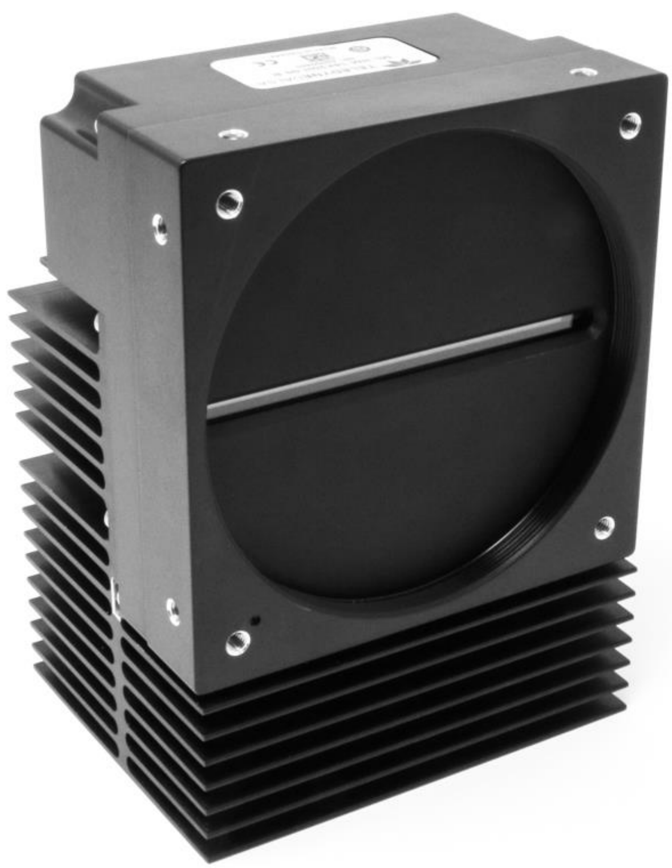
Linea ML Multiline Cameras

Camera User's Manual

Multiline Monochrome / HDR CMOS Line Scan Camera

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



Models

ML-FM-08K30H-00-R
ML-FM-16K07A-00-R
ML-FM-16K15A-00-R
ML-HM-08K30H-00-R
ML-HM-16K30H-00-R

03-032-20263-04
www.teledynedalsa.com

CAMERA Link HS™

TELEDYNE

Notice

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About Teledyne DALSA

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

Teledyne DALSA 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 ML Multiline Monochrome / HDR CMOS Cameras

Description

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

The Linea ML™ multiline monochrome / HDR cameras have 8k or 16k pixel resolution, a 5 µm x 5 µm pixel size, and are compatible with fast, high magnification lenses.

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
(LC or CX4, resolution dependent).

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

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

Available Camera Models

Part Number	Description
ML-FM-08K30H-00-R	8,192 x 4 pixels, a maximum line rate of 280 kHz (up to 300 kHz using AOI), 5 µm x 5 µm pixel size, mono / HDR output, CLHS LC fiber optic connector.
ML-FM-16K07A-00-R	16,384 x 1 pixels, a maximum line rate of 70 kHz, 5 µm x 5 µm pixel size, mono output, CLHS LC fiber optic connector.
ML-FM-16K15A-00-R	16,384 x 1 pixels, a maximum line rate of 140 kHz, 5 µm x 5 µm pixel size, mono output, CLHS LC fiber optic connector.
ML-HM-08K30H-00-R	8,192 x 4 pixels, a maximum line rate of 300 kHz, 5 µm x 5 µm pixel size, mono / HDR output, CLHS CX4 connector.
ML-HM-16K30H-00-R	16,384 x 4 pixels, a maximum line rate of 300 kHz, 5 µm x 5 µm pixel size, mono / HDR output, CLHS CX4 connector.

Camera Highlights

Key Features

- Highly responsive multiline CMOS
- 8K or 16K pixel resolution
- Up to 300 kHz line rates
- Very low noise
- Bi-directionality with fixed optical center
- Binning
- Robust Camera Link HS interface
- LC fiber optic or CX4 Camera Link HS control & data connector
- Smart lens shading correction
- High dynamic LUT mode

Programmability

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

Applications

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

Part Numbers and Software Requirements

The camera is available in the following configurations:

Table 1: Camera Models Comparison

Part Number	Resolution	Max. Line Rates	Pixel Size	Control & Data Connector
ML-FM-08K30H-00-R	8,192 x 4 pixels	280 kHz monochrome 140 kHz x 2 HDR mode (300 kHz / 150 x 2 kHz using AOI)	5.0 x 5.0 µm	Camera Link HS LC fiber optic
ML-FM-16K07A-00-R	16,384 x 1 pixels	70 kHz monochrome	5.0 x 5.0 µm	Camera Link HS LC fiber optic
ML-FM-16K15A-00-R	16,384 x 1 pixels	140 kHz monochrome	5.0 x 5.0 µm	Camera Link HS LC fiber optic
ML-HM-08K30H-00-R	8,192 x 4 pixels	300 kHz monochrome 150 kHz x 2 HDR mode	5.0 x 5.0 µm	Camera Link HS CX4
ML-HM-16K30H-00-R	16,384 x 4 pixels	300 kHz monochrome 150 kHz x 2 HDR mode	5.0 x 5.0 µm	Camera Link HS CX4

Table 2: Frame Grabber

Compatible Frame grabber	ML-FM-08K30H	ML-HM-16K30H ML-HM-08K30H	ML-FM-16K15A ML-FM-16K07A
Teledyne DALSA	OR-A8S0-FX840	OR-A8S0-PX870	OR-A8S0-FX840
Other compatible frame grabbers may be available from third-party vendors.			

Table 3: Software

Software	Product Number / Version Number
Camera firmware	Embedded within camera
GenICam™ support (XML camera description file)	Embedded within camera
Sapera LT, including CamExpert GUI application and GenICam for Camera Link imaging driver	Latest version on the TeledyneDALSA Web site

Performance Specifications

Table 4: Camera Performance Specifications

Specifications	**ML-HM-08K30H**	**ML-FM-08K30H**	**ML-HM-16K30H**	**ML-FM-16K07A ML-FM-16K15A**
Imager Format	High speed CMOS multiline sensor			
Resolution	8,192 x 4 pixels mono		16,384 x 4 pixels mono	16,384 x 1 pixels mono
Pixel Size	5.0 µm x 5.0 µm			
Pixel Fill Factor	100 %			
Line Rate	0 kHz to 300 kHz monochrome mode 150 kHz x 2 HDR mode	0 kHz to 280 kHz monochrome mode 140 kHz x 2 HDR (300 / 150 kHz x 2 achievable using AOI)	0 kHz to 300 kHz monochrome mode 150 kHz x 2 HDR mode	16K07A = 70 kHz 16K15A = 140 kHz monochrome mode
Exposure Time	3.2 µs to 1.4 ms			
Bit Depth	8 bit or 12 bit, selectable			
Connectors and Mechanicals	**ML-HM-08K30H**	**ML-FM-08K30H**	**ML-HM-16K30H**	**ML-FM-16K07A ML-FM-16K15A**
Control & Data	Camera Link HS CX4	Camera Link HS LC fiber optic	Camera Link HS CX4	Camera Link HS LC fiber optic
Power	+12 V to +24 V DC, Hirose 12-pin circular			
Typical Power Dissipation	15 W	15 W	25 W	21 W
Size	76 (W) x 76 (H) x 85 (D) mm	76 (W) x 76 (H) x 85 (D) mm	97 (W) x 140.5 (H) x 78.6 (D) mm	97 (W) x 140.5 (H) x 78.6 (D) mm
Mass	< 500 g	< 500 g	1.2 kg	1.2 kg
Operating Temp	+0 °C to +65°C, front plate temperature			
Optical Interface	**ML-HM-08K30H**	**ML-FM-08K30H**	**ML-HM-16K30H**	**ML-FM-16K07A ML-FM-16K15A**
Lens Mount	M58 x 0.75 mm	M58 x 0.75 mm	M90 x 1 mm	M90 x 1 mm
Sensor to Camera Front Distance	12 mm			
Sensor Alignment (aligned to sides of camera) Flatness Θ y (parallelism) x y z Θ z	 50 µm 100 µm ± 300 µm ± 300 µm ± 300 µm ± 0.4°			

Operating Ranges	Performance (all models)	Notes
Random Noise*	< 0.3 DN rms (10 e-)	Typical
Peak Responsivity *Low Responsivity Line* *High Responsivity Line*	 3 DN / (nJ / cm^2) 18 DN / (nJ / cm^2)	
Gain	1x to 10x	
DC Offset	5 DN	Can be adjusted as required
Dynamic Range	73 dB	
Full Well *Low Responsivity Line* *High Responsivity Lines*	 44,000 e- 7,200 e-	Typical, single row
PRNU	< ±2%	50% of calibration target
FPN	< ±2 DN	
SEE *Low Responsivity Line* *High Responsivity Lines*	 90 nJ / cm^2 14 nJ / cm^2	
NEE *Low Responsivity Line* *High Responsivity Lines*	 100 pJ /cm^2 17 pJ /cm^2	
Anti-blooming	> 100x Saturation	
Integral non-linearity	< 2%	

Notes:

*DN = digital number

Test Conditions unless otherwise specified:

- Values measured using 8 bit, 1x gain
- 40 kHz line rate
- Light source: White LED if wavelength not specified
- Front plate temperature: 45º C

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

Flash Memory Size

Table 5: Camera Flash Memory Size

Camera	Flash memory size
All models	4 GByte

Certification & Compliance

Table 6: Camera Certifications and Compliance

Compliance
See Declarations of Conformity.
KC Registration
Verified equipment registered under the Clause 3, Article 58-2 of Radio Waves Act. ML-HM-16K30H registration no. R-R-Td2-ML-HM-16K30H. Registration date 2019-01-22. *ML-FM-08K30H registration pending.*

Camera Pixel Arrangement

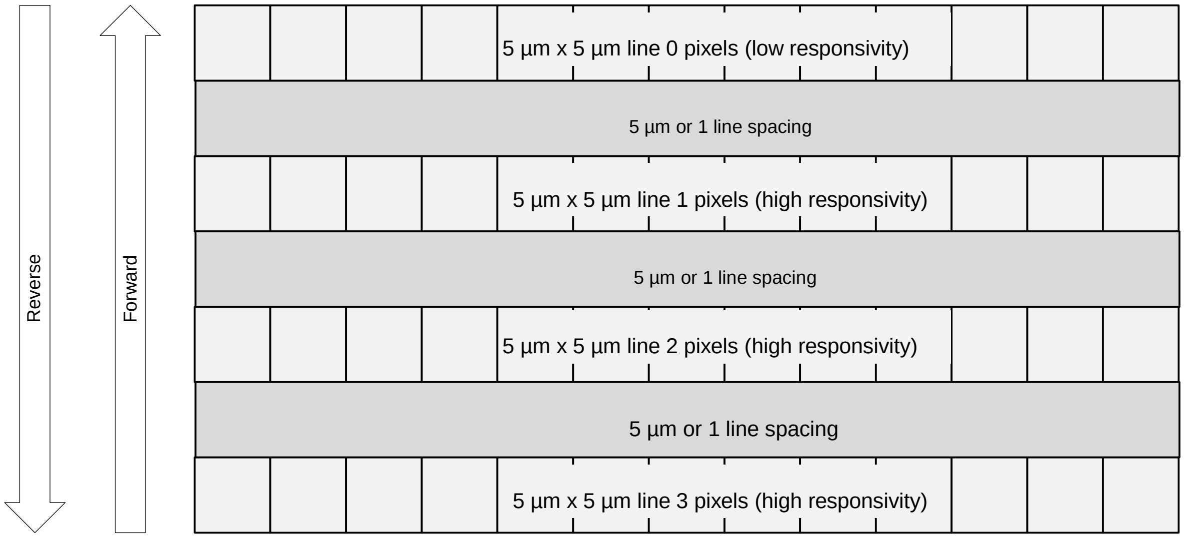


Figure 1: ML-FM-08K30H, ML-HM-08K30H and ML-HM-16K30H Pixel Structure

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

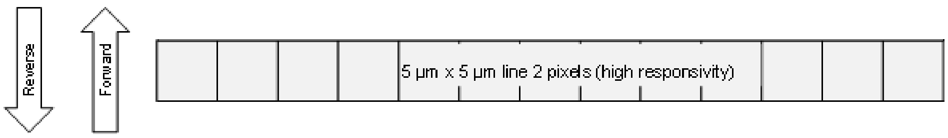
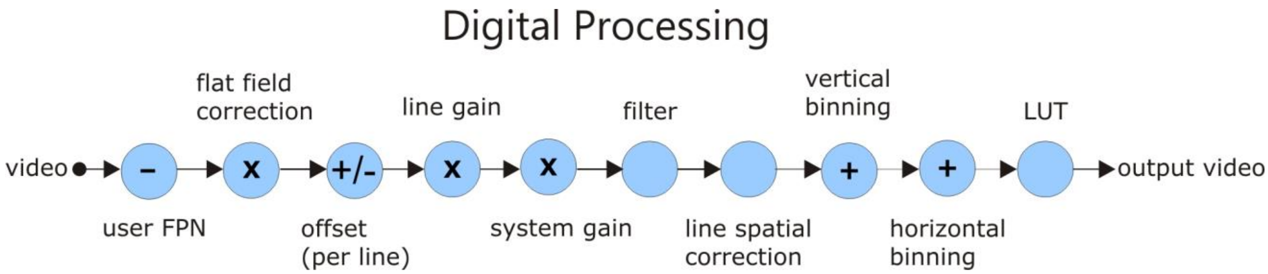


Figure 2: ML-FM-16K07A and ML-FM-16K15A Pixel Structure

The ML-FM-16K07A and ML-FM-16K15A cameras operate with a single high sensitivity line output only. There is no difference in camera operation when the scanning direction is changed.

Camera Processing Chain

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



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 cameras come with two different output mediums. The ML-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 ML 8K camera the SFP+ modules are built into the camera. Either one or both SFP+ modules can be used but using only one SFP+ / fiber optic will sacrifice available bandwidth.

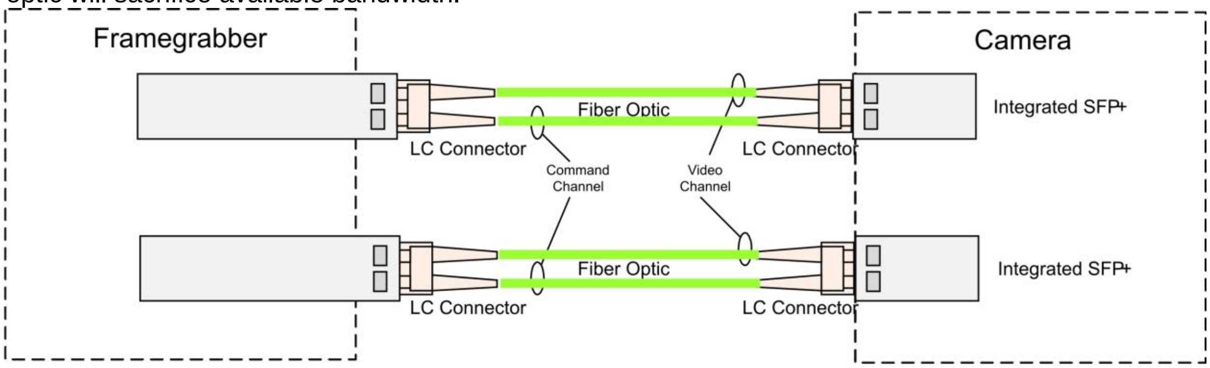


Figure 3. Linea ML Dual LC/SFP+ Connector Configuration

The ML-HM camera models use a CX4 connector for the output—using up to 5 lanes.

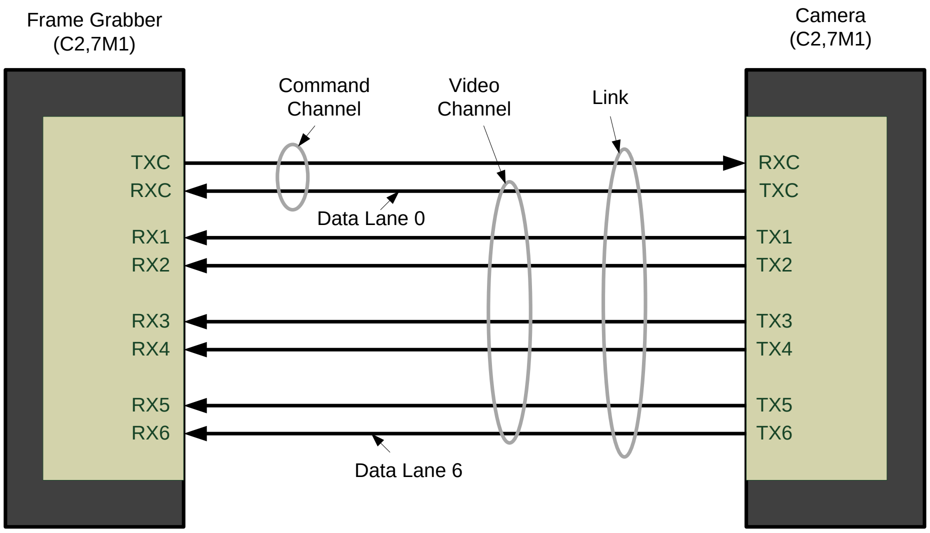


Figure 4. Single CLHS Connector Configuration

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. With two SFP+ modules populated, the CLHS protocol will auto negotiate which one will be dedicated as the command channel. Data and command transmission is done with CLHS X protocol (64b / 66b) at the default speed of 10 Gbs.

Data Cables

LC Fiber Optic (ML-FM Cameras)

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

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

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

Recommended fiber optic cables are types OM3 and OM4.

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

Contact Teledyne DALSA Support for more information on recommended cables.

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

CX4 AOC (ML-HM Cameras)

For the ML-HM camera models, the 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.

Responsivity & QE Plots

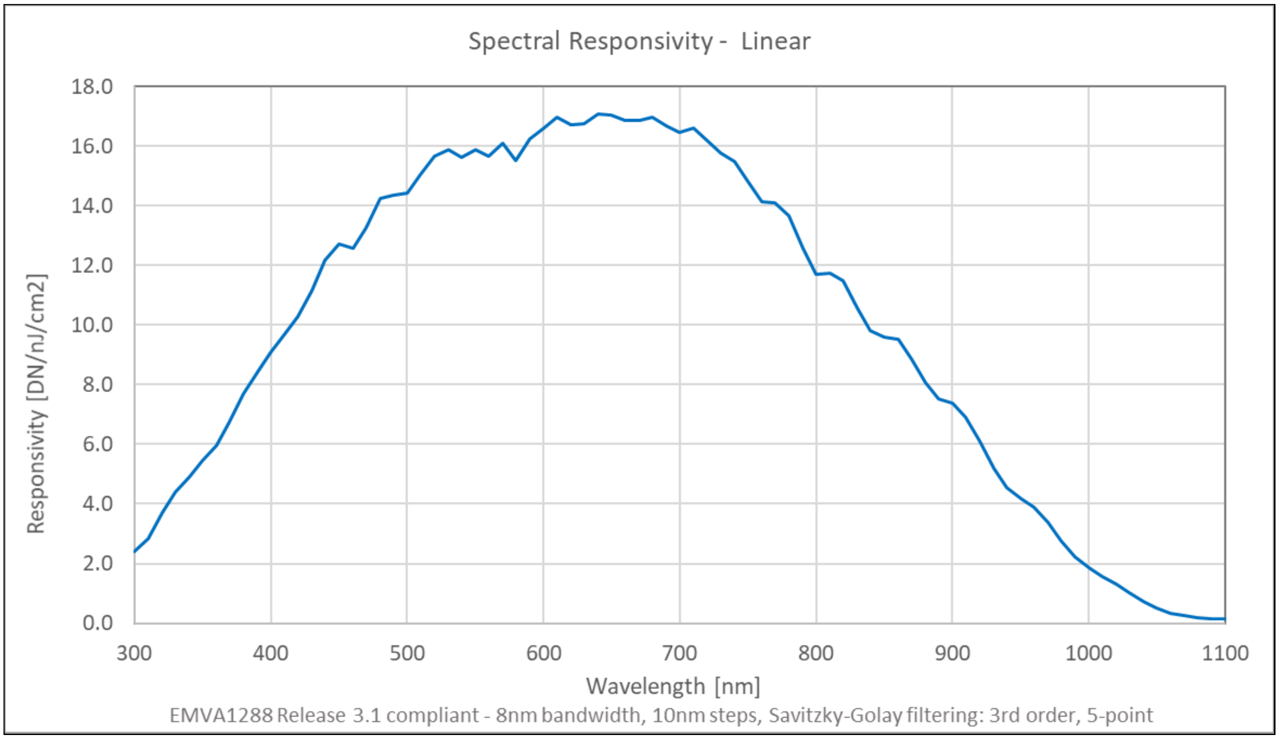


Figure 5. Camera Spectral Responsivity

Note: Responsivity values measured using 8-bit, 1x gain, single row.

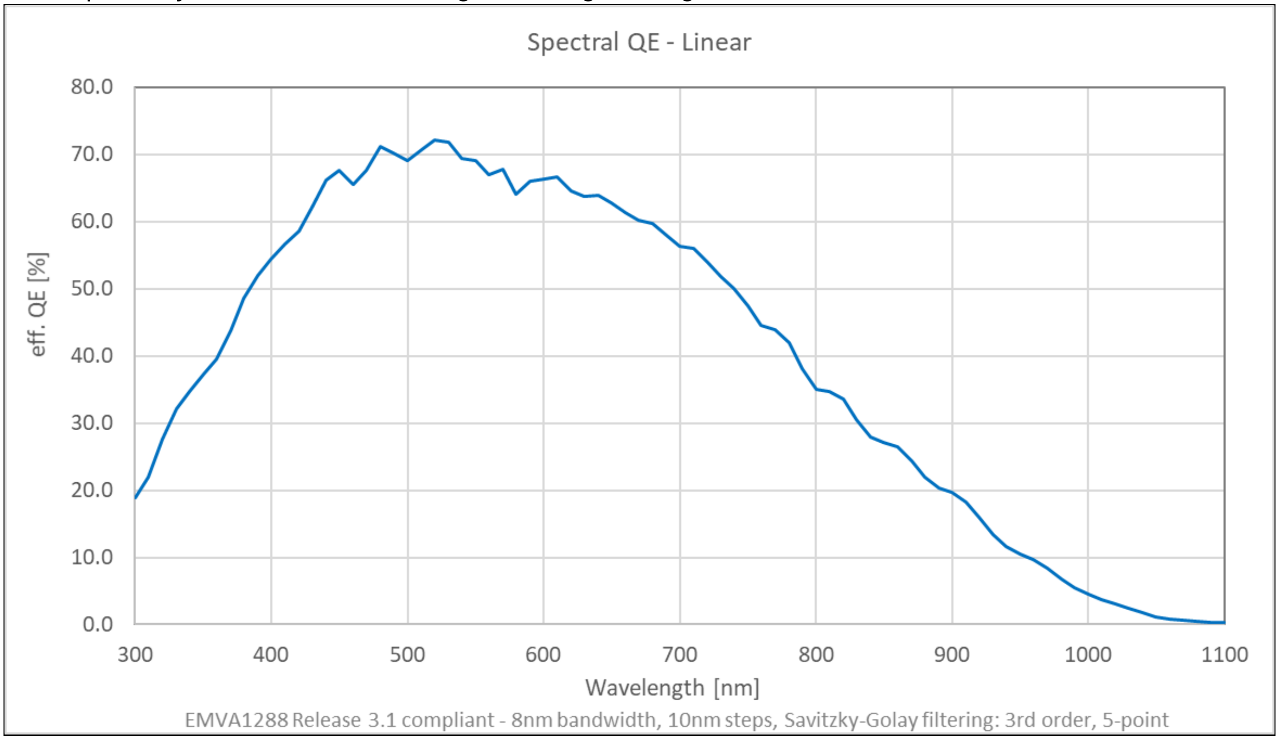


Figure 6. Camera Quantum Efficiency

Mechanical Drawings

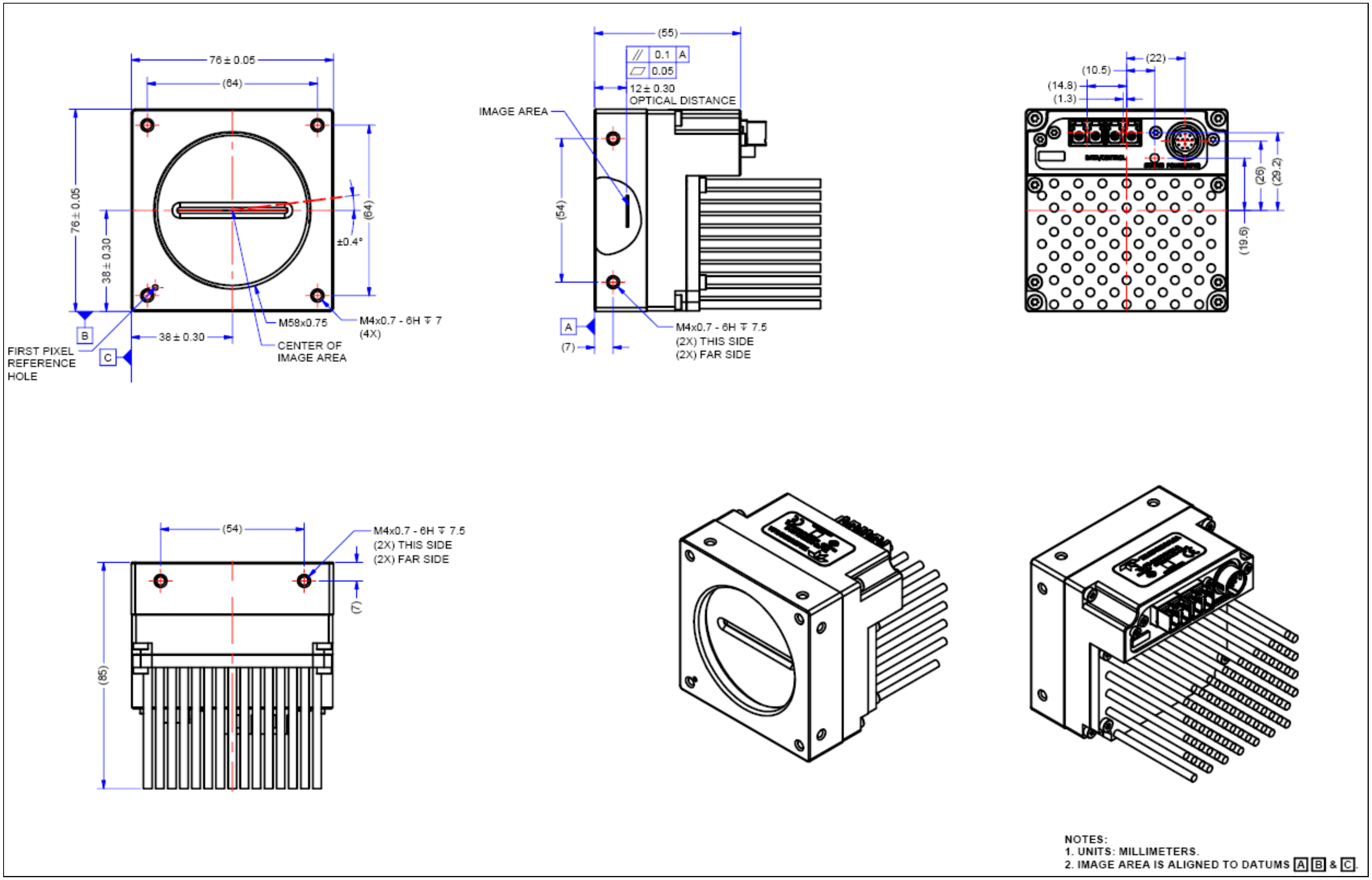


Figure 7. Linea ML-FM-8K Camera Mechanical

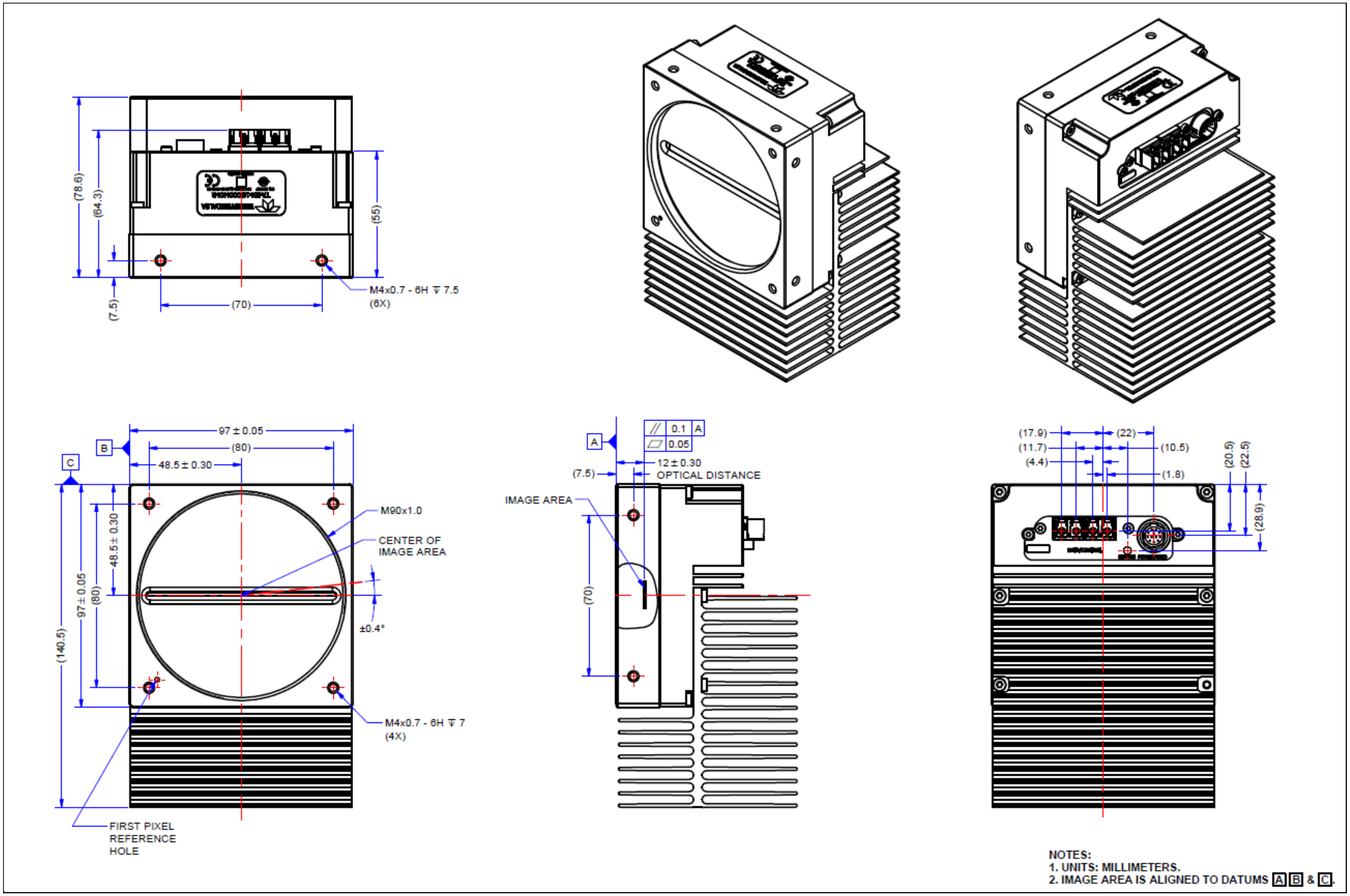


Figure 8. Linea ML-FM-16K Camera Mechanical

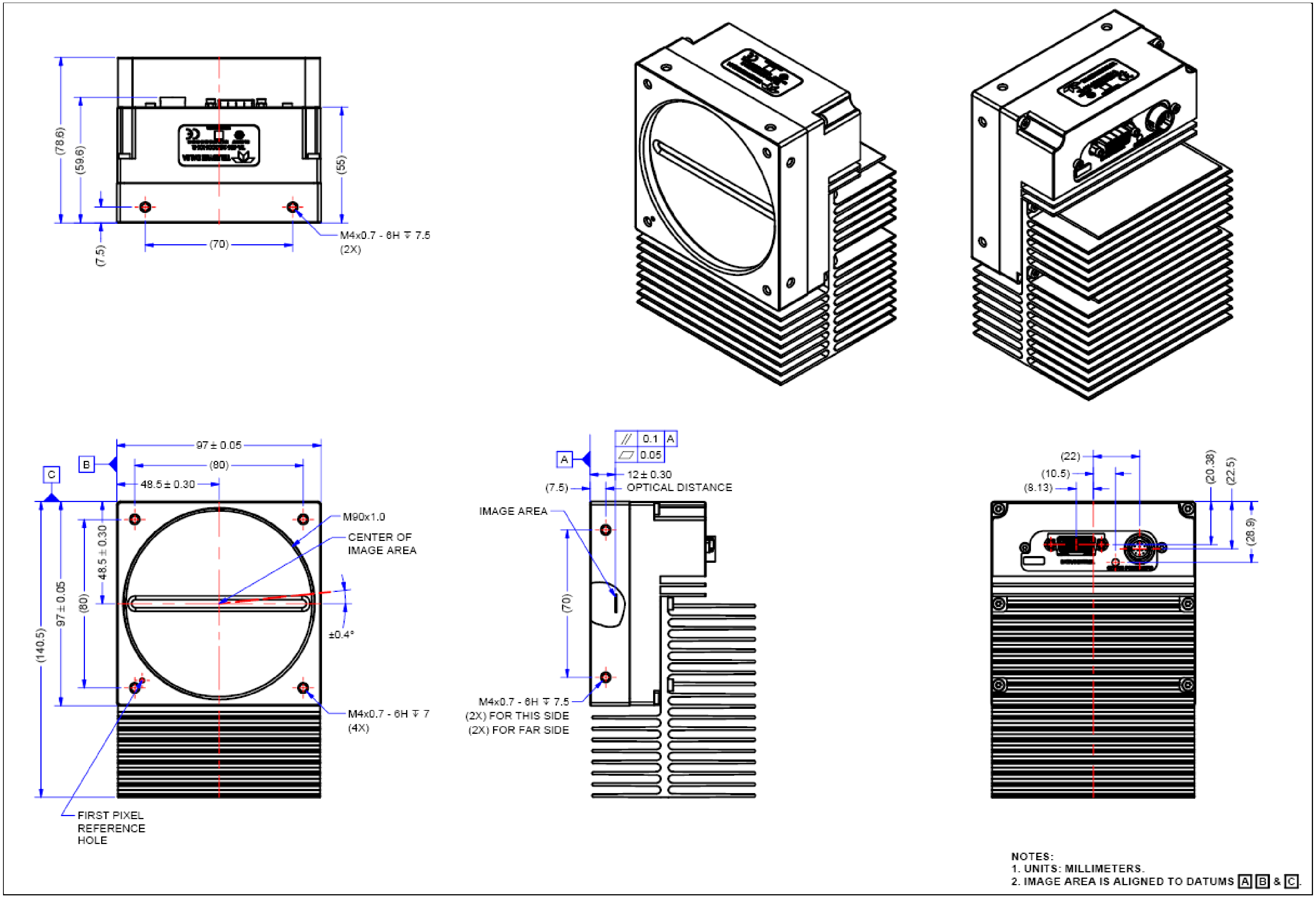


Figure 9. Linea ML-HM-16K Camera Mechanical

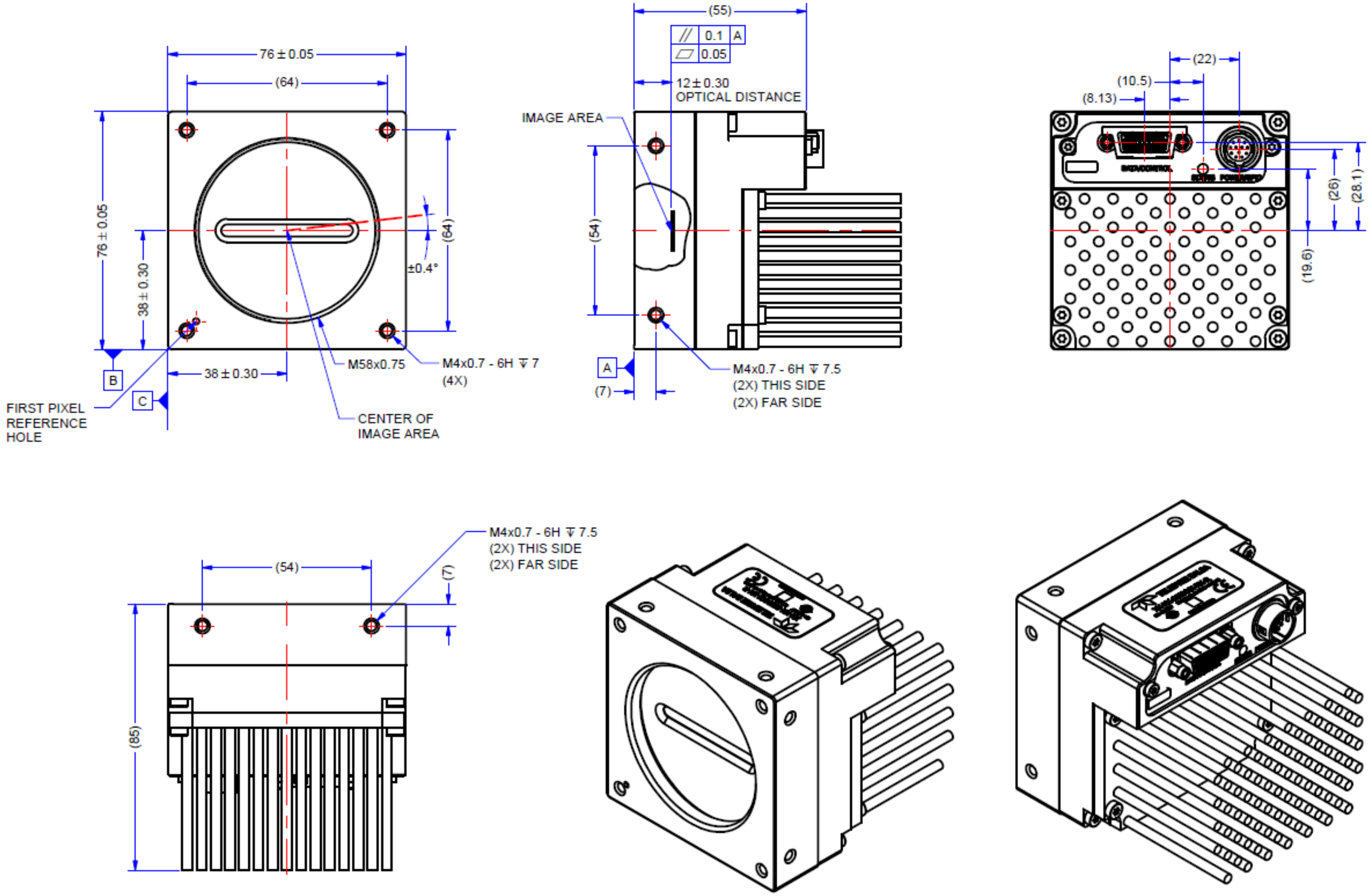


Figure 10: ML-HM-08K camera mechanical

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 has the ability to measure its internal temperature. Use this feature to record the internal temperature of the camera when it is mounted in your system and operating under the worst case conditions. The camera will stop outputting data if its internal temperature reaches +80 °C.

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 required by these cameras, we recommend a compatible Teledyne DALSA frame grabber (part numbers: OR-A8S0-FX840 (ML-FM) or OR-A8S0-PX870 (ML-HM)), or equivalent, described in detail on the teledynedalsa.com site here.

The frame grabber requirements for the various camera models are different. Follow the manufacturer's installation instructions.

A GenICam compliant XML device description file is embedded with the camera firmware and 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 access a camera's features and parameters, and to test the operating modes. In addition, CamExpert can be used to save the camera's user settings configurations to the camera or 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 the user to verify the timing or control parameters in real-time, without needing to run a separate acquisition program.

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

Note: The availability of features depends on the CamExpert user setting. Not all features are available to all users. The examples shown are for illustrative purposes and may not entirely reflect the features and parameters available from the camera model used in your application.

CamExpert Panes

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

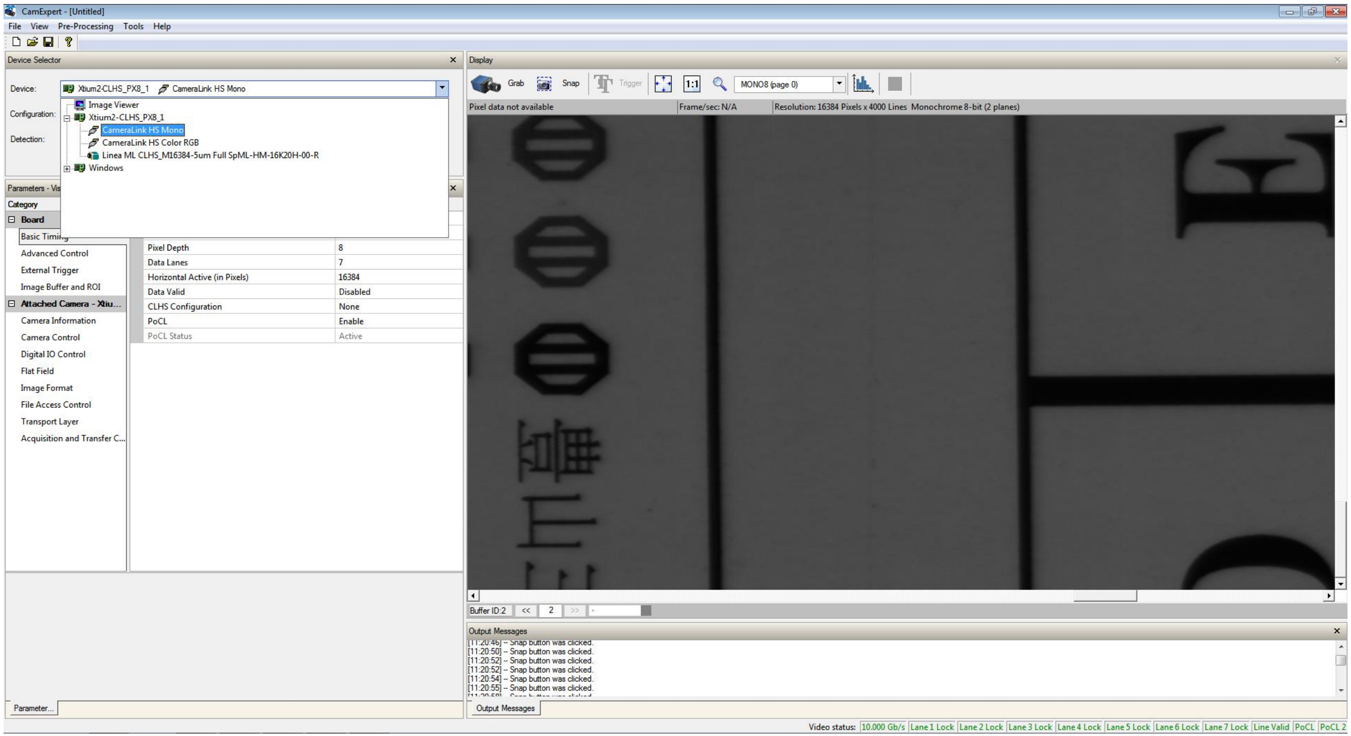


Figure 11. CamExpert Frame Grabber Control Window

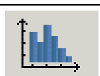
The CamExpert application uses panes to organize the selection and configuration of camera files or acquisition parameters.

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 by the user.

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

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

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

	**Acquisition control button:** Click once to start live grab, click again to stop.
	**Single frame grab:** Click to acquire one frame from device.
	**Trigger button:** With the I/O control parameters set to Trigger Enabled, click to send a single trigger command.
	**CamExpert display controls:** (these do not modify the frame buffer data) Stretch image to fit, set image display to original size, or zoom the image to virtually any size and ratio.
	**Histogram / Profile tool:** Select to view a histogram or line/column profile during live acquisition or in a still image.

Output Message Pane: Displays messages from CamExpert or the device driver.

At this point you are ready to start operating the camera, acquire images, set camera functions, and save settings.

Setting Up for Imaging

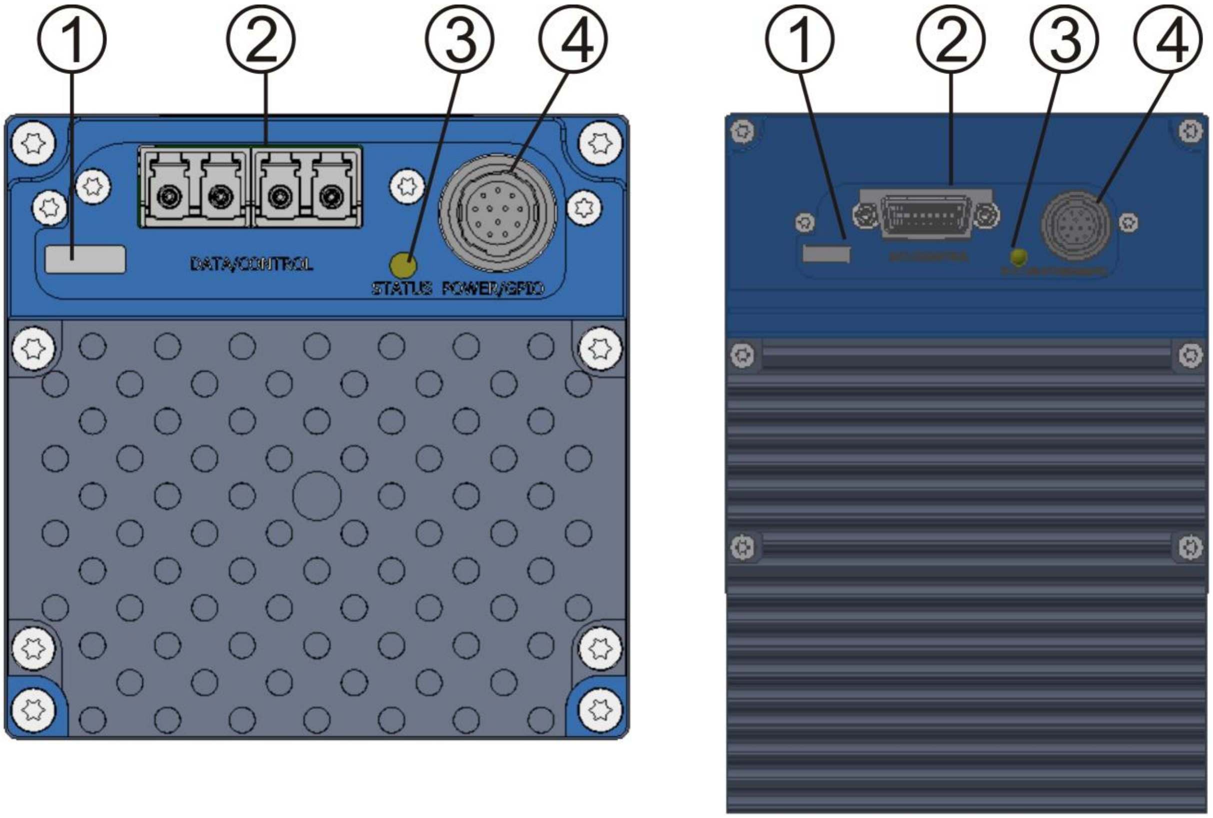


Figure 12. Camera I / O Connectors: ML-FM models (left) & ML-HM models (right).

Camera I / O Connectors

1) Factory use only.

2) Data and control connectors: LC or CX4 AOC.

3) LED status indicators.

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

Powering the Camera

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

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

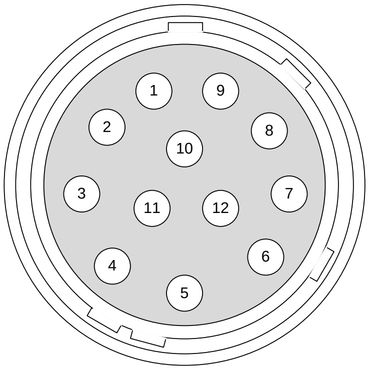
Note: If your power supply does not meet these requirements, then the camera performance specifications are not guaranteed.

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.



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

*Connect all power pins. Each pin is rated 2A.

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

Mating GPIO Cable Assembly

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

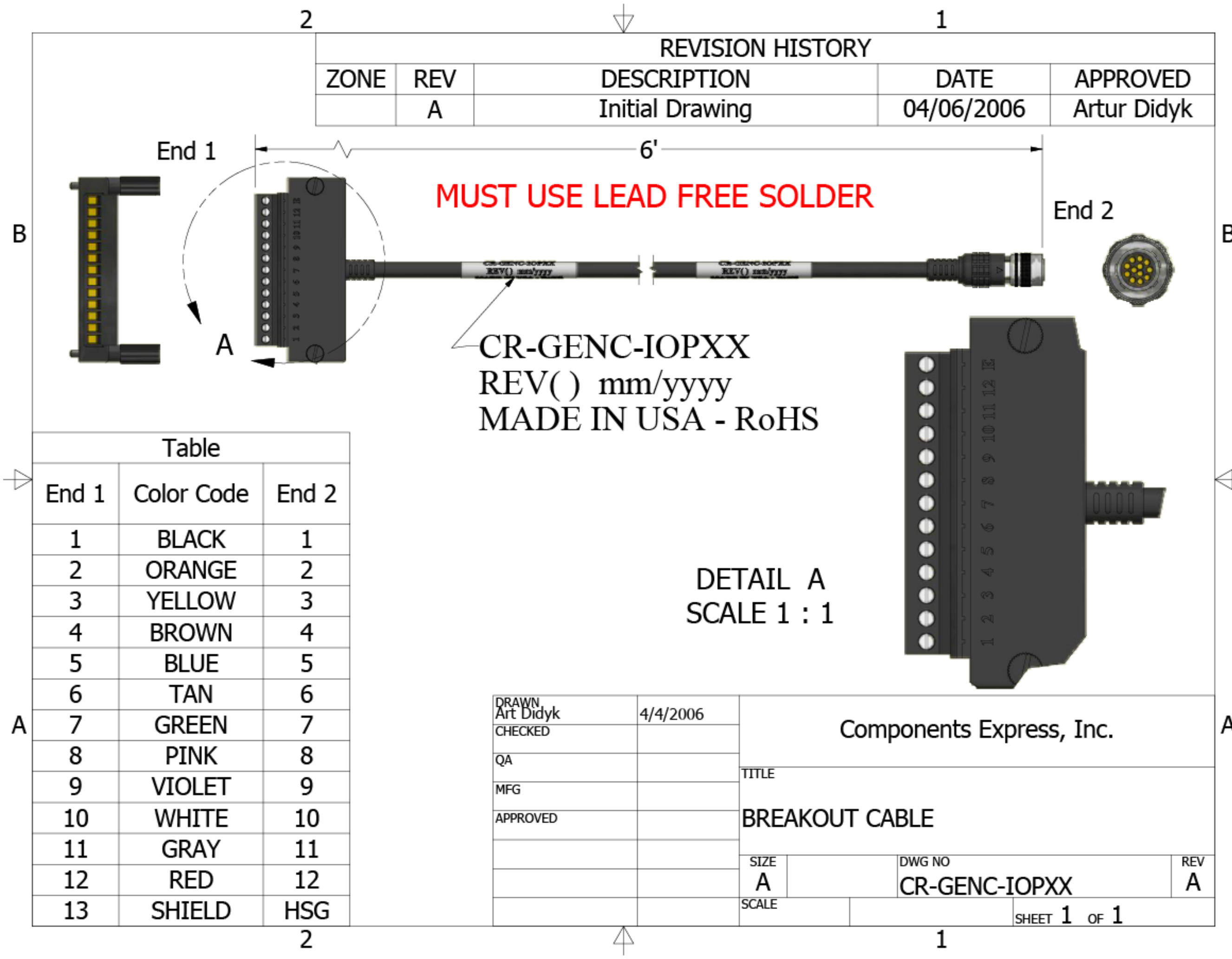


Table		
End 1	Color Code	End 2
1	BLACK	1
2	ORANGE	2
3	YELLOW	3
4	BROWN	4
5	BLUE	5
6	TAN	6
7	GREEN	7
8	PINK	8
9	VIOLET	9
10	WHITE	10
11	GRAY	11
12	RED	12
13	SHIELD	HSG

External Input Electrical Characteristics

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

External Input Timing Reference

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

External Output Electrical Characteristics

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

*See Linear Technology data sheet LTC2854

External Output Timing Reference

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

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

Establishing Camera Communications

When you power up the camera, observe the LED status indication on the back. The LED will indicate one of the following status conditions:

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

When the camera's LED state is steady green open CamExpert.

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

In a change from previous versions of the Sapera GUI, only one instance of CamExpert is required to send commands to the camera and view images.

Selecting the Data Format

The camera can output data in the following formats:

Mono8

Mono12

Please refer to the frame grabber user's documentation for further details on selection of input and output pixel formats.

Establishing Data Integrity

1. Use the camera's internal triggering. This allows for initial imaging with a static object and no encoder input is required.
2. Enable the camera to output a test pattern.
3. Use CamExpert 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.
4. Disable the test pattern output.

Camera Performance and Features

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

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

Synchronizing to Object Motion

Acquiring Images: Triggering the Camera

Related Features: ExposureMode, TriggerMode, TriggerSource, TriggerActivation

A number of different methods that can be used to trigger image acquisition in the camera:

Internal Trigger

The simplest method is to set the Trigger Mode to “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 command is set to “External”, the triggers to the camera can come from different sources, set using the Trigger Source feature.

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

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

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

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 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 Rate (Trigger)

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 line rate that the camera can achieve is determined by the number of CLHS lanes used and by the number of cables installed, as shown in the following table:

Maximum Line Rate (1 sensor line output, 8 bit)			
Camera Model	**One Fiber Optic Cable**	**Two Fiber Optic Cables**	**One AOC cable**
ML-FM-08K30H-00-R	140 kHz	280 kHz	NA
ML-FM-16K07A-00-R	70 kHz	70 kHz	NA
ML-FM-16K15A-00-R	71 kHz	143 kHz	NA
ML-HM-08K30H-00-R	NA	NA	300 kHz
ML-HM-16K30H-00-R	NA	NA	300 kHz

Minimum Line Rate

The minimum line rate for all camera models is 0 kHz. Cameras go to full stop without image anomaly.

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 multiline camera requires the user to tell the camera the direction of travel of the object being imaged.

The scan direction is set using the sensorScanDirectionSource command. The options are: Internal, Line 2 (pin 6 on the GPIO connector), and the rotary encoder feature (using pin 5 and pin 6 of the GPIO connector).

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

Direction Change Time

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

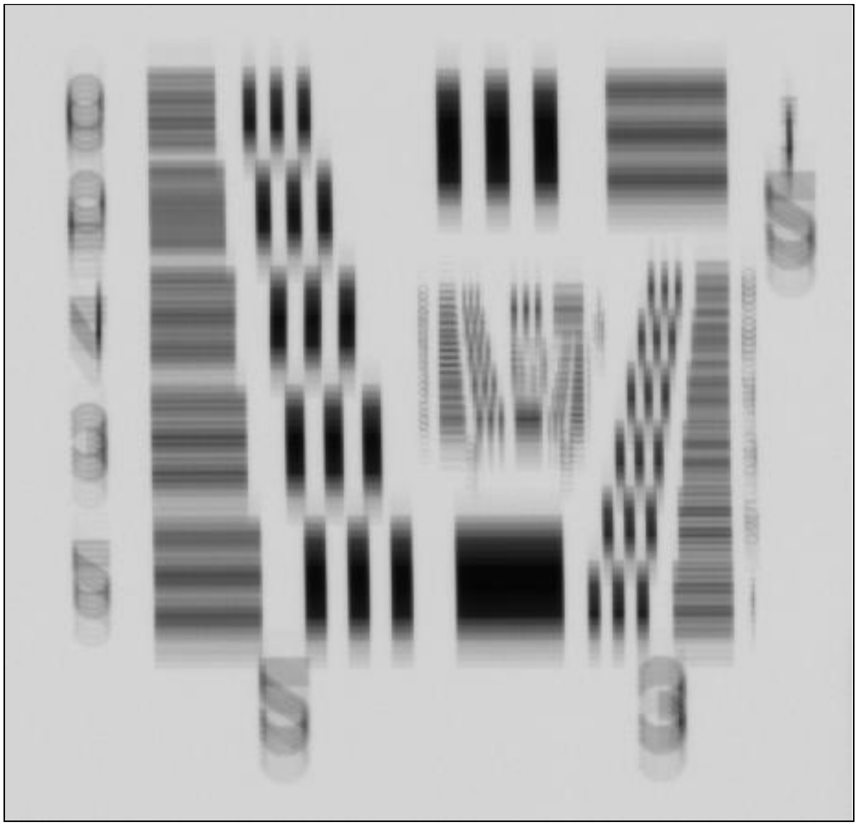


Figure 13. Image with incorrect scan direction

Camera Orientation

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

	Note: The diagram assumes the use of a lens on the camera, which inverts the image.

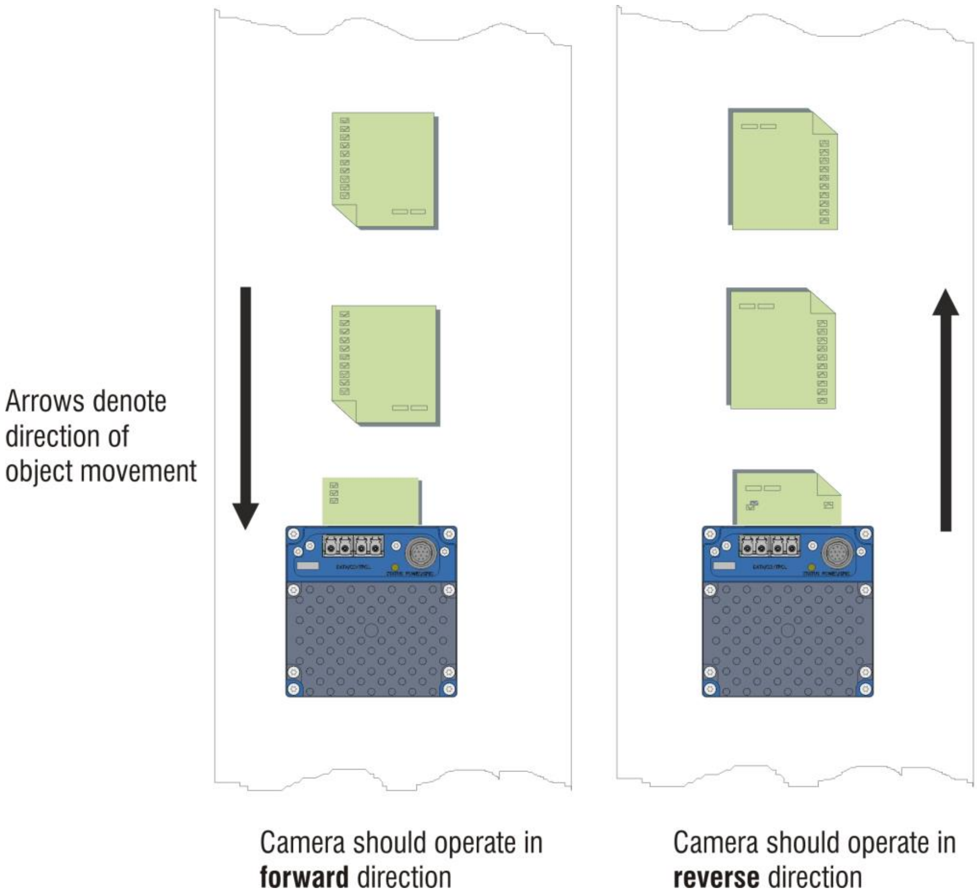


Figure 14: Example of Object Movement and Camera Direction (8K camera shown)

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 AOI 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, including the lines that are not valid, as a result of the direction change. 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.

Compensating for Encoder Errors (Spatial Correction)

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

Related Feature: sensorLineSpatialCorrection

To achieve a sharp image in the vertical direction when running the camera in TDI mode or in HDR mode it is important that the lines being used are aligned correctly. The line spatial correction feature is used to ensure that these lines align.

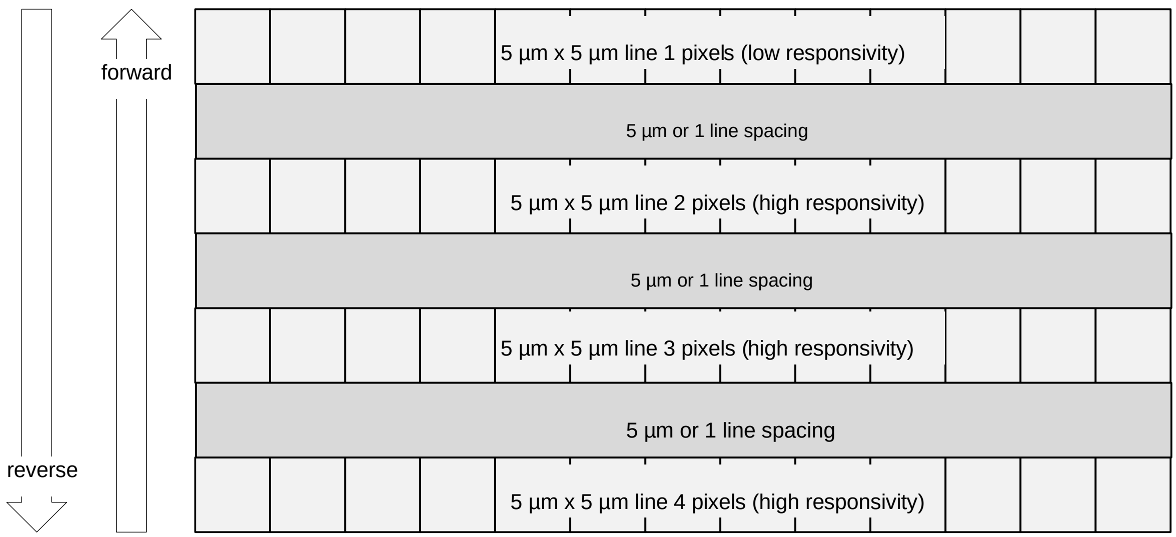


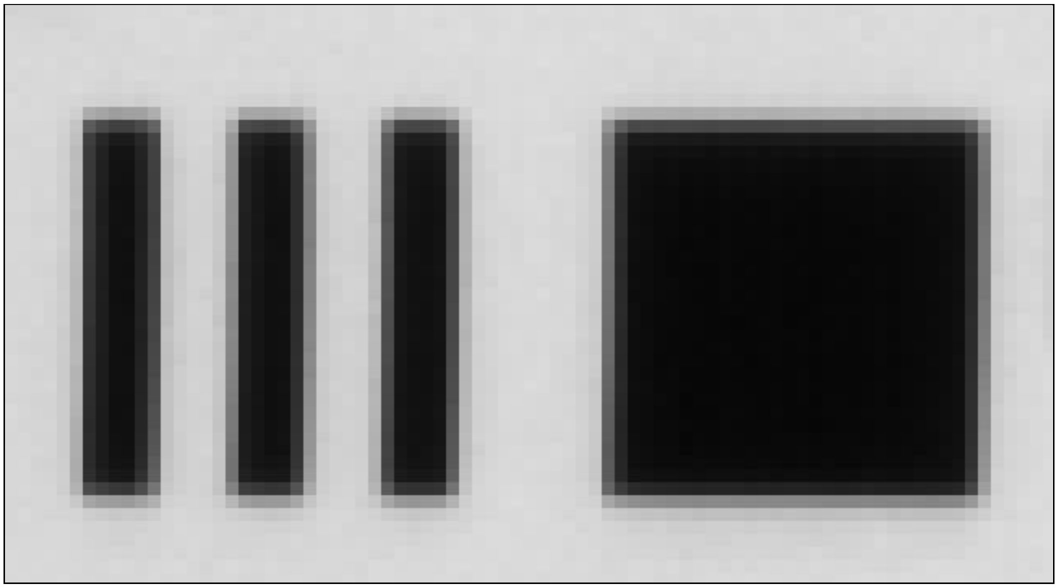
Figure 15. Camera Line spacing

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

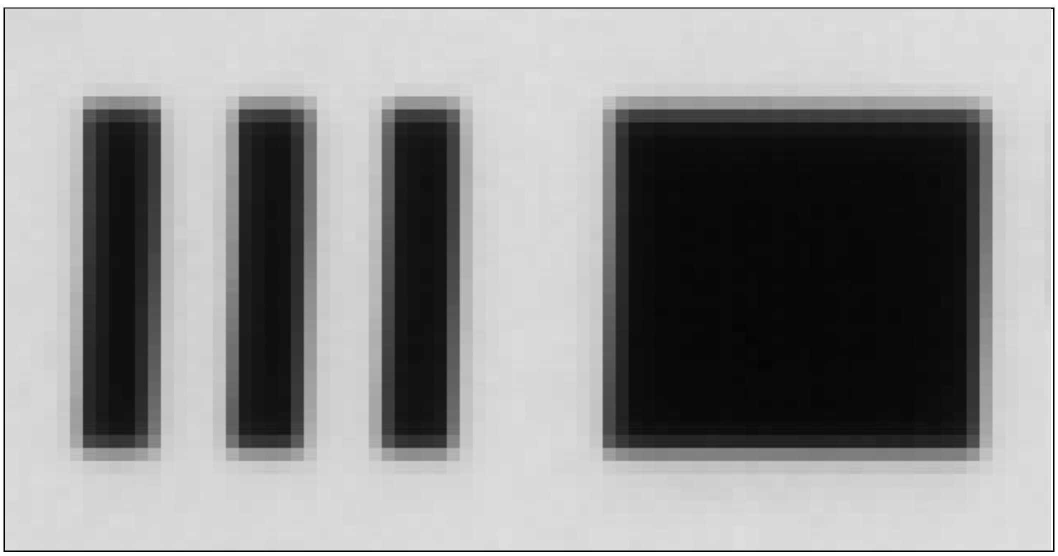
Assuming that the encoder generates a pulse that is equal to the object pixel, Line Spatial Correction will be 1. However, guaranteeing the encoder pulse accuracy may not always be possible. In addition, lens magnification may not be exact—which will introduce a similar error.

The camera has a Line Spatial Correction feature that can correct for these small encoder or magnification errors on a sub-pixel level. The sub-pixel spatial correction resolution is $1/16^{th}$ of a row. The feature accepts up to two decimal places and will adjust the entered sub-pixel adjustment component accordingly. This feature can only be adjusted when the acquisition is stopped.

Examples of artifacts generated by a small encoder error:



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



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

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

For example, as the camera angle moves away from perpendicular, the image row spacing increases. If the encoder resolution remains at that for perpendicular operation, many encoder pulses will be too closely spaced, apparent row spacing will increase and the line spatial correction will need to change. The Line Spatial correction feature can accommodate these potentially larger encoder errors where the spatial correction value has an adjustment range from 0 to 1.5.

The following section details more aspects of using the camera at angles.

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

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

Related Features: imageDistortionCorrectionMode, imageDistortionCorrectionAlgorithm, imageDistortionCorrectionLineSelector, imageDistortionParallaxCorrectionPixelStretch

When using a camera at an angle to the objects surface, the object pixel sizes for the three arrays are slightly different—this is due to parallax.

If the camera angle and the lens angular field of view are sufficiently large it may cause blurring at the extremities of the image in TDI mode. The camera includes a Parallax feature that can correct these artifacts.

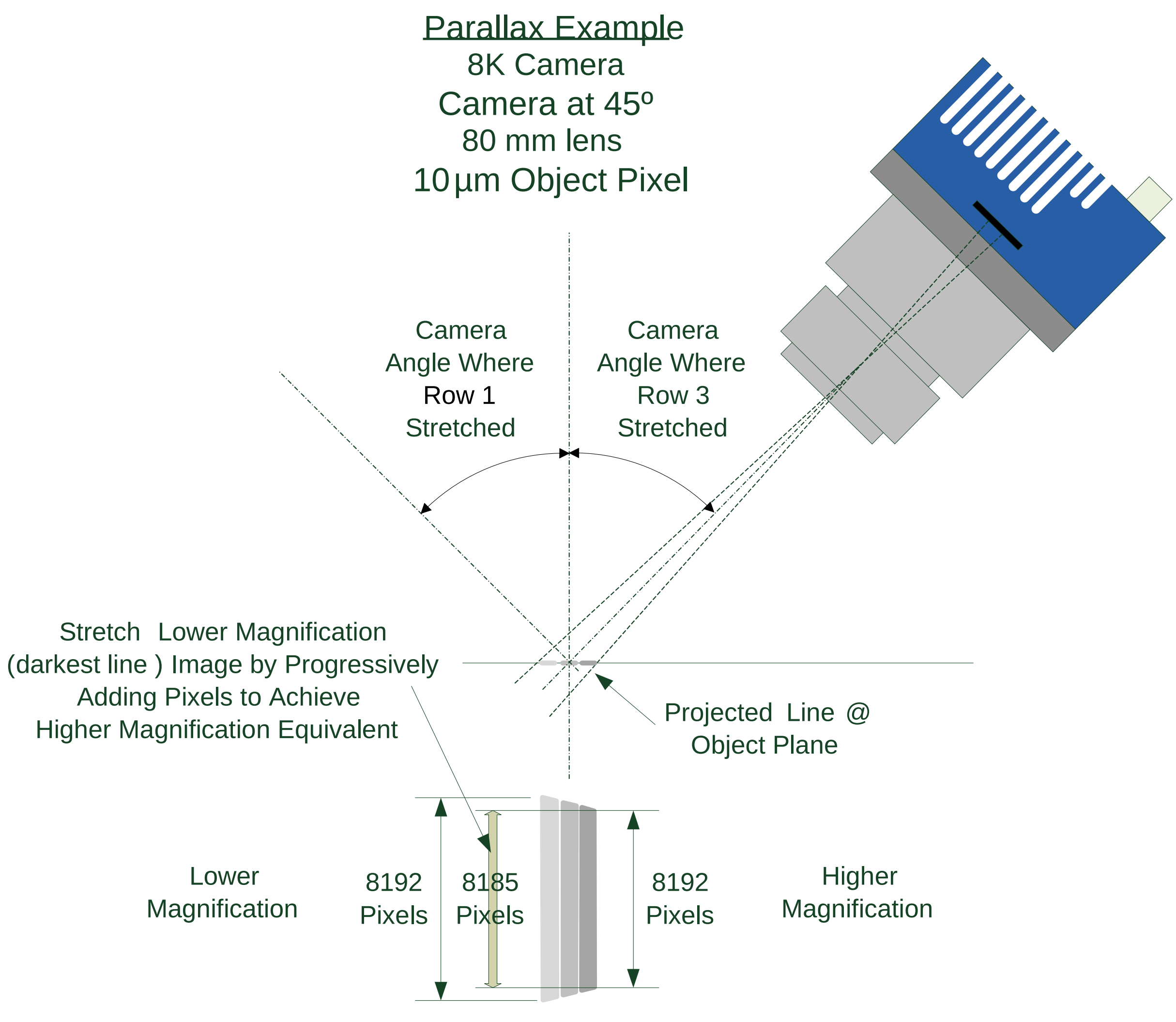


Figure 16. Camera Angle Creates Parallax

Notes:

- The selection of the line to adjust is dependent on positive or negative angle. It is not sensitive to scan direction.

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

30^{O} Camera Angle, 8k Camera, 80 mm lens, 20 µm Object Pixel,
Spatial Correction =9.2, No Parallax Correction

Establishing the Desired Response

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

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

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

The ideal test setup meets the following conditions:

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

Exposure Mode

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

Related Features: ExposureMode (Timed, Sequential)

ExposureMode has 2 options: Timed and Sequential. Timed is the standard exposure operation as found in Teledyne DALSA line scan cameras. For operation of sequential mode, please see the section titled Exposure Mode Sequential. See the Exposure Control Section.

Line Rate Jitter

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

Exposure Control

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

Related features: ExposureMode, exposureTimeSelector, exposureDelay, ExposureTime

The camera has two exposure modes:

- Timed: where the sensor rows are exposed at the same time.
- Sequential: where the sensor rows are exposed one after the other.

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

Timed Exposure Mode

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

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

Sequential Exposure Mode

In this mode the rows are exposed in order: 0, 1, 2, 3. Use this for multi-spectral imaging using strobe illumination. In this mode the delay before the exposure can be configured for each row. The counters are smaller in this mode and so the maximum delay or exposure time is 45.48 µs. Similar to timed mode, the sum of the delays and exposure times will limit the line rate.

Strobe lighting is synchronized using the General Purpose Outputs in the Digital IO Control category. Set the row with the LineSelector feature. Set the outputLineSource to On. And then set the outputLinePulseDelay, outputLinePulseDuration, and LineInverter.

Exposure Time Selector

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

Relevant Feature: exposureTimeSelector

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

Note: If TDIstagesSelector is set to 2 or 3 all lines will automatically be set to the same exposure time.

Sequential Mode Application Example

The Linea ML is equipped with an innovative new mode that allows each line of the sensor to be exposed in a serial sequence with a single trigger applied to the camera. This can allow an object to be imaged with various lighting condition on a single pass of the image object past the camera.

A typical camera/lighting setup is illustrated below in Figure 17. In this application the system consists of bright field, dark field and back lighting to allow imaging of the object. The camera has the ability to control the lighting in coordination with the exposure on each sensor line.

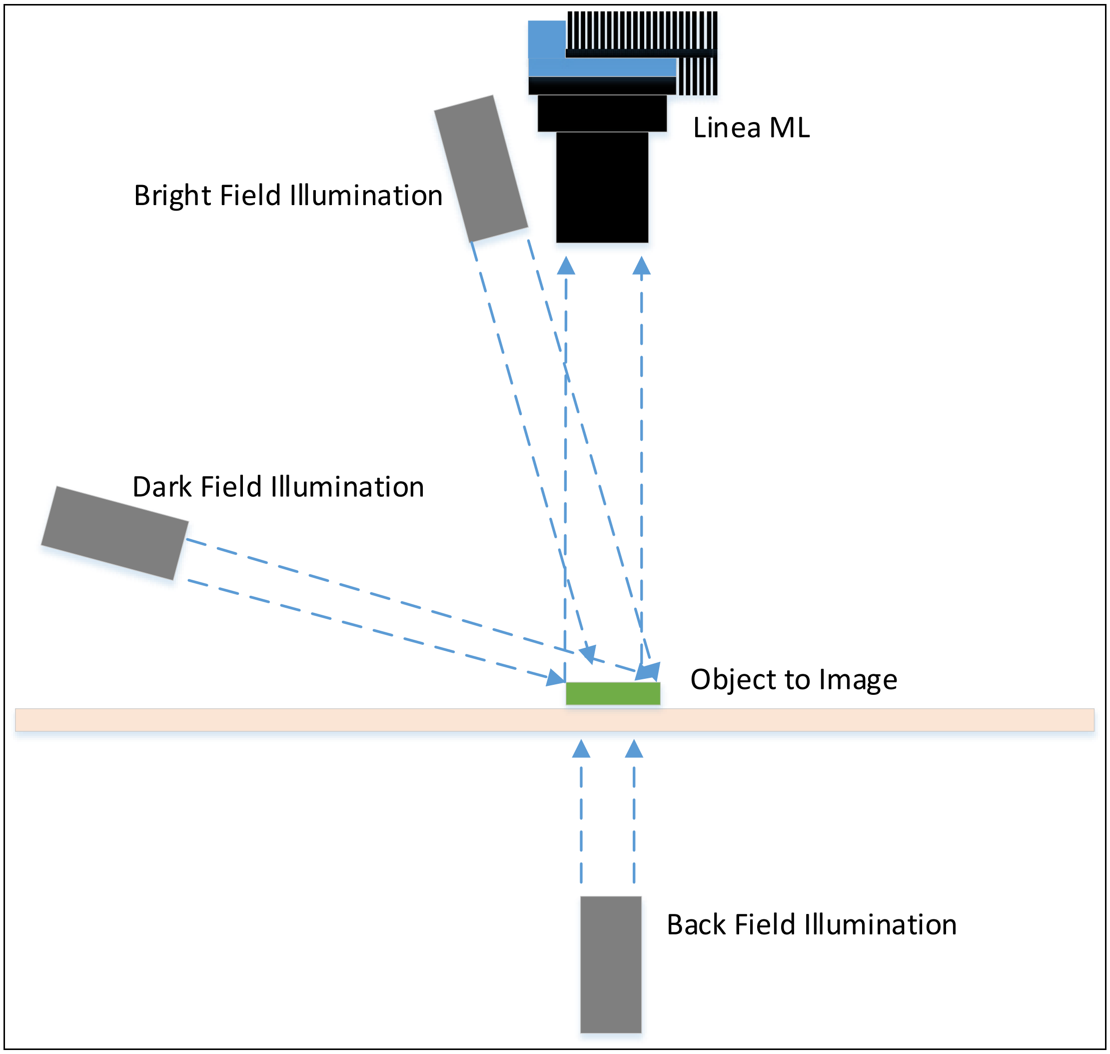


Figure 17. Typical Lighting Configuration

Exposure Mode Sequential

Relevant Features: ExposureMode, ExposureTime, ExposureDelay, TriggerDelay, outputLinePulseDelay, outputLinePulseDuration

Unique to the Linea ML camera is the sequential exposure mode. For each trigger entering the camera the exposure for each line can be executed separately and in a serial sequence. This allows the user to set up different lighting conditions for each line. The figure below shows a typical time case for exposure mode sequential:

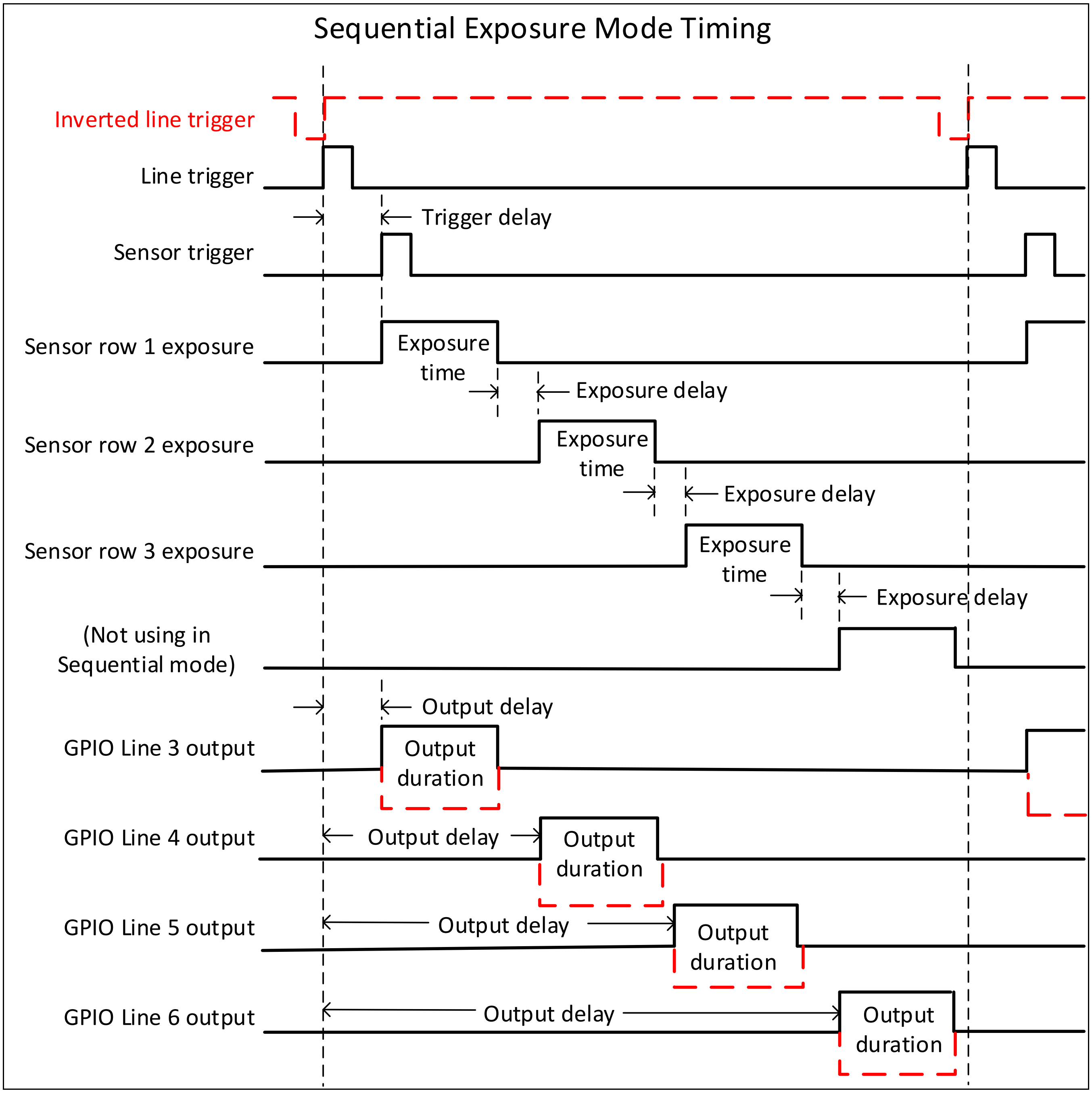


Figure 18 Typical Sequential Timing

The trigger signal entering the camera is routed to the sensor and also to each of the output control features.

The TriggerDelay feature delays the trigger going to the sensor. This delay allows the user to turn on the LED before exposing the sensor.

Each line can be delayed relative to the previous line using the ExposureDelay feature.

Note: The ExposureDelay feature can only be applied to the second, third or fourth lines being exposed.

The exposures for each line cannot overlap.

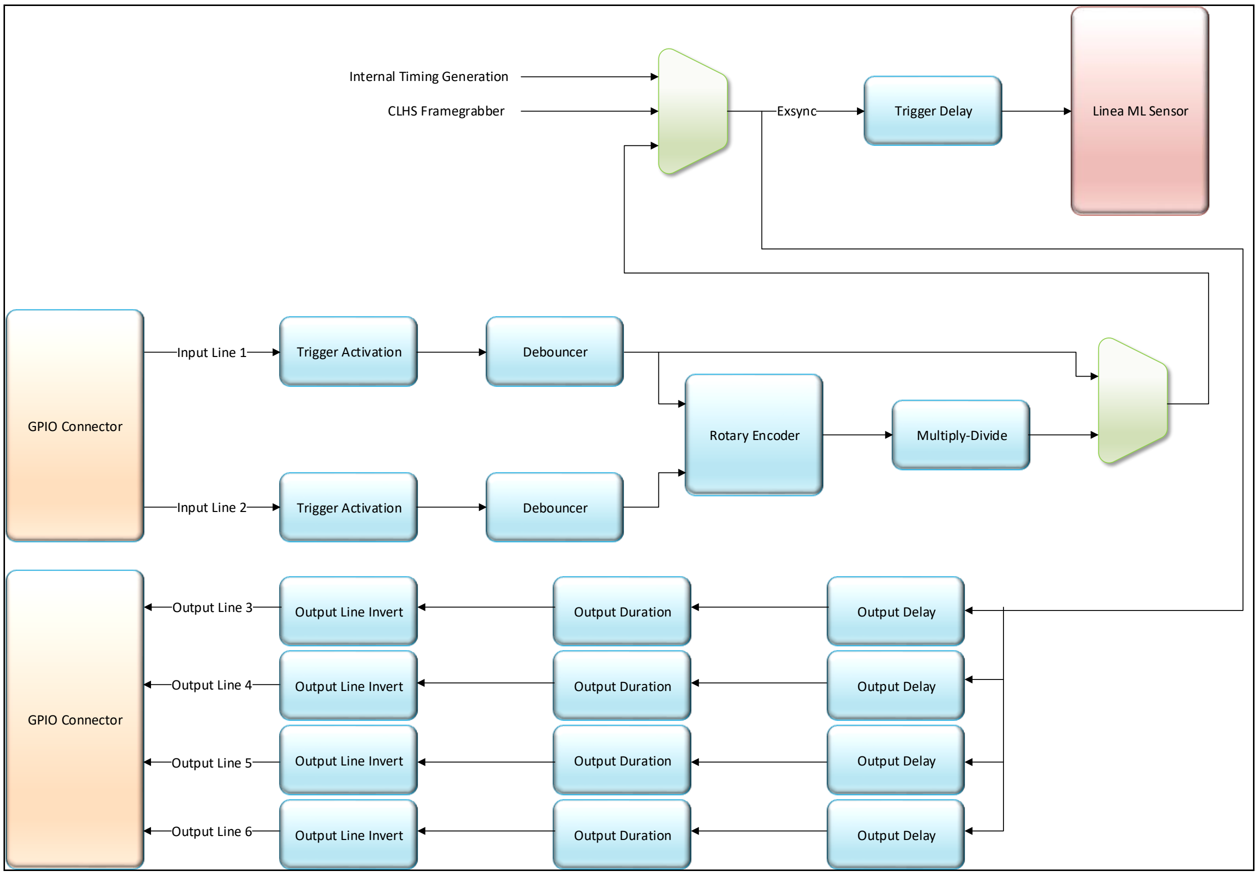


Figure 19. GPIO block diagram

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

Adjusting Responsivity

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

Relevant Features: GainSelector, Gain

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

There are two gain adjustments available: sensor row gains, which can be set independently for each sensor row; and the system gain, which is applied to all sensor rows.

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, Calibration Target

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

The camera can compensate for edge roll-off and other optical non-uniformities 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, and illumination intensity, spectral content, plus illuminator beam structure.
- Flat field calibration should be performed when the camera temperature has stabilized.
- When the camera is asked to run a flat field calibration it will adjust all pixels to have the same value as that of the peak pixel value or target level, as per the calibration mode selected.
- If 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 that the best flat field calibration can be achieved by performing it at the mid DN level of the working range used in the operation. Any flat field error associated with residual non-linearity in the pixel will be halved as compared to performing a calibration at the peak value of the operating range. A simple way of performing this is to reduce exposure time to half what is used in the operation in order to get the mid DN level for flat field calibration. Once complete, return the exposure time to its original setting.

Those areas of the image where high roll-off is present will show higher noise levels after flat field calibration due to the higher gain values of the correction coefficients. Flat field calibration can only compensate for up to an 8:1

variation. If the variation exceeds 8:1 then the line profile after calibration will include pixels that are below the un-calibrated peak level.

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

Saving & Rapidly Loading a PRNU Set Only

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

Use the User PRNU Set Selector parameter to select the set you want to save or load. 17 sets are available—16 user and 1 factory. Loading the Factory Set is a good way to clear the user PRNU.

The *Factory Set* is read-only. 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” feature. 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 file format is described in the document 03-084-20133 Linea ML Binary File Format, which can be obtained from Teledyne DALSA Technical Support. This document also includes Excel spread sheet examples.

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 section 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. This filter is a 33 pixel moving average.

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: flatfieldROIOffsetX, flatfieldROIWidth

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, the next ROI can be defined and flat field calibrated.

TDI Stage Selections and Full Well

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

Relevant Features: sensorTDIModeSelection, sensorTDIStagesSelection, sensorFullWellMode

The camera's sensor has 3 high-responsivity lines. These line scans be summed to further increase the responsivity. The TDI Stage Selection feature with values of 1, 2, or 3 lines allows the user to increase the responsivity proportionally but at the sacrifice of the maximum line rate.

Lines Summed / Averaged	Maximum Line Rate, 8 bit
1	300 kHz
2	150 kHz
3	100 kHz

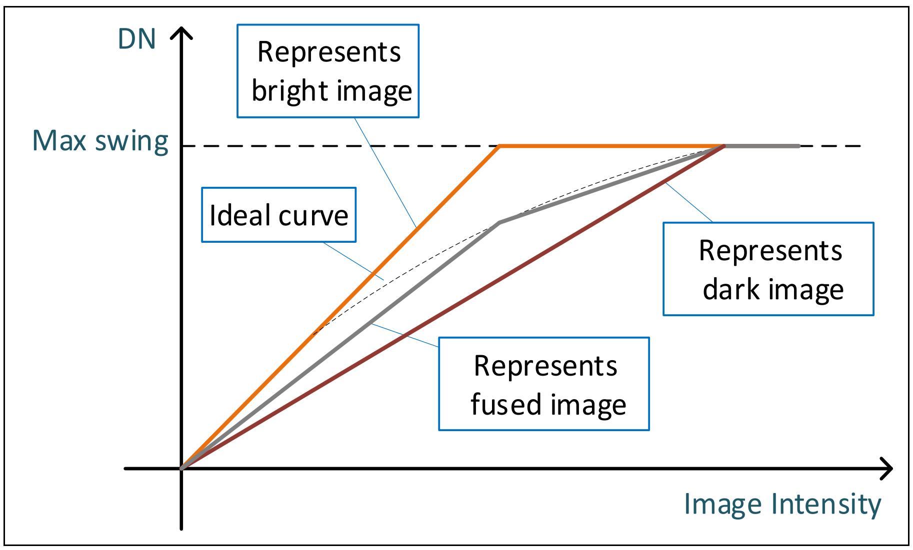
Along with a reduction in line rate, other features need to be considered when using the stage selection feature. SensorScanDirection and sensorLineSpatialCorrection need to be set correctly if summing 2 or more lines using the TDI stage selection control. If only using one line, sensorScanDirection and sensorLineSpatialCorrection are not relevant.

SensorTDIMode allows the user to either sum the lines or average the lines. This allows the user to optimize the responsivity/full well or the signal to noise ratio.

If using 1 line only, there is the option of having high or low full well, using the sensorFullWellMode. There is a 4x difference in responsivity between these two modes and also a 4x difference in the full well.

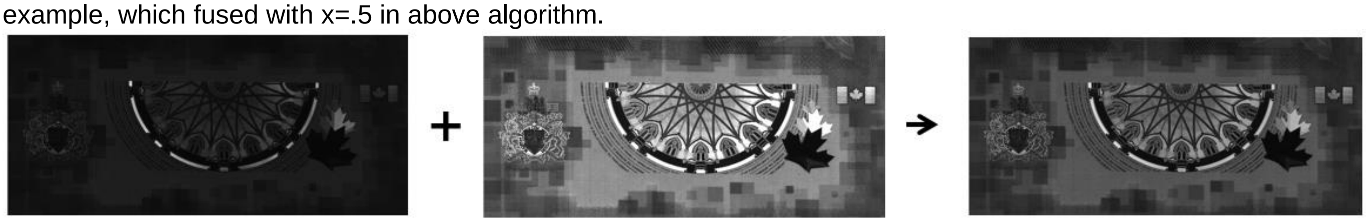
HDR Demo Mode

In planar mode, the camera can be configured to output sensor row 0 and 1 separately. Under the same conditions, the row 1 is 4x more responsive than the row 0. The contrast ratio does not always have to be 4:1, it can be varied depending on the contrast of the object. The user can change the ratio by changing the exposure time and/or gain. Two different responsivities give two different intensity images in a single scan. In conjunction with the user's algorithms, a High Dynamic Range (HDR) image can be created based on the two images. This merging process is called fusing. The goal of fusing is to replace all low contrast parts with the bright image accordingly and replace all saturated or near saturated parts with the dark image accordingly. Simple replacement, however, does not generate a seamless image, which we desire. In order to get an image which dark parts are enhanced, but no saturations occur, and which is fused seamlessly, an algorithm needs to be applied.



The HDR Demo mode demonstrates HDR imaging with a simple fusing algorithm, *y = ax + b (1-x), where 0<x<1, a and b represent dark and bright images, respectively.*

The gray curve in above graph represents this algorithm's result. The result is moderate, yet not perfect. The user can develop their own algorithm to better suit their applications' requirements. The following is a banknote example, which fused with x=.5 in above algorithm.



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: Horizontal Binning, Vertical Binning

In certain applications, lower image resolution may be acceptable if the desired defect detection can still be achieved.

Binning is a process whereby adjacent pixels are summed. The camera supports 1x, 2x, and 4x binning in both horizontal and vertical directions.

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

Vertical 2x binning will half the line rate output because two triggers are required read out the two lines to be summed. 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. In these cameras, since adjacent pixels are summed (not averaged) the image gets brighter. 1 x 2 and 2 x 1 are twice as bright, 2 x 2 is four times brighter.

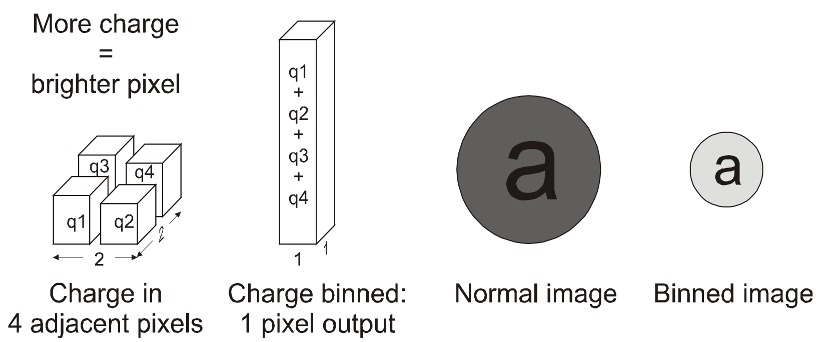


Figure 20. 2x2 Binning

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 to Reduce Image Data & Enhance Performance

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

Related Features: AOI Count, AOI Selector, AOI Offset, AOI Width

If the camera's field of view includes areas that are not needed for inspection (also refer to the description in the 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's, it will be able to extract and process each individual AOI from the single larger image.

Steps to Setup Area of Interest

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

Rules for Setting Areas of Interest

The rules are dictated by how image data is organized for transmission over the available CLHS data lanes.

- The camera / XML will enforce these rules, truncating entered values where necessary.

1. Acquisition must be stopped to change the AOI configuration.
2. 1-4 AOI's can be selected.
3. Minimum width is 96 pixels per AOI.
    a. Minimum total of all AOI widths summed together must be at least 1,024.
4. Maximum width of all AOI widths summed together must be no more than = 16,384.
    a. There can be maximum 8k bytes per CLHS lane.
5. AOI width step size is 32 pixels.
6. The offset of each AOI may be 0 to (16,384 – 96 = 16,288).
    a. Therefore, overlapping AOI's are allowed.
7. Offset and width for individual AOI's will "push" one another.
    a. E.g. if AOI has offset 0, width 16,384, and the offset is changed to 4096, then the width will be "pushed" to 12,288.
    b. AOI's only affect one another by limiting the maximum width.
8. AOI's are concatenated together in numerical order and sent to the frame grabber starting at column zero.
9. If the AOI count is reduced to less than the current AOI count, the AOI selector will be changed to the largest of the new AOI count available.

Customized Linearity Response (LUT)

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

Related Features: lutMode, gammaCorrection

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

The Linea ML 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 ML Binary File Format which can be obtained from Teledyne DALSA Technical Support. This document also includes Excel spread sheet examples.

How to Generate LUT with CamExpert

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

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

Important points:

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

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: Gain Selector, Gain, Offset

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

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

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

The camera has an offset feature that allows a specified level to be subtracted from the image data. The gain feature can then be used to return the peak image data to near output saturation with the result being increased image contrast.

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

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

Changing Output Configuration

Pixel Format

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

Related Feature: Pixel Format

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

The Mono8 Pixel Format are selected when the user wants to process image data as one, two, or three separate image planes.

Note: The Pixel Format and associated features 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 acquisitions.

Using Two CLHS Cables

See the section Image Format Control Category in Appendix A for GenICam features associated with this section and how to use them. ML-FM camera models support up to 2 fiber optic cables. ML-HM models only support 1 CX4 output connector.

Relevant Features: Next CLHS Device Configuration

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

Saving & Restoring Camera Setup Configurations

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

Related Features: Power-up Configuration Selector, UserSet1 thru UserSet16, User Set Selector, Power-on User Set, Current User Set

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

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

The relationship between the settings is illustrated in Figure 21. Relationship between the Camera Settings:

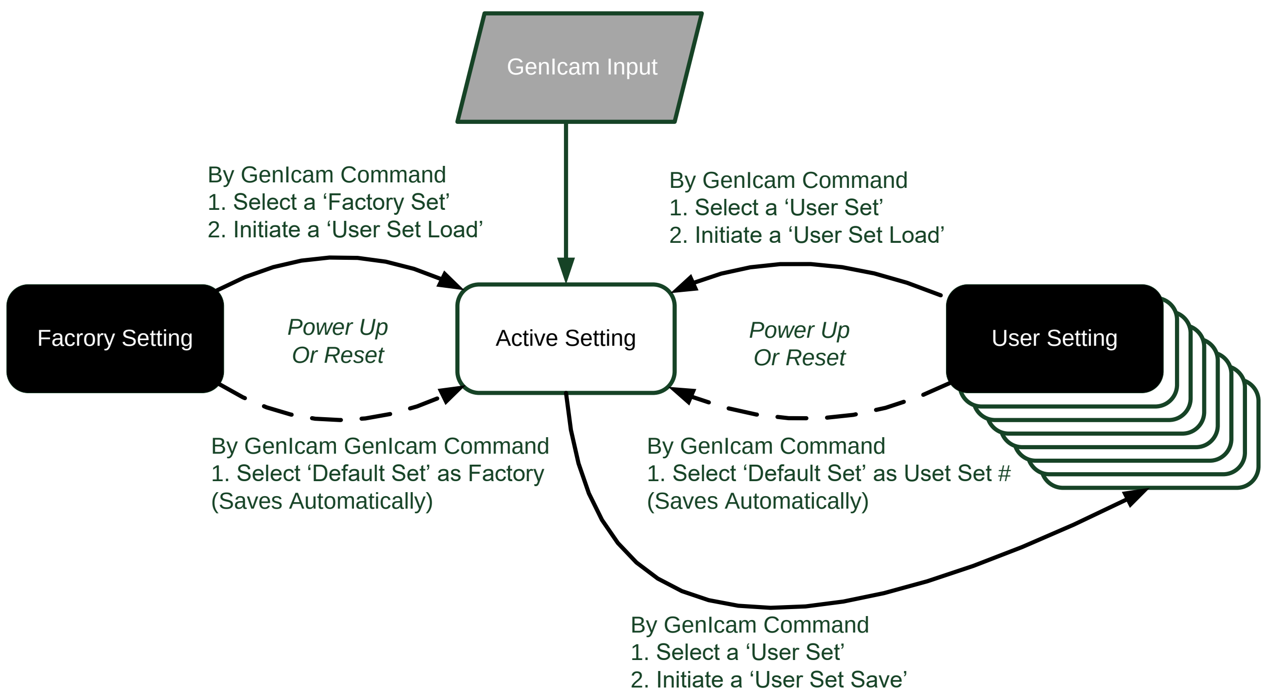


Figure 21. Relationship between the Camera Settings

Active Settings for Current Operation

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

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

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

User Setting

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

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

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

Factory Settings

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

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

Default Setting

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

Appendix A: GenICam Commands

This appendix lists the available GenICam camera features. The user may accesses 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 Standard 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: CamExpert examples are 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.

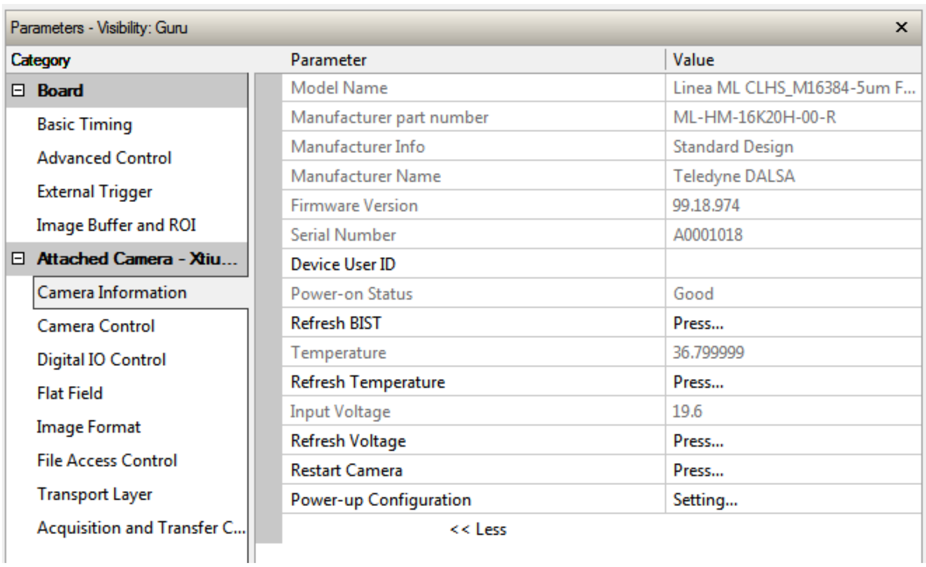


Figure 22: CamExpert Camera Information Category

Camera Information Feature Descriptions

Display Name	Feature	Description	Standard & View
Model Name	DeviceModelName	Displays the device model name. (RO)	Beginner
Vendor Name	DeviceVendorName	Displays the device vendor name. (RO)	Beginner
Part Number	deviceManufacturesPartNumber	Displays the device vendor part number. (RO)	Beginner
Standard	DeviceVersion	Displays the Standard. Highlights if the firmware is a beta or custom design. Updates when firmware upgraded. (RO)	Beginner
Manufacturer Info	DeviceManufacturerInfo	This feature provides extended manufacturer information about the device. E.g. Whether product is standard or custom. (RO)	Beginner
Serial Number	DeviceSerialNumber	Displays the device's factory set camera serial number. Same as the camera label. (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-up Configuration Selector	UserSetDefaultSelector	Selects the camera configuration set (Factory, UserSet 1 – 16) to load and make active on camera power-up or reset. The camera configuration sets are stored in camera non-volatile memory. (RW)	Beginner

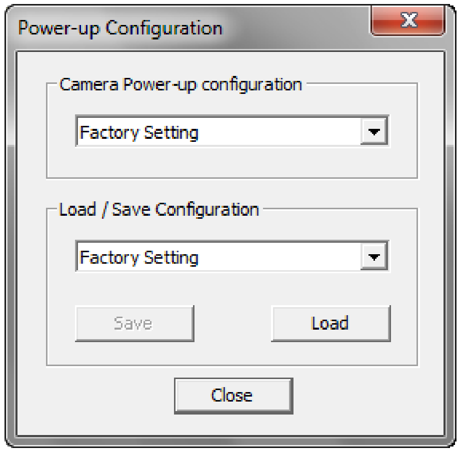
Display Name	Feature	Description	Standard & View
Load & Save Configuration	UserSetSelector	Selects the camera configuration set (Factory, UserSet 1 – 16) to load feature settings from or save current feature settings to. The Factory set contains default camera feature settings. (RW)	Beginner
Power-on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

Built-In Self-Test Codes (BIST)

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

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

Camera Power-Up Configuration Selection Dialog



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

Camera Power-up Configuration

The first drop list selects the camera configuration state to load on power-up (see feature *UserSetDefaultSelector*). The user chooses from 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.

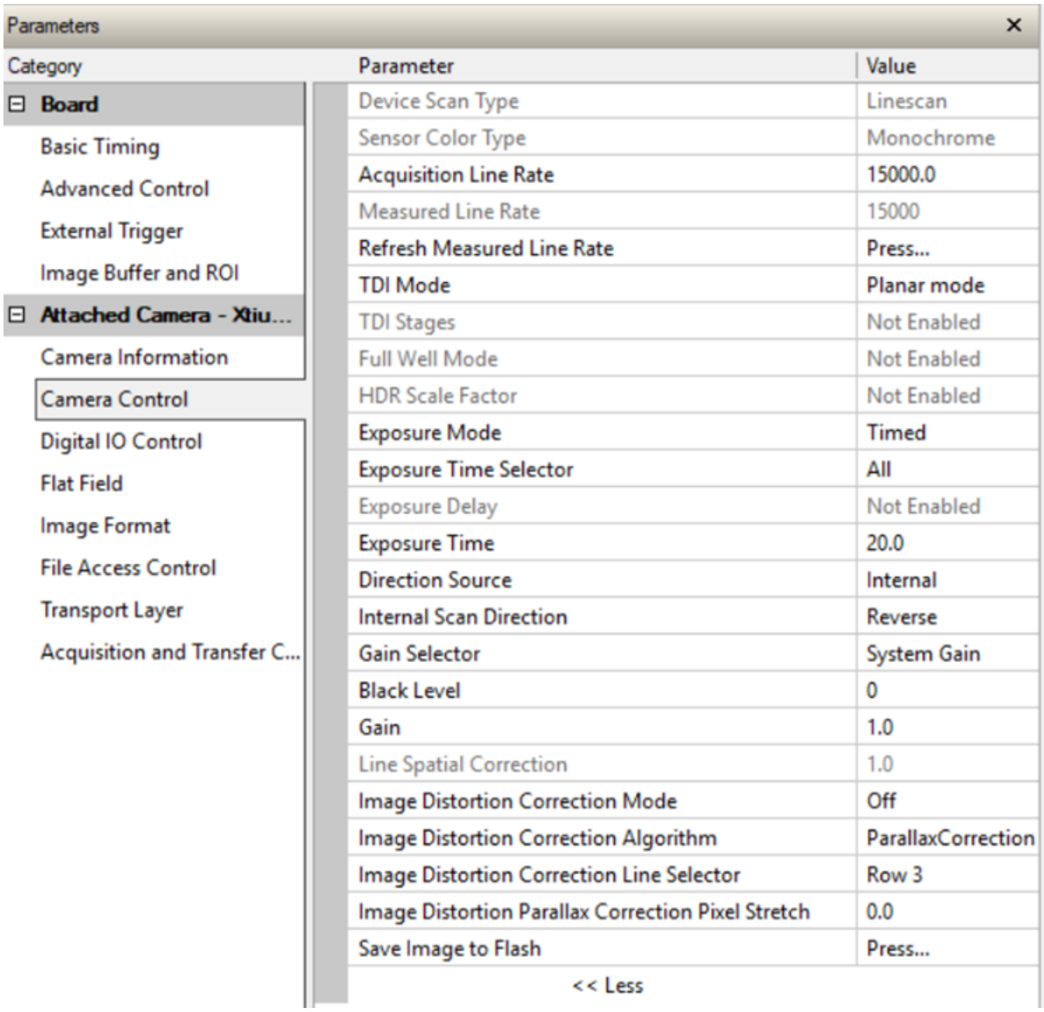


Figure 23: CamExpert Camera Control Category

Camera Control Feature Descriptions

Display Name	Feature	Description	Standard & View
Device Scan Type	DeviceScanType	Used to set the camera scanning mode. Only standard line scan mode is available. (RO)	Beginner
Linescan	*Linescan*	*Linescan sensor.*	
Sensor Color Type	sensorColorType	Identifies the sensor color type “Monochrome.” (RO)	Beginner
Acquisition Line Rate	AcquisitionLineRate	Specifies the camera internal line rate, in Hz when Trigger mode set to internal.	Beginner
Measured Line Rate	measuredLineRate	Specifies the line rate provided to the camera by either internal or external source (RO)	Beginner DFNC
Refresh Measured Line Rate	refreshMeasuredLineRate	Press to update measuredLineRate.	Beginner DFNC
TDI Mode	sensorTDIModeSelection	Used to select the camera mode of operation	Beginner DFNC
Planar Mode	*TdiOff*	*Each row enabled is output starting with low CCE (charge conversion efficiency).*	
Summed	*TdiSum*	*Rows summed together (starting with second sensor row).*	
Average	*TdiAvg*	*Rows averaged (starting with second sensor row).*	
HDR Demo	*TdiHdr*	*Combines high and low full well sensor rows to produce a single High Dynamic Range row.*	
TDI Stages	sensorTDIStagesSelection	Used to determine the number of rows to be summed or averaged. Not enabled when in planar or HDR modes. In planar mode the lines to output are configured using the component features in the Image Format category. HDR is fixed to the bottom two lines.	Beginner DFNC
1	*Lines1*	*Single line.*	
2	*Lines2*	*Two lines summed/averaged together.*	
3	*Lines3*	*Three lines summed/averaged together.*	
Full Well Mode	sensorFullWellMode	Selects between low and high full well sensor row when TDI Stages is one. Low full well is four times more responsive.	Beginner DFNC
Low	*Low*	*Low full well row.*	
High	*High*	*High full well row.*	

Display Name	Feature	Description	Standard & View
Exposure Mode	ExposureMode	Sets the operation mode for the camera's exposure (or shutter). (RO)	Beginner
Timed	*Timed*	*The sensor lines are exposed at the same time. The exposure duration time is set using the Exposure Time feature. If the lines have different exposure times then the longest starts immediately after the line trigger and the others are delayed so that they all finish at the same time.*	
Sequential	*Sequential*	*Put the camera in a mode where each line will be exposed separately but in a serial sequence*	
Exposure Time Selector	exposureTimeSelector	Select which sensor line the exposure time applies to	Beginner DFNC
Exposure Delay	exposureDelay	In Sequential exposure mode this feature defines the delay before each line is exposed. May be different for each row.	Beginner DFNC
Exposure Time	ExposureTime	Sets the exposure time (in microseconds).	Beginner
Direction Source	SensorScanDirectionSource	This feature specifies how the scan direction is controlled.	Beginner
Internal	*Internal*	*Direction set with the sensorScanDirection feature*	
Line 2	*GPIO2*	*Direction controlled by Line 2:* *Forward: low* *Reverse: high*	
Rotary Encoder	*Encoder*	*Direction is determined from the shaft encoder. Only available when shaft encoder has been selected as the trigger source.*	
Internal Scan Direction	sensorScanDirection	When ScanDirectionSource is set to Internal, determines the direction of the scan.	Beginner
Forward	*Forward*		
Reverse	*Reverse*		
Gain Selector	GainSelector	Used to select which sensor line the gain is applied to.	Beginner
System Gain	*System*	*Overall camera gain applied to every sensor line equally.*	
All Rows	*All*	*Gain applied to all sensor lines.*	
Sensor Row 0	*Line0*	*Gain applied to all sensor row 0 only.*	
Sensor Row 1	*Line1*	*Gain applied to all sensor row 1 only.*	
Sensor Row 2	*Line2*	*Gain applied to all sensor row 2 only.*	
Sensor Row 3	*Line3*	*Gain applied to all sensor row 3 only.*	
Gain	Gain	Sets the gain as per the gain selector setting.	Beginner
Black Level	BlackLevel	Controls the black level as an absolute physical value. This represents a DC offset applied to the video signal, in DN (digital number) units. The value may be positive or negative.	Beginner
Line Spatial Correction	sensorLineSpatialCorrection	Sets the number of rows each line is delayed to establish spatial alignment. Must stop acquisition to change.	Beginner DFNC
Image Distortion Correction Mode	imageDistortionCorrectionMode	Used to enable parallax correction.	Expert DFNC
Off	*Off*		
Active	*Active*		

Display Name	Feature	Description	Standard & View
Image Distortion Correction Algorithm *ParallaxCorrection*	imageDistortionCorrectionAlgorithm *ParallaxCorrection*	Read only. Indicates the type of correction algorithm used, for example, Parallax.	Expert DFNC
Image Distortion Correction Line Selector *Row 1* *Row 3*	imageDistortionCorrectionLineSelector *Row1* *Row 3*	Used to select which line will be stretched to correct the image	Expert DFNC
Image Distortion Parallax Correction Pixel Stretch	imageDistortionParallaxCorrectionPixelStretch	The stretch value in pixels at the ends of line one or three. Note the stretch value for line two is always half that of the stretch value regardless of which line is selected.	Expert DFNC
Save Image To Flash	saveLastImageToFlash	Captures the current line and saves it to the cameras Flash memory as a TIFF file that can be retrieved using the File Access Control Features	Guru

Digital I / O Control Category

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

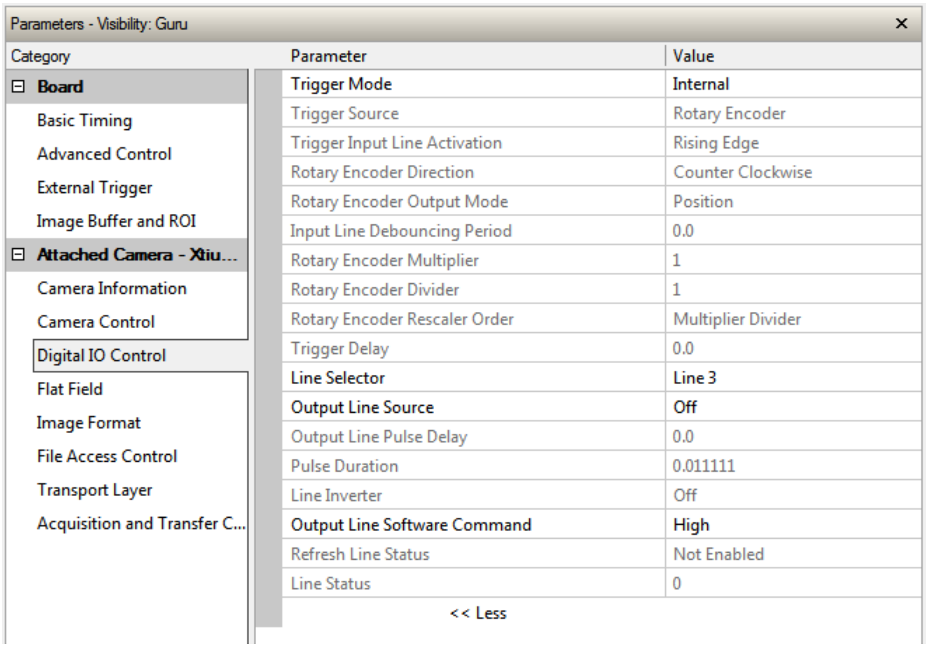


Figure 24: CamExpert Digital I/O Control Category

Digital I/O Control Feature Descriptions

Display Name	Feature	Description	Standard & View
Trigger Mode	TriggerMode	Determines the source of trigger to the camera, internal or external	DFNC Beginner
	Internal		
	External		
Trigger Source	TriggerSource	Determines the source of external trigger	DFNC Beginner
	CLHS In	*Source of trigger is from the frame grabber.*	
	Rotary Encoder	*Source of trigger is from the two shaft encoder inputs.*	
	GPIO1	*Source of trigger is from Line 1 of the GPIO connector.*	
Trigger Input Line ActivationEdge	TriggerActivation	Determines which edge of a input trigger will activate on. The two inputs are XOR'd together when Shaft Encoder is selected to provide a single signal.	DFNC Beginner
	RisingEdge	*The trigger is considered valid on the rising edge of the line source signal (after any processing by the line inverter module).*	
	FallingEdge	*The trigger is considered valid on the falling edge of the line source signal.*	
	AnyEdge	*The trigger is considered valid on any edge.*	

Display Name	Feature	Description	Standard & View
Rotary Encoder Direction	rotaryEncoderDirection	Specifies the phase which defines the encoder forward direction.	DFNC Beginner
Counter Clockwise	*CounterClockwise*	*Inspection goes forward when the rotary encoder direction is counter clockwise (phase A is ahead of phase B).*	
Clockwise	*Clockwise*	*Inspection goes forward when the rotary encoder direction is clockwise (phase B is ahead of phase A).*	
Rotary Encoder Output Mode	rotaryEncoderOutputMode	Specifies the conditions for the Rotary Encoder interface to generate a valid Encoder output signal.	DFNC Beginner
	Position	*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	*The triggers are generated for all motion increments in either direction.*	
Input Line Debouncing Period	lineDebouncingPeriod	Specifies the minimum delay before an input line voltage transition is recognizing as a signal transition.	DFNC Beginner
Rotary Encoder Multiplier	rotaryEncoderMultiplier	Specifies a multiplication factor for the rotary encoder output pulse generator.	DFNC Beginner
Rotary Encoder Divisor	rotaryEncoderDivider	Specifies a division factor for the rotary encoder output pulse generator.	DFNC Beginner
Rotary Encoder Rescaler Order	rotaryEncoderRescalerOrder	Specifies the order that the multiplier and divider are applied.	DFNC Beginner
Multiplier Divider	*multiplierDivider*	*The signal is multiplied before been divided.*	
Divider Multiplier	*dividerMultiplier*	*The signal is divided before been multiplied.*	
Trigger Delay	TriggerDelay	Allows the trigger to the sensor to be delayed relative to camera input trigger	DFNC Beginner
Line Selector	LineSelector	Selects the physical line (or pin) of the external device connector to configure.	DFNC Beginner
Line 1	*GPIO 1*	*External trigger or rotary encoder A.*	
Line 2	*GPIO 2*	*External direction or rotary encoder B.*	
Line 3	*GPIO 3*	*Output 1.*	
Line 4	*GPIO 4*	*Output 2.*	
Line 5	*GPIO 5*	*Output 3.*	
Line 6	*GPIO 6*	*Output 4.*	
Output Line Source	outputLineSource	Selects which internal signal to output on the selected line.	DFNC Beginner
On	*On*	*Current output line is set with outputLineSoftwareCmd*	
Off	*Off*	*Current output line is configured with outputLinePulseDelay, outputLinePulseDuration, and LineInverter.*	
Output Line Pulse Delay	outputLinePulseDelay	Sets the delay (in µs) before the output line pulse signal. Applicable for the OutputLineSource feature.	DFNC Beginner
Output Line Pulse Duration	outputLinePulseDuration	Sets the width (duration) of the output line pulse in microseconds.	DFNC Beginner
Line Inverter	LineInverter	Controls whether to invert the polarity of the selected input or output line signal.	DFNC Beginner
On	*On*		
Off	*Off*		

Display Name	Feature	Description	Standard & View
Output Line Software Command *Low* *High*	outputLineSoftwareCmd *Low* *High*	Set the GPIO out value when outputLineSource is off.	DFNC Expert
Refresh Line Status	refreshLineStatus	Command CamExpert to update LineStatus	DFNC Expert
Line Status *Low* *High*	LineStatus *Low* *High*	Returns the current status of the line selected with LineSelector. (RO)	DFNC Expert

Flat Field Category

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

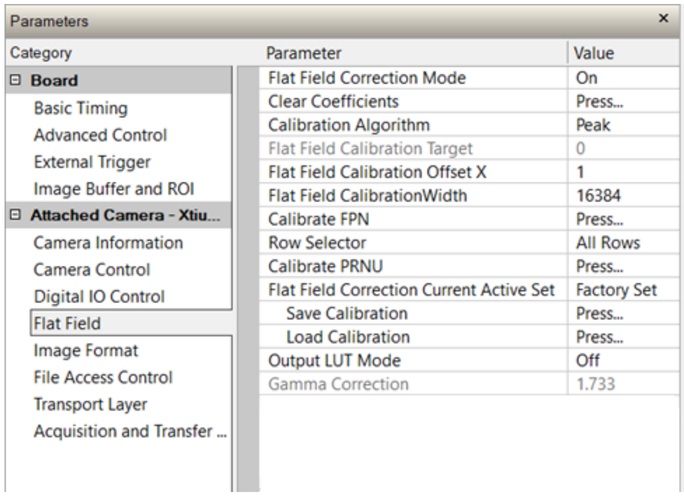


Figure 25: CamExpert Flat Field Category

Flat Field Control Feature Descriptions

Display Name	Feature	Description	Standard & View
Flat Field Correction Mode	flatfieldCorrectionMode		Beginner DFNC
	Off	*FPN and PRNU correction disabled.*	
	On	*FPN and PRNU correction enabled.*	
Clear Coefficents	flatfieldCalibrationClearCoefficient	Reset all FPN to 0 and all PRNU coefficients to 1.	
Calibration Algorithm	flatfieldCorrectionAlgorithm	Selection between four different PRNU algorithms.	Beginner DFNC
Peak	*Peak*	*Calculation of PRNU coefficients to bring all pixels to the peak.*	
Peak, Image Filtered	*PeakFilter*	*A low pass filter is applied to the average line values before calculating the coefficients. Use this algorithm if the calibration target is not uniformly white or if it is not possible to defocus the image. Because of the low pass filter, this algorithm is not able to correct pixel-to-pixel variations and so it is preferable to use the “Peak” algorithm.*	
Set Target	*Target*	*Calculation of PRNU coefficients to bring all pixels to the target value.*	
Set Target, Image Filtered	*TargetFiltered*	*A low pass filter is applied to the average line values before calculating the coefficients. Use this algorithm if the calibration target is not uniformly white or if it is not possible to defocus the image. Because of the low pass filter this algorithm is not able to correct pixel-to-pixel variations and so it is preferable to use the “Target” algorithm.*	
Flat Field Calibration Target	flatfieldCalibrationTarget	Sets the target value for the “Calibrate PRNU” feature.	
Flat Field ROI Offset X	flatfieldCalibrationROIOffsetX	Set the starting point of a region of interest where a flat field calibration will be performed	Beginner DFNC

Display Name	Feature	Description	Standard & View
Flat Field ROI Width	flatfieldCalibrationROIWidth	Sets the width of the region of interest where a flat field calibration will be performed	Beginner DFNC
Calibrate FPN	flatfieldCalibrationFPN	Initiates the FPN calibration process	Beginner DFNC
Calibrate PRNU	flatfieldCalibrationPRNU	Initiates the PRNU calibration process	Beginner DFNC
Flat Field Correction Current Active Set	flatfieldCorrectionCurrentActiveSet	Selects the User PRNU set to be saved or loaded.	Guru DFNC
Factory Set	*Factory*	*Factory set can only be loaded.*	
User Set 1 (1 thru 16)	*UserSet1 (1 thru 16)*	*Only the PRNU values are saved or loaded which is much faster than saving or loading the full Factory or User set.*	
Save Calibration	flatfieldCalibrationSave	Saves the User PRNU set specified by flatfieldCorrectionCurrentActiveSet to the camera.	Guru DFNC
Load Calibration	flatfieldCalibrationLoad	Loads the User PRNU set specified by flatfieldCorrectionCurrentActiveSet to the camera and makes it active.	Guru DFNC
Output LUT Mode	lutMode	Allows the output LUT to be selected	Beginner DFNC
Off	*Off*	*The output LUT is disabled and linear data is output*	
Gamma Correction	*Gamma Correction*	*The output LUT is populated using the gamma correction equation.*	
User Defined	*User Defined*	*LUT uploaded by the user is used.*	
Gamma Correction	gammaCorrection	The output LUT is populated using the following gamma correction equation: $DN_{out} = 255 \times \left(\frac{DN_{in}}{255}\right)^{\frac{1}{\gamma}}$	Beginner DFNC

Image 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.

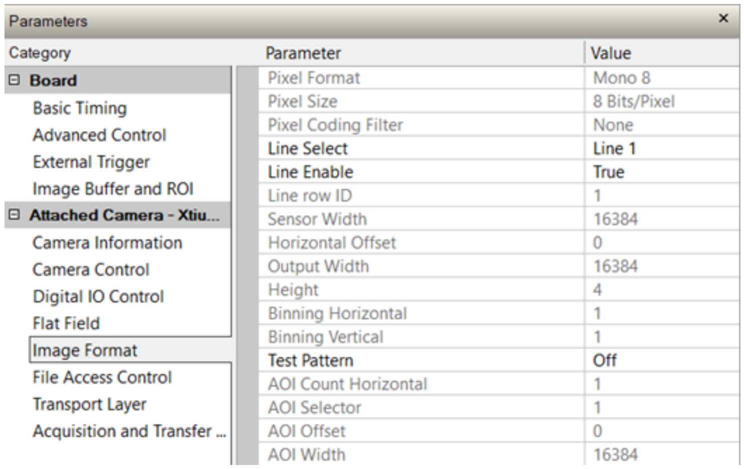


Figure 26: CamExpert Image Format Category

Image Format Control Feature Description

Display Name	Feature	Description	Standard & View
Pixel Format *Mono8* *Mono12*	PixelFormat *Mono8* *Mono12*	Output image pixel coding format of the sensor.	Beginner
Pixel Size	PixelSize	Number of bits per pixel (RO)	
Pixel Color Filter	PixelColorFilter	Always "None" for mono camera (RO)	Beginner DFNC
Line Select	ComponentSelect	Select line (0-3) to enable when in planar mode.	
Line Enable *False* *True*	ComponentEnable *False* *True*	Enable/disables the selected line. Available only in planar mode.	Beginner DFNC
Sensor Width	WidthMax	Indicates the maximum number of pixels available in the long (line) axis the sensor. Read only	Beginner DFNC
Horizontal Offset	OffsetX	Output image horizontal offset from the origin. This is always zero. Read only	Beginner DFNC
Output Width	Width	Horizontal width of the out pixels. Equals the sum of AOI's. Read only	Beginner DFNC
Height	Height	Height of the image provided by the device (in object pixels) [1-4] Read only.	Beginner DFNC
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 [1, 2, 4]	Beginner

Display Name	Feature	Description	Standard & View
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 [1, 2, 4]	Beginner
Test Pattern	TestImageSelector	Selects the type of test image that is sent by the camera.	Beginner DFNC
Off	*Off*	*Selects sensor video to be output from sensor*	
Each Tap Fixed	*EachTapFixed*	*Selects a grey scale value that is increased every 512 pixels.*	
Grey Horizontal Ramp	*GreyHorizontalRamp*	*Selects a grey scale ramp.*	
Grey Vertical Ramp	*GreyVertica Ramp*	*Selects a grey scale ramp progressively for each row.*	
Grey Diagonal Ramp	*GreyDiagonalRamp*	*Selects a combination of horizontal and vertical raps to form a diagonal grey scale.*	
User Pattern	*UserTp*	*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 (128DN) test image.*	
AOI Count	multipleROICount	Specified the number of AOI's in an acquired image, 1 to 4	Beginner
AOI Selector	multipleROISelector	Select 1 of up to 4 AOI's when setting the AOI Offset & AOI Width	Beginner
AOI Offset	multipleROIOffsetX	Location of the start of a single Area of Interest to be output, must be a multiple of 32.	Beginner
AOI Width	multipleROIWidth	Width of the start of a single Area of Interest to be output. Minimum is 96 per lane. e.g., if there is only one AOI spread across the 5 lanes then the minimum is 5 x 96 = 480. Maximum of the sum of AOI width's is the sensor width. e.g., for a 16k sensor, if there are two AOI's with the first 12k wide, then the second can be no wider than 4k.	Beginner
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*	

Transport Layer Control Category

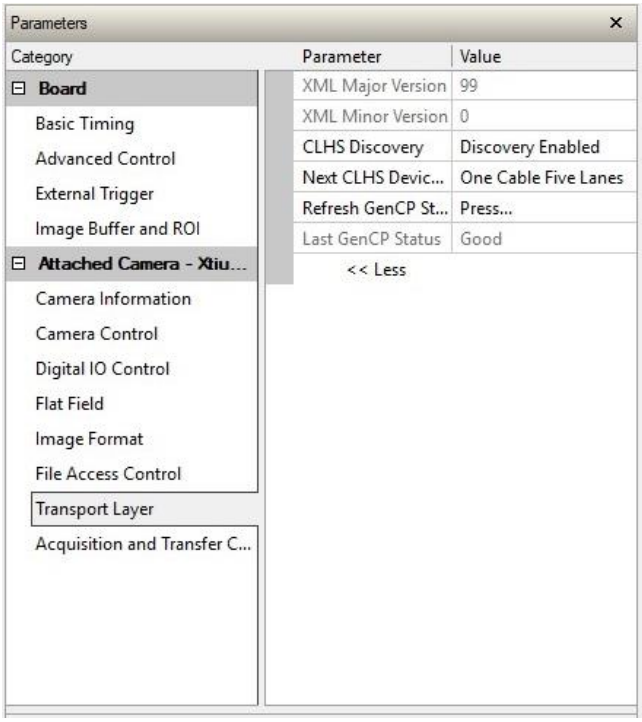


Figure 27: CamExpert Transport Layer Category

Transport Layer Feature Descriptions

Display Name	Feature	Description	Standard & View
XML Major Version	DeviceManifestXMLMajorVersion	Together with DeviceManifestXMLMinorVersion specifies the GenICam™ feature description XML file version. (RO)	Beginner DFNC
XML Minor Version	DeviceManifestXMLMinorVersion	Together with DeviceManifestXMLMajorVersion specifies the GenICam™ feature description XML file version. (RO)	Beginner DFNC
Refresh GenCP Status	refreshGenCPStatus	Press to update the GenCP Status	Beginner
Last GenCP Status	genCPStatus	Returns the last error. If a feature read or write fails then Sapera only returns that it fails – read this feature to get the actual reason for the failure Reading this feature clears it.	Beginner DFNC

Display Name	**Feature**	**Description**	**Standard & View**
CLHS Discovery	clhsDiscovery	Selects whether the camera needs to be commanded to send image data after power up.	Guru DFNC
Discovery Disabled	*DiscoverDisable*	*POGO (Power On & GO mode) – as soon as the camera detects a cable it enables its transmitters and starts sending image data.*	
Discovery Enabled	*DiscoveryEnable*	*Camera waits for LL_Device_ID to be set before enabling its transmitters. User must then read XML and all features and then send an Acquisition Start before the camera will send image data.*	
Next CLHS Device Configuration	clhsNext DeviceConfig	When the camera is next powered up, the specified CLHS lane configuration will be set for the camera.	Guru DFNC
One cable five lanes	*OneCableFiveLanes*		
One cable one lane	*OneCableOneLane*		
Two cable one lane	*TwoCablesOneLane*		

Acquisition and Transfer Control Category

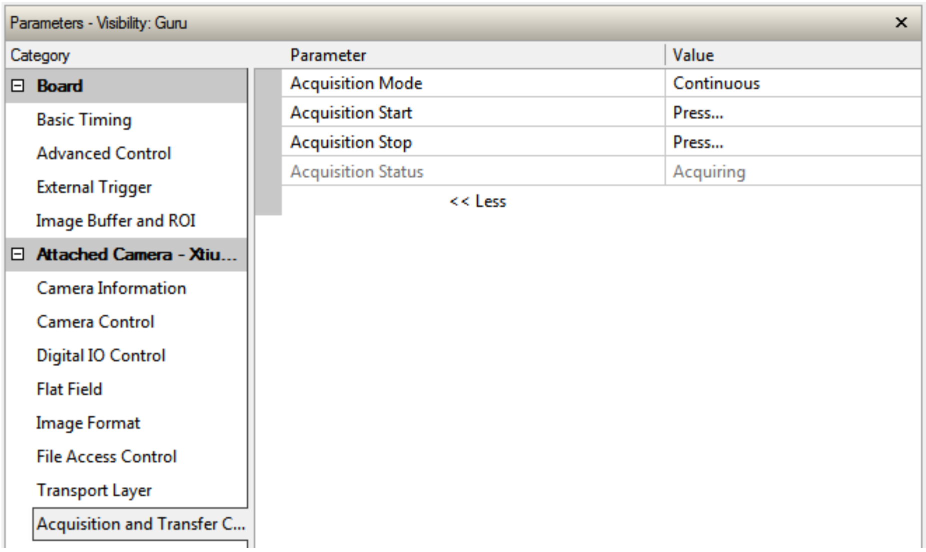


Figure 28: Cam Expert Acquisition & Transfer Control Category

Acquisition and Transfer Control Feature Descriptions

Display Name	Feature	Description	Standard & View
Acquisition Mode *Continuous*	AcquisitionMode	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 DFNC
Acquisition Start	AcquisitionStart	Commands the camera to start sending image data. (WO)	Beginner DFNC
Acquisition Stop	AcquisitionStop	Commands the camera to stop sending image data at the end of the current line (WO)	Beginner DFNC
Acquisition Status	AcquisitionStatus	Indicates whether the camera has been commanded to stop or to send image data.	Beginner DFNC

File Access Control Category

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

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

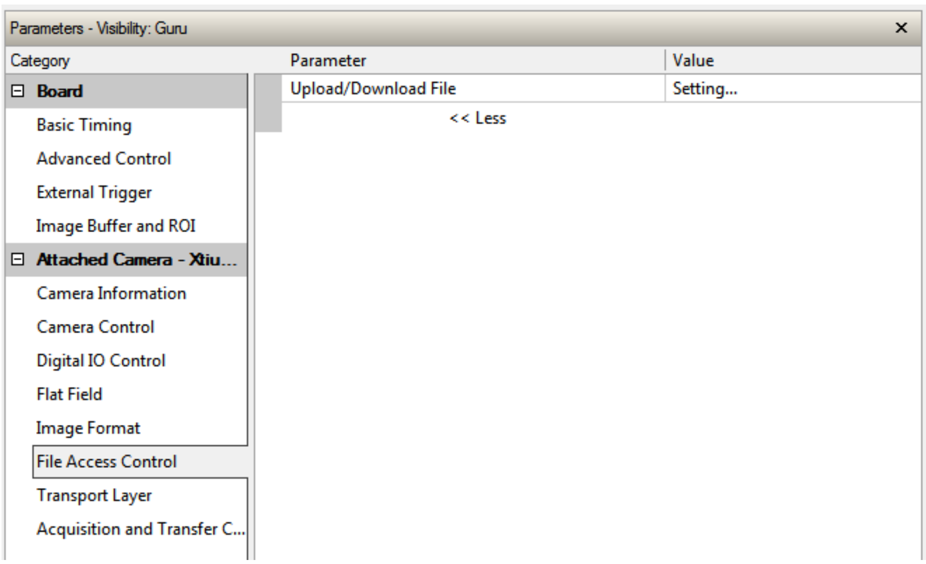


Figure 29: CamExpert File Access Control Category

File Access Control Feature Descriptions

Display Name	Feature	Description	Standard & View
File Selector	FileSelector	Selects the file to access. The files which are accessible are listed in the XML.	Beginner DFNC
Device 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.*	
Look-up Table	*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).*	
CameraData	*CameraData*	*Download camera information and send for customer support.*	

Display Name	Feature	Description	Standard & 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 Write	Read Write	Select READ only open mode 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

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

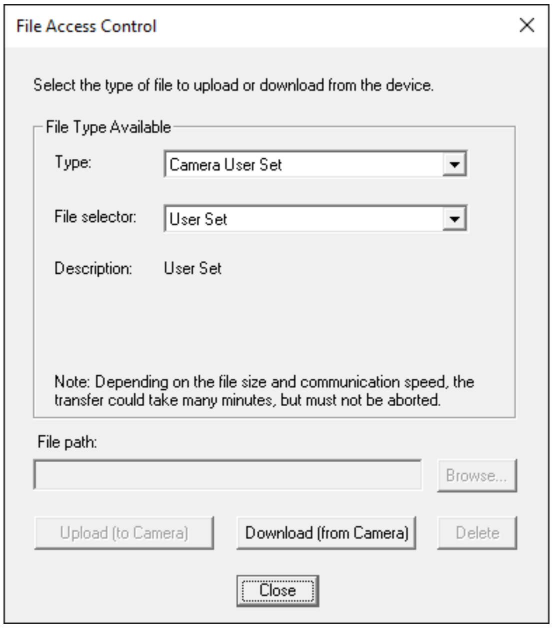


Figure 30: File Access Control Tool

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

CLHS File Transfer Protocol

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

Upload File

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

Download File

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

Download a List of Camera Parameters

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

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

Appendix B: 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 Saving & Restoring Camera Setup Configurations of the user manual 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 Camera CamExpertGUI > Camera Information tab. Press the associated refresh button for a real-time measurement.

Test Patterns – What Can They Indicate?

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

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

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

- Each Tap Fixed
  - Starting at 64 increases in by 4 steps every 512 pixels ending in 188.
- Grey Horizontal Ramp
  - 2 horizontal ramps starting at 0 increases in by 1 every 32 pixels.
- Grey Vertical Ramp
- 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 pane 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, or if there is insufficient air circulation or heat sinking.

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.

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

Resolving Camera Issues

Communications:

No Camera Features when Starting CamExpert

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

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

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

No LVAL

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

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

Image Quality Issues

Vertical Lines Appear in Image after Calibration

The purpose of flat field calibration is to compensate for the lens edge roll-off and imperfections in the illumination profiles by creating a uniform response. When performing a flat field calibration, the camera must be imaging a flat white target that is illuminated by the actual lighting used in the application. Though the camera compensates for illumination imperfection, it will also compensate for imperfections such as dust, scratches, paper grain, etc. in the white reference. Once the white reference is removed and the camera images the material to be inspected, any white reference imperfections will appear as vertical stripes in the image. If the white reference had imperfections that caused dark features, there will be a bright vertical line during normal imaging. Similarly, bright features will cause dark lines. It can be very difficult to achieve a perfectly uniform, defect-free white reference. The following two approaches can help in minimizing the effects of white reference defects:

1. Move the white reference closer to or further away from the object plane such that it is out of focus. This can be effective if the illumination profile changes minimally when relocating the white reference.
2. If the white reference must be located at the object plane, then move the white reference in the scan direction or sideways when flat field calibration is being performed. The camera averages several thousand lines when capturing calibration reference images so any small imperfections are averaged out.
3. Use the cameras flat field calibration filter feature, as detailed in the user manual Flat Field Calibration Filter section. This algorithm implements a low pass moving average that covers several adjacent pixels. This filter can help minimize the effects of minor imperfections in the white reference.

Note: This filter is NOT USED in normal imaging.

Over Time, 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 user manual 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.

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 image artifacts in the scan direction. Changing the scan direction to the opposite direction should resolve this problem.

Refer to 'Camera Orientation' in the user manual to determine the correct direction orientation for the camera.

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

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

Randomly Compressed Images

It is possible that when the scan speed nears the maximum allowed, based on the exposure time used, the image will be randomly compressed and possibly smeared for 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 image 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 of between +12 V to +24 V.

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

Note: The camera will not start to draw current until the input supply is above approximately 10.5 V and 200 msec has elapsed. If the power supply stabilizes in less than 200 msec, then inrush current will not exceed normal operating current.

It is important to consider how much voltage loss occurs in the power supply cabling to the camera, particularly if the power cable is long and the supply is operating at +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
4.
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.

CE 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.	February 26, 2019
01	• Note added that 300 kHz line rate achievable using AOI feature in 8k cameras. • Power / GPIO connector pin 8 revised to line 6 out. • Added revised mechanical drawings to include Θ z of ± 0.4° • HDR Demo Mode section revised and expanded. • Sequential Exposure Mode timing diagram revised.	June 13, 2019
02	Added ML-FC-16K04T-00-R model	November 1, 2019
03	Added ML-FM-16K07A-00-R and ML-HM-08K30H-00-R models Corrected External Output Timing Reference Updated Notice, Declarations of Conformity and Contact Information.	January 23, 2023
04	Removed Input Current column in External Input Timing table (section Power and GPIO Connections). Added Dynamic Range to performance specifications table.	September 11, 2024

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Technical Support

Submit any support question or request via our web site:

https://www.teledynedalsa.com/en/support/options/

Available support information includes:

Warranty Information	**Camera Accessories**	**Documentation**
Third-Party Components	**Calculators**	**Partners**
Legacy Products	**Compatible Products**	**Software Registration**