Linea™ HS2 Series

Camera User's Manual

Monochrome CMOS TDI Line Scan

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

Model

H2-HM-16k100H-00-B

03-032-25036-05

www.teledynevisionsolutions.com

CAMERA Link HS™

TELEDYNE DALSA
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Notice

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About Teledyne DALSA, a business unit of Teledyne Digital Imaging Inc.

Teledyne DALSA 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.

Contents

LINEA™ HS2 SERIES TDI LINE SCAN CAMERAS ____ 1
OVERVIEW 1
CAMERA HIGHLIGHTS 2
Key Features *2*
Programmability & Setup *2*
Applications *2*
PART NUMBERS 3
HARDWARE AND SOFTWARE ENVIRONMENTS....3
SUPPORTED INDUSTRY STANDARDS....4
GenICam™....*4*
Camera Link HS®....*4*

SPECIFICATIONS ____ 5
COMMON CAMERA SPECIFICATIONS 5
Environmental Specifications *6*
Flash Memory Size....*6*
Certification & Compliance *6*
MODEL SPECIFICATIONS....7
RESPONSIVITY AND QUANTUM EFFICIENCY GRAPHS 8
CAMERA PIXEL ARRANGEMENT 9
CAMERA PROCESSING CHAIN....9

INSTALLATION ____ 10
HANDLING PRECAUTIONS....10
PREVENTING OPERATIONAL FAULTS DUE TO ESD 11
REQUIREMENTS....12
Frame Grabber *12*
Camera Link HS Data Cable *12*
Power Cable and Power Supply....*13*
Firmware, Software, and Device Driver Downloads....*13*
QUICK START USING A TELEDYNE DALSA FRAME GRABBER 15
INSTALLATION DETAILS 16
Installing Sapera LT....*17*
Installing the Frame Grabber Driver *18*
Connecting and Powering-up the Camera *18*
Testing Acquisition....*22*
USING CAMEXPERT WITH LINEA HS2 24
CamExpert Panes....*24*

TECHNICAL SPECIFICATIONS ____ 26
LABELING....26
THERMAL MANAGEMENT....26
MECHANICAL DRAWINGS....27
SENSOR ALIGNMENT SPECIFICATION....28
Lens Mount Center and Optical Center....*28*
CONNECTORS 30
Camera I/O Connectors....*30*
Powering the Camera....*30*
Power and GPIO Connections *31*
Recommended Cable Providers....*34*

OVERVIEW OF TDI TECHNOLOGY 35
Arrays and Stages ... 36

CAMERA OPERATION 37
SYNCHRONIZING TO OBJECT MOTION ... 37
Triggering the Camera ... 37
Measured Line Rate ... 38
Scan Direction ... 38
Line Spatial Correction ... 40
Alignment Markers ... 42
ACHIEVING MAXIMUM LINE RATE ... 44
Minimum Line Rate ... 44
IMAGING MODES ... 45
TDI Mono ... 45
TDI Low-Mono ... 45
TDI HDR Mono ... 45
TDI HFW Mono ... 45
Area Mono ... 46
Area Extended ... 46
Imaging Mode and Line Rate ... 46
ESTABLISHING THE OPTIMAL RESPONSE ... 48
Exposure Control by Light Source Strobe ... 48
Flat Field Correction (FFC) and Photo-Response Non-Uniformity (PRNU) ... 50
Saving & Loading a PRNU Set Only ... 51
Flat Field Calibration Region of Interest ... 51
Operating at Low Line Rates ... 51
ADJUSTING RESPONSIVITY AND CONTRAST ENHANCEMENT WITH GAIN AND BLACK LEVEL ... 52
Black Level ... 52
Gain ... 52
BINNING ... 53
Digital Binning ... 53
Sensor Vertical Charge-Domain Binning ... 53
Setting up Binning ... 54
AREAS OF INTEREST (AOIS) ... 55
Rules for Setting Areas of Interest ... 55
Setting up Areas of Interest ... 56
ENHANCEMENT OF INTEREST (EOI) ... 57
CUSTOMIZED LINEARITY RESPONSE (LUT) ... 58
How to Generate a LUT with CamExpert ... 58
CHANGING OUTPUT PIXEL FORMAT ... 61
SAVING & RESTORING CAMERA SETUP CONFIGURATIONS ... 62
Camera Power-up Configuration ... 62
Load / Save Configuration ... 62

OPERATIONAL REFERENCE 64
CAMERA FEATURE CATEGORIES ... 64
CAMERA INFORMATION CATEGORY ... 65
Camera Information Feature Descriptions ... 65
CAMERA CONTROL CATEGORY ... 67
Camera Control Feature Descriptions ... 67
DIGITAL IO CONTROL CATEGORY ... 69
Digital IO Control Feature Descriptions ... 69
FLAT FIELD CATEGORY ... 72
Flat Field Control Feature Description ... 72
IMAGE FORMAT CATEGORY ... 74
Image Format Control Feature Description ... 74
Using Areas of Interest (AOIs) ... 76

TRANSPORT LAYER CONTROL CATEGORY 77
Transport Layer Feature Descriptions 77
ACQUISITION AND TRANSFER CONTROL CATEGORY 79
Acquisition and Transfer Control Feature Descriptions 79
FILE ACCESS CONTROL CATEGORY 80
File Access Control Feature Descriptions 80
File Access and Firmware Update 81
CLHS File Transfer Protocol 83
Download a List of Camera Parameters 84

ADDITIONAL REFERENCE INFORMATION ____ 85
OPTICAL CONSIDERATIONS 85
Illumination 85
Light Sources 85
Back Focal Variance when Using any Filter 85
Lens Modeling 86
Magnification and Resolution 86
SENSOR HANDLING INSTRUCTIONS 88
Electrostatic Discharge and the Sensor 88
Protecting Against Dust, Oil and Scratches 88
Cleaning the Sensor Window 88
Cleaning the Camera Housing Surface 89

TROUBLESHOOTING GUIDE ____ 90
BEFORE CONTACTING TECHNICAL SUPPORT 90
DIAGNOSTIC TOOLS 90
Camera Data File 90
Voltage & Temperature Measurement 90
Test Patterns – What Can They Indicate? 91
Built-In Self-Test (BIST) Status Codes 91
RESOLVING CAMERA ISSUES 93
Communications 93
Image Quality Issues 94
Power Supply Issues 96
Causes for Overheating & Power Shut Down 96

DECLARATIONS OF CONFORMITY ____ 98
FCC Statement of Conformance 98
CE and UKCA Declaration of Conformity 98

APPENDIX A – PERFORMING FLAT FIELD CALIBRATION USING CAMEXPERT ____ 99
Flat Field Calibration White Target 99
Set up Dark and Bright Image Acquisitions with the Histogram Tool 99
Flat Field Correction Calibration 101

REVISION HISTORY ____ 106

CONTACT INFORMATION ____ 107
SALES INFORMATION 107
TECHNICAL SUPPORT 107

Linea™ HS2 Series TDI Line Scan Cameras

Overview

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

The Linea HS™2 Series TDI 16k cameras have a 5 µm x 5 µm pixel size, HDR capability, operate at up to 1 MHz line rate, and are compatible with standard high magnification lenses.

The cameras use the Camera Link HS® (CLHS) interface—the industry standard for very high-speed camera interfaces with long transmission distances and cable flexing requirements (CX4).

Teledyne DALSA's Linea HS2 cameras and compatible frame grabbers combine to offer a complete solution for the next generation of automatic optical inspection systems. This camera excels at detecting small defects at high speeds and over a large field of view in semiconductor wafers, LCD and OLED flat panel displays, high density packaging, DNA sequencing, printed circuit boards, film, and large format web materials.

Figure 1. The Linea HS2 16K, front and back.

Camera Highlights

Key Features

- Highly sensitive CMOS TDI
- Monochrome 16K pixel resolution
- Up to 1 MHz line rate
- Low noise
- Bidirectionality
- Robust Camera Link HS interface, CX4 connector, Active Optical cables for EMI immunity and data integrity over long distances, including error detection
- Smart lens shading correction
- Horizontal and vertical binning
- Multi-array configurations for higher dynamic range or more responsivity

Programmability & Setup

- Multiple areas of interest
- Flat field and lens shading correction
- Test patterns & diagnostics
- Area mode for focus and illumination alignment
- Alignment markers with projection lines for ease of alignment to the web
- Look-up tables and pre-defined user configurations

Applications

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

Part Numbers

The camera is available in the following configurations.

Table 1: Part number. Resolution is followed by the number of stages in each array of pixels.

Part Number	Resolution	Max. Line Rates	Pixel Size	Control & Data
H2-HM-16K100H-00-B*	16,384 x (128+128+32)	1 MHz mono	5.0 µm x 5.0 µm	2 x CLHS CX4

* Backside illumination

Hardware and Software Environments

One, two or four frame grabbers may be used. To achieve maximum line rate, four Xtium2 or two Xtium3 frame grabbers are required.

Table 2: Frame Grabber

Compatible Frame grabber	Part Number
Teledyne DALSA Xtium2 CLHS PX8	OR-A8S0-PX870
Teledyne DALSA Xtium3 CLHS PX8	OR-B8S0-PX870 (Available late Q1 2025)

Table 3: Software

Software	Product Number / Version Number
Sapera™ LT 8.7 or higher Sapera LT is a free image acquisition and control software development toolkit (SDK) for Teledyne DALSA's 1D / 2D / 3D cameras and frame grabbers. Hardware independent in nature, Sapera LT offers a rich development ecosystem for machine vision OEMs and system integrators. Sapera LT includes CamExpert, an intuitive graphical interface that allows configuring and setup of cameras. It provides live image acquisition with interactive parameter configuration capabilities.	Latest version available for download on the Sapera LT SDK | Teledyne Vision Solutions website
Camera firmware	Embedded within camera
GenICam™ support (XML camera description file)	Embedded within camera
Sapera Processing Imaging Development Library Available for Windows® or Linux®— sold separately	Contact Teledyne DALSA Sales

Third Party GenICam Software Platform Requirements	
Support of GenICam™ GenApi version 2.3	General acquisition and control. File access: firmware, FFC, configuration data, upload and download.
Support of GenICam XML camera description file (schema version 1.1)	Embedded within camera

Supported Industry Standards

GenICam™

The camera is GenICam compliant and implements a superset of the GenICam Standard Features Naming Convention (SFNC) specification 1.5.

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 1.0) to communicate over the Camera Link HS command lane.

For more information on the GenICam standard see European Machine Vision Association.

Camera Link HS®

The camera is Camera Link HS (CLHS) 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.

For more information on the Camera Link HS standard see A3 Vision & Imaging.

Specifications

Test conditions unless otherwise specified (specifications not guaranteed when operating in area mode).

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

Common Camera Specifications

Table 4: Common Camera Performance Specifications.

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

1 - Calibration at 80% saturation, measurements at 50% saturation.

2 - Light sources vary spectrally and spatially: re-calibrate cameras in actual system.

Environmental Specifications

Table 5: Environmental Specifications

Environmental Specifications	
Storage temperature range	-20 °C to +80 °C
Humidity (storage and operation)	15% to 85% relative, non-condensing

Flash Memory Size

Table 6: Camera Flash Memory Size

Camera	Flash memory size
H2-HM-16K100H-00-B	4 GB

Certification & Compliance

This camera complies with the following standards: RoHS 2, CE/UKCA/FCC, KC, GenICam SFNC 1.5.

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

Model Specifications

Specifications for 10-bit camera output.
SEE: saturation equivalent exposure.
NEE: noise equivalent exposure.

Table 7. Specifications for the Linea HS2.

Specifications	**H2-HM-16K100H-00-B (Backside Illumination)**
Resolution	16,384 x (128+128+32)
Line Rate Max (8-bit)	1 MHz (16K pixels, dual port with data forwarding, TDI Mode)
Line Rate Min (8-bit)	20 kHz
Camera Output Bit Depth §	8-bit, 10-bit
TDI Mono Mode	Yes
TDI Low-Mono Mode	Yes
TDI HDR Mono Mode	Yes
TDI HFW Mono Mode	Yes
Area Mono Mode	Yes
Area Extended Mode	Yes
Areas of Interest	Up to 4 AOIs per CLHS port
Binning	2x on-sensor (vertical) 2x, 4x digital (horizontal and vertical)
Power Dissipation (typical)	56 W
Width x Height x Depth	97 x 180 x 76.9 mm
Mass	1480 g
Lens Mount	M90 x 1 mm
Random Noise * (typical) (10-bit)	< 2 DN
Peak Responsivity (10-bit)	3000 DN/(nJ/cm^2)
Dynamic Range	65 dB
Full Well	30 ke$^-$
SEE @ 670 nm	0.350 nJ/cm^2
NEE @ 670 nm	0.3 pJ/cm^2

§ Sensor ADC readout is 10 bits.
* Random noise below quantization limit cannot be measured accurately; use higher bit depth or higher gain for comparison.

Responsivity and Quantum Efficiency Graphs

The following graph shows the spectral responsivity and QE from the main array (128 stages), in 10-bit.

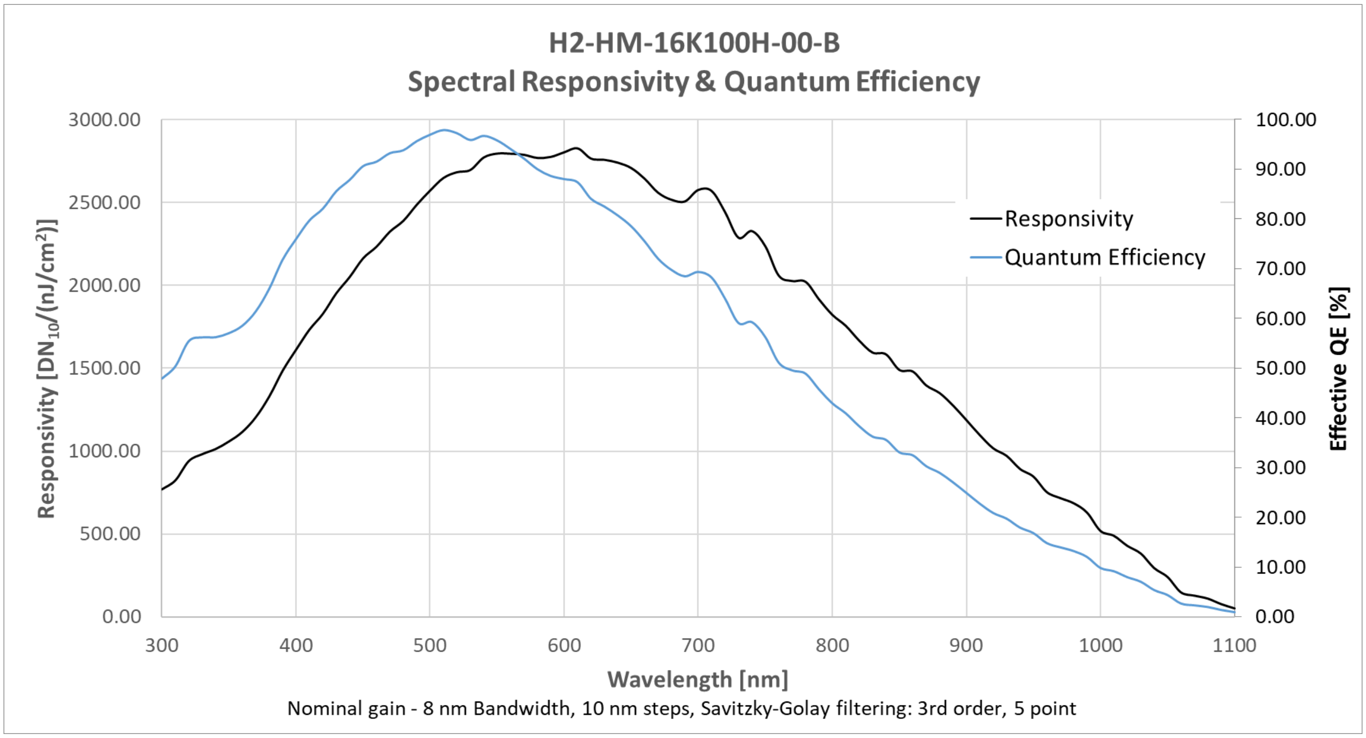


Figure 2: Spectral responsivity and QE.

Camera Pixel Arrangement

The camera sensor consists of multiple rows (stages) grouped into 3 arrays of 128, 128 and 32 stages respectively. The arrays are separated by 40 rows (200 µm). Depending on the chosen imaging mode, one or more arrays are used. Pixels are 5 µm x 5 µm. See Imaging Modes.

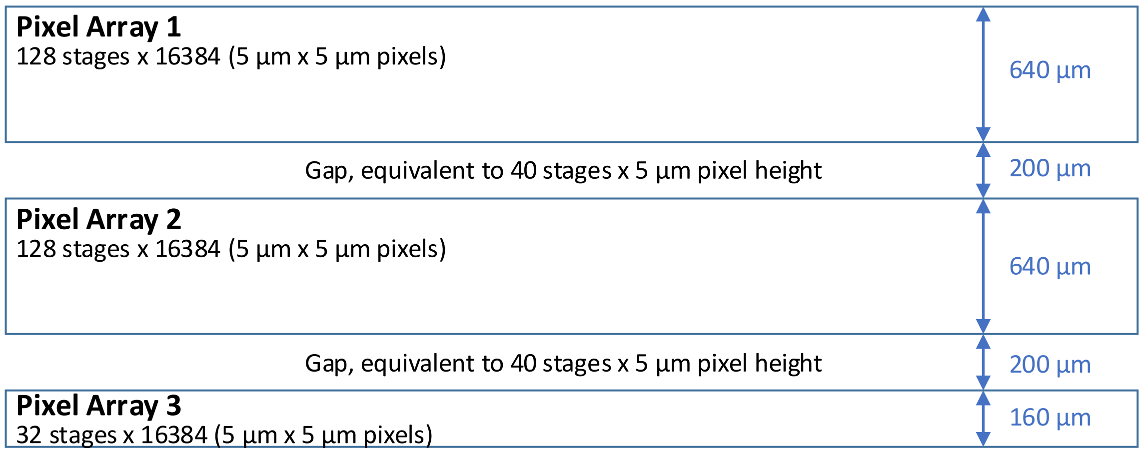


Figure 3. The Linea HS2 16K sensor arrays. Arrays are separated by a 40-row gap.

Camera Processing Chain

The diagram below details the sequence of user-adjustable, arithmetic operations performed on the camera sensor data. These adjustments are using camera features outlined in this chapter.

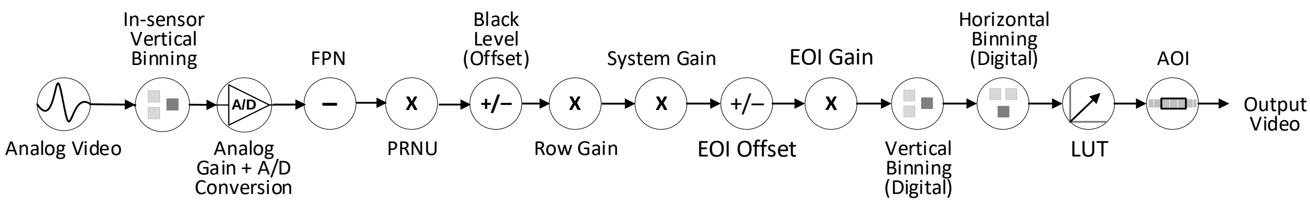


Figure 4: Video data processing chain.

Installation

Please carefully read section Handling Precautions and Preventing Operational Faults Due to ESD before installation.

If you are familiar with Camera Link HS (CLHS) cameras and Teledyne DALSA frame grabbers, follow the Quick Start section to quickly install and test image acquisition with the Linea HS2 and the CamExpert tool provided with Sapera LT.

If using line scan cameras with frame grabbers is new to you, review the Requirements section for what you need before you start, then go to Installation Details for additional information on frame grabber and software installation, and camera connection. Refer to your frame grabber's user manual for instructions related to the board installation.

Note that you need administrator rights for installation and updates.

Handling Precautions

WARNING
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 +50 °C during operation. The camera can measure and report its internal temperature through the RefreshTemperature and DeviceTemperature features. Use those features 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 discharge, violent vibration, and excess moisture.
- 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.

CAUTION – HOT SURFACE

The temperature of the camera body can quickly rise to high temperatures capable of causing burns to the skin if the camera is free standing (that is, not mounted).

Use of an external cooling fan is advised in this situation.

Preventing Operational Faults Due to ESD

WARNING
Static electricity can disrupt camera operation or damage sensitive electronic components. Before handling the camera, always discharge any static electrical charge from your body by touching a grounded surface.

Teledyne DALSA has performed ESD testing on cameras using an 8 kV ESD generator without any indication of operational faults.

To help prevent ESD problems, mount the camera on a metallic platform with a good connection to earth ground.

See also Handling Precautions.

Requirements

Frame Grabber

The following Teledyne DALSA frame grabbers are recommended.

Table 8: Frame grabbers

Compatible Frame grabber	Part Number
Teledyne DALSA Xtium2-CLHS PX8	OR-A8S0-PX870
Teledyne DALSA Xtium3 CLHS PX8 (available late Q1 2025)	OR-B8S0-PX870

NOTE

To achieve maximum line rate, four Xtium2 frame grabbers or two Xtium3 are required (see Connection Configurations).

Camera Link HS Data Cable

The camera requires 1–4 Camera Link HS CX4 AOC (active optical cable) data cables, depending on the chosen configuration (see Connection Configurations).

The command channel is used by the frame grabber to send commands, configuration, and programming data to the camera and to receive command responses, status, and image data from the camera. Data and command transmission use the CLHS X protocol (64b / 66b) at the default speed of 10.3125 Gbps.

NOTE

Data transmits at 10.3125 Gbps, which limits the effective distance of copper-based cables.

Cables can be purchased from an OEM, such as Alysium and Hewtech. OEM cables are also available for applications where flexing is present. Contact Teledyne DALSA support for recommended cable vendors, cables, and part numbers.

CX4 AOC Data Cables

The Linea HS2 family supports the use of Camera Link HS CX4 AOC (Active Optical Cable) cables. These are designed to handle very high data rates over longer distances than copper cables.

These cables accept the same electrical inputs as traditional copper cables but utilize optical fiber for data transmission. 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.

NOTE

CX4 AOC cables are unidirectional: ensure that the **Camera** end is attached to the camera and the **FG** end is attached to the frame grabber.

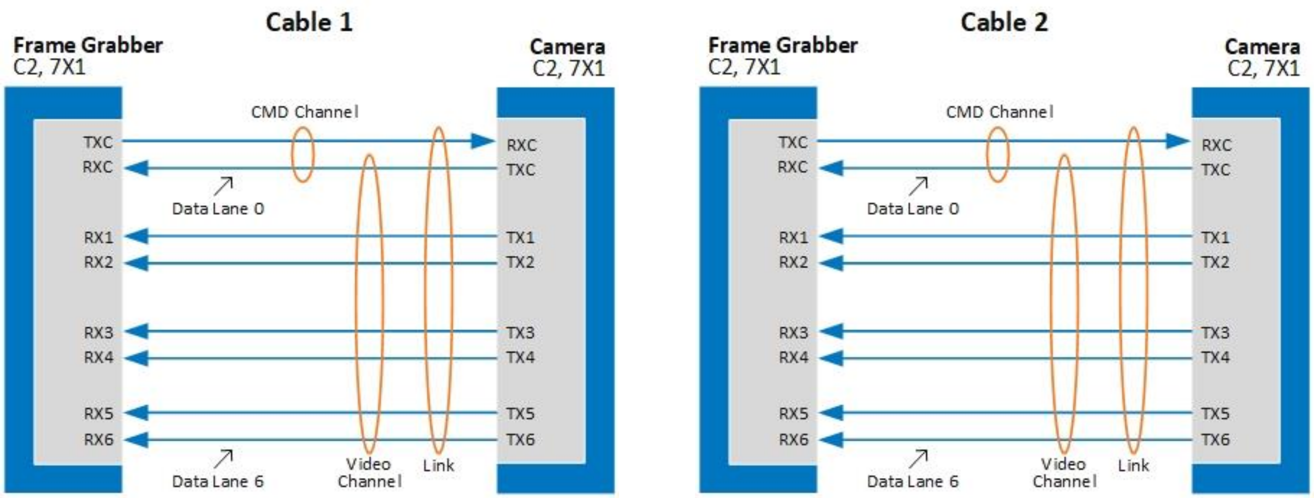


Figure 5: Depiction of a CLHS link with 7 data lanes.

Power Cable and Power Supply

All Linea HS2 models require a **+24 V DC** 4 A power supply, using a 12-pin Hirose circular male connector. This connector is used for power, trigger, and strobe signals. The mating connector is *Hirose model HR10A-10P-12S*.

Teledyne DALSA has an optional GPIO breakout cable for purchase (12-pin Female Hirose to 13-Pos Euro Block). Use accessory number CR-GENC-IOP00 to order (see Mating GPIO Cable Assembly for more information).

WARNING

See Power and GPIO Connections for connector signal wiring details.

NOTE

The frame grabber PoCL (Power-over-Camera Link) powers the electronics in the Active Optical Cable (AOC) module. This frame grabber feature must remain Enabled when using AOC cables.

Firmware, Software, and Device Driver Downloads

Sapera LT SDK

Sapera LT SDK is the image acquisition and control software development kit for Teledyne DALSA cameras. It includes the CamExpert application, which provides a graphical user interface to access camera features for configuration and setup. Sapera LT is available for download from the Teledyne Vision Solutions website:

Sapera LT SDK | Teledyne Vision Solutions

Frame Grabber Driver

Xtium2/Xtium3-CLHS PX8 Device Drivers are available from the Teledyne Vision Solutions website. Follow the installation instructions from the board's User Manual for the computer requirements, installation, and update. Use driver version 1.41 or higher.

Software & Firmware Downloads | Teledyne Vision Solutions

Camera Firmware

A new camera will typically require a firmware update. Contact your Teledyne DALSA representative for the latest firmware for your camera model.

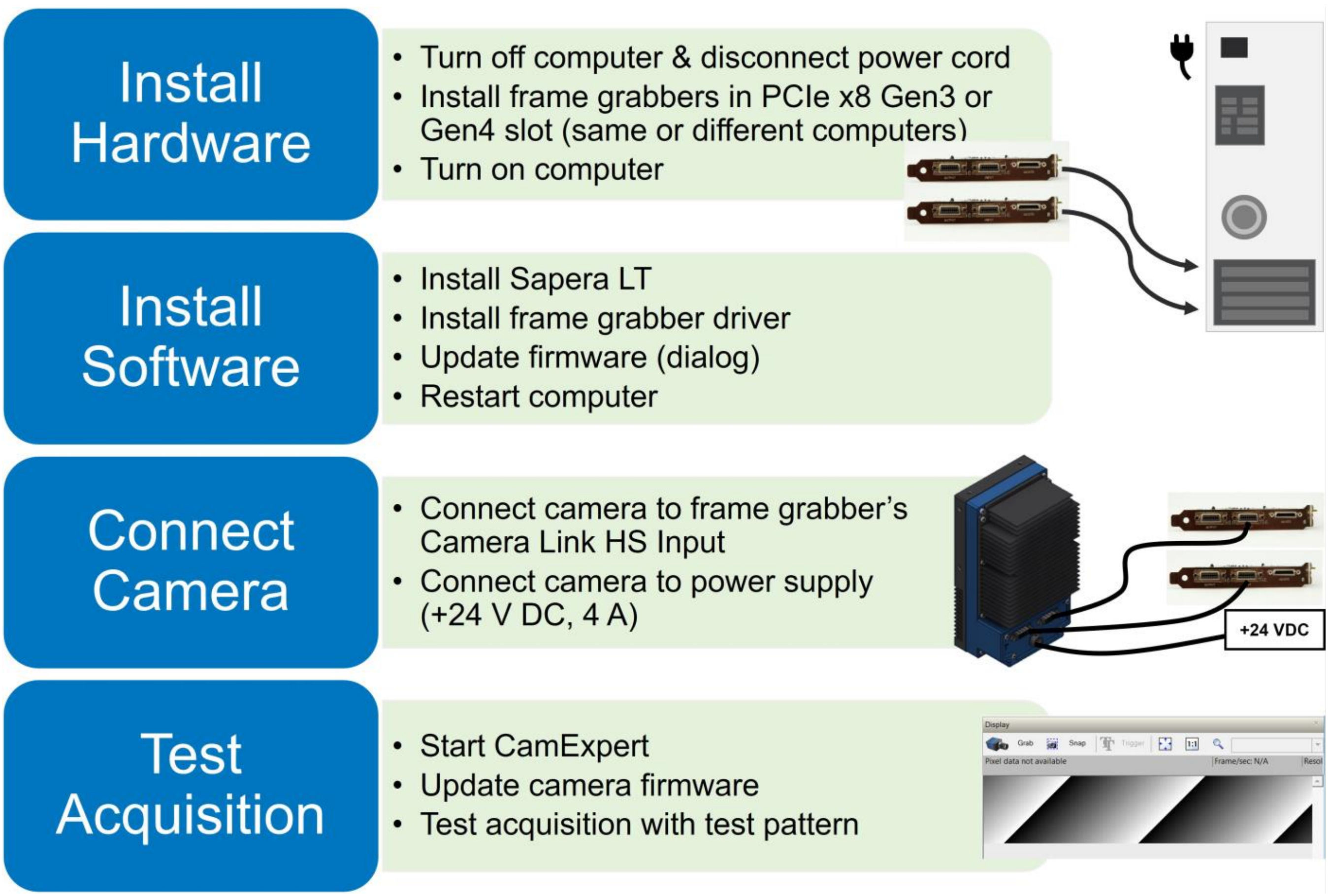
Camera Configuration File

You will need configuration files (.ccf) to begin operating with your camera. The configuration files contain appropriate settings for the frame grabber(s) and camera (each frame grabber will need a slightly different configuration). Contact your Teledyne DALSA representative for the required configuration files.

Quick Start Using a Teledyne DALSA Frame Grabber

The following steps summarize the installation procedure. See Installation Details for further information on each step.

NOTE
You need administrator rights for software installation and updates.



Installation Details

Install Frame Grabber Hardware

Follow instructions in the frame grabber's user manual.

WARNING – GROUNDING INSTRUCTIONS
Static electricity can damage electronic components. It's critical that you discharge any static electrical charge by touching a grounded surface, such as the metal computer chassis, before handling the frame grabber.

1. Turn off computer and disconnect power cord.
2. Install the Xtium2 CLHS PX8 frame grabber board(s) into an available PCI Express x8 Gen3 slot. The Xtium3 requires a Gen4 slot.
3. Reconnect the power cord and turn on the computer.

Install Software

See Installing Sapera LT and Installing the Frame Grabber Driver for details.

4. Download and install the Sapera LT SDK or its runtime library. You must install Sapera LT before the frame grabber driver.
5. Download and install the Xtium2/Xtium3 CLHS PX8 frame grabber driver.
6. Restart the computer.

Connect Camera

See Connecting and Powering up the Camera for details.

7. Connect the Linea HS2 to the frame grabber with CLHS cables according to chosen configuration (see Connection Configurations).
8. Connect and power up the camera using an appropriate power supply. The Linea HS2 status LED will turn on, with a steady green color when connected. See section Camera Status LED Indicator for a description of the LED states.

Test Acquisition

See Testing Acquisition for details.

9. Start **CamExpert**. The plug-and-play feature of the frame grabber and camera will automatically configure frame buffer, data lanes, and frame rate parameters to match the Linea HS2 model being used. Do not configure for an external trigger yet.
10. Upload new camera firmware. (Typically, a new camera will require a firmware update, which will be provided. Otherwise, contact your Teledyne DALSA representative). See File Access and Firmware Update.
11. Upload configuration files (.ccf) (**File** > **Open Configuration**).
12. Select the appropriate CLHS Mode according to the chosen configuration (Transport Layer Control > Next CLHS Device Configuration):
    - For single-port configuration, select *One Cable Seven Lanes.*

- For dual-port configuration, select *Two Cables Seven Lanes*.

You will need to reboot the camera after changing this selection before the change will take effect.

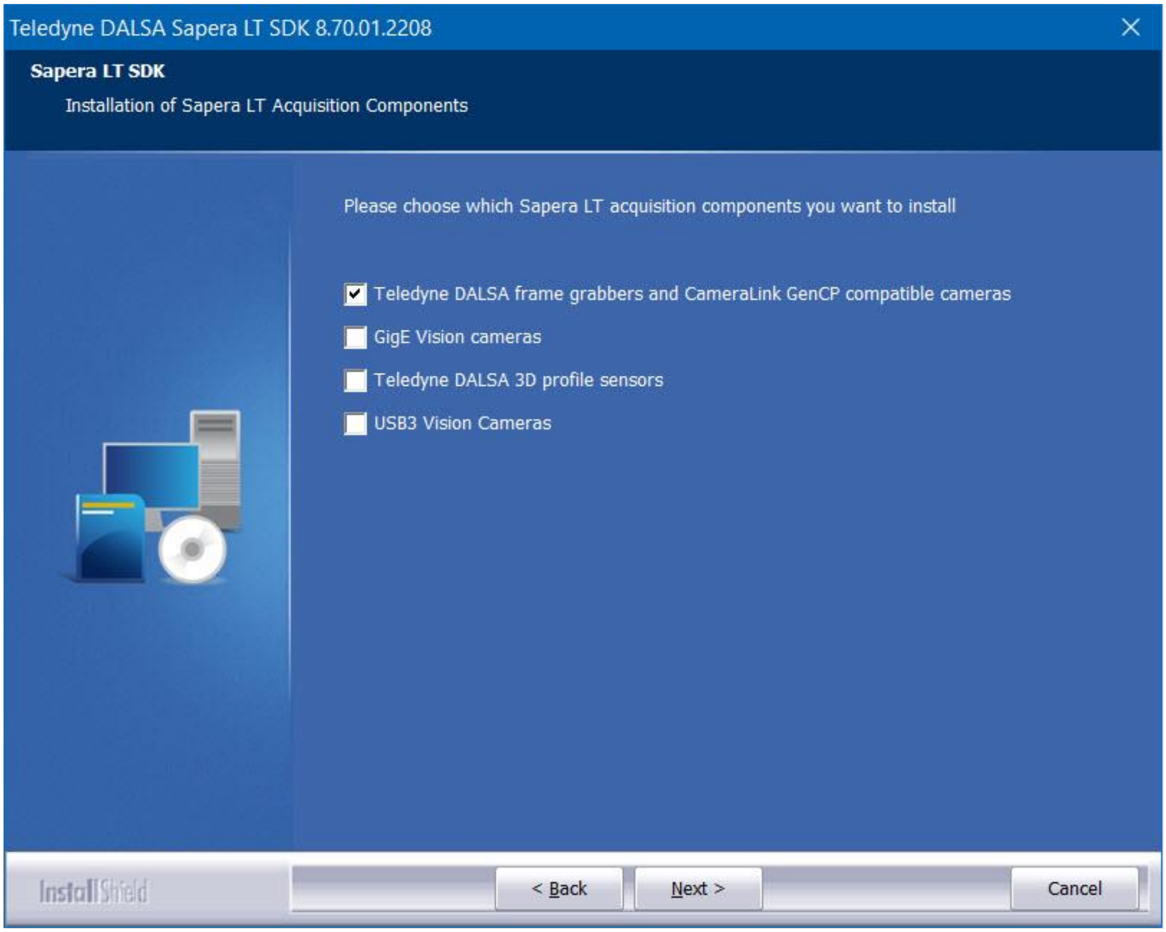
13. In the Transport Layer Control Category, select the *Number of Frame Grabbers* currently connected to the camera.
14. In the Image Format Category, select a test pattern from the *Test Image Selector* parameter and click **Grab**. You will see the pattern in the CamExpert display window.
15. If a lens is attached to the camera, turn off the test pattern and grab live again. Adjust the lens aperture and focus, and/or adjust the camera's Acquisition Line Rate as required.

Installing Sapera LT

Download Sapera LT SDK and install Sapera LT or its runtime library.

The Sapera LT download includes several components. If you intend to develop applications, install Sapera LT SDK for Developers (SaperaLTSDKSetup.exe), which includes CamExpert as well as demos and examples. If no Sapera development is required, you may install the Sapera LT runtime with CamExpert (SaperaLTCamExpertSetup.exe).

Start the Sapera LT installer and follow instructions. On the **Acquisition Components** page, select the *Teledyne DALSA frame grabbers and CameraLink GenCP compatible cameras* option.



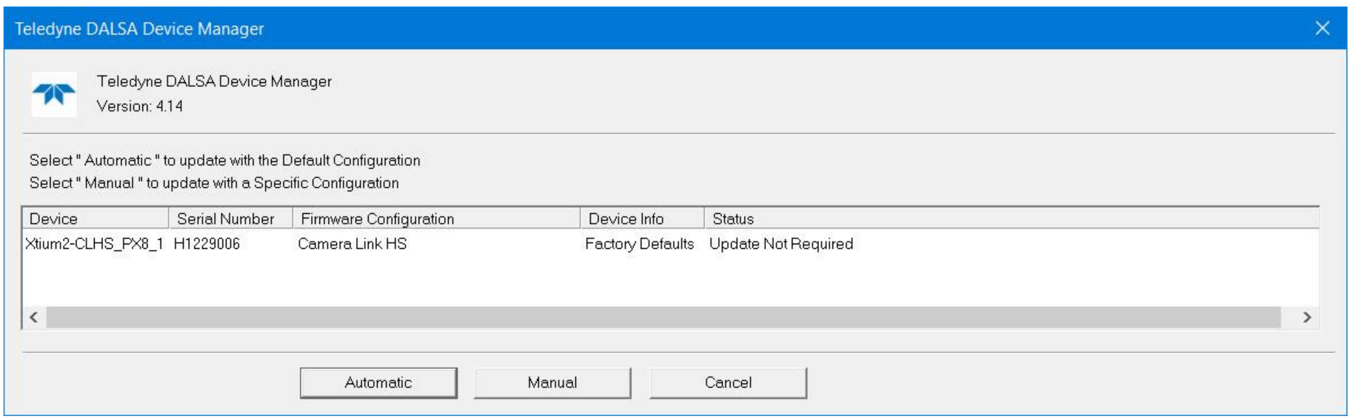
The installation program will prompt to reboot the computer. It is not necessary to reboot the computer between the installation of Sapera LT and the installation of the frame grabber driver. Reboot will be required after software and driver are installed.

Installing the Frame Grabber Driver

Download the latest Xtium2/Xtium3-CLHS frame grabber device driver version 1.41 or higher. Follow instructions in the frame grabber's user manual for installation of the driver.

During the last stages of the installation, the Device Manager window will open, allowing you to update the firmware. Choose **Automatic** to update with the default configuration (Full Camera Link), or **Manual** to select another configuration option.

Restart after installation.



Connecting and Powering-up the Camera

The camera may be connected to one or two frame grabbers, with or without data forwarding. The different configurations are depicted in section Connection Configurations.

For guidelines on connectors, power supply and connector pinout, see section Connectors.

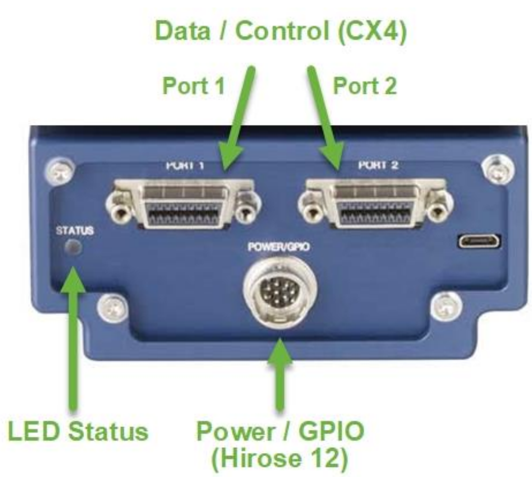


Figure 6: Back side connectors and LED.

WARNING
Carefully read section Powering the Camera before applying power to the camera. Appropriate voltage is +24 V DC. Incorrect voltage may damage the camera.

To connect camera

CLHS CX4 cables are directional: the **Camera** end must be connected to a camera port or to the Output port of a frame grabber; the **FG** end must be connected to the Input port of a frame grabber.

1. Connect the camera to the frame grabber according to the preferred configuration, as depicted in section Connection Configurations.
2. Connect the power cable to the Power/GPIO connector of the camera.

Connection Configurations

The camera provides two data/control CX4 ports and may be operated in single-port or dual-port CLHS modes. In single-port mode, one CLHS cable can be connected to either Port 1 or Port 2 on the camera. In dual-port mode, both ports are connected. For higher line rates, additional frame grabbers can be operated in data-forwarding mode. See Achieving Maximum Line Rate for a table listing achievable max line rates according to configuration.

The CLHS mode must also be selected in CamExpert using parameter Next CLHS Device Configuration under the Transport Layer Control Category. The camera must be restarted after a change. See Testing Acquisition.

After restarting the camera, under the Transport Layer Control category, select the *Number of Frame Grabbers* to match your choice in the sections below. This will allow you to select from a valid range of line rates for your configuration.

Note that in dual-port CLHS mode, camera features are only available on the parent (master) frame grabber. Typically, the first frame grabber connected becomes the parent; if both are connected at power up, then Port 1 becomes the parent.

Single-port operation (Xtium2 / Xtium3)

This mode allows the camera to run with the minimum number of frame-grabbers and cables. Only one CLHS cable and one frame grabber are required. This may be useful for camera configuration and test, but with a restricted maximum line rate.

- Connect the CLHS cable from either Port on the camera to the Input port on the frame grabber.

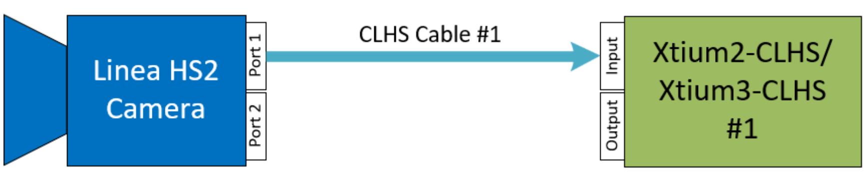


Figure 7: CLHS connections for single port, single frame grabber operation.

Single-port operation with data forwarding (Xtium2 only)

This configuration uses two CLHS cables and two frame grabbers in a data-forwarding setup. This configuration may be useful in some cases; however, higher line-rates can be obtained for the same number of frame grabbers when the camera is set for dual-port operation (see next configuration).

- Connect CLHS cable #1 from Port 1 on the camera to the Input port on frame grabber #1.
- Connect CLHS cable #2 from the Output port on frame grabber #1 to the Input port on frame grabber #2.

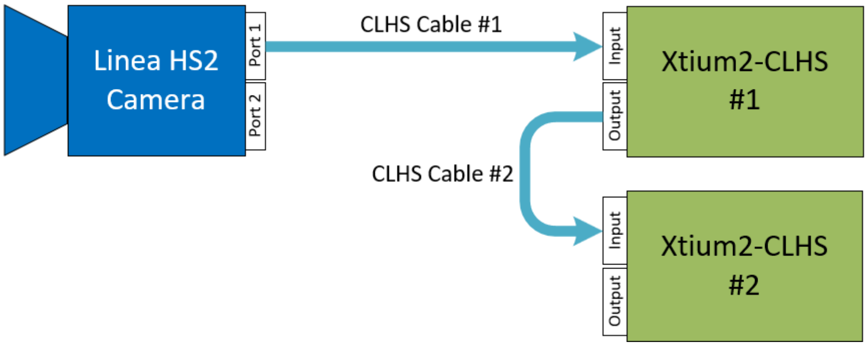


Figure 8: CLHS connections for single port, two frame grabber operation.

Dual-port operation (Xtium2 / Xtium3)

This configuration requires two CLHS cables and two frame grabbers. Bandwidth is divided equally between the two camera ports, resulting in a higher achievable line-rate. This is a good combination of cost vs. performance.

- Connect CLHS cable #1 from Port 1 on the camera to the Input port on frame grabber #1.
- Connect CLHS cable #2 from Port 2 on the camera to the Input port on frame grabber #2.

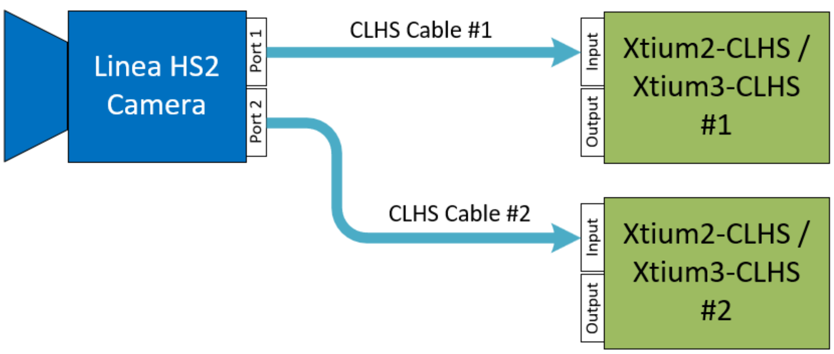


Figure 9: CLHS connections for dual port, two frame grabber operation.

Dual-port operation with data forwarding (Xtium2 only)

This configuration provides maximum performance and allows the camera to output maximum line-rates. Four CLHS cables and four frame grabbers are required for this setup. Each camera-port feeds into two frame grabbers in a data-forwarding setup.

- Connect CLHS cable #1 from Port 1 on the camera to the Input port on frame grabber #1.
- Connect CLHS cable #2 from the Output port on frame grabber #1 to the Input port on frame grabber #2.
- Connect CLHS cable #3 from Port 2 on the camera to the Input port on frame grabber #3.
- Connect CLHS cable #4 from the Output port on frame grabber #3 to the Input port on frame grabber #4.

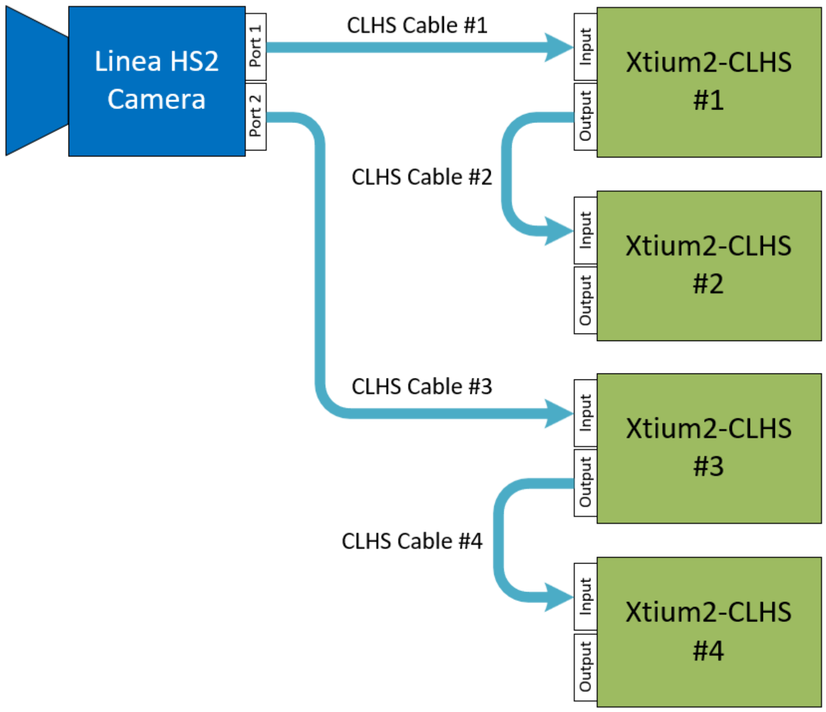


Figure 10: CLHS connections for dual port, four frame grabber operation.

Camera Status LED Indicator

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

In case of error, the Built-In Self-Test (BIST) error codes can be found in the Camera Information category under Power-on Status. See Built-In Self-Test (BIST) Status Codes for diagnosis.

Table 9: Status LED States

LED State	Description
Off	Camera not powered up or waiting for the software to start.
Constant Red	The camera BIST status is not good.
Blinking Red	The camera has shut down due to an over temperature condition / Camera is updating firmware.
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 the camera is ready for data transfer to begin.

When the camera's LED state is steady green:

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

Testing Acquisition

Starting Sapera CamExpert

Sapera CamExpert is included as part of the Sapera LT SDK. It is Teledyne DALSA's camera and frame grabber interfacing tool that allows you to quickly validate hardware setup, change parameter settings, and test image acquisition. It is available from the desktop shortcut (created at installation), or from the Windows **Start** menu under **Teledyne DALSA Sapera LT**. See section Using CamExpert with Linea HS2 for details.

If there is only one Teledyne DALSA frame grabber, the **Device** list in CamExpert automatically has the frame grabber selected, and the connected camera detected as shown in the image below.

If the camera is not automatically detected, verify that the camera is properly powered, and that the fiber optic cable is connected correctly to the appropriate connectors on the frame grabber and camera; the cable is directional, and connectors are labelled *Camera* and *F G* (frame grabber).

NOTE

If you have selected a dual-port configuration, Port 1 becomes the parent port, Port 2 becomes the child. You will need to open another instance of CamExpert for the frame grabber attached to Port 2 of the camera.

From the **Device** list, open the Teledyne DALSA frame grabber node and select the attached camera. If only one frame grabber and camera are installed, they are automatically selected.

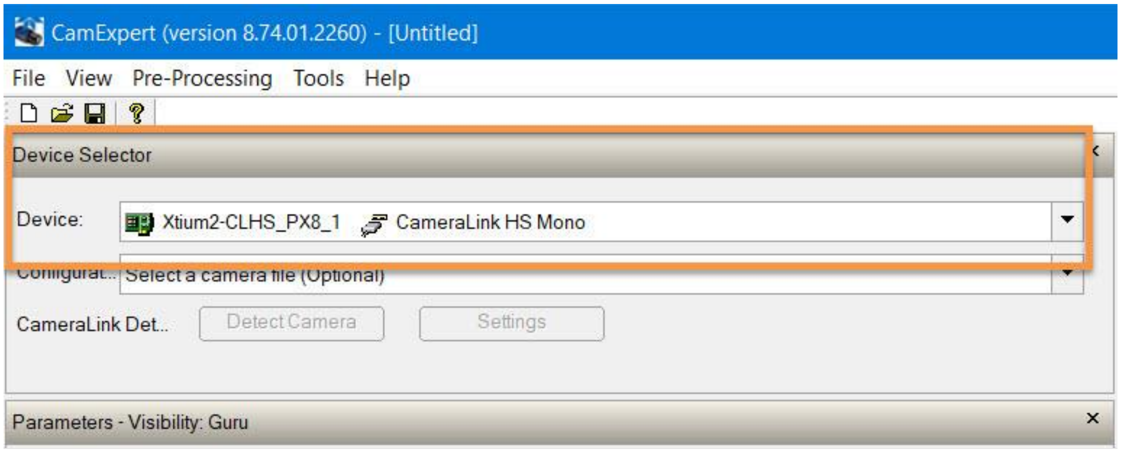


Figure 11: CamExpert and the Device Selector pane

Uploading Camera Firmware

If a firmware file was provided by your Teledyne DALSA representative, upload the firmware to the camera using the Upload/Download File feature in the File Access Control category. See File Access and Firmware Update.

Uploading Camera Configuration Files

You will need configuration files (.ccf) to begin operating with your camera. The configuration files contain appropriate settings for the frame grabber(s) and camera.

Note that parent and child frame grabbers will need a slightly different configuration, hence a different configuration file. Contact your Teledyne DALSA representative for configuration files.

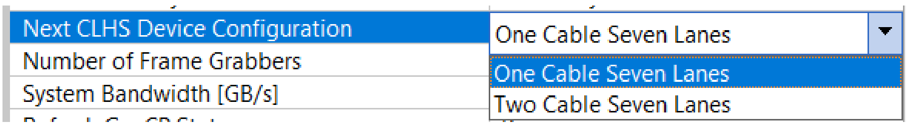
To upload a configuration file, in CamExpert select **File** > **Open Configuration**, then choose the appropriate .ccf file.

If there are two or more frame grabbers on the same computer, a separate instance of CamExpert must be opened for each connected framegrabber.

Selecting CLHS Mode and Number of Frame Grabbers

Depending on your connection configuration, you might need to change your CLHS Mode using the Next CLHS Device Configuration parameter under the Transport Layer Control category.

- For single-port configurations (with or without data forwarding), select *One Cable Seven Lanes*.
- For dual-port configurations (with or without data forwarding), select *Two Cables Seven Lanes*.



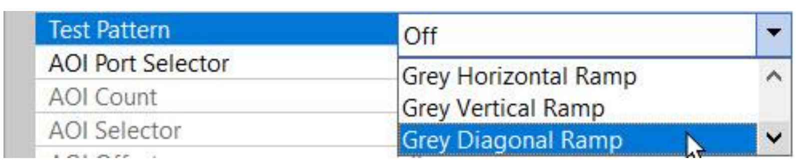
NOTE

You MUST restart the camera after changing this parameter (Camera Information > Restart Camera).

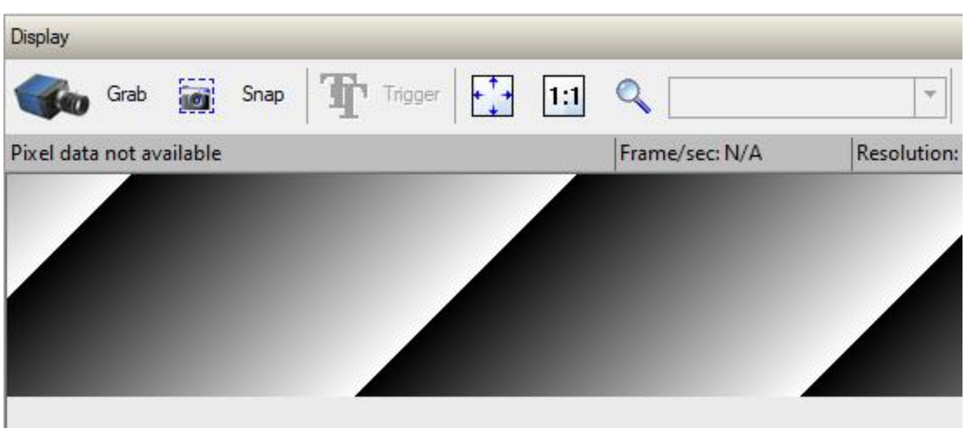
Verifying Basic Acquisition

To verify basic acquisition, the camera can output a test pattern to validate that parameter settings are correctly configured between the camera and frame grabber.

- In the Image Format category, select Test Pattern > *Grey Diagonal Ramp*.



- Click **Snap** to view the diagonal ramp.



Using CamExpert with Linea HS2

CamExpert is the camera interfacing tool supported by the Sapera library. When used with the camera, CamExpert allows a user to test all camera operating modes. In addition, CamExpert can be used to save the camera's user settings configurations to the camera or to save multiple configurations as individual camera parameter files on the host system (.ccf).

NOTE

A separate instance of CamExpert must be opened for each frame grabber in use. Camera controls will only be displayed on the parent frame grabber. The remaining CamExpert instances are for image acquisition only.

CamExpert can also be used to update the camera's firmware.

A key component of CamExpert is its live acquisition display window. This window allows verification of timing or control parameters in real-time, without need for a separate acquisition program.

CamExpert Panes

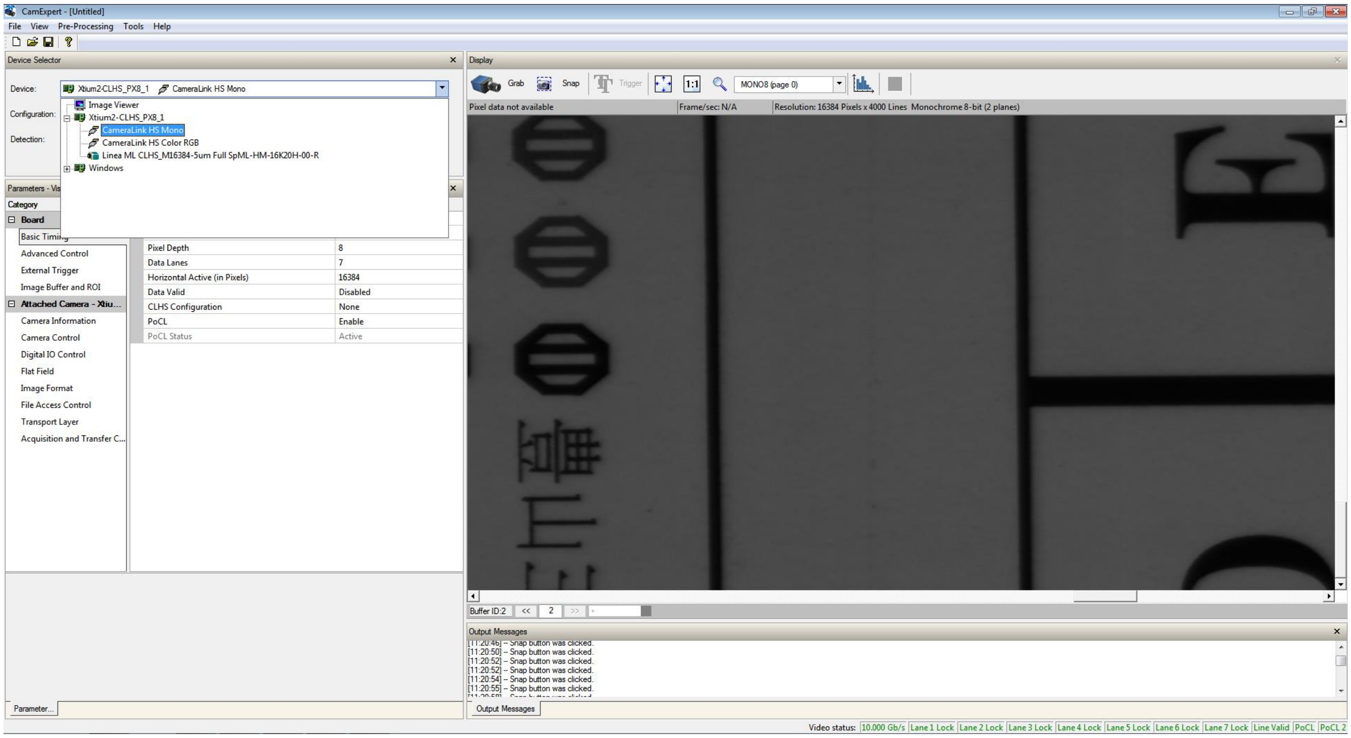


Figure 12: CamExpert Frame Grabber Control Window

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

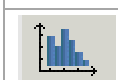
Device Selector pane: View and select from any installed Sapera acquisition device. Once a device is selected, CamExpert will only show acquisition parameters for that device. Optionally, select a camera file included with the Sapera installation or saved previously.

Parameters pane: Allows the viewing or changing of all acquisition parameters supported by the device. CamExpert displays parameters only if those parameters are supported by the installed device.

NOTE
The visibility of features depends on the CamExpert user setting. Not all features are available to all users.

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 commands.

	**Live acquisition** Click once to start live grab, click again to stop.
	**Single frame acquisition** Click to acquire one frame from device.
	**Software trigger** With the I/O control parameters set to Trigger Enabled, click to send a single trigger command.
	**Display controls** (these do not modify the frame buffer data) Select **Fit Display to Screen**, **Reset Display to 1:1 Ratio** or **Advanced Display Options** to change image display.
	**Histogram / Profile** 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.

Technical Specifications

Labeling

Linea HS2 cameras have an identification label applied to the case, with the following information:

Model Part Number
Serial number
2D barcode
Made in Canada

Thermal Management

Linea HS2 cameras are designed to optimally transfer internal component heat to the outer metallic body.

CAUTION – HOT SURFACE

The temperature of the camera body can quickly rise to high temperatures capable of causing burns to the skin if the camera is free standing (that is, not mounted).

Use of an external cooling fan is advised in this situation.

Basic heat management is achieved by mounting the camera onto a metal structure via its mounting screw holes. Heat dissipation is further improved by using thermal paste between the camera body (not the front plate) and the metal structure plus the addition of a heatsink structure.

The heatsink provided with the camera is effective at maintaining the camera temperature when used in an environment with free-moving air. If the camera is to be used in an enclosed space, it is recommended to provide airflow over the heatsink.

The camera has an internal temperature monitor and will automatically stop imaging if the temperature rises above 80 °C. To prevent this, the temperature of the front plate camera should always be kept below 50 °C.

Mechanical Drawings

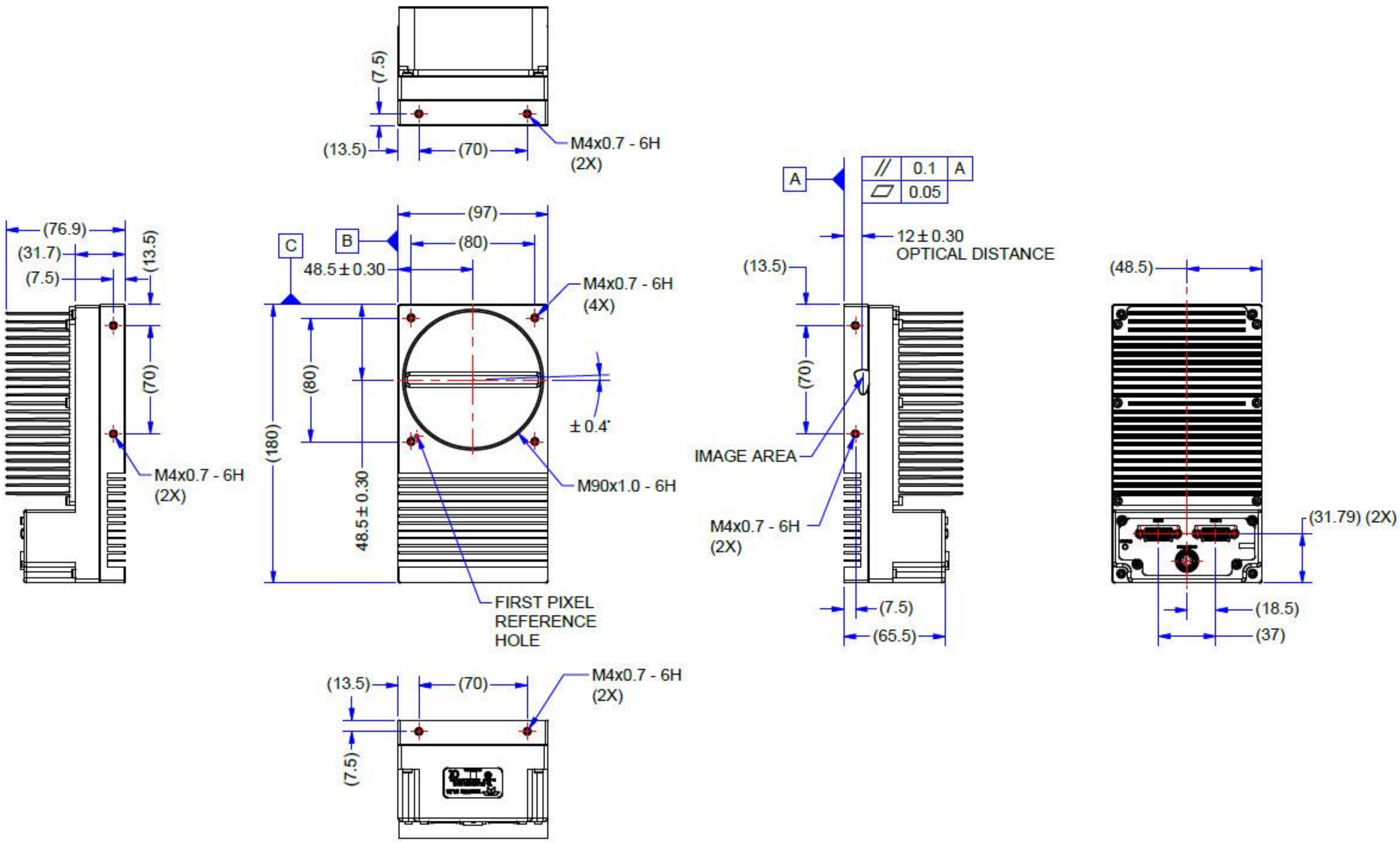


Figure 13: H2-HM-16K100H-00 Mechanical Drawing

Sensor Alignment Specification

The following figure depicts sensor alignment for Linea HS2, where all specifications define the absolute maximum tolerance allowed for production cameras. Dimensions X, Y and Z, are in microns and referenced to the camera's mechanical body or the optical focal plane (for the z-axis dimension). Theta specifies the sensor rotation relative to the sensor's center and camera mechanical.

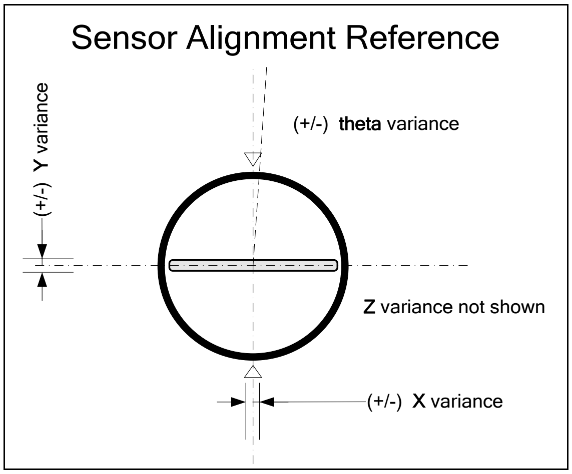


Figure 14: Sensor Alignment Reference

X variance	± 300 µm
Y variance	± 300 µm
Z variance	± 300 µm
Theta variance	± 0.4°

Lens Mount Center and Optical Center

The lens mount center corresponds to the center of the sensor window on the camera body.

The optical center is defined as the center of the currently active arrays, which depends on the imaging mode (e.g. TDI HDR Mono uses pixel arrays 2 and 3, while TDI Mono uses pixel array 2 only). The offset between the lens mount center and the optical center in each imaging mode will therefore vary (see Table 10).

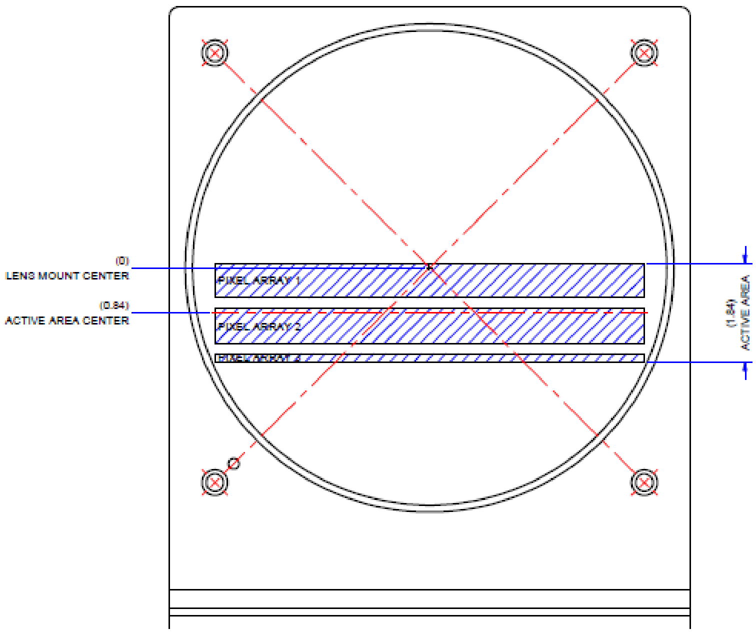


Figure 15: Depiction of the lens mount center relative to the pixel arrays (active area) of the sensor. The lens mount center is located 80 µm below the top of pixel array 1.

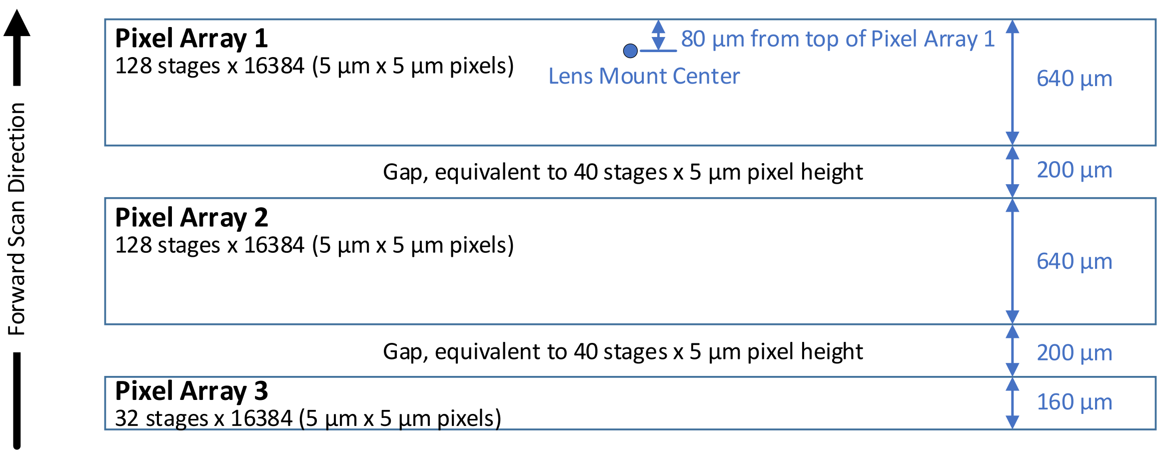


Figure 16: Location of the lens mount center relative to the 3 sensor arrays.

Table 10: Optical center relative to the lens mount center, according to imaging mode.

Imaging Modes	Active Pixel Arrays	Optical Center
TDI Mono	2	1080 µm below lens mount center
TDI Low-Mono	3	1680 µm below lens mount center
TDI HDR Mono	2 + 3	1260 µm below lens mount center
TDI HFW Mono	1 + 2	660 µm below lens mount center
Area Mono	2	1080 µm below lens mount center
Area Extended	1 + 2 + 3	840 µm below lens mount center

Connectors

Camera I/O Connectors

- Data/Control: 2 CLHS CX4 connectors
- Power/GPIO: +24 V DC ± 10%, Hirose 12-pin circular

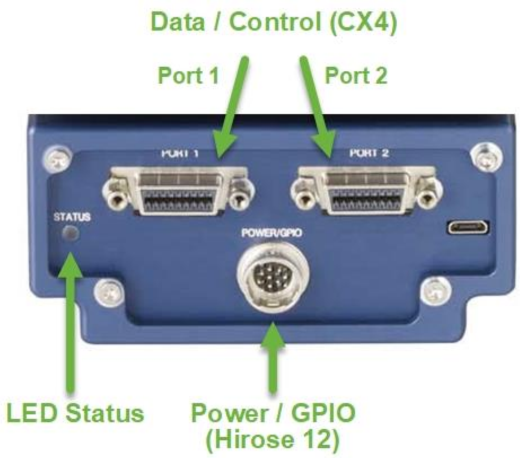


Figure 17: Camera CX4 data and I/O connectors

Powering the Camera

WARNING

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

- Apply only +24 V to the camera. Incorrect voltage may damage the camera.
- Connect the power supply +24 V to BOTH pins 2 AND 10 on the camera.
- Connect the power supply ground (supply negative) to BOTH the camera power ground pins 1 AND 9.
- Do not connect the power supply ground (supply negative) to the camera chassis or the signal ground (pins 11 and 12). Doing so will not damage the camera; however, it will bypass the internal reverse voltage protection circuits.
- Before connecting power to the camera, test all power supplies.
- Protect the camera with a 4 A slow-blow fuse between the power supply and the camera.
- The ground shield on the Power/GPIO cable must not be connected to the power supply ground (supply negative) or to the camera power pins 1 and 9. It can be connected to the camera chassis or earth ground at the power supply if the power supply ground (supply negative) is isolated from earth ground.
- Keep leads as short as possible to reduce voltage drop.
- Use high quality cables and power supply to minimize noise.

NOTE

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

Power and GPIO Connections

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

12-Pin Hirose Connector Signal Details

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

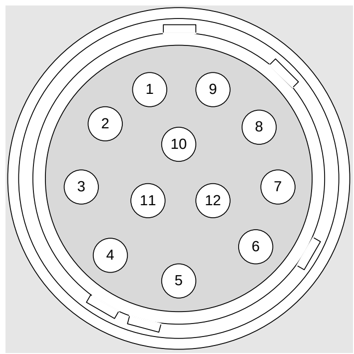


Figure 18: 12-pin Hirose pin numbering (mating side of cable)

The wire gauge of the power cable should be sufficient to accommodate a surge during power-up of at least 4 A with a minimum voltage drop between the power supply and camera.

The camera can only accept +24 V. Refer to the section Voltage & Temperature Measurement for more details.

NOTE
Connect **all power** pins as indicated; the rated current is too high for just one pin. Each pin is rated 2 A.

Table 11: 12-pin Hirose Pin Assignment

Pin	Input / Output	Signal Details	Notes
1	Power Input	Power Ground	**Connect pins 1 AND 9** to Negative terminal of 24 V DC power supply. Warning: Do not connect to pins 11 or 12, or to the camera chassis.
2	Power Input	+24 V power	**Connect pins 2 AND 10** to Positive terminal of 24 V DC power supply.
3	Output	Line 3 Out	0 to 3.3 V TTL output. Single-ended or open collector.
4	Output	Line 4 Out	0 to 3.3 V TTL output. Single-ended or open collector.
5	Input	Line 1 / Trigger Input / Phase A Input	0 to 24 V input. Selectable threshold voltages for 3.3 V, 5 V, 12 V and 24 V logic.
6	Input	Line 2 / Scan Direction / Phase B Input	0 to 24 V input. Selectable threshold voltages for 3.3 V, 5 V, 12 V and 24 V logic.
7	Output	Line 5 Out	0 to 3.3 V TTL output. Single-ended or open collector.
8	Output	Line 6 Out	0 to 3.3 V TTL output. Single-ended or open collector.
9	Power Input	Power Ground	**Connect pins 1 AND 9** to Negative terminal of 24 V DC power supply. Warning: Do not connect to pins 11 or 12, or to the camera chassis.
10	Power Input	+24 V power	**Connect pins 2 AND 10** to Positive terminal of 24 V DC power supply.
11	Signal Ground	Signal Ground	Return path for GPIO signal only. Not a power ground. Warning: Do not connect to pins 1 or 9, or to the camera chassis.
12	Signal Ground	Signal Ground	Return path for GPIO signal only. Not a power ground. Warning: Do not connect to pins 1 or 9, or to the camera chassis.

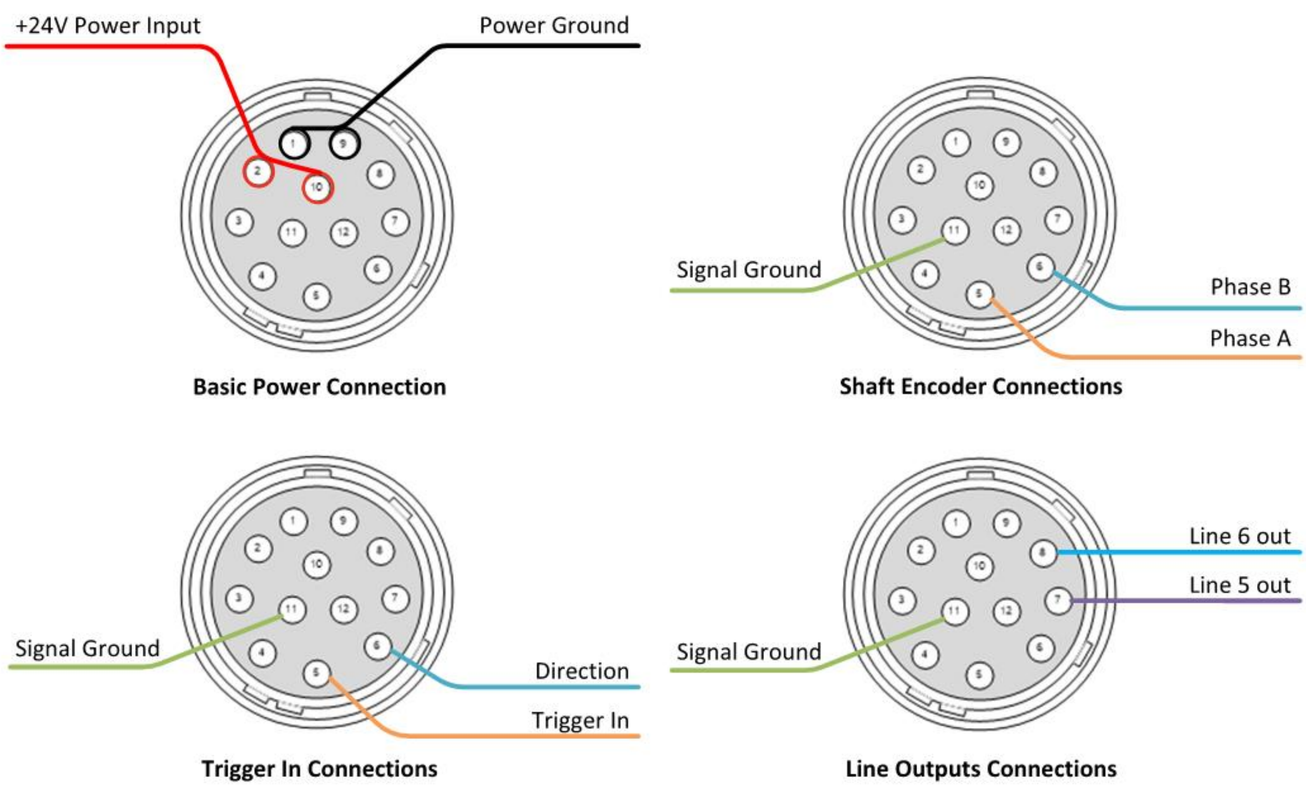


Figure 19: Depiction of power and IO connections.

External Input Electrical Characteristics

Table 12: External Input Electrical Characteristics

	Switching Voltage		
Input Level Standard*	**Low to high**	**High to low**	**Input Impedance**
3.3 V TTL	2.1 V	1 V	> 96 kΩ
5 V TTL	3.5 V	1.65 V	
12 V	8 V	4.0 V	
24 V	15.9 V	8 V	

*Selectable using lineDetectionLevel feature in Digital IO Control Category

External Input Timing Reference

Table 13: External Input Timing Reference

Input Level Standard	Max Input Frequency	Min Pulse Width	Max Signal Propagation Delay @ 60°C	
3.3 V TTL	20 MHz	25 ns	0 to 3.3 V	< 100 ns
			3.3 V to 0	< 100 ns

External Output Electrical Characteristics

Table 14: External Output Electrical Characteristics

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

*See Linear Technology data sheet LTC2864.

External Output Timing Reference

Table 15: External Output Timing Reference

Output Level Standard	Max Output Frequency	Min Pulse Width	Output Current	Max Signal Propagation Delay @ 60°C	
3.3 V TTL	Line rate dependent	25 ns	< 180 mA	0 to 3.3 V	< 100 ns
				3.3 V to 0	< 100 ns

NOTE

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

Mating GPIO Cable Assembly

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

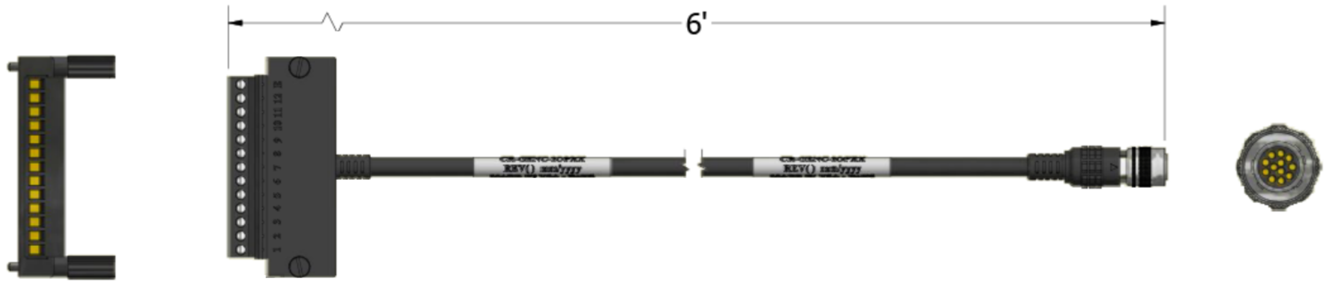


Figure 20: GPIO cable accessory #CR-GENC-IOP00

Recommended Cable Providers

The following is a recommended OEM supplier of power cables.

Components Express

The following are recommended OEM data cable providers.

Alysium

Alysium-Tech - Cable, Connectors and Assemblies for high performance industry solutions in Robotic, Automotive and Machine Vision Sectors.

Hirakawa Hewtech Corp.

Hirakawa Hewtech Corporation.

Overview of TDI Technology

A basic line scan sensor consists of a single row of pixels acquiring light from an object. As the object moves past the sensor, the output lines build up to create a 2D image. The image is built one line at a time, and each line of the image is the result of a single exposure from the sensor.

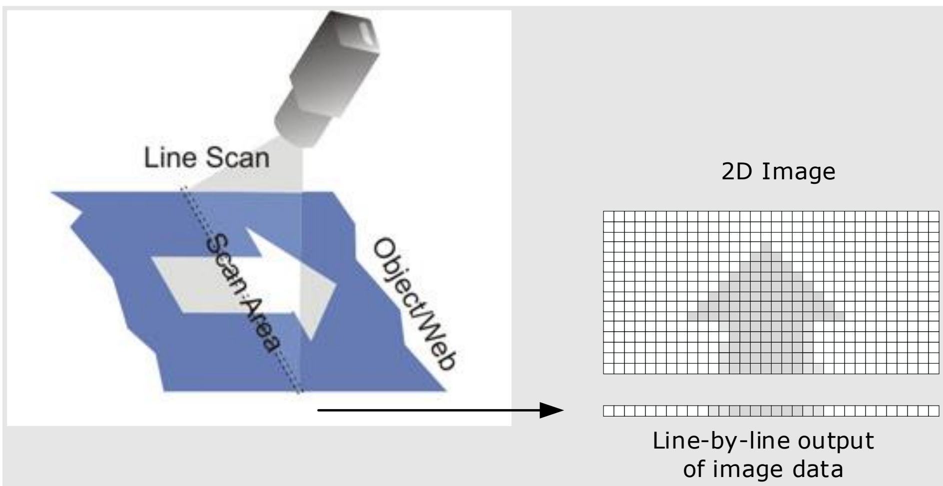


Figure 21: Line Scan Operation

Time delay integration (TDI) is based on the concept of accumulating multiple exposures of the moving object, effectively increasing the time available to collect incident light (integration time). A TDI camera sensor contains multiple rows of pixels, called stages, grouped into an array. A stage collects light, and as the object moves across the array, the following stage collects more light for the same image segment, and so on, up to the last stage. Each line of the image is thus acquired many times and corresponds to the sum of the exposures from the stages of the sensor.

The effective integration time is:

(1 / Line rate) * Number of TDI Stages

To ensure a crisp image, the object's motion must be synchronized with the exposures so that each stage in the array successively captures the same image segment. See section Synchronizing to Object Motion on ways to ensure proper synchronization of acquisition and object motion.

See the TDI Primer - High Sensitivity Line Scanning on Teledyne Vision Solutions website for an illustration of how TDI works.

Arrays and Stages

A TDI sensor may comprise one or more arrays of pixels, where each array consists of two or more stages (rows). The following figure illustrates a single array sensor of 16,384 pixels x 128 stages.

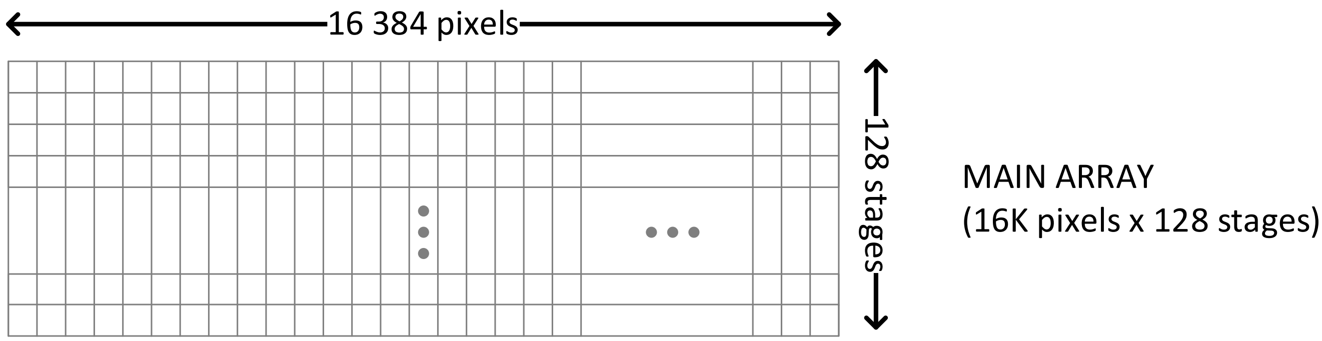


Figure 22: A 16K x 128 single array TDI sensor comprises 16K pixels across and 128 stages (rows).

In a multiple-array TDI sensor, arrays are physically separated by a few rows. The number of arrays used may sometimes be specified, depending on the TDI mode. Multiple arrays are often used for increasing the dynamic range or improving signal to noise ratio.

The following figure illustrates a dual array sensor of 16K pixels x 160 (128 + 32) stages.

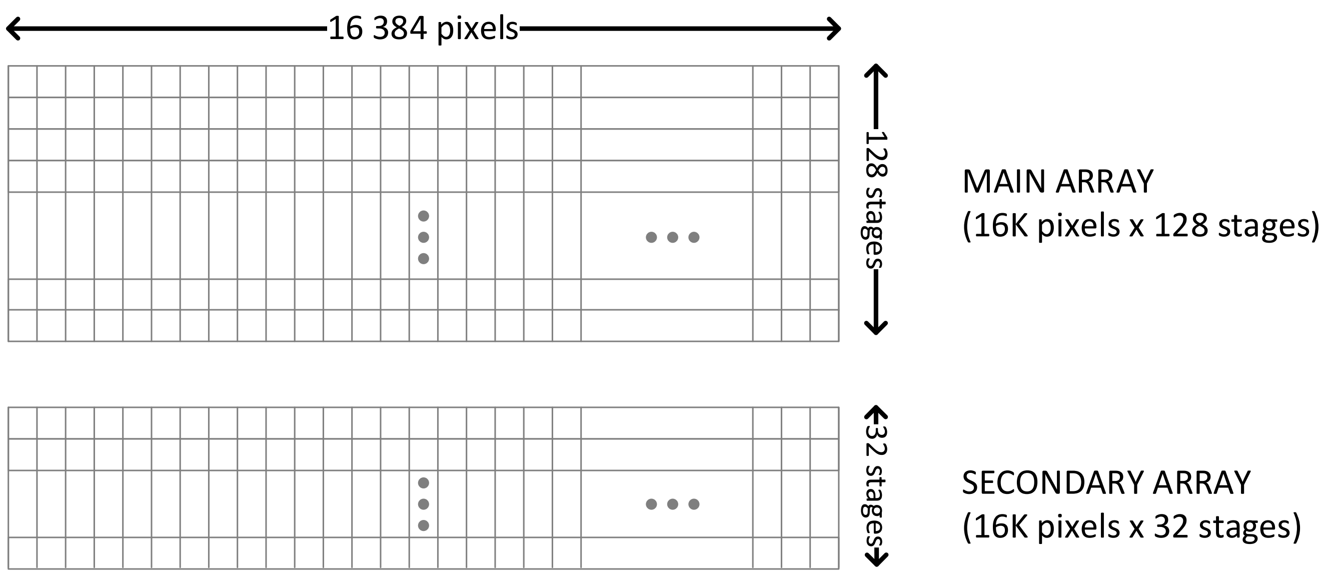


Figure 23: A 16K x 160 (128+32), dual array TDI sensor. The main array includes 128 stages, the secondary array has 32 stages. The arrays are separated by several rows, typically a multiple of the pixel size.

Camera Operation

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

Synchronizing to Object Motion

With TDI cameras, synchronization between acquisition and object motion is essential to get clear images with a correct aspect ratio. There are several features involved, described below. Basically, to properly synchronize acquisition with object motion:

- Choose an appropriate trigger and trigger rate for acquisition. Typically, an external trigger is used, such as a signal from an encoder.
- Set the scan direction. Make sure the camera is perpendicular to the scan direction.
- Use spatial correction when more than one array is used.

Refer to application note Application Guideline for TDI Cameras for details on the effects of misalignment and unoptimized synchronization on image quality.

Triggering the Camera

See Digital IO Control Category for GenICam features associated with this section.

Related Features: TriggerMode, TriggerSource, TriggerActivation

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

Internal Trigger

Trigger Mode = *Internal*. The simplest method is to use the camera's internal timer to trigger acquisition. In this mode, the camera trigger rate can be adjusted using the *Acquisition Line Rate* feature.

External Trigger

Trigger Mode = *External*. In this mode, the acquisition trigger signal comes from an external hardware source selected through the *Trigger Source* feature.

Trigger Source options are: *Line 1* (pin 5 of the GPIO connector), *CLHS In* (Camera Link HS frame grabber), or *Rotary Encoder* (pins 5 and 6 of the GPIO connector).

The *Trigger Activation* feature lets you choose the edge that triggers acquisition. *Trigger Activation* options are: *Rising Edge*, *Falling Edge* or *Any Edge*. When using *Any Edge*, be careful that the edges do not trigger acquisition at a rate that exceeds the maximum line rate of the camera. If the line rate is exceeded, the extra edges will be ignored.

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

Measured Line Rate

See Camera Control Category for GenICam features associated with this section.

Related Features: measuredLineRate, refreshMeasuredLineRate

The Measured Line Rate feature returns the line rate provided to the camera by either internal or external source. The Refresh Measured Line Rate command is used to read the line (trigger) rate being applied, externally or internally, to the camera.

Line Rate and Rotary Encoder Synchronization

When using a rotary encoder, a continuous stream of encoder trigger pulses synchronized to the object motion establishes the line rate. The faster the object's motion is, the higher the line rate. The camera can accommodate triggers up to its specified maximum frequency. If the maximum frequency is exceeded, the camera will continue to output image data at the maximum specified. The result will be that some trigger pulses will be missed and there will be an associated distortion (compression in the scan direction) of the image data. When the line rate returns to or below the maximum specified, normal imaging will be reestablished.

See section Achieving Maximum Line Rate for a table of achievable line rates.

Scan Direction

See Camera Control Category for GenICam features associated with this section.

Related Features: sensorScanDirectionSource, sensorScanDirection

A TDI camera requires the user to indicate to the camera the direction of travel of the object (*sensorScanDirection* = *Forward* or *Reverse*, see Figure 25). It can be set manually or controlled by an external signal, depending on the value of the *sensorScanDirectionSource* feature:

- *Internal*: The *sensorScanDirection* feature sets the scan direction (manual setting).
- *Line 2* (pin 6 on the GPIO connector): Signal on Line 2 controls the scan direction.
- *Rotary Encoder* (pins 5 and 6 of the GPIO connector): The encoder controls the scan direction. The option is only available when *TriggerSource* is *RotaryEncoder* and *rotaryEncoderOutputMode* is set to *Motion*.

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

Scan Direction Change Time

The direction change time between forward and reverse depends on the imaging mode, specifically on the number of arrays used when imaging.

Table 16. Direction change time with respect to imaging mode. Change time is per array.

Imaging Mode	# Arrays Used	Direction Change Time per array (µs)
TDI Mono, TDI Low-Mono, Area Mono	1	51
TDI HDR, TDI HFW Mono	2	85
Area Extended	3	117

Setting the Correct Scan Direction

Whether the scan direction is set correctly can easily be seen in live imaging.

- If the optical setup is correct, the image will appear normal, sharp and focused.
- If the optical setup is not properly focused, blur will occur in both horizontal (cross-scan) and vertical (in-scan) directions.
- If image blurring occurs only in the scan direction (see below), the scan direction is set incorrectly or trigger rate is not optimal.

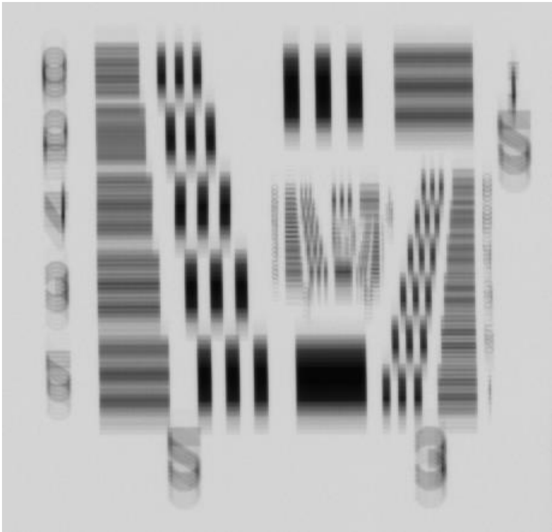


Figure 24: Image with incorrect scan direction

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.

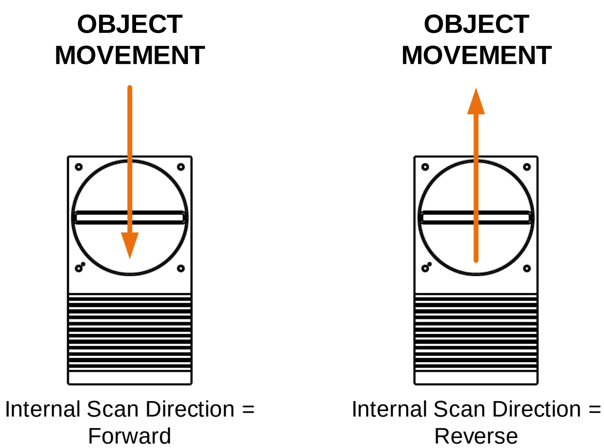


Figure 25: Object movement and scan direction. In Forward direction, the object crosses the sensor line from top to bottom. In Reverse direction, the object crosses the sensor line from bottom to top.

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

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

Line Spatial Correction

See Camera Control Category for GenICam features associated with this section.

Related Feature: sensorLineSpatialCorrection

Spatial correction is necessary when using multiple array output, such as when using HDR. To achieve a sharp image in the scan direction, it is important that the lines being used are aligned correctly. Line spatial correction is used to that end.

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

FYI
Teledyne DALSA Xtium2/Xtium3 CLHS frame grabbers automatically perform spatial correction for Linea HS2 cameras.

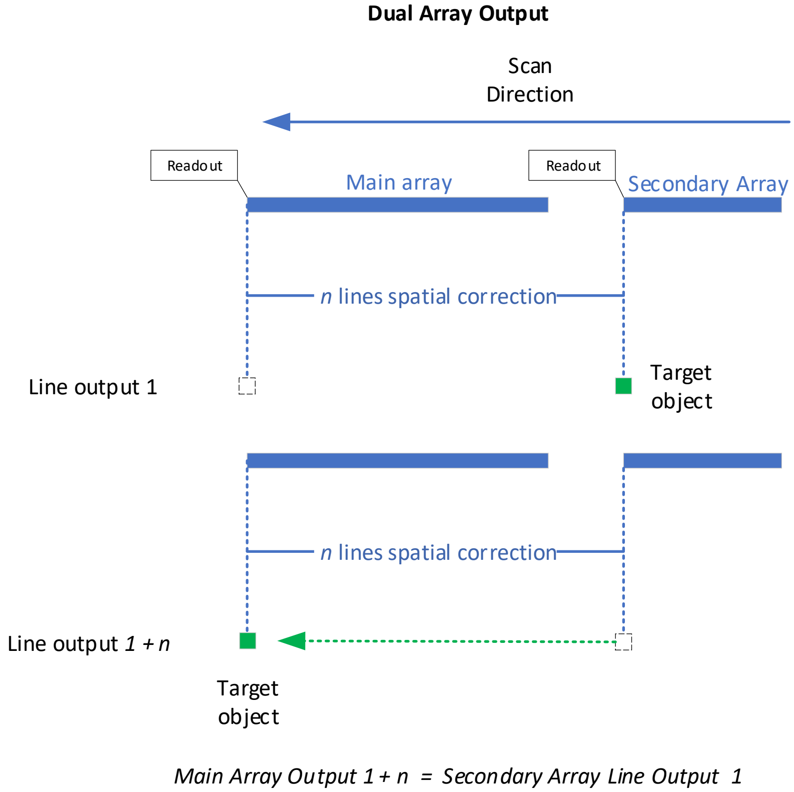


Figure 26: Spatial Correction

At a high level, spatial correction is a two-step process;

1) Camera assigns row spacing data to each row.

2) The frame grabber uses this row spacing data to align the image data. All data buffering is performed by the frame grabber as the camera does not have adequate memory resources for this function.

Spatial correction compensates for the direction of travel and changes to the scan direction. In the case of a 128 x 128 two-array camera, assuming a 40-row gap between arrays, the readout lines are 168 lines apart, regardless of scan direction. In a dual array output with different number of stages (e.g., 128 x 32), the distance between the readout lines would differ according to scan direction.

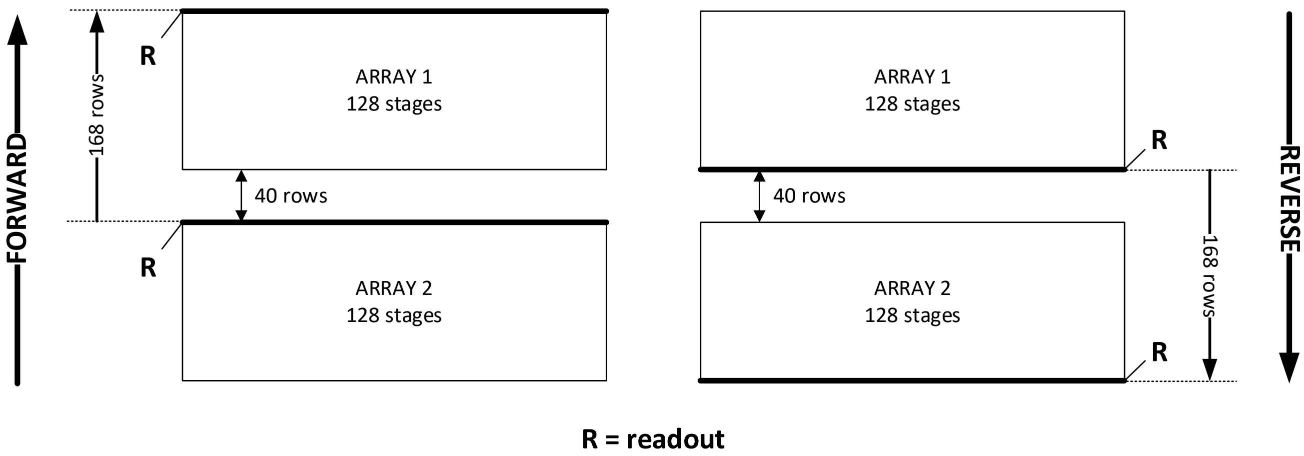


Figure 27: Camera Line Spacing. This example depicts a two-array sensor, where each array consists of 128 stages. Forward and Reverse scan directions have identical line spacing.

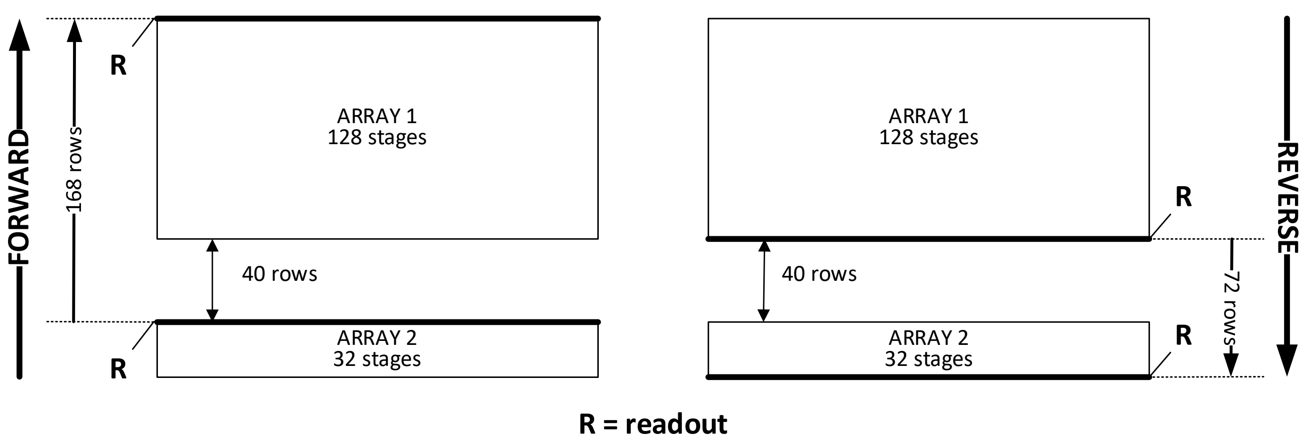


Figure 28. Camera Line Spacing. This example depicts a dual-array sensor, where arrays consist of 128 and 32 stages, respectively. Line spacing differs depending on scan direction.

Alignment Markers

See <u>Image Format Category</u> for GenICam features associated with this section.

Related Features: alignmentMarkerEnable, alignmentMarkerVerticalSpacing, alignmentMarkerVerticalOffset, alignmentMarkerHorizontalSpacing, alignmentMarkerHorizontalOffset and alignmentMarkerBlack

Use alignment markers to help align the camera so that the TDI arrays are perpendicular to the scan direction. Proper sensor alignment ensures that in each stage, the pixels capture the same part of the object as it moves; misalignment can result in blurred or smeared images.

When enabled, alignment markers are displayed as a grid overlay in the image output. Spacing, offset and color of markers may be adjusted to facilitate alignment.

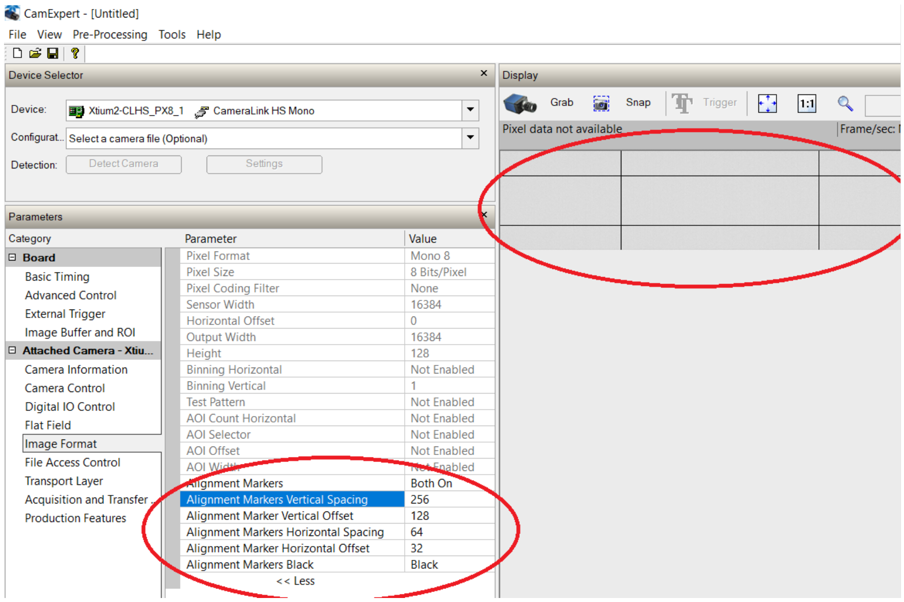


Figure 29: Alignment Markers

Achieving Maximum Line Rate

The maximum achievable line rate is determined by the CLHS mode, the TDI mode, the number of frame grabbers installed, the AOI windows, and the bit depth, as shown in the table below. Note that the frame grabbers must be configured differently depending on their number and on whether used in data forwarding mode or not.

The maximum line rates are achieved with 8-bit camera output (10-bit sensor ADC) in a single array TDI Mode (TDI Mono or TDI Low-Mono). The image data should be divided equally across frame grabbers, e.g., for a 16k image, set up the camera to have 8k AOI on each port, and then further divide the image data to 4k on each frame grabber (Xtium2 frame grabbers in data-forwarding mode). See Table 17.

Note that using 10-bit data output will reduce the maximum line rate to approximately 80% of the maximum 8-bit line rate in equivalent operating conditions.

Table 17: Maximum line rates for acquiring a 16k image at 8-bit and 10-bit in TDI Mono mode, according to CLHS mode, AOI and number of Xtium2 frame grabbers (FG) in use. Shaded cells indicate the frame grabber is used in data forwarding mode.

Linea HS2 Camera Configuration			**Xtium2 CLHS PX8 Frame Grabber Configuration**					**Max Line Rate (kHz)**	
CLHS Mode	**Port 1 AOI**	**Port 2 AOI**	**# FG in use**	**FG #1 AOI**	**FG #2 AOI**	**FG #3 AOI**	**FG #4 AOI**	**8-bit pixel output**	**10-bit pixel output**
Single	Width 16394 Offset 0	–	1	Width 16394 Offset 0	–	–	–	360	214
Single	Width 16394 Offset 0	–	2	Width 8192 Offset 0	Width 8192 Offset 8192	–	–	500	401
Dual	Width 8192 Offset 0	Width 8192 Offset 8192	2	Width 8192 Offset 0	Width 8192 Offset 0	–	–	720	428
Dual	Width 8192 Offset 0	Width 8192 Offset 8192	4	Width 4096 Offset 0	Width 4096 Offset 4096	Width 4096 Offset 0	Width 4096 Offset 4096	**1000**	806

** Targeted maximum. Ensure that the frame grabbers are updated to the latest firmware, and that there are sufficient PCI resources on the host PC.*

Table 18: Maximum line rates for acquiring a 16k image at 8-bit according to CLHS mode, tap mode and number of Xtium3 frame grabbers (FG) in use.

Linea HS2 Camera Configuration		**Xtium3 CLHS PX8 Frame Grabber Configuration**			
CLHS Mode (Single/Dual)	**# Frame Grabbers**	**Tap Mode**	**Data Lanes**	**CLHS Data Rate**	**Max Line Rate***
Single	1	Half	7	10.3125 Gbps	500 kHz (8-bit)
Dual	2	Full	14	10.3125 Gbps	1 MHz (8-bit)

** Targeted maximum. Ensure that the frame grabbers are updated to the latest firmware, and that there are sufficient PCI resources on the host PC.*

Minimum Line Rate

The minimum practical line rate is 20 kHz. Devices can be operated under the minimum line rate, but specifications will no longer be valid.

Imaging Modes

See Camera Control Category for GenICam features associated with this section.

Relevant Features: sensorTDIModeSelection

The Linea HS2 models can be operated in different modes: TDI Mono, TDI Low-Mono (Low Sensitivity), TDI HDR Mono (High Dynamic Range), TDI HFW Mono (High Full Well), Area Mono and Area Extended.

TDI Mono

TDI Mono is the default operating mode for the camera. In this mode, the camera combines multiple exposures of an object as it passes each row in the array. Only the main 128-stage array is used, and the maximum line rate can be achieved. See Figure 30.

TDI Low-Mono

This is a low-sensitivity mode, which operates like TDI Mono except the camera uses the 32-stage array of the sensor. The resulting image will be 4 times less saturated than with the 128-stage array. See Figure 30.

TDI HDR Mono

HDR (high dynamic range) enables imaging of (exceedingly) bright and dark areas in a single scan, replacing dual-scan setups with dedicated cycles. In TDI HDR Mono mode, image data is collected from two TDI arrays (one 128-stage array and one 32-stage array), providing a 4:1 ratio; the two output rows are combined in the host to create an HDR image.

This mode reduces the maximum line rate to half the maximum line rate of single-array modes. See Figure 30.

TDI HFW Mono

HFW (high full well) collects image data from two 128-stage TDI arrays, and outputs them to the host to be combined as desired:

- Summing the arrays provides a 2x full well increase at lower responsivity.
- Averaging the arrays maintains responsivity, with $\sqrt{2}$ improved NEE.

This mode reduces the maximum line rate to half the maximum line rate of single-array modes. See Figure 30.

ABOUT AREA MODES

Area modes are intended to assist with alignment of the camera during installation and commissioning.

In area mode, the camera will output the full sensor-width image to the primary frame grabber only.

Features from the Image Format Category such as binning and AOIs are unavailable in area mode.

There is no cosmetic image-quality specification for area modes. Area mode images may appear noisy, contain dark lines, or other image artifacts.

Area Mono

In Area Mono mode, the camera simulates a 16k x 128 8-bit area scan camera and constructs a 2D image using the main 128-stage array. Area Mono mode is intended for use during setup, both for aligning and focusing the camera. See Figure 30.

When selecting Area Mono mode, the Device Scan Type feature changes to *Areascan* and the Height feature changes to *128*, automatically. Note that binning and AOI features are unavailable in area mode.

Area Extended

This mode operates like Area Mono but outputs all three arrays as 16k x 128 8-bit 2D images, which can be assembled in the in the host. Area Extended mode is intended for use during setup, both for aligning and focusing the camera. See Figure 30.

Note that the camera outputs the arrays as three separate 16k x 128 images. The 32-stage array is output as 128 rows, with the only top 32 rows active, and the remaining 96 rows dark.

For Area Extended mode the maximum frame rate is reduced to 1/3 of the Area Mono frame rate.

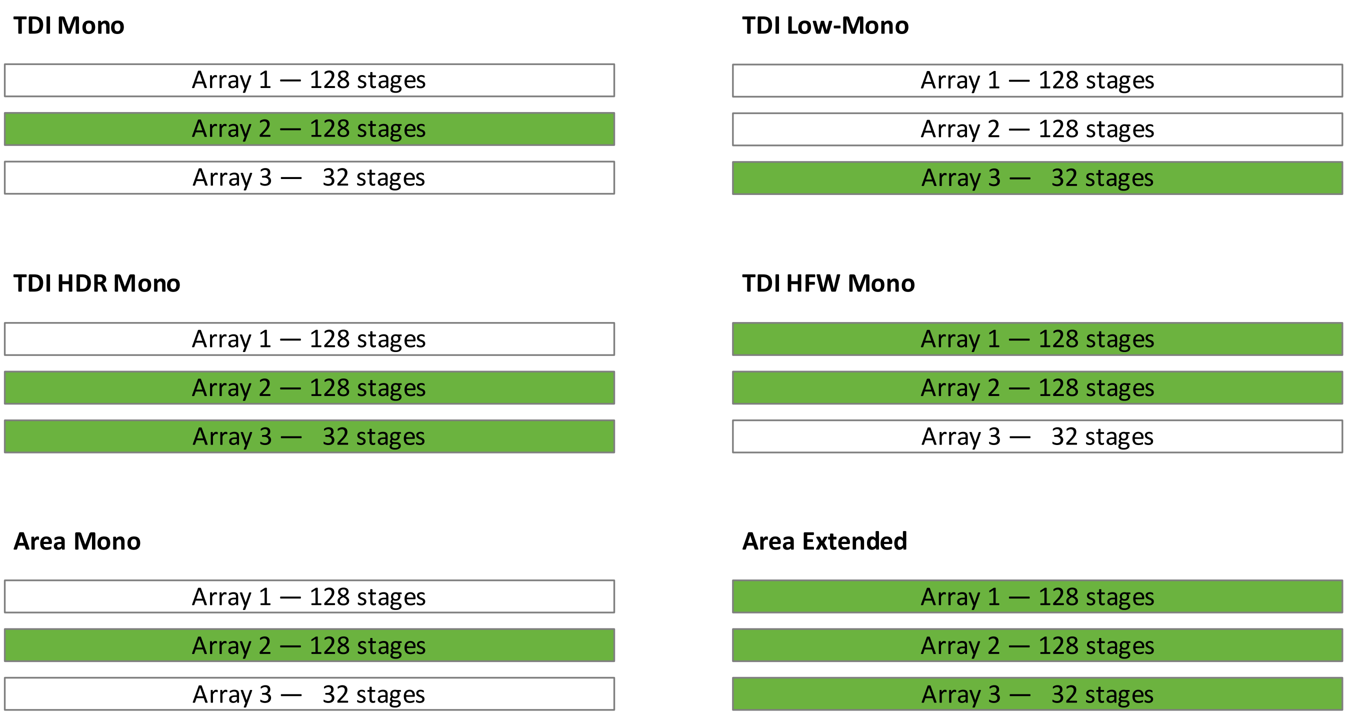


Figure 30. Arrays used in the different TDI and area modes.

Imaging Mode and Line Rate

See Camera Control Category for GenICam features associated with this section.

Related Feature: AcquisitionFrameRate, AcquisitionLineRate

When the Trigger Mode feature is set to *Internal*, the line rate is controlled with the AcquisitionLineRate or AcquisitionFrameRate feature. The chosen TDI mode, number of areas of interest (AOIs), bit depth (8-bit vs. 10-

bit) and number of cables (single- or dual-port CLHS mode), affect the maximum achievable rate as indicated in section Maximum Line Rate.

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

- **TDI Mono** (default): The maximum line rate is as indicated in the specifications.
- **TDI Low-Mono**: The maximum line rate is as indicated in the specifications.
- **TDI HDR Mono**: The line rate is ½ of the TDI mode maximum line rate as this mode combines the output from two arrays.
- **TDI HFW Mono**: The line rate is ½ of the TDI mode maximum line rate as this mode combines the output from two arrays.
- **Area Mono**: The maximum frame rate is 1,500 Hz.
- **Area Extended**: The maximum frame rate is 500 Hz.

Table 19: Maximum line rates, in hertz, for 16k images for each mode and bit depth.

# Active CLHS Ports	# Frame Grabbers (Xtium2)	Bit Depth	TDI Mono	TDI Low	TDI HFW	TDI HDR	TDI Extended	Area Mono	Area Extended
1	1	8-bit (16384 px)	362319	362319	180723	180723	120579	1500	500
		10-bit (16384 px)	214286	214286	107296	107296	71497	-	-
1	2	8-bit (2 x 8192 px)	500000	500000	250000	250000	167038	-	-
		10-bit (2 x 8192 px)	401070	401070	200535	200535	133690	-	-
2	2	8-bit (2 x 8192 px)	721154	721154	362319	362319	241158	-	-
		10-bit (2 x 8192 px)	428571	428571	214286	214286	143130	-	-
2	4	8-bit (4 x 4096 px)	**1000000** 824176*	**1000000** 824176*	500000	500000	333333	-	-
		10-bit (4 x 4096 px)	806452	806452	401070	401070	267857	-	-

** With Vertical sensor binning x2 enabled.*

Establishing the Optimal Response

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

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

The ideal test setup meets the following conditions:

- The lens is in focus, at the desired magnification and with the desired aperture.
- The illumination intensity is equal to that of the inspection system and aligned with the camera's field of view.
- The camera's line rate determines the exposure time: exposure time (us) = 1,000,000 / line rate (Hz).

Exposure Control by Light Source Strobe

See Digital IO Control Category for GenICam features associated with this section.

Relevant Features: outputLineSource, outputLinePulseDelay, outputLinePulseDuration, LineInverter

NOTE

TDI sensors do not have exposure control built in. Pixels continuously convert photons to electrons.

After receiving a line trigger, the camera instructs the sensor to execute the analog read operation. During this time incoming photons are still detected and may associate with the current or subsequent line. This effect is negligible when constant lighting is used.

When using strobed lighting, ensure a minimum delay of 1.4 µs between the rising edge of EXSYNC and powering-on of the light source.

Using the GPIO controls the camera can be set up to strobe a light source, effectively giving exposure control. Figure 31 shows an example of an output signal used as a strobe signal.

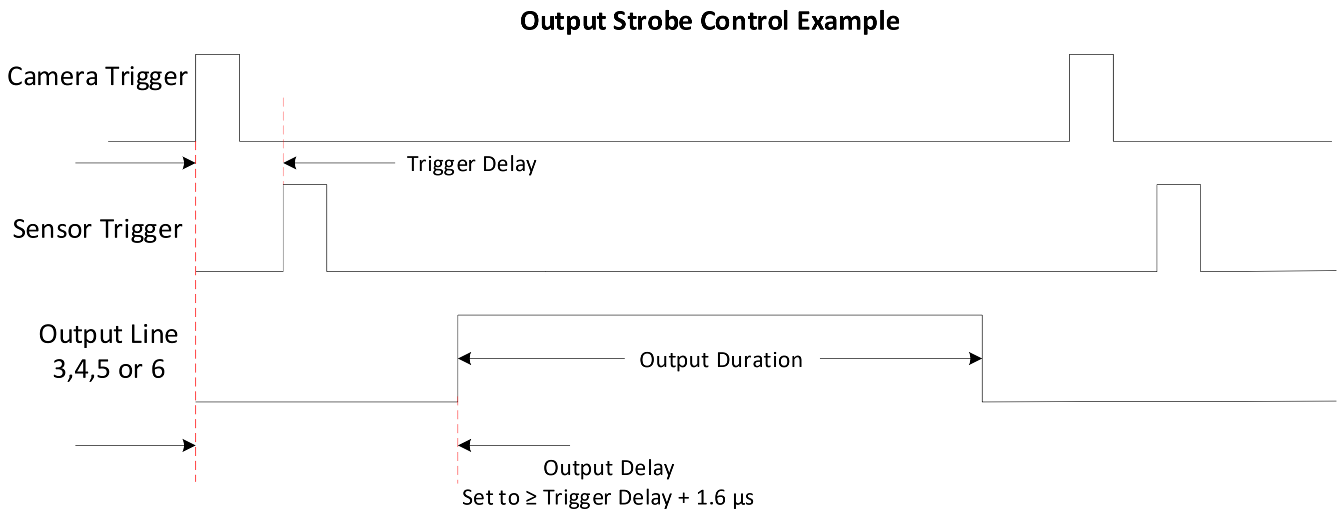


Figure 31: Strobe Timing.

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

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

The following diagram illustrates the logical control signal flow in the Linea HS2 series camera family.

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

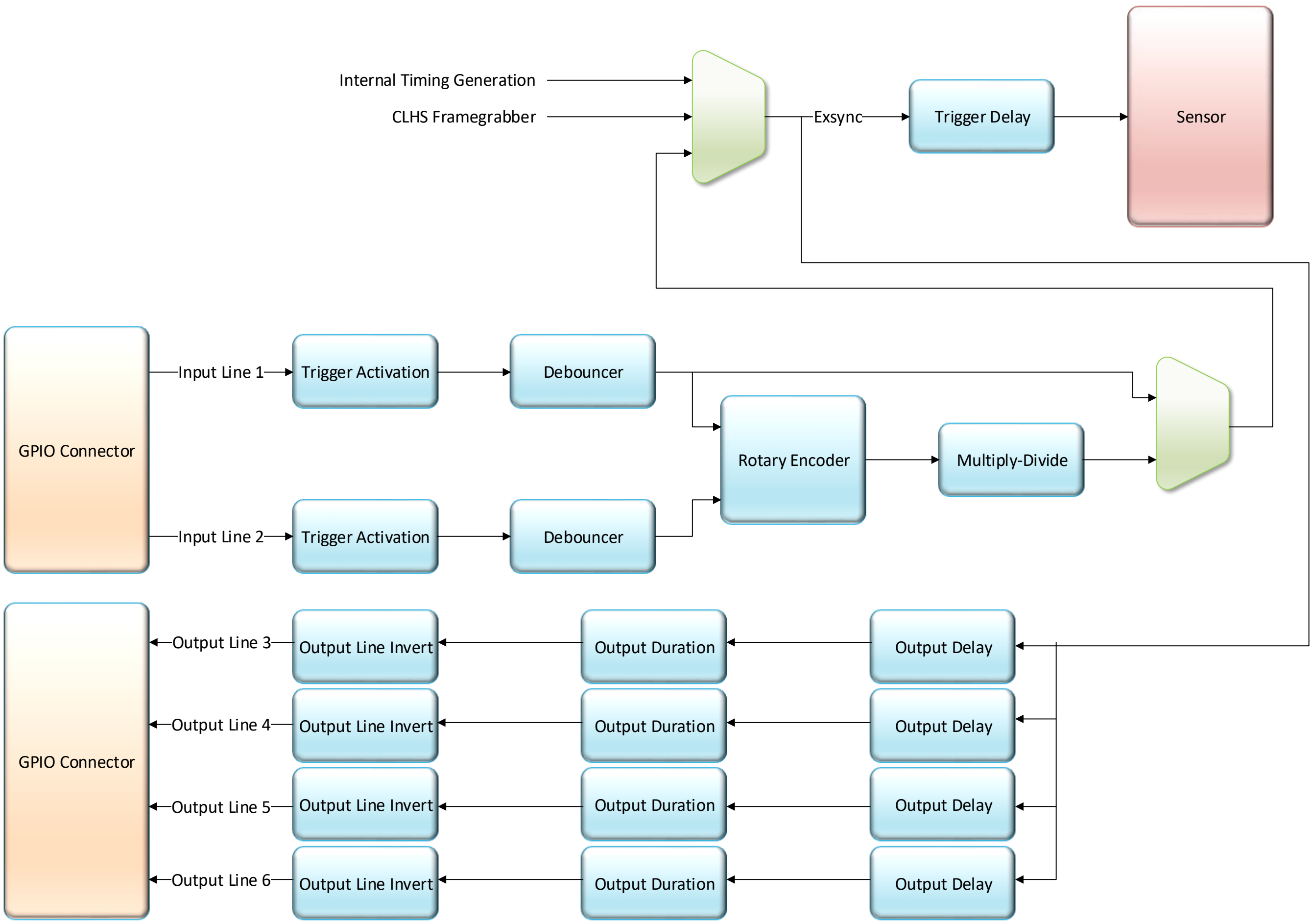


Figure 32: GPIO functionality block diagram.

Flat Field Correction (FFC) and Photo-Response Non-Uniformity (PRNU)

See Flat Field Category for GenICam features associated with this section.

Related Features: flatfieldCalibrationFPN, flatfieldCalibrationPRNU, flatfieldCorrectionAlgorithm, flatfieldCalibrationTarget

Sensor pixels do not output the exact same value under uniform illumination due to slight differences in the responsivity of individual pixels. This results in a non-uniform but static pattern. Flat Field Correction (FFC) is used to adjust the gain and offset of each pixel individually so that all pixels of a sensor produce a uniform response under uniform lighting conditions.

FFC uses two coefficients per pixel to correct the pixel's gain and offset. FFC applies the following formula:

newPixelValue[x] = (sensorPixelValue[x] – FFCOffset[x]) * FFCGain[x]

where:

- [**x**] is the pixel coordinate.
- **newPixelValue** is the pixel value after Flat Field Correction is applied.
- **sensorPixelValue** is the pixel value before Flat Field Correction is applied.
- **FFCOffset** is the offset coefficient value to subtract from the sensorPixelValue.
- **FFCGain** is the gain coefficient value that is multiplied with the sensorPixelValue.

FFC is achieved by performing FPN (fixed pattern noise) calibration and PRNU (photo-response non-uniformity) calibration (see Appendix A – Performing Flat Field Calibration Using CamExpert). FPN and PRNU coefficient can be saved in a user set.

IMPORTANT
It is imperative to perform FPN and PRNU calibration under the same imaging mode and conditions as the camera is to be used in, including acquisition line rate and direction of scan. Line rate and internal camera temperature need to be similar to the expected operating conditions.

Saving & Loading a PRNU Set Only

See Flat Field Category for GenICam features associated with this section.

Related Features: flatfieldCorrectionCurrentActiveSet, flatfieldCalibrationSave, flatfieldCalibrationLoad

A user set includes all the configuration settings (for example, gain, line rate), including FPN coefficients, PRNU coefficients, and LUT. Loading a complete user set takes approximately 1 second. Loading only the PRNU coefficients takes less than 200 milliseconds.

The Flat Field Correction Current Active Set, Save Calibration, and Load Calibration parameters let you save/load just the PRNU coefficients. Select a set as the Current Active Set, then save or load the coefficients to/from that set with the Save Calibration and Load Calibration commands. There are 17 sets available—16 user and 1 factory. The *Factory Set* is read-only and contains all "1"s. Loading the *Factory Set* is a good way to clear the user PRNU.

Flat Field Calibration Region of Interest

See Flat Field Category for GenICam features associated with this section.

Related Features: flatfieldCalibrationROIOffsetX, flatfieldCalibrationROIWidth

There are occasions when the camera's field of view includes areas that are beyond the material to be inspected. For instance, when a camera's image includes the edge of a panel or web, the edge of the material may not be illuminated in the same way as the area of inspection and, therefore, will cause problems with a flat field calibration.

The camera can accommodate a no inspection zone 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 defined using the Flat Field Calibration Offset X and Flat Field Calibration Width parameters.

Operating at Low Line Rates

If flat field calibration (FFC) was performed at a high line rate, but the application requires operation at line rates below 30 kHz, it is recommended to recalibrate the FFC coefficients; the difference in FPN is minimized if the camera is used at higher line rates but may become noticeable at reduced speed.

Adjusting Responsivity and Contrast Enhancement with Gain and Black Level

See Camera Control Category for GenICam features associated with this section.

Related Features: GainSelector, BlackLevel, Gain

To achieve the desired output from the camera, it may be necessary to adjust the responsivity. The gain and black level (offset) features can be used to that end. Gain and black level settings are applied as follows:

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

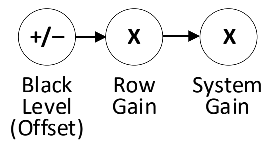


Figure 33: Black Level, Gain and System Gain Processing Chain.

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

Black Level

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

To determine the offset value to subtract from the image with the current gain setting, use the histogram of the Statistics tool on the Display toolbar. Then set this as a negative offset value and apply additional gain to achieve the desired peak image data values. The offset values range from –32 to +31 for 8-bit output.

NOTE

Because black level is applied before gain, it is saved for unity gain. However, the displayed black level value will automatically update to reflect any applied additional gain and indicate its effect on the final output. For instance, if at 1x gain the black level is set to 10, then at 2x gain the black level value will show 20.

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.

Gain

For monochrome cameras in TDI HDR Mono mode, row gain can be adjusted independently for output rows from 1 to ~4x. System Gain can be adjusted from 1 to 10x.

Binning

See Image Format Category for GenICam features associated with this section.

Related Features: BinningHorizontal, BinningVertical, binningHorizontalAvgEN, binningVerticalAvgEN, BinningSensorVertical

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

Binning is a process whereby the charges of adjacent pixels are summed. The camera supports horizontal and vertical digital binning, and vertical charge-domain binning.

Digital Binning

Horizontal binning is achieved by summing adjacent pixels in the same row of the TDI array, vertical binning by summing adjacent pixels in the same column. For instance, 2x horizontal binning results in the object pixel doubling in size horizontally. In addition, because pixels are summed, the image gets brighter: 1x2 and 2x1 bins are twice as bright, 2x2 is four times as bright, and so forth. Binning 2x also halves the amount of image data out of the camera. This can be used to save processing bandwidth in the host and storage space by creating smaller image file sizes.

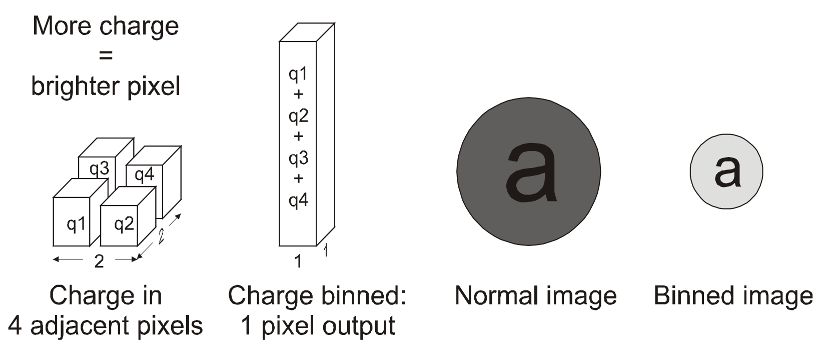


Figure 34: 2x2 Binning

Averaging Option

Adjacent pixels in both the horizontal and vertical direction can optionally be averaged instead of summed. This case is useful for reducing image noise due to sampling each pixel over a larger area.

Sensor Vertical Charge-Domain Binning

The Linea HS2 sensor silicon has the capability to internally perform a 2x charge-based vertical binning. When this is enabled, a single line trigger will execute two line-transfers inside the sensor, which will be charge-binned prior to readout from the sensor.

The camera line rate remains almost the same, but the pixel height doubles: the object scan speed must also double to bring the image into focus.

NOTE

In 8-bit mode, the maximum line rate achievable with vertical sensor binning enabled will be reduced. See Table 19.

NOTE

You must stop acquisition to modify binning parameters. See Setting up Binning below.

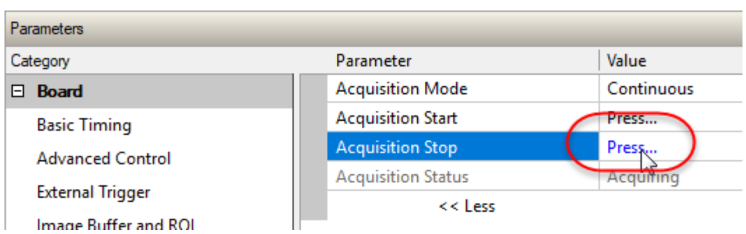
NOTE

Binning is unavailable when the camera is operating in Area mode.

Setting up Binning

To setup binning

1. Ensure the camera is operating in one of the TDI modes (Camera Control > TDI Mode).
2. In CamExpert, select Acquisition and Transfer Control > Acquisition Stop > Press.



The Acquisition Status feature should now indicate *Not Acquiring*.

3. In the Image Format category, select values for features Binning Horizontal, Binning Vertical, Averaging Horizontal, Averaging Vertical, Binning Sensor Vertical.
4. Start acquisition, using Acquisition and Transfer Control > Acquisition Start > Press.

Areas of Interest (AOIs)

See Image Format Category for GenICam features associated with this section.

Related Features: portRoiSelector, multipleROICount, multipleROISelector, multipleROIOffsetX, multipleROIWidth

Areas of interest are used to eliminate unwanted image data from being processed by the host computer, which may result in an increase of the maximum allowable line rate. AOIs are also used to split the image between camera ports in dual-port configurations.

The camera can accommodate up to four AOIs per cable. Image data outside the AOIs is discarded. Each AOI is user selected and its pixel boundaries defined. The camera assembles the individual AOIs into one contiguous image line with a width equal to the sum of the individual AOIs.

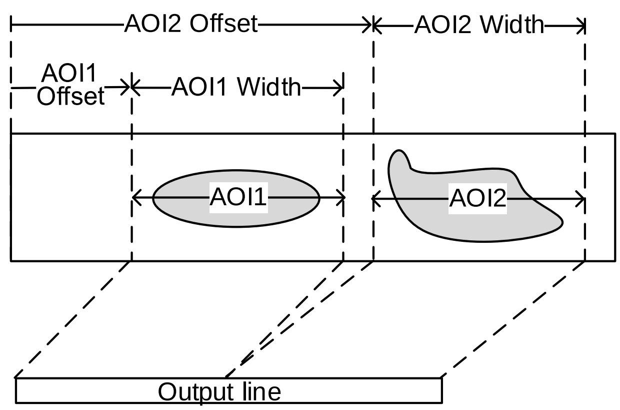


Figure 35: In this figure, objects to scan can be found within 2 regions of interest. The width of the output line is the sum of the width of the defined AOIs.

NOTE
The frame grabber will need to be adjusted to accommodate the smaller overall image width. As the host computer defined the size of each individual AOI, it will be able to extract and process each individual AOI from the single larger image.

Rules for Setting Areas of Interest

The rules are dictated by how image data is organized for transmission over the available CLHS data lanes. The camera/XML will enforce these rules, truncating entered values where necessary.

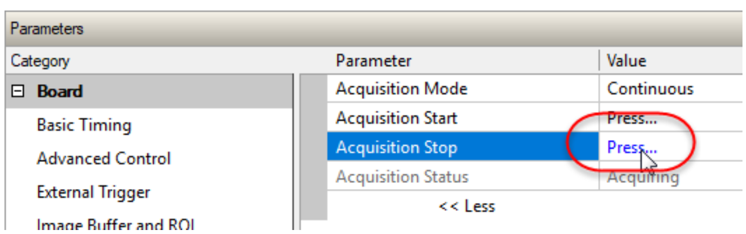
NOTE
You must stop acquisition to modify AOI parameters. See Setting up Areas of Interest below.

- 1-4 AOIs per cable (CLHS port) can be selected.
- Minimum width is 96 pixels per AOI.
  - The total width of all AOIs must be at least 1,024.
  - The total width of all AOIs must be no more than 16,384.
  - Maximum 8k bytes per CLHS lane.
- AOI width step size is 32 pixels.
- The offset of each AOI may range from 0 to 16,288 (16,384 – 96).
- Overlapping AOIs are allowed.
- Offset and width for individual AOI's will adjust one another.
  - For example, if an AOI has offset 0 and width 16,384, and the offset is changed to 4096, then the width will be adjusted to 12,288.
  - AOI's only affect one another by limiting the maximum width.
- AOIs are concatenated together in numerical order and sent to the frame grabber starting at column zero. If the AOI count is reduced to less than the current AOI count, the AOI selector will be changed to the largest of the new AOI count available.

Setting up Areas of Interest

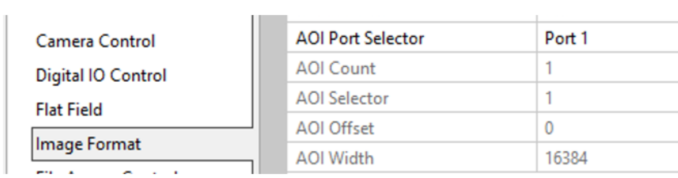
To setup an area of interest

1. In CamExpert, select Acquisition and Transfer Control > Acquisition Stop > Press.



   The Acquisition Status feature should now indicate *Not Acquiring*.

2. In the Image Format category, select the port to configure using the AOI Port Selector parameter. Note: if only one port is enabled then only the port connected will be available.
3. Set the number of AOIs using the AOI Count Horizontal (multipleROICount) feature.



4. Select the first AOI using the AOI Selector parameter and set its offset and width. If the other AOIs are large you may need to select them first and reduce their widths.
5. Repeat for each AOI in turn.
6. Start acquisition, using Acquisition and Transfer Control > Acquisition Start > Press.

Enhancement of Interest (EOI)

See Flat Field Category for GenICam features associated with this section.

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

Enhancements of Interest (EOI) allow rapid gain and offset settings to be applied to up to 4 regions in the image. EOIs are supported in all imaging modes.

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

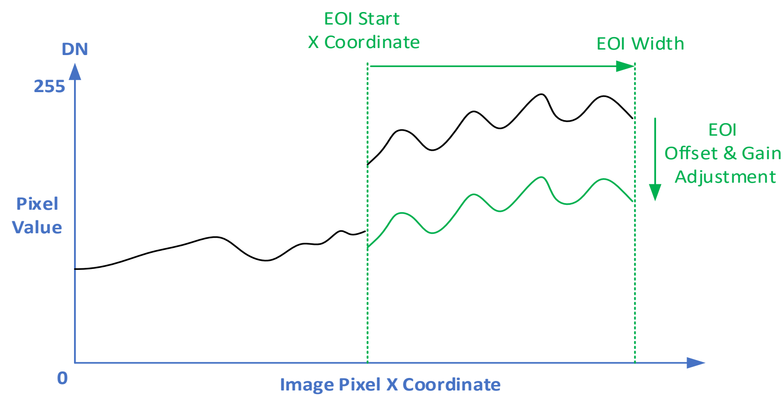


Figure 36: Enhancement of Interest

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

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

To set up EOIs

1. Set EOI > *Off*.
2. Set EOI count.
3. For each EOI, set:
   a. EOI Start
   b. EOI Width
   c. EOI Offset
   d. EOI Gain
4. Set EOI > *On*.

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

Customized Linearity Response (LUT)

See Flat Field Category for GenICam features associated with this section.

Related Features: lutMode and gammaCorrection

The camera allows the user to access a LUT (Look Up Table) to customize the linearity of the camera response. This can be done by uploading a LUT to the camera using the file transfer features, or by using the Gamma Correction feature.

NOTE

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

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. It is recommended that the fixed Offset available in the Camera Control category be set to zero. The LUT can be used in any camera mode.

To upload a LUT, use File Access Control Category > Upload / Download File > Settings and select Look Up Table to upload a file. LUTs are saved with User Sets.

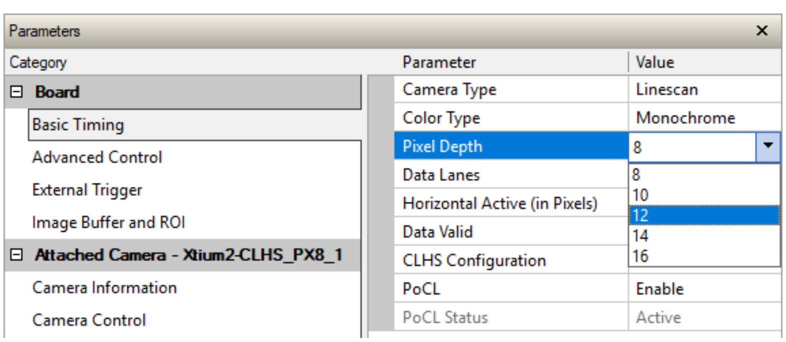
A spreadsheet is available from Teledyne DALSA Technical Support, which allows LUTs to be viewed, edited and saved.

How to Generate a LUT with CamExpert

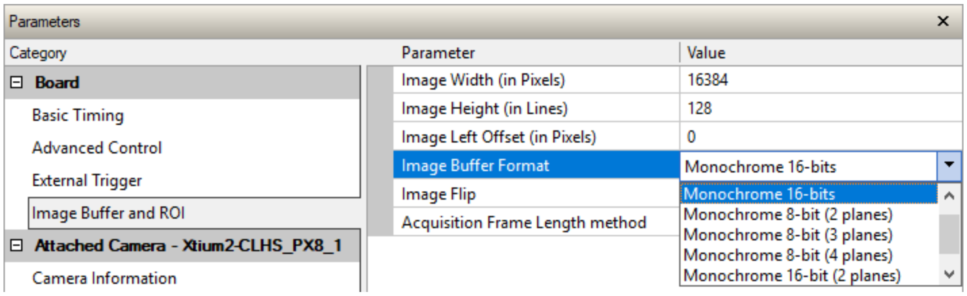
CamExpert can be used to create a LUT file. The camera uses a 10-bit in/10-bit out LUT (even if the camera is outputting an 8-bit image). CamExpert can be configured to create a 10-bit in/16-bit out LUT - the camera will convert it to the required format.

To generate a LUT

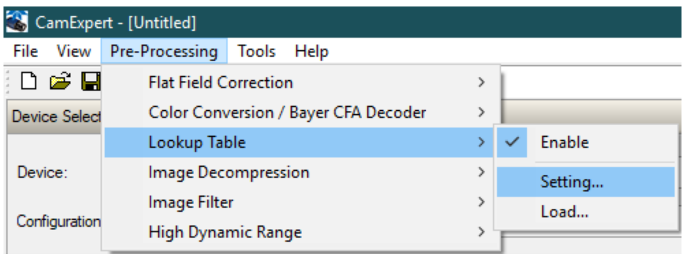
1. Under Board, set Basic Timing > Pixel Depth to 12.



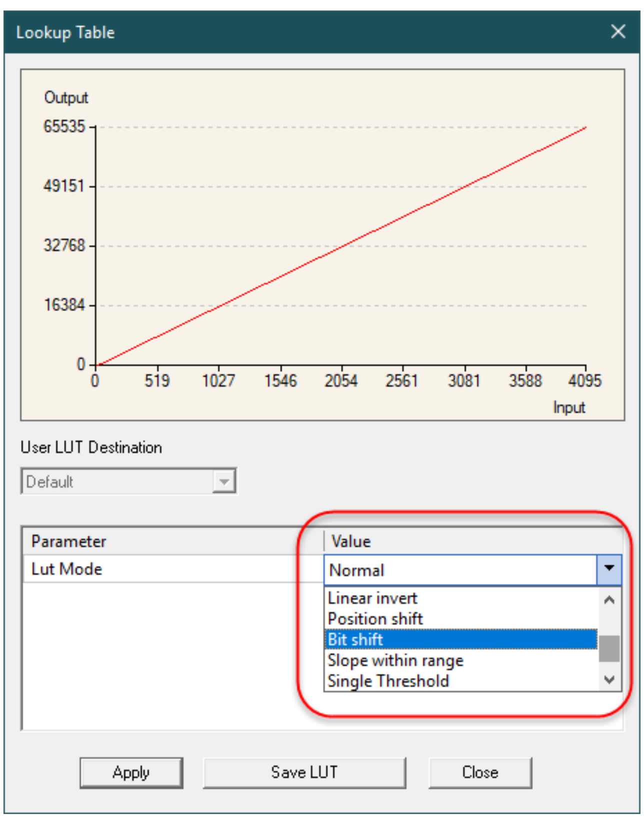
2. Under Board, set Image Buffer and ROI > Image Buffer Format to Monochrome 16-bits.



3. In CamExpert's menu bar, select Pre-Processing > Lookup Table, then
   - select Enable
   - select Setting.



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



5. Click Save LUT to create a LUT file.

   This file can be loaded into the camera using CamExpert's Pre-Processing > Lookup Table command. 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.

6. Deselect the Lookup Table > Enable.
7. Return the Board parameters to their original settings:
   - Basic Timing > Pixel Depth = 8
   - Image Buffer and ROI > Image Buffer = 8-bits.

IMPORTANT

- The frame grabber must be configured mono 10-bits in, 16-bits out.
- In the Parameters pane, 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.

Changing Output Pixel Format

See Image Format Control Category for GenICam features associated with this section.

Related Feature: PixelFormat, AcquisitionStart and AcquisitionStop

The camera can output video data in 8-bit, 10-bit.

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

NOTE
Pixel Format, and associated features, can only be changed when the image transfer to the frame grabber is stopped. Refer to the Acquisition and Transfer Control Category section for details on stopping and starting the acquisition.

To change pixel format from 8-bit to 10-bit

1. In Acquisition and Transfer Control category, click **Press** next to Acquisition Stop.
2. In Image Format category, set Pixel Format to Mono 10.
3. In Basic Timing category of the frame grabber, set Pixel Depth to 10.
4. In Acquisition and Transfer Control category, click **Press** next to Acquisition Start.

Saving & Restoring Camera Setup Configurations

See Camera Information Category for GenICam features associated with this section.

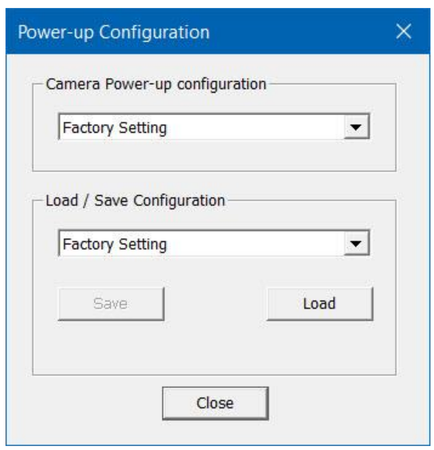
Related Features: UserSetSelector, UserSetDefaultSelector, UserSetLoad, UserSetSave

An inspection system may use multiple illumination, resolution, and responsivity configurations in order to cover the different types of inspection it performs. The camera includes 16 user sets where camera setup information can be saved to and restored from—either at power up or dynamically during inspection. User sets contain FFC coefficients (FPN, PRNU), gain(s), spatial correction, trigger mode, exposure mode, binning, acquisition line rate, AOI, LUTs, etc.

User sets and factory settings are saved in non-volatile memory on the camera. CamExpert provides a dialog that combines the features to select the camera settings at power-up, to save the current camera settings in a user set, or to load a saved set and make it active.

To open the Power-up Configuration dialog

- In the Camera Information Category, next to Power-up Configuration click **Setting**.



Camera Power-up Configuration

The **Camera Power-up Configuration** list allows the user to select the camera configuration to load when the camera is powered-up or reset (see UserSetDefaultSelector). The user chooses from the factory set or one of the user sets.

Load / Save Configuration

The **Load / Save Configuration** list allows the user to change the camera configuration any time after a power-up (see UserSetSelector).

To reset the camera to factory configuration

- Select *Factory Setting* and click **Load**.

To save the current camera configuration

- Select one of the user sets and click **Save**.

To restore a previously saved configuration

- Select a user set and click **Load**.

NOTE
Changes made after a configuration is loaded will be lost if the camera resets, is powered down or loses power, unless the current configuration is saved again.

TIP
By default, all user sets contain the factory settings.

Operational Reference

Camera Feature Categories

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

Many of the features shown in CamExpert may be changed directly in CamExpert or programmatically via an imaging application. Their availability may depend on other feature settings, and while some features are read-only (RO), others may be changed even during acquisition. Note that features shown by CamExpert may change with different device models implementing different sensors, image resolutions, and color versions; that is, a specific camera model may not support the full feature set defined in a category and described here.

The following description tables list and describe the device features along with their visibility attribute (Beginner, Expert, Guru). The View column also indicates whether the 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).

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.

NOTE
The CamExpert screen captures are shown for illustrative purposes and may not entirely reflect the features and parameters available from the camera model used in your application. The features described below may not all be available in your camera model.

Camera Information Category

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

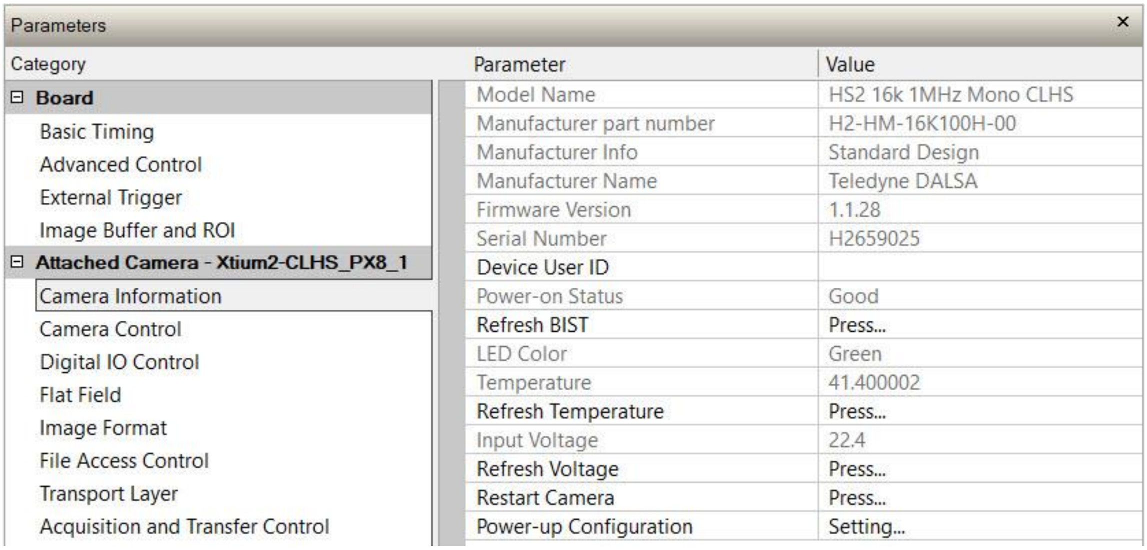


Figure 37: Example CamExpert Camera Information Panel

Camera Information Feature Descriptions

Display Name	Feature	Description	View
Model	DeviceModelName	Displays the device model name. (RO)	Beginner
Part number	deviceManufacturerPartNumber	Displays the part number of the device model. (RO)	Beginner DFNC
Manufacturer Info	DeviceManufacturerInfo	This feature provides extended manufacturer information about the device. (RO)	Beginner
Manufacturer Name	DeviceVendorName	Displays the device vendor name. (RO)	Beginner
Firmware Version	DeviceFirmwareVersion	Displays the currently loaded firmware version. (RO)	Beginner
Serial Number	DeviceSerialNumber	Displays the device's factory set serial number.(RO)	Beginner
Device User ID	DeviceUserID	Stores a user-programmable identifier. The default factory setting is the camera serial number. (RW)	Beginner
Power-on Status	deviceBISTStatus	Displays the status of the Built-In Self Test (BIST). Possible return values are device-specific. (RO) See Built-In Self-Test Status Codes for status code details.	Beginner DFNC
Refresh BIST	deviceBIST	Performs an internal test to determine the status of the device. (WO)	Beginner DFNC
LED Color	deviceLEDColorControl	Select the mode for the LED.	Beginner DFNC
Off	*Off*	*Off*	
Red	*Red*	*BIST error.*	
Green	*Green*	*Operational.*	
Waiting for EXSYNC	*Fast_Green*	*4 Hz Green.*	
Thermal Shutdown	*Medium_Red*	*2 Hz Red.*	
Looking for link	*Slow_Green*	*1 Hz Green.*	
Busy	*Medium_Orange*	*2 Hz Orange.*	

Display Name	Feature	Description	View
Temperature	DeviceTemperature	Internal temperature in degrees Celsius (C). (RO)	Beginner
Refresh Temperature	refreshTemperature	Press to refresh the Temperature readout. (WO)	Beginner DFNC
Input Voltage	deviceInputVoltage	Device input voltage at the power connector (V). (RO)	Beginner DFNC
Refresh Voltage	refreshVoltage	Press to refresh the Input Voltage. (WO)	Beginner DFNC
Restart Camera	DeviceReset	Resets the device to its power up state. (WO)	Beginner
Power-up Configuration			
Power-on User Set	UserSetDefaultSelector	Selects the camera configuration user set to load and make active on camera power-up or reset. The camera configuration sets are stored in camera non-volatile memory. See Saving & Restoring Camera Setup Configurations.	Beginner
Factory Set	*Factory*	*Load factory-default feature settings.*	
User Set 1, …, User Set 16	*UserSet1, …, UserSet16*	*Select the user-defined configuration set to load at camera power-up or reset.*	
Current User Set	UserSetSelector	Selects the camera configuration user set to configure. The Factory set contains default camera feature settings and is read-only.	Beginner
Factory Set	*Factory*	*Select the default camera feature settings saved by the factory.*	
User Set 1, …, User Set 16	*UserSet1, …, UserSet16*	*Select User Set [1-16].*	
Load User Set	UserSetLoad	Loads the user set specified by the User Set Selector to the camera and makes it active.	Beginner
Save User Set	UserSetSave	Saves the user set specified by the User Set Selector to the camera. The user sets are located on the camera in non-volatile memory.	Beginner

Camera Control Category

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

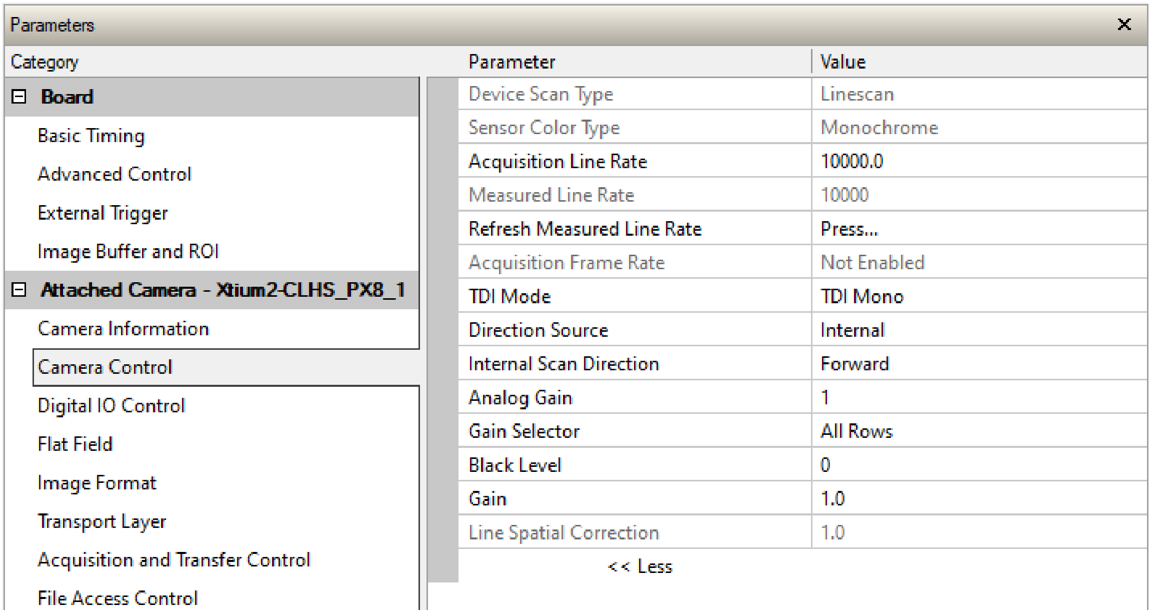


Figure 38: Camera Control Panel

Camera Control Feature Descriptions

Display Name	Feature	Description	View
Device Scan Type *Areascan* *Linescan*	DeviceScanType *Areascan* *Linescan*	Scan type of the sensor. *2D areascan sensor.* *Linescan sensor.*	Beginner
Sensor Color Type *Monochrome*	sensorColorType *Monochrome*	Defines the sensor color type of the device. *Monochrome sensor.*	Beginner DFNC
Acquisition Line Rate	AcquisitionLineRate	Specifies the camera line rate, in Hz.	Beginner
Measured Line Rate	measuredLineRate	Measured line rate in Hz. (RO)	Beginner DFNC
Refresh Measured Line Rate	refreshMeasuredLineRate	Refresh the Measured Line Rate. (WO)	Beginner DFNC
Acquisition Frame Rate	AcquisitionFrameRate	Specifies the camera frame rate, in Hz. (Valid when camera is running in Area mode.)	Beginner

Display Name	Feature	Description	View
TDI Mode	sensorTDIModeSelection	Selects how to combine the sensor rows for processing.	Beginner DFNC
TDI Mono	*Tdi*	*Output one 128-stage TDI row.*	
TDI Low-Mono	*TdiLow*	*Output one 32-stage TDI row.*	
TDI HDR Mono	*TdiHdr*	*Output one 128-stage TDI row and one 32-stage TDI row. (High dynamic range mode)*	
TDI HFW Mono	*TdiHfw*	*Output two 128-stage TDI rows. (High full well mode)*	
Area Mono	*TdiArea*	*Output one 128-stage array.*	
Area Extended	*TdiMultiArea*	*Output the 32-stage array plus two 128-stage arrays in area mode.*	
Direction Source	sensorScanDirectionSource	Specifies whether scan direction is controlled by a feature or an external signal.	Beginner DFNC
Internal	*Internal*	*Direction controlled by Internal Scan Direction parameter.*	
Line 2	*GPIO2*	*Direction controlled by GPIO 2.*	
RotaryEncoder	*Encoder*	*Channel A and B from encoder go to GPIO 1 and 2 respectively. Direction is determined from phase.*	
Internal Scan Direction	sensorScanDirection	When Direction Source is set to *Internal*, this feature specifies the direction of the scan.	Beginner
Forward	*Forward*	*Forward scan direction.*	
Reverse	*Reverse*	*Reverse scan direction.*	
Gain Selector	GainSelector	Selects which gain and (black level) offset are accessed.	Beginner
All Rows	*All*	*Gain and offset applied to all rows.*	
Row 1	*Row1*	*Gain and offset applied to the first row.*	
Row 2	*Row2*	*Gain and offset applied to the second row.*	
Row 3	*Row3*	*Gain and offset applied to the third row.*	
System Gain	*System*	*Gain applied after row gains.*	
Analog Gain	AnalogGain	Sets the analog gain. Select row with Gain Selector.	Beginner
1	*One*	*No gain applied.*	
2	*Two*	*2X analog gain applied.*	
4	*Four*	*4X analog gain applied.*	
Black Level	BlackLevel	A signed offset added to the output. DN_out = (DN_in + Black_Level) * Gain	Beginner
Gain	Gain	Amplification factor applied to the video signal.	Beginner
Line Spatial Correction	sensorLineSpatialCorrection	Sets the number of lines of delay between output planes from the sensor for spatial correction. Stop acquisition to change.	Beginner DFNC

Digital IO Control Category

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

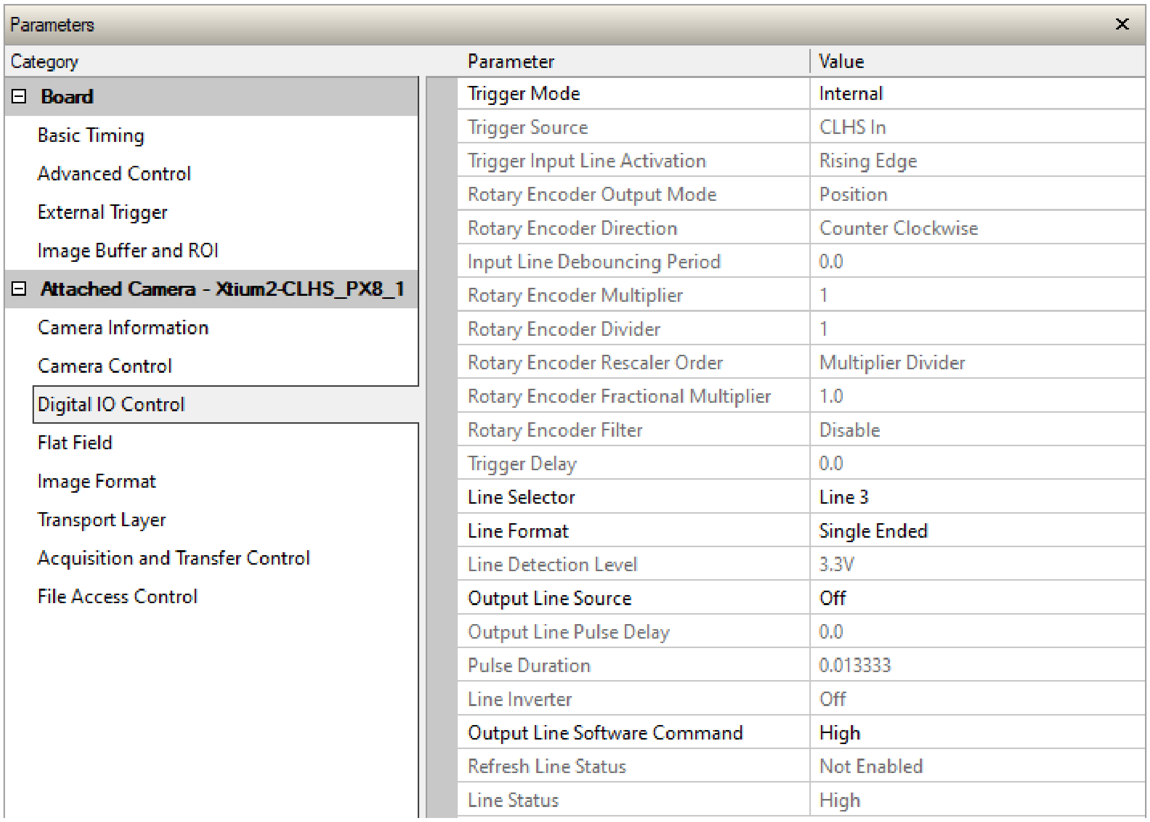


Figure 39: Digital I/O Control Panel

Digital IO Control Feature Descriptions

Display Name	Feature	Description	View
Trigger Mode	TriggerMode	Controls whether the external trigger is active.	Beginner
Internal	*Internal*	*Line rate is controlled with AcquisitionLineRate feature.*	
External	*External*	*Trigger comes from CLHS (frame grabber) or GPIO.*	
Trigger Source	TriggerSource	Determines the source of the external trigger. Trigger Mode must be set to *External*.	Beginner
CLHS In	*CLHS*	*Trigger comes from the frame grabber over CLHS.*	
Rotary Encoder	*Encoder*	*Channel A and B from encoder go to GPIO 1 and 2 respectively. Direction is determined from phase.*	
Line 1	*GPIO1*	*Trigger source is Line 1.*	
Trigger Input Line Activation	TriggerActivation	Edge of the input signal that will trigger the camera.	Beginner
Rising Edge	*RisingEdge*	*Rising edge trigger activation.*	
Falling Edge	*FallingEdge*	*Falling edge trigger activation.*	
Any Edge	*AnyEdge*	*Any edge trigger activation*	

Display Name	Feature	Description	View
Rotary Encoder Output Mode	rotaryEncoderOutputMode	Specifies the conditions for the Rotary Encoder interface to generate a valid Encoder output signal.	Beginner DFNC
Position	*Position*	*Triggers are generated at all new position increments in the selected direction. If the encoder reverses no trigger events are generated until it has again passed the position where the reversal started.*	
Motion	*Motion*	*The triggers are generated for all motion increments in either direction.*	
Rotary Encoder Direction	rotaryEncoderDirection	Specifies the phase which defines the encoder forward direction.	Beginner DFNC
Counter Clockwise	*CounterClockwise*	*Inspection goes forward when the rotary encoder direction is counter-clockwise (phase A is ahead of phase B).*	
Clockwise	*Clockwise*	*Inspection goes forward when the rotary encoder direction is clockwise (phase B is ahead of phase A).*	
Input Line Debouncing Period	lineDebouncingPeriod	Specifies the minimum delay (us) before an input line voltage transition is recognized as a signal transition.	Beginner DFNC
Rotary Encoder Multiplier	rotaryEncoderMultiplier	Specifies a multiplication factor for the rotary encoder output pulse generator.	Beginner DFNC
Rotary Encoder Divider	rotaryEncoderDivider	Specifies a division factor for the rotary encoder output pulse generator.	Beginner DFNC
Rotary Encoder Rescaler Order	rotaryEncoderRescalerOrder	Specifies the order in which the multiplier and divider are applied. For details, see Application Note for Multiplier and Divider.	Expert DFNC
Multiplier Divider	*multiplierDivider*	*The signal is multiplied before being divided.*	
Divider Multiplier	*dividerMultiplier*	*The signal is divided before being multiplied.*	
Fractional Multiplier Divider	*fractionalMultiplierDivider*	*The signal is multiplied by the fractional number before being divided.*	
Rotary Encoder Fractional Multiplier	rotaryEncoderFractionalMultiplier	Specifies a fractional multiplication for the rotary encoder output pulse generator.	Beginner DFNC
Rotary Encoder Filter	rotaryEncoderFilter	Rotary Encoder Trigger Filter value.	Beginner DFNC
+/- 5.69 us	*F569*	*+/- 5.69 us*	
+/- 2.84 us	*F284*	*+/- 2.84 us*	
+/- 1.42 us	*F142*	*+/- 1.42 us*	
+/- 711 ns	*F711*	*+/- 711 ns*	
+/- 356 ns	*F356*	*+/- 356 ns*	
+/- 178 ns	*F178*	*+/- 178 ns*	
+/- 89 ns	*F89*	*+/- 89 ns*	
Disable	*disable*	*Disable*	
Trigger Delay	TriggerDelay	Specifies the delay in microseconds (µs) to apply after the trigger reception before activating it.	Beginner
Line Selector	LineSelector	Selects the physical line (or pin) of the external device connector to configure.	Beginner
Line 1	*GPIO1*	*Selects GPIO 1 (input 1).*	
Line 2	*GPIO2*	*Selects GPIO 2 (input 2).*	
Line 3	*GPIO3*	*Selects GPIO 3 (output 1).*	
Line 4	*GPIO4*	*Selects GPIO 4 (output 2).*	
Line 5	*GPIO5*	*Selects GPIO5 (output 3).*	
Line 6	*GPIO6*	*Selects GPIO6 (output 4).*	

Display Name	Feature	Description	View
Line Format	LineFormat	Specify the electrical format of the selected physical input or output.	Beginner
Single Ended	*SingleEnded*	*The line is a single-ended input for 1.65V/2.5V/6V/12V, or output for 3.3V LVTTL*	
Open Collector	*OpenCollector*	*The line is output as open-collector.*	
Line Detection Level	lineDetectionLevel	Specifies the voltage threshold required to recognize a signal transition on an input line.	Beginner DFNC
3V3	*Threshold_for_3V3*	*A signal below 1.65V will be detected as a Logical LOW and a signal greater than 1.65V will be detected as a Logical HIGH on the selected input line.*	
5V	*Threshold_for_5V*	*A signal below 2.5V will be detected as a Logical LOW and a signal greater than 2.5V will be detected as a Logical HIGH on the selected input line.*	
12V	*Threshold_for_12V*	*A signal below 6V will be detected as a Logical LOW and a signal greater than 6V will be detected as a Logical HIGH on the selected input line.*	
24V	*Threshold_for_24V*	*A signal below 12V will be detected as a Logical LOW and a signal greater than 12V will be detected as a Logical HIGH on the selected input line.*	
Output Line Source	outputLineSource	Indicates which features control the output on the selected line.	Beginner DFNC
Off	*Off*	*Line output level is controlled by the outputLineSoftwareCmd feature.*	
On	*On*	*Line output level is controlled by outputLinePulseDelay, outputLinePulseDuration and LineInverter features.*	
Output Line Pulse Delay	outputLinePulseDelay	Sets the delay (µs) before the output line pulse duration signal.	Beginner DFNC
Pulse Duration	outputLinePulseDuration	Sets the width (duration) of the output line pulse in microseconds (µs).	Beginner DFNC
Line Inverter	LineInverter	Controls whether to invert the polarity of the selected input or output line signal.	Beginner
Off	*Off*	*Leave signal unchanged.*	
On	*On*	*Invert line signal.*	
Output Line Software Command	outputLineSoftwareCmd	Set the GPIO out value when outputLineSource is *Off*.	Expert DFNC
Low	*Low*	*Output line is low.*	
High	*High*	*Output line is high.*	
Refresh Line Status	refreshLineStatus	Updates the LineStatus.	Beginner DFNC
Line Status	LineStatus	Returns the current state of the selected input line.	Expert
Low	*Low*	*Line is low.*	
High	*High*	*Line is high.*	

Flat Field Category

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

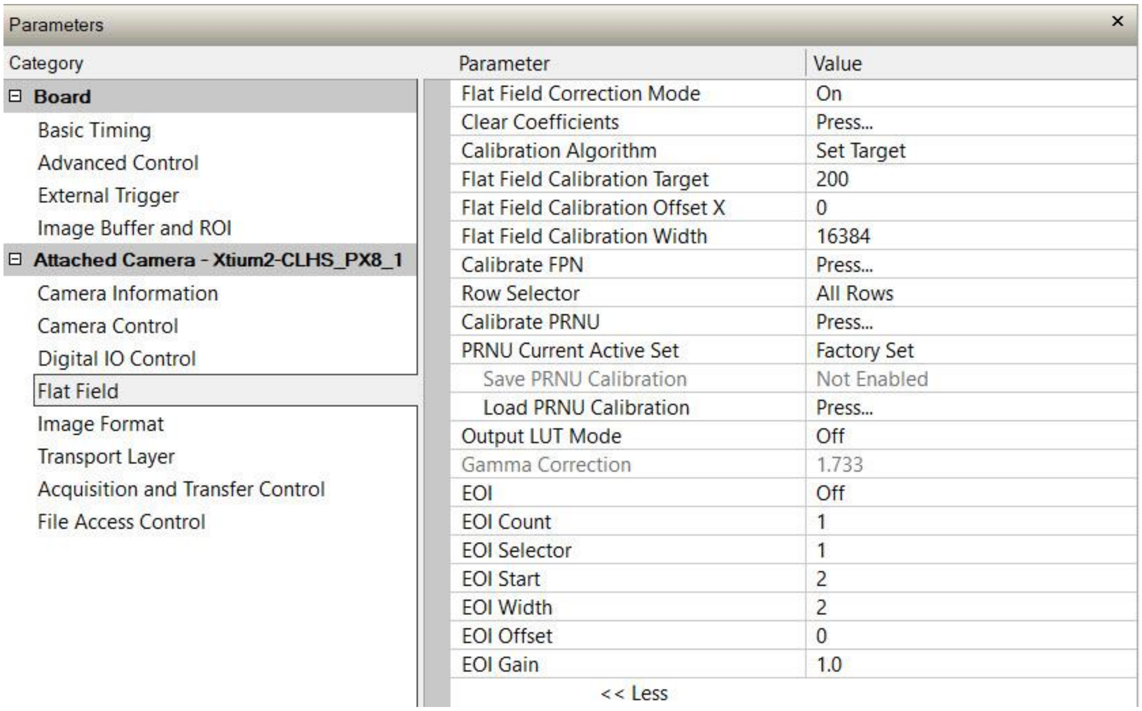


Figure 40: Flat Field Panel

Flat Field Control Feature Description

Display Name	Feature	Description	View
Flat Field Correction Mode	flatfieldCorrectionMode	Sets the mode for flat field correction.	Beginner DFNC
Off	*Off*	Flat field correction is disabled.	
On	*On*	Flat field correction enabled.	
Clear Coefficents	flatfieldCalibrationClearCoefficient	Sets all FPN coefficients to 0 and all PRNU coefficients to 1.	Beginner DFNC
Calibration Algorithm	flatfieldCorrectionAlgorithm	Specifies the flatfield calibration algorithm to use.	Beginner DFNC
Peak	*Peak*	*Each pixel is gained up to the brightest.*	
Set Target	*Target*	*Each pixel is gained up to the value specified in the Calibration Target parameter.*	
Flat Field Calibration Target	flatfieldCalibrationTarget	Sets the target value for the “Calibrate PRNU” feature.	Beginner DFNC
Flat Field Calibration Offset X	flatfieldCalibrationROIOffsetX	Sets the flat field calibration Region of Interest (ROI) start pixel. Will push ROI Width if necessary.	Beginner DFNC
Flat Field Calibration Width	flatfieldCalibrationROIWidth	Sets the flat field calibration Region of Interest (ROI) width. Will push ROI Offset X if necessary.	Beginner DFNC
Calibrate FPN	flatfieldCalibrationFPN	Captures the Fixed Pattern Noise (FPN) for each pixel. When flat field correction mode is *On*, the FPN is subtracted from the image.	Beginner DFNC

Display Name	Feature	Description	View
Row Selector	flatfieldCalibrationColorSelector	Selects which row/color is calibrated.	Beginner DFNC
All Rows	*All*	*All rows calibrated.*	
Row 1	*Row1*	*Row 1 calibrated.*	
Row 2	*Row2*	*Row 2 calibrated.*	
Calibrate PRNU	flatfieldCalibrationPRNU	Calibrates Photo-Response Non-Uniformity (PRNU) so that the responsivity of each pixel is the same. When flat field correction mode is *On*, the image is multiplied by the PRNU (after the FPN is subtracted).	Beginner DFNC
PRNU Current Active Set	flatfieldCorrectionCurrentActiveSet	Selects the User PRNU set save or load.	Guru DFNC
Factory Set	*Factory Set*	*Factory set.*	
User Set 1 (1 thru 16)	*UserSet1 (1 thru 16)*	*User Set [1-16].*	
Save PRNU Calibration	flatfieldCalibrationSave	Saves the User PRNU set specified by *flatfieldCorrectionCurrentActiveSet* to the camera.	Guru DFNC
Load PRNU Calibration	flatfieldCalibrationLoad	Loads the User PRNU set specified by *flatfieldCorrectionCurrentActiveSet* to the camera and makes it active.	Guru DFNC
Output LUT Mode	lutMode	Sets the mode for the output LUT.	Guru DFNC
Off	*Off*	*Output LUT is disabled.*	
Gamma Correction	*Gamma*	*Output LUT uses Gamma correction.*	
User Defined	*UserDefined*	*Output LUT defined by user file.*	
Gamma Correction	gammaCorrection	Sets the output HDR LUT Gamma correction factor. DN_out = 255 x ((DN_in / 255) ^ (1 / Gamma))	Guru DFNC
Enable EOI	enhancedImage	Enables enhanced region(s) of interest (EOI).	Guru DFNC
Off	*Off*	*Disable EOIs.*	
On	*On*	*Enable EOIs.*	
EOI Count	enhancedImageCount	Specifies the number of EOIs to define in an acquired image.	Guru DFNC
EOI Selector	enhancedImageSelector	Selects the EOI to define.	Guru DFNC
EOI Start	enhancedImageStart	Specifies the start of the selected EOI.	Guru DFNC
EOI Width	enhancedImageWidth	Sets the width of the selected EOI.	Guru DFNC
EOI Offset	enhancedImageOffset	Sets the black level offset to apply to the selected EOI. Possible values range from -127 to 127.	Guru DFNC
EOI Gain	enhancedImageGain	Sets the gain to apply to the selected EOI.	Guru DFNC

Image Format Category

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

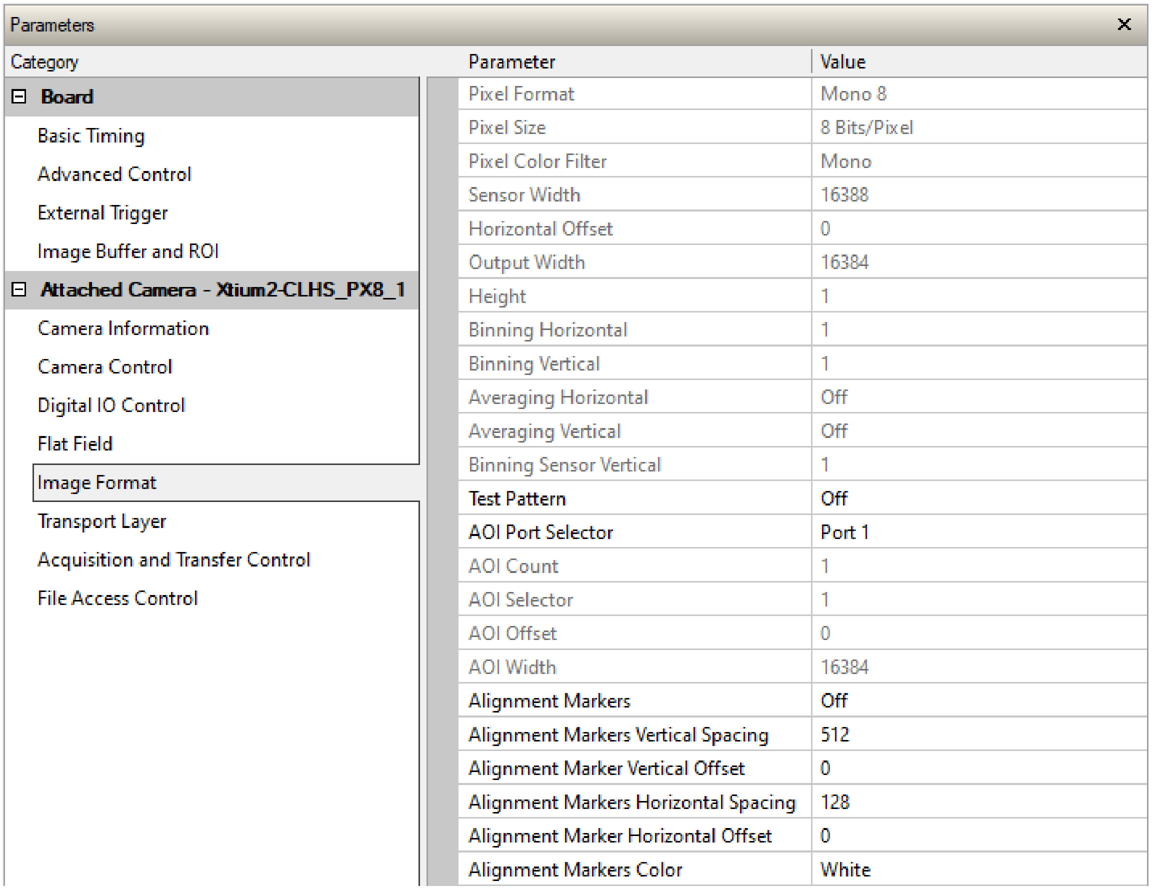


Figure 41: Image Format Panel

Image Format Control Feature Description

Display Name	Feature	Description	View
Pixel Format	PixelFormat	Output image pixel coding format of the sensor. Combines information of PixelCoding, PixelSize and PixelColorFilter.	Beginner
Mono 8	*Mono8*	*Monochrome 8-bit.*	
Mono 10	*Mono10*	*Monochrome 10-bit.*	
Pixel Size	PixelSize	Total size in bits of an image pixel. (RO)	Guru
8 Bits/Pixel	*Bpp8*	*8 bits per pixel.*	
10 Bits/Pixel	*Bpp10*	*10 bits per pixel.*	
Pixel Color Filter	PixelColorFilter	Indicates the type of color filter applied to the image. (RO)	Guru DFNC
Mono	*None*	*Monochrome.*	
Sensor Width	WidthMax	Sensor width in pixels. (RO)	Beginner
Horizontal Offset	OffsetX	Output image horizontal offset from the origin (always zero). (RO)	Beginner

Display Name	Feature	Description	View
Output Width	Width	Horizontal width in output pixels for the selected CLHS port. Equals the sum of AOI widths divided by the horizontal binning factor. (RO)	Beginner
Height	Height	Height of the image provided by the device (in pixels).	Beginner
Binning Horizontal	BinningHorizontal	Number of horizontally adjacent pixels to sum together. This increases the intensity of the pixels and reduces the horizontal resolution of the image.	Beginner
4	*Four*	*4*	
2	*Two*	*2*	
1	*One*	*1*	
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. The output line rate will be one half the input trigger.	Beginner
4	*Four*	*4*	
2	*Two*	*2*	
1	*One*	*1*	
Averaging Horizontal	binningHorizontalAvgEN	When feature is enabled, it reduces the system gain by the horizontal binning factor.	Beginner
Off	*Off*	*Digitally binned pixels are summed.*	
On	*On*	*Digitally binned pixels are averaged.*	
Averaging Vertical	binningVerticalAvgEN	When feature is enabled, it reduces the system gain by the vertical binning factor.	Beginner
Off	*Off*	*Digitally binned pixels are summed.*	
On	*On*	*Digitally binned pixels are averaged.*	
Binning Sensor Vertical	binningSensorVertical	Number of vertically adjacent pixels to sum together in the sensor (charge domain). This reduces the vertical resolution of the image while maintaining the line rate. The object speed will need to be doubled so the intensity will remain unchanged.	Beginner
2	*Two*	*2*	
1	*One*	*1*	
Test Pattern	TestImageSelector	Selects a test image to output from the camera.	Beginner
Off	*Off*	*Image is from the camera sensor.*	
Each Tap Fixed	*EachTapFixed*	*Each tap has a fixed value.*	
Grey Horizontal Ramp	*GreyHorizontalRamp*	*Image is filled horizontally with an image that goes from the darkest possible value to the brightest.*	
Grey Vertical Ramp	*GreyVerticalRamp*	*Image is filled vertically with an image that goes from the darkest possible value to the brightest.*	
Grey Diagonal Ramp	*GreyDiagonalRamp*	*Image is filled diagonally with an image that goes from the darkest possible value to the brightest.*	
User Pattern	*UserTp*	*User PRNU applied to quarter scale.*	
AOI Port Selector	PortRoiSelector	Select which CLHS port's AOI Offset and AOI Width to configure.	Beginner DFNC
Port 1	*Port1*	*CLHS port 1*	
Port 2	*Port2*	*CLHS port 2*	
AOI Count	multipleROICount	Specifies the number of AOIs (Areas of Interest) in an acquired image.	Beginner DFNC
AOI Selector	multipleROISelector	Specifies which AOI (Area of Interest) to configure.	Beginner DFNC
AOI Offset	multipleROIOffsetX	Horizontal offset in pixels from the left to the current AOI (Area of Interest).	Beginner DFNC

Display Name	Feature	Description	View
AOI Width	multipleROIWidth	Horizontal width in pixels of the current AOI (Area of Interest).	Beginner DFNC
Alignment Markers	alignmentMarkerEnable	Enable alignment markers.	Beginner DFNC
Off	*Off*	*Disable alignment markers.*	
Vertical On	*Vertical*	*Enable Vertical Alignment Markers.*	
Horizontal On	*Horizontal*	*Enable Horizontal Alignment Markers.*	
Both On	*Both*	*Enable Vertical and Horizontal Alignment Markers.*	
Alignment Marker Vertical Spacing	alignmentMarkerVerticalSpacing	Vertical spacing between alignment markers, in pixels.	Beginner DFNC
512	*Ver512*	*512 pixels between vertical alignment markers.*	
256	*Ver256*	*256 pixels between vertical alignment markers.*	
128	*Ver128*	*128 pixels between vertical alignment markers.*	
64	*Ver64*	*64 pixels between vertical alignment markers.*	
Alignment Marker Vertical Offset	alignmentMarkerVerticalOffset	Pixel count before first vertical alignment marker.	Beginner DFNC
Alignment Marker Horizontal Spacing	alignmentMarkerHorizontalSpacing	Horizontical spacing between alignment markers, in pixels.	Beginner DFNC
128	*Hor128*	*128 pixels between horizontal alignment markers.*	
64	*Hor64*	*64 pixels between horizontal alignment markers.*	
32	*Hor32*	*32 pixels between horizontal alignment markers.*	
16	*Hor16*	*16 pixels between horizontal alignment markers.*	
Alignment Marker Horizontal Offset	alignmentMarkerHorizontalOffset	Pixel count before first horizontal alignment marker.	Beginner DFNC
Alignment Markers Color	alignmentMarkerBlack	Specifies the alignment markers color.	Beginner DFNC
White	*White*	*White alignment markers.*	
Black	*Black*	*Black alignment markers.*	

Using Areas of Interest (AOIs)

Linea HS2 can accommodate up to four AOIs per port. Use AOI features to select and define the pixel boundaries of each AOI for each port. The camera assembles the individual AOI's into one contiguous image line with a width equal to the sum of the individual AOIs.

For details see Areas of Interest (AOIs).

Transport Layer Control Category

The Transport Layer Control category is used to configure features related to CLHS connection.

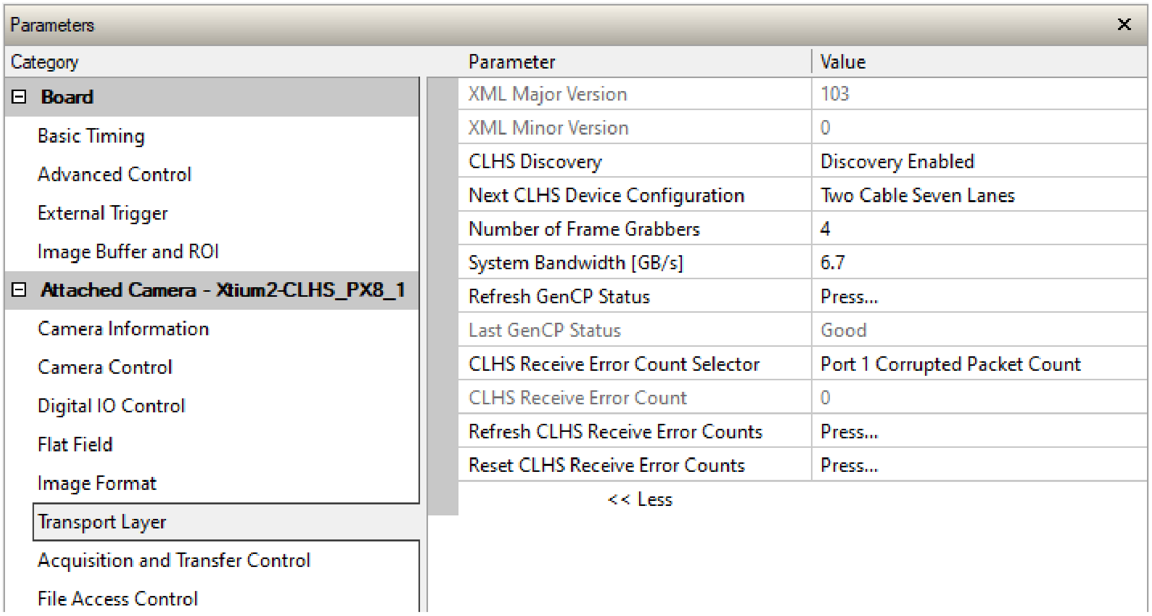


Figure 42: Transport Layer Panel

Transport Layer Feature Descriptions

Display Name	Feature	Description	View
XML Major Version	DeviceManifestXMLMajorVersion	Indicates the major version number of the XML file of the selected manifest entry. (RO)	Beginner
XML Minor Version	DeviceManifestXMLMinorVersion	Indicates the minor version number of the XML file of the selected manifest entry. (RO)	Beginner
CLHS Discovery	clhsDiscovery	Disable CLHS Discovery if not implemented in the frame grabber. If disabled then camera will enable image transmitters as soon as the cable is connected.	Beginner DFNC
Discovery Disabled	*DiscoveryDisable*	*Discovery disabled.*	
Discovery Enabled	*DiscoveryEnable*	*Discovery enabled.*	
Next CLHS Device Configuration	clhsNextDeviceConfig	Select next CLHS device configuration from valid list. Reboot or reconnect cable to activate.	Beginner DFNC
One Cable Seven Lanes	*OneCableSevenLanes*	*One cable seven lanes.*	
Two Cables Seven Lanes	*TwoCablesSevenLanes*	*Two cables seven lanes.*	
Number of Frame Grabbers	clhsNumberFrameGrabbers	Number of frame grabbers connected to the camera, including those forwarded to. Set to "0" to use System Bandwidth value instead.	Beginner DFNC
System Bandwidth [GB/s]	clhsSystemBandwidth	Sum of the PCIe bandwidth of all frame grabbers as shown in Sapera Diagnostics tool.	Beginner DFNC
Refresh GenCP Status	refreshGenCPStatus	Refresh GenCP Status. (WO)	Beginner DFNC
Last GenCP Status	genCPStatus	Last bad GenCP status. Check this if previous command failed.	Beginner DFNC

Display Name	Feature	Description	View
CLHS Receive Error Count Selector	clhsErrorCountSelector	Select the error to count that the next three features apply to.	Guru DFNC
Port 1 Corrupted Packet Count	*CorruptedPacketCntA*	*Count of corrupted CLHS packets on port 1.*	
Port 1 Corrected Packet Count	*CorrectedPacketCntA*	*Count of corrected CLHS packets on port 1.*	
Port 2 Corrupted Packet Count	*CorruptedPacketCntB*	*Count of corrupted CLHS packets on port 2.*	
Port 2 Corrected Packet Count	*CorrectedPacketCntB*	*Count of corrected CLHS packets on port 2.*	
CLHS Receive Error Count	clhsErrorCount	CLHS Receive Corrupted/Corrected Count.	Guru DFNC
Refresh CLHS Receive Error Counts	clhsErrorCountRefresh	Refresh CLHS Receive Corrupted/Corrected Counts.	Guru DFNC
Reset CLHS Receive Error Counts	clhsErrorCountReset	Reset CLHS Receive Corrupted/Corrected Counts to zero.	Guru DFNC

Acquisition and Transfer Control Category

The Acquisition and Transfer Control commands are used to start and stop image acquisition to allow some features to be changed, such as binning and areas of interest (AOIs).

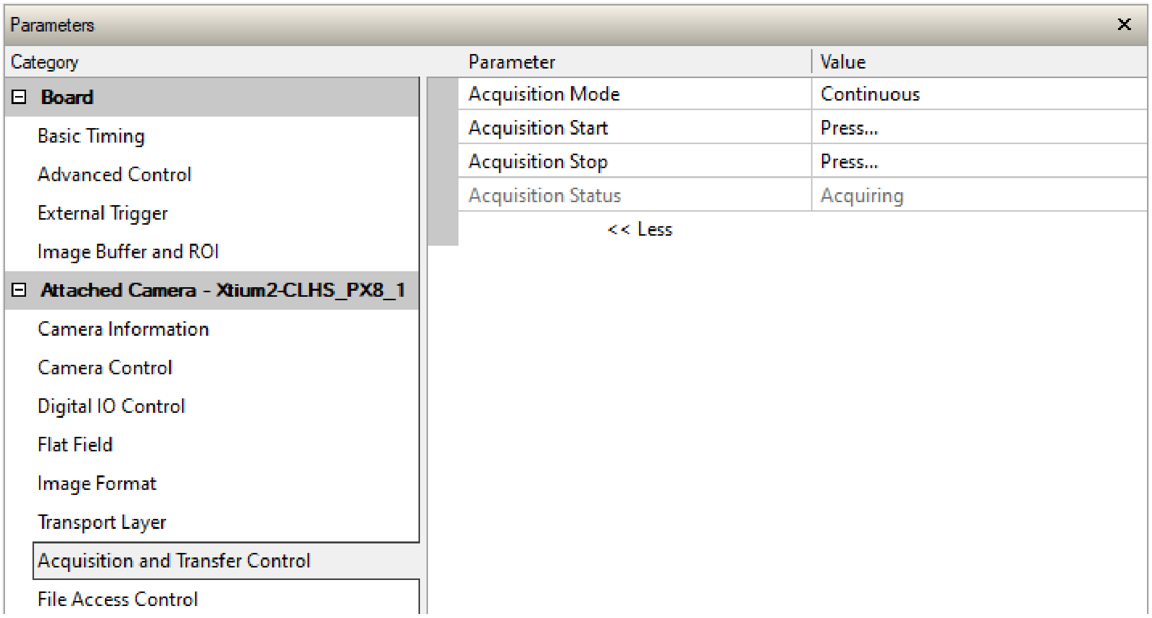


Figure 43: Acquisition & Transfer Control Panel

Acquisition and Transfer Control Feature Descriptions

Display Name	Feature	Description	View
Acquisition Mode	AcquisitionMode	The device acquisition mode defines the way that frames are acquired.	Beginner
Continuous	*Continuous*	*Frames are captured continuously until stopped with the Acquisition Stop command.*	
Acquisition Start	AcquisitionStart	Commands the camera to start sending image data. (WO)	Beginner
Acquisition Stop	AcquisitionStop	Commands the camera to stop sending image data at the end of the current line. (WO)	Beginner
Acquisition Status	AcquisitionStatus	Indicates whether the camera has been commanded to send image data.	Beginner
Acquiring	*Acquiring*	*Acquiring and sending image data.*	
Not Acquiring	*NotAcquiring*	*Not acquiring or sending image data.*	

File Access Control Category

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

NOTE

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

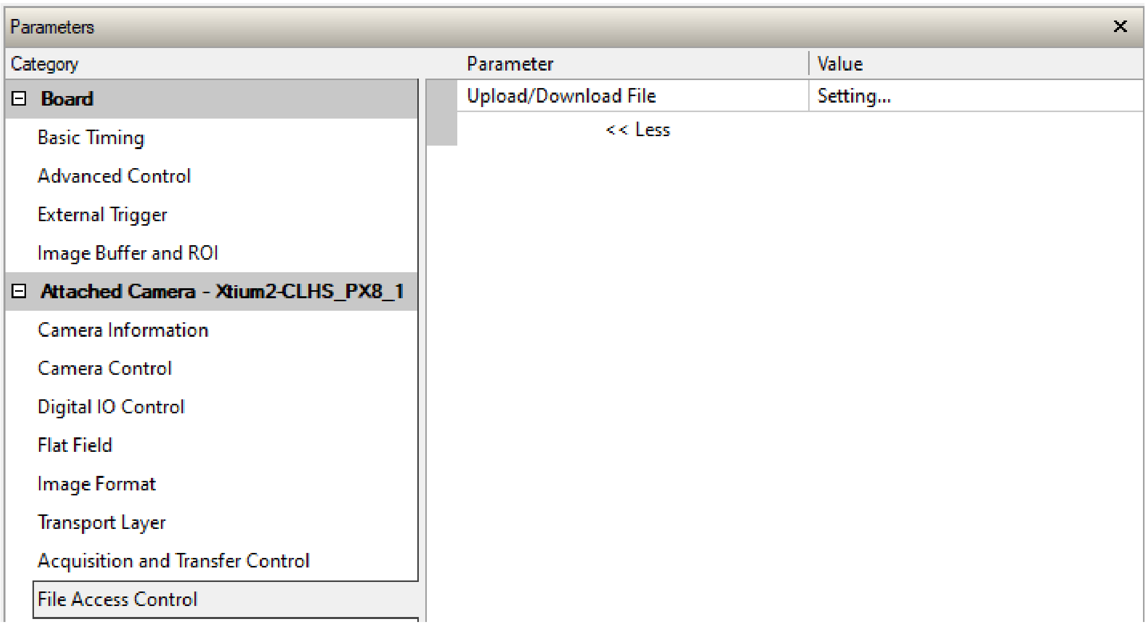


Figure 44: File Access Control Panel

File Access Control Feature Descriptions

Display Name	Feature	Description	View
File Selector	FileSelector	List of device files that can be uploaded or downloaded.	Hidden
All Firmware	*Firmware1*	*All firmware - FPGA code, microcode, XML and start-up script.*	
User Set	*User_Set*	*Configuration User Set.*	
Output LUT	*Output_LUT*	*Use UserSetSelector to specify which LUT to access.*	
User FPN	*User_FPN*	*User FPN coefficients.*	
User PRNU	*User_PRNU*	*User PRNU coefficients.*	
Current PRNU	*Cur_PRNU*	*PRNU coefficients that are currently being used by the camera (not necessarily saved).*	
Camera Data	*CameraData*	*This is a text file, please ensure that it has a ".txt" file name extension.*	

Display Name	Feature	Description	View
File Operation Selector	FileOperationSelector	Selects the target operation for the selected file in the device. This operation is executed when the FileOperationExecute feature is called.	Hidden
Open	*Open*	*Select the Open operation.*	
Close	*Close*	*Select the Close operation.*	
Read	*Read*	*Select the Read operation.*	
Write	*Write*	*Select the Write operation.*	
File Operation Execute	FileOperationExecute	Executes the operation selected by File Operation Selector on the selected file.	Hidden
File Open Mode	FileOpenMode	Selects the access mode in which a file is opened on the device.	Hidden
Read	*Read*	*READ mode.*	
Write	*Write*	*WRITE mode.*	
File Access Buffer	FileAccessBuffer	Defines the intermediate access buffer that allows the exchange of data between the device file storage and the application.	Hidden
File Access Offset	FileAccessOffset	Controls the file offset where the read or write operation will be performed.	Hidden
File Access Length	FileAccessLength	The number of bytes to transfer between the file and the FileAccessBuffer.	Hidden
File Operation Status	FileOperationStatus	Returns the status of the last file operation.	Hidden
Success	*Success*	*The last file operation has completed successfully.*	
Invalid Parameter	*InvalidParameter*	*The last file operation has completed unsuccessfully because of an invalid parameter.*	
Write Protect	*WriteProtect*	*The last file operation has completed unsuccessfully because the file is read only.*	
File Not Open	*FileNotOpen*	*The last file operation has completed unsuccessfully because the selected file has not been opened.*	
File Too Big	*FileTooBig*	*The last file operation has completed unsuccessfully because 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	The number of successfully read/written bytes during the last operation.	Hidden
File Size	FileSize	Represents the size of the selected file in bytes. (RO)	Hidden

File Access and Firmware Update

To update the firmware

1. Select the File Access Control category, and next to Upload/Download File, click **Setting** to open the File Access Control dialog box.

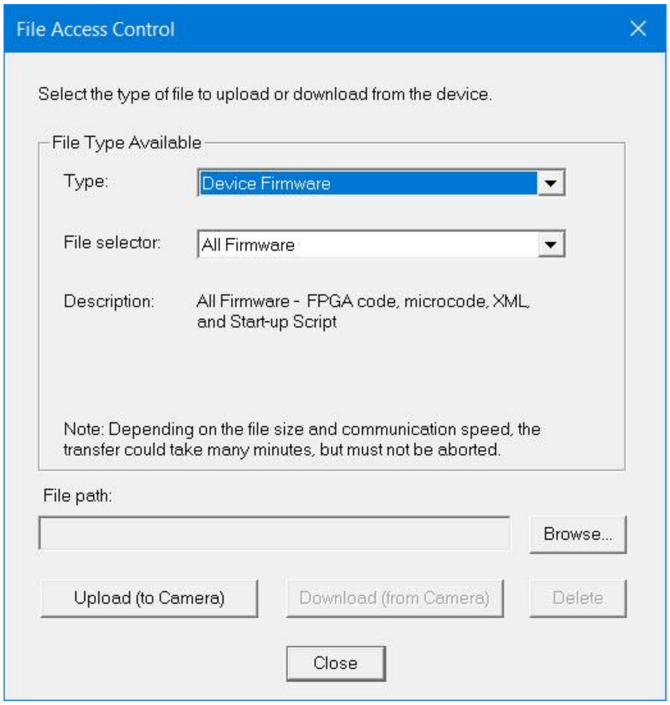


Figure 45: File Access Control Tool

2. From the **Type** list, select *Device Firmware*.
3. From the **File Selector** list, select *All Firmware*.
4. Click **Browse** and select the. cbf firmware file.
5. Click **Upload (to Camera)**.

Firmware changes require that the camera be reset. When the firmware update is successfully completed, a message box opens to reset the camera. Click **Yes** to reset the camera.

Caution: Do not interrupt file transfers by powering down the camera or closing CamExpert.

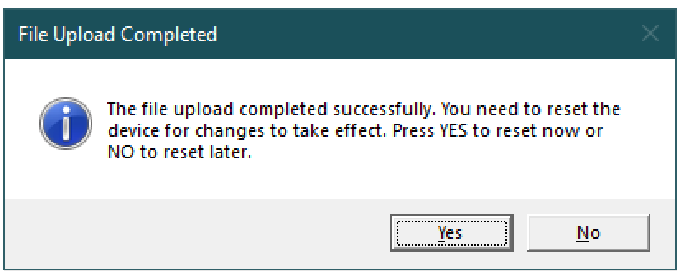


Figure 46: Firmware Upload Completed Message Box.

To upload or download files other than firmware

For other types of files to upload or download, select other from the **Type** and **File Selector** lists, click **Browse**, then **Upload (to Camera)** or **Download (from Camera)**.

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.

To download a file from camera

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

To upload a file to camera

- Select the file by setting the FileSelector feature.
- Set the FileOpenMode to Write.
- Set the FileOperationSelector to Open.
- Open the file by setting FileOperationExecute to 1. This is a read-write feature - poll it every 100 ms until it returns 0 to indicate it has completed
- Read FileOperationStatus to confirm that the file opened correctly. A return value of 0 is success. Error codes are listed in the XML.
- Read FileSize to get the maximum number of bytes allowed in the file.
  - Abort and jump to Close if this is less the file size on the host
- From FileAccessBuffer.Length you will know that maximum number of bytes that can be written through FileAccessBuffer is 988.

- For Offset = 0 While ((Offset < Host File Size) and (Status = 0)) Do
    - Set FileAccessOffset to Offset
    - Set FileAccessLength to min(Host File Size - Offset, FileAccessBuffer.Length), the number of bytes to write
    - Read next FileAccessLength bytes from host file.
    - Write the bytes to FileAccessBuffer
    - Set the FileOperationSelector to Write
    - Write to the file by setting FileOperationExecute to 1 and poll until 0 and complete
    - Read FileOperationStatus to confirm the write worked
    - Read FileOperationResult to confirm the number of bytes written.
- Next Offset = Offset + number of bytes written.
- Set the FileOperationSelector to *Close*.
- Close the file by setting FileOperationExecute to 1 and poll until 0 and complete.
- Read FileOperationStatus to confirm the close worked.

Download a List of Camera Parameters

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

- In the File Access Control tab click **Settings**.
- In the **Type** list select *Miscellaneous*.
- In the **File Selector** list select *CameraData*.
- Click **Download (from Camera)**.
- Save the text file and send the file to Teledyne DALSA customer support.

Additional Reference Information

Optical Considerations

This section provides an overview to illumination, light sources, filters, lens modeling, and lens magnification. Each of these components contribute to the successful design of an imaging solution.

Illumination

The wavelengths and intensity of light required to capture useful images vary per application. The image will be affected by speed, spectral characteristics, line rate/exposure time, light source characteristics, environmental and acquisition system specifics, etc. Browse the Teledyne Vision Solutions Machine Vision Learning Center for articles on this potentially complicated issue.

Exposure settings have more effect than illumination. The total amount of energy (which is related to the total number of photons reaching the sensor) is more important than the rate at which it arrives.

Example: 5 $\mu J/cm^2$ can be achieved by exposing 5 mW/cm^2 for 1 ms or exposing 5 W/cm^2 for 1 μs.

Light Sources

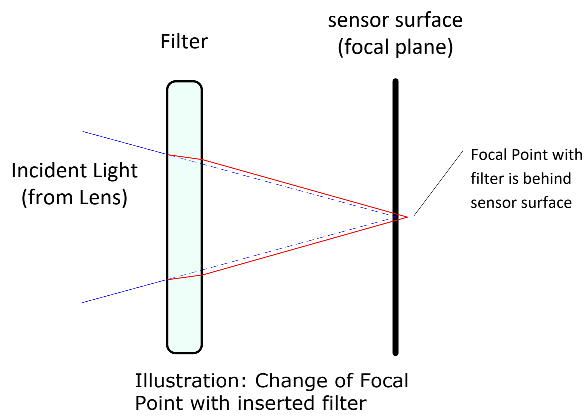
Keep these guidelines in mind when selecting and setting up a light source:

- LED light sources are inexpensive and provide a uniform field with a longer life span compared to other light sources.
- Some light sources age and produce less illumination in some areas of the spectrum.

Back Focal Variance when Using any Filter

Inserting a filter between a lens and sensor changes the back focal point of the lens used. A variable focus lens simply needs to be adjusted, but in the case of a fixed focus lens, the changed focal point needs correction.

The following simplified illustration describes this but omits any discussion of the optics, physics, and math behind the refraction of light through glass filter media.



In this example when a glass filter is inserted between the lens and the camera sensor, the focal point is now about 1/3 of the filter thickness behind the sensor plane.

Lens Modeling

Any lens surrounded by air can be modeled for camera purposes using three primary points: the first and second principal points and the second focal point. The primary points for a lens should be available from the lens data sheet or from the lens manufacturer. Primed quantities denote characteristics of the image side of the lens. That is, h is the object height and h′ is the image height.

The focal point is the point at which the image of an infinitely distant object is brought to focus. The effective focal length (f′) is the distance from the second principal point to the second focal point. The back focal length (BFL) is the distance from the image side of the lens surface to the second focal point. The object distance (OD) is the distance from the first principal point to the object.

Primary Points in a Lens System

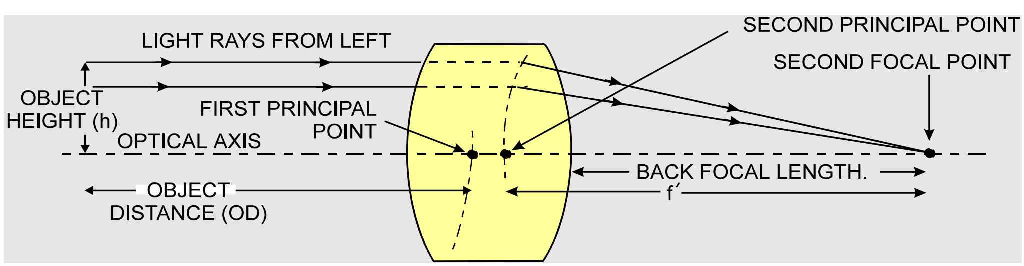


Figure 47: Primary Points in a Lens System

Magnification and Resolution

The magnification of a lens is the ratio of the image size to the object size:

$m = h'/h$	Where m is the magnification, h' is the image height (pixel size) and h is the object height (desired object resolution size).

By similar triangles, the magnification is alternatively given by:

$m = f'/OD$	Where f' is the focal length and OD is the target object distance.

These equations can be combined to give their most useful form:

$h'/h = f'/OD$	This is the governing equation for many object and image plane parameters.

Example: An acquisition system has a 512 x 512-element 10 µm pixel pitch, a lens with an effective focal length of 45 mm. For each pixel in the image sensor to correspond to 100 µm in the object space, using the preceding equation, the object distance must be 450 mm (0.450 m).

$(10\ \mu m)/(100\ \mu m) = (45\ mm)/OD$	$OD = 450\ mm\ (0.450\ m)$

Sensor Handling Instructions

This section reviews procedures for handling, cleaning or storing the camera. The sensor must be kept clean and away from static discharge to maintain design performance.

Electrostatic Discharge and the Sensor

Camera sensors containing integrated electronics are susceptible to damage from electrostatic discharge (ESD). See section Preventing Operational Faults Due to ESD for precautions.

Protecting Against Dust, Oil and Scratches

The sensor window is part of the optical path and must be handled with extreme care.

Dust can obscure pixels producing dark patches on the sensor image. Dust is most visible when the illumination is collimated. The dark patches shift position as the angle of illumination changes. Dust is normally not visible when the sensor is positioned at the exit port of an integrating sphere where illumination is diffused.

Blowing compressed air on the window will remove dust particles unless they are held by an electrostatic charge. In this case, either an ionized air blower or a wet cleaning is necessary.

Touching the surface of the window will leave oily residues. Using rubber finger cots and rubber gloves can prevent oil contamination. Avoid friction between the rubber and window or electrostatic charge build up may damage the sensor.

When handling or storing the camera without a lens always install the protective cap.

NOTE
When exposed to uniform illumination, a scratched window will normally display brighter pixels adjacent to darker pixels. The location of these pixels will change with the angle of illumination.

Cleaning the Sensor Window

Even with careful handling, the sensor window may need cleaning. The following steps describe techniques to clean minor dust particles or accidental finger touches.

- Use compressed air to blow off loose particles. This step alone is usually sufficient to clean the sensor window. Avoid moving or shaking the compressed air container and use short bursts of air while moving the camera in the air stream. Agitating the container will cause condensation to form in the air stream. Long bursts will chill the sensor window causing more condensation. Condensation, even when left to dry naturally, will deposit more particles on the sensor.
- When compressed air cannot clean the sensor, Teledyne DALSA recommends using lint-free ESD-safe cloth wipers or swabs that do not contain particles that can scratch the window. Do not use regular cotton swabs, since these can introduce static charge to the window surface. Wipe the window carefully and slowly when using these products.

Cleaning the Camera Housing Surface

To clean the surface of the camera housing, use a soft, dry cloth. 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 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.

Troubleshooting Guide

Before Contacting Technical Support

Carefully review the issues described in this Troubleshooting section. To aid the Teledyne DALSA technical support team, include the following information with the request for support:

- Log Viewer Messages. From the **Start** menu, select **Teledyne DALSA Sapera LT** > **Sapera Log Viewer**. Start CamExpert or your acquisition program. On the Log Viewer's **File** menu, select **Save All Messages** to generate a log text file.
- Report the firmware version and Sapera version used.
- Report the frame grabber used and device driver version.
- Include the camera data file, which can be downloaded from the camera. See Camera Data File.
- Report the value of the Power-on Status parameter of the camera. See Built-In Self-Test (BIST) Status Codes.

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 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 features are accessed using the CamExpert > Camera Information tab. Press the associated refresh button for a real-time measurement.

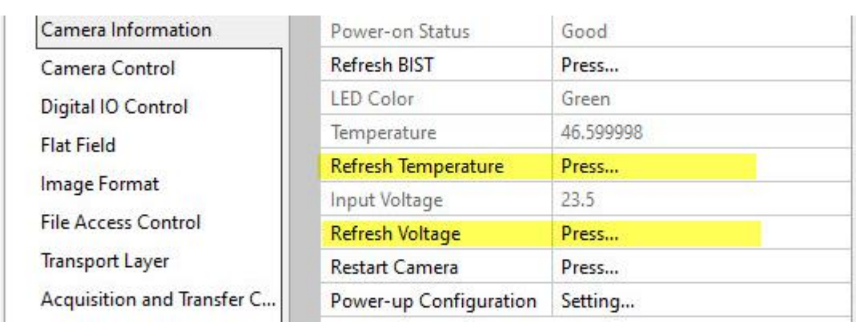


Figure 48: CamExpert Voltage & Temperature Features

Test Patterns – What Can They Indicate?

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

NOTE
Gray images are displayed so that any bit error will immediately be apparent as colored pixels in the image.

There are several test patterns that can be selected via the Image Format > Test Pattern parameter in CamExpert.

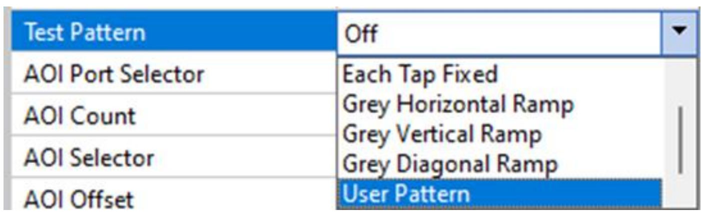


Figure 49: CamExpert Test Pattern Options.

They have the following format when using 8-bit data:

- **Each Tap Fixed**. Starting at 0 increases in by 4 steps every 256 pixels ending in 251.
- **Grey Horizontal Ramp**. Two horizontal ramps starting at 00H increasing by 01H every 64 pixels.
- **Grey Vertical Ramp**. Vertical ramp starting with 1st row 0, next row 2, and incrementing by 2 every line.
- **Grey Diagonal Ramp**. Add horizontal and vertical ramps.
- **User Pattern**. When selected, the camera will first output all pixel values to be half full scale. The user can then generate a custom test pattern by uploading PRNU coefficients that appropriately manipulate the half scale data to achieve the desired pattern. See section Saving & Loading a PRNU Set Only.

Built-In Self-Test (BIST) Status Codes

The Power-on Status parameter in the Camera Information category reports the current status of the camera. If the device is working properly, the Power-On Status indicates *Good*, otherwise a BIST status code is reported (see list below). None of these should occur in a properly functioning camera except OVER_TEMPERATURE, which may occur if there is insufficient air circulation or heat sinking.

Table 20: Built-In Self-Test (BIST) Codes

Bit Number	Name	Hex Position	Binary Translation
1	I2C	0x00000001	0000 0000 0000 0000 0000 0000 0000 0001
2	FPGA_NO_INIT	0x00000002	0000 0000 0000 0000 0000 0000 0000 0010
3	FPGA_NO_DONE	0x00000004	0000 0000 0000 0000 0000 0000 0000 0100
4	SENSOR_SPI	0x00000008	0000 0000 0000 0000 0000 0000 0000 1000
5	ECHO_BACK	0x00000010	0000 0000 0000 0000 0000 0000 0001 0000
6	FLASH_TIMEOUT	0x00000020	0000 0000 0000 0000 0000 0000 0010 0000
7	FLASH_ERROR	0x00000040	0000 0000 0000 0000 0000 0000 0100 0000
8	NO_FPGA_CODE	0x00000080	0000 0000 0000 0000 0000 0000 1000 0000
9	NO_COMMON_SETTINGS	0x00000100	0000 0000 0000 0000 0000 0001 0000 0000
10	NO_FACTORY_SETTINGS	0x00000200	0000 0000 0000 0000 0000 0010 0000 0000
11	OVER_TEMPERATURE	0x00000400	0000 0000 0000 0000 0000 0100 0000 0000
12	SENSOR_PATTERN	0x00000800	0000 0000 0000 0000 0000 1000 0000 0000
13	NO_USER_FPN	0x00001000	0000 0000 0000 0000 0001 0000 0000 0000
14	NO_USER_PRNU	0x00002000	0000 0000 0000 0000 0010 0000 0000 0000
15	CLHS_TXRDY_RETRY	0x00004000	0000 0000 0000 0000 0100 0000 0000 0000
16	INVALID_UPGRADE	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
25	IN_FACTORY_PARTITION	0x01000000	0000 0001 0000 0000 0000 0000 0000 0000

Resolving Camera Issues

Communications

No Camera Features when Starting CamExpert

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

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

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

AOC (Active optical cables) are directional. The connector end labelled **Camera** should always be connected to a camera port (or to the Output port of a frame grabber when connecting two frame grabbers together in data-forwarding configuration). The connector end labelled **F G** should only be connected to the Input port of a frame grabber.

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.

- Set Digital I / O Control > Trigger Mode to *Internal*, and
- Set Camera Control > Acquisition Line Rate to the maximum that will be used.

The trigger signal from the frame grabber will not be used and the LVAL status should now be green. This will confirm the integrity of the image data portion of the CLHS cabling and connectors.

- Set Digital I / O Control > Trigger Mode to *External*.
- From the Frame Grabber > Advanced Control:
    - set Line Sync Source to *Internal Line Trigger*
    - set Internal Line Trigger to the maximum frequency that will be used.

The trigger source is now being generated by the frame grabber and the LVAL status should be green. This will confirm the integrity of the General Purpose I / O portion of the CLHS cabling and connectors.

- From the Frame Grabber > Advanced Control:
    - set Line Sync Source to *External Line Trigger* and
    - set Line Trigger Method to *Method 2*.
- From the Frame Grabber > External Trigger, set External Trigger to *Enable*.

If LVAL status turns red, check the following:

- Is the transport system moving such that encoder pulses are being generated?

- Has the encoder signal been connected to the correct pins of the I/O connector of the frame grabber? See the Xtium2-CLHS frame grabber user manual for details.
- Do the encoder signal levels conform to the requirements outlined in the Xtium2-CLHS frame grabber user manual?

Image Quality Issues

Distortion and Blurring Due to Unoptimized Alignment or Electrical Settings

Mounting, relative object motion, and synchronization requirements for TDI cameras are stricter than for non-TDI cameras. Errors introduced by rotational misalignment, vibration, or incorrect trigger rate can lead to image distortion and blurring.

Please refer to application note Application Guideline for TDI Cameras, which discusses the effects of various types of mounting and trigger signal errors on image quality.

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 difficult to achieve a perfectly uniform, defect-free white reference. The following two approaches can help in minimizing the effects of white reference defects:

- Move the white reference closer to or further away from the object plane such that it is out of focus. This can be effective if the illumination profile changes minimally when relocating the white reference.
- If the white reference must be located at the object plane, then move the white reference in the scan direction or sideways when flat field calibration is being performed. The camera averages several thousand lines when capturing calibration reference images so any small imperfections are averaged out.

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.

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 File Access and Firmware Update for details on downloading and uploading camera files using CamExpert.

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

Smeared & Distorted Images

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

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

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

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

Continuously Smeared, Compressed or Stretched Images

When accurate synchronization is not achieved, the image appears smeared in the scan direction.

If the EXSYNC pulses are coming too fast, then the image will appear smeared and stretched in the machine direction. If the pulses are too slow, then the image will appear smeared and compressed.

Check the resolution of the encoder used to generate the EXSYNC pulses, along with the size of the rollers, pulleys, gearing, etc. to ensure that one pulse is generated for one pixel size of travel of the object.

It is also important that the direction of image travel across the sensor is matched to the camera's scan direction, as set by the user. See 'Scan Direction' in the user manual for more information.

If the scan direction is incorrect, then the image will have a significant smear and color artifacts in the scan direction. Changing the scan direction to the opposite direction should resolve this problem.

Refer to section Scan Direction for more information on how to determine the correct direction orientation for the camera.

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

Randomly Compressed Images

It is possible that when the scan speed nears the maximum allowed, based on the line rate 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 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's 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 +24 V DC (+/- 10%).

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

Assume a worst-case power consumption of +56 W and a 150% current rating for the breaker or fuse.

Reading the input supply voltage as measured by the camera will indicate the supply drop.

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 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 +50 °C and the internal temperature kept below +70 °C.

As camera temperature increases, the amount of noise in the image also increases. It is always preferable to maintain the camera at the lowest possible temperature.

Many applications, such as in clean rooms, cannot tolerate the use of forced air cooling (fans) and therefore must rely on natural 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 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 of the Teledyne Vision Solutions website or by request.

FCC Statement of Conformance

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

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

FCC Class A Product

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

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

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

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.

Appendix A – Performing Flat Field Calibration Using CamExpert

The goal of camera flat field calibration is to produce a uniform image at a desired gray level while imaging a uniform white target in the application setup environment. CamExpert tool provides a GUI that facilitates flat field calibration. The process requires the user to plan acquisitions in dark and bright conditions, followed by the FFC procedure itself. These steps are detailed below.

Before performing a FFC follow these guidelines:

- Ensure the camera is at normal operating temperature. Apply power for at least 30 minutes.
- All parameters should meet your application's specifications. If parameters change after FFC completion, the results may no longer be accurate. Perform another FFC.
- FFC should be performed for both scan directions.

Flat Field Calibration White Target

Flat field calibration requires a white target that consists of a controlled diffused light source aimed directly at the lens or a non-glossy paper (or evenly lit wall) with the lens slightly out of focus. Ideally, use a professional target. If a sheet of material is being used, 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, creating vertical stripes in scanned images.

One way to minimize this effect is to have the white target in motion or to defocus the lens during calibration. This has the result of averaging out any dirt or texture present.

Set up Dark and Bright Image Acquisitions with the Histogram Tool

To prepare for calibration, follow the guidelines:

- Verify the camera's dark and bright acquisition with a live grab.
  - Dark image acquisition requires a lens cap.
  - Bright acquisition requires a flat, light image. See Flat Field Calibration White Target.
- Use CamExpert **Statistics** command while grabbing to display the image characteristics. In the Statistics dialog, use the **Selected view** list to select *Histogram* or *Line Profile*.

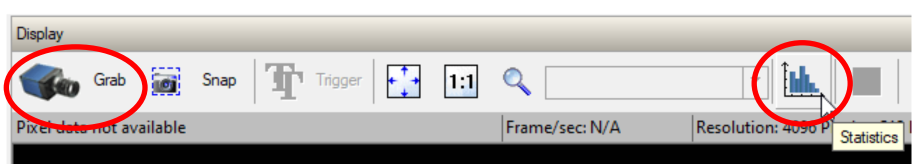


Figure 50: CamExpert – Grab & Statistics Buttons

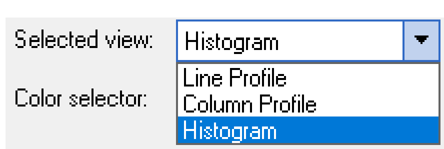


Figure 51: CamExpert Statistics Dialog – Selected View

Set up Dark Image

Dark acquisition requires that the lens be covered with the lens cap. During acquisition, the **average** pixel value for the frame should be close to zero. If some of the pixel output is zero, adjust the Black Level feature offset value to ensure that all pixel output is above zero.

The following figure shows a typical histogram for a camera grabbing a dark image.

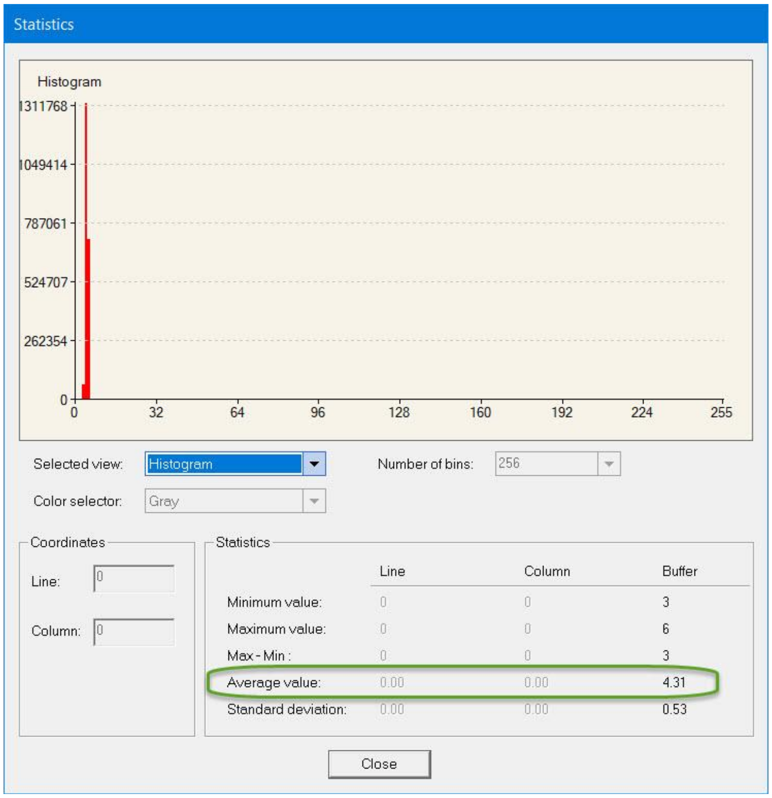


Figure 52: CamExpert Statistics Dialog – Average Dark Pixel Value

Set up Bright Image

For a bright image, use a white target (see Flat Field Calibration White Target). During acquisition, use the lens iris to adjust for a bright but unsaturated gray level, around 200 (for 8-bit).

During calibration, you may choose to adjust all pixels to a target value, e.g., 200, or to the peak pixel value, depending on the chosen flatfieldCorrectionAlgorithm option. When choosing the target option, it is preferable to set a target value that is above and not too far from the uncorrected peak.

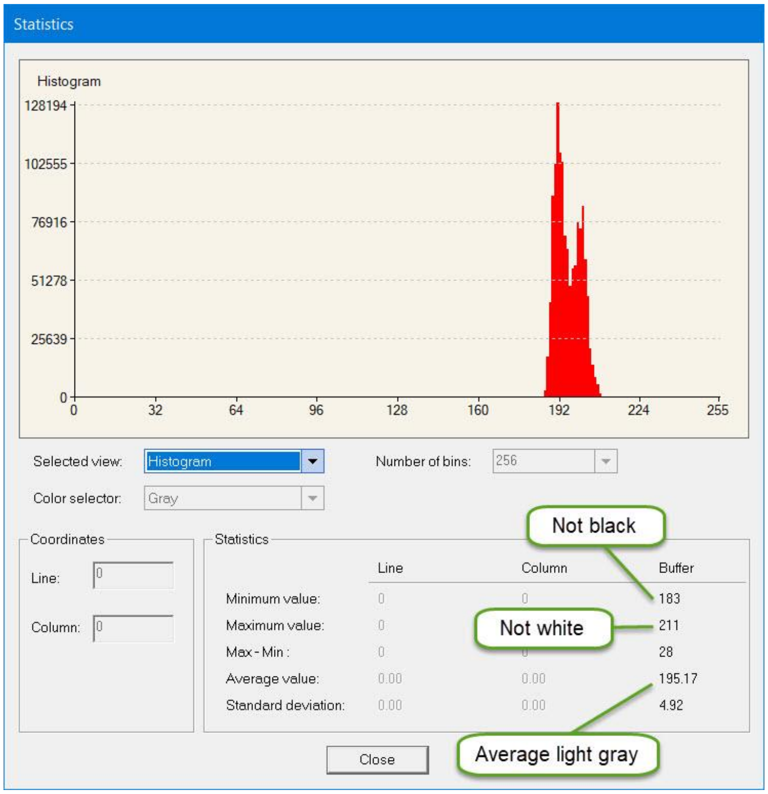


Figure 53: CamExpert Statistics Dialog – Verifying Bright Acquisition

When the bright image acquisition setup is complete, note the camera and lens iris position for repeatability in the future.

Flat Field Correction Calibration

Flat Field Correction Calibration (FFC) involves:

- Evaluating a bare image.
- Performing FPN (Fixed Pattern Noise).
- Performing PRNU (Photon Response non-uniformity) corrections.

NOTE

During calibration, no other feature settings should be accessed or modified.

Before you begin

- Set black level value = 0.
- Set system gain and digital gain values = 1.
- Clear FFC coefficients.

Bare Image Evaluation

Before you perform the FFC, Teledyne DALSA recommends that you to try to improve the bare image quality first: a good bare image will improve the quality of the FFC. A bare image is obtained using your bright target with no gain applied.

To obtain a bare image

1. Set the Flat Field Correction Mode feature to *Off*.
2. Use the Gain Selector to set the Gain value of all options to *1.0.*

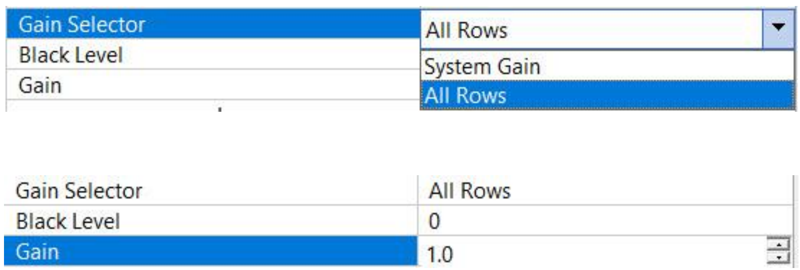


Figure 54: CamExpert – Gain

3. Click **Grab** and open the **Statistics** tool with the *Line Profile* view option to evaluate a bare image.

A line profile is mainly characterized by two factors: flatness and height.

- **Flatness.** Line profile should be as flat as possible. Note that due to lens-shading effect, light falls off near the edges, which results in lower output. This produces higher noise levels near the edges. A smaller aperture opening and longer focal length can reduce lens–shading effect. In some demanding applications, optimized low–shading lenses should be considered.
- **Height.** An average value near your calibration target is ideal. Level can be higher, but a much lower level is not desirable. An extremely low output height compared to the target will increase noise level significantly after the PRNU is corrected. To avoid SNR and/or DNR not meeting your application requirements, the profile should reach a level near the calibration target.

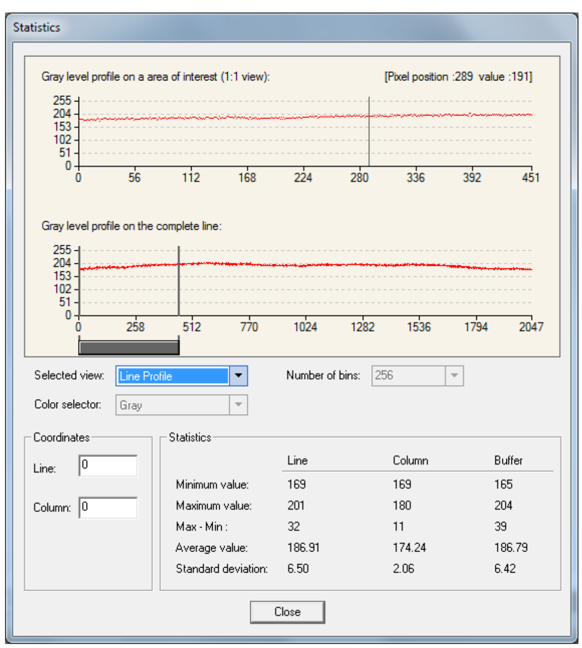


Figure 55: CamExpert Statistics Dialog – Line Profile of a bare image of a white uniform target.

To improve a bare image profile, increasing the output level by enhancing illumination (light source, lens, line rate, etc.) is the preferred method. If, despite the above effort, you still do not meet your goals, you may try adjusting gain features in the SNR allowable range. Keep in mind that changes to gain do not improve the image quality from an SNR perspective. All gains are digital multipliers and, as such, the gain scales up signal and noise proportionally. Use this method only as long as the SNR meets your application requirements.

Keep the following in mind:

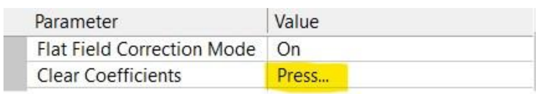
- Ensure that the camera's temperature is in a stable condition.
- All parameters should meet your application's specifications. If you change parameters after the FFC is done, then the FFC results many no longer be relevant. When parameters change, you should run the FFC procedure again.

Once a good bare image is achieved, you can proceed with the FPN calibration.

FPN Calibration

To perform FPN Calibration

1. Set the Flat Field Correction Mode to *On*.
2. Click **Press** next to Clear Coefficients.



3. Cover the lens (place the sensor in dark).
4. Click **Grab** and check the line profile/histogram. If some, or all, of the pixels outputs are zero, adjust the Black Level offset (Camera Control category) value to ensure that all pixel output is above zero.

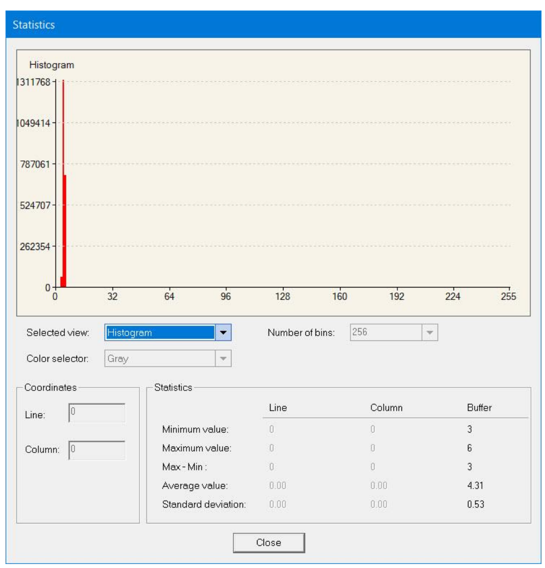


Figure 56: CamExpert Statistics Dialog – FPN Pixel Output

5. Click **Press** next to Calibrate FPN.

You may proceed with PRNU calibration.

PRNU Calibration

To perform PRNU Calibration

1. Uncover the lens and point the camera at a diffused light source or at your chosen white target, using the setup and iris position tested before.
2. If using the *Set Target* option in the Calibration Algorithm parameter, adjust the Flat Field Calibration Target. A value of 200 DN is commonly used target in 8-bit output format. Set the target pixel close to the uncorrected peak.

Parameter	Value
Flat Field Correction Mode	On
Clear Coefficients	Press...
Calibration Algorithm	Set Target
Flat Field Calibration Target	200

3. Click **Grab**.
4. Click **Press** next to Calibrate PRNU.

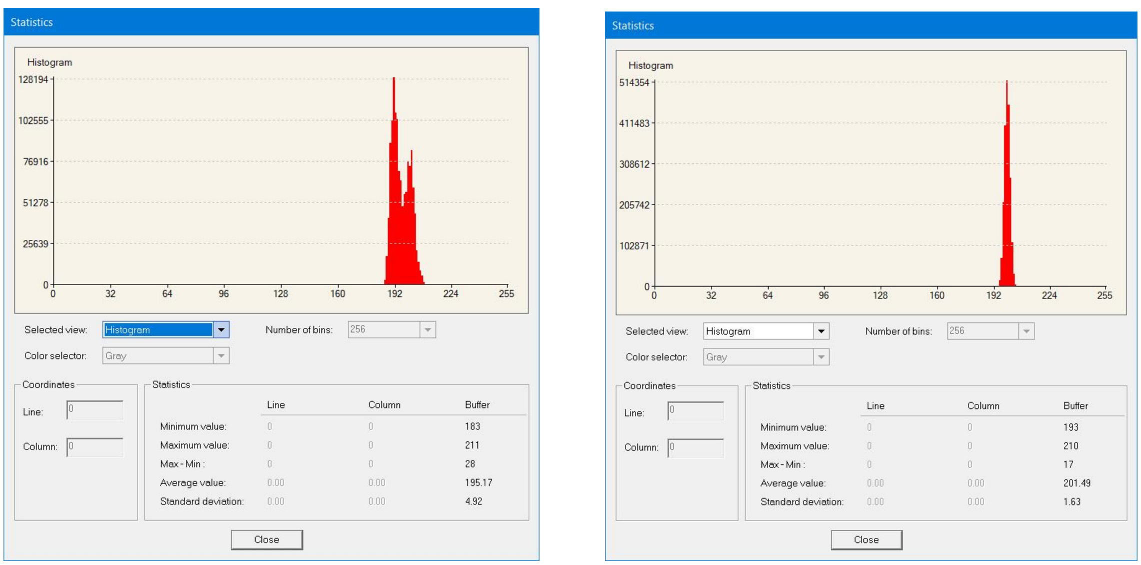


Figure 57. Histogram before and after PRNU calibration using a 200 DN target.

5. Select a user set from the PRNU Correction Current Active Set list, then click **Press** next to Save Calibration. The FFC results will be stored in the selected user set.

PRNU Current Active Set	User Set 5
Save Calibration	Press...
Load Calibration	Press...

NOTE

Saving a calibration in this way only saves the PRNU coefficients. To save FPN coefficients as well, you need to save a User Set in the Power-up Configuration dialog (see below).

6. To save this calibration and all current settings for future use, save it to a camera configuration user set through the Power-up Configuration dialog (see Saving & Restoring Camera Setup Configurations). The dialog allows you to save or load a configuration user set dynamically, or to load automatically a selected user set when resetting or powering the camera.

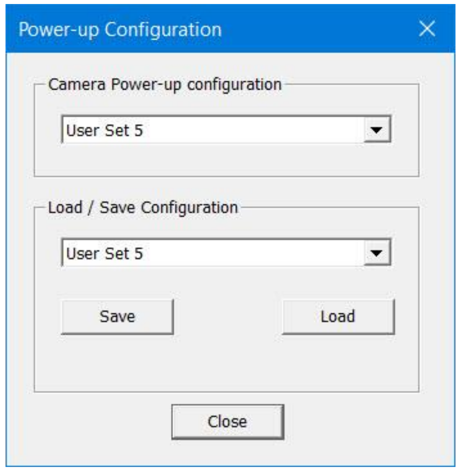


Figure 58: CamExpert – Power-up Configuration Dialog.

Revision History

Revision	Description	Date
00	Preliminary release.	2024-02-16
01	Preliminary release. New H2-HM-16k33T-50 model. New implemented features: binning, load/save PRNU calibration, additional TDI imaging modes. Related updates.	2024-05-08
02	Preliminary release. New H2-HM-16k100H-00-B backside illumination model. Implementation of external trigger sources (GPIO, rotary encoder); new TDI and area modes. Appendix on flat field calibration. Related updates.	2024-06-18
03	Preliminary release. Implementation of alignment markers, LUT, gamma correction, EOI (enhanced regions of interest). Related updates.	2024-08-12
04	Preliminary release. Addition of Xtium3 frame grabber and related updates. Model specification updates. New Sensor Alignment Specification section. Depiction of I/O connections of Hirose connector to underline the importance of connecting the correct pins. Added power cable provider and updated GPIO breakout cable accessory diagram. Updated Flat Field Calibration and PRNU section Upated links to new Teledyne Vision Solutions website.	2024-11-01
05	Initial release. Updated Model Specifications and added Responsivity and QE graph. Thermal management caution update. Expanded TDI and area modes descriptions in section Imaging Mode. New table for max line rate according to imaging mode and bit depth in section Imaging Mode and Line Rate. Various updates. Changed CLHS bandwidth from 10.3Gbps to 10.3125 Gbps. Updated connection configuration diagrams. Added AOC cable direction to troubleshooting section. Added mention '*Available 2025*' to Xtium3 part number.	2024-11-25

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