrections across the whole image.

Adjusting Flat Field Calibration Coefficients

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

Relevant Features: flatfieldCorrectionCurrentActiveSet, flatfieldCalibrationSave, flatfieldCalibrationLoad

Further, applications may also have several different lighting conditions each requiring their own flat field coefficients and the means to quickly and easily switch between them. To this end, the following features are provided:

- The ability to save and load user PRNU coefficients independent of a user set that contains all adjustable parameters.

We recommend that before saving custom PRNU profiles you first save all the current camera settings using the Camera Information > Settings feature. The Save User PRNU set only stores the revised PRNU coefficients in the desired User Set.

These new features are found under the Flat Field tab and are only visible in Guru mode. Press "More >>" in CamExpert to display the full list of parameters.

Saving & Loading a PRNU Set Only

Loading a user set takes approximately 800 ms while loading only the user PRNU coefficients takes less than 200 ms.

Use the User PRNU Set Selector parameter to select the set you want to save or load. (There are 17 sets available—16 user and one factory.) Loading the Factory Set is a good way to clear just the user PRNU.

Save the current user PRNU coefficients with the *"Save User PRNU Set" feature*. Load the user PRNU coefficients from the set specified with *"User PRNU Set Selector" and* with the *"Load User PRNU Set"* command feature.

Setting Custom Flat Field Coefficients

There may also be circumstances when the user wants to upload their own Flat Field (PRNU) coefficients. Flat Field 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 03-084-20133 Linea ML 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: flatfieldCorrectionAlgorithm

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 effect is for the white target to be moving during the calibration process. This has the effect 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: this filter is only capable of compensating for small, occasional contaminants. It will not overcome large features in a target's texture.

This filter is a 33-pixel moving average.

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: flatfieldCalibrationROIOffsetX, flatfieldCalibrationROIWidth

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 a Region of Interest (ROI) where flat field calibration is performed. Image data outside the ROI is ignored by the flat field calibration algorithm.

The 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.

Image Filters

Relevant Features: imageFilterMode, imageFilterType, imageFilterKernelSize, imageFilterContrastRatio

The camera has a selection of image filters that can be used to reduce image noise.

Use the feature imageFilterMode to turn the filtering on or off. Use the feature imageFilterType to read the user information of the type of filter that is being used. In this case, a weighted average filter is applied.

Kernels

Use the ImageFilterKernelSize feature to select the number of pixels involved in the filter or the kernel size. The options are: 1 x 3, and 1 x 5 filter kernels. The 1 x 3 and 1 x 5 filter kernels are "weighted average" filters.

The 1 x 3 filter kernel uses 75% of the original pixel and 12.5% of the adjacent pixels.

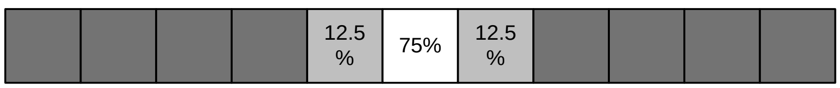


Figure 14: 1 x 3 kernel

The 1 x 5 filter kernel uses 50% of the original pixel and 12.5% of the adjacent two pixels on both sides of the original pixel.

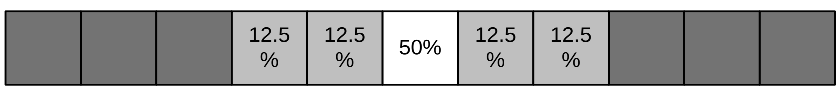


Figure 15: 1 x 5 kernel

Image Filter Contrast Ratio

The image filter contrast ratio feature is used to determine when the filter is applied to the image data. The control looks at the ratio between two adjacent pixels (prior to filter processing) on the sides of the relevant pixel and determines the difference or contrast between those pixels. If the contrast ratio is greater than the value set by the user, then the filter automatically turns off for those two pixels. If the contrast is below the set value, then the pixel filter is applied.

A value of 0 will turn off the filters for all pixels and a value of 255 will keep the filter on for all pixels.

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: BinningHorizontal, BinningVertical

Binning is the process where the charge on two (or more) adjacent pixels is combined. This results in increased light sensitivity as there is twice the sensor area to capture photons. The sensor spatial resolution is reduced but the improved low-light sensitivity, plus lower signal-noise ratio, may solve a difficult imaging situation.

One reason to use binning is to capture higher quality images at low-light levels. Binning allows the user to trade off resolution for sensitivity. For low-light imaging, binning can offer dramatic improvements in image quality.

The camera supports 1x, 2x, and 4x binning in both horizontal and vertical directions.

Horizontal binning is achieved by summing adjacent pixels in the same line. Vertical Binning is achieved by summing adjacent pixels in the same column. Therefore, 2x binning results in the object pixel doubling in size vertically, horizontally, or in both axes, as selected by the Binning feature.

In addition, since adjacent pixels are summer (not averaged), the image gets brighter. That is, 1x2 and 2x1 are twice as bright, 2x2 is four times brighter, etc.

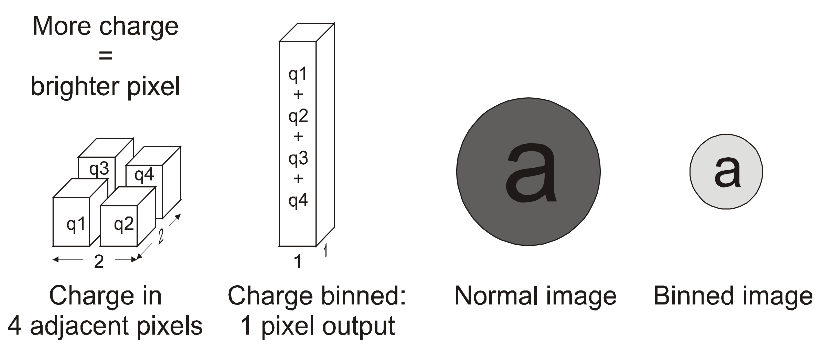


Figure 16: 2x2 Binning

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

	Note: The Binning parameters can only be changed when image transfer to the frame grabber is stopped. Refer to the "Acquisition and Transfer Control' category in the appendix for details on stopping and starting the acquisition.

Using Area of Interest (AOIs)

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: multipleROICount, multipleROISelector, multipleROIOffsetX, multipleROIWidth

If the camera's field of view includes areas that are not needed for inspection (also refer to the description in the 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.

The camera can accommodate up to four Areas of Interest (AOI). Image data outside the AOI are discarded. Each AOI is user selected and its pixel boundaries defined. The camera will assemble all individual AOI's 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's, 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. Set the number of AOI's.
4. Select the first AOI and set the offset and width.
5. If the other AOI's are large you may need to select them first and reduce their widths.
6. Repeat for each AOI in turn.
7. Start acquisition.

Rules for Setting Areas of Interest

- 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 1,024.
4. Maximum width of all AOI widths summed together must be no more than = 16,384.
    a. There can be maximum 8k bytes per CLHS lane.
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 affect 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. 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.

Customized Linearity Response (LUT)

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

Related Features: lutMode, gammaCorrection

Note: these features may only be useful in applications that use the frame grabber's Mono Image Buffer Format. (See also the Pixel Format section.)

The camera allows the user to access a LUT (Look Up Table) so the user can customize the linearity of how the camera responds. This can be done by uploading a LUT to the camera using the file transfer features or by using the gammaCorrection feature.

The gamma correction value can be adjusted by the user at any time.

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. Further, when the LUT is enabled, it is recommended that the fixed Offset available in the Camera Control category be set to zero.

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 03-084-20133 Linea Binary File Format which can be obtained from Teledyne DALSA Technical Support. This document also includes Excel spread sheet examples.

How to Generate LUT with CamExpert

CamExpert can also be used to create a LUT file. The camera uses a 12-bit in / 12-bit out LUT (even if the camera is outputting an 8-bit image). CamExpert can be configured to create a 12-bit in / 16-bit out LUT - the camera will convert it to the required format.

1. Open CamExpert > version 8.40.
2. *Device* should be an *Xtium2* connected to a *Linea* camera.
3. Under *Board* select *Basic Timing* and set *Pixel Depth* to *12.*
4. Under *Board* select *Image Buffer and ROI* and set *Image Buffer Format* to *Monochrome 16 bits*
5. Leave *Image Buffer and ROI* selected.
6. In the top menu select *Pre-Processing* | *Lookup Table* and set *Enable.*
7. In the same menu select *Setting…*
8. Configure the output LUT here by scrolling through the different options under *Value.*
    a. Some selections have additional parameters to configure (e.g. *Gamma correction* requires a *Correction factor*).
9. Click on the *Save LUT* button to create a LUT file.
10. This file can loaded into the camera using the *File Access* features. It is saved with the current *Load / Save Configuration* user set; ensure that a user set and not the factory set is selected, otherwise the upload will fail.
11. Deselect the *Lookup Table* | *Enable* feature.
12. Return CamExpert to *Pixel Depth* = 8, and *Image Buffer* = 8 bits.

Important points:

- The frame grabber must be configured mono 12 bits in, 16 bits out.
- In the Parameters explorer a frame grabber feature must be selected, not a camera feature.
- The Lookup table must be enabled to be created. But should be disabled to use the camera LUT.

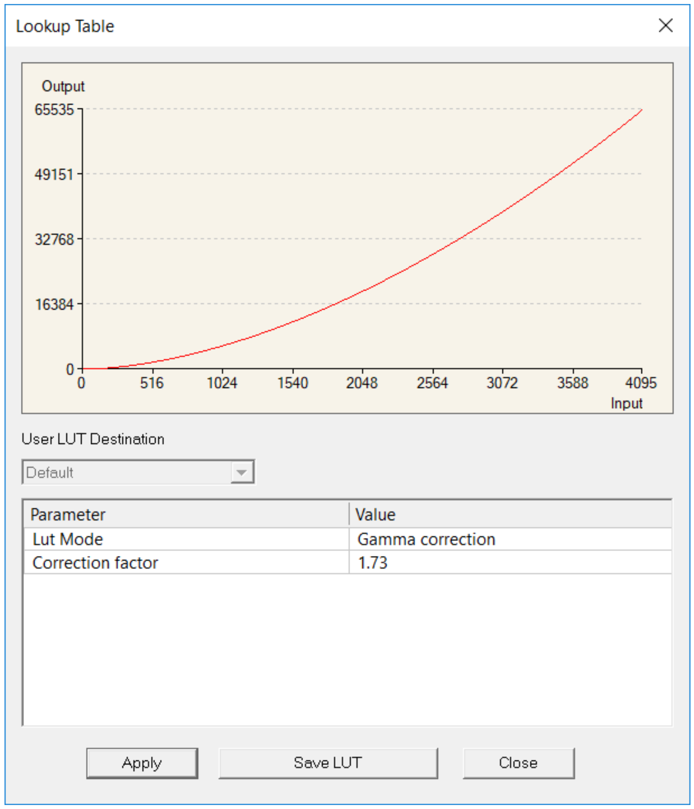


Figure 17: CamExpert LUT Creation Dialog

Adjusting Responsivity and Contrast Enhancement

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

Related Features: GainSelector, Gain, BlackLevel

It is best 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 gain feature that can be used to adjust the camera's responsivity.

Gain adjustment is available to independently adjust each line or all of them together. System Gain can be adjusted from 1 to 10x. Individual line gains can be adjusted from 1 to 4x.

When an image contains no useful dark image data below a specific threshold, then it may be beneficial to increase the contrast of the image.

The camera has an offset feature that allows a specified 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 as a 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.

Changing Output Configuration

Pixel Format

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

Relevant Features: PixelFormat, ComponentSelector, ComponentEnable, ComponentID

***Mono8*Color Combinations (Color ID)**	**Approximate Maximum Line Rate Enhancement**
Blue Only	2.8x
Green Only	2.8x
Red Only	2.8x
NIR Only	2.8x
Blue & Green Only	1.75x
Blue & Red Only	1.75x
Green & Red Only	1.75x
NIR & Blue Only	1.75x
NIR & Green Only	1.75x
NIR & Red Only	1.75x
Blue, Green & Red	1.25x
NIR, Blue, Green & Red	1x

ML-FC-08K07N-00-R relative speed increases

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. The SFP+ camera models support up to 2 fiber optic cables. The 16K ML-HC model only supports 1 CX4 output connector.

Relevant Features: clhsNextDeviceConfig

The ML-FC cameras have two CLHS compliant connectors. Control / Data1 is assigned as the master with Data 2 connector as the slave. Use the 'Next CLHS Device Configuration' to select the desired number of cables (not relevant for the 16K). This feature also controls lane selection. The Next CLHS Device Configuration becomes active after power cycling the camera or reconnecting the cables.

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: UserSetSelector, UserSet1 thru UserSet16, UserSetDefaultSelector, UserSetLoad, UserSetSave

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 camera includes 16 user sets where camera setup information can be saved to and restored from—either at power up, or dynamically during inspection.

The settings active during the current operation can be saved using the user set selector and user set save features.

A previously saved user setting (User Set 1 to 16) or the factory settings can be restored using the user set selector and user set load features.

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

The relationship between the settings is illustrated in Figure 18. Relationship between the Camera Settings:

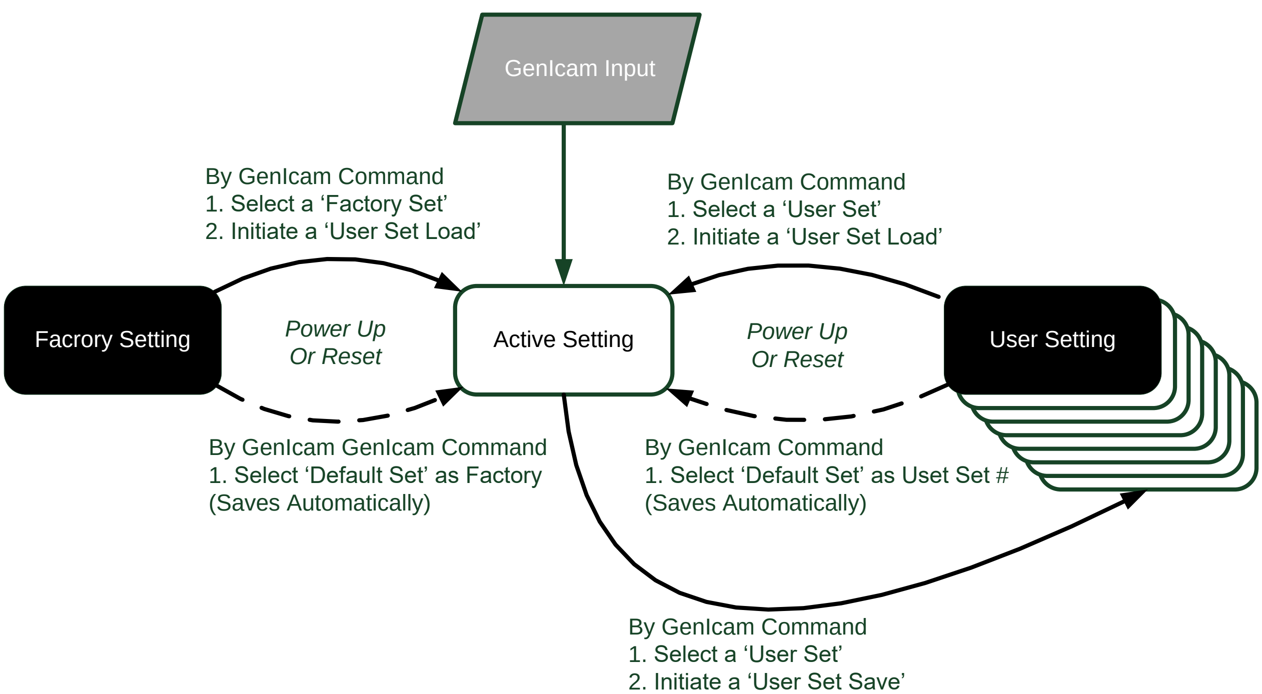


Figure 18. Relationship between the Camera Settings

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 user set configured as the default set when it powers up.

To restore a saved user set, set the user set selector to the set 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

The default setting is the set loaded when the camera is powered up. 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.

Appendix A: GenICam Commands

This appendix lists the available GenICam camera features. The user may access these features using the CamExpert interface or equivalent GUI.

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 View column indicates 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

	Note: The CamExpert 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 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.

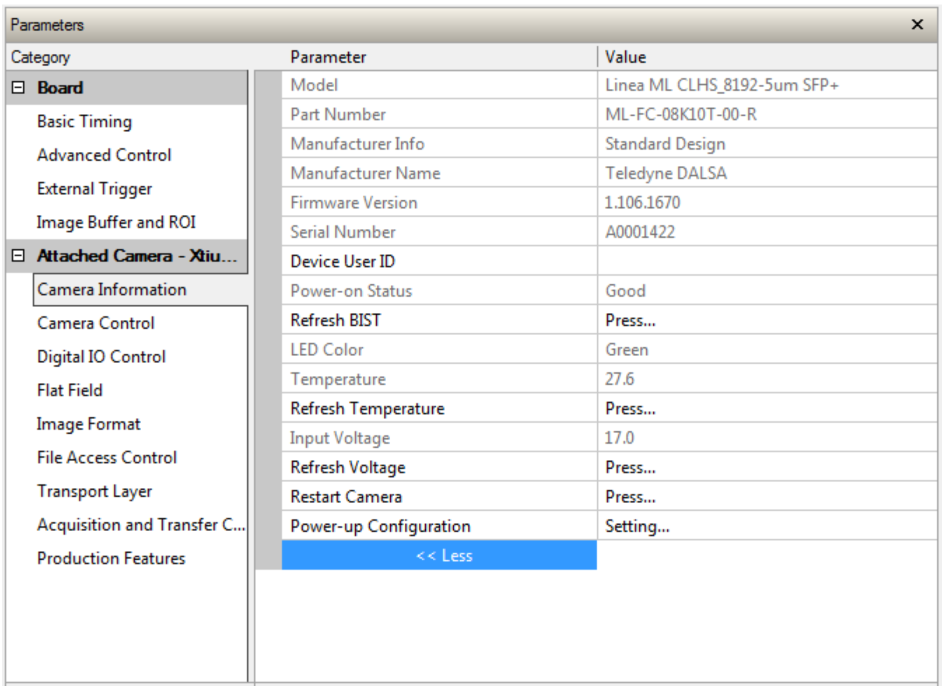


Figure 19 CamExpert Camera Information Panel

Camera Information Feature Descriptions

Display Name	Feature	Description	View
Model Name	DeviceModelName	Displays the device model name. (RO)	Beginner
Vendor Name	DeviceVendorName	Displays the device vendor name. (RO)	Beginner
Part Number	deviceManufacturesPartNumber	Displays the device vendor part number. (RO)	Beginner DFNC
Device Version	DeviceVersion	Displays the device version. This tag will also highlight if the firmware is a beta or custom design. (RO)	Beginner
Manufacturer Info	DeviceManufacturerInfo	This feature provides extended manufacturer information about the device. (RO)	Beginner
Firmware Version	DeviceFirmwareVersion	Displays the currently loaded firmware version number. Firmware files have a unique number and have the .cbf file extension. (RO)	Beginner
Serial Number	DeviceID	Displays the device's factory set camera serial number. (RO)	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)	Beginner

Display Name	Feature	Description	View
Power-on User Set	UserSetDefaultSelector	Selects the camera configuration set to load and make active on camera power-up or reset. Allows the user to select between the factory set and 1 to 16 user sets to be loaded at power up The camera configuration sets are stored in camera non-volatile memory. (RW)	Beginner
Current User Set	UserSetSelector	Selects the camera configuration set to load feature settings from or save current feature settings to when the UserSetLoad or UserSetSave command is used. The Factory set contains default camera feature settings. (RW)	Beginner
Load Configuration	UserSetLoad	Loads the camera configuration set specified by the User Set Selector feature, to the camera and makes it active. (W)	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)	Beginner
Device Built-In Self-Test Status	deviceBISTStatus	Determine the status of the device using the 'Built-In Self-Test' (BIST). Possible return values are device-specific. (RO)	DFNC Beginner
Temperature	deviceTemperature	Displays the internal operating temperature of the camera. (RO)	DFNC Beginner
Refresh Temperature	refreshTemperature	Press to display the current internal operating temperature of the camera.	DFNC Beginner
Input Voltage	deviceInputVoltage	Displays the input voltage to the camera at the power connector (RO)	DFNC Beginner
Refresh Voltage	refreshVoltage	Press to display the current input voltage of the camera at the power connector	DFNC Beginner
Restart Camera	DeviceReset	Used to restart the camera (Warm restart)	Beginner
Device Reset	DeviceReset	Press to reset or reboot the camera	Beginner

Built-In Self-Test Codes (BIST)

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 BIST codes can be found in the Trouble Shooting Guide in Appendix B.

Camera Power-Up Configuration Selection Dialog

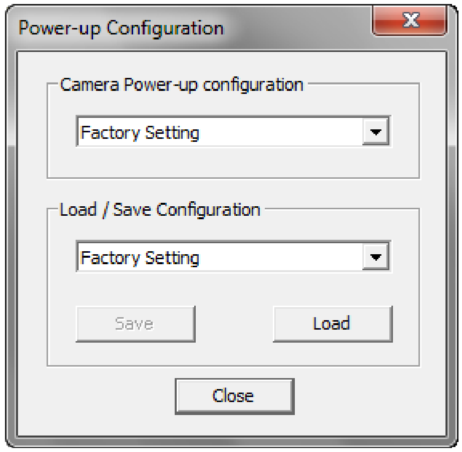


Figure 20 CamExpert Power-up Configuration Dialog

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 the factory data set or from one of 16 available user-saved states.

User Set Configuration Management

The second drop list allows the user to change the camera configuration any time after a power-up (see feature *UserSetSelector*). To reset the camera to the factory configuration, select *Factory Set* and click Load. To save a current camera configuration, select User Set 1 to 16 and click Save. Select a saved user set and click Load to restore a saved configuration.

Camera Control Category

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

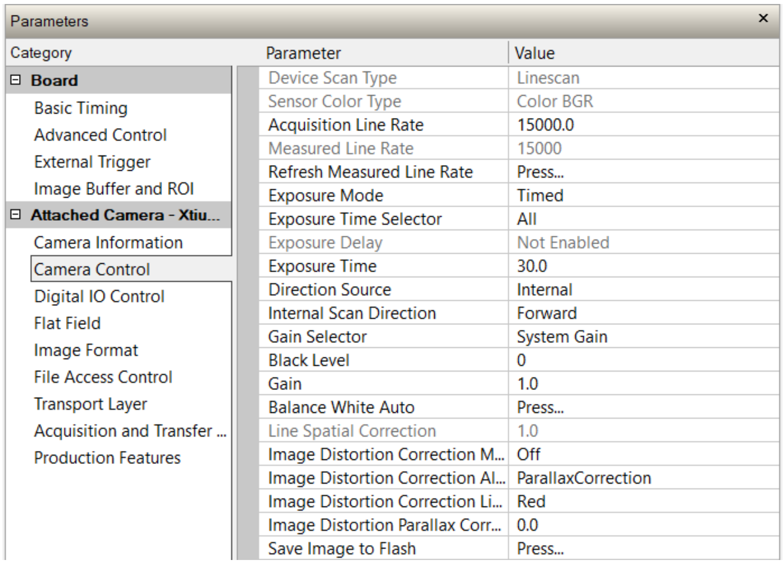


Figure 21: Camera Control Panel

Camera Control Feature Descriptions

Display Name	Feature	Description	View
Device Scan Type	DeviceScanType	Used to set the camera scanning mode. Only standard line scan mode is available.	Beginner
Linescan	*Linescan*	*Linescan sensor.*	
Color Type RGB or RGB+NIR	sensorColorType	Used to set the sensor color type mode.	Beginner DFNC
	CFA_BGR	*Color BGR.*	
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. If necessary, the exposure time will be decreased to fit within the line time.	Beginner
Measured Line Rate	measureLineRate	Specifies the line rate provided to the camera by either internal or external source (RO)	Beginner DFNC
Refresh Measured Line Rate	refreshMeasureLineRate	Press to show the current line rate provided to the camera by either internal or external sources	Beginner DFNC
Exposure Mode	ExposureMode	Sets the operation mode for the camera's exposure	Beginner
Timed	*Timed*	The exposure duration time is set using the Exposure Time feature and the exposure starts with a LineStart event.	

Display Name	Feature	Description	View
Exposure Time	ExposureTime	Sets the exposure time (in microseconds). Can set all or individual rows.	Beginner
Exposure Time Selector	exposureTimeSelector	Selects which line the exposure time is applied to.	Beginner DFNC
All	*All*	*Exposure time applied to all channels.*	
Red	*Red*	*Exposure time applied to red channel.*	
Green	*Green*	*Exposure time applied to green channel.*	
Blue	*Blue*	*Exposure time applied to Blue channel.*	
NIR	*NIR*	*Exposure time applied to NIR channel.*	
Direction Source	sensorScanDirectionSource	Direction determined by value of:	Beginner DFNC
Internal	*Internal*	*SensorScanDirection*	
Line 2	*GPIO2*	*Pin 6 (Low: forward, high: reverse)*	
RotaryEncoder	*Encoder*	*Rotary encoded (must be selected in Digital IO Control | Trigger Source)*	
Internal Scan Direction	sensorScanDirection	When *ScanDirectionSource* is set to Internal, determines the direction of the scan	Beginner DFNC
Forward	*Forward*	*Forward scan direction.*	
Reverse	*Reverse*	*Reverse scan direction.*	
Gain Selector	GainSelector	Selects which gain is controlled when adjusting gain.	Beginner
Blue	*Blue*	*Gain and offset applied to blue channel.*	
Green	*Green*	*Gain and offset applied to green channel.*	
Red	*Red*	*Gain and offset applied to red channel.*	
All Rows	*All*	*Gain and offset applied to all channels.*	
Color Selector	GainSelector	*System gain will apply the gain value while maintaining the existing gain ratios.*	
Blue	Blue		
Green	Green		
Red	Red		
NIR	NIR		
All Colors	All Colors		
System Gain	*System*		
Gain	Gain	Sets the gain as per the gain selector setting.	Beginner
Black Level	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. The value may be positive or negative.	Beginner
Balance White Auto	BalanceWhiteAuto	Initiates white balance bringing all colors equal to the color with the high value using the color gains	Beginner
Line Spatial Correction	sensorLineSpatialCorrection	Sets the number of rows each color is delayed to establish spatial alignment. Must stop acquisition to change.	Beginner DFNC
Image Distortion Correction Mode	imageDistortionCorrectionMode	Used to enable parallax correction. Acquisition must be stopped to modify.	Expert DFNC
Off	*Off*	*Disabled.*	
Active	*Active*	*Enabled.*	

Display Name	Feature	Description	View
Image Distortion Correction Algorithm	imageDistortionCorrectionAlgorithm	Read only. Indicates the type of correction algorithm used i.e Parallax	Expert DFNC
Image Distortion Correction Line Selector	imageDistortionCorrectionLineSelector	Selects whether the Blue (and green) line or the Red (and green) line is stretched. Acquisition must be stopped to modify. See 'Using the Camera at Non-Perpendicular Angles to the Object (Parallax Correction)' section on determining which color is associated with which camera angle	Expert DFNC
Blue	*Blue*	*Blue (and green) line is stretched.*	
Red	*Red*	*Red (and green) line is stretched.*	
Image Distortion Parallax Correction Pixel Stretch	imageDistortionParallaxCorrectionPixelStretch	The stretch value in pixels at the ends of the Blue or Red line. Note the stretch value for green is always half that of the stretch value regardless of which color is selected.	Expert DFNC
Save Image To Flash	saveLastImageToFlash	Captures the current line and saves it to the cameras Flash memory as a TIFF file that can be retrieved using the File Access Control Features	Guru DFNC

Digital I/O Control Category

The camera's Digital I/O Control category is used to configure the camera's GPIO pins.

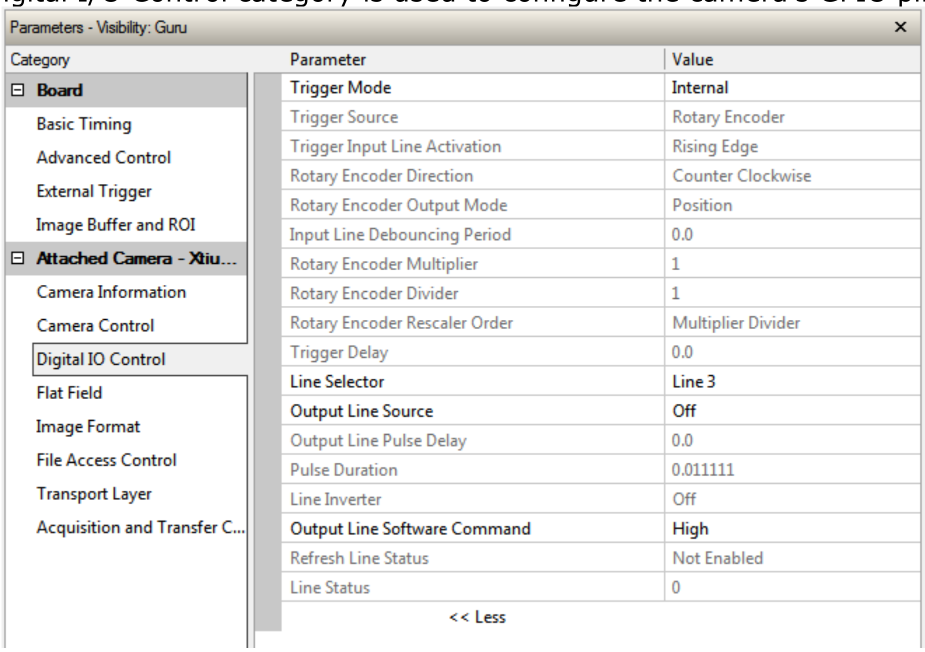


Figure 22: Digital I/O Control Panel

Digital I/O Control Feature Descriptions

Display Name	Feature	Description	View
Trigger Mode	TriggerMode	Determines the source of trigger to the camera.	Beginner
Internal	*Internal*	*Line rate is controlled with AcquisitionLineRate feature.*	
External	*External*	*Trigger comes from CLHS (frame grabber) or GPIO.*	
Trigger Source	TriggerSource	Determines the source of external trigger.	Beginner
CLHS In	*CLHS*	*Source of trigger is from the frame grabber over CLHS.*	
Rotary Encoder	*Encoder*	*Trigger source is from the two shaft encoder inputs.*	
Line 1	*GPIO1*	*Trigger source is from Line 1 of the GPIO connector.*	
Trigger Input Line ActivationEdge	TriggerActivation	Determines which edge of a input trigger will activate on	Beginner
Rising Edge	*RisingEdge*	*The trigger is considered valid on the rising edge of the line source signal (after any processing by the line inverter module).*	
Falling Edge	*FallingEdge*	*The trigger is considered valid on the falling edge.*	
Any Edge	*AnyEdge*	*The trigger is considered valid on any edge.*	

Display Name	Feature	Description	View
Rotary Encoder Direction	rotaryEncoderDirection	Specifies the phase which defines the encoder forward direction.	DFNC Beginner
Counter Clockwise	*CounterClockwise*	*Inspection goes forward when the rotary encoder direction is counter clockwise (phase A is ahead of phase B).*	
Clockwise	*Clockwise*	*Inspection goes forward when the rotary encoder direction is clockwise (phase B is ahead of phase A).*	
Rotary Encoder Output Mode	rotaryEncoderOutputMode	Specifies the conditions for the Rotary Encoder interface to generate a valid Encoder output signal.	DFNC Beginner
Position	*Position*	*Triggers are generated at all new position increments in the selected direction. If the encoder reverses no trigger events are generated until it has again passed the position where the reversal started.*	
Motion	*Motion*	*The triggers are generated for all motion increments in either direction.*	
Input Line Debouncing Period	lineDebouncingPeriod	Specifies the minimum delay before an input line voltage transition is recognizing as a signal transition.	DFNC Beginner
Rotary Encoder Multiplier	rotaryEncoderMultiplier	Specifies a multiplication factor for the rotary encoder output pulse generator.	DFNC Beginner
Rotary Encoder Divisor	rotaryEncoderDivider	Specifies a division factor for the rotary encoder output pulse generator.	DFNC Beginner
Rotary Encoder Rescaler Order	rotaryEncoderRescalerOrder	Specifies the order that the multiplier and divider are applied.	DFNC Beginner
Multiplier Divider	*multiplierDivider*	*The signal is multiplied before been divided.*	
Divider Multiplier	*dividerMultiplier*	*The signal is divided before been multiplied*	
Trigger Delay	TriggerDelay	Allows the trigger to the sensor to be delayed relative to camera input trigger	Beginner
Line Selector	LineSelector	Selects the physical line (or pin) of the external device connector to configure.	Beginner
Line 1 *Line 2* *Line 3* *Line 4* *Line 5* *Line 6*	*GPIO1* *GPIO2* *GPIO3* *GPIO4* *GPIO5* *GPIO6*	*Index of the physical line and associated I/O control block to use.*	
Output Line Source	outputLineSource	Selects which features control the output on the selected line.	DFNC Beginner
Off	*Off*	*Line output level is controlled by the outputLineSoftwareCmd feature.*	
On	*On*	*Line output level is controlled by outputLinePulseDelay, outputLinePulseDuration, and LineInverter features.*	
Output Line Pulse Delay	outputLinePulseDelay	Sets the delay (in µs) before the output line pulse signal. Enabled by the OutputLineSource feature.	DFNC Beginner
outputLinePulseDuration	outputLinePulseDuration	Sets the width (duration) of the output line pulse in microseconds.	DFNC Beginner
Line Inverter	LineInverter	Controls whether to invert the polarity of the selected input or output line signal.	Beginner
Off	*Off*	*The line signal is not inverted.*	

Display Name	Feature	Description	View
On	*On*	*The line signal is inverted.*	
Output Line Software Command	outputLineSoftwareCmd	Set the GPIO out value when outputLineSource is off.	DFNC Expert
Refresh Line Status	refreshLineStatus	Update the LineStatus feature	DFNC Expert
Line Status	LineStatus	Returns the current state of the GPIO line selected with the LineSelector feature. (RO)	DFNC Expert

Flat Field Category

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

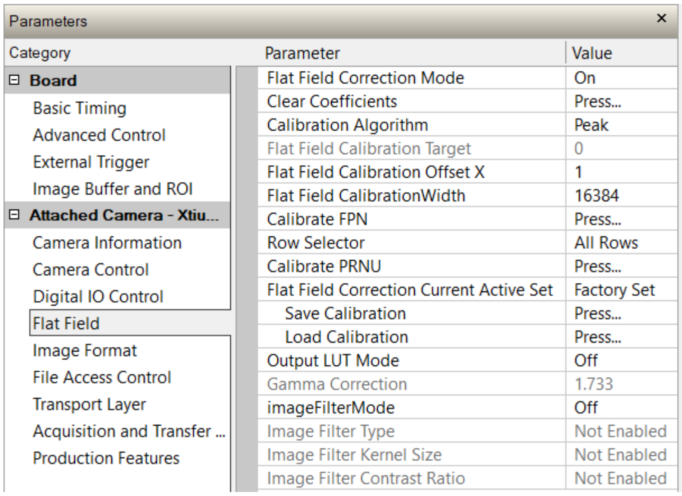


Figure 23: *Flat Field Panel*

Flat Field Control Feature Description

Display Name	Feature	Description	View
Mode	flatfieldCorrectionMode		Beginner DFNC
Off	*Off*	FPN and PRNU correction disabled.	
On	*On*	FPN and PRNU correction enabled.	
Clear Coefficents	flatfieldCalibrationClearCoefficient	Reset all FPN to 0 and all PRNU coefficients to 1.	Beginner DFNC
Calibration Algorithm	flatfieldCorrectionAlgorithm	Selection between four different PRNU algorithms.	Beginner DFNC
Peak	*Peak*	*Calculation of PRNU coefficients to bring all pixels to the peak.*	
Peak, Image Filtered	*PeakFilter*	*A low pass filter is applied to the average line values before calculating the coefficients. Use this algorithm if the calibration target is not uniformly white or if 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 "Peak" algorithm.*	
Set Target	*Target*	*Calculation of PRNU coefficients to bring all pixels to the target value.*	

Display Name	Feature	Description	View
Set Target, Image Filtered	*TargetFiltered*	*A low pass filter is applied to the average line values before calculating the coefficients. Use this algorithm if the calibration target is not uniformly white or if 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 "Target" algorithm.*	
Flat Field Calibration Target	flatfieldCalibrationTarget	Sets the target value for the "Calibrate PRNU" feature.	Beginner DFNC
Flat Field ROI Offset X	flatfieldCalibrationROIOffsetX	Set the starting point of a region of interest where a flat field calibration will be performed	Beginner DFNC
Flat Field ROI Width	flatfieldCalibrationROIWidth	Sets the width of the region of interest where a flat field calibration will be performed	Beginner DFNC
Calibrate FPN	flatfieldCalibrationFPN	Initiates the FPN calibration process	Beginner DFNC
Row Selector	flatfieldCalibrationColorSelector	Specify which sensor rows to perform PRNU calibration on, all or individual colors.	Beginner DFNC
Calibrate PRNU	flatfieldCalibrationPRNU	Initiates the PRNU calibration process	Beginner DFNC
Flat Field Correction Current Active Set	flatfieldCorrectionCurrentActiveSet	Selects the User PRNU set to be saved or loaded.	Guru DFNC
Factory Set	*Factory Set*	*Factory set can only be loaded.*	
User Set 1 (1 thru 16)	*UserSet1 (1 thru 16)*	*Only the PRNU values are saved or loaded which is much faster than saving or loading the full Factory or User set.*	
Save Calibration	flatfieldCalibrationSave	Saves the User PRNU set specified by *flatfieldCorrectionCurrentActiveSet* to the camera.	Guru DFNC
Load Calibration	flatfieldCalibrationLoad	Loads the User PRNU set specified by latfieldCorrectionCurrentActiveSet to the camera and makes it active.	Guru DFNC
Output LUT Mode	lutMode	Allows the output LUT to be selected When enabled, the same LUT is used for all colors	Beginner DFNC
Off	*Off*	*The output LUT is disabled and linear data is output*	
Gamma Correction	*Gamma*	*LUT populated using the Gamma correction equation*	
User Defined	*UserDefined*	*LUT uploaded by the user is used.*	
Gamma Correction	gammaCorrection	The output LUT is populated using the following gamma correction equation: $DN_{out} = 255 \times \left(\frac{DN_{in}}{255}\right)^{\frac{1}{\gamma}}$	Beginner DFNC
Image Filter Mode	imageFilterMode	Enable image filter.	Beginner DFNC
Off	*Off*	*Disable the image filter.*	

Display Name	Feature	Description	View
Active	*Active*	*Enable the image filter*	
Image Filter Type	imageFilterType	Specifies the image filter type. Read-only.	Beginner DFNC
Weighted Average	*Weighted_Average*	*Wieght average algorithm.*	
Image Filter Kernel Size	imageFilterKernelSize	Selects the kernel size.	Beginner DFNC
Kernel 1x3	*KERNEL_1x3*	1x3 kernel.	
Kernel 1x5	*KERNEL_1x5*	1x5 kernel.	
Image Filter Contrast Ratio	imageFilterContrastRatio	Sets the image filter contrast ratio threshold. Values range from 0 to 1.	

Image Format Control Category

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

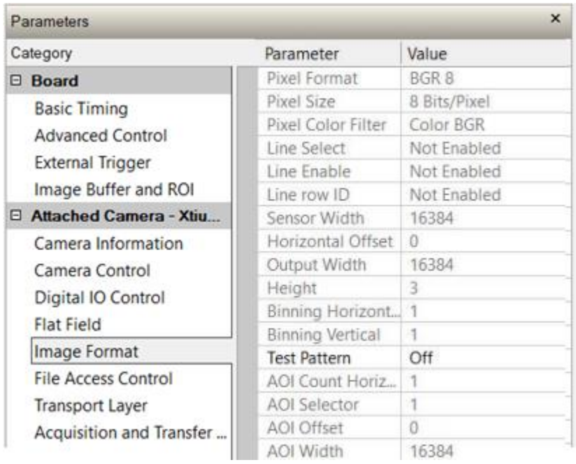


Figure 24: Image Format Panel

Image Format Control Feature Description

Display Name	Feature	Description	Device Version & View
Pixel Format	PixelFormat*r*	Output image pixel coding format of the sensor.	Beginner
Mono 8	*Mono8*	*8-bit monochrome format is used when processesing each color separately.*	
BGR	*RGB8_Planar*	*BGR 8-bit planar color format is used to process and display color images.*	
Pixel Size	PixelSize	Total size in bits of an image pixel. Read-only.	Beginner
8 Bits/Pixel	*Bpp8*	*8 Bits / Pixel.*	
Pixel Coding Filter	PixelCodingFilter	Indicates the type of color filter used in the camera. Read only.	Beginner DFNC
None	*Mono*	*No pixel coding filter when pixel format is Mono 8.*	
BGR	*BGR*	*BGR pixel coding filter used when pixel format is BGR 8.*	
Line Select	ComponentSelector	Selects the color to enable/disable. Available only with Mono formats.	Beginner
NIR	*NIR*	*NIR channel.*	
Blue	*Blue*	*Blue channel.*	
Green	*Green*	*Green channel.*	
Red	*Red*	*Red channel.*	
Line Enable	ComponentEnable	Enable/disables the selected color. Available only with Mono formats.	Beginner
False	*False*	*Disable the selected color.*	
True	*True*	*Enable the selected color*	

Line row ID	ComponentID	Indicates which color buffer the data will be written to in the frame grabber Applicable only to Mono formats Read only	Beginner
Sensor Width	WidthMax	Indicates the maximum number of pixels available in the long (line) axis the sensor. Read only	Beginner
Horizontal Offset	OffsetX	Output image horizontal offset from the origin. This is zero for color cameras. Read only	Beginner
Output Width	Width	Horizontal width of the pixels output. Equals the sum of AOI's divided by the horizontal binning factor. Read only	Beginner
Height	Height	Height of the image provided by the device (in object pixels). 1 to 3. Read only.	Beginner
Binning Horizontal	BinningHorizontal	Number of horizontally adjacent pixels to sum together. This increases the intensity of the pixels and reduces the horizontal resolution of the image	Beginner
Binning Vertical	BinningVertical	Number of vertically adjacent pixels to sum together. This increases the intensity of the pixels and reduces the vertical resolution of the image	Beginner
Test Pattern	TestImageSelector	Selects the type of test image that is sent by the camera. Note. Grey images are displayed so that any bit error will immediately be apparent as a color.	Beginner
Off	*Off*	*Selects sensor video to be output*	
Each Tap Fixed	*EachTapFixed*	*Selects a grey scale value that is increased every 512 pixels.*	
Grey Horizontal Ramp	*Grey Horizontal Ramp*	*Selects a grey scale ramp*	
Grey Vertical Ramp	*Grey Vertical Ramp*	*Selects a grey scale ramp progressively for each row.*	
Grey Diagonal Ramp	*Grey Diagonal Ramp*	*Selects a combination of horizontal and vertical raps to form a diagonal grey scale.*	
User Pattern	*User Pattern*	*User can define a test pattern by uploading to the camera a PRNU file using the FileAccess > Miscellaneous > User PRNU feature. The PRNU coefficient will be applied to a midscale (128 DN) test image.* *Contact Teledyne DALSA support for an Excel file that can help with this.*	
AOI Count Horizoontal	multipleROICount	Specified the number of AOI's in an acquired image, 1 to 4.	Beginner DFNC
AOI Selector	multipleROISelector	Select 1 of up to 4 AOI's when setting the AOI Offset & AOI Width	Beginner DFNC
AOI Offset	multipleROIOffsetX	Location of the start of a single Area of Interest to be output, must be a multiple of 32.	Beginner DFNC

AOI Width	multipleROIWidth	Width of the start of a single Area of Interest to be output. Minimum is 96 per lane. e.g., if there is only one AOI spread across the 5 lanes then the minimum is 5 x 96 = 480. Maximum of the sum of AOI width's is the sensor width. e.g., for a 16k sensor, if there are two AOI's with the first 12k wide, then the second can be no wider than 4k.	Beginner DFNC

Transport Layer Control Category

Note: All features shown in Guru visibility.

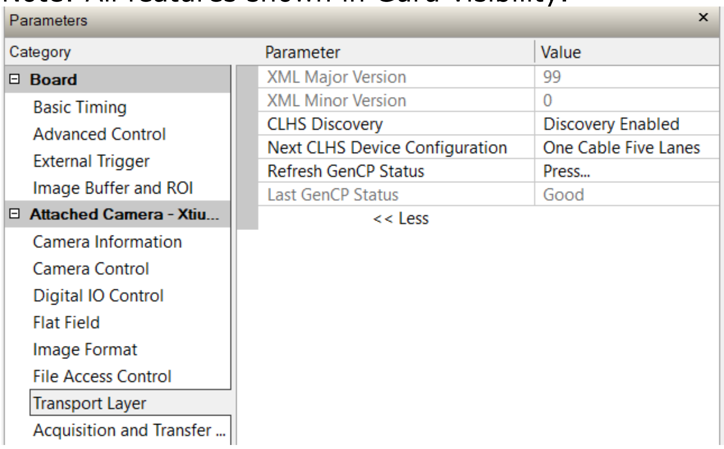


Figure 25: Transport Layer Panel

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)	Beginner
XML Minor Version	DeviceManifestXMLMinorVersion	Together with DeviceManifestXMLMajorVersion specifies the GenICam™ feature description XML file version (RO)	Beginner
Next CLHS Device Configuration	clhsNextDeviceConfig	When the camera is next powered up, the specified CLHS lane configuration will be set for the camera.	Guru DFNC
One Cable Five Lanes	*OneCableFiveLanes*	*CX4 configuration*	
One Cable One Lane	*OneCableOneLane*	*SFP+ One Cable*	
Two Cables One Lane	*TwoCablesOneLane*	*SFP+ Two Cables*	
Refresh GenCP Status	refreshGenCPStatus	Press to update the GenCP Status.	Beginner DFNC
Last GenCP Status	genCPStatus	If a feature read or write returns that it fails, read this feature to get the actual reason for the failure Returns the last error. Reading this feature clears it. Sapera only.	Beginner DFNC

Acquisition and Transfer Control Category

The Acquisition and Transfer controls as shown by CamExpert, has parameters used to configure the acquisition modes of the device.

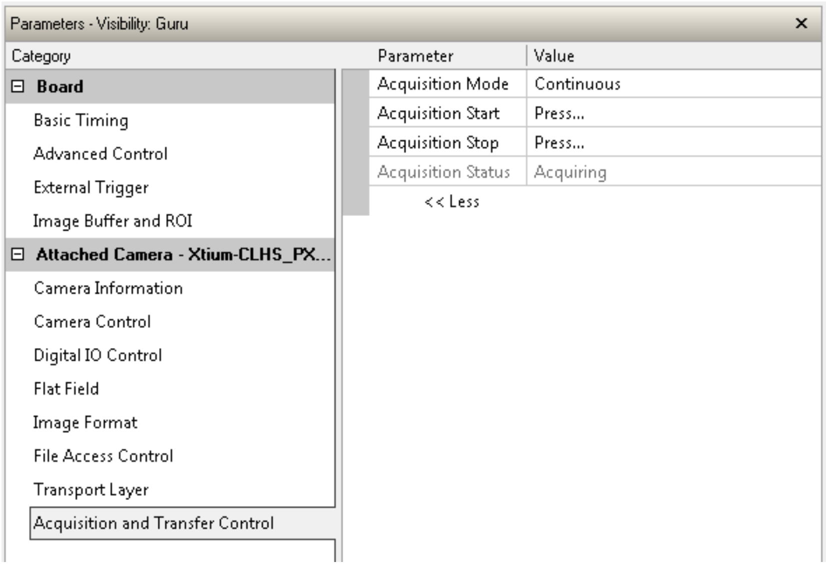


Figure 26: Acquisition & Transfer Control Panel

Acquisition and Transfer Control Feature Descriptions

Display Name	Feature	Description	Device Version & View
Acquisition Mode	AcquisitionMode	The device acquisition mode defines the number of frames to capture during an acquisition and the way it stops	Beginner
Continuous	Continuous	Only continuous mode is currently available.	
Acquisition Start	AcquisitionStart	Commands the camera to start sending image data. (WO)	Beginner
Acquisition Stop	AcquisitionStop	Commands the camera to stop sending image data at the end of the current line (WO)	Beginner
Acquisition Status	AcquisitionStatus	Indicates whether the camera has been commanded to stop or to send image data.	Beginner

File Access Control Category

The File Access control in CamExpert allows the user to quickly upload and download various data files to/from the connected the camera. The supported data files for the 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.

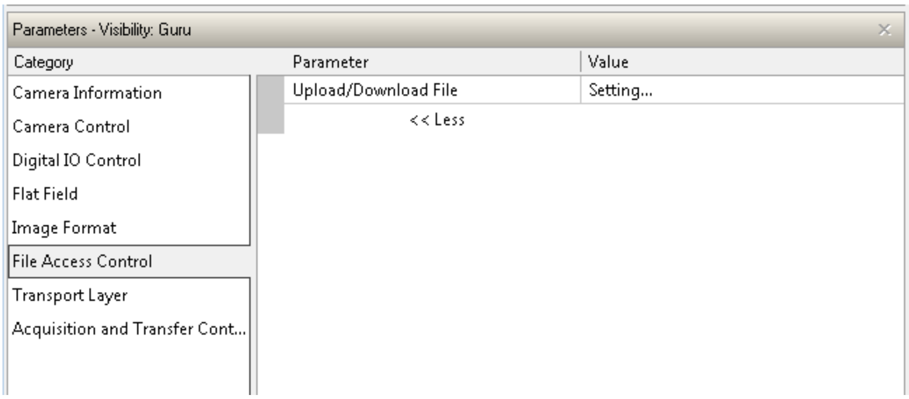


Figure 27: File Access Control Panel

File Access Control Feature Descriptions

Display Name	Feature	Description	View
File Selector	FileSelector	Selects the file to access. The files which are accessible are listed in the XML:	Beginner
All Firmware	*Firmware1*	*Upload micro code, FPGA code & XML as a single file to the camera which will execute on the next camera reboot cycle.*	
User Set	*User_Set*	*Use UserSetSelector to specify which user set to access.*	
Output LUT	*Output_LUT*	*Use UserSetSelector to specify which LUT to access.*	
User PRNU	*User_PRNU*	*Use UserSetSelector to specify which user PRNU to access.*	
User FPN	*User_FPN*	*Use UserSetSelector to specify which user FPN to access.*	
Current PRNU	*Cur_PRNU*	*Accesses the PRNU coefficients that are currently being used by the camera (not necessarily saved).*	
Camera_Data	*CameraData*	*Download camera information and send for customer support.*	
File Operation Selector	FileOperationSelector	Selects the operation for the selected file in the device. This operation is executed when the File Operation Execute feature is called.	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.*	
File Operation Execute	FileOperationExecute	Executes the operation selected by File Operation Selector on the selected file.	Guru
File Open Mode	FileOpenMode	Selects the access mode used to open a file on the device.	Guru
Read	*Read*	*Select READ only open mode*	
Write	*Write*	*Select WRITE only open mode*	

Display Name	Feature	Description	View
File Access Buffer	FileAccessBuffer	Defines the intermediate access buffer that allows the exchange of data between the device file storage and the application.	Guru
File Access Offset	FileAccessOffset	Controls the mapping offset between the device file storage and the file access buffer.	Guru
File Access Length	FileAccessLength	Controls the mapping length between the device file storage and the file access buffer.	Guru
File Operation Status	FileOperationStatus	Displays the file operation execution status. (RO).	Guru
Success	Success	The last file operation has completed successfully.	
Invalid Parameter	InvalidParameter	An invalid parameter was passed to the last feature called.	
Write Protect	WriteProtect	Attempt to write to a read-only (factory) file.	
File Not Open	FileNotOpen	The file has not been opened yet.	
File Too Big	FileTooBig	The file is larger than expected.	
File Invalid	FileInvalid	The last file operation has completed unsuccessfully because the selected file is not present in this camera.	
File Operation Result	FileOperationResult	For Read or Write operations, the number of successfully read/written bytes is returned. (RO)	Guru
File Size	FileSize	Represents the size of the selected file in bytes.	Guru

File Access via the CamExpert Tool

1. Click on the “Setting…” button to show the file Access Control dialog box.

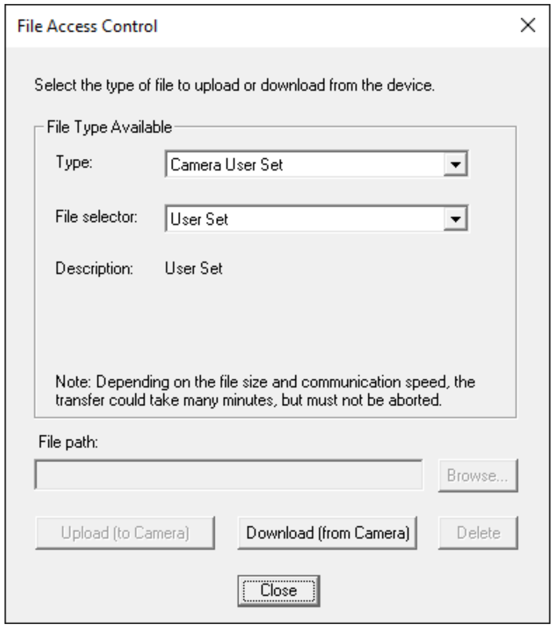


Figure 28: File Access Control Tool

2. From the Type drop menu, select the file type that will be uploaded to the camera or downloaded from the camera.
3. From the File Selector drop menu, select the file to be uploaded or downloaded.
4. To upload a file, click the Browse button to open a typical Windows Explorer window.
    a. Select the specific file from the system drive or from a network location.
    b. Click the Upload button to execute the file transfer to the camera.
5. Alternatively, click the Download button and then specify the location where the file should be stored.
6. Note that firmware changes require that the camera be powered down and then back up. Additionally, CamExpert should be shut down and restarted following a reset.
7. Caution: Do not interrupt the file transfer by powering down the camera or closing CamExpert.

CLHS File Transfer Protocol

If you are not using CamExpert to perform file transfers, pseudo-code for the CLHS File Transfer Protocol is as follows.

Download File from Camera

1. Select the file by setting the FileSelector feature
2. Set the FileOpenMode to Write
3. Set the FileOperationSelector to Open
4. Open the file by setting FileOperationExecute to 1
   This is a read-write feature - poll it every 100 ms until it returns 0 to indicate it has completed
   a. Read FileOperationStatus to confirm that the file opened correctly.
   b. A return value of 0 is success. Error codes are listed in the XML.
5. Read FileSize to get the maximum number of bytes allowed in the file
   a. Abort and jump to Close if this is less the file size on the host
6. From FileAccessBuffer.Length you will know that maximum number of bytes that can be written through FileAccessBuffer is 988.
7. For Offset = 0 While ((Offset < Host File Size) and (Status = 0)) Do
   a. Set FileAccessOffset to Offset
   b. Set FileAccessLength to min(Host File Size - Offset, FileAccessBuffer.Length), the number of bytes to write
   c. Read next FileAccessLength bytes from host file.
   d. Write the bytes to FileAccessBuffer
   e. Set the FileOperationSelector to Write
   f. Write to the file by setting FileOperationExecute to 1 and poll until 0 and complete
   g. Read FileOperationStatus to confirm the write worked
   h. Read FileOperationResult to confirm the number of bytes written
8. Next Offset = Offset + number of bytes written
9. Set the FileOperationSelector to Close
10. Close the file by setting FileOperationExecute to 1 and poll until 0 and complete
11. Read FileOperationStatus to confirm the close worked

Upload File to Camera

1. Select the file by setting the FileSelector feature
2. Set the FileOpenMode to Read
3. Set the FileOperationSelector to Open
4. Open the file by setting FileOperationExecute to 1
   This is a read-write feature - poll it every 100 ms until it returns 0 to indicate it has completed
5. Read FileOperationStatus to confirm that the file opened correctly
   A return value of 0 is success. Error codes are listed in the XML.
6. Read FileSize to get the number of bytes in the file
7. From FileAccessBuffer.Length you will know that maximum number of bytes that can be read through FileAccessBuffer is 988.
8. For Offset = 0 While ((Offset < FileSize) and (Status = 0)) Do
   a. Set FileAccessOffset to Offset
   b. Set FileAccessLength to min(FileSize - Offset, FileAccessBuffer.Length), the number of bytes to read
   c. Set the FileOperationSelector to Read
   d. Read the file by setting FileOperationExecute to 1 and poll until 0 and complete
   e. Read FileOperationStatus to confirm the read worked
   f. Read FileOperationResult to confirm the number of bytes read
   g. Read the bytes from FileAccessBuffer
   h. Write bytes read to host file.
9. Next Offset = Offset + number of bytes read
10. Set the FileOperationSelector to Close
11. Close the file by setting FileOperationExecute to 1 and poll until 0 and complete
12. Read FileOperationStatus to confirm the close worked

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.

Appendix B: Trouble Shooting Guide

Diagnostic Tools

Camera Data File

The Camera Data file includes the operational configuration and status of the camera. 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 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.

Note: gray images are displayed so that any bit-error will immediately be apparent as colored pixels in the image

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 64 increases in by 4 steps every 512 pixels ending in 188
- Grey Horizontal Ramp
  - 2 horizontal ramps starting at 0 increases in by 1 every 32 pixels
- Grey Vertical Ramp
  - Vertical ramp starting with blue 5, green 12, red 19, and incrementing by 3 every line
- Grey Diagonal Ramp
  - Add horizontal and vertical ramps
- 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 Flat Field Coefficients for details.

Built-In Self-Test Codes

The Built-In Self-test (BIST) codes are located in the Camera Information pane under Power-on Status. None of these should occur in a properly functioning camera except OVER_TEMPERATURE. OVER_TEMPERATURE occurs if there ambient temperature is too high, there is insufficient air circulation or heat sinking.

Table 16: BIST Codes

Bit Number	Name	Hex Position	Binary Translation
1	I2C	0x00000001	0000 0000 0000 0000 0000 0000 0000 0001
2	FPGA_NO_INIT	0x00000002	0000 0000 0000 0000 0000 0000 0000 0010
3	FPGA_NO_DONE	0x00000004	0000 0000 0000 0000 0000 0000 0000 0100
4	SENSOR SPI	0x00000008	0000 0000 0000 0000 0000 0000 0000 1000
5	ECHO_BACK	0x00000010	0000 0000 0000 0000 0000 0000 0001 0000
6	FLASH_TIMEOUT	0x00000020	0000 0000 0000 0000 0000 0000 0010 0000
7	FLASH_ERROR	0x00000040	0000 0000 0000 0000 0000 0000 0100 0000
8	NO_FPGA_CODE	0x00000080	0000 0000 0000 0000 0000 0000 1000 0000
9	NO_COMMON_SETTINGS	0x00000100	0000 0000 0000 0000 0000 0001 0000 0000
10	NO_FACTORY_SETTINGS	0x00000200	0000 0000 0000 0000 0000 0010 0000 0000
11	OVER_TEMPERATURE	0x00000400	0000 0000 0000 0000 0000 0100 0000 0000
12	SENSOR PATTERN	0x00000800	0000 0000 0000 0000 0000 1000 0000 0000
13	NO_USER_FPN	0x00001000	0000 0000 0000 0000 0001 0000 0000 0000
14	NO_USER_PRNU	0x00002000	0000 0000 0000 0000 0010 0000 0000 0000
15	CLHS_TXRDY_RETRY	0x00004000	0000 0000 0000 0000 0100 0000 0000 0000
16	(Reserved)	0x00008000	0000 0000 0000 0000 1000 0000 0000 0000
17	NO_USER_SETTINGS	0x00010000	0000 0000 0000 0001 0000 0000 0000 0000
18	NO_ADC_COEFFICIENTS	0x00020000	0000 0000 0000 0010 0000 0000 0000 0000
19	NO_SCRIPT	0x00040000	0000 0000 0000 0100 0000 0000 0000 0000
20	(Reserved)	0x00080000	0000 0000 0000 1000 0000 0000 0000 0000
21	(Reserved)	0x00100000	0000 0000 0001 0000 0000 0000 0000 0000
22	(Reserved)	0x00200000	0000 0000 0010 0000 0000 0000 0000 0000
23	NO_FACT_PRNU	0x00400000	0000 0000 0100 0000 0000 0000 0000 0000
24	NO_FATFS	0x00800000	0000 0000 1000 0000 0000 0000 0000 0000

Status LED

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

Table 17: Status LED States

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 stopped output and has shut down some components 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 been broken.
Constant Green	The CLHS Link has been established and data transfer may begin

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 XTIUM-CLHS frame grabber user manual for details.
    c. Do the encoder signal levels conform to the requirements outlined in the XTIUM-CLHS 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 cameras 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 Flat Field 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.

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 and color artifacts 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.

It is not always possible to establish the exact EXSYNC resolution or lens magnification ensures accurate synchronization. To alleviate this problem, the camera has a spatial correction feature that can make fine adjustment to restore the alignment. (See section 'Compensating for Encoder Errors' for details.)

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 loss EXSYNC due to over-speed may also cause horizontal color artifacts.

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 Slowing Down Changing Direction

The camera must align the three colors in a fashion that accurately follows the object motion. When the scan direction changes the 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.

Power Supply Issues

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

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 front 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 front 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 to approximately +70% of normal operation. If the camera's temperature continues to rise, at +90°C the camera will further reduce it 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.

Declarations of Conformity

Copies of the Declarations of Conformity documents are available on the product page on the Teledyne DALSA website or by request.

FCC Statement of Conformance

This equipment complies with Part 15 of the FCC rules. Operation is subject to the following conditions:

1. The product may not cause harmful interference; and
2. The product must accept any interference received, including interference that may cause undesired operation.

FCC Class A Product

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

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

This equipment is intended to be a component of a larger industrial system.

EU and UKCA Declaration of Conformity

Teledyne DALSA declares that this product complies with applicable standards and regulations.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

This product is intended to be a component of a larger system and must be installed as per instructions to ensure compliance.

Document Revision History

Revision	Description	Date
00	Preliminary Draft.	Aug 1, 2020
01	Updated spectral and QE response graphs	Feb 10, 2022

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