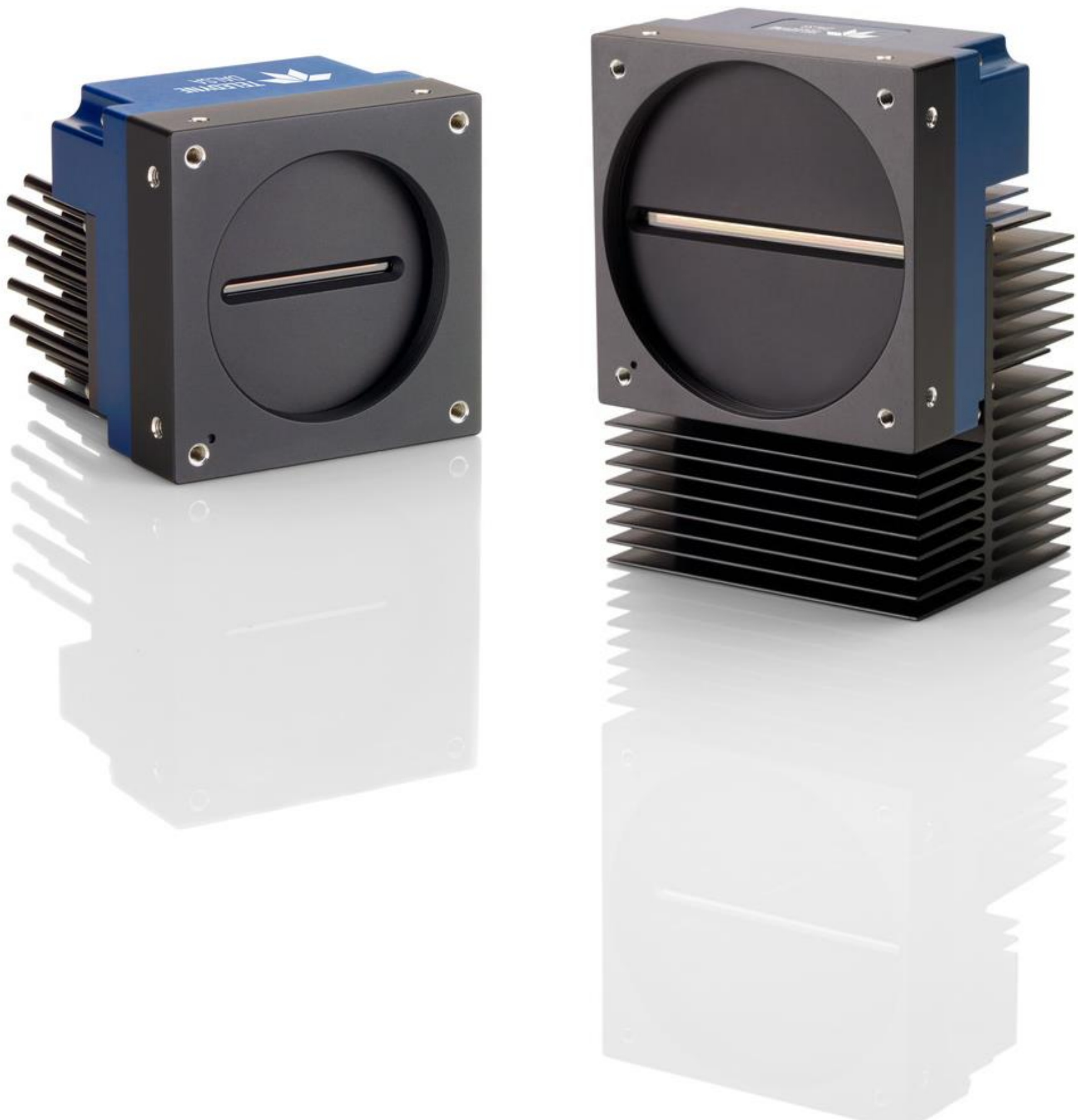
Linea HS Series

Camera User's Manual

Monochrome, Color and Multifield TDI Line Scan

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



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CAMERA Link HS™

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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-aperformance semiconductor and Electronics Company that designs, develops, manufactures, and markets digital imaging products and solutions, in addition to providing wafer foundry services.

Teledyne DALSA 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.

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Linea HS Series Cameras

Description

Teledyne DALSA introduces a breakthrough CMOS TDI line scan camera format with unprecedented speed, responsivity and exceptionally low noise.

The Linea HS™ TDI cameras have 4k, 8k,13k, 16k or 32k pixel resolution, a 5 µm x 5 µm pixel size and are compatible with fast, high magnification lenses.

The Linea HS 32k camera is capable of capturing 32768 pixel wide images with a patent-pending sensor design that enables users to significantly improve subpixel defect detectability while using existing optical lenses. These cameras have a maximum line rate of 400 kHz with up to 32k resolution.

The camera uses the Camera Link HS™ interface—the industry standard for very high-speed camera interfaces with long transmission distances and cable flexing requirements (CX4 or LC connector).

Teledyne DALSA's Linea HS cameras and compatible frame grabbers combine to offer a complete solution for the next generation of automatic optical inspection 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, DNA sequencing, printed circuit boards, film and large format web materials.

Monochrome Models

Part Number	Description
HL-FM-04K30H-00-R	4096 x 192 pixels, maximum line rate of 300 kHz, 5 µm x 5 µm pixel size, monochrome / HDR output, Camera Link HS LC fiber optic connector.
HL-FM-08K30H-00-R	8192 x 192 pixels, maximum line rate of 280 kHz (up to 300 kHz using AOI), 5 µm x 5 µm pixel size, monochrome / HDR output, Camera Link HS LC fiber optic connector.
HL-HM-08K30H-00-R	8192 x 192 pixels, maximum line rate of 300 kHz, 5 µm x 5 µm pixel size, monochrome / HDR output, Camera Link HS CX4 connector.
HL-HM-08K40H-00-R	8192 x 192 pixels, maximum line rate of 400 kHz, 5 µm x 5 µm pixel size, monochrome / HDR output, Camera Link HS CX4 control & data connector.
HL-FM-13K18H-00-R	13056 x 192 pixels, maximum line rate 180 kHz, 5 µm x 5 µm pixel size, monochrome / HDR output, Camera Link HS LC fiber optic connector.
HL-HM-13K30H-00-R	13056 X 192 pixels, maximum line rate 300kHz, monochrome / HDR output, Camera Link HS CX4 data connector.
HL-FM-16K15A-00-R	16384 x 128 pixels, maximum line rate of 143 kHz (up to 150 kHz using AOI, 5 µm x 5 µm pixel size, monochrome output, Camera Link HS LC fiber optic connector.
HL-HM-16K30H-00-R	16384 x 192 pixels, maximum line rate of 300 kHz, 5 µm x 5 µm pixel size, monochrome / HDR output, Camera Link HS CX4 data connector.
HL-HM-16K40H-00-R	16384 x 192 pixels, maximum line rate of 400 kHz, 5 µm x 5 µm pixel size, monochrome / HDR output, Camera Link HS CX4 control & data connector, front side illuminated (FSI).
HL-HM-16K40H-00-B	16384 x 192 pixels, maximum line rate of 400 kHz, 5 µm x 5 µm pixel size, monochrome / HDR output, Camera Link HS CX4 control & data connector, back side illuminated (BSI).
HL-HM-32K40S-00-R	32,768 pixels x 64, maximum line rate of 400 kHz, 2.5 µm x 2.5 µm pixel size, monochrome output, Camera Link HS CX4 control & data connector.

Color and Multifield Technology

Multifield is a new imaging technology that enables capturing multiple images using various lighting conditions (for example, brightfield, darkfield and backlight) in a single scan.

Teledyne DALSA's Linea HS multifield camera is the first product in the industry capable of capturing up to three images using light sources at different wavelengths.

The camera uses advanced wafer-level coated dichroic filters with minimum spectral crosstalk to spectrally isolate three images captured by separate TDI arrays. Depending on the light sources used, narrowband filters may be needed at the light sources.

This new technology significantly improves the inspection speeds and image quality, as it eliminates the need for multiple scans in an inspection system.

The difference between traditional color imaging and multifield imaging is in the filter technology. Conventional color filters have significant spectral crosstalk between RGB channels, while the multifield filters have minimal spectral crosstalk.

Color and Multifield Models

Part Number	Description
HL-HC-16K10T-00-R	16384 x (64 + 128 +64) pixels, maximum line rate of 300 kHz (100 kHz x 3), 5 µm x 5 µm pixel size, RGB output, Camera Link HS CX4 control & data connector.
HL-HF-16K13T-00-R	16384 x (64 + 128 +64) pixels, maximum line rate of 400 kHz (400/3 kHz), 5 µm x 5 µm pixel size, multifield output, Camera Link HS CX4 control & data connector.

Camera Highlights

Common Features

- Highly sensitive CMOS TDI
- Up to 400 kHz line rates
- Very low noise
- Bidirectionality
- Horizontal and Vertical Binning
- Robust Camera Link HS interface
- CX4 or LC Camera Link HS control & data connector
- Smart lens shading correction
- High dynamic LUT mode

Resolution

- Monochrome Models: 4K, 8K, 13K, 16K 32k pixel resolution
- Color and Mulitifield Model: 16K pixel resolution

Programmability

- Multiple areas of interest for data reduction
- Region of interest for easy calibration of lens and shading correction
- Smart lens shading correction
- Test patterns & diagnostics

Applications

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

Part Numbers and Software Requirements

The camera is available in the following configurations.

Table 1: Camera Models Comparison

Part Number	Resolution	Max. Line Rates	Pixel Size	Control & Data
Monochrome				
HL-FM-04K30H-00-R	4096 x 192 (128 + 64)	300 kHz mono /150 kHz x 2 HDR	5.0 x 5.0 µm	Camera Link HS LC fiber optic
HL-FM-08K30H-00-R	8192 x 192 (128 + 64) pixels	280 kHz mono / 140 kHz x 2 HDR (300 kHz / 150 kHz x 2 using AOI)	5.0 x 5.0 µm	Camera Link HS LC fiber optic
HL-HM-08K30H-00-R	8192 x 192 (128 + 64) pixels	300 kHz mono / 150 kHz x 2 HDR	5.0 x 5.0 µm	Camera Link HS CX4
HL-HM-08K40H-00-R	8192 x 192 (128 + 64) pixels	400 kHz mono / 200 kHz x 2 HDR	5.0 x 5.0 µm	Camera Link HS CX4
HL-FM-13K18H-00-R	13056 x 192 (128 + 64)	180 kHz mono / 90 kHz x 2 HDR	5.0 x 5.0 µm	Camera Link HS LC fiber optic
HL-HM-13K30H-00-R	13056 x 192 (128 + 64)	300 kHz mono / 150 kHz x 2 HDR	5.0 x 5.0 µm	Camera Link HS CX4
HL-FM-16K15A-00-R	16384 x 192 (128 + 64) pixels	140 kHz mono (150 kHz using AOI)	5.0 x 5.0 µm	Camera Link HS LC fiber optic
HL-HM-16K30H-00-R	16384 x 192 (128 + 64) pixels	300 kHz mono / 150 kHz x 2 HDR	5.0 x 5.0 µm	Camera Link HS CX4
HL-HM-16K40H-00-R	16,384 x 192 (128 + 64) pixels	400 kHz mono / 200 kHz x 2 HDR	5.0 x 5.0 µm	Camera Link HS CX4
HL-HM-16K40H-00-B	16,384 x 192 (128 + 64) pixels	400 kHz mono / 200 kHz x 2 HDR	5.0 x 5.0 µm	Camera Link HS CX4
HL-HM-32K40S-00-R	32,768 x 64 pixels	400 kHz	2.5 x 2.5 µm	Camera Link HS CX4
Color				
HL-HC-16K10T-00-R	16,384 x (64 + 128 + 64) pixels	100 kHz x 3	5.0 x 5.0 µm	Camera Link HS CX4
Multifield				
HL-HF-16K13T-00-R	16,384 x (64 + 128 + 64) pixels	400/3 kHz	5.0 x 5.0 µm	Camera Link HS CX4

Table 2: Maximum Linerate of each mode

Mode	Maximum Linerate (kHz)
TDI BGR	400/3
TDI Red	400/1
TDI Green	400/1
TDI Green Red	400/2
TDI Blue Red	400/2
TDI Blue Green	400/2
TDI Area	2 (frame rate, kHz)
TDI Extended Area	650 (frame rate, Hz)

Table 3: Frame Grabber

Compatible Frame grabber	Linea HS Model
Teledyne DALSA Xtium2-CLHS FX8 (OR-A8S0-FX840)	HL-FM-04K30H HL-FM-08K30H HL-FM-13K18H HL-FM-16K15A
Teledyne DALSA Xtium2-CLHS PX8 (OR-A8S0-PX870)	HL-HM-08K30H HL-HM-08K40H HL-HM-13K30H HL-HM-16K30H HL-HF-16K13T HL-HM-16K40H HL-HC-16K10T
Teledyne DALSA Xtium2-CLHS PX8-HR (OR-A8S0-HX870)*	HL-HM-32K40S
Other compatible frame grabbers may be available from third-party vendors.	

*Required for custom patent-pending pixel processing: HL-HM-32K40 S-00-R is currently only compatible with this frame grabber.

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 [Teledyne DALSA Web site]

Specifications

Test Conditions unless otherwise specified:

- 8-bit, 1x gain
- 100 kHz line rate
- Light source: White LED if wavelength not specified
- Front plate temperature: +45º C
- DN = digital number

Specifications not guaranteed when operating in area mode

Common Camera Specifications

The following specifications apply to all models.

Table 5: Common Camera Performance Specifications

Specifications		
Imager Format	High speed CMOS TDI	
Pixel Size	5.0 µm x 5.0 µm	
Pixel Fill Factor	100%	
Connectors and Mechanicals		
Control & Data Interface	Camera Link HS CX4 or LC	
Power	+12 V to +24 V DC, Hirose 12-pin circular	
Operating Temp	+0 °C to +65°C (front plate temperature)	
Optical Interface		
Sensor to Camera Front Distance	12 mm	
Sensor Alignment (Relative to sides of camera)		
Flatness	50 µm	
Θ y	100 µm (Parallelism vs. front plate)	
x	± 300 µm (Cross-Scan Direction)	
y	± 300 µm (In-Scan Direction)	
z	± 300 µm (Along optical axis)	
Θ z	± 0.4° (Rotation around optical axis)	
Performance		**Notes**
Analog Gain	1x, 2x, 4x or 8x	
Digital Gain	1x to 10x	
DC Offset	0 DN	Adjustable
PRNU	< ±2%	At 50% saturation (1,2)
DSNU (FPN)	< ±2 DN	
Integral non-linearity	< 2%	

1) Calibration at 80% saturation, measurements at 50% saturation
2) Light sources vary spectrally and spatially: re-calibrate cameras in actual system

Monochrome 300kHz Models

The following specifications apply to the standard Linea HS models:

- HL-FM-04K30H
- HL-FM-13K18H
- HL-HM-13K30H

Table 6: Standard Camera Models Performance Specifications

Specifications	**HL-FM-04K30H**	**HL-FM-13K18H**	**HL-HM-13K30H**
Resolution	4096 x (128+64)	13056 x 128	13056 x (128+64)
Line Rate, maximum	300 kHz (mono) 150 kHz x 2 (HDR)	180 kHz (mono) 90 kHz x2 (HDR)	300 kHz (mono) 150 kHz x 2 (HDR)
Line rate, min	10 kHz		
Bit Depth	8-bit or 12-bit selectable		
Connectors and Mechanicals	**HL-FM-04K30H**	**HL-FM-13K18H**	**HL-HM-13K30H**
Typical Power Dissipation	17 W	22 W	30 W
Size Width (cross scan) Height (in scan) Depth (optical axis)	76 mm 76 mm 85 mm	97 mm 140.5 mm 78.6 mm	97 mm 140.5 mm 78.6 mm
Mass	< 500 g	1.2 kg	1.2 kg
Optical Interface	**HL-FM-04K30H**	**HL-FM-13K18H**	**HL-HM-13K30H**
Lens Mount	M58 x 0.75 mm	M90 x 1 mm	M90 x 1 mm
Performance [1)]			**Notes**
Random Noise	< 0.2 DN rms (10 e^-)		Typical [(1)]
Peak Responsivity	500 DN/nJ/cm^2 (8K models) 600 DN/nJ/cm^2 (16K models)		@670 nm
Dynamic Range	70 dB		Typical
Full Well	25,000 e^-		Typical
SEE	0.5 nJ/cm^2		At 670 nm
NEE	0.4 pJ/cm^2		At 670 nm

The following specifications apply to the standard Linea HS models:

- HL-FM-08K30H
- HL-FM-16K15A
- HL-HM-08K30H
- HL-HM-16K30H

Table 7: Standard Camera Models Performance Specifications

Specifications	**HL-FM-08K30H**	**HL-FM-16K15A**	**HL-HM-08K30H**	**HL-HM-16K30H**
Resolution	8192 x (128+64)	16384 x 128	8192 x (128+64)	16384 x (128+64)
Line Rate, maximum	300 kHz (mono) 150 kHz x 2 (HDR)	150 kHz	300 kHz (mono) 150 kHz x 2 (HDR)	300 kHz (mono) 150 kHz x 2 (HDR)
Line rate, min	10 kHz			
Bit Depth	8-bit or 12-bit selectable			
Connectors and Mechanicals	**HL-FM-08K30H**	**HL-FM-16K15A**	**HL-HM-08K30H**	**HL-HM-16K30H**
Typical Power Dissipation	17 W	22 W	18 W	30 W
Size Width (cross scan) Height (in scan) Depth (optical axis)	76 mm 76 mm 85 mm	97 mm 140.5 mm 78.6 mm	76 mm 76 mm 85 mm	97 mm 140.5 mm 78.6 mm
Mass	< 500 g	1.2 kg	< 500 g	1.2 kg
Optical Interface	**HL-FM-08K30H**	**HL-FM-16K15A**	**HL-HM-08K30H**	**HL-HM-16K30H**
Lens Mount	M58 x 0.75 mm	M90 x 1 mm	M58 x 0.75 mm	M90 x 1 mm
Performance [1)]			**Notes**	
Random Noise	< 0.2 DN rms (10 e^-)		Typical [(1)]	
Peak Responsivity	500 DN/nJ/cm^2 (8K models) 600 DN/nJ/cm^2 (16K models)		@670 nm	
Dynamic Range	70 dB		Typical	
Full Well	25,000 e^-		Typical	
SEE	0.5 nJ/cm^2		At 670 nm	
NEE	0.4 pJ/cm^2		At 670 nm	

1) Random Noise below quantization limit cannot be measured accurately; use higher bit depth or higher gain for comparison purposes

Monochrome 400kHz Models

The following specifications apply to the high-speed Linea HS models:

- HL-HM-08K40H-00R
- HL-HM-16K40H-00R
- HL-HM-16K40H-00B

Table 8: High Speed Camera Model Performance Specifications

Specifications	**HL-HM-08K40H-00-R**	**HL-HM-16K40H-00-R**	**HL-HM-16K40H-00-B**	**Notes**
Resolution	8192 x 192	16384 x 192	16384 x 192	128 + 64 dual array
Line Rate, maximum	400 kHz (monochrome mode) 200 kHz x 2 (HDR mode)			
Line Rate, minimum	10 kHz			
Bit Depth	8-bit or 12-bit selectable output			Sensor readout is 11-bits only.
Connectors and Mechanicals	**HL-HM-08K40H-00-R**	**HL-HM-16K40H-00-R**	**HL-HM-16K40H-00-B**	**Notes**
Control & Data Interface	Camera Link HS CX4			
Power	+12 V to +24 V DC, Hirose 12-pin circular			
Typical Power Dissipation	18 W	30 W	30 W	100 kHz per UM
Size Width Height Depth	76 mm 76 mm 85 mm	97 mm 140.5 mm 78.6 mm	97 mm 140.5 mm 78.6 mm	Cross-Scan direction In-Scan direction Along optical axis
Mass	< 500 g	1.2 kg	1.2 kg	
Operating Temp	+0 °C to +65°C			front plate temperature
Optical Interface	**HL-HM-08K40H-00-R**	**HL-HM-16K40H-00-R**	**HL-HM-16K40H-00-B**	**Notes**
Lens Mount	M58 x 0.75 mm	M90 x 1 mm	M90 x 1 mm	
Performance [1)]	**HL-HM-08K40H-00-R**	**HL-HM-16K40H-00-R**	**HL-HM-16K40H-00-B**	**Notes**
Random Noise	< 0.2 DN rms (14 e^-)	< 0.2 DN rms (14 e^-)	< 0.2 DN rms (14 e^-)	Typical [(1)]
Peak Responsivity	500 DN/nJ/cm^2	600 DN/nJ/cm^2	680 DN/nJ/cm^2	8 bit (See details in Figs. 1-2-3)
Dynamic Range	67 dB	67 dB	67 dB	Typical
Full Well	25,000 e^-	Typical	27,000 e^-	Full Well
SEE	0.5 nJ/cm^2	0.5 nJ/cm^2	< 0.4 nJ/cm^2	At 670 nm
NEE	< 0.4 pJ/cm^2	< 0.4 pJ/cm^2	< 0.2 pJ/cm^2	At 670 nm

1) Random Noise below quantization limit cannot be measured accurately; use higher bit depth or higher gain for comparison purposes.

Color and Multifield Models

The following specifications apply to the color and multifield Linea HS models:

- HL-HF-16K13T
- HL-HC-16K10T

Table 9: Color and Multifield Camera Model Performance Specifications

Specifications	HL-HC-16K10T	HL-HF-16K13T	Notes
Resolution	16,84 x (64+128+64)	16,384 x (64+128+64)	3 TDI arrays 64 + 128 + 64 stages
Line Rate, maximum	100kHz x 3	400/3 kHz	
Line rate, min	10 kHz x 3		Limited by dark current
Bit Depth	8-bit or 12-bit	8-bit or 12-bit	selectable
Connectors and Mechanicals	**HL-HC-16K10T**	**HL-HF-16K13T**	**Notes**
Typical Power Dissipation	30W	30 W	
Size Width Height Depth	97 mm 140.5 mm 78.6 mm	97 mm 140.5 mm 78.6 mm	Cross-Scan direction In-Scan direction Along optical axis
Mass	1.2 kg	1.2 kg	
Optical Interface	**HL-HC-16K10T**	**HL-HF-16K13T**	**Notes**
Lens Mount	M90 x 1 mm	M90 x 1 mm	
Performance [1]	**HL-HC-16K10T**	**HL-HF-16K13T**	**Notes**
Random Noise	< 0.2 DN rms (10 e^-)	< 0.2 DN rms (10 e^-)	Typical [2]
Peak Responsivity	Blue 180 Green 230 Red 290	Blue 180 Green 230 Red 290	DN / nJ / cm^2 8-bit
Digital Gain	1x to 10x	1x to 10x	
Dynamic Range	69 dB	69 dB	Typical
Full Well	25,000 e^-	25,000 e^-	Typical
SEE	Blue 1.3 nJ/cm^2 Green 1 nJ/cm^2 Red 0.8 nJ/cm^2	Blue 1.3 nJ/cm^2 Green 1 nJ/cm^2 Red 0.8 nJ/cm^2	At 460 nm At 560 nm At 660 nm
NEE	Blue 0.5 pJ/cm^2 Green 0.4 pJ/cm^2 Red 0.3 pJ/cm^2	Blue 0.5 pJ/cm^2 Green 0.4 pJ/cm^2 Red 0.3 pJ/cm^2	At 460 nm At 560 nm At 660 nm

1) Random Noise below quantization limit cannot be measured accurately; use higher bit depth or higher gain for comparison purposes

Super Resolution Monochrome Model

The following specifications apply to the super resolution Linea HS models:

- HL-HM-32K40S

Table 10: Super Resolution Camera Model Performance Specifications

Specifications	HL-HM-32K40S	Notes
Resolution	32768 pixels x 64	16k dual array
Pixel Size	5.0 µm x 5.0 µm/2.5x2.5um	5x5um physical pixel size, 2.5x2.5 µm pixel output
Line Rate, maximum	400 kHz	32k Super Resolution modes
Line rate, min	10 kHz	Limited by dark current
Bit Depth	8-bit	
Connectors and Mechanicals	**HL-HM-32K40S**	**Notes**
Typical Power Dissipation	28 W	
Size Width Height Depth	76 mm 97 mm 140.5 mm	Cross-Scan direction In-Scan direction Along optical axis
Mass	1.2 kg	
Optical Interface	**HL-HM-32K40S**	**Notes**
Lens Mount	M90 x 1 mm	
Performance [1)]	**HL-HM-32K40S**	**Notes**
Random Noise	< 0.1 DN rms (16 e^-)	Typical [2)]
Peak Responsivity	250 DN/nJ/cm^2	@670 nm
Dynamic Range	70 dB	Typical [2)]
Full Well	50,000 e^-	Typical
SEE	1 nJ/cm^2	At 670 nm
NEE	< 0.4 pJ/cm^2	At 670 nm

Environmental Specifications

Table 11: Environmental Specifications

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 12: Camera Flash Memory Size

Camera	Flash memory size
All models	4 GB

Certification & Compliance

Table 13: Camera Certification & Compliance

Compliance
See the Declarations of Conformity section at the end of this manual.

Specifications: Monochrome Models

The following specifications apply to these Linea HS models:

- HL-FM-04K30H-00-R
- HL-FM-08K30H-00-R
- HL-HM-08K30H-00-R
- HL-HM-08K40H-00-R
- HL-FM-13K18H-00-R
- HL-HM-13K30H-00-R
- HL-FM-16K15A-00-R
- HL-HM-16K30H-00-R
- HL-HM-16K40H-00-R
- HL-HM-16K40H-00-B

Responsivity & QE

The following graphs show the spectral Responsivity and QE from the main array (128 stages), in 8-bit, for 4K and 8K camera models.

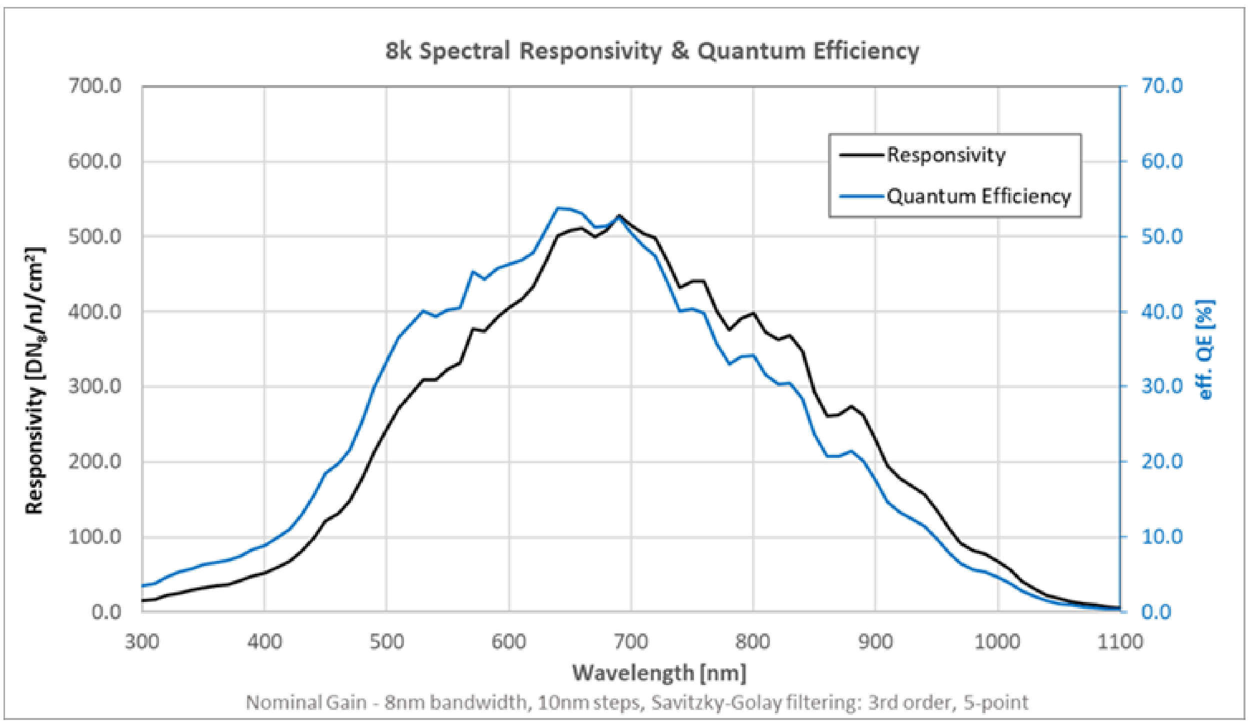


Figure 1: 4K & 8K Monochrome Models Spectral Responsivity & QE

The following graphs show the spectral Responsivity and QE from the main array (128 stages), in 8-bit, for 13K and 16K camera models.

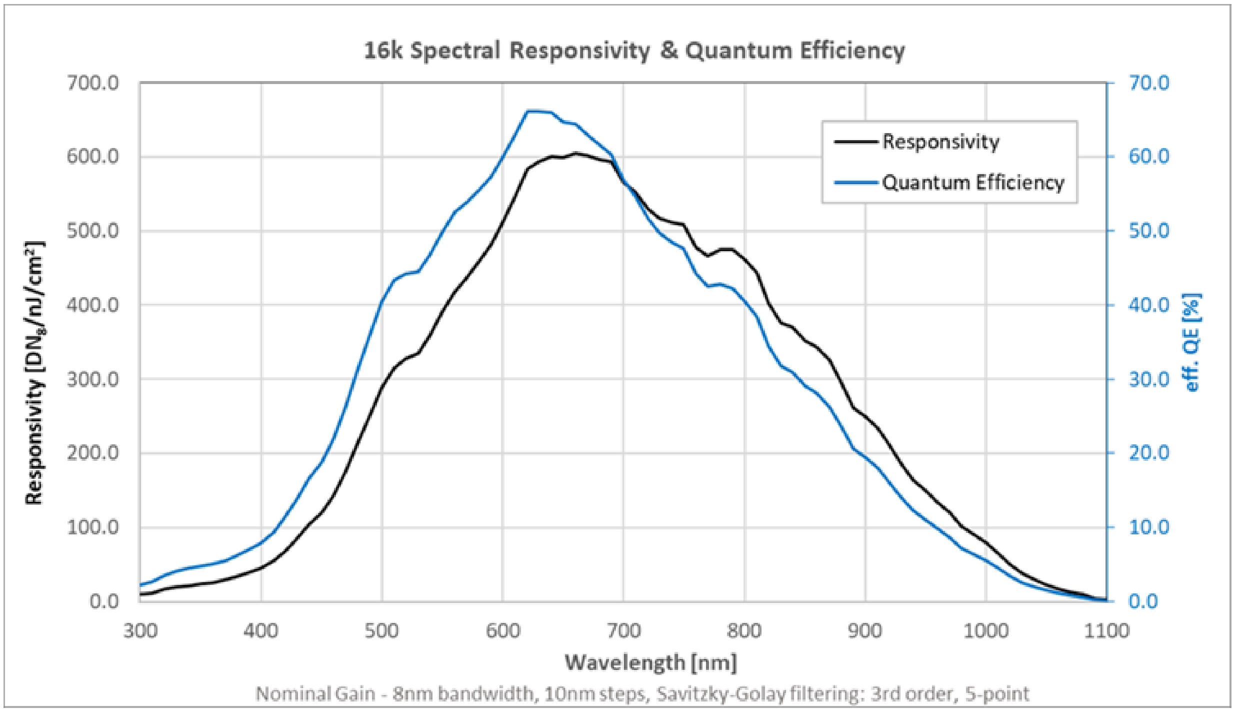


Figure 2: 13K and 16K Monochrome Models Spectral Responsivity & QE

The following graphs show the spectral Responsivity and QE from the main array (128 stages), in 12-bit, for 16K camera models.

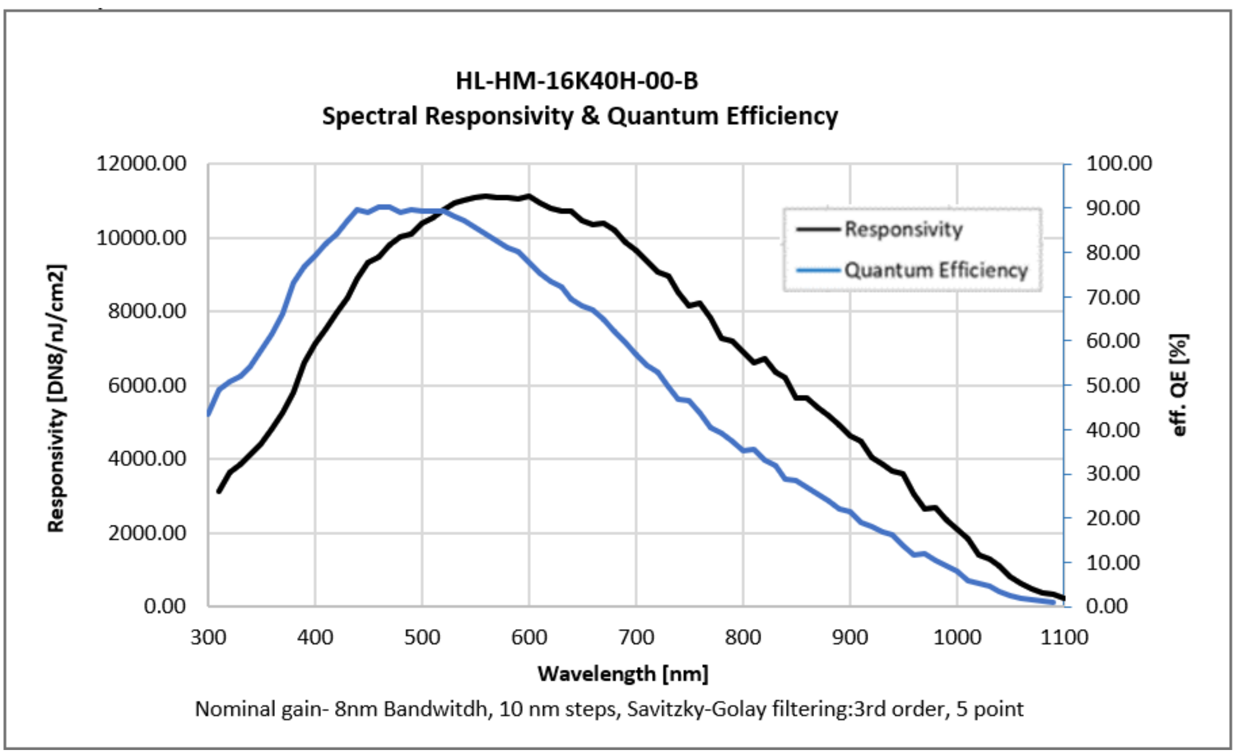
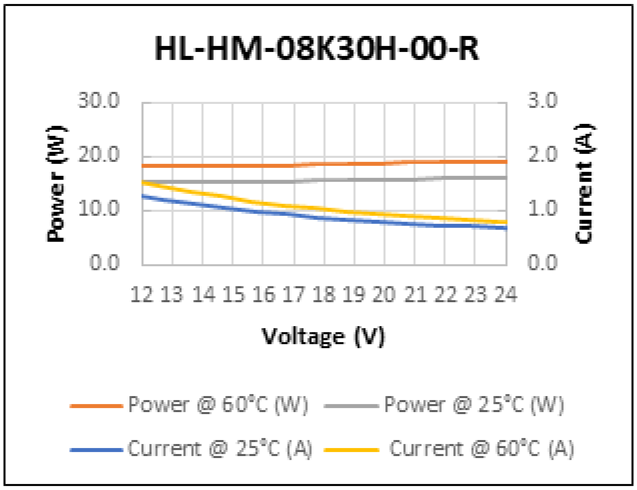


Figure 3: 16K Monochrome Models Spectral Responsivity & QE

Camera Input Power

The following graphs detail the power vs. input voltage for each model.



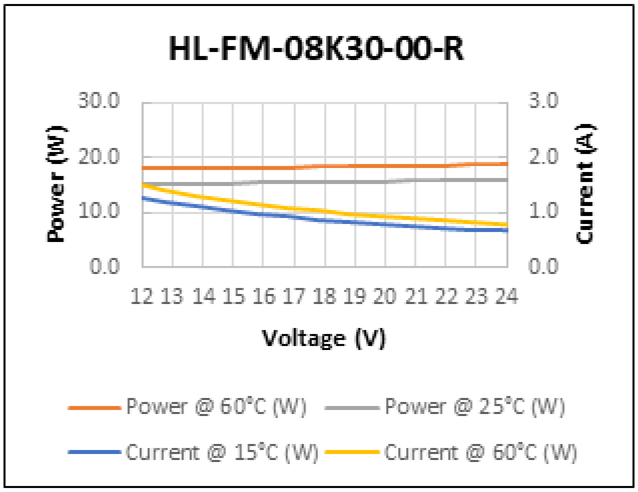
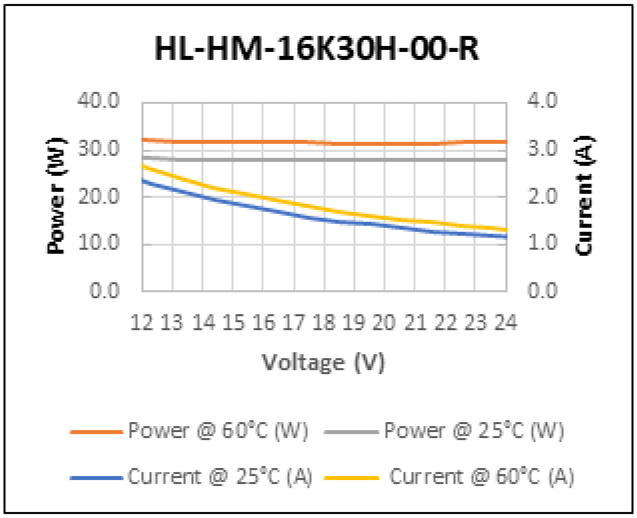


Figure 4: Standard 8K Models (CX4 and SFP+) Power vs. Input Voltage



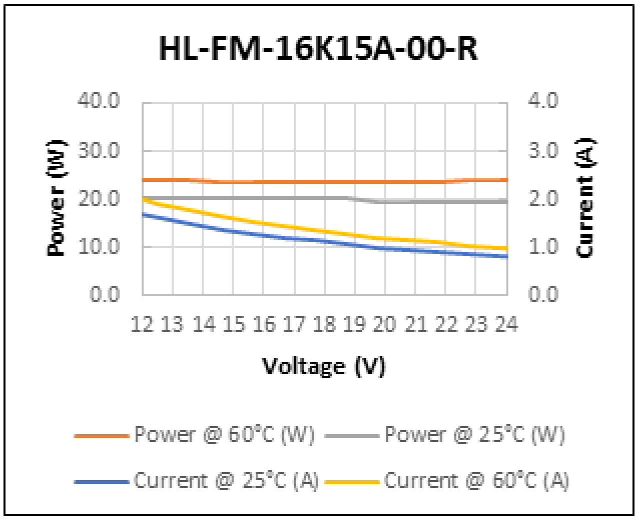


Figure 5: Standard 16K Models (CX4 and SFP+) *Power Vs. Input Voltage*

Test conditions: Max line rate—300 kHz, TDI Mode—128, Bit Mode—8, Black Level—31, Temperature—Ambient

The following graphs detail the power vs. input voltage for the HL-HM-16K40H-00.

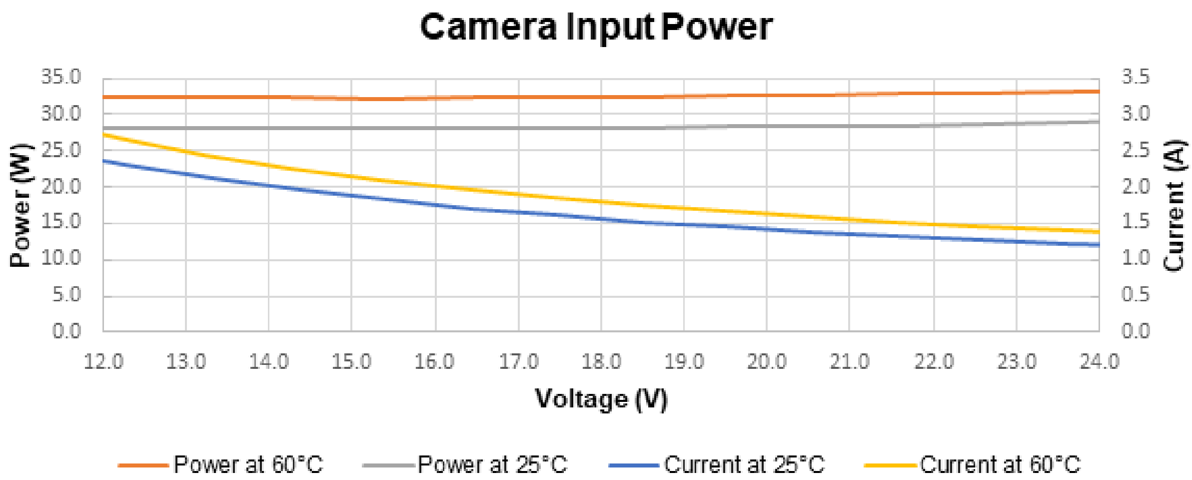


Figure 6: HL-HM-16K40H-00 Power Vs. Input Voltage

Test conditions: Max line rate—400 kHz, TDI Mode—128, Bit Mode—8, Black Level—31, Temperature—Ambient

Specifications: Color Model

The following specifications apply to the color Linea HS model:

- HL-HC-16K10T-00-R

Responsivity & QE

The following graphs show the spectral Responsivity and QE, 8-bit, 1x gain.

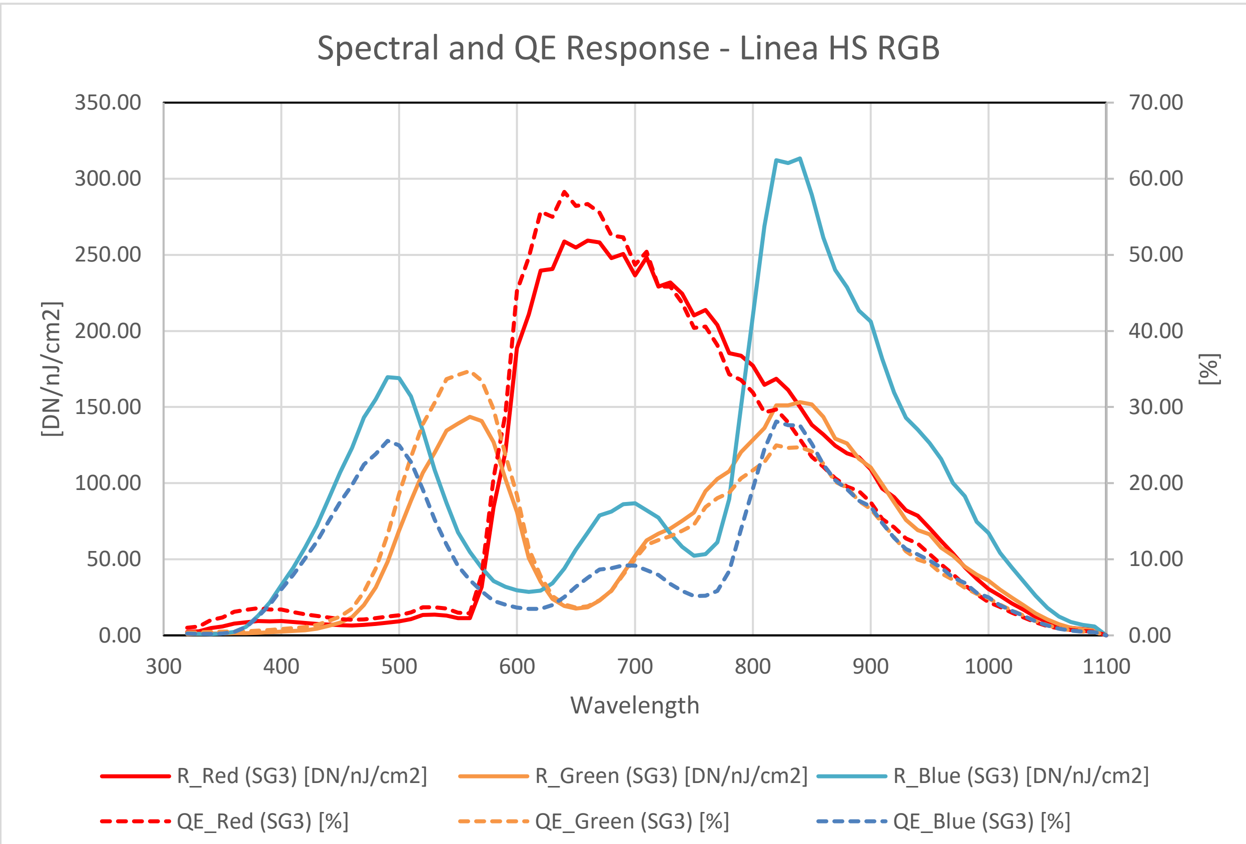


Figure 7: Color Model Spectral Responsivity and QE

Camera Input Power

The following graph details the power vs. input voltage for the camera.

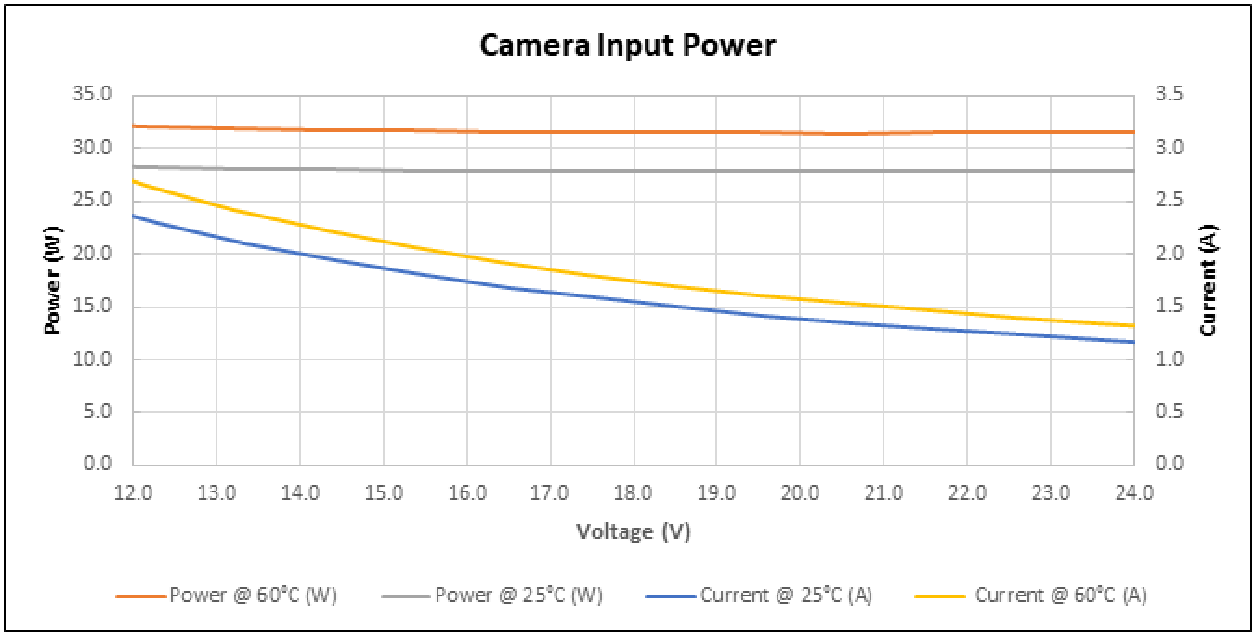


Figure 8: Color Model Power Vs. Input Voltage

Test conditions: Max line rate—300 kHz, Bit Mode—8, Black Level—31, Temperature—Ambient

Specifications: Multifield Model

The following specifications apply to the multifield Linea HS model:

- HL-HF-16K13T

Responsivity & QE

The following graphs show the spectral Responsivity and QE, 8-bit, 1x gain.

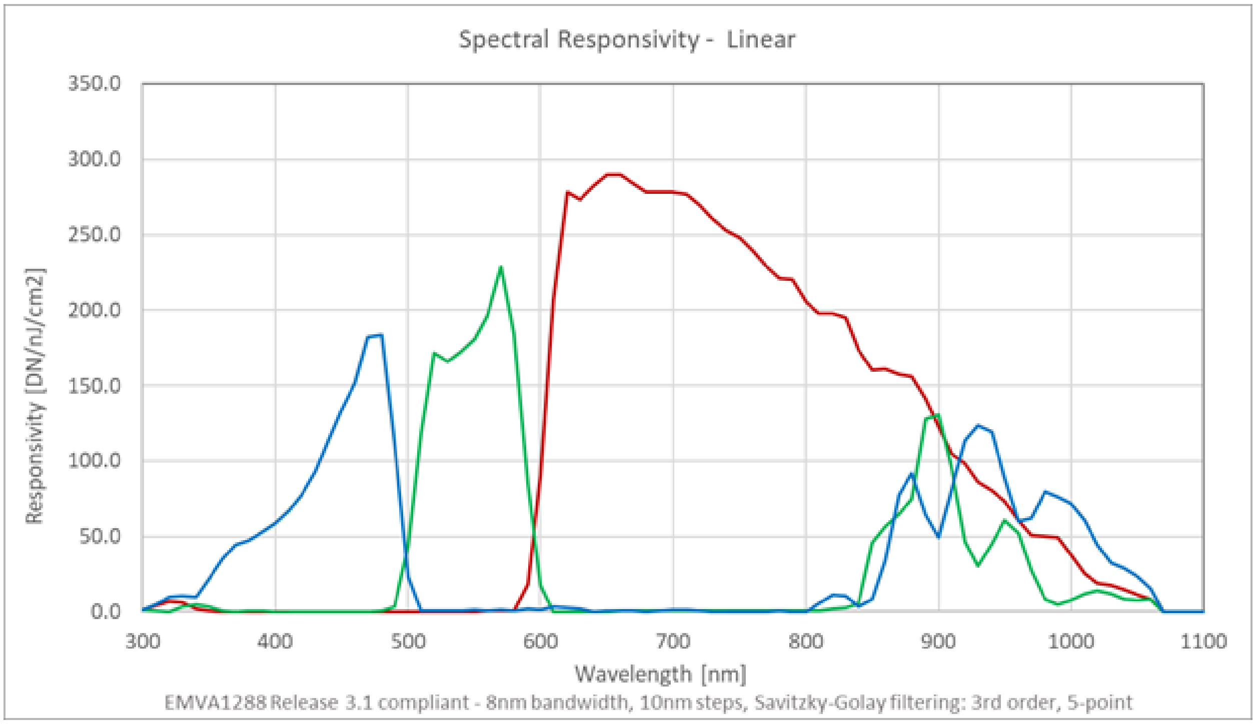


Figure 9: Multifield Model Spectral Responsivity

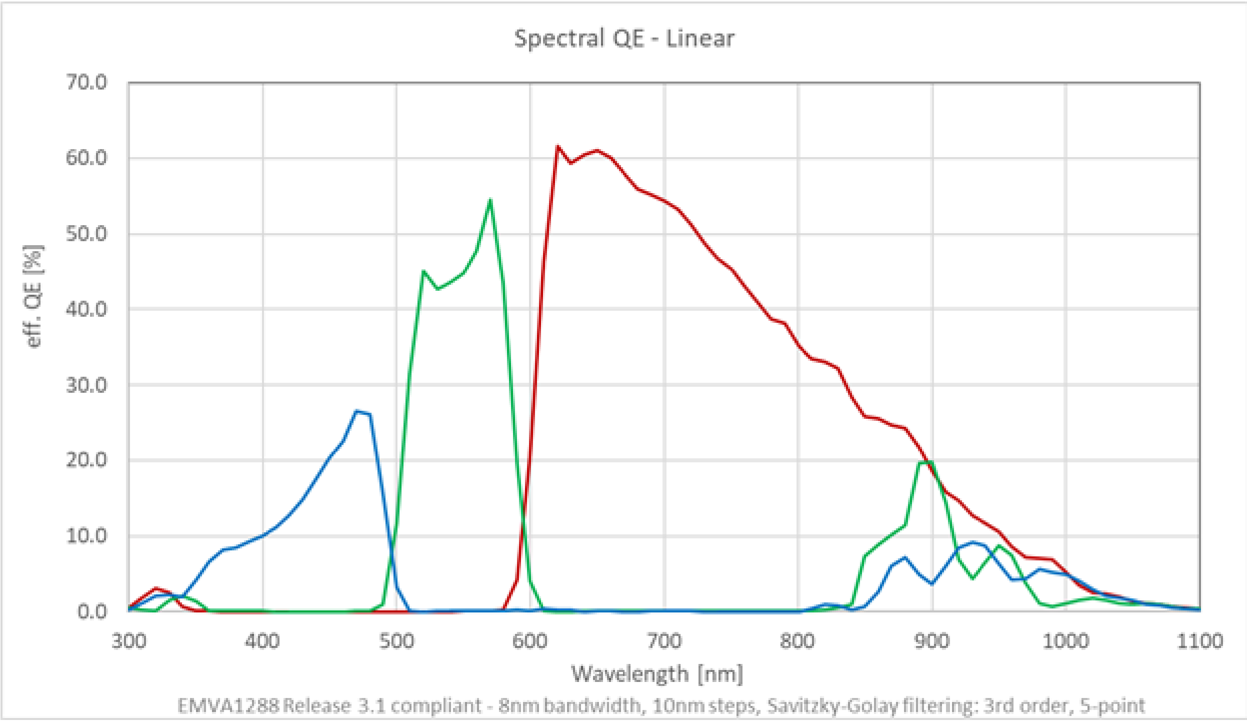


Figure 10: Multifield Model QE

Camera Input Power

The following graph details the power vs. input voltage for the camera.

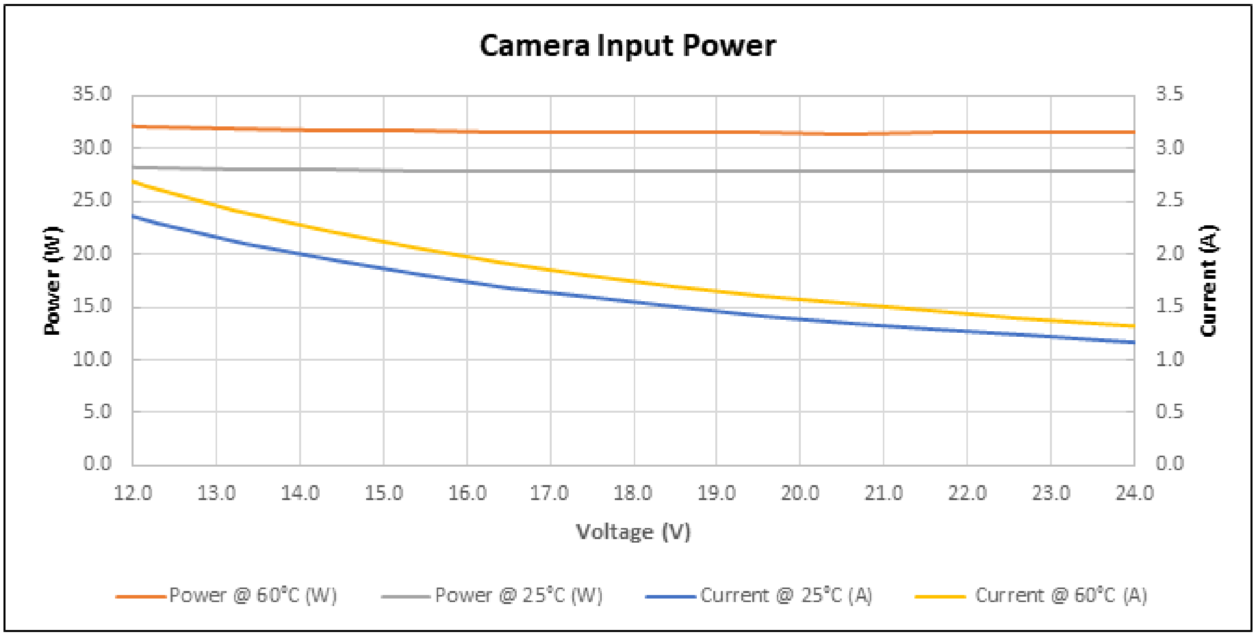


Figure 11: Multifield Model Power Vs. Input Voltage

Test conditions: Max line rate—300 kHz, Bit Mode—8, Black Level—31, Temperature—Ambient

Specifications: Super Resolution 32k Model

The following specifications apply to the super resolution Linea HS model:

- HL-HM-32K40S-00-R

Responsivity & QE

The following graphs show the spectral responsivity and QE in 32k super resolution mode; for 16k modes, multiply responsivity values by 2.

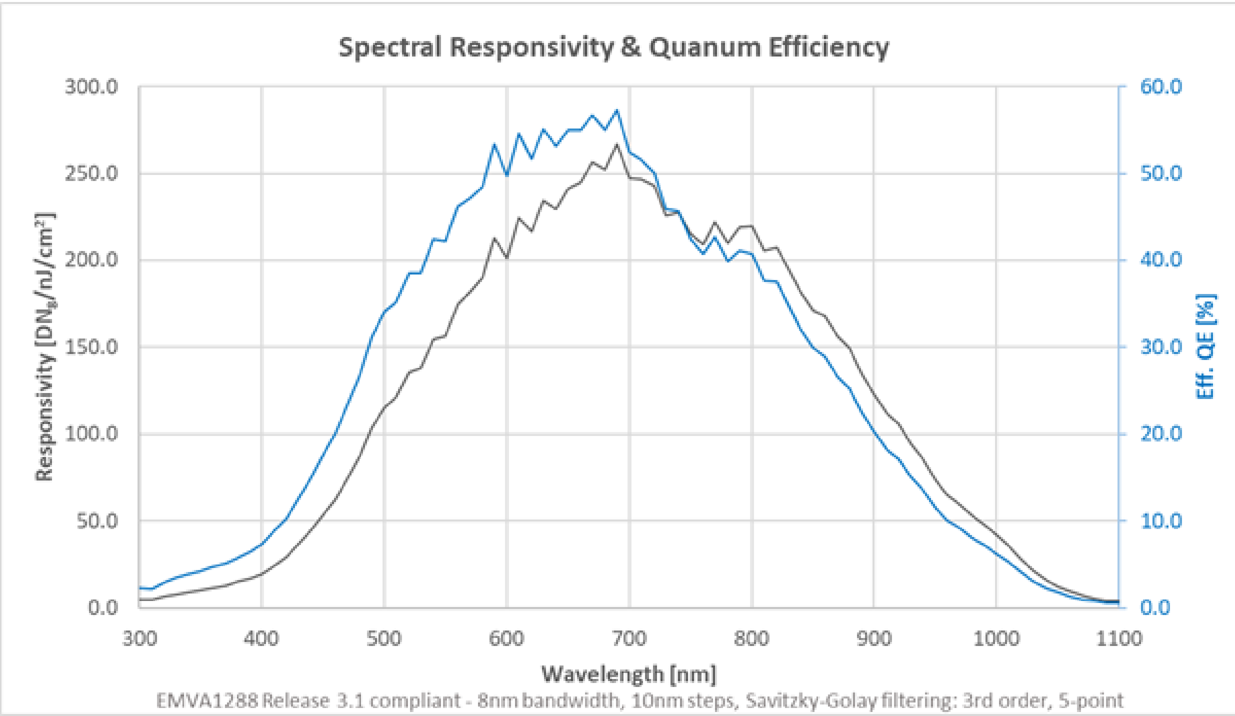


Figure 12: Super Resolution Model Spectral Responsivity & QE, 32k SR Mapped, 1x gain

Camera Input Power

The following graphs detail the power vs. input voltage for the HL-HM-32K40S-00-R

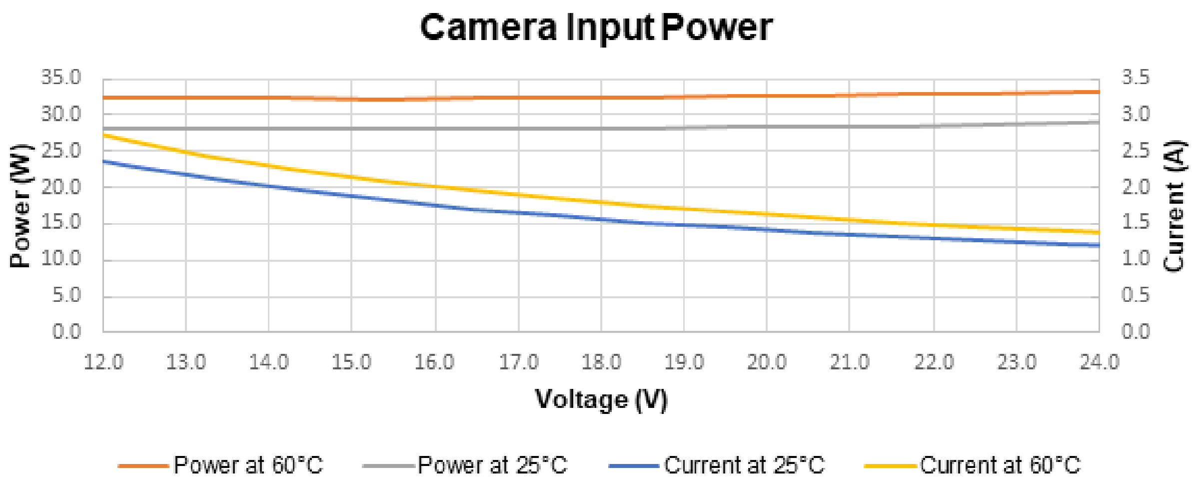


Figure 13: Super Resolution Model Power Vs. Input Voltage

Test conditions: Max line rate—300 kHz, TDI Mode—128, Bit Mode—8, Black Level—31, Temperature—Ambient

Linea HS Dark Current

Dark current increases with both temperature and line exposure time.

- Increases linearly with the sensor exposure time:

  (1 / (Line rate)) * (number of TDI Stages)

- Increases exponentially with temperature, doubling approximately every 7°C.

For best performance Teledyne DALSA recommends recalibrating the dark flat field coefficients (FPN) at a stable operating temperature; for more information of flat field correction, refer to the Image Response Uniformity & Flat Field Calibration section.

Note that higher dark current is expected with back side illuminated cameras such as model HL-HM-16K40H-00-B, compared to front side illuminated cameras. The difference in dark signal is minimized at higher line rates but can become noticeable in the image at reduced speed. If the application requires operation at line rates below 30 kHz, it is recommended to use dark current correction. See section Flat Field FPN Calibration - Dark Current Correction to do calibration.

	**Note:** A minimum line rate of 10 kHz is recommended. When using low line rates active cooling of the sensor is recommended to avoid offset drift due to minor temperature fluctuations.

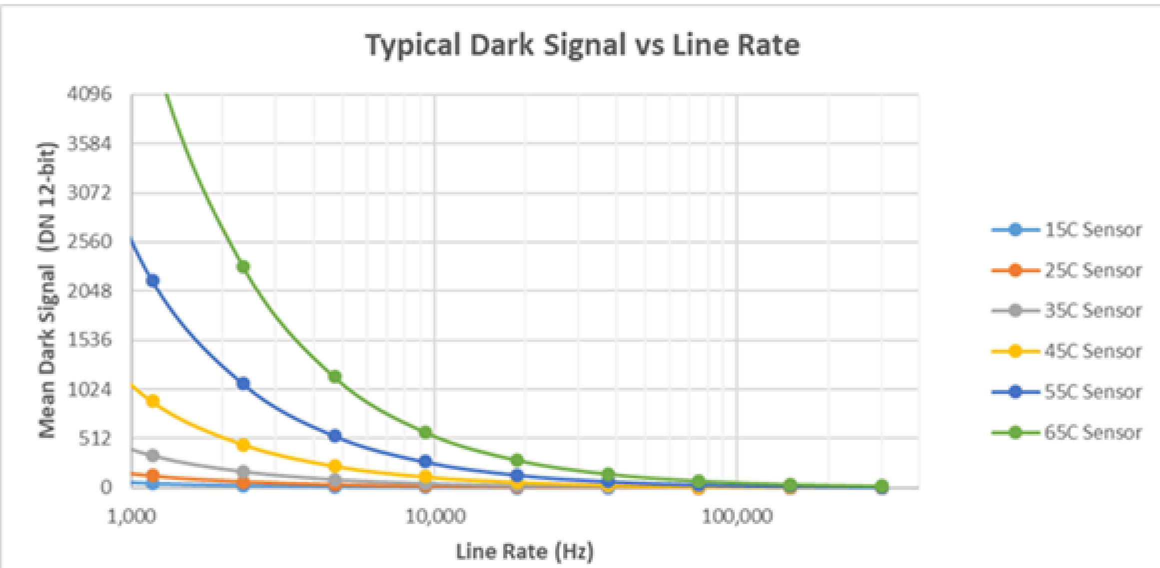


Figure 14: Typical Dark Signal vs. Line Rate

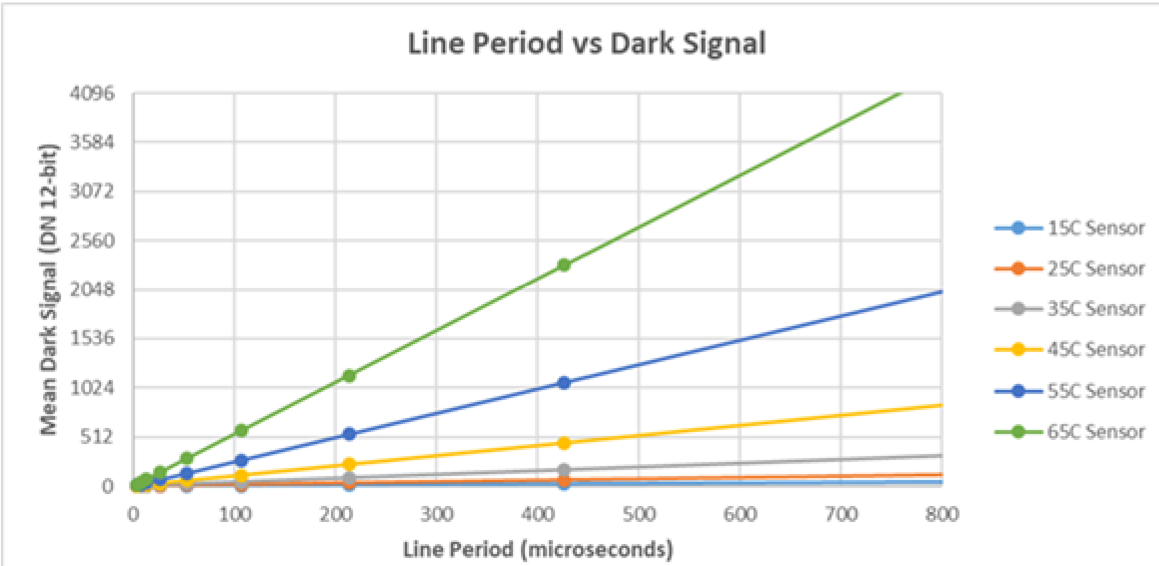


Figure 15: Line Period vs. Dark Signal

Camera Processing Chain

The diagram below details the sequence of user-adjustable, arithmetic operations performed on the camera sensor data. These adjustments are using camera features outlined in the 'Review of Camera Performance and Features' section.

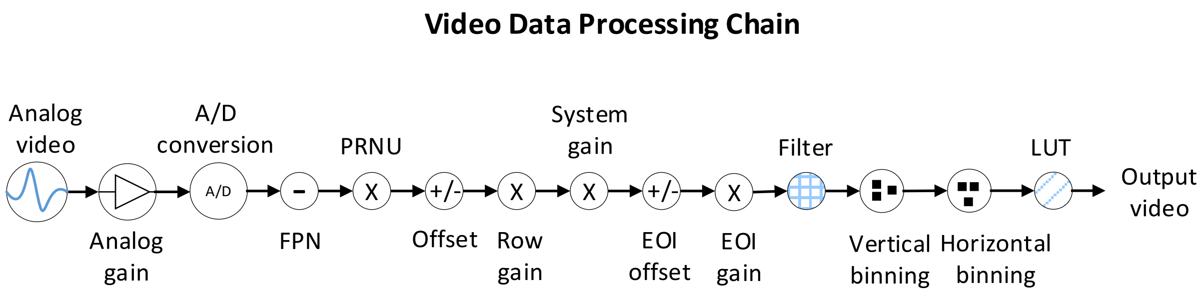


Figure 16: Video data processing chain

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.emva.org/standards-technology/genicam/.

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 grabbers, and with data rates exceeding those supported by the standard Camera Link.

The Linea HS cameras come with two different output mediums; CX4 AOC Data Cables or LC Fiber Optic (HL-FM cameras only).

HL-FM camera models use two LC connectors for data output. These two LC connectors are part of the SFP+ standard but in the case of Linea HS camera the SFP+ modules are built into the camera. Either one or both SFP+ modules can be used but using only one SFP+ / fiber optic will sacrifice available bandwidth.

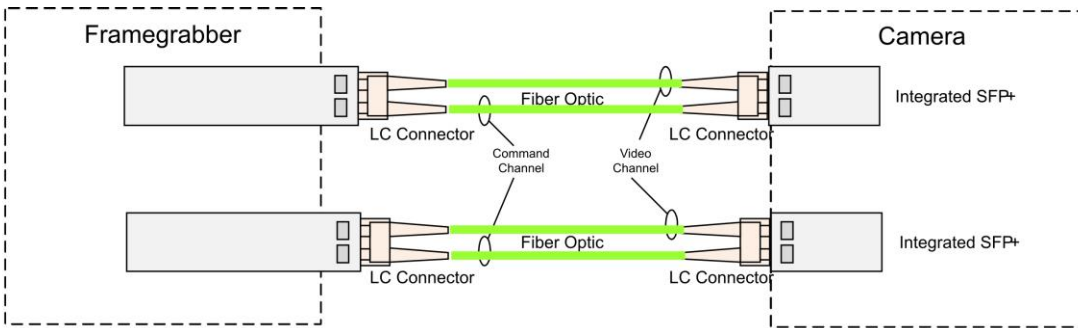


Figure 17: Linea HS Dual LC/SFP+ Connector Configuration

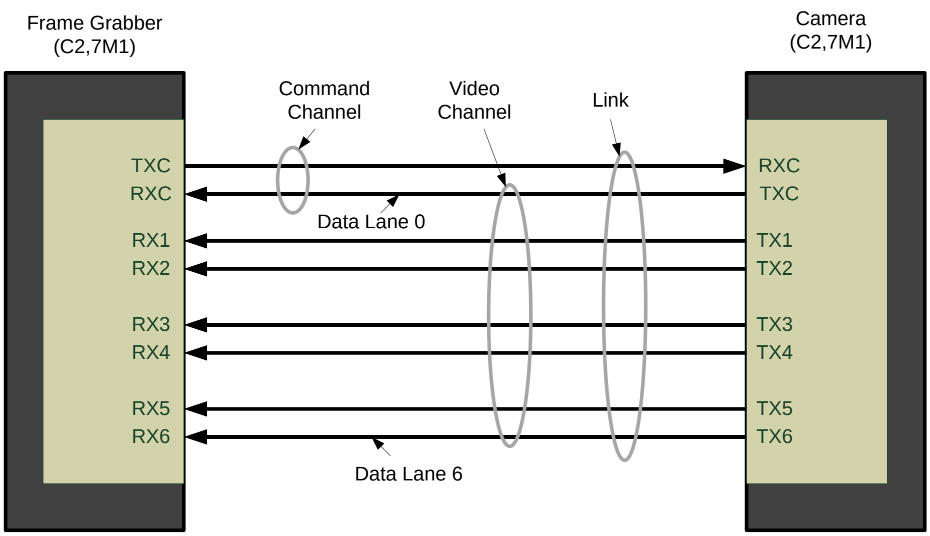


Figure 18: Single CLHS Connector Configuration

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. Data and command transmission are done with CLHS X protocol (64b / 66b) at the default speed of 10 Gbps.

Note: high speed data transmission limits the effective distance of copper-based cables.

Data Cables

LC Fiber Optic (HL-FM Cameras)

Used by the following camera models:

- HL-FM-04K30H-00-R
- HL-FM-08K30H-00-R
- HL-FM-13K18H-00-R
- HL-FM-16K15A-00-R

The fiber optic cables for the HL-FM camera models require LC connections on both ends of the cable. The frame grabber requires the LC connector to be plugged into an 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 on recommended cables.

Table 14: LC Fiber Optic Cable Details

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

CX4 AOC Data Cables

Used by the following camera models:

- HL-HM-08K30H-00-R
- HL-HM-13K30H-00-R
- HL-HM-16K30H-00-R
- HL-HM-16K40H-00-R
- HL-HM-16K40H-00-B
- HL-HM-08K40H-00-R
- HL-HM-32K40S-00-R
- HL-HC-16K10T-00-R
- HL-HF-16K13T-00-R

Camera Link HS CX4 AOC (Active Optical Cable) cables are made to handle very high data rates. These cables accept the same electrical inputs as traditional copper cables, but also use optical fibers. AOC uses electrical-to-optical conversion on the cable ends to improve speed and distance performance of the cable without sacrificing compatibility with standard electrical interfaces.

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.

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

Mechanical Drawings

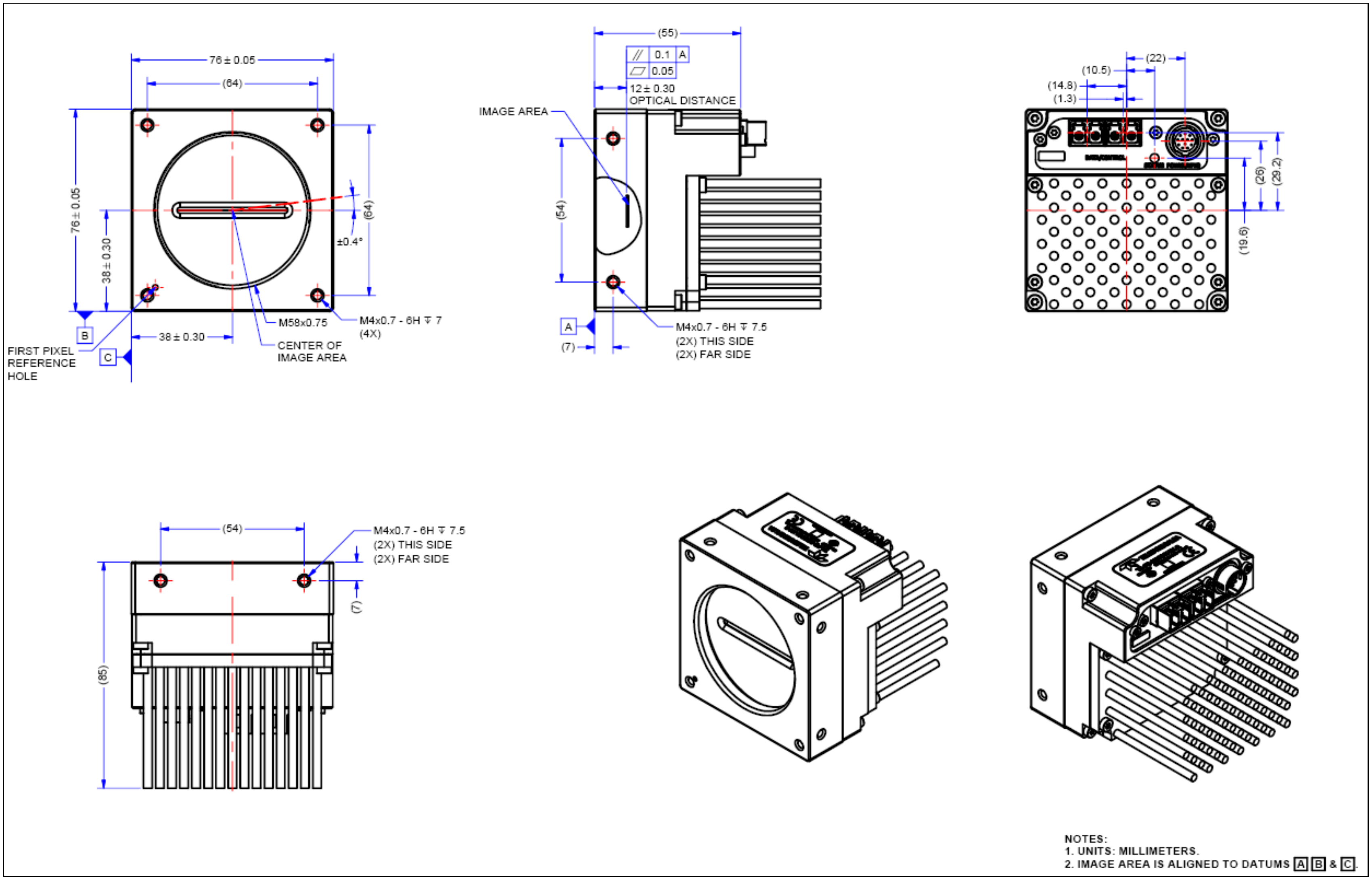


Figure 19:HL-FM-04K30H-00-R and HL-FM-08K30H-00-R Mechanical Drawing

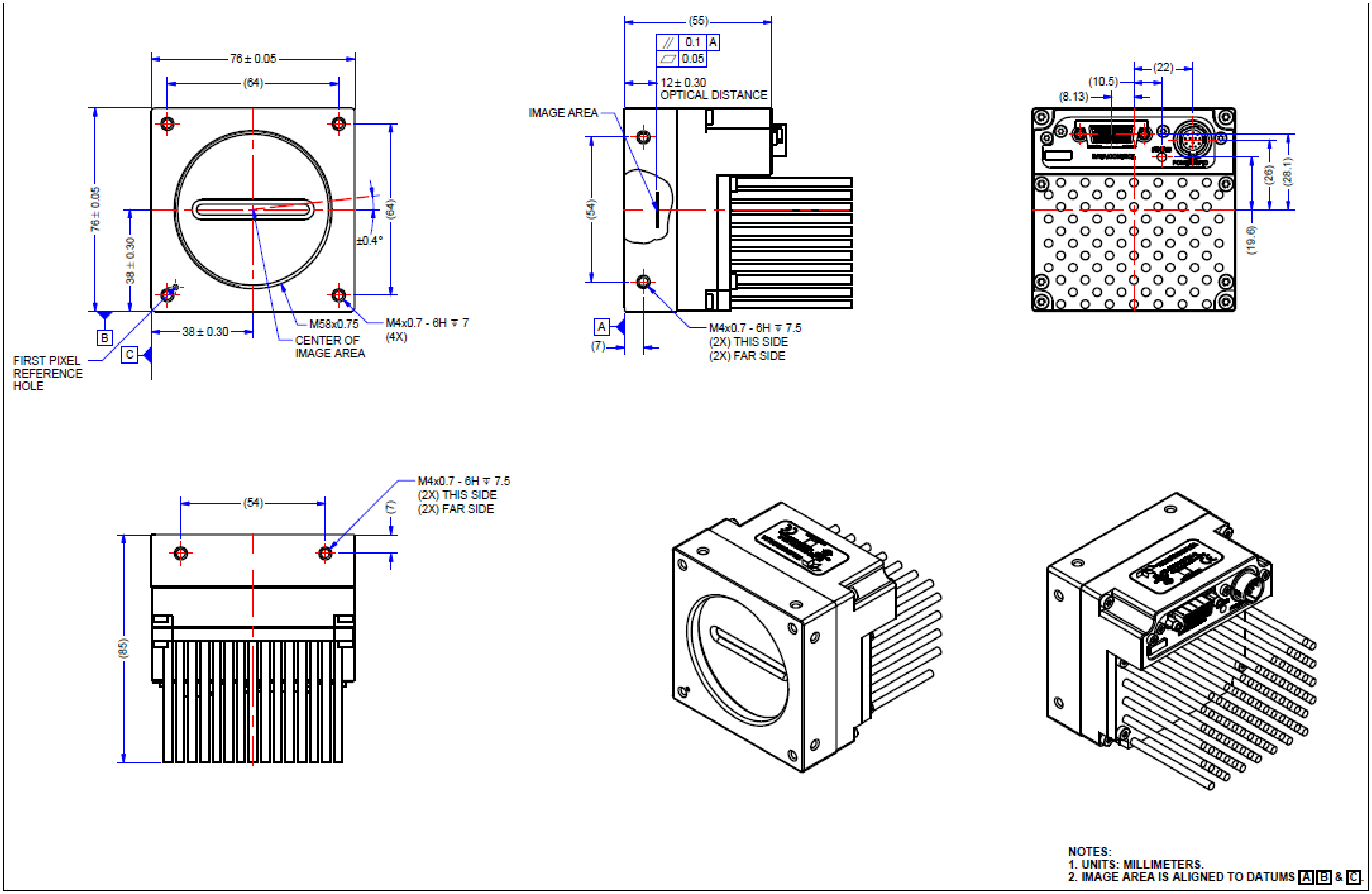


Figure 20: HL-HM-08K30H-00-R and HL-HM-08K40H-00-R Mechanical Drawing

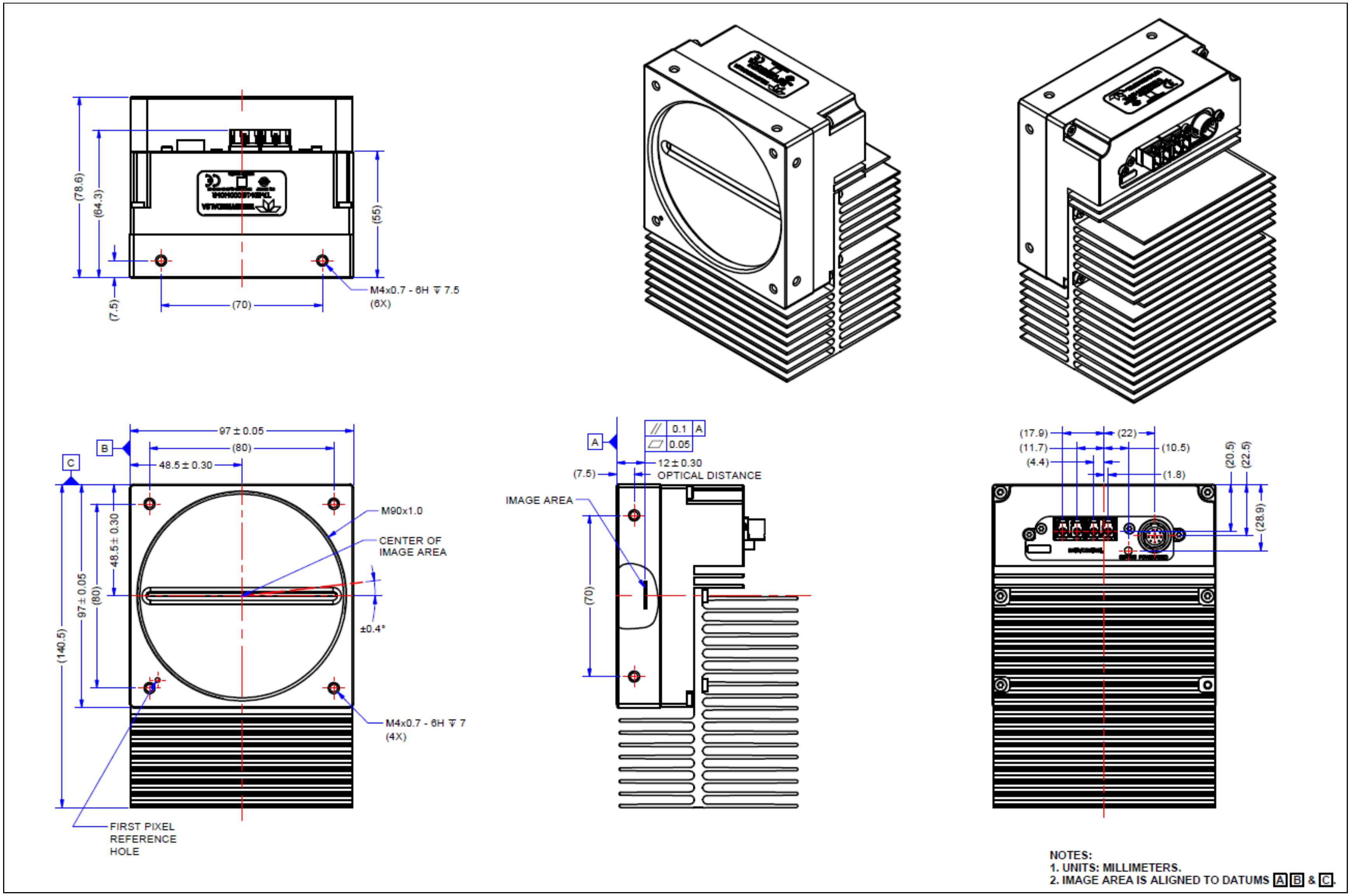


Figure 21: HL-FM-13K18H-00-R and HL-FM-16K15A-00-R Mechanical Drawing

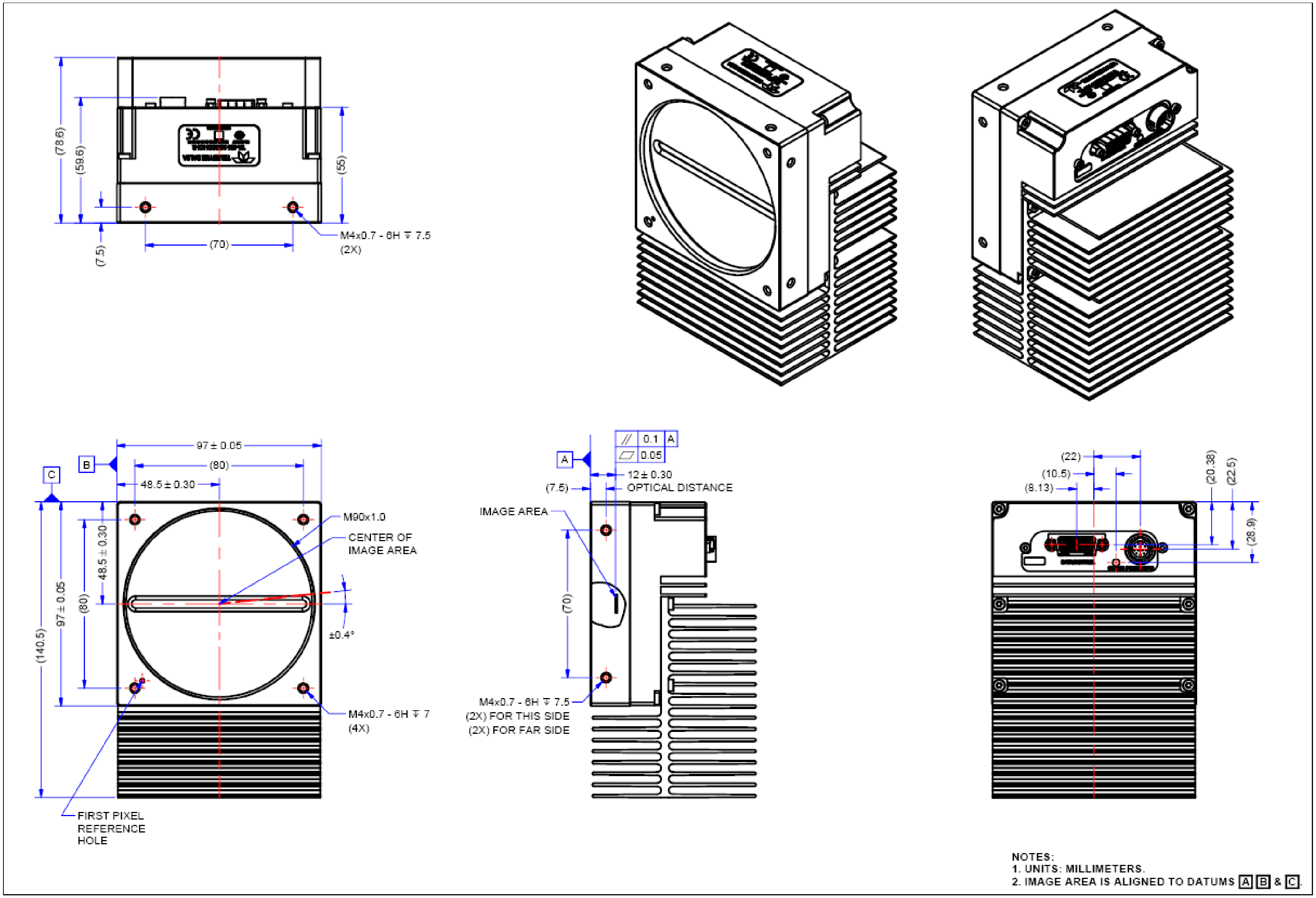


Figure 22: HL-HM-13K30H-00-R, HL-HM-16K30H-00-R, HL-HM-16K40H-00-R, HL-HM-16K40H-00-B, HL-HC-16K10T-00-R, HL-HM-32K40S-00-R and HL-HF-16K13T-00-R Mechanical Drawing

Precautions

Read these precautions 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 stop outputting data if its internal temperature reaches +80 °C.

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

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

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

Electrostatic Discharge and the CMOS Sensor

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

Install & Configure Frame Grabber & Software

Because of the high bandwidth of these cameras, a compatible Teledyne DALSA frame grabber (Xtium2-CLHS PX8 (OR-A8S0-PX870)), or equivalent, is recommended. The frame grabber requirements for the 8K and 16K camera differ. Follow the manufacturer's installation instructions. For more details see the Teledyne DALSA website:
https://www.teledynedalsa.com/en/products/imaging/frame-grabbers/

A GenICam compliant XML device description file is embedded with the camera firmware. It allows GenICam compliant applications to recognize the camera's capabilities, once connected.

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 test all camera operating modes. In addition, CamExpert can be used to save the camera's user settings configurations to the camera or to save 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 verification of timing or control parameters in real-time, without need for a separate acquisition program.

The central section of CamExpert provides access to the camera features and parameters.

Note: The availability of features depends on the CamExpert user setting. Not all features are available to all users. 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 using the **Device** list.

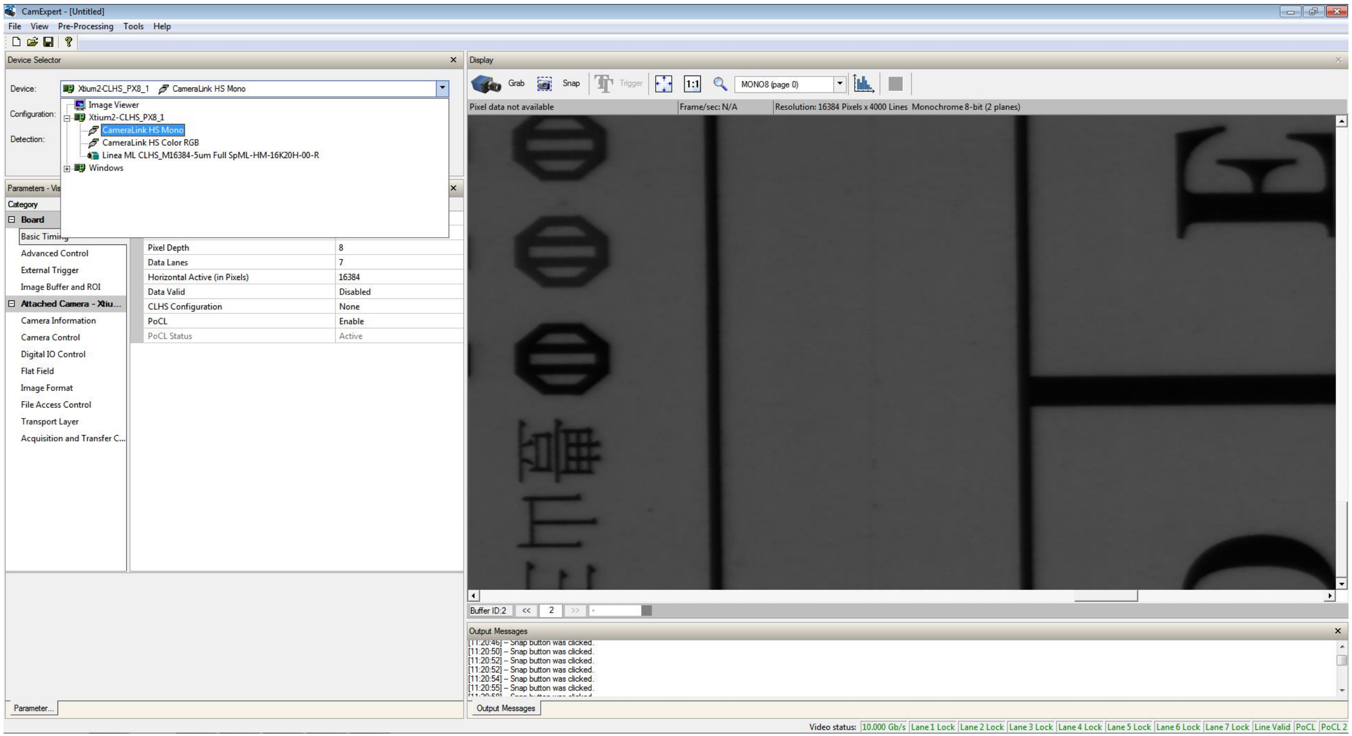


Figure 23: CamExpert Frame Grabber Control Window

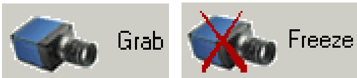
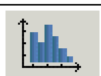
The CamExpert application uses panes to organize the selection and configuration of camera files or acquisition parameters.

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

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, acquire images, set camera functions and save settings.

Setting Up for Imaging

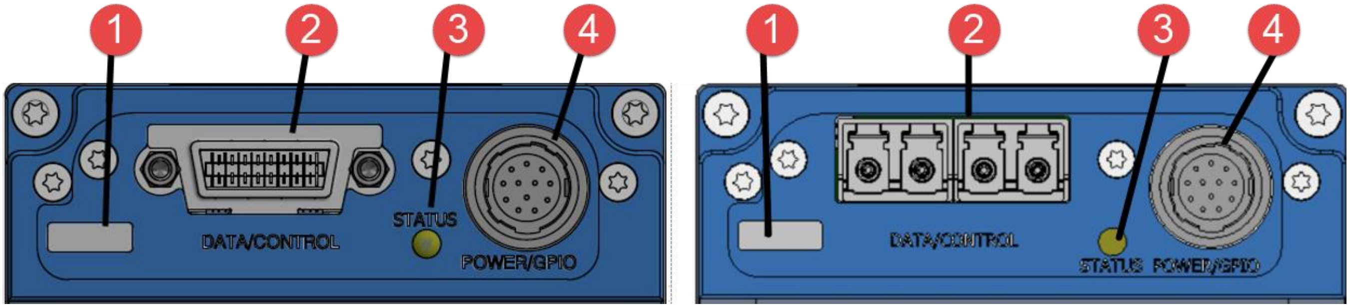


Figure 24: Camera I / O Connectors: CX4 (left) & LC Fiber Optic (right)

Camera I / O Connectors

1) Factory use only

2) Data and control connectors - CX4

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.
- The power supply ground (supply negative) must only be connected to the camera power ground pins 1 and 9.
- Do not connect the power supply ground (supply negative) to the camera chassis or the signal ground (pins 11 and 12). Doing so will not damage the camera, however, it will bypass the internal reverse voltage protection circuits.
- 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.
- The ground shield on the Power/GPIO cable must not be connected to the power supply ground (supply negative) or to the camera power pins 1 and 9. It can be connected to the camera chassis or earth ground at the power supply if the power supply ground (supply negative) is isolated from earth ground.
- Keep leads as short as possible in order to reduce voltage drop.
- Use high quality supplies in order 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.

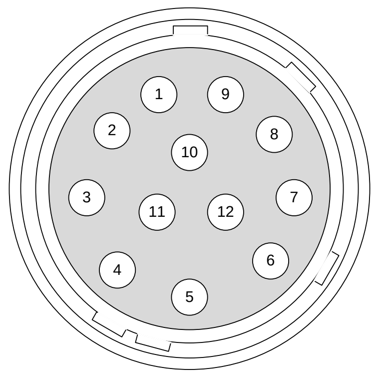


Figure 25: 12-pin Hirose Pin Numbering

Table 15: 12-pin Hirose Pin Assignment

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

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 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.

External Input Electrical Characteristics

Table 16: 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	10 K Ω

External Input Timing Reference

Table 17: External Input Timing Reference

Input Level Standard	Max Input Frequency	Min Pulse Width	Input Current	Maximum Signal Propagation Delay @ 60°C	
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 18: External Output Electrical Characteristics

Output Level Standard	V_{OL}	V_{OH}
3.3 V TTL	<0.8 V @ 10 mA*	>3.1 V @ 10 mA*

*See Linear Technology data sheet LTC2864

External Output Timing Reference

Table 19: External Output Timing Reference

Output Level Standard	Max Output Frequency	Min Pulse Width	Output Current	Maximum Signal Propagation Delay @ 60°C	
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.

Mating GPIO Cable Assembly

An optional GPIO breakout cable (12-pin Female Hirose to 13-Pos Euro Block) is available for purchase from Teledyne DALSA under accessory number #CR-GENC-IOP00 to order.

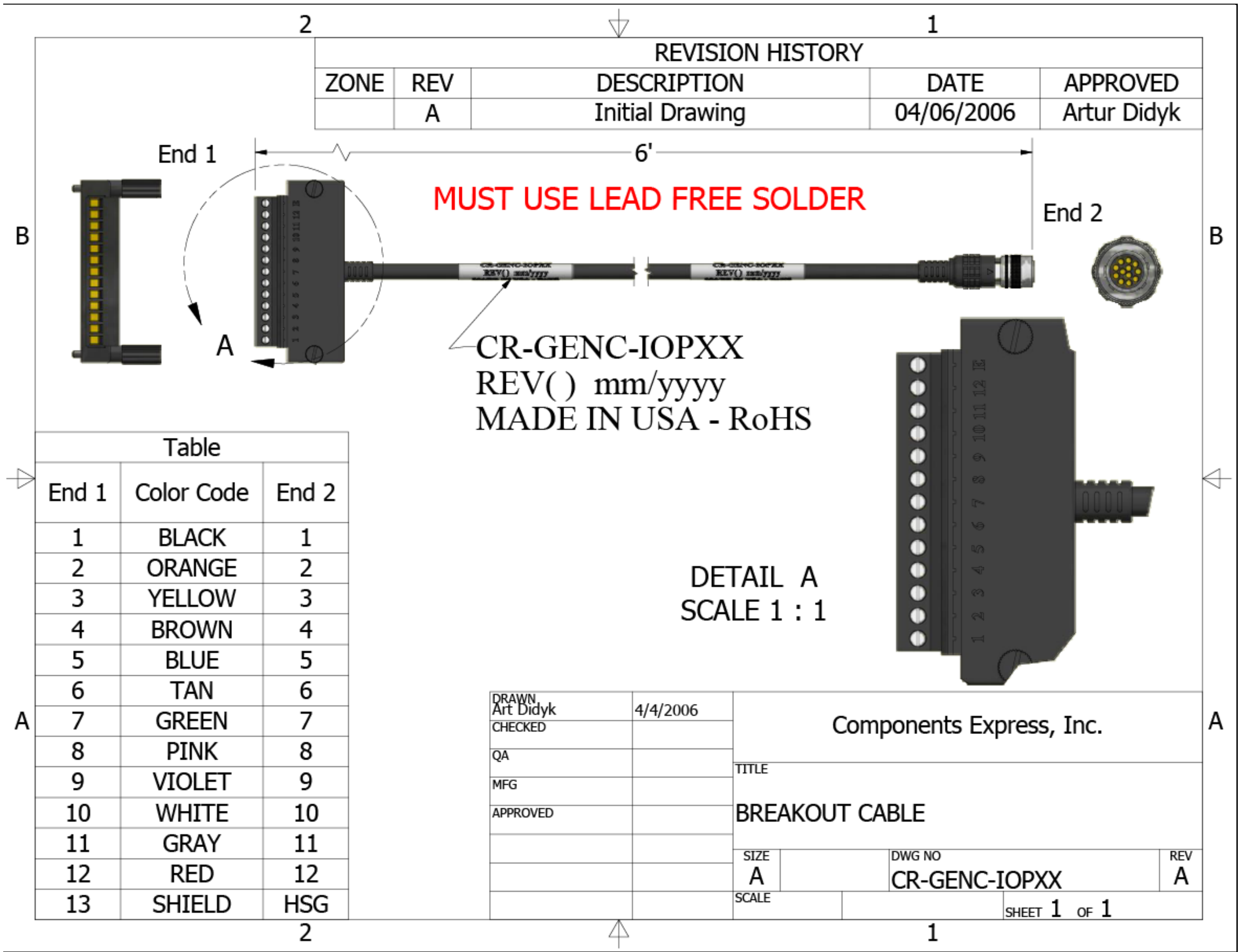


Table		
End 1	Color Code	End 2
1	BLACK	1
2	ORANGE	2
3	YELLOW	3
4	BROWN	4
5	BLUE	5
6	TAN	6
7	GREEN	7
8	PINK	8
9	VIOLET	9
10	WHITE	10
11	GRAY	11
12	RED	12
13	SHIELD	HSG

Figure 26: GPIO cable accessory #CR-GENC-IOP00

Establishing Camera Communications

When powering up the camera, the status LED on the back will indicate one of the following conditions:

Table 20: LED States

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

When the camera's LED state is steady green:

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

Selecting the Data Format

Cameras output data in the following formats:

Table 21: Output Data Formats

Output Format	Camera Models
Mono8 Mono12	HL-FM-04K30H-00-R HL-FM-13K18H-00-R HL-HM-13K30H-00-R HL-FM-08K30H-00-R HL-FM-16K15A-00-R HL-HM-08K30H-00-R HL-HM-16K30H-00-R HL-HM-08K40H-00-R HL-HM-16K40H-00-R HL-HM-16K40H-00-B HL-HM-32K40S-00-R HL-HF-16K13T-00-R (Multifield)
RGB8_Planar RGB12_Planar	HL-HF-16K13T-00-R (Multifield) HL-HC-16K10T-00-R

The camera always outputs data to the frame grabber in a 'planar' format—when multiple arrays are used the corresponding lines are output separately one after the other. Please refer to the frame grabber user's documentation for further details on selection input and output pixel formats.

Establishing Data Integrity

- Use the camera's internal triggering. This allows for initial imaging with a static object and no encoder input is 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.

Camera Performance and Features

This section is intended to be a progressive introduction to camera features, including explanations of how to use them effectively.

Synchronizing to Object Motion

Acquiring Images: Triggering the Camera

Related Features: TriggerMode, TriggerSource, TriggerActivation

Several different methods can be used to trigger image acquisition in the camera:

Internal Trigger

The simplest method is to set the *Trigger Mode* feature to "Internal". This results in the camera being triggered by an internal timer, which can be adjusted using the *Acquisition Line Rate* feature.

External Triggers

When the *Trigger Mode* feature is set to "External", the camera triggers come from a different source selected through 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 that triggers the camera. The options are: *Rising Edge*, *Falling Edge* or *Any Edge*. When using *Any Edge* be careful that the time between edges does not exceed the maximum line rate of the camera. If the line rate is exceeded one of those edges will be ignored.

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.

Line Rate & Synchronization

A 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 triggers 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 or below the maximum specified, then normal imaging will be reestablished.

Measuring Line (Trigger) Rate

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

Related Feature: measuredLineRate

The *Measured Line Rate* command is used to read the line (trigger) rate being applied, externally or internally, to the camera.

Maximum Line Rate

The maximum achievable line rate is determined by the number of CLHS lanes and the number of cables installed, as shown in the following tables for the available Linea HS models:

Table 22: Standard Models Maximum Line Rates

Camera Model	Maximum Line Rate (kHz) (1 sensor line output)			
	8-bit	**8-bit HDR mode**	**12-bit**	**12-bit HDR mode**
HL-FM-04K30H-00-R	300 kHz	150 kHz x 2	300 kHz	150 kHz x 2
HL-FM-08K30H-00-R	280 kHz	140 kHz x 2	180 kHz	90 kHz x 2
HL-HM-08K30H-00-R	300 kHz	150 kHz x 2	300 kHz	150 kHz x 2
HL-FM-13K18H-00-R	180 kHz	90 kHz x 2		
HL-HM-13K30H-00-R	300 kHz	150 kHz x 2	230 kHz*	115 kHz x 2*
HL-FM-16K15A-00-R	140 kHz	NA	90 kHz	NA
HL-HM-16K30H-00-R	300 kHz	150 kHz x 2	230 kHz*	115 kHz x 2*

Table 23: High Speed Models Maximum Line Rates

Camera Model	Maximum Line Rate (kHz) (1 sensor line output)			
	AOI Window	**Bit Depth**	**With 1 frame grabber**	**With 2 frame grabbers**
HL-HM-08K40H-00-R HL-HM-16K40H-00-R HL-HM-16K40H-00-B	16k	12-bit	205 KHz	275 KHz
	16k	8-bit	360 KHz	400 KHz
	12K	12-bit	275 KHz	368 KHz
	12K	8-bit	400 KHz	400 KHz
	9K	12-bit	367 KHz	400 KHz
	9K	8-bit	400 KHz	400 KHz
	8K	12-bit	400 KHz	400 KHz
	8K	8-bit	400 KHz	400 KHz

Table 24: Multifield Model Maximum Line Rates

Camera Model	Maximum Line Rate (kHz) (3 sensor colors output)		Maximum Line Rate (kHz) (2 sensor colors output)		Maximum Line Rate (kHz) (1 sensor color output)	
	8-bit	**12-bit**	**8-bit**	**12-bit**	**8-bit**	**12-bit**
HL-HF-16K13T-00-R	133 kHz	88 kHz*	200 kHz	133 kHz*	400 kHz	266 kHz*
HL-HC-16K10T-00-R	100 kHz	76 kHz*	150 kHz	115 kHz*	300 kHz	230 kHz*

Table 25: Super Resolution Model Maximum Line Rates

Camera Model	**Maximum Line Rate (kHz)**			
	32k Super Resolution	**16k TDI**	**Area**	**Extended Area**
HL-HM-32K40S-00-R	2 lines @ 200 kHz	400 kHz	2 kHz	650 Hz

*Linea HS maximum line rate values shown here are theoretical. The maximum achievable line rate depends on the frame grabber and imaging system (including CPU) used. Depending on your setup, lower line rates may be experienced.

These line rates were achieved using an Xtium2-CLHS PX8 (OR-A8S0-PX870) frame grabber in a system setup in our lab. The maximum achievable line rate depends on the frame grabber and imaging system (including CPU) used. Depending on your setup, lower line rates may be experienced.

With a system bandwidth of 6740 MB/s the following line rates were achieved:

- 12-bit: 200 kHz
- 12-bit HDR mode: 100 kHz x 2

For advice on your setup and achieving higher line rates, contact Teledyne DALSA customer support.

Minimum Line Rate

The minimum line rate for the HL-HM-16K40H-00-B model is 30 kHz; for all other camera models, the minimum line rate is 10 kHz.

Devices can be operated under 10 kHz, but specifications will no longer be valid. Dark current correction will help optimize dark current. See Flat Field FPN Calibration – Dark Current Correction.

Scan Direction

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

Related Feature: sensorScanDirectionSource, sensorScanDirection

A TDI camera model requires the user to indicate to the camera the direction of travel of the object being imaged.

The source of the scan direction is set using the *sensorScanDirectionSource* feature. The options are: *Interna*l, *Line 2* (pin 6 on the GPIO connector), or the *rotary encoder* feature (using pin 5 and pin 6 of the GPIO connector, only available when *TriggerSource* is "*RotaryEncoder*" and *rotaryEncoderOutputMode* is set to "*Motion*").

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

It is important to perform and save a flat field calibration in the actual system with both directions used.

Direction Change Time

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

Setting the correct scan direction

Whether the scan direction is set correctly can easily be seen in live imaging. An image will appear “normal”, sharp and focused. If the optical setup is not properly focused, blur will occur in both, horizontal (cross-scan) and vertical (in-scan), directions.

If blur occurs only in scan direction (see below), the scan direction is set incorrectly.

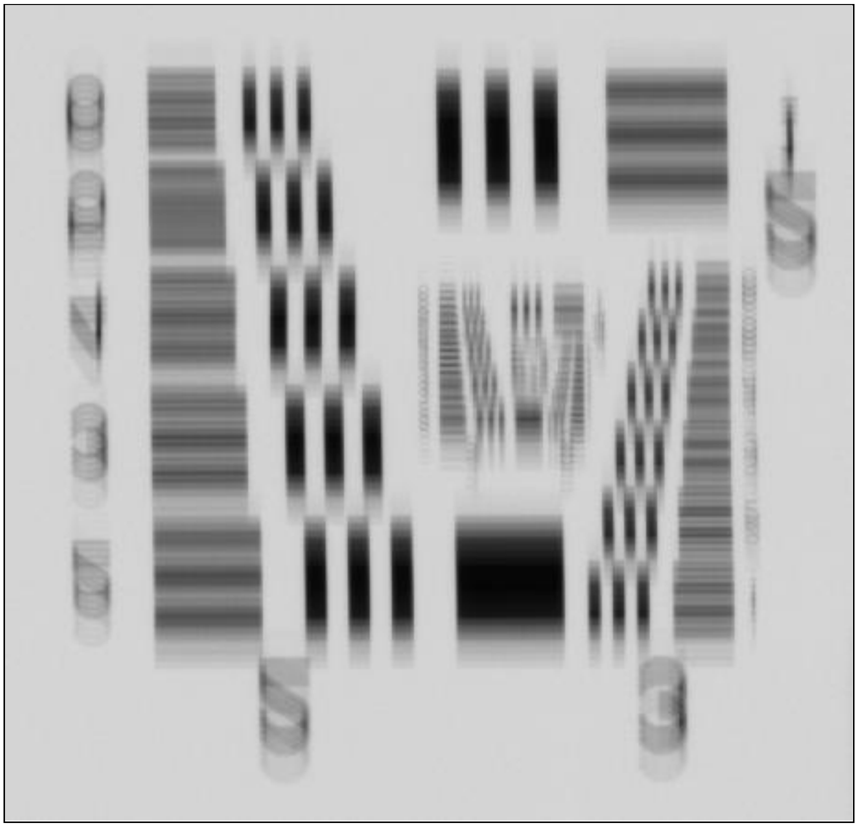


Figure 27: Image with incorrect scan direction

Camera Orientation

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

⚠	• The diagram assumes the use of a lens on the camera, which inverts the image. • In model **HL-HM-16K40H-00-B**, the mage is flipped compared to the other models. The image can be flipped back in the frame grabber.

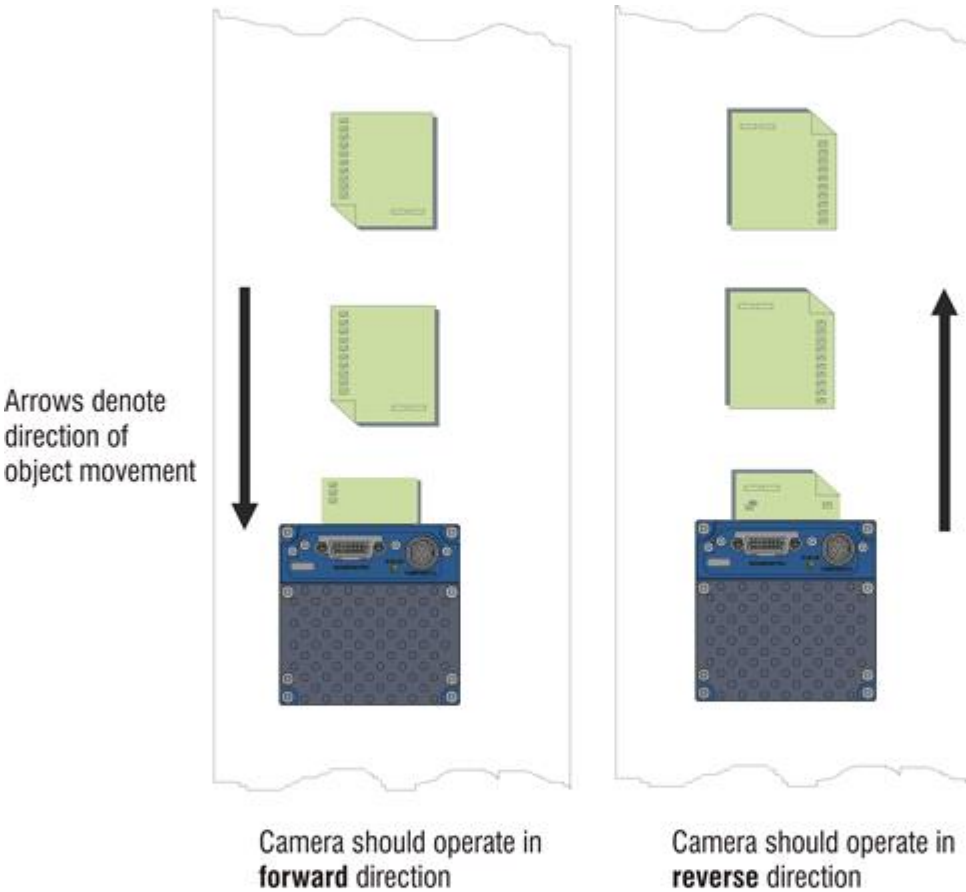


Figure 28: Example of Object Movement and Camera Direction

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

Some inspection systems require that the scan direction change at regular intervals. For example, scanning a panel forwards, coming to a stop and then scanning backward as the camera's field of view is progressively indexed over the entire panel.

It is necessary for the system to over-scan the area being imaged by at least the 128 stages of the TDI sensor before the direction is changed. This ensures that valid data will be generated on the return path as the camera's field of view reaches the area to be inspected.

Spatial Correction

Spatial correction is necessary when using multiple array output, such as when using HDR or high full well modes. To achieve a sharp image in the vertical direction when running the camera in modes that use multiple array output, it is important that the lines being used are aligned correctly. Line spatial correction is used to ensure that these lines align.

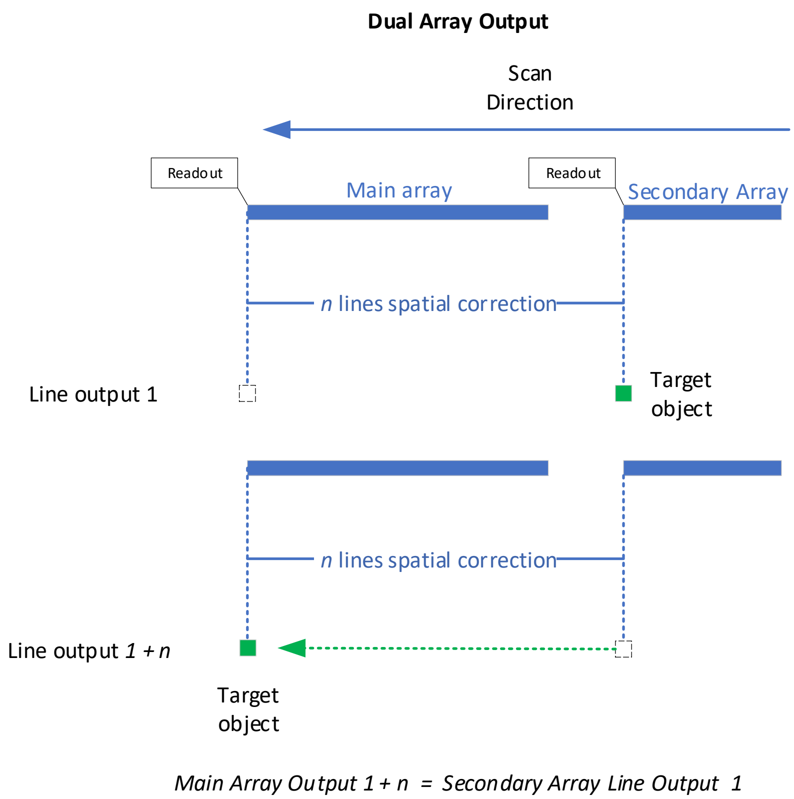


Figure 29: Spatial Correction

	Teledyne DALSA Xtium CLHS frame grabbers automatically perform spatial correction for Linea HS cameras.

At a high level, spatial correction is two step process; one, camera assigns row spacing data to each row; and two, the frame grabber uses this row spacing data to align the image data. All data buffering is performed by the frame grabber as the camera does not have adequate memory resources for this function.

Spatial correction compensates for the direction of travel and changes to the scan direction. For example, in dual array output, the main array row output that aligns to the second array output either to 163 or 99 rows apart depending on the scan direction.

	Note: The frame grabber must be set to two planes to align the data for dual array output; for 3 array output 3 planes are required.

Spatial correction is not necessary when using the camera with the main array only. For single array TDI operation this functionality is not needed and is disabled.

Standard and High-Speed Models Dual Array Line Spacing

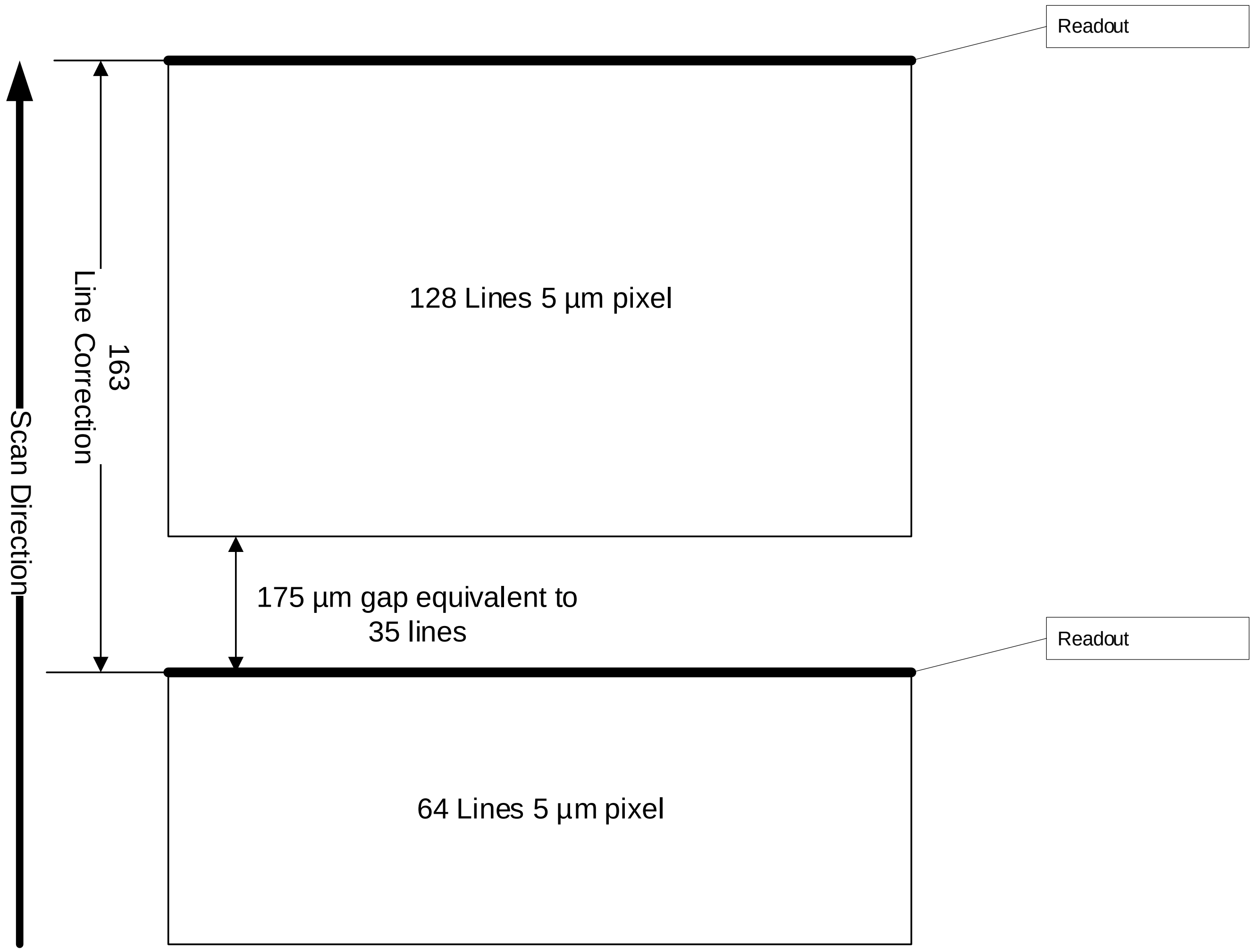


Figure 30: Standard and High-Speed Camera Line Spacing – Forward Scan Direction

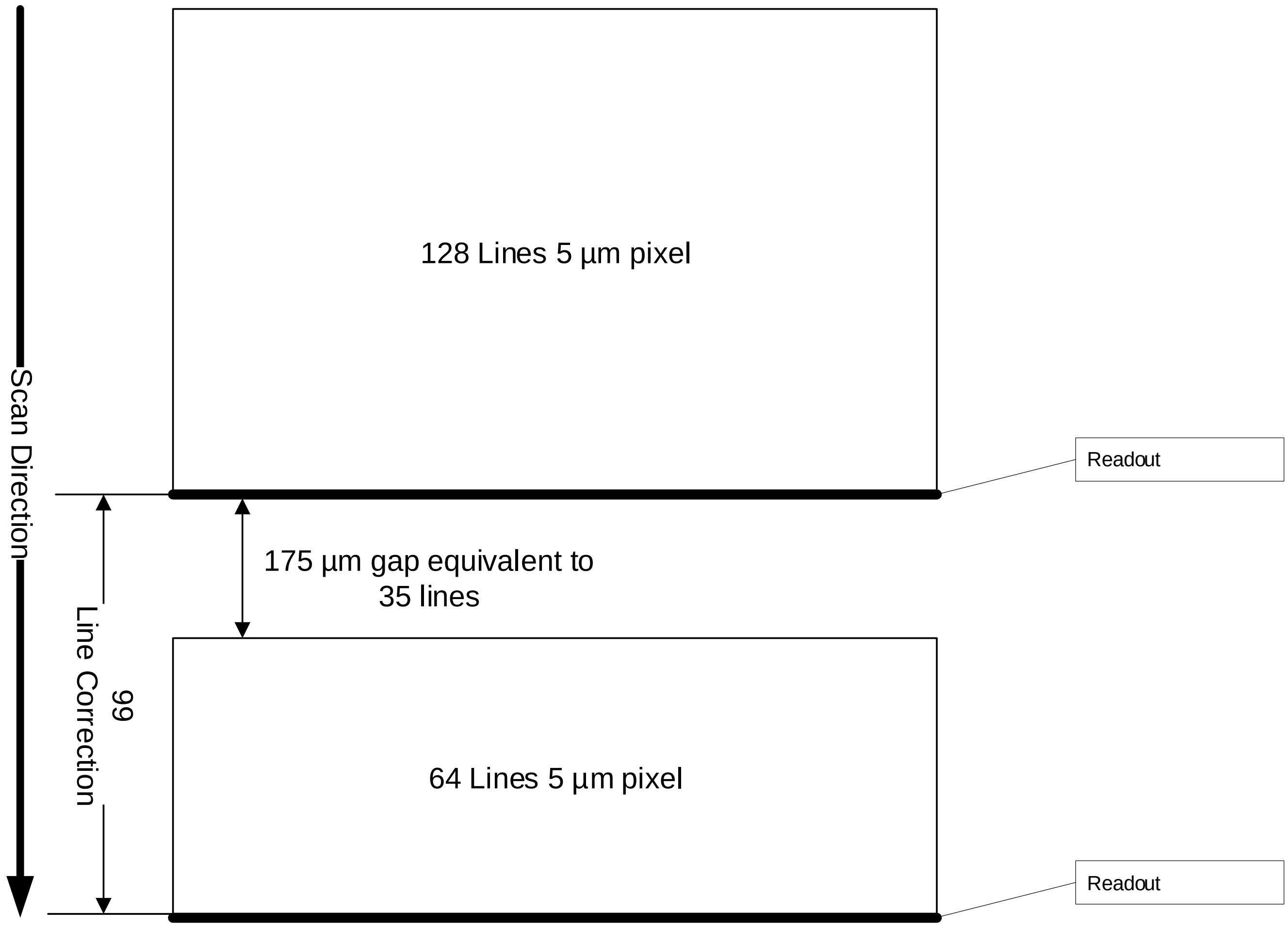


Figure 31: Standard and High-Speed Camera Line Spacing – Reverse Scan Direction

Multifield Model Array Spacing

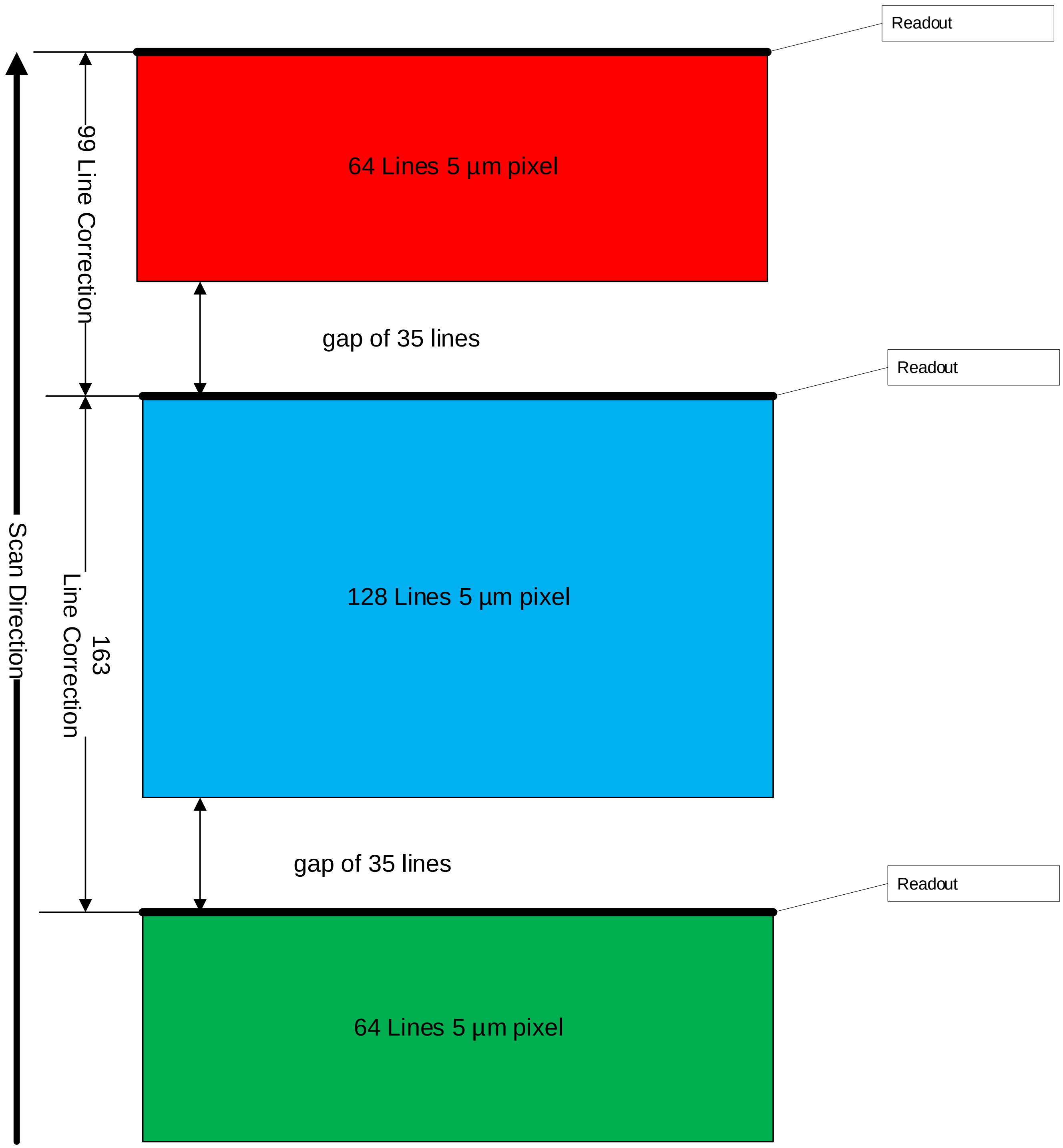


Figure 32: Multifield Camera Line Spacing – Forward Scan Direction

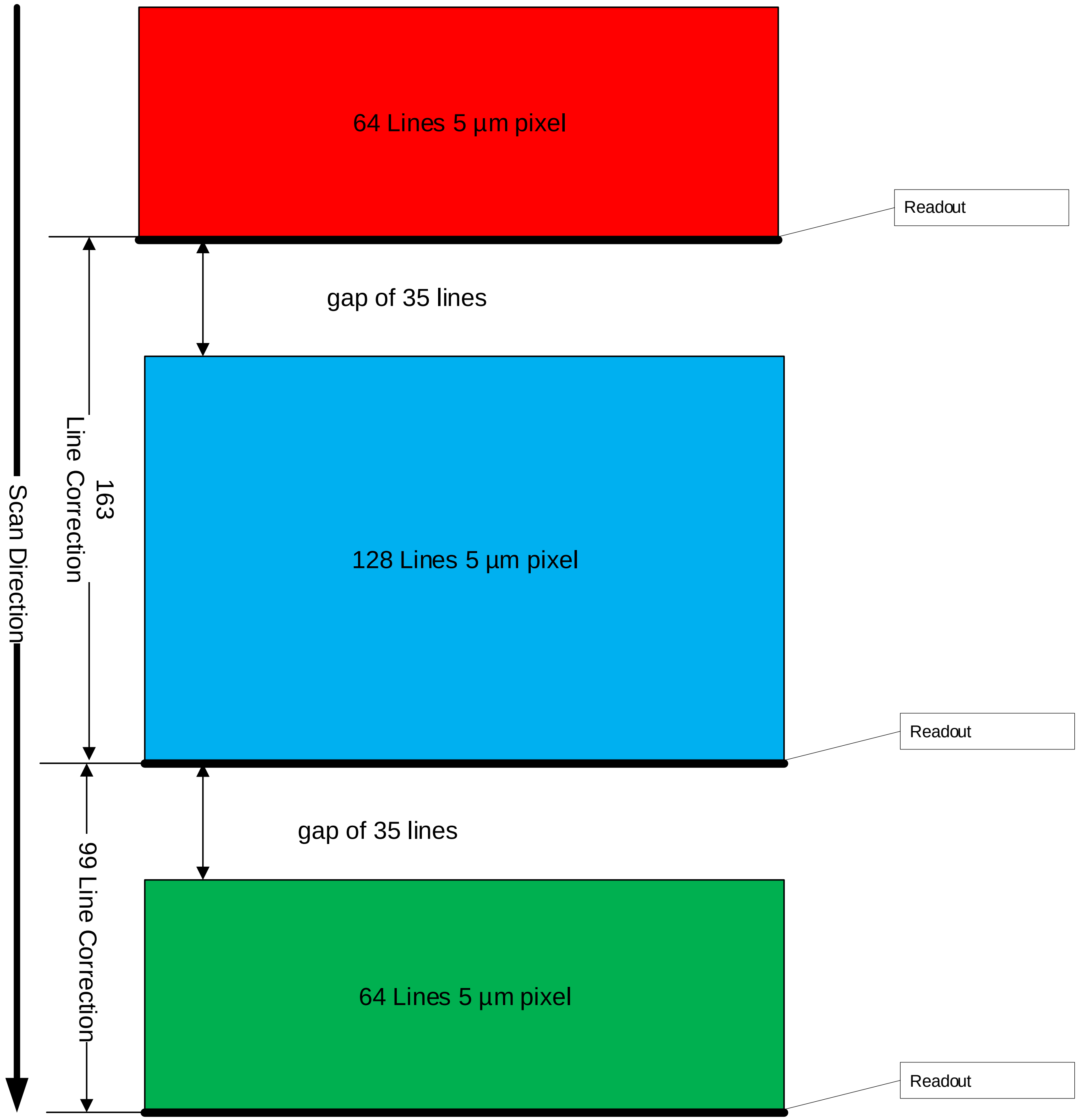


Figure 33: Standard and High-Speed Camera Line Spacing – Reverse Scan Direction

Super Resolution Spatial Array Spacing

The 32k super resolution camera uses multiple sensor arrays of 5um pixels to combine into a 32k 2.5um effective pixel pitch super resolution image. The multiple arrays are aligned automatically in the frame grabber using row spacing data provided by the camera.

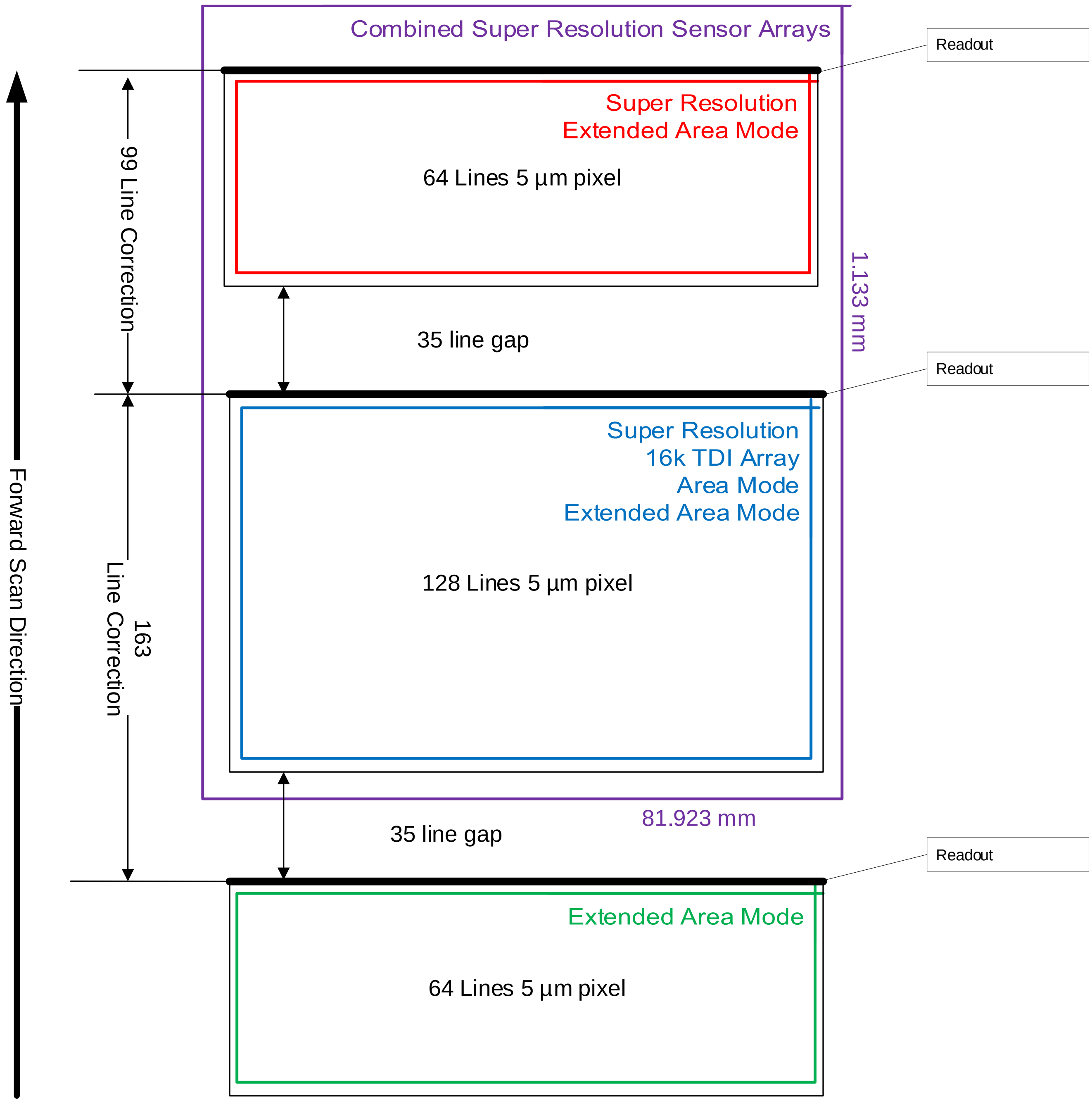


Figure 34: Super Resolution Camera Line Spacing – Forward Scan Direction

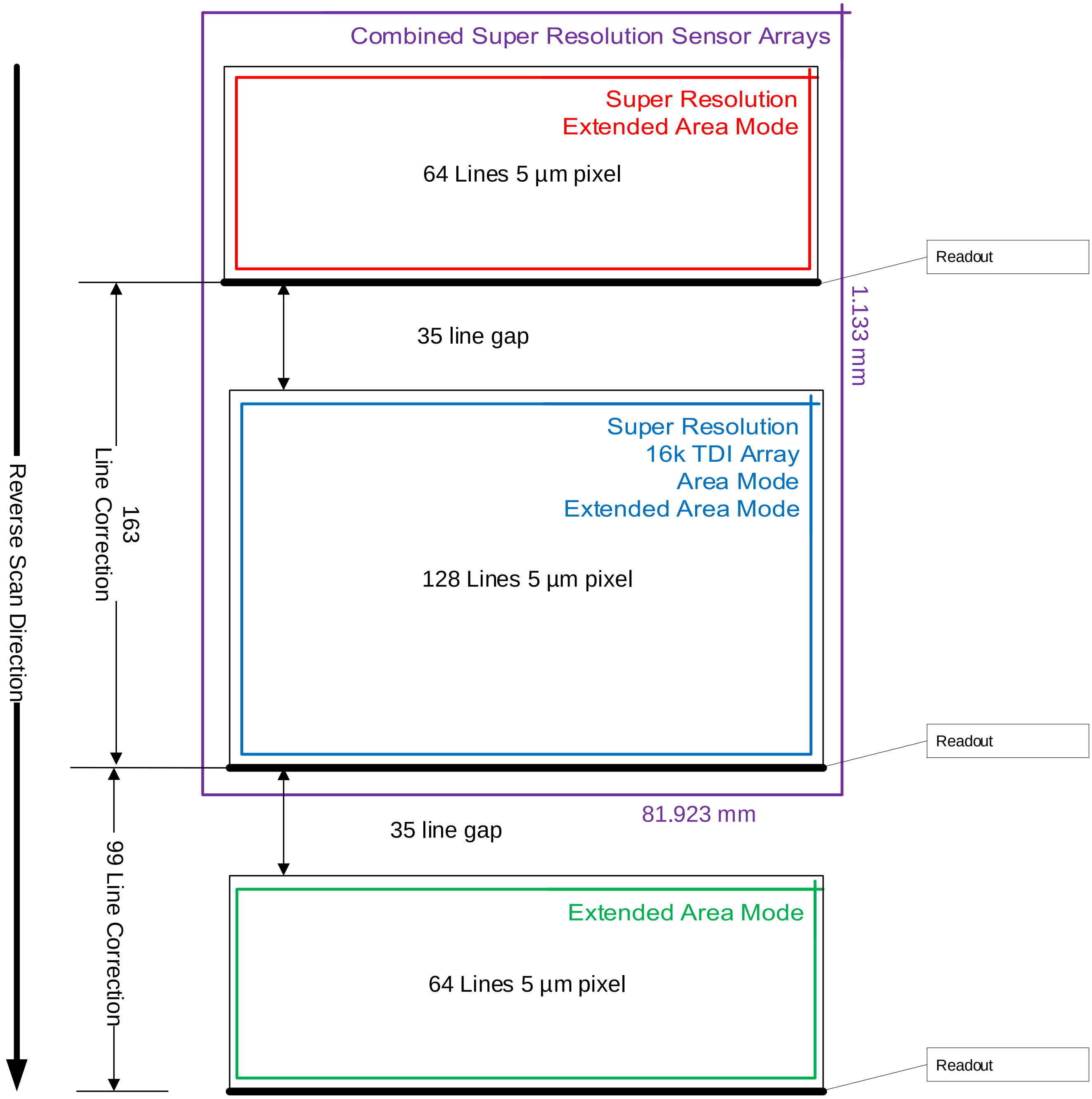


Figure 35: Super Resolution Camera Line Spacing – Reverse Scan Direction

Alignment Markers

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

Related Features: [alignmentMarkerEnable](), [alignmentMarkerVerticalSpacing](), [alignmentMarkerVerticalOffset](), [alignmentMarkerHorizontalSpacing](), [alignmentMarkerHorizontalOffset]() and *[alignmentMarkerBlack]()*

Use alignment markers to assist in aligning the camera to ensure that all sensor columns align vertically given the target object movement. Sensor alignment is important since up to 128 columns in an array are summed in TDI operation; misaligned columns can result in blurred or smeared images. When enabled, alignment markers are displayed as graphic overlays in the image output.

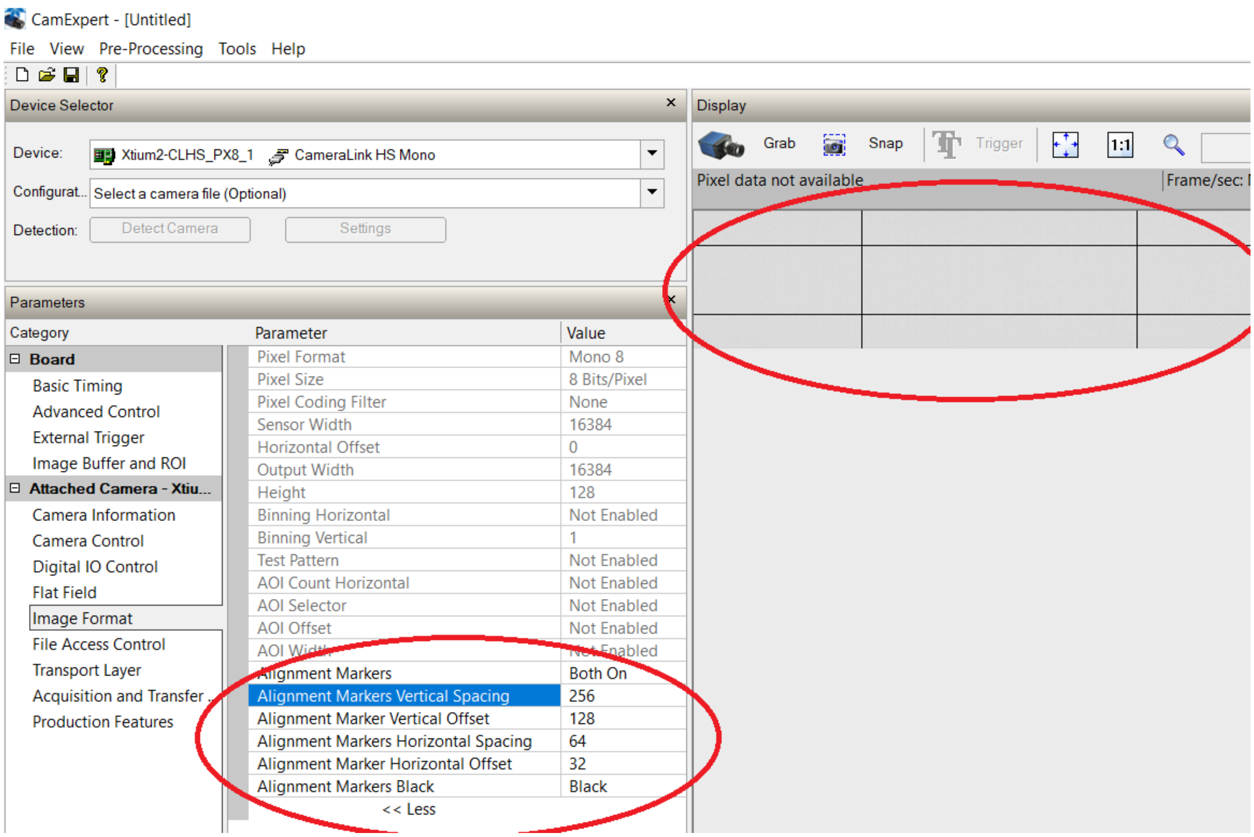


Figure 36: Alignment Markers

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

When using a camera at an angle to the objects surface, the object pixel size for the different sensor arrays (for example, 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 artifacts at the extremities of the image.

To correct for parallax pixels at lower magnification can be interpolated to provide the required resolution. That is, for lower magnification array output, each pixel represents a slightly larger real-world distance, therefore a smaller number of pixels are equivalent to the higher magnification array output. Selection of the arrays to adjust is dependent on positive or negative angle; it is not sensitive to scan direction.

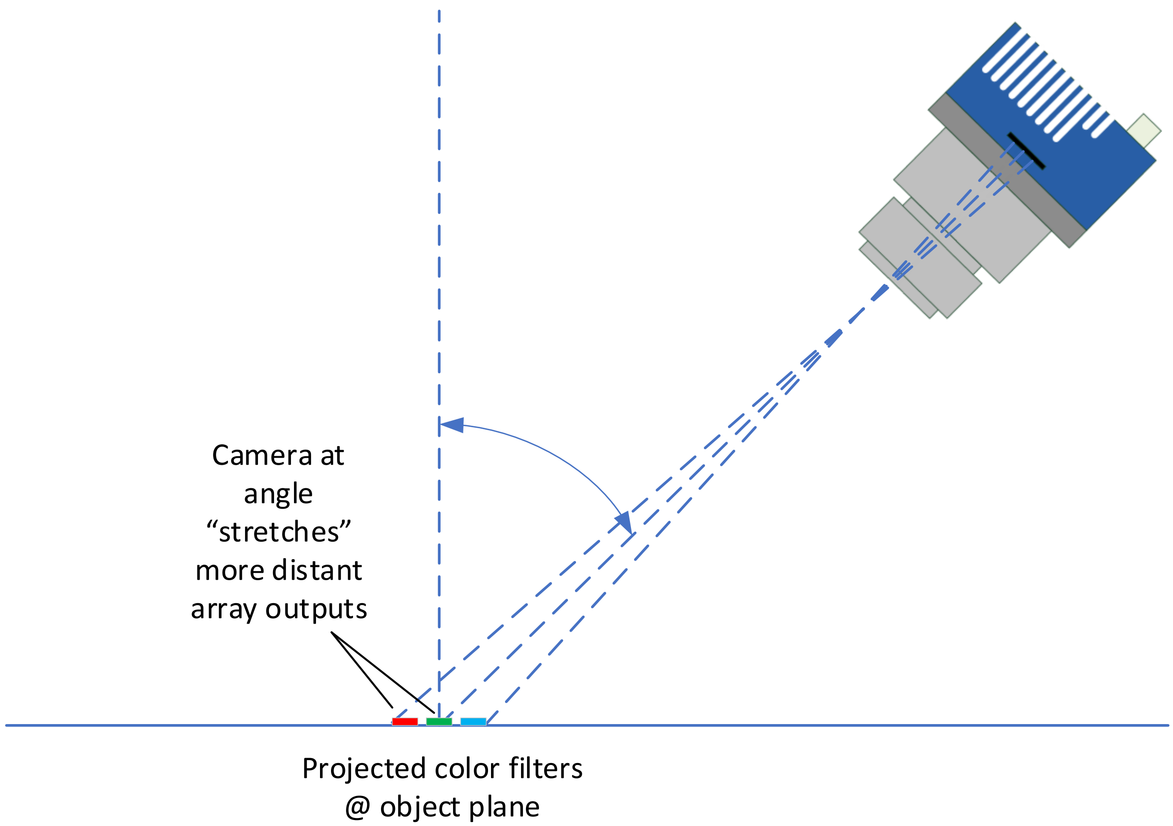


Figure 37: Camera Angle Parallax

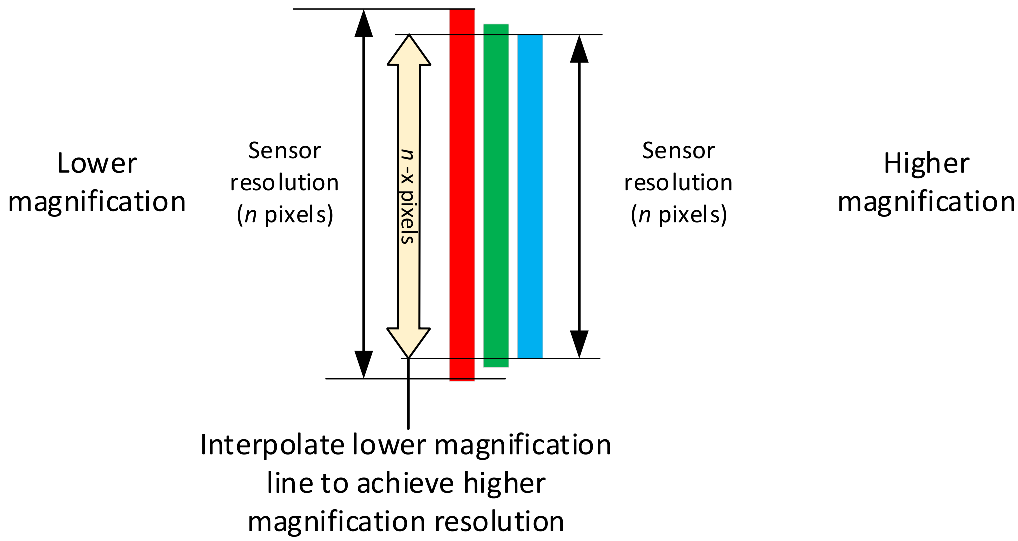


Figure 38: Parallax Effect on Sensor Arrays Output

For example, with a sensor resolution of 8192 pixels, if the lower magnification equivalent distance is 8185 pixels, these pixels would be interpolated (in other words, stretched) to provide 8192 pixels, such that all pixels represent the same real-world measurement.

Note: Parallax correction of the individual arrays 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.

Imaging Modes

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

Relevant Features: *sensorTDIModeSelection*

The Linea HS standard and high-speed models are capable of being run in four different modes: TDI, TDI HDR (High Dynamic Range), TDI HFW (High Full Well) and TDI Area mode.

The Multifield camera is capable of being run in the following modes: TDI RGB, TDI Red, TDI Green, TDI Blue, TDI Red Green, TDI Red Blue, TDI Green Blue and TDI Area.

The Linea HS 32k super resolution model is capable of being run in five different modes: 32k SR Detail Restored, 32k SR Mapped, TDI, TDI Area mode and TDI Extended Area.

TDI Mode

TDI mode is the default operating mode for the camera. The camera combines multiple exposures of an object as it passes each row in the array into one high sensitivity image. In this mode the main 128 stage array is used, and the full 300 kHz line rate can be achieved.

TDI Stage Selections

When operating in different TDI modes the number of stages in the array is adjusted, resulting in different responsivities.

In TDI mode, the main array is configurable to 128 or 64 stages; secondary arrays are not used.

Table 26: TDI Mode Stages

Array	Number of Stages
Main Array	128, 64
Sub Array	64, 16 (not used)

It is important to execute flat field correction based on the number of stages in the final application, since pixel behavior changes with stage selection.

High Dynamic Range (HDR)

HDR enables imaging of (exceedingly) bright and dark areas in a single scan, replacing dual-scan setups with dedicated cycles. Simultaneous capture improves system throughput (no overhead from direction change) and stability / repeatability (close association between dark & bright image).

Note: In HDR mode image data is collected from 2 TDI arrays; the camera outputs two rows that will have to be combined to create an HDR image. This limits the maximum line rate to 150 kHz x 2 (or 200 kHz x 2 for high speed models).

To adapt to the imaged scene dynamic range, the HDR ratio can be selected, as shown in the table below. This ratio controls the number of stages used in each TDI pixel array.

Table 27: HDR Mode Stages

HDR Ratio	Main Array Stages	Secondary Array Stages
2:1	128	64
4:1	64	16
8:1	128	16

High Full Well

High Full Well (HFW) mode sets both arrays at equal stage count, providing an additional bit of output data. Processing the upper bits [N..1] provides a 2x Full Well increase at lower Responsivity. Processing the lower bits [N-1…0] maintains Responsivity with √2 improved NEE

Table 28: High Full Well Mode Stages

Ratio	Main Array Stages	Secondary Array Stages
1:1	64	64

Area Mode

In Area Mode, the camera operates as an area array camera (16,384 x 128 or 8,192 x 128 pixels) using a two-dimensional array of pixels. Area Mode is useful during setup, both for aligning and focusing the camera. In sufficiently slow applications, area mode can provide a high-aspect 2D image.

When selecting TDI Area mode, the Device Scan Type changes to Area scan and the height feature changes to 128, automatically.

Multifield Modes

The multifield TDI modes allow the output of any combination of the three color arrays; single colors only (R, G or B), color pairs (RG, RB or GB) or all three colors (RGB).

32k Super Resolution Modes

Unlike typical bilinear or bicubic interpolation methods, Teledyne DALSA's proprietary and patent-pending super resolution system derives a balanced, artifact free 32k image that provides higher detectability, especially for small defects, high MTF (modulation transfer function, also known as spatial frequency response), low noise and high SNR, all with the responsivity of a 5um pixel. The combination of camera, CLHS interface and High-Resolution frame grabber enables this functionality up to 150kHz line rate.

32k SR Mapped

The SR mapped function utilizes the first stage in Teledyne DALSA's patented processing chain. The high-resolution image is created, benefitting the system with higher Full Well, higher SNR and lower noise.

This mode provides the lowest level of data processing in the Teledyne DALSA system and hence poses the lowest risk of affecting subsequent user data processing.

Use this mode in the initial setup to evaluate whether your system benefits enough from the 32k SR operation and to avoid conflicts for your algorithms.

32k SR Detail Restored

The Detail Restored mode, when selected, enables the "SR Strength" (*srStrength*) parameter for user adjustment.

With "Detail Restored", the full Teledyne DALSA patented processing chain is activated. Sub-pixel information is extracted and enhanced via the "strength" parameter. This function gradually increases the system MTF and provides higher effective SNR for small and sub-pixel defects without affecting noise significantly.

It is highly recommended that the user tests these settings in their own application and adjust the "strength" (between 0 and 1) to identify the best balance between enhanced detection (higher SNR for given defects) and potential false positives that subsequent algorithms may identify.

Extended Area Mode

In Extended Area Mode each of the three sensor arrays is output as separate imaging planes. Each output is 16384 x 128 pixels. However, as the top and bottom arrays have 64 rows, the bottom half of their images will be blanked out.

Internal Trigger Mode

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

Related Feature: AcquisitionFrameRate, AcquisitionLineRate

In the different TDI Modes use the following features to set the internal trigger rate:

Standard Models

Table 29: Standard Models Internal Trigger Rate Features

TDI Mode	Trigger Rate Feature	Maximum
TDI	AcquisitionLineRate	300 kHz
HDR / HFW	AcquisitionLineRate	150 kHz
Area	AcquisitionFrameRate	2 kHz

High Speed Models

Table 30: High Speed Models Internal Trigger Rate Features

TDI Mode	Trigger Rate Feature	Maximum
TDI	AcquisitionLineRate	400 kHz
HDR / HFW	AcquisitionLineRate	200 kHz
Area	AcquisitionFrameRate	2 kHz
Multi-Area	AcquisitionFrameRate	650 kHz

Multifield Model

Table 31: Multifield Model Internal Trigger Rate Features

TDI Mode	Trigger Rate Feature	Maximum
TDI (One color)	AcquisitionLineRate	300 kHz
TDI (Two colors)	AcquisitionLineRate	150 kHz
TDI (Three colors)	AcquisitionLineRate	100 kHz
Area	AcquisitionFrameRate	2 kHz
Multi Area	AcquisitionFrameRate	650 Hz

Super Resolution 32k Model

Table 32: Super Resolution Model Internal Trigger Rate Features

TDI Mode	Trigger Rate Feature	Maximum
32k Modes	AcquisitionLineRate	150 kHz
16k TDI	AcquisitionLineRate	300 kHz
Area	AcquisitionFrameRate	2 kHz
Multi Area	AcquisitionFrameRate	650 Hz

Establishing the Optimal Response

An important camera performance characteristic is its responsivity and associated noise level at the system's maximum line rate and with the required illumination and lens configuration.

Responsivity and noise performance can be assessed using a stationary, plain white target under bright field illumination. However, to accurately evaluate the camera's real-life performance, it is important that the setup is representative of the final 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 inspection system and 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 Control by Light Source Strobe

Relevant Features: outputLineSource, outputLinePulseDelay, outputLinePulseDuration, LineInverter

> **Note:** TDI sensors do not have exposure control built in. Pixels continuously convert photons to electrons.
>
> After receiving a line trigger, the camera instructs the sensor to execute the analog read operation. During this time incoming photons are still detected and may associate with the current or subsequent line. This effect is negligible when constant lighting is used.
>
> When using strobed lighting, assure a minimum delay of 1.4 µs between the rising edge of EXSYNC and powering-on of the light source.

Using the GPIO controls the camera can be set up to strobe a light source effectively giving exposure control. Figure 39 shows an example of an output signal used as a strobe signal.

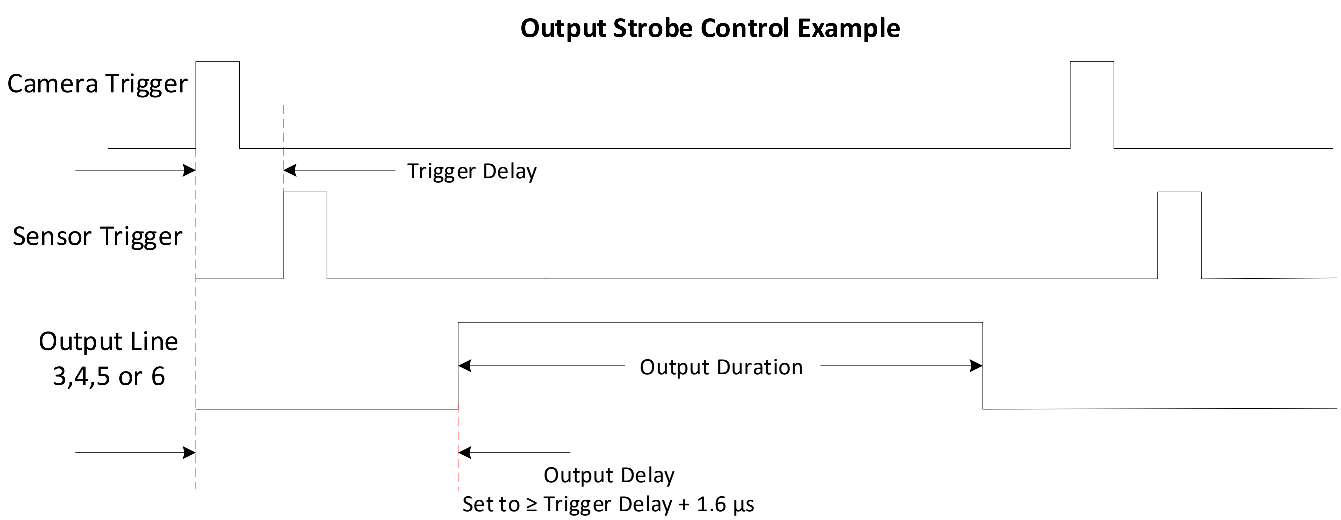


Figure 39: Strobe Timing

The camera logic enables simplified control of external, pulsed light sources to assure reliable timing association.

For this purpose, the trigger signal received from the system is managed by the camera to trigger sensor response and data processing. In addition, an Exposure Active signal is generated and can be supplied to any of the GPIO outputs. This allows triggering or timing external light sources.

The following diagram illustrates the logical control signal flow in the Linea HS series camera family.

The *outputLineSource*, *outputLinePulseDuration*, *outputLinePulseDelay*, and *LineInvert* features allow the user to control a strobe light source in order to coordinate with the sensor exposure.

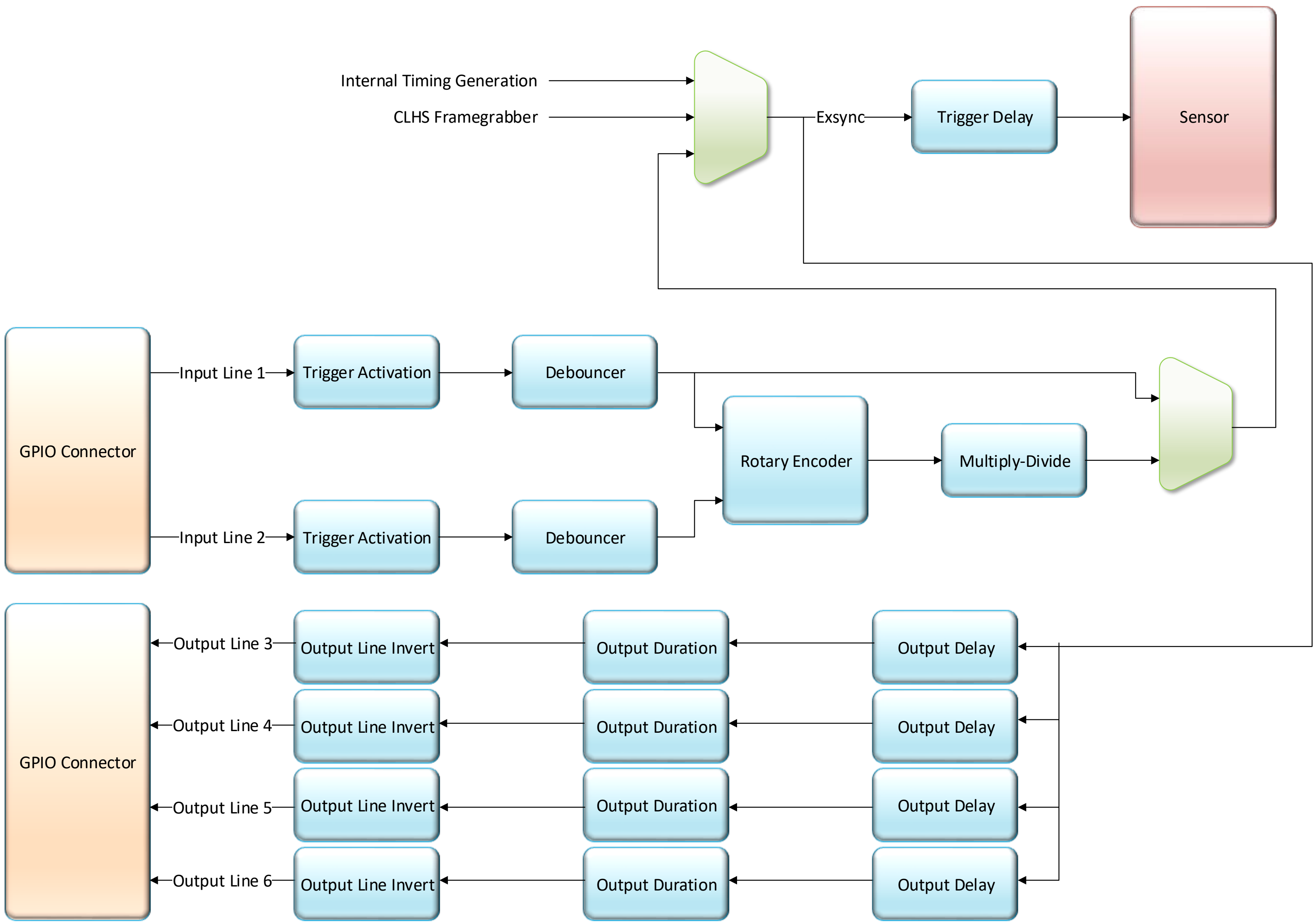


Figure 40: GPIO functionality block diagram

Image Response Uniformity & Flat Field Calibration

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

Related Features: flatfieldCalibrationFPN, flatfieldCalibrationPRNU, flatfieldCorrectionAlgorithm, flatfieldCalibrationTarget

Images commonly have lower response at the edges of the camera's field of view compared to its center. This is a result of lens vignetting and structure in the illumination source.

Diffusing elements in the light path removes structure in the illumination and may improve edge-responsivity.

Decreasing the lens aperture can also improve edge-responsivity, if barrel vignetting (a shadow cast on the sensor by the focus helical or extension tubes) is present.

The camera can compensate for edge roll-off and other optical non-uniformities by using 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, illumination intensity, spectral content and illuminator beam structure.
- Flat field calibration should be performed when the camera temperature has stabilized.
- Flat field calibration will adjust all pixels to have the same value as the peak pixel value or target level, as per the calibration mode selected.
- If the flat field calibration is 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 255 DN with increasing illumination and the PRNU deteriorates. This effect can be resolved by decreasing the light level or exposure control time.

Following a flat field calibration, all pixels should be at their un-calibrated peak value or target value. Changing gain values now allows the user to make refinements to the operating responsivity level.

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

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

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

Flat Field FPN Calibration – Dark Current Correction

Related Features: flatfieldCalibrationFPN, flatfieldCorrectionAlgorithmFPN

Sweeping line rates at the lower line rates of camera operation may cause unwanted noise to be introduced. This is due to the dark current in the sensor, which at **low** line rates and **high** temperatures will be more pronounced.

Dark noise (FPN) calibration is done at a certain line rate. However, if the camera is operated using sweeps or changes in line rates, then the calibration will not be perfect across the line rate range. For example, when sweeping the line rate between 4 kHz and 60 kHz, if one calibrates at either end (4 or 60 kHz), the output won't be perfectly corrected at the other end because the correction coefficients were created for a different line rate.

The FPN Calibration Algorithm feature (flatfieldCorrectionAlgorithmFPN) includes a *Dark Current* option whose goal is to correct for the sensor's dark current at lower line rates (i.e., 4-60 kHz) by applying a calculated scale factor internally. Note that this option is only available with HL models.

Note that:

- Factory standard FPN calibration is done at 100 kHz.
- Dark current calibration will subtract a scaled FPN value for line rates between 4 and 60 kHz; above or below this line rate, the coefficients at closest limit will be applied.
  - For instance, at 1.9 kHz, the coefficients applied will be the same as the ones at 4 kHz.
  - At line rates above 60 kHz, it is OK to use standard FPN correction, as dark current is not as pronounced at higher line rates.

In order to use this feature:

1. Wait until the camera is at a steady state operating temperature (e.g., 55°C).
2. Block light from entering the sensor (i.e., close shutter or cover lens).
3. In the FlatField category, set the *FPN Calibration Algorithm* feature value to *Dark Current*.
4. Select *Calibrate FPN* and perform the FPN calibration procedure.
5. Once FPN calibration is complete, open the shutter and continue calibration with PRNU calibration if needed.
6. To save the coefficients in a user set (along with all other current settings), select *Camera Information* -> *Power up configuration* -> *Settings*, choose a user set and click **Save**.
7. To load the coefficients at start up, choose the same user set from the **Power-up Configuration** list.

The *FPN Calibration Algorithm* selected will be saved to the user set / start up settings. See Saving & Restoring Camera Setup Configurations for details.

Caution

Since the correction coefficients are generated at a particular temperature (e.g., 55°C), if the camera is cooled down, the coefficients will overcorrect the output, which may cause the output to go below 0 DN in a dark environment.

- You can see this by changing the "Black Level" feature to the maximum value and observing some pixel values are less than the Black Level.
- The output will become normal again as the camera heats up to the temperature at which it was calibrated.

Example

- Calibrate dark current correction at 55°C. Output looks good, everything works as expected.
- Camera is then powered off and allowed to cool down.
- Camera is powered on and allowed to reach 30°C, with dark current correction enabled and using the coefficients created previously at 55°C.
  - Camera output is now at 0 DN in dark; this is due to the coefficients over correcting the pixels.
  - The user can either:
    - Wait until the camera reaches its steady state (55°C), at which point the output will be back to normal.
    - Recalibrate at the current temperature so the output will be the proper DN. However, it is recommended to calibrate at the steady state temperature for best performance.

Saving & Loading a PRNU Set Only

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

Related Features: flatfieldCorrectionCurrentActiveSet, flatfieldCalibrationSave, flatfieldCalibrationLoad

A user set includes all the "settings" (for example, gain, line rate), FPN (Fixed Pattern Noise) and PRNU (Photo Response Non-Uniformity) coefficients and a LUT. These three features let you save/load just the PRNU coefficients. Loading a complete user set takes approximately 1 second while loading only the user PRNU coefficients takes less than 200 milliseconds.

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 1 factory.

The *Factory Set* is read-only and contains all ones. Loading the Factory Set is a good way to clear the user PRNU.

Save the current user PRNU coefficients using the "Save User PRNU Set" command. Load the user PRNU coefficients from the set specified using the "User PRNU Set Selector" and the "Load User PRNU Set" command features.

Setting Custom Flat Field Coefficients

Flat Field (PRNU) coefficients can be custom modified and uploaded to the camera. They can also be downloaded from the camera.

To upload or download coefficients, use File *Access Control Category > Upload / Download File > Settings* and then select *Miscellaneous > Current PRNU* to download / upload a file.

The PRNU coefficients are used by the camera as soon as they are uploaded. To avoid loss at power up or while changing row settings, the uploaded coefficients should be saved to one of the available user sets.

Flat Field Calibration Filter

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

Related Feature: flatfieldCorrectionAlgorithm

If a sheet of material is being used as a white target, it must be completely free of blemishes and texture.

The presence of dirt or texture will generate a variation in the image that will be incorporated into the calibration coefficients of the camera. Further, 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. Dirt or texture that has bright characteristics will appear as dark vertical lines.

One way to minimize this effect is to have the white target in motion during the calibration process. This has the result 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 applied while 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.

Flat Field Calibration Regions of Interest

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

Related 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 when cameras image off the edge of a panel or web or when an inspection system is imaging multiple lanes of material. The edge of the material or area between lanes may not be illuminated in the same way as the areas of inspection and, therefore, will 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 selected by the user and 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 set, another ROI can be defined and flat field calibrated.

Operating HL-HM-16K40H-00-B at Low Line Rates

Related Features: flatfieldCalibrationFPN, flatfieldCorrectionAlgorithmFPN

Higher FPN is expected in back side illuminated cameras, such as model HL-HM-16K40H-00B, compared to front side illuminated cameras. The difference in FPN is minimized at higher line rates but can become noticeable in the image at reduced speed. If the application requires operation at line rates below 30 kHz, it is recommended for the user to recalibrate the FFC coefficients.

Similarly, higher dark current is expected in model HL-HM-16K40H-00B compared to front side illuminated cameras. The difference in dark signal is minimized at higher line rates but can become noticeable in the image at reduced speed. If the application requires operation at line rates below 30 kHz, dark current correction is recommended.

See Flat Field FPN Calibration – Dark Current Correction.

Image Filters

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

Related Features: imageFilterMode, imageFilterType, imageFilterKernalSize, imageFilterContrastRatio

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

Use the *imageFilterMode* feature to turn the filtering on or off. Use the *imageFilterType* feature to read the type of filter that is being used.

Kernels

Use the *ImageFilterKernalSize* 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.

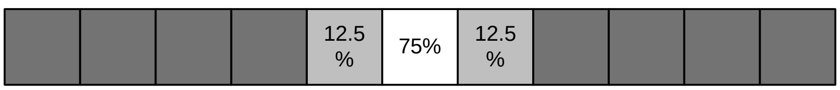


Figure 41: 1 x 3 kernel

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.

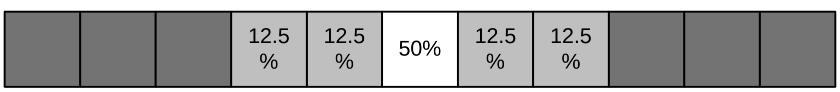


Figure 42: 1 x 5 kernel

Image Filter Contrast Ratio

The *imageFilterContrastRatio* 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 1 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.

Related Features: [BinningHorizontal] and [BinningVertical]

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

Binning is a process whereby adjacent pixels are summed. The camera supports 1x, 2x, and 4x horizontal and vertical binning. Vertical binning is only available in TDI single plane mode.

Horizontal binning is achieved by summing adjacent pixels in the same line. Therefore, 2x binning results in the object pixel doubling in size horizontally. 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, and so forth.

Horizontal 2x binning will halve the amount of image data out of the camera. This can be used to save processing bandwidth in the host and storage space by creating smaller image file sizes.

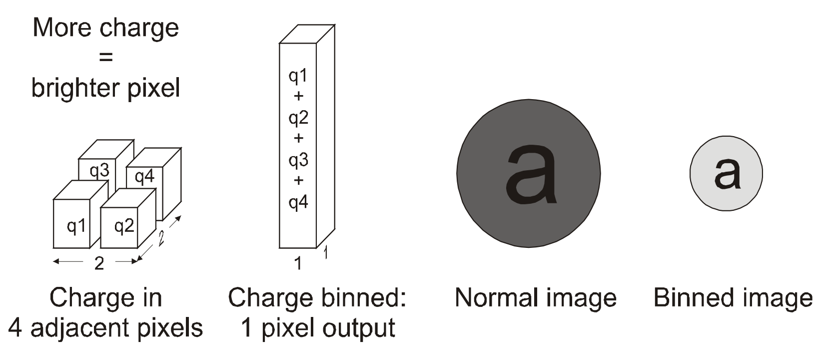


Figure 43: 2x2 Binning

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

Note: 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 and Acquisition and Transfer Control Category in Appendix A for GenICam features associated with this section and how to use them

Related Features: multipleROICount, multipleROISelector, multipleROIOffsetX, multipleROIWidth, AcquisitionStart, AcquisitionStop and AcquisitionStatus

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 section) then the user may want to ignore this superfluous image data.

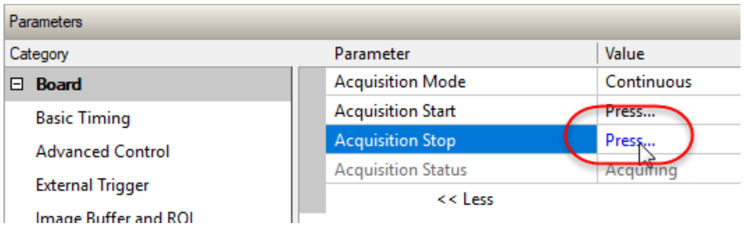
Eliminating unwanted image data that is visible in the camera’s field of view reduces the amount of information the host computer needs to process. This may result in an increase to the maximum allowable line rate when using 12-bit output data.

The camera can accommodate up to four AOIs. Image data outside the AOIs is discarded. Each AOI is user selected and its pixel boundaries defined. The camera assembles the individual AOI’s into one contiguous image line with a width equal to the sum of the individual AOIs. The frame grabber will need to be adjusted to accommodate the smaller overall image width. As the host computer defined the size of each individual AOI, it will be able to extract and process each individual AOI from the single larger image.

Note: AOIs are not supported by the Linea HS 32k Super Resolution model (HL-HM-32K15S-00-R).

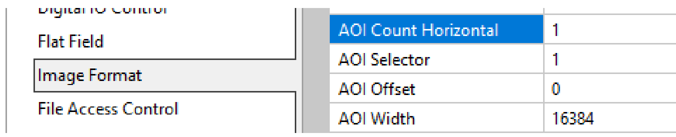
Steps to Setup Area of Interest

1. Plan your AOIs.
2. Stop acquisition, using the *AcquisitionStop* feature. In CamExpert this feature is available in the Acquisition and Transfer Control category:



The *AcquisitionStatus* feature displays the current status as Acquiring or Not Acquiring.

3. Set the number of AOIs using the AOI Count Horizontal (*multipleROICount*) feature. In CamExpert AOI related features are available in the Image Format category:



4. Select the first AOI and set the offset and width.
5. If the other AOIs are large you may need to select them first and reduce their widths.
6. Repeat for each AOI in turn.
7. Start acquisition, using the AcquisitionStart feature.

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.

Note: AOI 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.

- Acquisition must be stopped to change the AOI configuration.
- 1-4 AOIs can be selected.
- Minimum width is 96 pixels per AOI.
    - Minimum total of all AOI widths summed together must be at least 1,024.
- Maximum width of all AOI widths summed together must be no more than = 16,384.
    - Maximum 8k bytes per CLHS lane.
- AOI width step size is 32 pixels.
- The offset of each AOI may be 0 to (16,384 – 96 = 16,288).
    - Overlapping AOIs are allowed.
- Offset and width for individual AOI's will "push" one another.
    - For example, if AOI has offset 0, width 16,384, and the offset is changed to 4096, then the width will be "pushed" to 12,288.
    - AOI's only affect one another by limiting the maximum width.
- AOIs 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.

Enhancement of Interest (EOIs) Regions

Reduce Image Data & Enhance Performance

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

Related Features: enhancedImage, enhancedImageCount, enhancedImageSelector, enhancedImageStart, enhancedImageWidth, enhancedImageOffset and *enhancedImageGain*

Enhancement of Interest (EOI) regions allow rapid gain and offset settings to be applied to up to 4 regions in the image. EOIs are supported in all imaging modes except for Super Resolution mode.

The EOI feature has been optimized to load in minimum time (~ 50 ms) by only applying a gain and offset on a region rather than per-pixel.

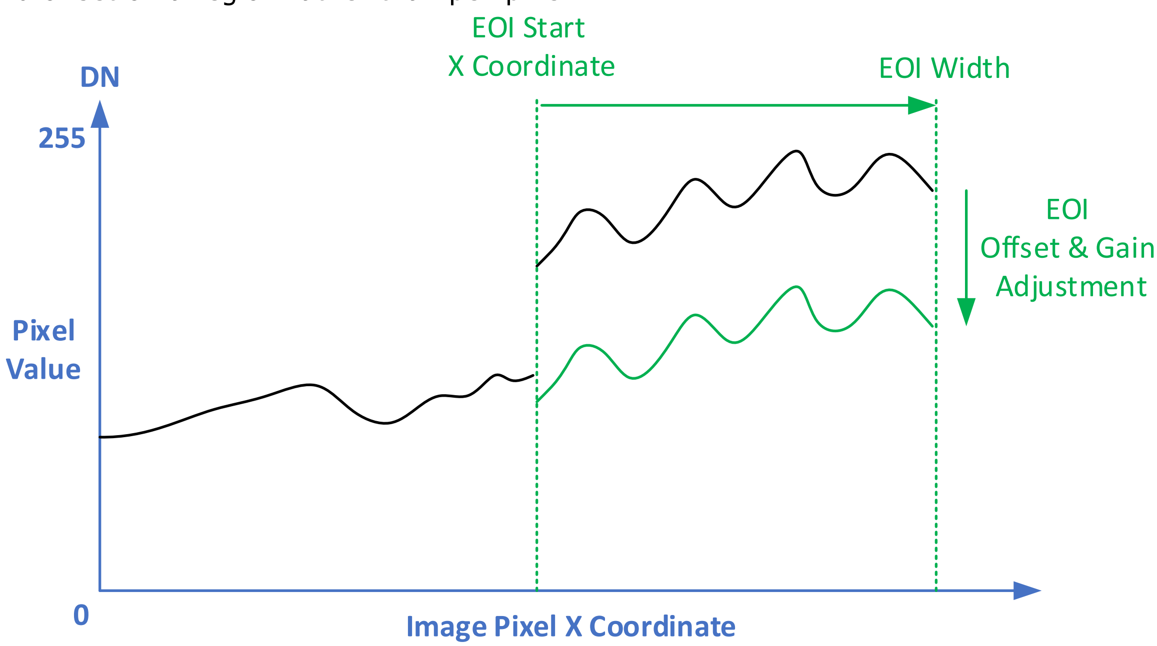


Figure 44: Enhancement of Interest

EOIs are designed for applications where maximum line rate is a priority and pixel flatness for the region is tolerable, as compared to HDR mode or regional flat field correction (FFC), which provide per pixel adjustments.

For example, if image has regions that are highly reflective and other regions that are dark, the response in a region can be adjusted to flatten the output. HDR mode or regional FFC can compensate for this by applying a per-pixel based correction, providing the best result for a flat image. However, HDR limits the maximum line rate due to dual line acquisition and FFC requires greater than 2 seconds to load user set coefficients and cannot be used to adjust to changes in image regions in real-time. Alternatively, EOIs provide the maximum line rate but with a flattened image region.

Note: EOI parameter settings are not stored in the camera and are erased at camera reset.

Customized Linearity Response (LUT)

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

Related Features: lutMode and gammaCorrection

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

The camera allows the user to access a LUT (Look Up Table) to allow the user to 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.

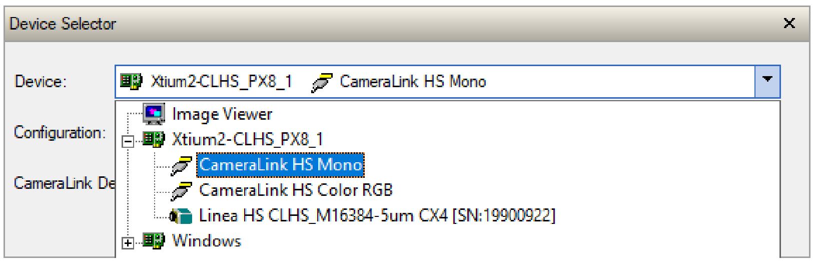
To upload a LUT, use *File Access Control Category > Upload / Download File > Settings* and select *Look Up Table* to upload a file.

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 spreadsheet examples.

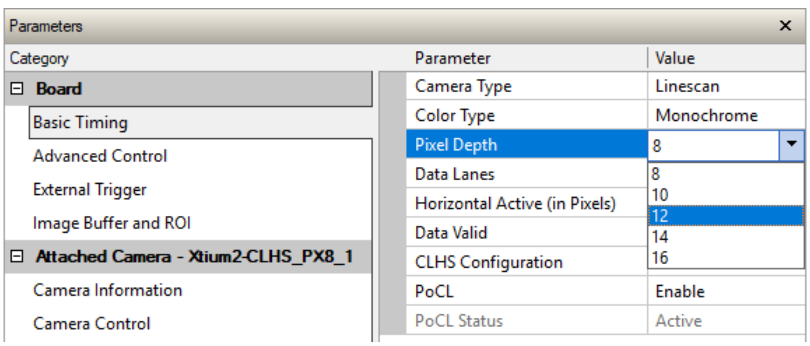
How to Generate LUT with CamExpert

CamExpert can 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.

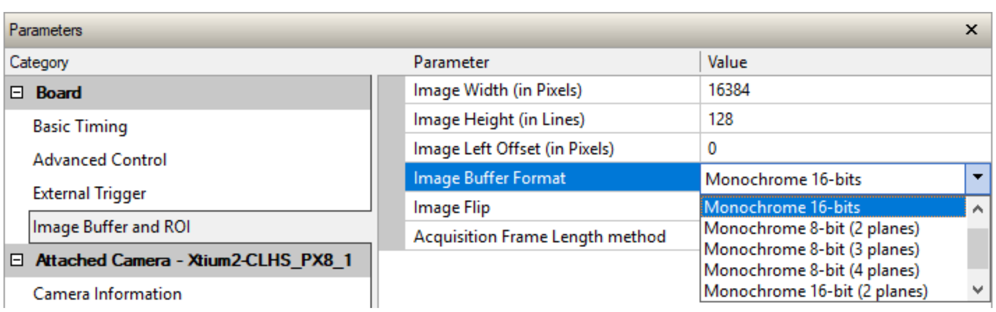
1. Open CamExpert (version 8.40 or higher)
2. Device should be an Xtium2 connected to a Linea HS camera.



3. Under Board select Basic Timing and set Pixel Depth to 12.

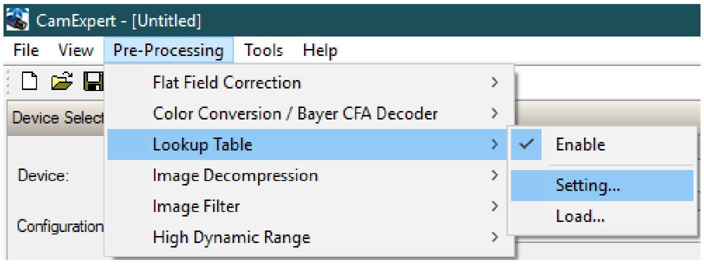


4. Under Board, select Image Buffer and ROI and set Image Buffer Format to Monochrome 16 bits.

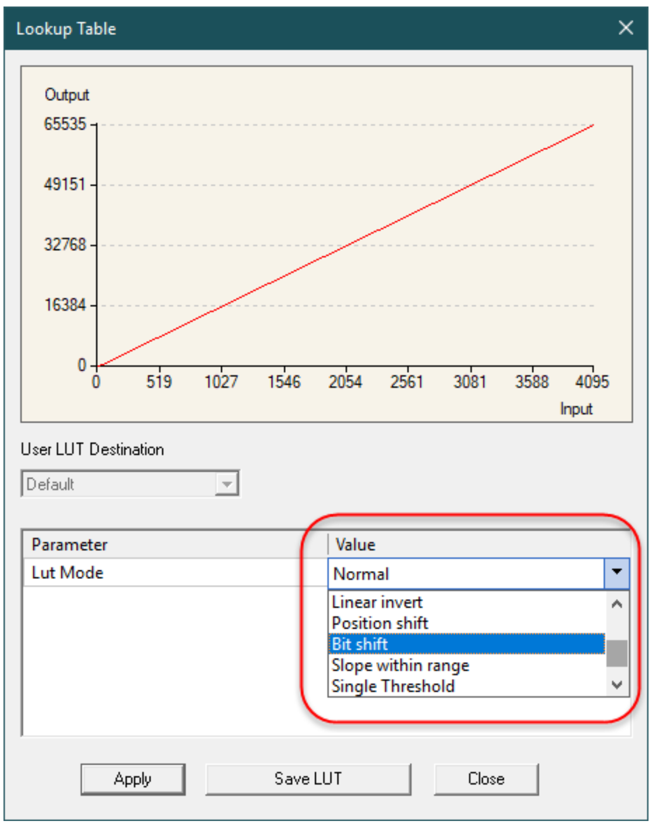


5. Leave Image Buffer and ROI selected.

6. In the command menu select Pre-Processing | Lookup Table and set Enable and click Setting...



7. In the Lookup Table dialog, select the output LUT by scrolling through the different options under Value and configure any required parameters (for example, Gamma correction requires a Correction factor).



8. Click on the Save LUT button to create a LUT file.
9. This file can be 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.
10. Deselect the Lookup Table | Enable feature.
11. Return the Board parameters *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.

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 gain and black level (offset) features that can be used to adjust the camera’s responsivity.

Gain and black level settings are applied as follows:

$$DN_{out} = ((DN_{in} + Black\ Level) * Gain) * System\ Gain$$

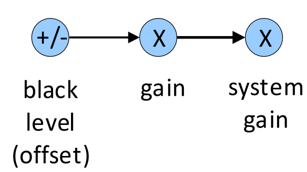


Figure 45: Black Level, Gain and System Gain Processing Chain

Refer to the Camera Processing Chain section for an overview of the entire processing chain.

For monochrome cameras gain adjustment is applied to all sensor array output rows; for the multifield color model gain can be applied to each color array output row individually. Row gains can be adjusted from 1 to ~4x. System Gain can be adjusted from 1 to 10x.

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.

Black Level

The camera has a black level (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 to subtract from the image with the current gain setting. 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

Related Feature: PixelFormat, AcquisitionStart and AcquisitionStop

The camera can output video data as 8-bit or 12-bit.

Use the Mono8 Pixel Format to process image data as one, or two separate image planes.

Note: Pixel Format, and associated features, can only be changed when the 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.

For example, to change from 8-bit to 12-bit pixel format:

1. In Acquisition and Transfer Control category, set Stop Acquisition.
2. In Image Format category, set Pixel Format to Mono 12 (or BGR 12 if supported).
3. In the host frame grabber configuration, set Pixel Depth to 12.
4. In Acquisition and Transfer Control category, set Start Acquisition.

Red Pixel Alignment

Red pixel alignment features apply to the color and multifield Linea HS models:

- HL-HF-16K13T
- HL-HC-16K10T

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

Related Features: Align Red Pixels, Align Red Threshold, Align Red X Shift and Align Red Y Shift

Red pixel alignment corrects for certain image artifacts that may occur due to sensor alignment.

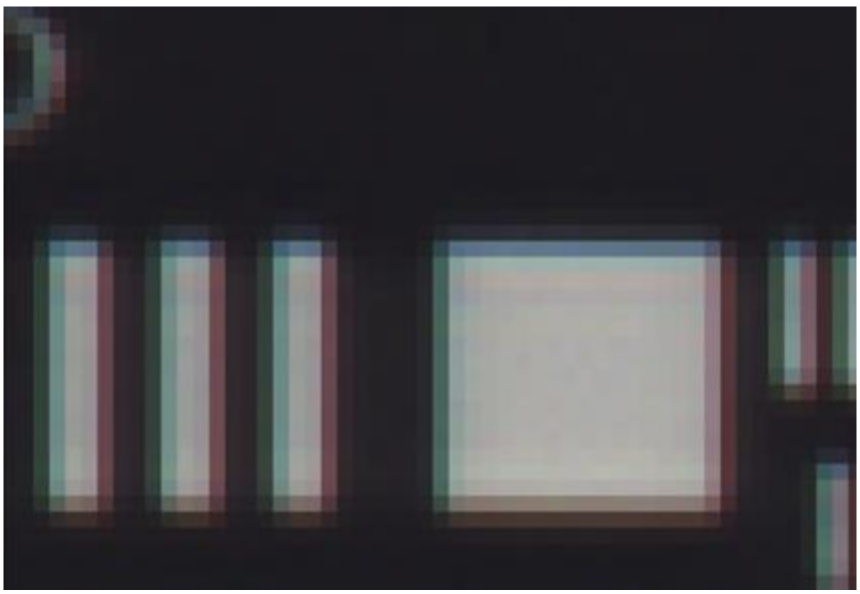


Figure 46: Red Pixel Artifacts

Before applying red pixel alignment correction, ensure that the system is mechanically setup as best as possible and the automatic white balance is applied.

To correct for red pixel artifacts:

1. Set the *Align Red Pixels* feature to Active.
2. Set the *Align Red Threshold* feature (default= 75). The threshold determines how many pixels are processed.
3. Use the *Align Red X Shift* and *Align Red Y Shift* features to fine-tune the correction (default = 0.5). The necessary values depend on the sensor direction and the target scene.

Red Shift X and Y

The intensity of the aligned red pixel is calculated by weighted average of the 4 neighbor pixels.

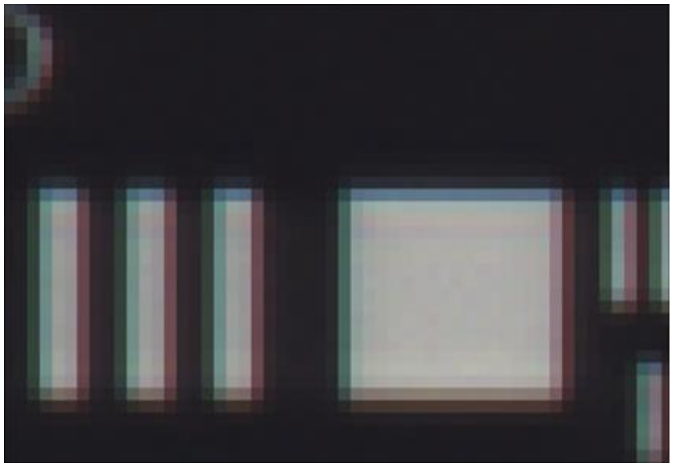
By adjusting the Align Red X Shift and Align Red Y Shift feature values, the weights are slightly tuned. Values range from 0 – 1, with 0.5 representing the center position. Adding a fraction from the center position shifts left and up, subtracting a fraction from the center position shifts right and down.

For example,

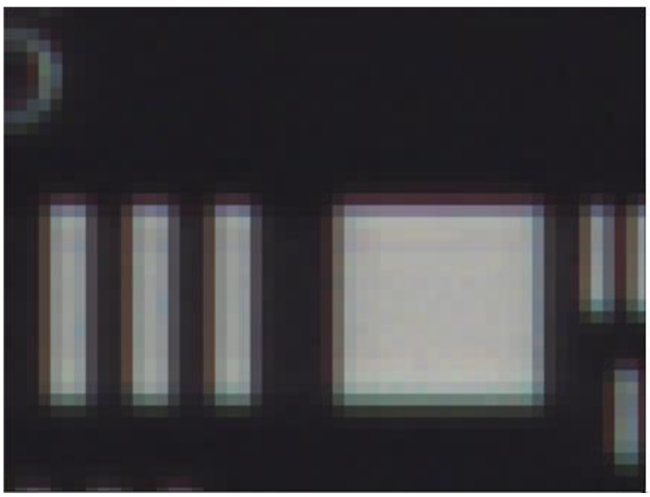
- Adjust X and maintain Y shifts horizontally (left / right).
- Adjust Y and maintain X shifts vertically (up / down).
- Adjust both X and Y shifts diagonally.

Figure 47: Align Red X Shift and Align Red Y Shift

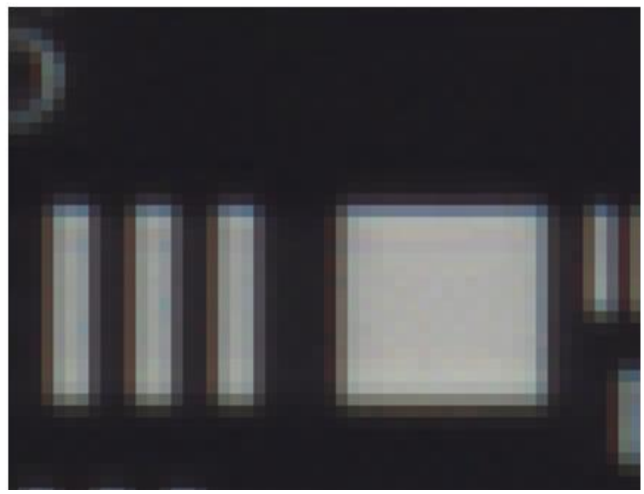
The following images demonstrate the effect of the red shift X and Y feature settings.



Original Image



Align Red Shift X = 0.5, Align Red Shift Y = 0.5
(default values)



Align Red Shift X = 0.5, Align Red Shift Y = 0.8

Figure 48: Effect of Align Red X / Y Shift Settings

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

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

An inspection system may use multiple illumination, resolution and responsivity configurations in order to cover the different types of inspection it performs. 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 (and thereby become the user setting) using the user set save feature.

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 selected as the default setting, by selecting the set in the user set default selector (Camera Power-up configuration option in the Power-up configuration dialog accessed from the Camera Information category). The set selected is selected as the default setting and is the set that is loaded and becomes active when the camera is reset or powered up.

The relationship between these four settings is illustrated in Figure 49: Relationship Between Camera Settings:

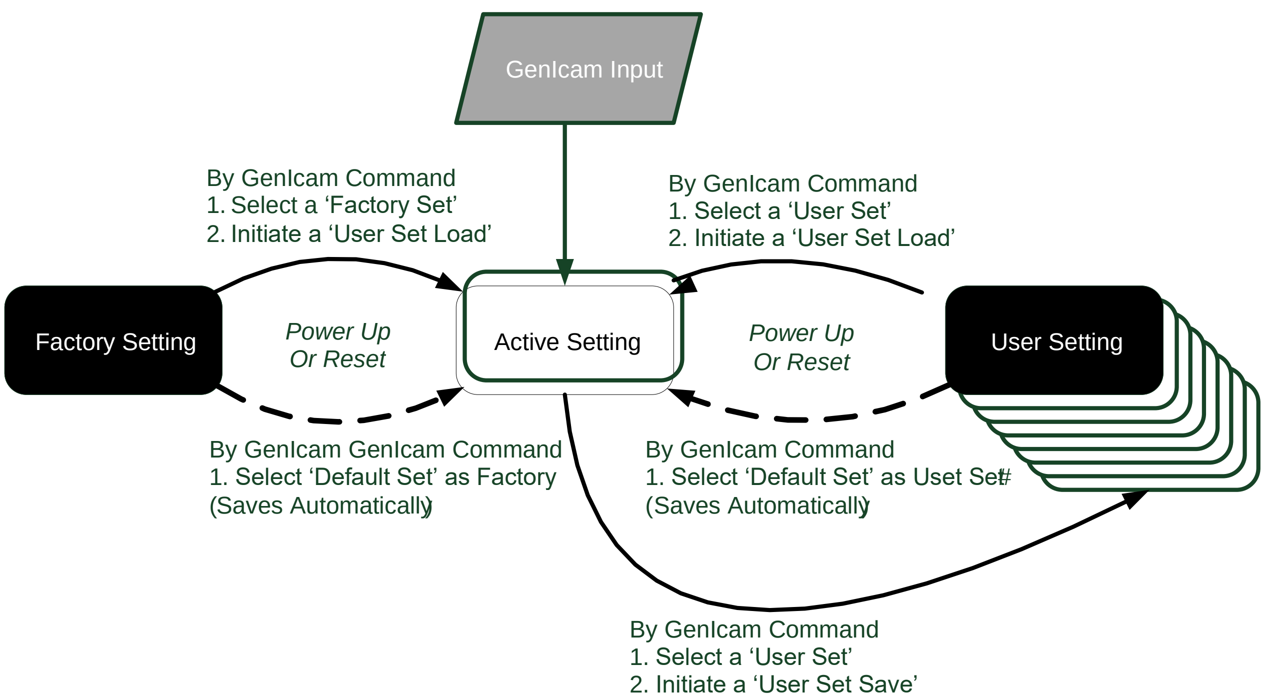


Figure 49: Relationship Between Camera Settings

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 load during the camera's first power-up. To load or restore the original factory settings, at any time, select the factory setting parameter and then select the user set load parameter.

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

Default Setting

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

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 Device Version column will indicate which parameter is a member of the DALSA Features Naming Convention (using the tag **DFNC**), versus the GenICam Standard Features Naming Convention (SFNC tag not shown).

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

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.

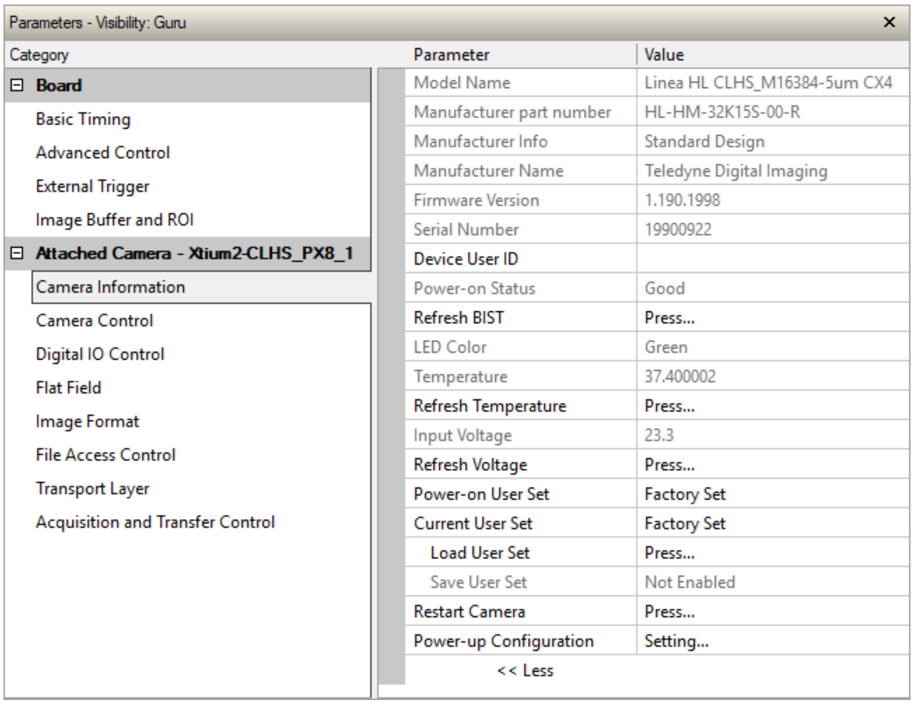


Figure 50: Example CamExpert Camera Information Panel

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
Manufacturer part number	deviceManufacturesPart Number	Displays the device vendor part number. (RO)	Beginner DFNC
Manufacturer Info	DeviceManufacturerInfo	This feature provides extended manufacturer information about the device. Indicates if it is a standard product or a custom camera(RO)	Beginner
Manufacturer Name	DeviceVendorName	Displays the device vendor name. (RO)	Beginner
Firmware Version	DeviceVersion	Displays the device firmware version. This tag will also highlight if the firmware is a beta or custom design. (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 31 characters. The default factory setting is the camera serial number. (RW)	Beginner
Power-on Status	deviceBISTStatus	Determine the status of the device using the 'Built-In Self Test' (BIST). Possible return values are device-specific. (RO) See Built-In Self-Test Codes for status code details.	Beginner DFNC

Display Name	Feature	Description	View
Refresh BIST	deviceBIST	Command to perform an internal test which will determine the device status. (W)	Beginner DFNC
LED Color	deviceLEDColorControl	Select the mode for the LED	Beginner DFNC
Off	*Off*	*Off*	
Red	*Red*	*BIST error.*	
Green	*Green*	*Operational.*	
Waiting for EXSYNC	*Fast_Green*	*4 Hz Green.*	
Thermal Shutdown	*Medium_Red*	*2 Hz Red.*	
Looking for link	*Slow_Green*	*1 Hz Green.*	
Busy	*Medium_Orange*	*2 Hz Orange.*	
Temperature	DeviceTemperature	Displays the internal operating temperature of the camera, in Celsius. (RO)	Beginner DFNC
Refresh Temperature	refreshTemperature	Press to update *DeviceTemperature*.	Beginner DFNC
Input Voltage	deviceInputVoltage	Displays the input voltage to the camera at the power connector (RO)	Beginner DFNC
Refresh Voltage	refreshVoltage	Press to update *deviceInputVoltage*.	Beginner DFNC
Power-on User Set	UserSetDefaultSelector	Selects the camera configuration set to load and make active on camera power-up or reset. The camera configuration sets are stored in camera non-volatile memory. (RW)	Beginner
Factory Set	*Factory*	*Load factory default feature settings*	
UserSet1	*UserSet1*	*Select the user defined configuration UserSet 1 as the Power-up Configuration.*	
UserSet2	*UserSet2*	*Select the user defined configuration UserSet 2 as the Power-up Configuration*	
UserSet3	*UserSet3*	*Select the user defined configuration UserSet 3 as the Power-up Configuration*	
UserSet4	*UserSet4*	*Select the user defined configuration UserSet 4 as the Power-up Configuration.*	
UserSet5	*UserSet5*	*Select the user defined configuration UserSet 5 as the Power-up Configuration.*	
UserSet6	*UserSet6*	*Select the user defined configuration UserSet 6 as the Power-up Configuration.*	
UserSet7	*UserSet7*	*Select the user defined configuration UserSet 7 as the Power-up Configuration.*	
UserSet8	*UserSet8*	*Select the user defined configuration UserSet 8 as the Power-up Configuration.*	
UserSet9	*UserSet9*	*Select the user defined configuration UserSet 9 as the Power-up Configuration.*	
UserSet10	*UserSet10*	*Select the user defined configuration UserSet 10 as the Power-up Configuration.*	
UserSet11	*UserSet11*	*Select the user defined configuration UserSet 11 as the Power-up Configuration.*	
UserSet12	*UserSet12*	*Select the user defined configuration UserSet 12 as the Power-up Configuration.*	
UserSet13	*UserSet13*	*Select the user defined configuration UserSet 13 as the Power-up Configuration.*	

Display Name	Feature	Description	View
UserSet14	*UserSet14*	*Select the user defined configuration UserSet 14 as the Power-up Configuration.*	
UserSet15	*UserSet15*	*Select the user defined configuration UserSet 15 as the Power-up Configuration.*	
UserSet16	*UserSet16*	*Select the user defined configuration UserSet 16 as the Power-up Configuration.*	
Current User Set	UserSetSelector	Selects the camera configuration set to load feature settings from or save current feature settings to. Points to which user set (1-16) or factory set that is loaded or saved when the UserSetLoad or UserSetSave command is used. The Factory set contains default camera feature settings and is read-only. (RW)	Beginner
Factory Set	*Factory*	*Select the default camera feature settings saved by the factory*	
UserSet 1	*UserSet1*	*Select the User-defined Configuration space UserSet1 to save to or load from features settings previously saved by the user.*	
UserSet 2	*UserSet2*	*Select the User-defined Configuration space UserSet2 to save to or load from features settings previously saved by the user.*	
UserSet3	*UserSet3*	*Select the User-defined Configuration space UserSet3 to save to or load from features settings previously saved by the user.*	
UserSet4	*UserSet4*	*Select the User-defined Configuration space UserSet4 to save to or load from features settings previously saved by the user.*	
UserSet5	*UserSet5*	*Select the User-defined Configuration space UserSet5 to save to or load from features settings previously saved by the user.*	
UserSet6	*UserSet6*	*Select the User-defined Configuration space UserSet6 to save to or load from features settings previously saved by the user.*	
UserSet7	*UserSet7*	*Select the User-defined Configuration space UserSet7 to save to or load from features settings previously saved by the user.*	
UserSet8	*UserSet8*	*Select the User-defined Configuration space UserSet8 to save to or load from features settings previously saved by the user.*	
UserSet9	*UserSet9*	*Select the User-defined Configuration space UserSet9 to save to or load from features settings previously saved by the user.*	
UserSet10	*UserSet10*	*Select the User-defined Configuration space UserSet10 to save to or load from features settings previously saved by the user.*	
UserSet11	*UserSet11*	*Select the User-defined Configuration space UserSet11 to save to or load from features settings previously saved by the user.*	
UserSet12	*UserSet12*	*Select the User-defined Configuration space UserSet12 to save to or load from features settings previously saved by the user.*	
UserSet13	*UserSet13*	*Select the User-defined Configuration space UserSet13 to save to or load from features settings previously saved by the user.*	

Display Name	Feature	Description	View
UserSet14 *UserSet15* *UserSet16*	*UserSet14* *UserSet15* *UserSet16*	*Select the User-defined Configuration space UserSet14 to save to or load from features settings previously saved by the user.* *Select the User-defined Configuration space UserSet15 to save to or load from features settings previously saved by the user.* *Select the User-defined Configuration space UserSet16 to save to or load from features settings previously saved by the user.*	
Load User Set	UserSetLoad	Loads the camera configuration set specified by the User Set Selector feature, to the camera and makes it active. (W)	Beginner
Save User Set	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

Built-In Self-Test Codes (BIST)

In the Camera Information screen shot example above, the Power-On Status is showing "Good", indicating that the camera powered up without any problems.

Details of the BIST codes can be found in the Appendix B: Troubleshooting Guide.

Camera Power-Up Configuration Selection Dialog

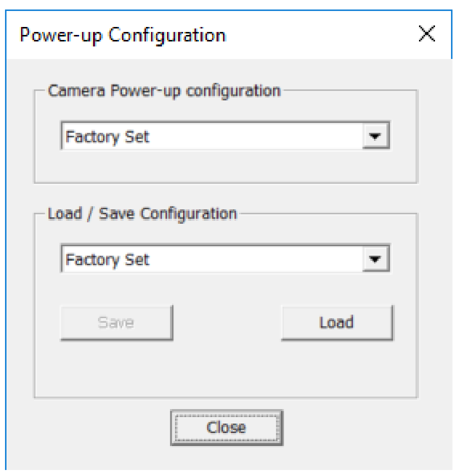


Figure 51: CamExpert Power-Up Configuration Dialog

CamExpert provides a dialog box which combines the GemICam features used to select the camera's power-up state and 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 set to load on power-up (see feature *UserSetDefaultSelector*). The user chooses 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.

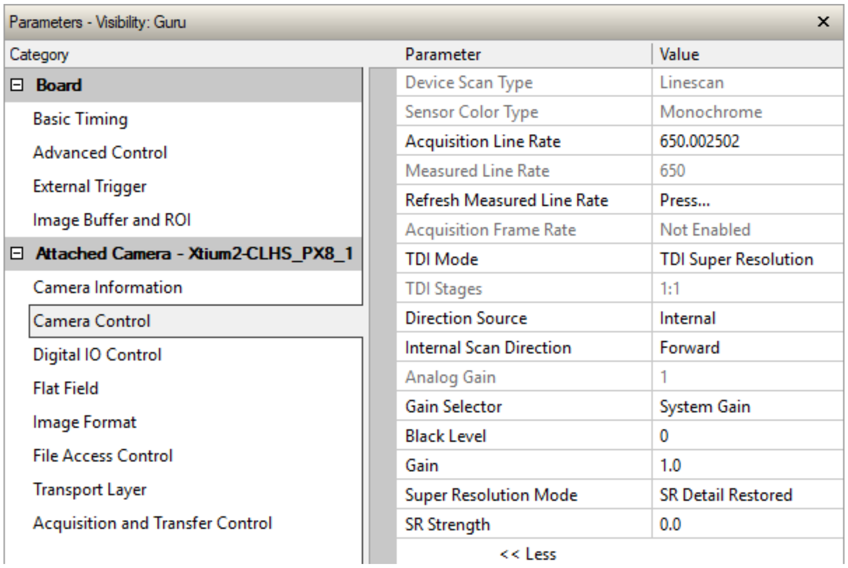


Figure 52: Camera Control Panel

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.*	
Sensor Color Type	sensorColorType	Used to set the sensor color type mode. Only monochrome is available.	Beginner DFNC
Monochrome	*Monochrome*	*Monochrome sensor.*	
BGR	*BGR*	*BGR color sensor. (Multifield color model only)*	
Acquisition 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
Acquisition Frame Rate	AcquisitionFrameRate	Displays the camera frame rate, in Hx.	Beginner

Display Name	Feature	Description	View
TDI Mode	sensorTDIModeSelection	Select the TDI mode for the sensor.	Beginner DFNC
TDI	*Tdi*	*Output one row from the main TDI array*	
TDI HDR	*Tdi2Array*	*High Dynamic Range mode. Output two rows, one from each of the main and secondary array with the responsivity ratio selectable.*	
TDI HFW	*TdiHfw*	*High Full Well mode. Output two rows, one from each of the main and secondary array, both set to 64 stages.*	
TDI Super Resolution	*TdiMTF*	*Combine the output from two arrays offset by ½ pixel.(Super resolution model only)*	
TDI Planar	*TdiTopTwoPlanar*	*Output two rows, one from each of the main and secondary array with the responsivity ratio selectable*	
TDI Area	*TdiArea*	*Output the entire 128 row main array with an FVAL.*	
TDI Extended Area	*TdiMultiArea*	*TDI mulitple array area mode for aligning camera.*	
TDI RGB	*TdiRGB*	*Output three rows, one from each array (R, G and B) (Multifield color model only)*	
TDI Red	*TdiRed*	*Output one row from red array (Multifield color model only)*	
TDI Green	*TdiGreen*	*Output one row from green array (Multifield color model only)*	
TDI Blue	*TdiBlue*	*Output one row from blue array (Multifield color model only)*	
TDI RedGreen	*TdiRedGreen*	*Output two rows, one from red and green array (Multifield color model only)*	
TDI GreenBlue	*TdiGreenBlue*	*Output two rows, one from green and blue array (Multifield color model only)*	
TDI RedBlue	*TdiRedBlue*	*Output two rows, one from red and blue array (Multifield color model only)*	
TDI Stages	sensorTDIStagesSelection	Selects the number of rows to integrate (sum/average) in TDI.	Beginner DFNC
1:1	*Ratio1*	*Single line (available when TDI Mode is TDI Super Resolution).*	
2:1	*Ratio05*	*Line 2 = 0.5 * Line 1 (available when TDI Mode is TDI Super Resolution)*	
4:1	*Ratio025*	*Line 2 = 0.25 * Line 1 (available when TDI Mode is TDI Super Resolution)*	
8:1	*Ratio0125*	*Three lines summed/averaged together. (available when TDI Mode is TDI Super Resolution)*	
64	*Lines64*	*64 lines summed/averaged together. (available when TDI Mode is TDI)*	
128	*Lines128*	*128 lines summed/averaged together. (available when TDI Mode is TDI)*	
Align Red Pixels	alignRedPixels	Vertically align red pixels with green and blue.	Beginner DFNC
Off	*Off*	*Do not vertically align red pixels with green and blue*	
Active	*Active*	*Vertically align red pixels with green and blue*	
Align Red Threshold	alignRedThreshold	Specifies the threshold to use for processing red pixels; the higher the value, the more pixels processed.	Beginner DFNC
Align Red X Shift	alignRedXShift	Represents a shift in sensor scanning direction (horizontal direction on image). Range [0, 1]. Center position is 0.5.	Beginner DFNC

Display Name	Feature	Description	View
Align Red Y Shift	alignRedYShift	Represents a shift in cross sensor scanning direction (vertical direction on image), range [0, 1]. Center position is 0.5.	Beginner DFNC
Direction Source	sensorScanDirectionSource	Direction determined by value of:	Beginner DFNC
Internal	*Internal*	*SensorScanDirection*	
Line 2	*GPIO2*	*Pin 6 (Low: forward, high: reverse). Available when TriggerSource is not Encoder.*	
RotaryEncoder	*Encoder*	*Rotary encoded. Available when TriggerSource is Encoder and rotaryEncoderOutputMode is Motion (see Digital IO Control category).*	
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.*	
Analog Gain	AnalogGain	Sets the analog gain.	Beginner
1	*One*	*No gain applied.*	
2	*Two*	*2X analog gain applied.*	
4	*Four*	*4X analog gain applied.*	
8	*Eight*	*8X analog gain applied.*	
Gain Selector	GainSelector	Selects which gain is controlled when adjusting gain.	Beginner
All Rows	*All*	*Gain and offset applied to all channels.*	
System Gain	*System*	*System gain will apply the gain value while maintaining the existing gain ratios.*	
Blue	*Blue*	*Gain and offset applied to blue channel. (Multifield color model only)*	
Green	*Green*	*Gain and offset applied to green channel. (Multifield color model only)*	
Red	*Red*	*Gain and offset applied to red channel. (Multifield color model only)*	
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.	
Gain	Gain	Sets the gain as per the gain selector setting.	
Super Resolution Mode	sensorLineSpatialCorrection	Sets the number of rows each color is delayed to establish spatial alignment. Must stop acquisition to change.	Beginner DFNC
Super Resolution Mode	superResolutionMode	Sets the super resolution mode.	Beginner DFNC
SR Mapped	*srMapped*	*Super Resolution Mapped.*	
SR Detail Restored	*srDetailRestored*	*Super Resolution Detail Restored.*	
SR Strength	srStrength	Super resolution strength. Values range from 0 to 1, in increments of 0.01.	Beginner DFNC
Balance White Auto	BalanceWhiteAuto	Executes the automatic white balance function. This calculates the RGB gain adjustments to bring the average of each color up to the average of the brightest color. (Multifield color model only)	Beginner
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. *(Multifield color model only)*	Beginner DFNC

Digital IO Control Category

The camera's Digital IO Control category is used to configure the cameras GPIO pins.

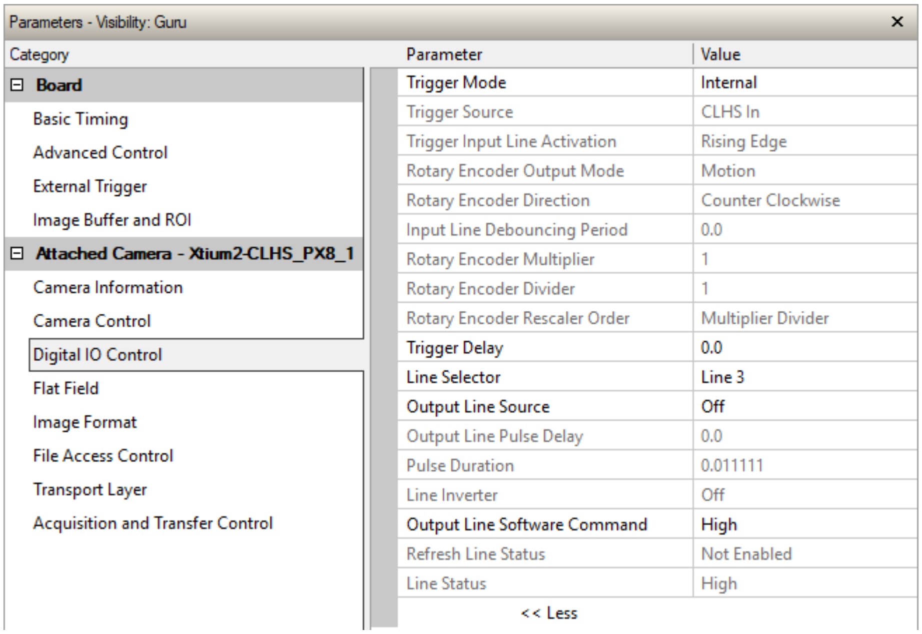


Figure 53: Digital I/O Control Panel

Digital IO 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.	Beginner DFNC
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.	Beginner DFNC
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.	Beginner DFNC
Rotary Encoder Multiplier	rotaryEncoderMultiplier	Specifies a multiplication factor for the rotary encoder output pulse generator.	Beginner
Rotary Encoder Divisor	rotaryEncoderDivider	Specifies a division factor for the rotary encoder output pulse generator.	Beginner DFNC
Rotary Encoder Rescaler Order	rotaryEncoderRescalerOrder	Specifies the order that the multiplier and divider are applied.	Beginner DFNC
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.	Beginner DFNC
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.	Beginner DFNC
Pulse Duration	outputLinePulseDuration	Sets the width (duration) of the output line pulse in microseconds.	Beginner DFNC
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.*	
On	*On*	*The line signal is inverted.*	

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

Flat Field Category

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

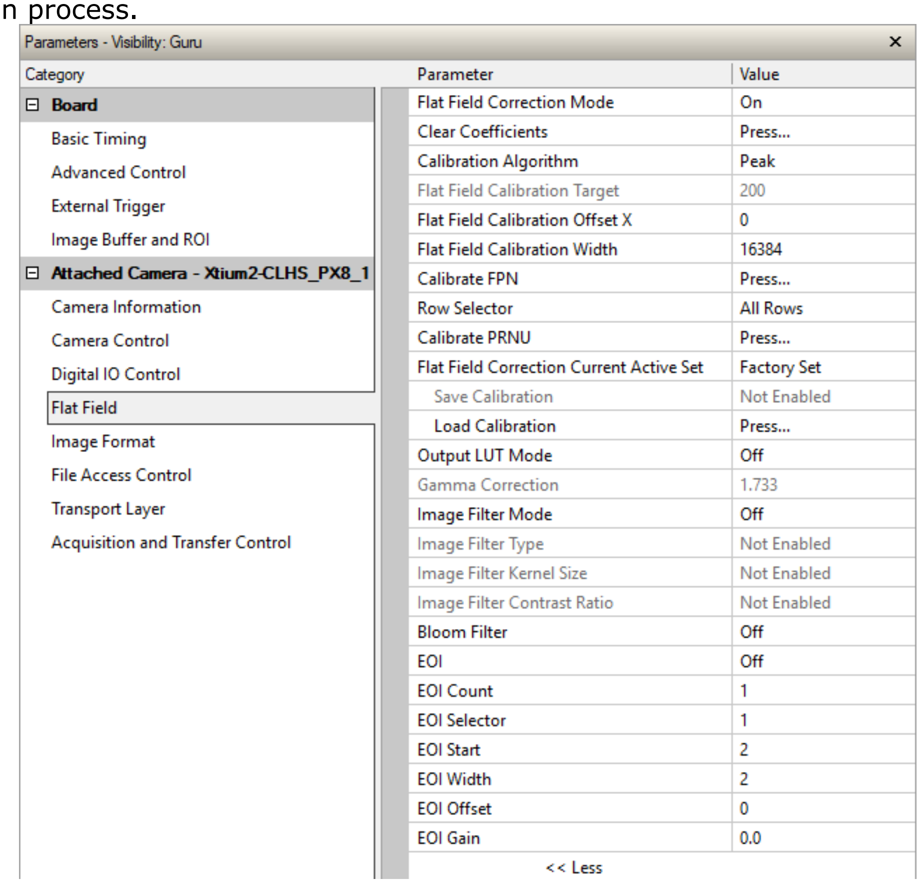


Figure 54: Flat Field Panel

Flat Field Control Feature Description

Display Name	Feature	Description	View
Flat Field Correction 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

Display Name	Feature	Description	View
Calibration Algorithm *Peak* *Peak, Image Filtered* *Set Target* *Set Target, Image Filtered*	flatfieldCorrectionAlgorithm *Peak* *PeakFilter* *Target* *TargetFiltered*	Selection between four different PRNU algorithms. *Calculation of PRNU coefficients to bring all pixels to the peak.* *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.* *Calculation of PRNU coefficients to bring all pixels to the target value.* *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.*	Beginner DFNC
Flat Field Calibration Target	flatfieldCalibrationTarget	Sets the target value for the "Calibrate PRNU" feature.	Beginner DFNC
FPN Calibration Algorithm *Standard* *Dark Current*	flatfieldCorrectionAlgorithmFPN *Standard* *DarkCurrent*	Selection between two different FPN algorithms. *Calculation of FPN coefficients to bring all pixels to the zero.* *HL Model only. Used for low line rates (4-60 kHz) which allows for more consistent FPN coefficient values when sweeping between line rates. Reduces effects of sensor dark current at high temperatures and low line rates.*	Beginner DFNC
Flat Field Calibration Offset X	flatfieldCalibrationROIOffsetX	Set the starting point of a region of interest where a flat field calibration will be performed	Beginner DFNC
Flat Field Calibration 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

Display Name	Feature	Description	View
Flat Field Correction Current Active Set *Factory Set* *User Set 1 (1 thru 16)*	flatfieldCorrectionCurrentActiveSet *Factory Set* *UserSet1 (1 thru 16)*	Selects the User PRNU set to be saved or loaded. *Factory set can only be loaded.* *Only the PRNU values are saved or loaded which is much faster than saving or loading the full Factory or User set.*	Guru DFNC
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 *Off* *Gamma Correction* *User Defined*	lutMode *Off* *Gamma* *UserDefined*	Allows the output LUT to be selected When enabled, the same LUT is used for all colors *The output LUT is disabled and linear data is output* *LUT populated using the Gamma correction equation* *LUT uploaded by the user is used.*	Beginner DFNC
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 *Off* *Active*	imageFilterMode *Off* *Active*	Enable image filter. *Disable the image filter.* *Enable the image filter*	Guru DFNC
Image Filter Type *Weighted Average*	imageFilterType *Weighted_Average*	Specifies the image filter type. Read-only. *Wieght average algorithm.*	Guru DFNC
Image Filter Kernel Size *Kernel 1x3* *Kernel 1x5*	imageFilterKernelSize *KERNEL_1x3* *KERNEL_1x5*	Selects the kernel size. 1x3 kernel. 1x5 kernel.	Guru DFNC
Image Filter Contrast Ratio	imageFilterContrastRatio	Sets the image filter contrast ratio threshold. Values range from 0 to 1.	Guru DFNC
Bloom Filter *Off* *Active*	 *Off* *Active*	Sets the enable state of the anti-blooming filter. *Disable the anti-blooming filter.* *Enable the anti-blooming filter*	Guru DFNC
EOI *Off* *On*	enhancedImage *Off* *On*	Sets the enable state of enhanced region of interest(s) (EOI). EOIs allow for rapid adjustment of gain and offset values for a speciifed region of the image. *Disable EOIs.* *Enable EOIs.*	Beginner DFNC
EOI Count	enhancedImageCount	Sets the number of EOIs. Up to 4 EOIs can be applied.	Beginner DFNC
EOI Selector	enhancedImageSelector	Selects which EOI is controlled when using the EOI features to adjust position, offset and gain.	Beginner DFNC

Display Name	Feature	Description	View
EOI Start	enhancedImageStart	Sets the starting X-coordinate position of the EOI.	Beginner DFNC
EOI Width	enhancedImageWidth	Sets the width of the EOI.	Beginner DFNC
EOI Offset	enhancedImageOffset	Sets the offset to apply to the EOI. Possible values range from -127 to 127.	Beginner DFNC
EOI Gain	enhancedImageGain	Set the gain to apply to the EOI. Possible values range from 0.011 to 3.99, in increments of 0.000001.	

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.

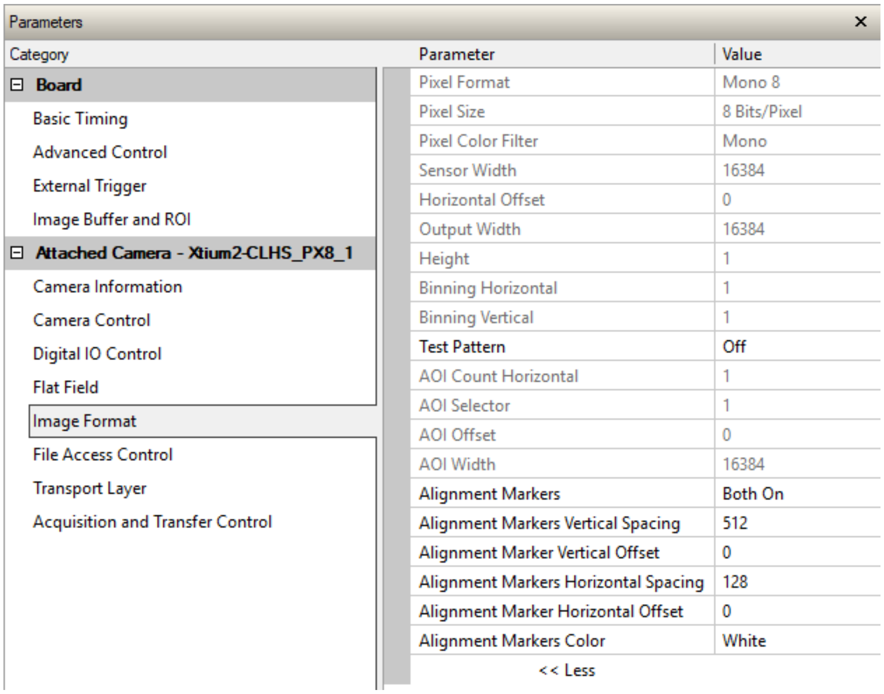


Figure 55: Image Format Panel

Image Format Control Feature Description

Display Name	Feature	Description	View
Pixel Format *Mono 8*	PixelFormat *Mono8*	Output image pixel coding format of the sensor. *8-bit monochrome format is used when processesing each color separately.*	Beginner
Pixel Size *8-bits/Pixel*	PixelSize *Bpp8*	Total size in bits of an image pixel. Read-only. *8-bits / Pixel.*	Guru
Pixel Coding Filter *None*	PixelCodingFilter *Mono*	Indicates the type of color filter used in the camera. Read only. *No pixel coding filter when pixel format is Mono 8.*	Beginner DFNC
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. 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

Display Name	Feature	Description	View
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. Only available in TDI single plane mode.	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	multipleROICount	Specifies the number of AOIs output.	Beginner DFNC
AOI Selector	multipleROISelector	Select the AOI to contorl when setting the AOI Offset & AOI Width.	Beginner DFNC
AOI Offset	multipleROIOffsetX	Location of the start of the AOI to be output. Multiple of 32.	Beginner DFNC
AOI Width	multipleROIWidth	Width of the AOI, in pixels. Minimum is 96 per lane. For example, 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. For example, for a 16k sensor, if there are two AOIs with the first 12k wide, then the second can be no wider than 4k.	Beginner DFNC
Alignment Markers	alignmentMarkerEnable	To assist with camera alignment, alignment markers can be enabled in the output.	Beginner DFNC
Off	*Off*	*Disable alignment markers*	
Vertical On	*Vertical*	*Enable Vertical Alignment Markers only*	
Horizontal On	*Horizontal*	*Enable Horizontal Alignment Markers only*	
Both On	*Both*	*Enable Vertical and Horizontal Alignment Markers*	
Alignment Marker Vertical Spacing	alignmentMarkerVerticalSpacing	Vertical spacing between alignment markers, in pixels.	Beginner DFNC
64	*Ver64*	*64 pixels between vertical alignment markers*	
128	*Ver128*	*128 pixels between vertical alignment*	
256	*Ver256*	*256 pixels between vertical alignment markers*	
512	*Ver512*	*512 pixels between vertical alignment markers*	

Display Name	Feature	Description	View
Alignment Marker Vertical Offset	alignmentMarkerVerticalOffset	Pixel count before first vertical alignment marker. Integer between 0 and *alignmentMarkerVerticalSpacing* value.	Beginner DFNC
Alignment Marker Horizontal Spacing	alignmentMarkerHorizontalSpacing	Horizontical spacing between alignment markers, in pixels.	Beginner DFNC
16	*Hor16*	*16 pixels between horizontal alignment markers*	
32	*Hor32*	*32 pixels between horizontal alignment markers*	
64	*Hor64*	*64 pixels between horizontal alignment markers*	
128	*Hor128*	*128 pixels between horizontal alignment markers*	
Alignment Marker Horizontal Offset	alignmentMarkerHorizontalOffset	Pixel count before first horizontal alignment marker. Integer between 0 and *alignmentMarkerHorizontalSpacing* value.	Beginner DFNC
Alignment Markers Color	alignmentMarkerBlack	Specifies the alignment marker color.	Beginner DFNC
White	*White*	*White alignment markers.*	
Black	*Black*	*Black alignment markers.*	
Input Pixel Size	pixelSizeInput	Size of the image input pixels, in bits per pixel. (RO)	DFNC Invisible
12-bits/Pixel	*Bpp12*	*Sensor input data path is 12-bits per pixel.*	

File Access Control Category

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

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

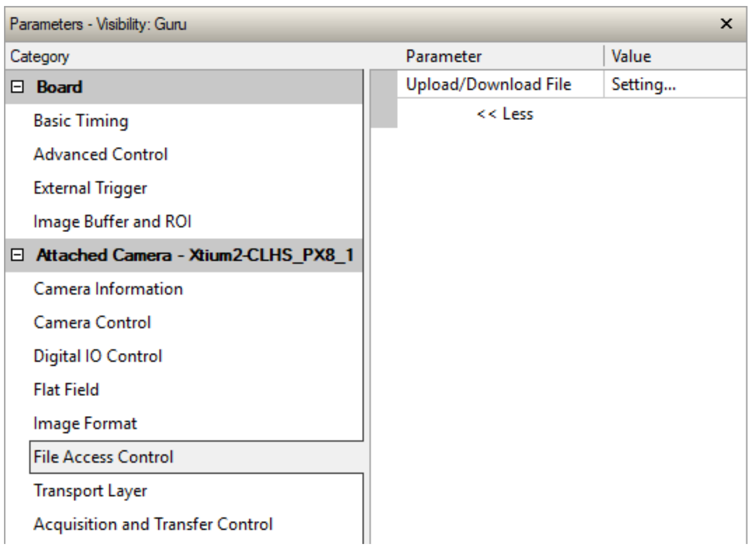


Figure 56: File Access Control Panel

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.*	

Display Name	Feature	Description	View
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*	
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

Click on the "Setting…" button to show the File Access Control dialog box.

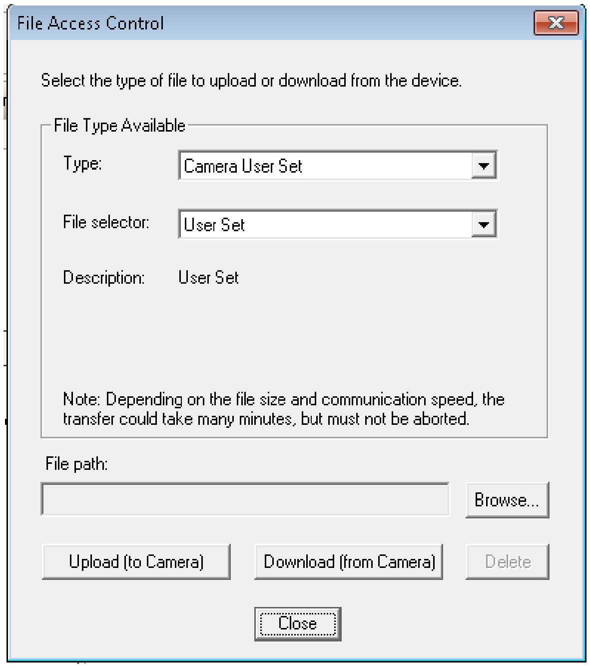


Figure 57: File Access Control Tool

From the Type drop menu, select the file type that will be uploaded to the camera or downloaded from the camera.
From the File Selector drop menu, select the file to be uploaded or downloaded.
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.

Alternatively, click the Download button and then specify the location where the file should be stored.

Firmware changes require that the camera be powered down and then back up. When the firmware update is successfully completed, a message box is displayed to reset the camera.

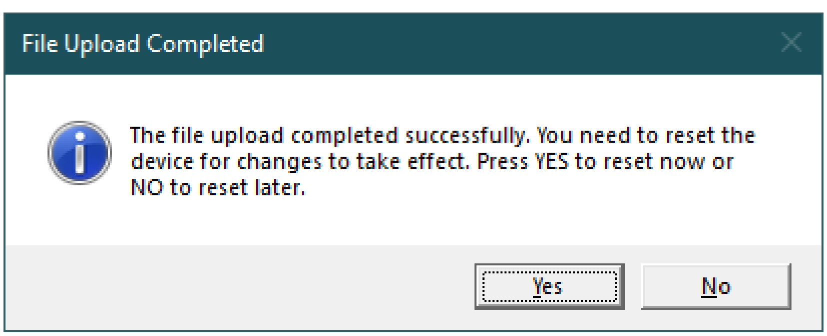


Figure 58: File Upload Completed Message Box

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

- Select the file by setting the FileSelector feature
- Set the FileOpenMode to Read
- Set the FileOperationSelector to Open
- 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
- Read FileOperationStatus to confirm that the file opened correctly
  - A return value of 0 is success. Error codes are listed in the XML.
- Read FileSize to get the number of bytes in the file
- From FileAccessBuffer.Length you will know that maximum number of bytes that can be read through FileAccessBuffer is 988.
- For Offset = 0 While ((Offset < FileSize) and (Status = 0)) Do
  - Set FileAccessOffset to Offset
  - Set FileAccessLength to min(FileSize - Offset, FileAccessBuffer.Length), the number of bytes to read
  - Set the FileOperationSelector to Read
  - Read the file by setting FileOperationExecute to 1 and poll until 0 and complete
  - Read FileOperationStatus to confirm the read worked
  - Read FileOperationResult to confirm the number of bytes read
  - Read the bytes from FileAccessBuffer
  - Write bytes read to host file.
- Next Offset = Offset + number of bytes read
- Set the FileOperationSelector to Close
- Close the file by setting FileOperationExecute to 1 and poll until 0 and complete
- Read FileOperationStatus to confirm the close worked

Upload File to Camera

- Select the file by setting the FileSelector feature
- Set the FileOpenMode to Write
- Set the FileOperationSelector to Open
- 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
- Read FileOperationStatus to confirm that the file opened correctly
  A return value of 0 is success. Error codes are listed in the XML.
- Read FileSize to get the maximum number of bytes allowed in the file
  - Abort and jump to Close if this is less the file size on the host
- From FileAccessBuffer.Length you will know that maximum number of bytes that can be written through FileAccessBuffer is 988.
- For Offset = 0 While ((Offset < Host File Size) and (Status = 0)) Do
  - Set FileAccessOffset to Offset
  - Set FileAccessLength to min(Host File Size - Offset, FileAccessBuffer.Length), the number of bytes to write
  - Read next FileAccessLength bytes from host file.
  - Write the bytes to FileAccessBuffer
  - Set the FileOperationSelector to Write
  - Write to the file by setting FileOperationExecute to 1 and poll until 0 and complete

    - Read FileOperationStatus to confirm the write worked
    - Read FileOperationResult to confirm the number of bytes written
- Next Offset = Offset + number of bytes written
- Set the FileOperationSelector to Close
- Close the file by setting FileOperationExecute to 1 and poll until 0 and complete
- 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.

- Go to File Access Control
- Click on Settings
- In the "Type" drop down box select "Miscellaneous."
- In the "File selector" drop down box select "CameraData."
- Hit "Download"
- Save the text file and send the file to Teledyne DALSA customer support.

Transport Layer Control Category

The Transport Layer Control category, as shown by CamExpert, has parameters used to configure features related to CLHS connection.

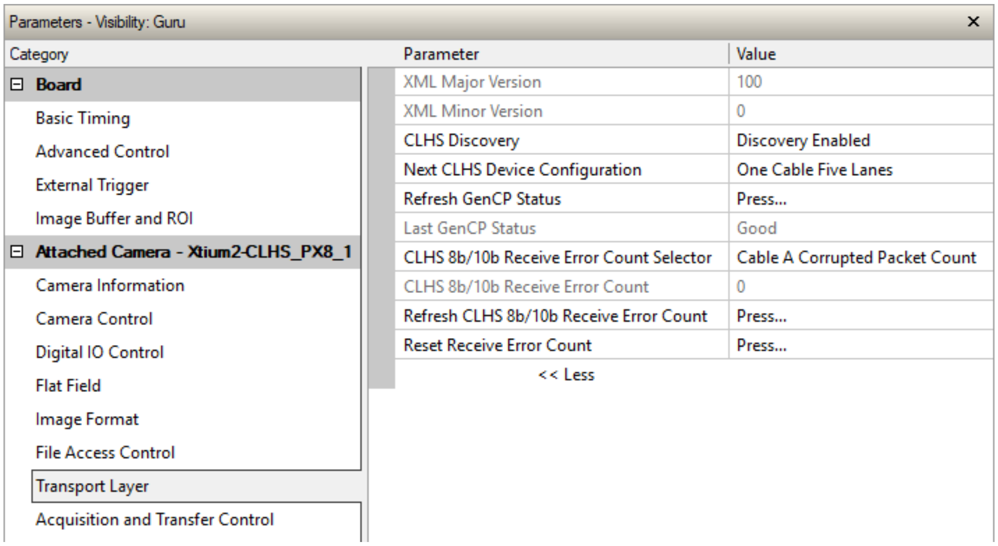


Figure 59: Transport Layer Panel

Transport Layer Feature Descriptions

Display Name	Feature	Description	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
CLHS Discovery	clhsDiscovery	Selects whether the camera needs to be commanded to send image data after power up. Disable CLHS Discovery if not implemented in the frame grabber.	Beginner DFNC
Discovery Disabled	*DiscoveryDisable*	*CLHS transmitters are enabled immediately on power up.*	
Discovery Enabled	*DiscoveryEnable*	*CLHS transmitters enable after sending Acquisition start.*	
Next CLHS Device Configuration	clhsNextDeviceConfig	When the camera is next powered up, the specified CLHS lane configuration will be set for the camera.	Beginner DFNC
One Cable Five Lanes	*OneCableFiveLanes*	*CX4 configuration*	
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

Display Name	Feature	Description	View
CLHS 8b/10b Receive Error Count Selector	clhsErrorCountSelector	Select the error to count	Guru DFNC
Cable A Corrupted Packet Count	*CorruptedPacketCntA*	*Count of corrupted packets on cable A.*	
Cable A Corrected Packet Count	*CorrectedPacketCntA*	*Count of corrected packets on cable A.*	
Cable B Corrupted Packet Count	*CorruptedPacketCntB*	*Count of corrupted packets on cable B.*	
Cable B Corrected Packet Count	*CorrectedPacketCntB*	*Count of corrected packets on cable B.*	
CLHS 8b/10b Receive Error Count	clhsErrorCount	CLHS 8b/10b Receive Error Count	Guru DFNC
Refresh CLHS 8b/10b Receive Error Count	clhsErrorCountRefresh	Refresh the selected *clhsErrorCount* value.	Guru DFNC
Reset Receive Error Count	clhsErrorCountReset	Reset the selected *clhsErrorCount* value to 0.	Guru DFNC

Acquisition and Transfer Control Category

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

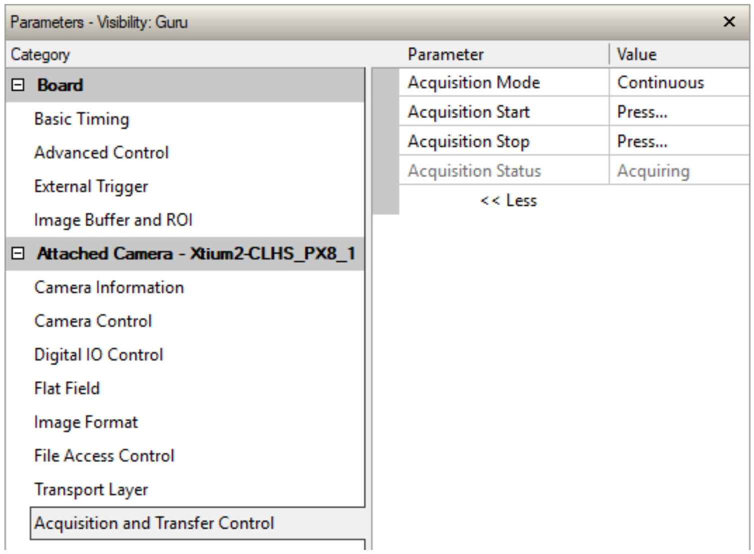


Figure 60: Acquisition & Transfer Control Panel

Acquisition and Transfer Control Feature Descriptions

Display Name	Feature	Description	View
Acquisition Mode *Continuous*	AcquisitionMode *Continuous*	The device acquisition mode defines the number of frames to capture during an acquisition and the way it stops *Only continuous mode is currently available.*	Beginner
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 *Acquiring* *Not Acquiring*	AcquisitionStatus *Acquiring* *NotAcquiring*	Reads the acquisition state. *Currently acquiring and sending image data.* *Currently not acquiring or sending image data.*	Beginner

Appendix B: Troubleshooting 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 the Saving & Restoring Camera Setup Configurations section for details on downloading the Camera Data file.

Voltage & Temperature Measurement

The camera can measure the input supply voltage at the power connector and the internal temperature. Both of these features are accessed using the CamExpert > Camera Information tab. Press the associated refresh button for a real-time measurement.

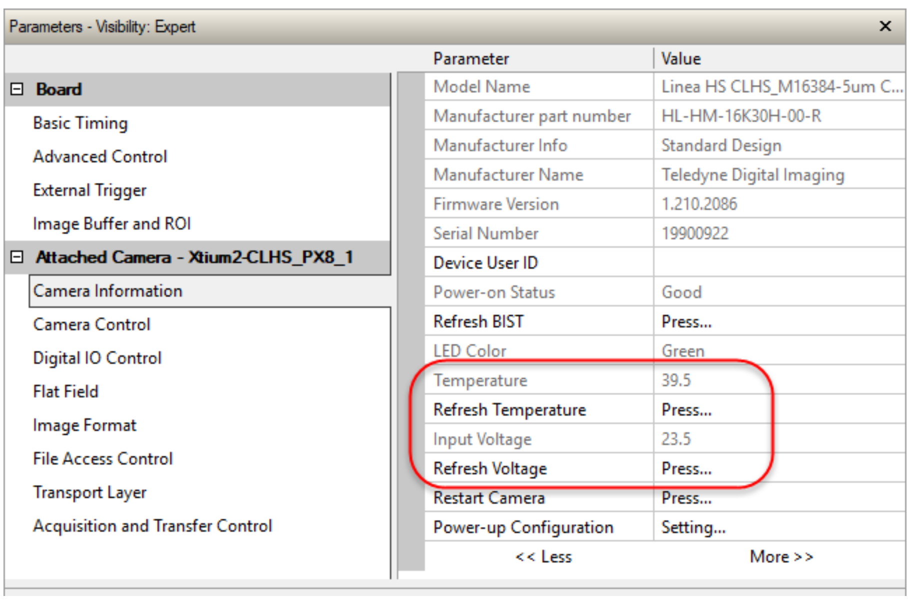


Figure 61: CamExpert Voltage & Temperature Features

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 CamExpert > Image Format tab.

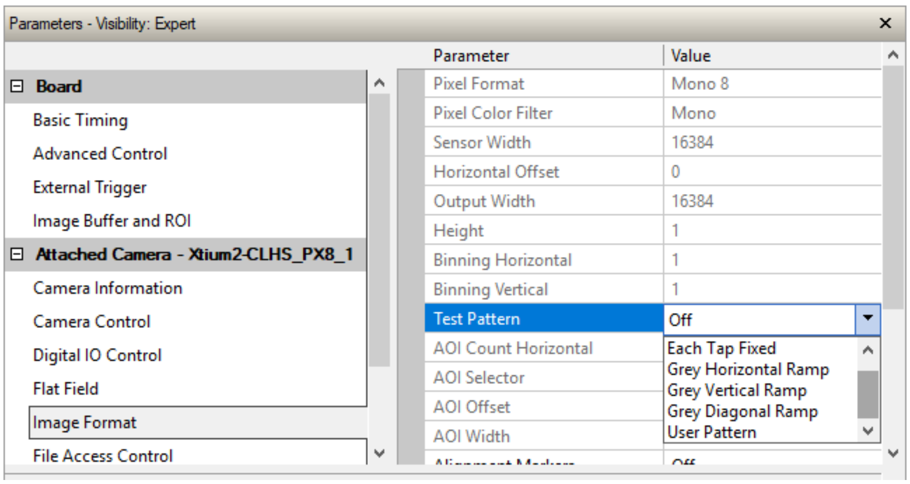


Figure 62: CamExpert Test Pattern Feature

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 00H increases in by 01H every 32 pixels.
- Grey Vertical Ramp
  - Vertical ramp starting with 1st row 5, next row 12, and incrementing by 3 every line
- Grey Diagonal Ramp
  - Add horizontal and vertical ramps
- User Pattern
  - When selected, the camera will first output all pixel 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 category under Power-on Status. None of these should occur in a properly functioning camera except OVER_TEMPERATURE. OVER_TEMPERATURE occurs if the ambient temperature is too high where there is insufficient air circulation or heat sinking.

Table 33: Built-In Self-Test (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 34: Status LED States

LED State	Description
Off	Camera not powerd 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 is opened and no features are listed, then the camera may be experiencing lane lock issues.

While using the frame grabber in CamExpert you should be able to see a row of status indicators below the image display 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.

- From the camera's 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.

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.
From the camera's CamExpert > Digital I / O Control tab, select External Trigger Mode.
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.
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.
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.
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 Xtium2-CLHS frame grabber user manual for details.
c. Do the encoder signal levels conform to the requirements outlined in the Xtium2-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:

- 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.

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.
Use the cameras flat field calibration filter feature, as detailed in the 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, Pixels Developing Low Response

When flat field calibration is performed using a white reference, as per the guidelines in the user manual, all pixels should achieve the same response. However, over time dust in the lens extension tube may migrate to the sensor surface and reduce the response of some pixels.

If the dust particles are small, they may have only a minor effect on responsivity, but still create vertical dark lines that interfere with defect detection and that need to be corrected.

Because repeating the flat field calibration with a white reference may not be practical while 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 location of the pixel returning 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 a flat field calibration.

See the File Access via the CamExpert Tool for details on downloading and uploading camera files using CamExpert.

> **Note:** Dust accumulation on the lens will not cause vertical lines. However, a heavy accumulation of dust on the lens will eventually degrade the camera’s responsivity and focus quality.

Smeared & Distorted Images

To achieve a well-defined image, the multiple lines are summed together and delayed in a manner that matches the motion of the image across the sensor.

This synchronization is achieved by sending an external synchronization (EXSYNC) signal to the camera, where one pulse is generated when the object moves by the size of one object pixel. See 'External Trigger Mode' in the user manual.

Any transport motion that is not correctly reflected in the EXSYNC pulses will cause image distortion in the scan direction. For standard line scan cameras, this type of image distortion may not greatly affect edge sharpness and small defect contrast; thereby having minimal impact on defect detection. However, TDI image quality is more sensitive to object motion synchronization errors.

The following subsections discuss causes of poor image quality resulting from the EXSYNC signal not accurately reflecting the object motion.

Continuously Smeared, Compressed or Stretched Images

When accurate synchronization is not achieved, the image appears 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 matched to the camera's scan direction, as 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 the Camera Orientation section for more information on how to determine the correct direction orientation for the camera.

Note: The lens has a reversing effect on motion. That is, if an object passes the lens-outfitted camera from left to right, the image on the sensor will pass from right to left. The diagrams in the user manual take the lens effect into account.

Randomly Compressed Images

It is possible that when the scan speed nears the maximum allowed, based on the exposure time used, the image will be randomly compressed and possibly smeared for short 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.

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 rows in a fashion that accurately follows the object motion.

When the scan direction changes, then 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 safe and reliable operation, the camera input supply must be +12 V to +24 V DC.

The power supply to the camera should be suitably current limited, as per the applied input voltage.

Assume a worst-case power consumption of +24 W and a 150% current rating for the breaker or fuse.

Note: The camera will not start to draw current until the input supply is above approximately 10.5 V and 200 ms has elapsed. If the power supply stabilizes in less than 200 ms, 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 +12 V where the current draw is highest.

Reading the input supply voltage as measured by the camera will give an indication of the supply drop being experienced.

The camera tolerates “hot” unplugging and plugging.

The camera has been designed to protect against accidental application of an incorrect input supply, up to reasonable limits.

With the following input power issues, the status LED will be OFF:

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

Causes for Overheating & Power Shut Down

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

Many applications, such as in clean rooms, cannot tolerate the use of forced air cooling (fans) and therefore must rely on convection.

The camera's body has been designed with integrated heat fins to assist with convection cooling. The fins are sufficient to keep the camera at an acceptable temperature if convection flow is unimpeded.

The camera also benefits from conducting heat away from the body via the face plate into the lens extension tubes and camera mount. It is therefore important not to restrict convection airflow around the camera body, especially the fins and the lens assembly and camera mount. Lowering the ambient temperature will equally lower the camera's temperature.

If the camera's internal temperature exceeds +80 °C, then the camera will partially shut down to protect itself 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 reapplying 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	Initial release.	December 17, 2020
02	Added the following models: HL-FM-04K30H, HL-FM-13K18H, and HL-HM-13K30H	April 6, 2021
03	Added model HL-HM-16k40H-00-B. Updated Powering the Camera section and added warning to Hirose pinout. Added section about FPN and dark current correction and related new feature. Various minor corrections and updates.	March 24, 2023

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